Improving Groupware Design for Loosely Coupled Groups

A Thesis Submitted to

The College of Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy

In the

Department of Computer Science

University of Saskatchewan

Saskatoon, Saskatchewan

By

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Abstract

Loosely coupled workgroups are common in the real world, and workers in these groups are autonomous and weakly interdependent. They have patterns of work and collaboration that distinguish them from other types of groups, and groupware systems that are designed to support loose coupling must address these differences. However, they have not been studied in detail in Computer-Supported Cooperative Work (CSCW), and the design process for these groups is currently underspecified. This forces designers to start from scratch each time they develop a system for loosely coupled groups, and they must approach new work settings with little information about how work practices are organized.

In this dissertation, I present a design framework to improve the groupware design process for loosely coupled workgroups. The framework has three main parts that add a new layer of support to each of the three stages in the general groupware design process: data collection about the target work setting, analysis of the data, and system design based on the analysis results. The framework was developed to provide designers with support during each of these stages so that they can consider important characteristics of loosely coupled work practice while carrying out design for the target group. The design framework is based on information from CSCW and organizational research, and on real-world design experiences with one type of loosely coupled workgroup—home care treatment teams.

The framework was evaluated using observations, interviews, and field trials that were carried out with multidisciplinary home care treatment teams in Saskatoon Health Region. A series of field observations and interviews were carried out with team members from each of the home care disciplines. The framework was then used to develop Mohoc, a groupware system that supports loosely coupled work practice in home care. Two field trials were carried out where the system was used by teams to support their daily activities. Results were analyzed to determine how well each part of the design framework performed in the design process. The results suggest that the

framework was able to fill its role in specializing the general CSCW design process for loosely coupled groups by adding consideration for work and collaboration patterns that are seen in loosely coupled settings. However, further research is needed to determine whether these findings generalize to other loosely coupled workgroups.

Publications from this dissertation

Materials and ideas from this dissertation have previously appeared in peer reviewed publications. The following list shows journal papers, conference papers, and workshop papers, and it notes the chapters where the papers were used.

Journal paper

Pinelle, D., Gutwin, C., Greenberg, S. (2003) Task analysis for groupware usability evaluation: modeling shared-workspace tasks with the mechanics of collaboration. *Transactions on Computer-Human Interaction (TOCHI)*, ACM Press, 10(4), 2003, pp. 281-311. Short summary in interactions, ACM Press, 11(2), 2003, pp. 7-8. (Chapter 5)

Conference papers

Pinelle, D., Gutwin, C. (2003) Designing for loosely coupled mobility. *Proceedings of ACM Group 2003*, Sanibel Island, Florida, November 2003, ACM Press, pp. 75-84. (Chapters 3, 6)

Pinelle, D., Gutwin, C. (2003) Awareness-based scheduling in a home care clinical information system. *Proceedings of American Medical Informatics Association (AMIA) Annual Symposium 2003*. Washington DC, November 2003, AMIA Press. (Chapter 7)

Pinelle, D., Dyck, J., Gutwin, C. (2003) Aligning work practices and mobile technologies: groupware design for loosely coupled mobile groups. *Proceedings Mobile HCI 2003*. Udine, Italy, September 2003, Springer-Verlag, 177-192. (Chapter 7)

Pinelle, D., and Gutwin, C. (2002) Supporting collaboration in multidisciplinary home care teams. *Proceedings of American Medical Informatics Association (AMIA) Annual Symposium 2002*. San Antonio, November 2002, AMIA Press, 617-621. (Chapter 3)

Pinelle, D., and Gutwin, C. (2002) Groupware walkthrough: adding context to groupware usability evaluation. *Proceedings of the 2002 SIGCHI conference on human factors in computing systems (CHI2002)*, Minneapolis, Apr 2002, ACM Press, 455– 462. (Chapter 5)

Workshop papers

Pinelle, D. (2002) Learning from home care: groupware design for widely distributed mobile groups, *ACM CSCW 2002 Conference Companion* (Doctoral Colloquium), ACM Press, New Orleans, Nov. 2002. (Chapters 3, 6)

Pinelle, D., and Gutwin, C. (2001) Group task analysis for groupware usability evaluations. *Proceedings 10th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET ICE'01)*, Cambridge, Massachusetts, June 2001, IEEE Press, 102-107. (Chapter 5)

Pinelle, D., and Gutwin, C. (2000) A review of groupware evaluations. *Proceedings 9th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET ICE'00)*, Gaithersburg, Maryland, June 2000, IEEE Press, 86-91. (Chapter 2)

Acknowledgements

Thanks to my advisor Carl Gutwin for his guidance through my years in graduate studies. I appreciate his patience, sound advice, and encouragement. I am also grateful for his commitment to my development as a researcher and for assisting me with my future career.

My advisory committee played a significant role in shaping and revising the final thesis, and I am grateful for their time and advice. The committee members were (in no particular order) Tony Kusalik, Gord McCalla, Eric Neufeld, Kevin Schneider, and Harley Dickinson. I also extend my sincerest appreciation to Rebecca Grinter for acting as the external for my defense.

I am grateful to all of the people in Saskatoon Health Region who assisted in this research. I thank the administrators, who agreed to allow this research to go forward, and I thank the management in Home Care, CPAS, Occupational Therapy, Physical Therapy, and Social Work—all of whom agreed to allow their employees to participate. Thanks to all of those who directly participated in this research during interviews, observations, field trials, or prototype evaluation sessions. I especially would like to acknowledge and thank Cec Charlebois, Myra Parcher, and Carla Patrick, all of whom played significant roles in planning and coordinating research activities.

I am fortunate for the support I received from many people in the Department of Computer Science. I am extremely grateful to Jan Thompson for her help and kindness and for her patience with my absentmindedness. I also thank Maureen Desjardins for her help through the years. I extend my thanks to the members of the Interaction Lab, many of who provided advice throughout this project, including: Jeff Dyck, Amy Skopik, Sonia Chiasson, Steve Levy, Reagan Penner, Chris Fedak, Roger Blum, and Scott Davis.

Thanks to Barry Brown. I appreciate his encouragement (which often seems to come when it is needed most), his advice (when I can decipher it), and his ongoing assistance (whatever that means).

I thank my wife Jacqueline Quail for always being there and for her continued patience through the years. She has always offered encouragement and understanding and has seldom complained—I am fortunate and grateful.

I thank my family in Texas and in Saskatoon. Thanks to my mother Annette Webber for her patience and understanding. Thanks to Wilson and Florence Quail for their encouragement and support. I regret that my father, Gilbert Pinelle, is not here to see the completion of this thesis, but I remember him fondly.

Finally, thanks to the Canadian Institutes of Health Research for funding this research.

Technical acknowledgements

Some of the development work for the groupware systems discussed in Chapter 7 was carried out in collaboration with Jeff Dyck. His main contributions to this project were in the form of advice, coding, and testing. In retrospect, it is difficult to recall all of his contributions, but the main ones were:

- Design, implementation, and integration of the Mohoc, Pocket Mohoc, and server side network layers
- Participation in testing the client and server applications
- Assistance in evaluating and selecting hardware for client machines
- Implementation and integration of encryption packages
- Implementation of the patching utility
- Advice on system architecture and project management issues
- Porting of Mohoc business logic layer to C# in preparation for the implementation of Pocket Mohoc
- Implementation of Pocket Mohoc, including a new GUI layer, dispatch layer, and network layer

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1 Introduction

Loosely coupled workgroups are common in the real world, and they have been identified in a number of domains including education, healthcare, knowledge work, and mobile service work. Workers in these groups have reduced interdependence and can function autonomously, and often without the need for immediate clarification or negotiation with others (Olson and Teasley 1996). They have patterns of work and collaboration that distinguish them from other types of groups, and groupware systems that are designed to support loose coupling must address these differences. However, these groups have not been studied in detail in Computer-Supported Cooperative Work (CSCW), and it is not clear what their design requirements are, or how groupware should be developed to address their needs.

Since groupware design for loosely coupled workgroups is underspecified, groupware designers must start from scratch each time they develop a system for one of these groups. This means that designers cannot make use of others' design experiences in similar groups, and must approach the work setting with little information about how work practices are organized. They must rely on a general CSCW design process where they collect data about the target work setting, analyze the data, and develop a system design based on the analysis results. However, without the benefit of information from others' design experiences, designers can overlook important work characteristics, and can develop designs that are not well-suited to work in context.

In this dissertation, I present a design framework to improve the groupware design process for loosely coupled groups. The framework has three main parts that add a new layer of support to each of the three stages in the general groupware design process: data collection, analysis, and system design. The framework was developed to provide designers with support during each of these stages so that they can consider important characteristics of loosely coupled work practice while carrying out design for the target group. The design framework is based on information from CSCW and organizational research, and on real-world design experiences with one type of loosely coupled workgroup—home care treatment teams.

1.1 Problem

Groupware design for loosely coupled workgroups is difficult because the design process is underspecified. Loosely coupled groups have different patterns of organization, work, and collaboration than more tightly coupled groups, and therefore have different design requirements. However, loosely coupled groups have not been studied in detail in CSCW literature, and it is not clear what their design requirements are, or how systems should be developed to address their needs. Designers involved in developing groupware for these groups must start from scratch, and are unable to benefit from others' design experiences.

The problem can be divided into four parts. First, "loose coupling" does not have an operational definition that allows designers to easily recognize it in the real world. Second, it is not clear what underlying social, environmental, and organizational factors can lead to the adoption of loose coupling. Third, it has not been clearly established how loosely coupled groups organize work and collaboration. Fourth, it is not clear how groupware applications should be designed to accommodate work, collaboration, and organizational patterns seen in loosely coupled workgroups.

Operational definition of loose coupling. Loose coupling has not been unambiguously defined for groupware designers. Current definitions for loose coupling do not provide clear criteria for deciding when it exists in groups and organizations. Therefore, it is difficult for designers to consistently recognize loose coupling in the real world, and it is difficult to learn from others' design experiences.

Reasons for loose coupling. It is not clear why groups adopt loosely coupled work practices. CSCW researchers have considered spatial and temporal reasons, such as physical distribution, schedule variability, and mobility. However, organizational and social factors may also play a role, but these have not been investigated in CSCW. Since the reasons for loose coupling have not been explored in detail, it is difficult for groupware designers to consider how their designs will impact the target group.

Work and collaboration patterns in loose coupling. It is not clear how loosely coupled groups organize work and collaboration. Real world work and collaboration patterns shape the design requirements of groupware systems. However, in loosely coupled groups, these patterns have only been considered at a superficial level, so it is difficult for groupware designers to determine how designs should be developed to support work and collaboration practice.

System design to support loose coupling. It is not clear how groupware applications should be designed to accommodate work, collaboration, and organizational patterns in loosely coupled groups. Since the problems outlined above are not yet resolved, it is not clear which real world aspects of loose coupling are important in the design of groupware systems. However, even when these aspects of loose coupling are understood, it will still not be clear how designers should choose general design approaches for groupware systems, and how specific features should be designed and implemented.

1.2 Solution

This dissertation presents a framework to improve the design of groupware for loosely coupled groups. Five major steps were needed to develop and evaluate the framework: examine loosely coupled groups in the real world, develop a design framework for loose coupling, design and evaluate prototypes based on the framework, implement the prototypes as a full groupware system, and conduct field trials of the groupware system.

1.2.1 Examine loosely coupled groups in the real world

I investigated the real world complexities of loose coupling by studying home care treatment teams. Home care provides a working example of loose coupling. In home care, workers from several different disciplines deliver health care services to patients in their homes. The workers who share a patient make up the patient’s treatment team.

Treatment team members' activities are interdependent since one worker's actions with the shared patient can influence the actions of others. These interdependencies are managed in a loosely coupled fashion—workers rarely see each other face-to-face, communicate infrequently, and do not have formal mechanisms for coordinating work.

I examined loose coupling in treatment teams by carrying out a series of field observations and interviews with team members from each of the home care disciplines. I analyzed the data generated during this step by examining transcripts to identify the work, collaboration, organization, and coupling patterns seen in home care. The result of this analysis was a qualitative report describing current patterns of work and collaboration in home care teams; factors that influence home care coupling patterns; and the impact loose coupling has on home care teams.

1.2.2 Develop design framework for loose coupling

I developed a framework to improve the design process for groupware developed for loosely coupled workgroups. The design framework is based on a general CSCW design process that includes data collection from the target work setting, analysis of the data, and system design based on the analysis results.

The framework has three main parts: a contextual model, an analysis technique, and a set of design approaches. The contextual model acts as a theoretical foundation for the rest of the framework and was developed to help designers understand loose coupling in real world settings. The analysis technique was developed to help designers to recognize and specify important features of loosely coupled work settings, and to organize that information in a way that makes it usable during the design process. The design approaches were developed to translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups.

1.2.2.1 Contextual model of loose coupling

The first part of the framework is a contextual model that describes loose coupling in real world settings. The contextual model was developed to help designers to understand work and collaboration patterns that are seen in loosely coupled groups. It is based on organizational research literature and CSCW literature, and it forms the theoretical foundation for the other two parts of the framework.

The result of this step was a model that contains:

- An operational definition of loose coupling for groupware designers
- A discussion of open systems theory and the levels of organization in loosely coupled system
- A discussion of interaction patterns seen between loosely coupled elements
- A list of reasons that can lead to the adoption of loose coupling and a discussion of each reason
- A list of outcomes associated with the adoption of loose coupling and a discussion of each outcome

1.2.2.2 Analysis technique for loosely coupled groups and settings

The second part of the framework is an analysis technique for loosely coupled work settings. The analysis technique helps designers to recognize and specify important features of the work setting, and to organize that information in a way that makes it usable during the design process. The technique is based on analysis and design work with home care teams, and partially incorporates three existing analysis techniques: Contextual Design work models (Beyer and Holtzblatt 1998), Collaboration Usability Analysis (Pinelle, Gutwin, and Greenberg 2003), and sociograms (Garton et al. 1997; Wigand 1988, p. 321).

The result of this step was an analysis technique that includes:

- A set of modeling techniques for analyzing workflows, collaboration patterns, and tasks in loosely coupled groups
- Examples that illustrate how the models can be used to capture important aspects of loose coupling in the real world
- A checklist to help guide and organize observational findings from loosely coupled work settings

1.2.2.3 Design approaches for loose coupling

The third part of the framework is a set of approaches for designing groupware applications for loosely coupled groups. The design approaches help designers to translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups. They are based on CSCW and organizational research, and on home care observations.

The result of this step was a set of design approaches. Each design approach in the set contains:

- A description of an approach for designing groupware systems to address a characteristic of loose coupling outlined in the contextual model and analysis technique
- A discussion of the tradeoffs and considerations inherent in using the approach, and how variations in contextual factors can change how the approach should be implemented
- Screen shots and written examples that illustrate the design approach

1.2.3 Design prototypes using framework

I used the framework to design low-fidelity prototypes of a groupware system. The prototypes were designed to support and augment work and collaboration in home care treatment teams. I based the design work on analysis results and on the design approaches.

The prototypes were evaluated and iteratively refined by carrying out prototype walkthroughs with members of each home care discipline. This process helped to identify design problems, and feedback from the walkthroughs was used to refine the designs. The final result of this step was a set of paper prototypes that had been evaluated using walkthroughs.

1.2.4 Implement prototypes as a groupware system

I implemented the low-fidelity prototypes as a full groupware application. Since the system implemented the low-fidelity prototypes, it was based on the design framework.

The result of this step was a groupware application that was ready to be deployed and evaluated in the home care work setting.

1.2.5 Conduct field trials of groupware system

I carried out two field trials where the groupware system was used by home care teams to support and augment team members' daily activities. The field trials allowed the groupware system and the underlying design framework to be evaluated to determine how well each part of the framework fulfilled its role in the design process. During the field trials, participants carried laptops or handhelds with them during the workday and used the application to support the services that they provided to the patients that were included in the trials.

Three main techniques were used to collect data during the field trials. First, participants were interviewed to determine how they used the system features, how they felt features impacted their work practices, and their overall satisfaction with the system and with specific system features. Second, participants' interactions with the system were recorded using system logs to provide another measure of how the system was used and how it fit into daily work practices. Third, questionnaires were administered during the second field trial to gather information about participants' views on work and collaboration patterns and how they changed with the introduction of the system.

1.3 Evaluation

The design framework is based on a general CSCW design process that includes data collection from the target work setting, analysis of the data, and system design based on the analysis results. It is the first design framework based on work patterns in loosely coupled work situations, and therefore, its evaluation was oriented towards gathering information about initial experience with the principles in real use. The design framework was evaluated in the home care setting to determine three things:

1. Whether the contextual model identified organizational, work, and collaboration patterns that are important for understanding loose coupling in the home care setting,

2. Whether the analysis technique captured and organized important contextual features of the home care setting in preparation for design, and
3. Whether the design approaches enabled important aspects of the work situation to be mapped to the design of system features.

The evaluation was primarily qualitative and was based on home care observations and interviews (step 1.2.1) and on field trial results (step 1.2.5). Each part of the framework was evaluated to determine how successful it was at fulfilling its role in the design process.

The contextual model was evaluated to determine how successful it was at identifying organization, work, and collaboration patterns found in the home care setting. The evaluation was based on home care interviews and observations. The evaluation of the contextual model addressed the following questions:

- What did the contextual model get right?
- What did the model get wrong?
- How can the contextual model be improved?

The analysis technique was evaluated to determine how effective it was at analyzing loose coupling in home care in preparation for design. The evaluation was based on the findings from the field trials. The evaluation of the analysis technique addressed the following questions:

- Was the analysis technique successful at capturing contextual factors that are important to design?
- Was the analysis technique successful at bridging contextual information into the design process?
- How can the analysis technique be improved?

The design approaches were evaluated to determine how successful they were at mapping contextual characteristics of loose coupling to appropriate design decisions.

The evaluation was based on the findings from the field trials. The evaluation of the design approaches addressed the following questions:

- How were the individual groupware features accepted and used by the field trial participants?
- Did the design approaches that were implemented in the system lead to problems for participants, for the organization, or for the team?
- How can the design approaches be improved?

1.4 Research sequence

A range of research activities were carried out to develop the design framework and to evaluate it in the home care setting. The activities were not always carried out in the strict sequence suggested by the sections above. Some were carried out in parallel and some were interleaved. Table 1.1 provides an overview of the sequence and relationships between research activities. The cells in the table do not show the actual time span for each activity since the timeline was not recorded during the project, and since it is now difficult to recall times and dates with much precision.

There were two main types of research activities: those that were directly involved in developing the framework, and those that were involved in collecting and interpreting data from home care. In some cases, one affected the other. For example, the analysis technique and design approaches were partially developed from home care data and design activities. In other cases, parts of the framework were developed separately from the home care activities. For example, the contextual model was developed from information in organizational research and CSCW research. Even though efforts were made to develop the contextual model separately, it was developed in parallel with early home care data collection activities, and the write up of the model took place during the field trials (see Table 1.1).

Table 1.1. Sequence of research activities. Shaded cells indicate when each activity was carried out in relation to others. Activities are listed in chronological order based on their starting times. Cells are used to indicate sequence and relationship between activities only, and they do not represent proportional time spans.

Discussions w/ HC management	■												
Lit review on loose coupling		■	■	■	■	■	■	■					
Identify loose coupling concepts		■	■	■	■	■	■	■					
Interviews, field observations		■	■	■	■	■	■						
Develop contextual model			■	■	■	■	■	■					
Analyze home care data				■	■	■	■						
Develop analysis technique				■	■	■	■	■	■	■	■		
Identify design principles					■	■	■	■	■				
Develop prototypes						■	■						
Develop design approaches						■	■	■	■				
Prototype walkthroughs							■						
Implement and test Mohoc								■					
Field trial 1									■				
Preliminary analysis of results										■			
Revisions to Mohoc											■		
Development of Pocket Mohoc											■		
Field trial 2												■	
Analysis of field trial results													■
Evaluation of framework													■

1.5 Contributions

The main contribution of this dissertation is a design framework that improves the design process for groupware developed for loosely coupled workgroups. The design framework is based on a general CSCW design process that includes data collection from the target work setting, analysis of the data, and system design based on the analysis results. It is the first design framework based on work patterns in loosely coupled work situations, and it improves the ability of a designer to see the important characteristics of a loosely coupled work situation, assists them in organizing data gathered from the domain, and provides them with a set of approaches for translating their analysis into system features.

There are also minor contributions to both the CSCW and medical informatics communities. There are two minor contributions related to the design and implementation of groupware systems. First, since the Mohoc system is a full implementation of a mobile groupware system in a real-world work setting, it is a novel contribution to CSCW research. Unlike other mobile groupware systems that have been studied in CSCW, the Mohoc system is more than a partial prototype, and the deployment and evaluation of the system over an extended period of time produced findings that are new to CSCW research. These include:

- The success of the store and forward approach used in the system for supporting mobile and disconnected work
- The tolerance that mobile home care workers had for delays in communication
- The success of the simple permissions policy for managing modifications to artifacts (see Section 7.4.3.2)
- The usefulness of asynchronous awareness information in managing weak interdependence in mobile work

Second, the prototyping and implementation work that was carried out to develop Mohoc led to the development of novel user interface representations and interaction techniques. These include:

- Transparent overlays that show information about others' activities without interfering with individual work
- A timeline-based visualization of a shared health record repository that includes embedded awareness information
- Asynchronous awareness representations including viewing histories, modification histories, and flags for interpreting others' recent activities in the system
- Chart, daily agenda, and schedule metaphors for arranging user interface and interaction support for home care teams

- User interface and interaction approaches for supporting clinical documentation practices on PC and handheld devices

These design techniques provide new options for designing groupware systems for other workgroups.

There are three minor contributions that are relevant to the home care and medical informatics communities. First, the analysis of loose coupling in home care work provides a detailed understanding of organizational issues that are relevant to designing applications for community-based healthcare workers. Second, the design and prototyping work in home care provides insight into how technologies can address homecare workflows. Third, the field trial results provide insight into how groupware technologies can support work and augment communication and coordination in home care teams.

1.6 Thesis outline

The rest of this thesis is organized as follows:

- *Chapter 2* presents a discussion of literature that is relevant to this research. Literature from several areas is covered, including: CSCW, human-computer interaction, organizational research, healthcare, and health informatics.
- *Chapter 3* presents a description of observations and interviews that were carried out with clinicians and managers in home care in Saskatoon Health Region. A discussion of the findings is also presented.
- *Chapter 4* presents a description of the first part of the design framework: the contextual model.
- *Chapter 5* presents a description of the second part of the design framework: the analysis technique.
- *Chapter 6* presents a description of the third part of the design framework: the design approaches.

- *Chapter 7* presents a description of the Mohoc groupware system that was developed to support home care treatment teams in Saskatoon Health Region. It also presents a description of Pocket Mohoc, a handheld client that supports home health aides.
- *Chapter 8* presents a description of the methodologies of the two field trials, and provides a narrative description of how the field trials unfolded.
- *Chapter 9* presents an evaluation of each part of the design framework. The evaluation is based on the observations and interviews described in Chapter 3 and on the field trials described in Chapter 8.
- *Chapter 10* presents a discussion of the results of this research. It synthesizes findings presented in other chapters and discusses unexpected results that were not covered in Chapter 9.
- *Chapter 11* summarizes the thesis and its contributions. It also presents a discussion of areas where future research is needed.
- *Appendix A* provides models from the home care setting including: diagrams showing a data model based on home care work patterns, and sample Contextual Design sequence models and flow models based on home care observations.
- *Appendix B* provides materials from the field trials including: questionnaires; and interview, training, and walkthrough scripts.

2 Related work

In this chapter, I discuss literature that is relevant to the proposed research. I begin by providing a high-level discussion of computer-supported cooperative work (CSCW) and groupware, and then I discuss current approaches used to design groupware systems. Next, I discuss organizational and CSCW research on loose coupling. Finally, I discuss loose coupling in healthcare and home care, and issues related to designing groupware support for healthcare clinicians.

This chapter is divided into the following sections:

- Computer-supported cooperative work and groupware
- Groupware design
- Loose coupling and organizational research
- Loose coupling and CSCW
- Loose coupling and healthcare
- Groupware technologies for healthcare clinicians

2.1 Computer-supported cooperative work and groupware

Computer-supported cooperative work is a research area that is concerned with how computer systems should be designed to support group work and with the effect those systems have on group work patterns (Dix et al. 1998, p. 463). The applications that are designed to support group work are often referred to as *groupware*, which has been defined as "technology that communicates and organizes unpredictable information, allowing dynamic groups to interact across time and space" (Cameron et al. 1995, p.28).

A wide variety of groupware systems have been developed in recent years, and some have received widespread acceptance while others have met with more limited success (Grudin 1994). Some examples include:

- Electronic mail (Sproull 1993)
- Group calendars (Lange 1993)
- Telemedicine applications (Horsch and Balbach 1999)
- Co-authoring tools (Neuwirth et. al. 1993)
- Group drawing tools (Greenberg et al. 1993)
- Audio- and video-conferencing tools (Bly et al. 1993)
- Workflow systems (Ellis 1999)
- Instant messaging (Isaacs et al. 2002)
- Newsgroups and network communities (Shneiderman 1998)
- Tabletop display groupware (Scott et al. 2003)
- Shared window systems (Lauwers et al. 1993; Lauwers et al. 1993)
- Electronic meeting systems (Mentei 1993; Nunamaker et al. 1993)
- Collaborative virtual environments (Hindmarsh et al. 1998)

Groupware systems are often classified according to the type of collaboration that they support. In this classification scheme, collaboration has a temporal and a spatial dimension, and these dimensions are commonly shown using the time-space matrix in Table 2.1 (Preece et al. 1994; Shneiderman 1998; Baecker 1993; Dix et al. 1998). According to the matrix, modes of interaction differ along a time dimension and can be either synchronous (occurring at the same time) or asynchronous (occurring at different times). They also differ along a place dimension, and can be co-located (collaborators are in the same location) or distributed (collaborators are in different locations).

Table 2.1. Time-space matrix (adapted from Preece et al. 1994; Shneiderman 1998)

		Time	
		Same time	Different times
Place	Same place	Face-to-face (tabletop displays, meeting support tools)	Asynchronous interaction (project scheduling, coordination tools, shift work systems)
	Different places	Synchronous distributed (shared editors, video- and audio-conferencing tools)	Asynchronous distributed (email, newsgroups)

In the next sections, I briefly discuss each of the four types of groupware shown on the time-space matrix, and a fifth type of groupware not covered in the matrix—mobile groupware. The discussion is organized according to the following themes:

- Synchronous distributed groupware
- Synchronous co-located groupware
- Asynchronous distributed groupware
- Asynchronous co-located groupware
- Mobile groupware

2.1.1 Synchronous distributed groupware

Synchronous distributed groupware allows users to work together at the same time even though they are in different locations (Baecker 1993). Most of these applications provide shared workspaces where group members can create and edit shared artifacts such as images, documents, or agendas (Gutwin and Greenberg 1999). These applications usually include real-time communication support using voice, video, or text messaging (Dix et al. 1998), and awareness features are often incorporated into the workspace to help each group member to understand others' activities (Dourish and Bellotti 1992; Gutwin and Greenberg 1996).

A number of synchronous groupware tools have been developed to allow collaboration between physically distributed workers. Groupware toolkits such as GroupKit (Roseman and Greenberg 1996), COAST (Schuckmann et al. 1996), and Rendezvous (Patterson et al. 1990) are all intended to help developers build real-time groupware applications. Additionally, many groupware applications provide features that allow collaboration across a distance such as videoconferencing tools (e.g. Okada et al. 1994), audioconferencing tools (e.g. Rodenstein and Donath 2000), shared whiteboards (e.g. Streitz et al. 1994), and shared editors (Olson et al. 1993).

2.1.2 Synchronous co-located groupware

Synchronous co-located groupware systems support face-to-face interactions between two or more collaborators. These systems help groups generate ideas and understanding, and common areas of support are research environments, design tasks, management meetings, and brainstorming sessions (Dix et al. 1998, p. 476). These systems can provide users with a single shared interactive display (Kruger et al. 2003) or with separate individual networked clients (Bruce et al. 1992).

A range of synchronous co-located groupware systems have been developed. For example, Foster and Stefik (1986) developed Cognoter to support idea generation in team meetings, and each team member has a separate networked client that allows them to enter new information into a shared information space. Pedersen et al. (1993) developed Tivoli, a single-display groupware application that uses a whiteboard metaphor. Users interact with the system's large display using a stylus, and the system allows the group to save and organize their work in several different workspaces.

2.1.3 Asynchronous distributed groupware

Asynchronous distributed groupware allows distributed groups to collaborate whenever it suits each member's schedule (Pankoke-Babatz and Syri 1997; Manohar and Prakash 1995). This approach frees them of the need to schedule common times to use the application, as is seen in real-time groupware applications. Information persists in the system so that it is available to users, regardless of the access time.

Most asynchronous distributed groupware systems use a client / server architecture, and information about the group's activities is stored on the server so that client applications can retrieve updates whenever it suits the user's schedule (Pankoke-Babatz and Syri 1997). As users interact with the client application, information is passed on to the central server so that it is available to others. This strategy is used in a number of systems including TeamRooms (Roseman and Greenberg 1996) and GroupDesk (Fuchs et al. 1995). On a more limited scope, USENET and bulletin board systems provide a central shared space for group communication.

2.1.4 Asynchronous co-located groupware

Asynchronous co-located groupware systems support collaboration between people at a single site, but at different times. These systems provide a central location for collaboration support, and users interact with the systems when it suits their schedule.

Asynchronous co-located groupware systems are varied in their architectures and uses. For example, GeoNotes (Espinoza et al. 2001) allows users to place virtual notes that are attached to real world locations. The notes can be accessed by others when they visit that location using mobile phones and PDAs, and workers are alerted when they come into close physical proximity with a note. Dix et al. (1998) discuss argumentation tools that are used by design teams to record design decisions and arguments that led to those decisions. These systems are typically used at a single site, and workers commonly utilize the system asynchronously.

2.1.5 Mobile groupware

With recent shifts toward increased mobility in the Western workforce (Dahlbom and Ljungberg 1998), mobile collaboration has increasingly become an important issue in CSCW. However, efforts to understand the implications that mobile work and mobile collaboration have for the design of technology are still in the early stages. Mobile groups are highly varied in the ways they organize work (e.g. Wiberg and Ljungberg 1999), in the physical dispersion of mobile workers (e.g. Orr 1996; Bellotti and Bly 1996), and in the styles of collaboration that take place between workers (e.g. Luff and Heath 1998). To help make sense of this diversity, recent efforts have been made to describe and classify these variations by focusing on specific types of mobility (Kristoffersen and Ljungberg 1998), types of physical distributions that occur in mobile groups (Luff and Heath 1998), and levels of coupling between mobile collaborators (Churchill and Wakeford 2001).

Luff and Heath (1998) consider the question of physical dispersion of workers in mobile settings, and they identified three types of mobile distributions: micro-mobility, local mobility, and remote mobility. Micro-mobility is described as the way an artifact can be moved and manipulated in a relatively circumscribed, “at hand” domain, but it is also suggested that it includes “ways of providing and receiving information whilst co-present with others.” Local mobility describes mobility around a single worksite. For example, an individual might move between different rooms or floors in a building. Remote mobility describes individuals who move around different locations or worksites.

Remotely mobile groups differ from the other types of groups on the CSCW time-space matrix since the time and place dimensions vary depending on each worker’s location and schedule. Collaboration in these groups has many of the same problems that are encountered in stationary distributed groups (e.g. Mark 2002; Gutwin and Greenberg 1999). However, since place and schedules vary, it is also difficult for workers to stay aware of others’ locations and availabilities (Fagrell et al. 2000; Bellotti and Bly 1996), and it can be difficult for workers to establish any type of intentional synchrony, even when technologies are utilized (Brown and O’Hara 2003).

In spite of ongoing advances in mobile computing platforms and networks, technical hurdles make it difficult to develop groupware for remotely mobile groups. In groups, members often need to coordinate their activities, stay aware of others’ activities, and explicitly communicate with each other (Malone and Crowston 1990). However, the wide area wireless networks that are needed to support remote mobility are less reliable than wired networks (Satyanarayanan 1996; Edwards et al. 1997), and group interaction is often challenging to support when synchrony and timeliness of information is an issue.

For mobile workers who work across a wide area, both interference and signal strength change frequently due to changes in location as well as natural variability. Some of the direct effects are periodic disconnections, loss of data, and long delays due to congestion, retransmission, or low bandwidth. Several techniques have been offered that lessen some of these consequences under particular circumstances. Data replication (e.g. Ratner et al. 2001) and caching increase availability of information during periods of disconnection and reduce delays. Consistency problems can be mitigated using optimistic replication schemes (Satyanarayanan 2002), automatically resolving conflicts when they happen (e.g. Demers et al. 1994), and representing conflicts to the user (e.g. Satyanarayanan 2002). Adaptive strategies (e.g. Satyanarayanan 2002; Noble and Satyanarayanan 1995) allow systems to make better use of their available resources, which can also lessen delay problems and help to make smooth transitions from connected and disconnected states (Edwards et al. 1997). Although these techniques have made many mobile collaboration problems more manageable, it is still difficult to mitigate, predict, and cope with wide area mobility problems at the user, application, and infrastructure levels (Jing et al. 1999).

At the application level, mobility issues have been addressed using asynchronous groupware that allows workers to carry out their work offline since network access may only be available intermittently (e.g. Fagrell et al. 2000; Kistler and Satyanarayanan 1992). In this approach, work is carried out on a client application that can be disconnected from a centrally accessible server, and the work is stored until a network connection is available. When network access becomes available, the client and server "synch up." Local work is forwarded to the server so that it is available to others, and the server sends the user information about others' activities. When stored data conflicts with changes that others have made, conflict resolution techniques may be utilized. Several systems use this approach, including Coda (Mummert et al. 1995; Kistler and Satyanarayanan 1992), Bayou (Edwards et al. 1997; Terry et al. 1995), and FieldWise (Fagrell et al. 2000).

2.2 Groupware design

Computer-supported cooperative work emphasizes human-human interaction over the human-computer interaction that is more commonly studied in computer science (Baecker 1993, p. 2). The need to account for human-human interaction in groupware designs means that traditional design approaches are often inadequate for developing software to support groups. CSCW developers and researchers have developed design strategies that are specific to groupware, and these continue to evolve in an effort to account for organizational, social, and collaborative issues.

In the next sections, I discuss issues related to groupware design. The discussion is organized around four themes:

- Strategies for studying groups
- Social and organizational characteristics
- Group collaboration processes
- Methods for designing groupware

2.2.1 Strategies for studying groups

Groupware developers and researchers have used a range of techniques to study groups and to understand how group characteristics can be addressed through technical designs. These techniques can be classified using McGrath's (1993) strategies for studying groups. McGrath identifies eight approaches for studying groups: laboratory experiments, experimental simulations, field experiments, field studies, computer simulations, formal theory, sample survey, and judgment studies.

McGrath's strategies are organized to indicate two things about each approach. First, they show the type of setting that the approach is carried out in: "I. Settings in natural systems, II. Contrived and created systems, III. Behavior not setting dependent, and IV. No observation of behavior required" (p. 201). The setting type is indicated along the centre of the circumplex shown in Figure 2.1. Second, the strategies indicate how well each approach maximizes:

A. The *generalizability* of the evidence over populations of actors
B. The *precision* of measurement of the behaviors
C. The *realism* of the situation or context (p. 201)

McGrath indicates that no single strategy can maximize all three of these factors, but that some are better at maximizing particular factors. The point where each of these factors is maximized is indicated along the perimeter of the circumplex shown in Figure 2.1.

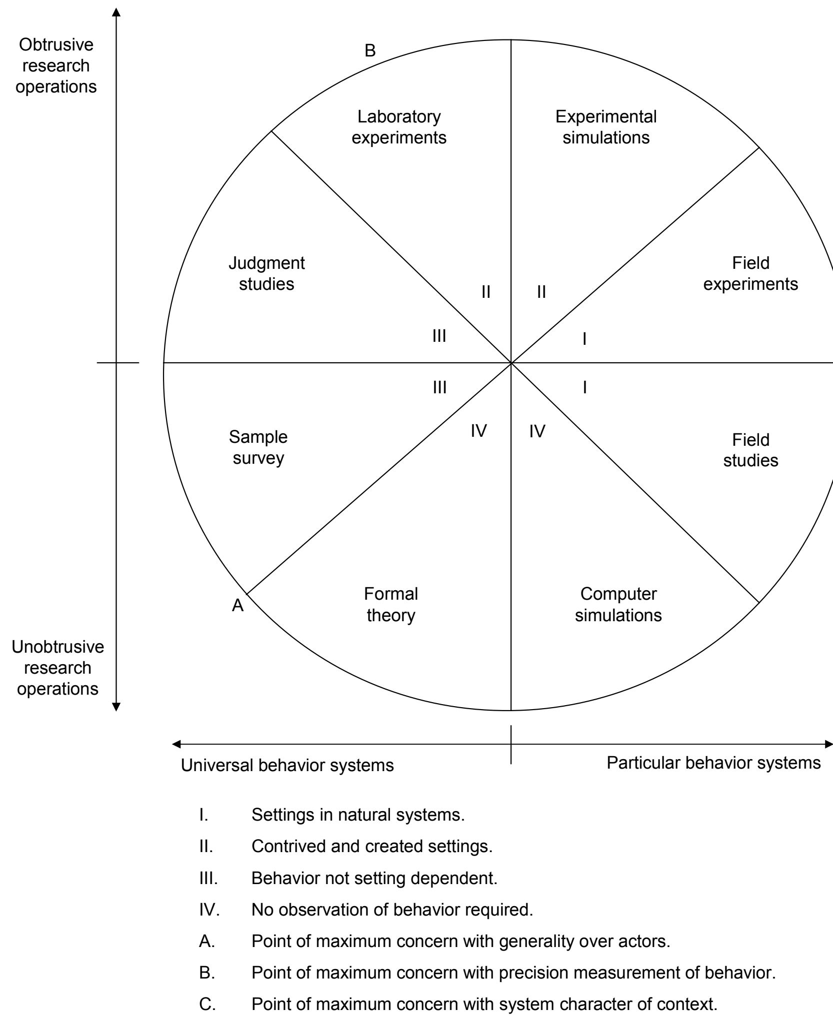


Figure 2.1. Strategies for studying groups (from McGrath 1993)

2.2.2 Social and organizational characteristics

Groupware acceptance and use can be influenced by social and organizational characteristics seen in groups, and when designers fail to adequately consider these characteristics, designs can be rejected by the users. It is often difficult to identify and design for these factors, but several approaches have been developed to help address these issues. I discuss social and organizational characteristics in the next two sections.

2.2.2.1 Social characteristics

The social relationships seen in groups are important to groupware developers, and can impact the success of groupware designs. According to Kling (1991), "fundamental and sometimes subtle social processes in work strongly influence the ways in which CSCW applications are adopted, used, and influence subsequent work" (p.84). However, since social relationships are often dynamic, it can be difficult to anticipate the variations that will be seen within groups. As stated by Kling (1991), "in practice, many working relationships can be multivalent with and mix elements of cooperation, conflict, conviviality, competition, collaboration, commitment, caution, control, coercion, coordination, and combat" (p. 85).

One of the main difficulties in designing for groups is that many important social aspects of group work are tacit and difficult to understand for the outside observer. As Grudin (1994) points out:

> Groupware may be resisted if it interferes with the subtle and complex social dynamics that are common to groups. The computer is happiest in a world of explicit, concrete information. Central to group activity, however, are social, motivational, political and economic factors that are rarely explicit or stable. Often unconsciously, our actions are guided by social conventions and by our awareness of the personalities and priorities of people around us, knowledge not available to the computer. Tacitly understood personal priorities are tactfully left unspoken, yet unless such information is made explicit, groupware will be insensitive to it. (p. 97)

One way to make tacit information about social practices explicit so that it can be incorporated into groupware designs is through involving users in the design process. Kyng (1991) describes "cooperative design" where users are put into contact with the groupware designs to help trigger their tacit knowledge so that they can help with evaluation. He suggests using mockups and prototypes and having users simulate work situations as part of this process.

2.2.2.2 Organizational characteristics

Work groups operate in a larger organizational contexts, and an organization's structure and culture influence the way a groupware system should be designed and will be used (Orlikowski 1992). When computer systems are designed without consideration for these factors, it is likely that the system will be used sub-optimally or will be discarded (Preece et al. 1994). However, since the introduction of groupware systems often leads to changes in the organization, it can be difficult to anticipate how groupware systems will impact organizations (Collins 1995).

The difficulties seen in dealing with organizational characteristics in groupware design are similar to those seen with social characteristics—it is difficult to understand tacit but relevant factors, and it is difficult to anticipate how designs will interact with those factors. These difficulties have given rise to several common problems with design and adoption. Grudin (1988) describes three of these:

- The application fails because it requires that some people do additional work, while those people are not the ones who perceive a direct benefit from the use of the application.
- The design process fails because our intuitions are poor for multi-user applications—decision-makers see the potential benefits for people similar to themselves, but don't see the implications of the fact that extra work will be required of others.
- We fail to learn from experience because these complex applications introduce almost insurmountable obstacles to meaningful, generalizable analysis and evaluation. (p. 86)

Several approaches have been proposed for analyzing organizational characteristics as a means of improving the groupware design process. Orlikowski (1992) proposes piloting technology in a single group in an organization, and deploying it more widely once the implications are understood. Ethnography has also received attention as a means for accounting for organizational characteristics since long term observations of work environments are able to provide significant detail on organizational aspects of group work (Shapiro 1994; Blythin et al. 1997; Hughes et al. 1994). However, one of the criticisms of this approach is that it does not mesh well with the needs of software development since ethnographic studies are often long term and are not able to meet the tight deadlines of software projects. Hughes et al. (1994) suggest several practical approaches for incorporating ethnography into system design to help address organizational issues:

- *Concurrent ethnography*: where design is influenced by an on-going ethnographic study taking place at the same time as systems development
- *Quick and dirty ethnography*: where brief ethnographic studies are undertaken to provide a general but informed sense of the setting for designers.
- *Evaluative ethnography*: where an ethnographic study is undertaken to verify or validate a set of already formulated design decisions.
- *Re-examination of previous studies*: where previous studies are re-examined to inform initial design thinking. (p. 432)

2.2.3 Group collaboration processes

Face-to-face collaboration is usually seen as the ideal means of working with others, and groupware designers often try to capture the collaborative processes seen in face-to-face work in system design (Dix et al. 1998, p. 510). These interactions often rely on subtle cues and exchanges, and to support these interactions in groupware, designers must understand those subtleties.

In the next sections, I discuss collaboration processes that are central to group work and how they have been supported in groupware systems. These are:

- Communication
- Information gathering and awareness
- Shared access and transfer
- High-level coordination and interdependence

2.2.3.1 Communication

Communication is the most fundamental element of collaboration, and most studies of communication in CSCW are based on face-to-face communication (Pinelle, Gutwin, and Greenberg 2003). Face-to-face communication has many subtleties including eye contact and gaze, gestures and body language, and turn taking (Dix et al. 1998). According to Daft and Lengel (1986), being face-to-face provides a rich communication channel that “can overcome different frames of reference or clarify ambiguous issues to change understanding in a timely manner” (p.560).

When communication is supported using groupware, the richness of the communication channel is often reduced from what is seen in face-to-face communication. For example, Olson and Olson (2000) argue that groupware technologies that support communication between distributed collaborators do “not support rapid back and forth in conversation or awareness and repair of ambiguity” (p. 163). This reduced richness is associated with differences in “capacity for immediate feedback, the number of cues and channels utilized, personalization, and language variety” (Daft and Lengel 1986, p. 560).

In spite of the communication limitations seen in many groupware applications, many systems have been successful and provide support that is well-suited to certain tasks and work situations. These include email (Sproull 1993), bulletin boards (Dix et al. 1998), newsgroups (Shneiderman 1998), instant messaging (Isaacs et al. 2002), audio-conferencing and video-conferencing (Bly et al. 1993). Other groupware systems allow users to collaborate using shared artifacts and shared workspaces. For example, the TeamRoom system (Roseman and Greenberg 1996) provides a text chat tool in shared workspaces and allows users to leave persistent PostIt notes for others.

2.2.3.2 Information gathering and awareness

In groups, people must be able to coordinate their actions. A prerequisite of coordination is that group members have an understanding of the actions of others so that they can determine how their individual actions can best contribute to progress toward shared goals (Dourish and Bellotti 1992, p. 107). This understanding, known as *awareness*, is vital in both face-to-face collaboration and in computer-supported cooperative work. During face-to-face work, close proximity allows group members to gather information using sensory cues in the environment. However, when groups rely on groupware applications, the rich sensory data of the workplace is lost, and group members are restricted to the information that is presented by the software.

In group work, awareness information encompasses the answers to questions posed by the six "W" words: who, what, when, where, why, and how (McDaniel 1996). For example, it might prove important to know that a specific group member (who) had modified (what) a specific section (where) of a document to make it fit within the limited space available on a page (why). Gutwin and Greenberg (1996) separate awareness information into two categories: information about what is happening with other group members and information about where it is happening. The relative importance of awareness information varies with work context, and different tasks and task settings demand different pieces of information.

Pinelle, Gutwin, and Greenberg (2003) discuss information gathering and awareness and break them into *mechanics of collaboration*, which they describe as "the small-scale actions and interactions that group members must carry out in order to get a task done in a collaborative fashion." Table 2.2 summarizes the information gathering mechanics, which include: basic awareness, feedthrough, consequential communication, overhearing, and visual evidence. According to Pinelle and colleagues, these mechanics represent the low-level actions that group members use to gather information about others, and they represent the basic building blocks for more complex group tasks.

Several strategies have been used in groupware systems to help users collect information about others' activities. Gutwin et al. (1996) describe a number of these approaches for real-time distributed groupware systems. Some of their approaches include: telepointers that show where other users' mouse pointers are positioned in the shared workspace; multi-user scrollbars that indicate others' views of the shared workspace; and a miniature "radar view" of the workspace that shows the entire workspace, the region of the workspace each user is viewing, and the location of their pointer.

Table 2.2. A subset of the mechanics of collaboration (adapted from Pinelle, Gutwin, and Greenberg 2003).

Category	**Mechanic**	**Typical actions**
Information gathering	Basic awareness	Observing who is in the workspace, what are they doing, and where are they working
	Feedthrough	Changes to objects Characteristic signs or sounds
	Consequential communication	Characteristic movement Body position and location Gaze direction
	Overhearing	Presence of talk Specific content
	Visual evidence	Normal actions
Shared access (to tools, objects, space, and time)	Obtain resource	Physically take objects or tools Occupy space
	Reserve resource	Move to closer proximity Notify others of intention
	Protect work	Monitor others' actions in area Notify others of protection
Transfer	Handoff object	Physically give/take object Verbally offer/accept object
	Deposit	Place object and notify

2.2.3.3 Shared access and transfer

When people work together, they must manage access to shared objects. As Pinelle, Gutwin, and Greenberg (2003) indicate, this is more difficult when there are shared resources that are limited in some way. These resources can include work artifacts (e.g. a puzzle piece or a drawing), tools (e.g. whiteboard markers, scissors, or rulers), the workspace itself (e.g. an empty space on the board for adding a new item, or a corridor for reaching across a table), or even time (e.g. an opening in the 'airtime' of a conversation).

Pinelle, Gutwin, and Greenberg (2003) provide mechanics of collaboration for shared access and transferring objects between collaborators. Table 2.2 shows shared access mechanics, which include: obtain resource, reserve resource, and protect work. It also shows two mechanics for transferring objects: handoff object and deposit. These mechanics represent low-level actions needed to share and transfer objects, and more complex tasks can be built from these mechanical building blocks.

In groupware, developers must consider how to manage shared access and transfers of artifacts between users—both at the user-interface level and at the architectural level. Several issues are that are central to managing shared access include privacy (Kling et al. 1992), ownership of data/artifacts (Mitchell et al. 1995), and concurrency control (Greenberg and Marwood 1994).

2.2.3.4 High-level coordination and interdependence

The mechanics that are discussed by Pinelle, Gutwin, and Greenberg (2003) represent low-level actions for coordinating group interactions. However, groups often make use of high-level coordination strategies. High-level coordination strategies are linked to the notion of interdependence between collaborators, which Scott (1987) defines as, "the extent to which the items or elements upon which work is performed or the work processes themselves are interrelated so that changes in the state of one element affect the state of others" (p. 214). When interdependence exists between collaborators, they must coordinate their actions so that they are complimentary and do not conflict. Malone and Crowston (1990) formally define coordination as, "the act of managing interdependencies between activities performed to achieve a goal." Malone and Crowston provide several examples of coordination activities, including: identifying goals, ordering activities, assigning activities to actors, allocating resources, and synchronizing activities.

The interdependence seen between work units plays a key role in shaping the coordination mechanisms that are seen in groups and organizations. This can be seen in the work of Thompson (1967), who identifies three types of interdependence: pooled interdependence, sequential interdependence, and reciprocal interdependence (see Table 2.3). For each successive type of interdependence in Thompson's typology, coordination becomes more difficult and costly. As is shown in Table 2.3, pooled interdependence can be managed with work standardization, which allows the organization to coordinate work with minimal effort. Sequential interdependence often requires planning and scheduling, and does not place a significant burden on the organization unless unexpected events lead to revisions in the sequence of work activities. Finally, when reciprocal interdependence exists, mutual adjustment is often needed, which requires significant effort since work units must monitor each other and must regularly communicate about work activities.

Table 2.3. Thompson's (1967) interdependence typology and coordination mechanisms

Interdependence type	**Coordination type**
Pooled interdependence. The work is interdependent since the efforts of each unit contribute to an overall shared goal.	*Standardization.* The development of rules and routine to guide work practices.
Sequential interdependence. Some activities must be carried out before those of others, and one unit must act before another unit can.	*Planning and scheduling.* Timing and order of work are specified.
Reciprocal interdependence. The interdependence is symmetrical; units mutually influence each other, and the output of one unit is the required input of another unit.	*Mutual adjustment.* Units must monitor and respond to other units' activities through ongoing communication.

Several groupware applications have been developed to support high-level coordination activities. For example, group calendar systems allow workers to share their schedules with other group and organization members (Lange 1993). Meeting support tools can help support idea generation, planning, and allocation of tasks (Foster and Stefik 1986; Pedersen et al. 1993). Systems designed to support organizational memory (Conklin 1993) can help workers to coordinate work over time, and can allow them to consider past outcomes when devising future plans.

2.2.4 Methods for designing groupware

Groupware designers must deal with the challenges of developing systems that support complex human-human interactions, and that fit target groups' tasks and their social and organizational work contexts. The need to account for human-human interaction in groupware designs means that traditional design approaches are often inadequate for developing software to support groups. To address this need, groupware designers have adopted four different approaches to design: 1) incorporate social science approaches into the design process, 2) use single user design approaches that consider users and their work contexts, 3) use groupware-specific analysis and evaluation approaches, and 4) use design recommendations and frameworks based on others' experiences.

Social science approaches. Social science theories and approaches have been used to conduct and analyze field observations, and to guide groupware design. Approaches that have been discussed in CSCW literature include: ethnography (Shapiro 1994; Blythin et al. 1997; Hughes et al. 1994), activity theory (Collins et al. 2002; Miettinen and Hasu 2002; Fjeld et al. 2002), and grounded theory (Grinter 1999; Grinter 1998; Fitzpatrick et al. 1996).

Single user approaches. Several techniques that are used for single user development have been used to design groupware systems (Halverson 2002). These approaches are based on field observations and on developing an understanding of users' tasks and work settings. These include: Contextual Design (Beyer and Holtzblatt 1998; Holtzblatt and Beyer 1993), participatory design (Greenbaum and Kyng 1991; Muller 1991), and user centered design (Norman and Draper 1986).

Groupware analysis and evaluation approaches. Several approaches have been developed for analyzing group tasks and/or evaluating the usability of groupware applications. These include: the mechanics of collaboration (Gutwin and Greenberg 2000), groupware walkthrough (Pinelle and Gutwin 2002; Pinelle and Gutwin 2001), groupware task analysis (van der Veer and van Welie 2002; van der Veer et al. 1996), collaboration usability analysis (Pinelle, Gutwin, and Greenberg 2003), and heuristic evaluation for groupware (Baker et al. 2002).

Design recommendations and frameworks. Several design recommendations and frameworks have been created to provide guidance on designing for groups that operate in specific domains or that have specific characteristics. These recommendations are commonly based on the observations, experiences, and insights of developers and researchers working in the field. For example, Luff and Heath (1998) discuss design for mobile workers; Scott et al. (2003) present a design framework for co-located workers using tabletop displays; and Brown and Chalmers (2003) discuss design for tourists.

2.3 Loose coupling and organizational research

Loose coupling describes relationships between member of groups and organizations. Work and collaboration patterns in loosely coupled groups differ from those seen in more tightly coupled groups, and as with other social and organizational characteristics, groupware designs that support loose coupling should consider these factors.

In the next sections, I discuss the organizational aspects of loose coupling, and how it shapes the way that collaborators arrange work activities. Loose coupling concepts were first developed in organizational research, and in the next sections, I discuss literature from several related fields, including sociology, education, management, administration, and systems theory. The discussion is organized around the following themes:

- Definitions of loose coupling in organizational research
- Open systems theory
- Reasons for loose coupling
- Outcomes associated with loose coupling

2.3.1 Definitions of loose coupling in organizational research

The term "loose coupling" was first used by Glassman (1973), who used it to describe linkages between elements in living systems including cell and organ, organism and group, organization and society. According to Glassman, systems are loosely coupled if they have few variables in common or if the variables they have in common are weak relative to other factors that influence them. When systems are loosely coupled, they can operate relatively independently of each other. However, in the case where systems share a large number of common variables or where those variables are strong, interdependencies increase between the systems, and their independence from each other decreases.

Weick (1976) adopted the notion of loose coupling to describe organizational structures in education. Wieck describes how operational elements in schools, such as teachers, are often loosely coupled with each other, with managers (e.g. principals), and with district administrators. Teachers have autonomy and flexibility in carrying out their daily work, and principals and administrators have difficulty in instituting change within schools. Weick (p. 3) defines loose coupling, and elaborates on some of its complexities:

> By loose coupling, the author intends to convey the image that coupled events are responsive, but that each event also preserves its own identity and some evidence of its physical or logical separateness. Thus, in the case of an educational organization, it may be the case that the counselor's office is loosely coupled to the principal's office. The image is that the principal and the counselor are somehow attached, but that each retains some identity and separateness and that their attachment may be circumscribed, infrequent, weak in its mutual affects, unimportant, and/or slow to respond. Each of those connotations would be conveyed if the qualifier loosely were attached to the word coupled. Loose coupling also carries connotations of impermanence, dissolvability, and tacitness all of which are potentially crucial properties of the 'glue' that holds organizations together. (p. 3)

In a later paper, Orton and Weick (1990) revisit Weick's early work (1976), and attempt to formulate a more precise definition for loose coupling. They argue against using what they describe as a unidimensional interpretation of loose coupling that views loose and tight coupling as opposite extremes along a scale. In this view, "tightly coupled systems are portrayed as having responsive components that do not act independently, whereas loosely coupled systems are portrayed as having independent components that do not act responsively" (p. 205). They argue that the unidimensional interpretation overlooks many of the intended subtleties in Weick's earlier work, and that it does not emphasize the connectedness that is a necessary part of loose coupling.

Instead, Orton and Weick advocate using what they describe as a dialectical interpretation of loose coupling that describes system elements according to their distinctiveness and responsiveness. Elements are distinctive if they are well-defined and semi-autonomous, and elements are responsive if they respond to the actions of other elements in the system:

> If there is neither responsiveness nor distinctiveness, the system is not really a system, and it can be defined as a noncoupled system. If there is responsiveness without distinctiveness, the system is tightly coupled. If there is distinctiveness without responsiveness, the system is decoupled. If there is both distinctiveness and responsiveness, the system is loosely coupled. (p. 205)

Orton and Weick's definition is restated by Foster (1983). According to Foster, "loose coupling implies the tying together of subsystems in such a fashion that neither can do without the other but neither has much control over the other" (p. 11).

Ingersoll (1993) summarizes many of the characteristics of loose coupling that are implicit in the definitions that are given by other authors:

1. unclear, diverse or ambiguous organizational means and goals;
2. low levels of coordination of employees' productive activities;
3. low levels of organizational control:
   high levels of employee autonomy
   low levels of managerial authority (p. 98)

2.3.2 Open systems theory

Literature on loose coupling in groups and organizations is based on an open systems model (e.g. Weick 1976; Glassman 1973; Orton and Weick 1990; Foster 1983). Systems theory is based on the notion of a system, which Scott (1987) describes as, "an assemblage or combination of parts whose relations make them interdependent" (p. 76), and systems theory is usually used to characterize the structure, relationship, and processes seen in systems and their parts (Hassard 1993, p. 30-31). The flexibility of the system definition allows for wide variation in the types of systems that can be studied, which can be seen through the application of systems theory in several dissimilar fields such as biology, physics, and sociology (Hassard 1993, p. 30).

The systems foundation provides flexibility to loose coupling concepts, since systems theory does not place constraints on the size and composition of system elements. For example, loose coupling theory is frequently used to describe relationships at different levels of granularity in social systems, including: between individuals (Orton and Weick 1990; DiTomaso 2001), between organizational subunits (Meyer and Rowan 1977; Weick 1976), and between organizations (Brusoni et al. 2001). In a survey of loose coupling literature, Orton and Weick (1990) expand on this notion and describe eight types of elements that have been studied in loosely coupled systems: individuals, subunits, organizations, hierarchical levels, organizations and environments, activities, ideas, and intentions and actions.

Loose coupling research is based on an *open* systems model (Scott 1985; Scott 1987; Lei et al. 1996). Open systems theory differs from closed systems theory (which is often used to describe mechanical systems) since it is based on the notion that systems dynamically interact with their external environments (Boulding 1956; Katz and Kahn 1978; Thompson 1967). This interaction allows systems to act to prevent deterioration and disruption, and to restore equilibrium. Scott (1985) points out that open systems "are capable of adaptive upgrading, becoming more differentiated and elaborate in their structures and processes over time" (p. 601).

Katz and Kahn (1978) define the environment as "everything in the universe, except the organization under study" (p. 122). However, they qualify this by stating that it is more productive to focus on those aspects of the environment that interact directly with organizations. They identify five environmental sectors that strongly influence organizations: the cultural environment, the political environment, the economic environment, the technological environment, and the ecological environment (p. 124).

The characteristics of an organization's environment place pressures on the organization, and to be successful, the organization must adopt behaviors and structures that allow it to handle those demands (Georgopoulos 1973, p. 102). Lorsch (1973) argues that "there must be a fit between internal organizational characteristics and external environmental requirements if an organization is to perform effectively in dealing with its environment" (p. 132).

Since organizations respond to their environment, specific environmental characteristics can lead to the adoption of structural and behavioral patterns in organizations. For example, unpredictable and changing work environments have often been described as one of the primary causes of loose coupling between an organization's elements (Orton and Weick 1990; Meyer and Rowan 1977; Lei et al. 1996). Lorsch (1973) illustrates this point:

> We would predict that in effective units involved in more uncertain parts of the environment, members would perceive less structure, would feel that they have high influence over their own work and would perceive egalitarian influence distribution in general, and that supervisory styles would be seen as participative. The opposite set of conditions would fit a unit effectively dealing with a more certain environment. (pp. 135-136)

2.3.3 Reasons for loose coupling

Organizational research literature identifies several underlying reasons that can lead to the adoption of loose coupling. These reasons can exist at different levels—at the organizational level, at the group level, at the interpersonal level, or in the external environment. In this section, I provide a brief overview of these factors. Each is discussed in further detail in Chapter 4. While each of the reasons listed here can lead to loose coupling, it has also been pointed out that some conditions may arise as the result of loose coupling (e.g. Foster 1983, p. 13). In compiling this section, I attempted to include factors that fit more logically as underlying contributors to the adoption of loose coupling; the outcomes associated with loose coupling are listed in Section 2.3.4.

- *Ambiguous evaluation criteria.* The criteria for evaluating worker or unit performance are unclear and poorly defined (Hasenfeld 1983).
- *Cryptic surveillance*. Inspection of organization members' activities is weak and undemanding (Weick 1980; Scheid-Cook 1990; Gamoran et al. 2000; Meyer and Rowan 1977; Hasenfeld 1983).
- *Environmental uncertainty and complexity*. The organization operates in an uncertain and/or complex environment (Orton and Weick 1990; Scott 1985; Aldrich 1979; Lei et al. 1996; Hansenfield 1983).
- *Non-routine and unpredictable tasks*. The tasks required to carry out work in the organization are not routine and are difficult to plan and predict (Hasenfeld 1983, pp. 154-155).
- *Organization / group size and complexity*. The social system is large and complex (Weick 1982, p. 382; Monane 1967).
- *Incompatible external expectations*. Environmental expectations for organizational behavior are incompatible with operational demands (Meyer and Rowan 1977; Hasenfeld 1983).
- *Internal conflicts*. Workers have personality conflicts or incompatible values and opinions (Cockburn and Jones 1995; Hasenfeld 1983; Weick 1982).
- *Professionalism*. The organization has professional employees (Kouzes and Mico 1979; DiTomaso 2001; Scheid-Cook 1990).
- *Specialized knowledge, expertise*. Employees have specialized knowledge and/or expertise (Brusoni et al. 2001; DiTomaso 2001).
- *Limited opportunities for interaction.* Group or organization members have limited opportunities to interact (Olson and Teasley 1996; Bellotti and Bly 1996; Fagrell et al. 2000; Smith 1973).

2.3.4 Outcomes associated with loose coupling

Organizational research literature identifies several outcomes that can result from the adoption of loose coupling. As with the factors discussed in 2.3.3, these outcomes can be seen at the organizational, group, or interpersonal level. In this section, I provide a brief overview of these outcomes. Each is discussed in further detail in Chapter 4. It should be noted that the outcomes discussed in this section are not wholly good and are not wholly bad (Firestone 1985, p.5; Weick 1976). Instead, the utility of each outcome depends on the specific circumstances confronted in the work situation (Scott 1987, p. 254).

- *Buffering*. Since loosely coupled elements function autonomously, problems in one element do not impact other elements (Weick 1976; Perrow 1999).
- *Information buffers*. Loosely coupled elements maintain local information repositories to support autonomous work (Kmetz 1984).
- *Partitioning of tasks*. Work is partitioned so that the need for ongoing negotiation and task allocation activities is minimized (Olson and Teasley 1996; Hasenfeld 1983, p. 150).
- *Autonomy and behavioral discretion*. Loosely coupled elements are free to use their own discretion in determining their behavior (Aldrich 1979; Tyler 1987; Perrow 1999).
- *Sensitivity to environmental stimuli*. Since loosely coupled systems have several distinct "sensors", they are sensitive to environmental stimuli (Weick 1976; Staber 2002; Brusoni and Prencipe 2001).
- *Adaptability*. Loosely coupled elements are able to adapt to the environments that they encounter locally (Rubin 1979; Horne 1992; Lutz 1982; Weick 1976; Scott 1987).
- *Persistence*. Since loosely coupled elements are distinct and autonomous, it can be difficult to institute changes to the system (Orton and Weick 1990; Weick 1976; Glassman 1973; Horne 1992; Spender and Grinyer 1995; March 1978).
- *Weak authority structure.* Authority structures are limited in their ability to sanction subordinates (Staber and Sydow 2002; Lorsch 1973).

2.4 Loose coupling and CSCW

Loose coupling concepts have been used in computer-supported cooperative (CSCW) research as a way of describing relationships between workers. This research usually focuses on the collaborative relationships in groups, and on the role that groupware technologies can play in supporting communication and coordination between workers.

In the next sections, I discuss these studies. I organize the discussion around three themes:

- Definitions of loose coupling in CSCW
- Factors influencing the adoption of loose coupling
- Design approaches for loose coupling

2.4.1 Definitions of loose coupling in CSCW

The terms “loose coupling” and “loosely coupled” are used in CSCW literature to describe loose connections between different types of elements. These include:

- Connections between groupware components (Parnes et al. 1997 p. 169; Ellis 1997 p. 416)
- Relationships between applications (Grønbæk et al. 1993, p. 344)
- Relationships between work groups and the rest of the organization (Egger and Wagner 1992)
- Relationships between individuals (Nomura et al. 1998)
- Relationships between members of a group (Gräther and Prinz 2001, p. 252)
- Relationships between teams (Grinter et al. 1999)

The formal definitions that CSCW authors have given for loose coupling focus on relationships between people. For example, according to Begole et al. (1999), “the degree to which collaborators work closely together or independently is referred to as tight versus loose coupling” (p. 98). Grinter et al. (1999) provide a similar but more descriptive definition. They suggest that loosely coupled work is carried out relatively independently of others, and it requires a reduced level of communication. Tightly coupled work is more interrelated, and requires more communication and coordination.

Olson and Teasley (1996) provide more formal definitions for loose and tight coupling. Their definitions emphasize two dimensions of work: the required response time, and the required level of interaction between collaborators:

> At one extreme, tightly coupled work involves two or more people whose work is directly dependent on each other, and their work typically involves a number of interactions to complete the task. Immediate

> interaction helps them to communicate clearly or to negotiate some resolution…In tightly coupled work, 'showstoppers' occur when people cannot communicate directly and promptly.
>
> At the other extreme, loosely coupled work is work in which people need to be aware of others' activity and decisions, but without the need for immediate clarification or negotiation. The work can proceed in parallel. (p. 422)

Edwards and Mynatt (1997) describe "autonomous collaboration", a term which they credit to Kolland (1994), which can be characterized as a special case of loose coupling:

> Autonomous collaboration is characterized by periods in which groups of users work independently on a loosely-shared artifact. These users then come together for periods of tightly-coupled sharing to integrate the disparate work done by collaborators. Coordination and comprehension of parallel, independent efforts necessitates awareness of current and past efforts among users. (p. 218)

To illustrate the concept of autonomous collaboration, Edwards and Mynatt (1997) describe a group writing scenario, where writers each take responsibility for a section of a document and work on it independently. Writers periodically collaborate in a tightly coupled fashion in order to merge their work, to divide tasks, and to develop new plans.

2.4.2 Reasons for the adoption of loose coupling

CSCW literature considers two reasons for the adoption of loose coupling. First, CSCW literature usually focuses on the temporal and spatial distributions of workers, and how those distributions influence the level of collaborative coupling seen in groups and organizations. Second, CSCW literature considers how organizational and environmental factors influence the adoption of loose coupling; however, these issues are not given significant attention, and are not explored in-depth.

2.4.2.1 Organizational and social factors

CSCW research often overlooks the underlying organizational and social factors that facilitate the adoption of loose coupling. Some researchers have briefly reported on these issues. However, these factors still have not been explored in-depth, and attempts have not yet been made to consider the implications they have for the design and acceptance of groupware applications.

Several researchers have discussed organizational factors that contribute to the adoption of loose coupling. For example, Grudin (1994) suggests that some organizations are intentionally structured to reduce collaboration between workers. Similarly, Grinter et al. (1999) show that organizations adopt different coupling patterns depending on work interdependencies and on the physical relationships of workers and workgroups.

Other researchers have suggested that social issues can influence the level of coupling that is seen between collaborators. Cockburn and Jones (1995) suggest that social factors can discourage collaboration between workers, regardless of the supporting mechanisms. As an example, they state that personality clashes between workers can make collaboration burdensome. Bradner and Mark (2002) point out that social issues influence users' willingness to collaborate when they are separated by physical distance: "the ability to persuade another and the willingness to initially cooperate decrease with distance while deception of another person increases with distance" (p. 234).

2.4.2.2 Temporal and spatial factors

In CSCW literature, loose coupling is often portrayed as a side effect of temporal and spatial factors that interfere with workers' abilities to collaborate. Researchers have identified three common temporal and spatial distributions that can lead to loose coupling: physical distribution of workers, schedule variability between workers, and worker mobility. Since these factors can increase the effort needed to collaborate, workers may adopt autonomous and loosely coupled work styles. For example, when workers are physically distributed and do not see each other face-to-face, it is more difficult to communicate and to coordinate work, so loose coupling is often adopted to minimize overhead.

In the next three sections, I discuss three temporal and spatial factors that can cause loose coupling:

- Physical distribution
- Schedule variability
- Mobility

2.4.2.2.1 Physical distribution

In CSCW literature, researchers have shown that collaboration frequency and quality is associated with the physical proximity of collaborators. This is illustrated by Kraut et al. (1988) in a study of collaboration practices between researchers. Their findings show that physical proximity increases the likelihood of collaboration between researchers, in part due to increased opportunities for unconstrained and opportunistic communication. They also point out that proximity allows face-to-face interactions that use multiple sensory channels, which result in high quality and more intense collaboration. Finally, they suggest that a significant amount of the communication that occurs between co-present researchers is not planned, and would not occur if it had to be planned.

The decreased collaboration that is associated with physical distribution can lead to loose coupling between workers. Olson and Teasley (1996) point out that when remote work is difficult to coordinate, it is often restructured to be loosely coupled. They describe an instance (p. 425) where a worker who was physically separated from the rest of the team was allowed to pick his work assignments. The worker selected work that was "cleanly partitionable", since this minimized ongoing coordination demands. In a discussion of organizational structure in research and development (R&D) work, Grinter et al. (1999) equate co-location with tight coupling and high communication requirements, and physical distribution with a loose coupling and reduced communication requirements.

2.4.2.2.2 Schedule variability

When workers maintain different work schedules, it can be difficult for them to collaborate in real-time. This schedule variability can facilitate loose coupling, since workers may have to expend extra effort to communicate and to coordinate work (Pinelle and Gutwin 2002). While it still may be possible to overcome schedule variations with formal appointments and meetings (Bellotti and Bly 1996), the extra coordination costs can discourage the routine flow of information between workers (Pinelle and Gutwin 2002).

Three major types of schedule variability have been discussed in CSCW literature. First, workers may have different "work rhythms", and they may carry out different tasks at different times (Begole et al. 2002; Reddy and Dourish 2002). These variations can make it difficult to establish common times when workers can collaborate (Begole et al. 2002). Second, workers may work in shifts, and one worker may begin the work day when another worker ends his or her work day (Kaplan 1997). Third, workers may work out of different time zones, and may not work during the same hours (Begole et al. 2002).

2.4.2.2.3 Mobility

When workers are mobile over a wide area, variations in workers' physical locations and schedules can introduce collaborative difficulties that facilitate loose coupling between workers. For example, Pinelle and Gutwin (2002) show that in mobile home care teams, workers have difficulties communicating and coordinating work with other mobile workers. They suggest that these difficulties partially contribute to the adoption of a loosely coupled, autonomous work style. Similarly, Fagrell et al. (2000) point out that mobile teamwork requires autonomy to deal with local situations, but that work interdependencies may exist that require collaboration.

Several collaboration difficulties can contribute to loose coupling between mobile workers. Since physical location is a changing dimension in mobile work, it is difficult for workers to stay aware of others' locations and availabilities (Fagrell et al. 2000; Belotti and Bly 1996), which makes it difficult for workers to communicate and coordinate work (Belotti and Bly 1996). In mobile groups, workers may have more opportunities to see each other face-to-face since they do not work out of distributed fixed locations. However, the variability in time and location seen when workers are mobile over a wide area can make it difficult to establish any type of intentional synchrony, even when technologies are utilized (Brown and O'Hara 2003).

Pinelle, Dyck, and Gutwin (2003) suggest that technical barriers can also play a role in the adoption of loose coupling between mobile workers. They suggest that the current technical constraints seen in mobile computing favor loosely coupled work. Support for tight coupling, which often requires synchrony between workers, is difficult to achieve when workers are mobile over a wide area due to interference and intermittent access to wireless networks. However, loosely coupled work practices that allow partitioning of work tasks, clear ownership of data and artifacts, and asynchronous collaboration reduce the need for real-time coordination and communication, which makes it well-suited to the unreliability of mobile networks.

2.4.3 Design approaches for loose coupling

CSCW researchers have investigated design for loose coupling. Most of this work focuses on improving the quality of collaboration between individuals in groups by providing support for communication, coordination, and awareness. However, many of the issues that organizational researchers have explored are overlooked in CSCW (e.g. Orton and Weick 1990; Weick 1976; Perrow 1999; Meyer and Rowan 1977), including the social, organizational, and environmental aspects of work, and CSCW literature does not provide guidance on how systems should be tailored to support and accommodate these factors.

Groupware applications that have been developed for loosely coupled collaborators use a range of high-level design strategies. Some designers attempt to change loosely coupled work patterns by introducing tools that increase awareness, communication, and coordination between workers and that lead to tighter coupling. Others provide support for mixed collaborative styles, where variable coupling styles are supported. Finally, others accommodate schedule variability by supporting asynchronous collaboration.

In the next three sections, I discuss the different general design approaches that have been used to support loosely coupled workers. I discuss the following approaches:

- Support tighter coupling: synchronous groupware
- Support mixed coupling styles: strict and relaxed WYSIWIS
- Accommodate schedule variability: asynchronous groupware

2.4.3.1 Support tighter coupling: synchronous groupware

One common approach for designing collaborative technologies to support loose coupling is to provide workers with synchronous tools that facilitate tighter coupling. This approach is usually used to address collaborative difficulties that arise when workers are physically distributed between different worksites (Erickson and Kellogg 2000). Synchronous groupware tools attempt to overcome these difficulties by supporting a more natural style of collaboration between physically distant workers (Gutwin and Greenberg 1999). In general, this approach is not practical for dealing with mobility and extreme schedule variability since real-time tools require workers to schedule common times for using the shared application.

Since real-time groupware applications constrain workers' schedules and can introduce additional interdependencies between workers, using these applications can lead to a more tightly coupled style of work (Ellis et al. 1991). To work together using synchronous groupware tools, workers must arrange their schedules so that all team members are at their computers at the same time so that they can participate in the supported tasks (Pankoke-Babatz and Syri 1997). Additionally, many real-time groupware tools tighten coupling by allowing workers to inspect others' work, and by supporting tighter coordination than might otherwise be seen in distant work. For example, real-time groupware applications often focus on tasks that require fine-grained coordination, such as multi-person editing tasks (e.g. Olson et al. 1993, Streitz et al. 1994). Coordination support is often provided using telepointers and other features that help users to maintain a detailed awareness of others' activities (Gutwin et al. 1996; Gutwin and Penner 2002).

2.4.3.2 Support mixed coupling styles: strict and relaxed WYSIWIS

Another groupware design approach for loosely coupled workers uses real-time collaborative support but allows workers to select between a tightly coupled operating mode and a loosely coupled operating mode (e.g. Begole et al. 1998). This is similar to the approach discussed in the last section—it attempts to bridge physical distances between workers by providing support for real-time collaboration and shared work. However, this approach gives workers greater flexibility in determining their level of collaborative coupling by allowing them to select an operating mode that is appropriate for addressing a given work situation.

Tightly coupled and loosely coupled modes are commonly implemented using two user interface approaches: strict WYSIWIS and relaxed WYSIWIS, respectively (What You See Is What I See — Stefik et al. 1987). Strict WYSIWIS mode forces users to share a common view of the shared workspace. For example, if one user scrolls the view of a shared document, all other users' views scroll as well. Since this approach limits users' autonomy in carrying out shared activities, it is usually called a tightly coupled operating mode (Schuckmann et al. 1999; Baecker et al. 1994). In a relaxed WYSIWIS mode, users can individually control their views without changing others' views. Since this allows more autonomy, it is usually called a loosely coupled operating mode (Schuckmann et al. 1999; Baecker et al. 1994).

A number of real-time groupware applications that have been discussed in CSCW literature allow workers to determine their "coupling mode" (e.g. Haake and Wilson 1992; Dewan and Choudhard 1991; Greenberg and Roseman 1996; Beaudouin-Lafon and Karsenty 1992). For example, Greenberg and Roseman (1996) describe GroupWeb, a shared web browser that provides two levels of view coupling. Users can either work with a "slaved view" where they must view the same webpage, or can view pages independently using the loosely coupled mode. Similarly, Baecker et al. (1994) describe SASSE, a collaborative text editor that provides two view modes. SASSE allows workers to work on different parts of the document using the loosely coupled mode; tightly coupled mode forces workers to share a common view of part of the document.

While this mixed coupling approach is in common use, it is worth noting that loosely coupled WYSIWIS modes do not necessarily support loose coupling as it is described using CSCW definitions (e.g. Grinter et al. 1999; Olson and Teasley 1996). For example, real-time groupware tools force workers to arrange their schedules so that they can use the application at the same time. This does not accommodate schedule variability between workers, it requires increased coordination, and it subjects work to increased inspection by others, even when loosely coupled mode is used. While loosely coupled mode does allow more autonomy in carrying out tasks within the application than tightly coupled mode, it is still unclear how well loosely coupled WYSIWIS operating modes support the complexities of loosely coupled work.

2.4.3.3 Accommodate schedule variability: asynchronous groupware

Another groupware design approach for loose coupling uses asynchronous tools that accommodate schedule variability between workers. This approach is suitable for workers that are physically distributed; for workers that work out of a shared location, but at different times (e.g. shift work); and for workers that are mobile. Asynchronous groupware applications allow workers to work and collaborate whenever it suits their schedule (Pankoke-Babatz and Syri 1997; Manohar and Prakash 1995), and this approach frees them of the need to schedule common times to use the application, as is seen in real-time groupware applications.

According to Olson and Teasley (1996), loosely coupled work does not require the same level of timeliness that is seen in tightly coupled work: "loosely coupled work is work in which people need to be aware of others' activity and decisions, but without the need for immediate clarification or negotiation" (p. 422). Asynchronous groupware applications accommodate this style of work. These applications usually allow more autonomy than real-time applications (Preguiça et al. 2000; Edwards et al. 1997), and do not force ongoing negotiation with others (Pankoke-Babatz and Syri 1997; Manohar and Prakash 1995). Edwards and Mynatt (1997) characterize collaboration that takes place in asynchronous groupware applications:

> While more loosely defined, asynchronous collaboration has typically been taken to mean collaboration that happens (or can happen) at different times. Group calendars and bulletin boards are the oft-cited examples. Users interact with some shared artifact, and this interaction doesn't necessarily have to happen at the same time. Even if it does happen at the same time, users may not be notified of the interactions of others since updates among users are not as fine grained as in synchronous interactions. (p. 218)

2.5 Loose coupling and healthcare

In this research, I base my investigation of loose coupling on observations from home care. Healthcare organizations have been described as loosely coupled organizations, with loosely coupled work practices. Since this characterization is relevant to understanding work practice and organizational patterns in this research, I review relevant literature in the next two sections. I begin by discussing loose coupling in healthcare and human service organizations, and then I discuss loose coupling and home care.

2.5.1 Healthcare and human service organizations

Healthcare organizations can be classified as *human service organizations*. Hasenfeld (1983) defines human service organizations as the "set of organizations whose principal function is to protect, maintain, or enhance the personal well-being of individuals by defining, shaping, or altering their personal attributes" (p. 1). He points out that two characteristics distinguish human service organizations from others: 1) people are the "raw material" of the organization, and the organization's purpose is to shape their attributes; and 2) the organizations are mandated to promote the welfare of the people that they serve. Examples of human service organizations include hospitals, medical centers, mental health centers, social service agencies, public health agencies, public schools, universities, nursing homes, police departments, correctional institutions, employment services, and probation departments (Kouzes and Mico 1979, p. 453).

The attributes of human service organizations differ from those of business and industrial organizations. According to Kouzes and Mico (1979), the underlying goals and motives differ between these two organization types, as do the organizational structure and processes. This is summarized in Table 2.4. Among these differences, they point out that business and industrial organizations tend to have tightly coupled events and units while human service organizations tend to have loosely coupled events and units.

Table 2.4. Comparison of attributes in Human Service Organizations and Business / Industrial Organizations (Adapted from Kouzes and Mico 1979).

Dimension	Human Service Organizations	Business / Industrial Organizations
Primary motive	Service	Profit
Primary beneficiaries	Clients	Owners
Primary resource base	Public taxes	Private capital
Goals	Relatively ambiguous and problematic	Relatively clear and explicit
Transformational processes	Staff-client interactions	Employee-product interactions
Connectedness of events and units	Loosely coupled	Tightly coupled
Outputs	Relatively unclear and intangible	Relatively visible and tangible
Measures of performance	Qualitative	Quantitative
Primary environmental influences	The political and professional communities	The industry and suppliers

Several researchers have discussed the reasons why loose coupling is seen in human service organizations. Meyer and Rowan (1977) state that organizations that rely on adherence to external "myths" for legitimacy (such as a government mandate, as is the case in many human service organizations), loose coupling is often adopted. This loose coupling allows work practice to be carried out according to the needs of the organization and with minimal inspection, since external myths may be ambiguous and may not promote rational work practice. Hasenfeld (1983, pp. 156-157) also identifies factors that contribute to loose coupling in human service organizations. According to Hasenfeld, the autonomy of frontline staff members plays a central role in the adoption of loose coupling:

1. Organizational activities are initiated through staff-client interactions rather than through directives following an organizational chain of command,
2. The visibility and observability of staff-client interactions is highly limited, and interactions are not open to inspection by management and other staff members,

3. Staff members control the information about staff-client interactions that is passed on to the organization and also control information from the organization that is passed on to the client,
4. Interactions between staff members and clients are not easy to coordinate centrally due to varying contexts—different staff members interact with clients for different reasons, and the locations and times vary.

Several authors discuss specific healthcare domains and the loose coupling that is seen between staff members. For example, Scott (1985) discusses mental health systems, and states that tight coupling is seen in funding flows, but that loose coupling is seen in the service delivery elements. Similarly, Scheid-Cook (1990) presents a case study of community mental health centers, and reports that loose coupling is seen in the lack of inspection and evaluation of professionals' work activities (both by peers and by management), and that members of the organization operate according a "logic of confidence and good faith" that others will fulfill their work responsibilities.

2.5.2 Loose coupling and home care

In recent years, home care has become an important part of healthcare organizations since it is a cost-effective and is preferred by patients over hospital and nursing home stays (Wilkins and Park 1998; Geraci 1997). In home care, healthcare workers deliver services to patients in their homes. Each patient is typically treated by a team of several people, including therapists, nurses, social workers, and home health aides (McNeal 1996).

Home care workers work together in a loosely coupled fashion (Pinelle and Gutwin 2003; Pinelle, Dyck, and Gutwin 2003). Workers are mobile and work out of different locations. They spend most of the day in the community and may only spend minimal time in the office, so informal communication is rare, and formal communication may be difficult to arrange due to schedule variability within the team (Neal 1997; Warner 1996). When communication does occur, it is often limited to a small subset of the treatment team, even though all team members might benefit from involvement. This fragmentation in communication can lead to difficulties in coordinating care plans and in planning shared outcomes (Warner 1996; Neal 1997; Benefield 1996).

In spite of collaboration difficulties, Pinelle and Gutwin (2003) note that in most cases home care workers can successfully carry out their work duties without consultation with other team members. They also indicate that the loose coupling seen in home care allows workers to deal with the uncertainties of working in the community. For example, traffic delays or unexpected events in patients' homes can force them to revise their actions and schedules, and since they are autonomous, they do not have to consult others first.

2.6 Groupware technologies for healthcare clinicians

The groupware application that will be developed as part of this research will be designed to support teams of mobile home care clinicians. Since medical informatics research has a core set of propositions that are relevant to designing clinical support, I review this literature in the next sections. The discussion is organized around the following themes:

- Clinical information systems and the electronic health record
- Support for communication and coordination
- Point-of-care clinical information systems

2.6.1 Clinical information systems and the electronic health record

Computer applications in healthcare domains are usually referred to as healthcare information systems (Raghupathi 1997). *Clinical information systems* (*CISs*) are the subset of these systems that are used by clinicians to support the provision of care to patients (Doolan et al. 2003). Doolan et al. (2003) identify several common types of clinical information systems:

- *Computerized results* systems support the storage, manipulation, and sharing of results, such as radiology images and results from lab tests.
- *Computerized ordering* systems provide decision-support for ordering medications and diagnostic tests.

- *Computerized note* systems support entry, storage, and management of clinical documentation.
- *Computerized event monitoring and notification* systems identify items of clinical significance in data and notify the clinician.
- *Clinical administration systems* help clinicians to manage their workload.

The *electronic health record* (*EHR*) is an important part of many clinical information systems (Fitzpatrick 2000). Raghupathi (1997) defines the EHR as "electronically stored health information about one individual uniquely identified by an identifier." The EHR can include patient-specific care-related data, including clinical, administrative, and biographical data. Potential benefits of adopting EHRs are improved decision making, better medication management, and improved resource utilization (Mount et al. 2000). Likewise, by computerizing health records, timeliness, accuracy, and information access may be improved (Benson et al. 1996).

In some cases, the electronic health record is seen as a simple replacement for the paper record that is maintained by most healthcare organizations. Fitzpatrick (2000) argues that this conceptualization of the "record as passive information repository" leads to a restrictive, data-centric view of the EHR. Systems that support this view tend to focus on the organization's data needs without consideration for the methods whereby health care is delivered (Coiera 1997, p.282). In contrast to the data-centric view, Berg et al. (1998) argue that the meaning of data is only "self-evident" in its use context and that EHRs should be developed with a hands-on insight of the work that it is intended to support. Fitzpatrick (2000) elaborates on this notion: "If we seek to replace existing paper systems with computerized systems, albeit improved on many counts, without understanding how paper systems are currently embedded in the practice of health care, not just as information repositories, then implementation is guaranteed to be problematic."

2.6.2 Support for communication and coordination

Communication and coordination are an important part of healthcare work practices, and clinical information systems can play an important role in supporting these processes

(Maij et al. 2000; Schoop 1999; Schoop and Wastrell 1999). Several researchers have considered how systems should be developed to support collaboration in healthcare settings (e.g. Berg 1999; Maij et al. 2000). For example, Fitzpatrick (2000) indicates that technology support for clinical practice should promote "conversations about the work at the point of work" so that the context of communications can be preserved. She also suggests that systems should provide a "representation of the status of the work" so that work is visible to others on the team.

Shared access to electronic health records through CISs can help facilitate collaboration at a basic level, since it conveys information about treatment activities and patients' statuses (Reddy et al. 2001). For example, Berg (1999) states that shared records can help with information sharing and with coordinating work. According to Berg, records *accumulate* data elements from different workers into meaningful wholes, and help to *coordinate* workers' actions across space and time without the need for face-to-face contact.

Other clinical information systems provide more explicit support for collaboration than is provided by shared clinical data repositories. There are several types of systems that provide this explicit support. Examples include:

- *Email.* Email is an oft cited means of communicating between clinicians, and email support can be provided as a stand-alone application (Acuff et al. 1997; Wagner et al. 1998) or can be integrated into larger clinical information systems (Gomez 1998).
- *Mailing lists.* Email mailing lists allow health care workers with common interests or similar areas of expertise to request and share information (Worth and Patrick 1997).
- *Cooperative document systems.* Cooperative document systems allow clinical documents to be jointly managed by all disciplines that treat a patient (e.g. sharing goals, diagnoses, assessments) (Schoop 1999; Schoop and Wastrell 1999).

- *Indexing systems*. Indexing systems allow users to look up people by their area of expertise so that they can identify those who can provide needed information and advice (van Mulligen et al. 2000).
- *Radiological telemedicine systems.* Radiological telemedicine systems allow distributed physicians to share high-resolution radiological images and usually provide audio- and video-conferencing features to allow real-time communication (Handels et al. 1997; Gomez et al. 1998; Gomez et al. 1996).
- *Telemedicine systems for consultation.* Other types of telemedicine systems allow distributed users to consult about patients using audio- and video-conferencing; shared files, and documents; and other collaborative tools such as shared editors, shared schedules, and address books (Makris et al. 1998; Goldberg 1998).

2.6.3 Point-of-care clinical information systems

Healthcare workers often need access to information when they treat patients, and this has led to the development of *point-of-care clinical information systems* that can integrate into the care delivery process (Ammenwerth et al. 2000). Since healthcare work often involves mobility at some level (for example, workers can be mobile across different settings: offices, exam rooms, hospitals, nursing homes, clinics), stationary workstations are not usually sufficient for meeting the needs of workers (Shiffman et. al 1999). Instead, point-of-care systems are usually developed and deployed on smaller mobile computing devices (Ammenwerth et al. 2000).

Most point-of-care systems have limited functionality and do not provide the range of features that are seen in other clinical information systems. Examples of mobile point-of-care systems include:

- *2-way pagers*. 2-way pagers can be used to promote relatively unobtrusive communication between mobile workers (Eisenstadt et al. 1998).
- *Mobile email*. Mobile devices can be used to receive email with minimal interruption to treatment activities (Acuff et al. 1997).

- *Clinical document repositories*. Applications developed for mobile devices can provide access to clinical document repositories that contain patients' electronic health records (Duncan and Shabot 2000).
- *Medical references*. Mobile devices can provide access to medical references so that practitioners can look up information to support patients' care (Kanter et al. 2000).
- *Decision support systems*. Mobile devices can provide access to clinical practice guidelines to help practitioners in making decisions about patients' care (Shiffman et al. 1999).

Currently, there are several limitations that make it difficult to develop point-of-care information systems. Duncan and Shabot (2000) discuss security issues related to transmitting patient information across mobile networks and related to maintaining physical security of the data stored on mobile devices. Kanter et al. (2000) discuss the difficulties of building systems that allow users to access information quickly enough to support care-related activities. Melles et al. (1998) discuss user-interface issues related to point-of-care systems and the potential for these systems to increase documentation time and to interfere with clinicians' thinking processes.

3 Home care observations

I have investigated loose coupling in the real world by carrying out a series of interviews and field observations with home care treatment teams in Saskatoon Health Region (SHR). In this chapter, I present a qualitative report based on that investigation that describes current work and collaboration practices in home care teams; factors that influence home care coupling patterns; and the impact loose coupling has on home care teams.

The chapter is divided into the following sections:

- Overview of home care in Saskatoon Health Region
- Method
- Organizational issues
- The work of home care delivery
- Management and the treatment team
- Relationships between workers of the same discipline
- Loose coupling in treatment teams

3.1 Overview of home care in Saskatoon Health Region

Patients who receive home care services in Saskatoon Health Region are treated in their homes by clinicians from several disciplines. A patient can receive services from as many as seven different disciplines, including: occupational therapy, physical therapy, social work, dietetics, nursing, case management, and home health aides. The set of community-based workers who share a common patient are called a home care treatment team. Since each worker treats multiple patients during a workday (usually 6-15 depending on the discipline), and since teams are formed around patients, each worker is a member of multiple teams.

Since treatment team members share a common patient, their work is interdependent, but the interdependence is managed in a loosely coupled fashion. Team members are autonomous in setting their schedules, determining their work activities, and carrying out work tasks. They spend much of their time carrying out activities that are not easily interrupted for communication, such as driving and delivering treatments in patients' homes, and it is difficult for them to maintain an awareness of others' locations, availabilities, and schedules. These work patterns often make collaboration difficult, and workers usually only communicate with each other intermittently, and often only when they believe the necessity of communication outweighs the effort required to communicate.

3.2 Method

I have investigated the patterns of work, collaboration, and organization in home care treatment teams by carrying out a series of interviews and field observations with workers from each clinical discipline.

I conducted four rounds of interviews. Each round consisted of 7-8 interviews, one with a member of each clinical home care discipline. The participants for interviews, and for field observations, were selected by health district managers, and participants varied in interview rounds in order to give a range of perspectives from each discipline. Each interview lasted from 1 to 1½ hours. Interviews with case managers, social workers, occupational therapists, and physical therapists were conducted at that person's desk; interviews with nurses (RNs and LPNs) and home health aides were conducted in a private meeting room at the home care office.

The first round of interviews was informal and exploratory in nature and focused on developing a general understanding of organizational issues and basic work patterns. The second round focused on identifying current information utilization practices in home care, including documentation practices, information sharing practices, and communication practices. The third round was used to follow up on the findings from the first two rounds, and to discuss issues in further detail.

Prior to the fourth round of interviews, each participant was asked to bring a patient's chart and a blank set of the paper-based forms that they use during the workday. The interview session was spent discussing the chart and how each form fits into the daily workflow. Since each home care discipline uses a different set of forms, each interview session covered the forms that are used by that participant's discipline. At the conclusion of each interview, the participant provided a blank set of forms for later analysis.

In addition to the interviews, I spent approximately 60 hours carrying out field observations with home care workers to develop a detailed understanding of workers' day-to-day work activities. A full workday was spent with a member of each clinical discipline. A total of seven workers were observed. The clinicians were observed while they carried out their daily work activities, with observations taking place in the office, in workers' cars, and in patients' homes.

The field notes from the observations and the audiotapes from the interviews were transcribed and analyzed to identify work, collaboration, and organization patterns that are relevant to system design for loose coupling. The forms that were collected during the fourth round of interviews were analyzed to extract workflow information requirements.

The data from home care were also analyzed in preparation for designing Mohoc, a groupware system for home care treatment teams. The data was analyzed using Contextual Design (Beyer and Holtzblatt, 1998) and other analysis techniques. This is discussed further in Chapters 7.

3.2.1 Validity of methods

A large number of participants were included from the major home care disciplines (approximately 25 different interview participants and 7 observation "targets"). This increased the likelihood that the participant pool provided a representative sample of the larger population of home care workers.

There were four rounds of interviews, and each interview round was based on the understanding that was gained through previous interviews. With 3 exceptions, each round had a different set of participants. Each session included a weak form of respondent validation, where participants were asked questions that overlapped with interview results from the previous round of interviews. This allowed for confirmation of previous results from other members of the participant's discipline.

The combination of interview and field observation provided multiple views of the work situation. The interviews provided data about work practice and organizational issues from the participant's perspective. Observation sessions provided a more in-depth look at work in context, and allowed details of work practice to be identified that would have been overlooked through interviews alone. This direct observation of work allowed data to be recorded from the researcher's perspective. To reduce chances for logging errors, observation notes were transcribed within 24 hours of each observation session, and interviews were audio-recorded and transcribed for later analysis.

3.2.2 Reliability of methods

Data collection was carried out by a single researcher, so it is unclear whether the results and conclusions that were reached would show significant variance if they were carried out by other researchers. Scripts were used during the interviews, but the line of questioning frequently deviated from the script to get clarification on participants' responses. This raises the possibility that others would obtain different results if they carried out interviews since the questions were not standardized.

The interviews involved a significant number of participants, were carried out in four rounds, and spanned approximately a year and a half. The results were generally stable over time. Questions focused on collaboration and work practice, and observations indicated that most workers manage their workdays in a similar fashion. This stability of results across interview rounds suggests that there was a significant level of test-retest reliability in the methods and the findings.

3.3 Organizational issues

In SHR, three different administrative units are responsible for providing services to community-based patients. Clinicians are assigned to these units based on their discipline. This partitioning of clinicians across several units, each with separate management structure, influences the patterns of work that are seen in home care teams. In the next sections, I provide an overview of major organizational issues in these units. I discuss the following issues: community-based disciplines, administrative units, and office sites.

3.3.1 Disciplines

In SHR, there are eight clinical disciplines that deliver home care services to patients in the community. The focus of each discipline is summarized below:

- Occupational therapists (OTs) try to improve patients' levels of function in activities of daily living, such as dressing, cooking, or writing, through retraining and exercise.
- Physical therapists (PTs) focus on improving a patient's gait and strength through exercise and gait training.
- Social workers provide patients with counseling services.
- Registered nurses (RNs) deliver a range of nursing services to patients. Common services include: wound care and medication management.
- Licensed practical nurses (LPNs) deliver nursing services to patients, but the range of services that they provide are a limited subset of those that are provided by RNs. Common services include: diabetic foot care and medication management.
- Client care coordinators (C3s) evaluate patients and make referrals for other services. They monitor the patient as time goes by to determine if new services are needed.
- Home health aides provide patients with a range of support services – they prepare meals, do laundry and other housekeeping tasks, and help patients get dressed in the morning.
- Dieticians educate diabetic patients on food preparation and dietary requirements.

3.3.2 Administrative units

Treatment team members are assigned to one of three administrative units, each according to their discipline. These units are: the Coordinated Assessment Unit, Home Care, and Community Services. Each unit is briefly described in the next sections.

3.3.2.1 Coordinated Assessment Unit (CAU)

The Coordinated Assessment Unit (CAU) employs client care coordinators (C3s) who are responsible for providing case management services to clients in the community. C3s are relatively autonomous professional workers (most are trained as social workers), but are ultimately accountable to the CAU manager (see Figure 3.1).

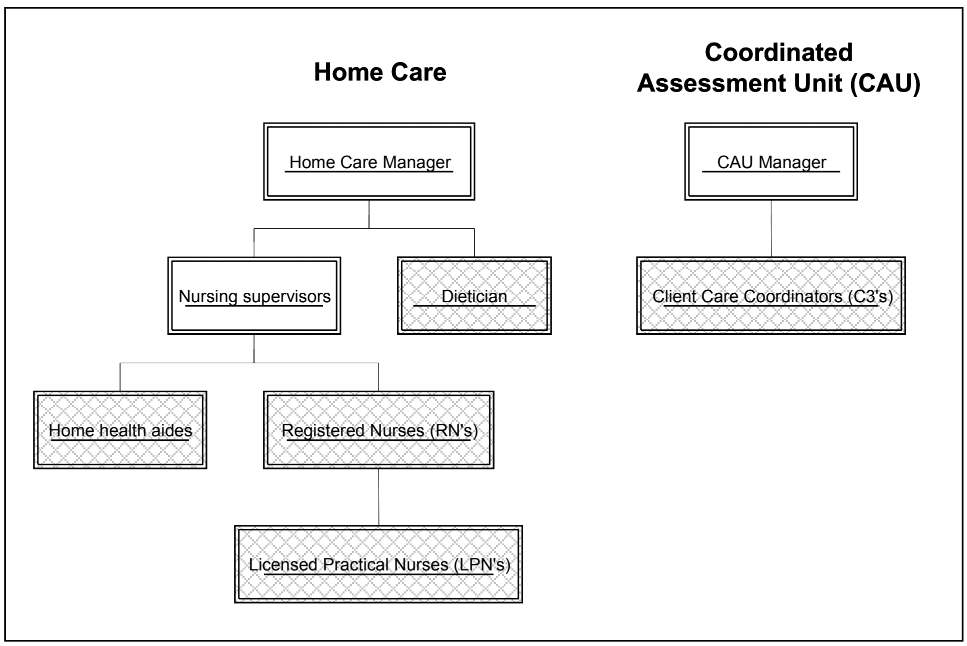


Figure 3.1. Home Care and Coordinated Assessment Unit organization charts. Cells with hatching represent workers that provide services in the community

3.3.2.2 Home Care

The Home Care unit employs workers from four different clinical disciplines. These include: RNs, LPNs, home health aides, and a dietician. Each Home Care discipline has different levels of autonomy, but they all fall within the same management structure. Ultimately, every worker in Home Care is accountable to the Home Care manager (see Figure 3.1). The home care manager directly supervises the dietician and four office-based nursing supervisors. The nursing supervisors are responsible for overseeing the work of the home health aides and the RNs. RNs directly supervise LPNs. Each patient that is treated by an LPN must also have a supervising RN, and LPNs can have a caseload with patients that are supervised by several different RNs.

3.3.2.3 Community Services

In Community Services, workers from three clinical disciplines share common clerical support and are housed in close physical proximity with each other, but they are not a formal administrative unit. Instead, workers from each of the three clinical disciplines are overseen by separate clinical departments that are responsible for providing services throughout the health district. These departments include: Occupational Therapy, Physical Therapy, and Social Work.

The administrative structure in each Community Services department allows workers to be supervised by managers who are members of their professional discipline. District wide, all OT, PT, and social work services are overseen by the professional leader for that department, with community-based workers making up only a small number of the workers that they oversee (see Figure 3.2). Within Community Services, each discipline is overseen by a senior worker from that discipline. This person is a clinician themselves but carries a scaled back caseload. The seniors are responsible for handling a range of administrative duties such as managing waiting lists, assigning patients to workers, and handling any problems that arise with the workers under their supervision.

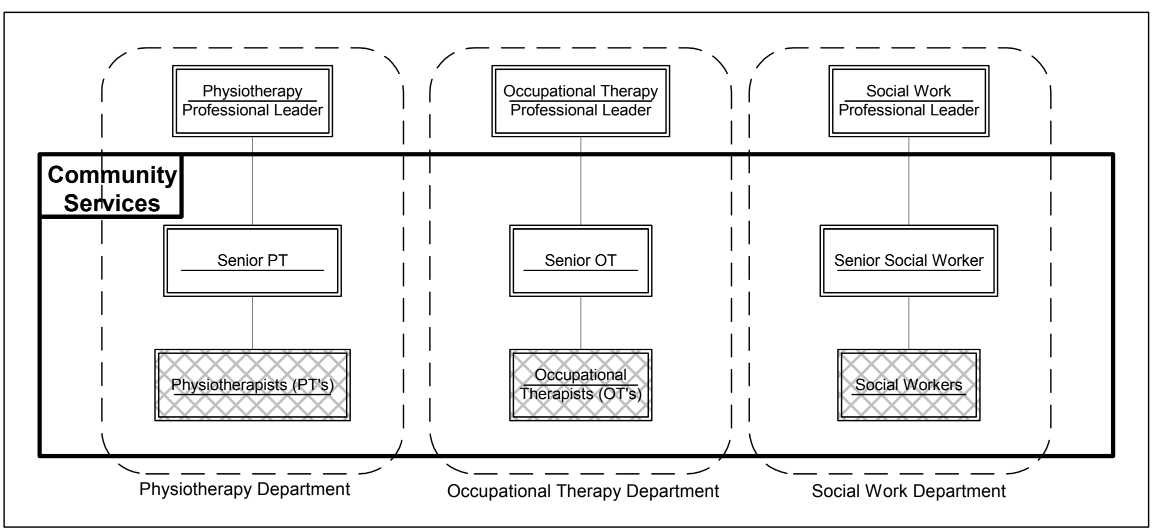


Figure 3.2. Community Services organization chart. Cells with hatching represent workers that provide services in the community

3.3.3 Office sites

Workers' offices are divided between two separate buildings across the city from each other. Community Services offices are located in a wing of Royal University Hospital. Home Care and CAU offices are several kilometers away on the second floor of a building in the downtown area.

At the hospital site, there are three separate rooms that house Community Services workers' desks. Workers desks are located in a room with other members of their professional discipline, as shown in Figure 3.3. They all share a common set of support staff that are responsible for answering phones and carrying out other clerical duties. Each senior has a private office in close proximity to the room that houses the workers from their discipline.

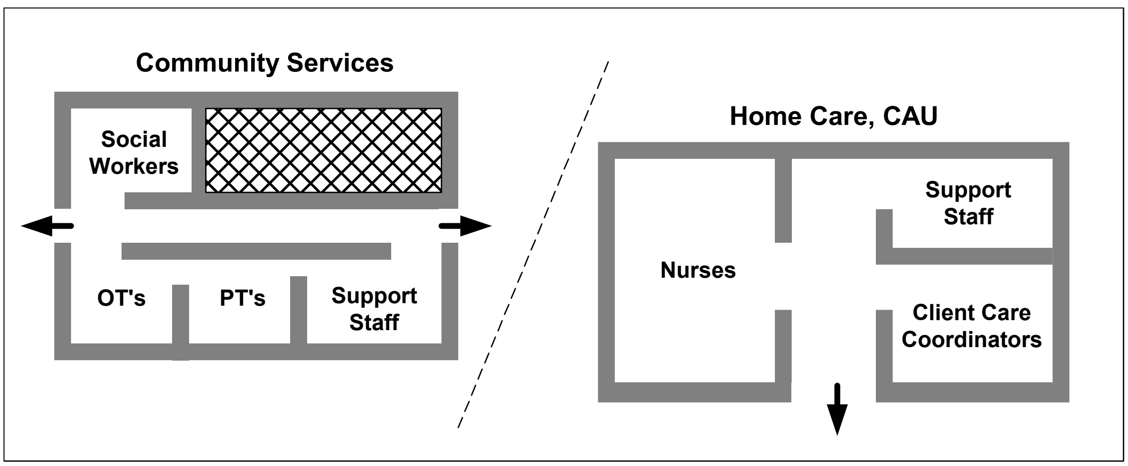


Figure 3.3. Physical distribution of office sites

Home Care and CAU are based out of downtown offices. There are no clear distinctions between the two units in the design of the office space. They share many common work spaces, such as meeting rooms, break rooms, and mail and photocopying areas, and they also share many of the same support staff members. With the exception of home health aides, each Home Care and CAU clinician has a desk in a common room with other members of their discipline (see Figure 3.3). Managers from each department have private offices at the site, as do the nursing supervisors. Notable support staff that are based out of this location include: schedulers who maintain home health aides' schedules, and information staff who are responsible for passing messages to and retrieving information for clinicians while they are in the field.

3.4 The work of home care delivery

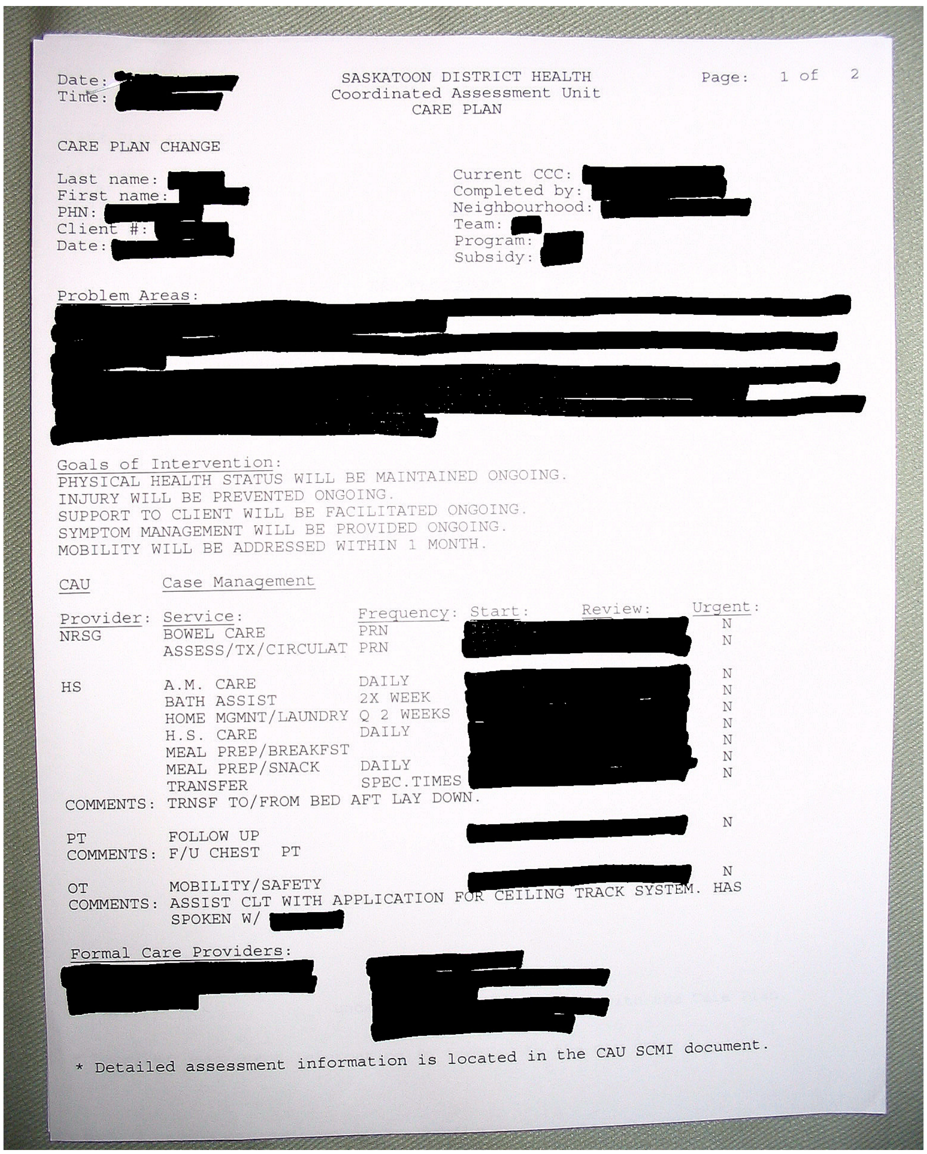
Regardless of the discipline, community based home care workers spend most of their time carrying out a relatively limited number of tasks. Most of their time is spend planning their workday, visiting patients, driving between patients' homes, and filling out paperwork. In this section, I discuss the most common work activities that are carried out in home care and other issues that that shape work practice. The discussion is divided into the following sections:

- Initiating new services
- Client care
- Paperwork practices
- Planning the workday
- The automobile and work practice
- Information technologies
- The work environment

3.4.1 Initiating new services

For an individual to be considered a candidate for home care services, someone must first flag them as a potential patient. Individuals can be flagged in a number of ways. One of the most common ways this happens is when concerns are raised about a patient's discharge status during a hospitalization. For example, a patient may be hospitalized, and healthcare workers in the hospital may determine that his or her post-hospitalization status requires ongoing services. Patients can also be flagged in outpatient settings. Patients are often referred for home care services by their general practitioner, by a specialist physician, or by healthcare workers in outpatient clinics.

All recommendations for home care services are directed to the Coordinated Assessment Unit. Clerical workers in the Coordinated Assessment Unit pass this information on to a Client Care Coordinator. The C3 then visits and evaluates that individual to determine their appropriateness for home care services. If the C3 decides that home care services are needed, they carry out a detailed assessment of the patient's status and their supports (the assessment is recorded on a 23 page assessment document), and they create a care plan document that specifies which clinical disciplines are needed to address the individual's needs. The care plan document specifies the recommended frequency and urgency of each service, and the interventions that the C3 recommends that each discipline provide. The care plan defines the initial treatment team for that individual. Figure 3.4 shows a sample care plan. The C3 faxes the care plan to clerical staff for each Community Services discipline or delivers a printed copy to the Home Care disciplines.



Date: [redacted]
Time: [redacted]

SASKATOON DISTRICT HEALTH
Coordinated Assessment Unit
CARE PLAN

Page: 1 of 2

CARE PLAN CHANGE

Last name: [redacted]
First name: [redacted]
PHN: [redacted]
Client #: [redacted]
Date: [redacted]

Current CCC: [redacted]
Completed by: [redacted]
Neighbourhood: [redacted]
Team: [redacted]
Program: [redacted]
Subsidy: [redacted]

Problem Areas:
[redacted]

Goals of Intervention:
PHYSICAL HEALTH STATUS WILL BE MAINTAINED ONGOING.
INJURY WILL BE PREVENTED ONGOING.
SUPPORT TO CLIENT WILL BE FACILITATED ONGOING.
SYMPTOM MANAGEMENT WILL BE PROVIDED ONGOING.
MOBILITY WILL BE ADDRESSED WITHIN 1 MONTH.

CAU Case Management

Provider:	Service:	Frequency:	Start:	Review:	Urgent:
NRSG	BOWEL CARE	PRN	[redacted]		N
	ASSESS/TX/CIRCULAT	PRN			N
HS	A.M. CARE	DAILY	[redacted]		N
	BATH ASSIST	2X WEEK			N
	HOME MGMNT/LAUNDRY	Q 2 WEEKS			N
	H.S. CARE	DAILY			N
	MEAL PREP/BREAKFST				N
	MEAL PREP/SNACK	DAILY			N
	TRANSFER	SPEC.TIMES			N
COMMENTS:	TRNSF TO/FROM BED AFT LAY DOWN.				
PT	FOLLOW UP		[redacted]		N
COMMENTS:	F/U CHEST PT				
OT	MOBILITY/SAFETY		[redacted]		N
COMMENTS:	ASSIST CLT WITH APPLICATION FOR CEILING TRACK SYSTEM. HAS SPOKEN W/ [redacted]				

Formal Care Providers:
[redacted]

* Detailed assessment information is located in the CAU SCMI document.

Figure 3.4. Coordinated Assessment Unit care plan document

Home Care and Community Services use different methods for assigning referrals to workers. In Home Care, clerical workers pass on the new referrals to nurses. Nurses cover specific regions of the health district, and referrals are assigned to a nurse if the patient lives within that coverage area. When referrals arrive for home health aide services, the referral is sent to the clerical staff members who are responsible for scheduling home health aides. These workers add information about the new patient to Procura, the computerized scheduling system, and appointments are generated for the new patient with one or more home health aides. Similar to nurses, home health aides generally work within a certain geographical region of the district, but these areas are not always well defined.

In Community Services, all new referrals are sent to the senior for each discipline. Community Services disciplines each have a waiting list, and each senior is responsible for maintaining that list and assigning patients to their subordinates. The seniors attempt to determine the urgency of new referrals, and urgent referrals are usually moved to the front of the waiting list. When space opens on a worker's caseload, the senior assigns a referral from the front of the waiting list to one of their subordinate workers, and passes on the documents that they have received from the C3.

3.4.2 Client care

Once a professional discipline begins treating a patient, the worker from that discipline determines their level of involvement in the patient's care and the course their services will take. The recommendations of the C3 are best guesses, but the discipline (OT, PT, RN, social worker, dietician) can change the content of treatments, treatment frequency, duration of services, and appointment times. All professional disciplines, then, are self-dispatched and self-directed once they receive the initial referral (in the form of the care plan) from the C3. This self-direction is partially a function of professionalism and specialized knowledge—workers from a given discipline are considered experts in their treatment domain and are considered the ones best able to direct their own treatment activities.

Unlike the professional disciplines, home health aides are more tightly supervised and do not have the same level of autonomy seen in other community-based workers. They are centrally scheduled using a computer-based scheduling system, and they pick up their printed schedules from the office twice a week. Similarly, they are not free to revise the services they deliver without discussing revisions first with an office-based nursing supervisor.

The focus of the services that are delivered is largely a function of a patient's status and prognosis. With some patients, the potential for improvement is minimal and home care services help them to maintain their current status and/or provide them with support services such as assistance with self-care or with taking medications. Other patients have more potential to improve, and home care workers focus their efforts on improving the patient's medical, physical, and functional status. For example, if a patient has recently had a stroke, physiotherapy may address balance and gait issues; occupational therapy may address activities of daily living and upper extremity status; and nursing may address unresolved medical issues.

The services that are provided to patients have different levels of urgency, and some services can easily be interrupted while others cannot. For example, it is a high priority that nurses visit diabetic patients in the morning to give them insulin injections, while it is a lower priority that a physiotherapist provides a patient with lower extremity exercises on a given day. When services are high priority, workers expend extra effort to guarantee that the services are delivered within the desired time frame. Low priority services are more easily rescheduled. In addition, some services can be interrupted once they are initiated, while others cannot. For example, a home health aide who gives a patient a shower, or a nurse who changes a patient's wound dressings cannot generally stop the task until it has been seen through to completion. Other tasks, however, can be interrupted, such as occupational and physical therapy exercise sessions, or an education session with the dietician.

Another important part of service delivery is maintaining open communication channels with the patient and/or their family or caregiver. Workers usually have conversations with patients and their caregivers during treatment sessions to learn about the patient's health and functional status. These discussions help workers determine how the patient is progressing, and they help to identify any problem areas that may need to be addressed.

A worker will usually continue providing services to a patient until the patient has reached the point where he or she can no longer benefit from the services. When workers are actively working toward improving the patients' status, services may be discharged when the patient has either met the treatment goals, or when the patient has plateaued in their progress and does not show potential for further improvements.

3.4.3 Paperwork practices

One of the main tasks involved in home care delivery is filling out paperwork to record each interaction the worker has with a patient. In general, all disciplines document each visit (or attempted visit) with varying degrees of detail. While many workers try to do their paperwork in patients' homes or in their cars, most (with the exception of home health aides, who do not have desks and do not spend time in the office) still end up spending time in the office each day completing paperwork from previous days.

Each discipline maintains a folder that holds their paperwork for each client, which is referred to as that client's chart. The chart acts as a history of the services that a discipline has provided to the patient, and of the patient's changing medical and functional status. Workers often need to access information in the chart while they deliver treatments, so (with the exception of home health aides) they carry patients' charts with them while they are in the field. The mobility of charts means that they are unavailable to other treatment team members.

Unlike other disciplines, home health aides maintain their paperwork in a binder that is kept in patients' homes. Since home health aides do not have office space like other disciplines, this practice allows them to pass charts to workers on other shifts and to keep paperwork in a location that is accessible to others should they unexpectedly miss a day of work. The binder also acts as a communication tool—it allows them to leave messages for other home health aides who treat the patient, and it allows family members and other team members to leave notes for the home health aides. The binder contains two types of lined forms to facilitate this communication, and they have the headings "Home Care Staff Communication" and "Family/Friend/Other Communication." Sample communication forms are shown in Figure 3.5.

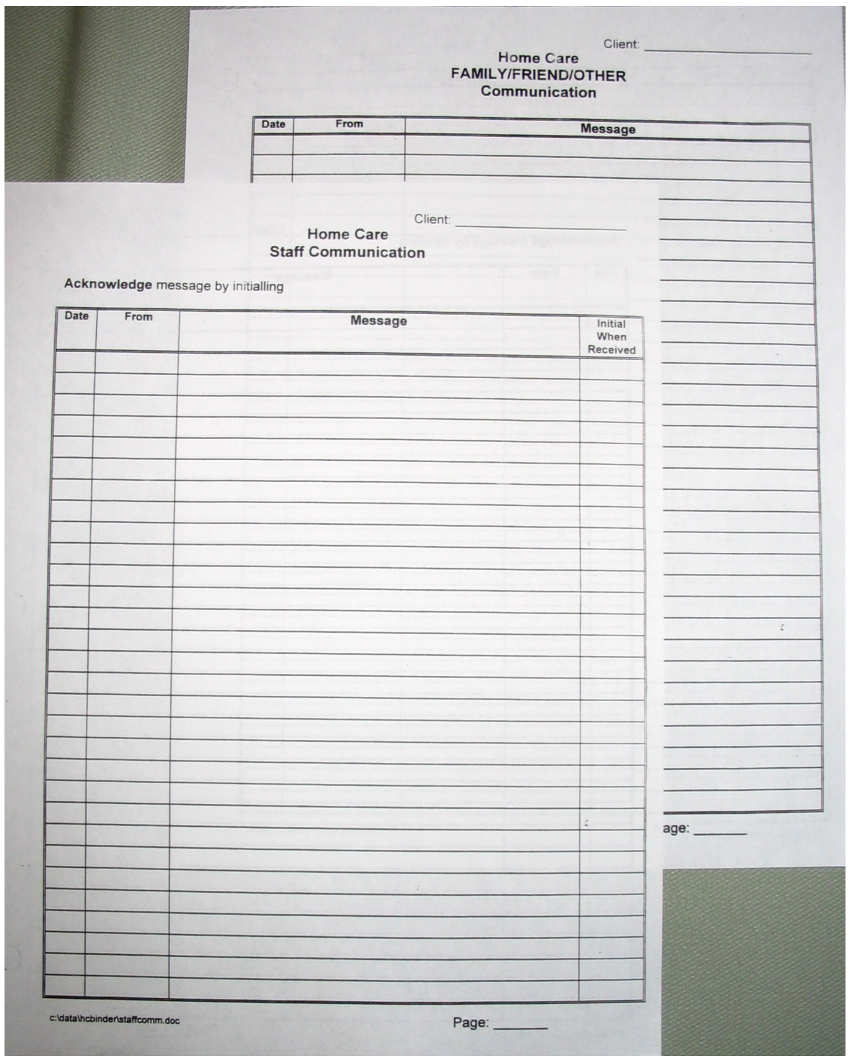
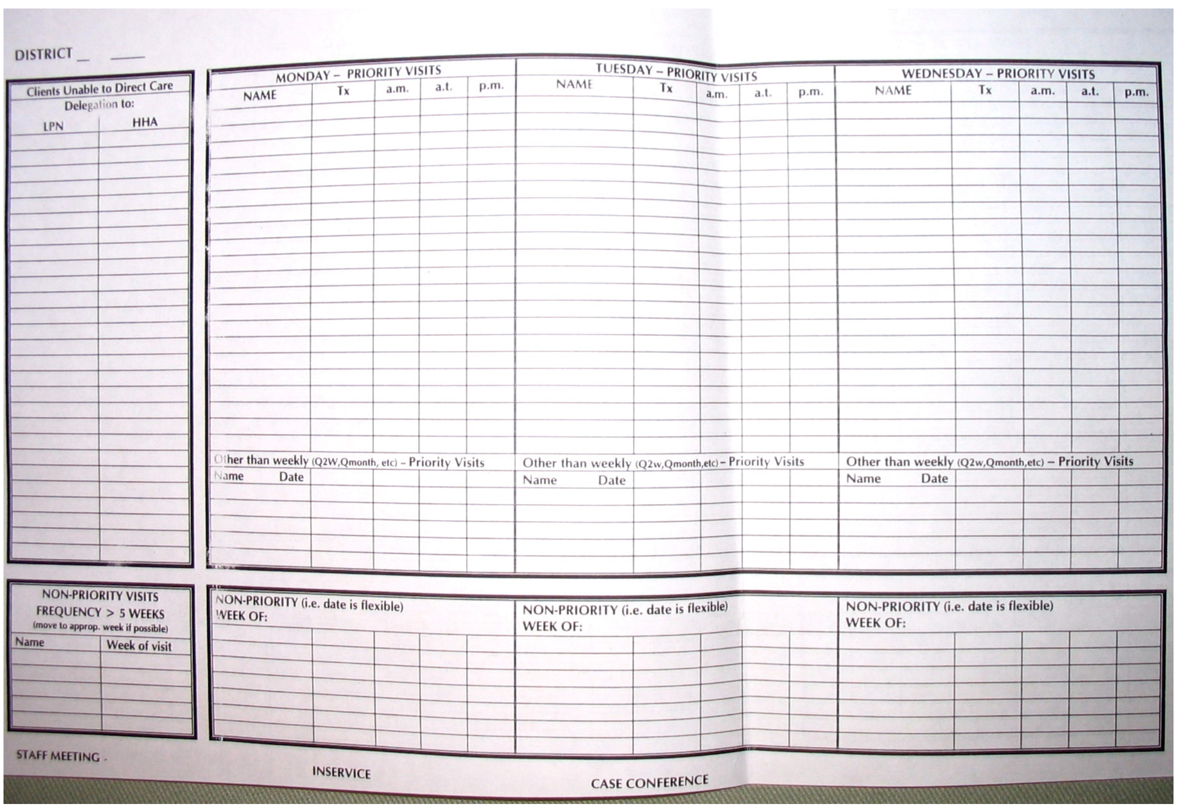


Figure 3.5. Communication forms from the communication binder

3.4.4 Planning the workday

Most home care workers spend time in the office in the morning to plan their workday (with the exception of home health aides, who do not have office space). This process is generally the same across disciplines, with minor variations.

Workers maintain a paper schedule that shows the times that they will visit patients on a given day. This schedule is usually developed during morning office time. Nursing sets up their appointments without contacting the patient first. However, other disciplines do not always visit patients as regularly as nurses do, so they may phone in the morning to verify visit times with patients. Social workers, OTs, PTs, C3s, and dieticians all try to phone patients prior to visiting them, unless visit times are regular and the visitation pattern has been well-established with the patient.


DISTRICT

Clients Unable to Direct Care
Delegation to:
LPN HHA

MONDAY – PRIORITY VISITS
NAME Tx a.m. a.t. p.m.

TUESDAY – PRIORITY VISITS
NAME Tx a.m. a.t. p.m.

WEDNESDAY – PRIORITY VISITS
NAME Tx a.m. a.t. p.m.

Other than weekly (Q2W,Qmonth, etc) – Priority Visits
Name Date

Other than weekly (Q2w,Qmonth,etc) – Priority Visits
Name Date

Other than weekly (Q2w,Qmonth,etc) – Priority Visits
Name Date

NON-PRIORITY VISITS
FREQUENCY > 5 WEEKS
(move to approp. week if possible)
Name Week of visit

NON-PRIORITY (i.e. date is flexible)
WEEK OF:

NON-PRIORITY (i.e. date is flexible)
WEEK OF:

NON-PRIORITY (i.e. date is flexible)
WEEK OF:

STAFF MEETING

INSERVICE

CASE CONFERENCE

Figure 3.6. Nursing schedule form

A worker's schedule is often influenced by the available coverage within their discipline. During the mornings, workers may be asked to cover another worker's patients when they phone in sick or have time off. This process can be one of ongoing negotiation where several workers agree to cover a small part of another's caseload. Once workers have established their schedule, they collect patients' charts and any supplies that they need to support their treatments. Workers leave a copy of their completed schedule with the clerical workers at their office site. Figure 3.6 shows the schedule form that is used by nursing.

3.4.5 The automobile and work practice

The automobile plays and important role in home care, and workers use their cars to support several of their work activities. The primary and obvious use is as a mode of transportation between patients' homes. Workers also spend time in their cars preparing for a visit—when they arrive at a patient's home, they often spend a few minutes in the car reviewing the patients' chart, collecting any needed equipment, and considering what they will do during the visit. After a visit, workers often spend a few minutes in their car filling out paperwork, and then reviewing their schedule prior to visiting another patient.

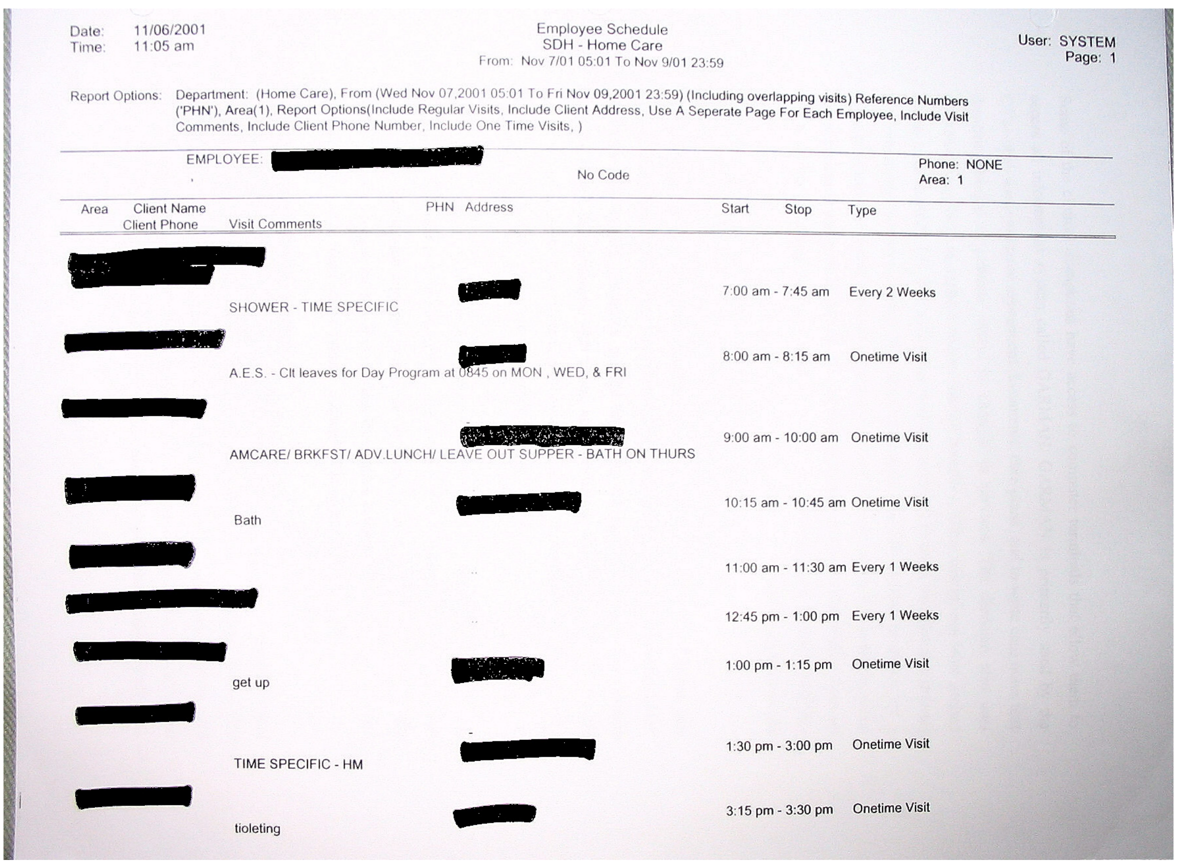
3.4.6 Information technologies

Home care workers utilize a number of information technologies, and the technologies that are available to workers vary across the disciplines. Home care clinicians make use of four different communications technologies: office phones, voice mail, pagers, and GARMAN. Table 3.1 shows how access to these technologies varies with each discipline. All workers except home health aides have office phones, and OT, PT, and social work have voice mail service on their phones. RNs, LPNs, home health aides, and the dietician all carry numeric pagers while they work in the community so that office based staff can contact them.

Table 3.1. Technology access by discipline

Discipline	Office phone	Voice mail	Pager	GARMAN
RN	√		√	
LPN	√		√	
Dietician	√		√	√
Home health aide			√	
C3	√			√
OT	√	√		Shared
PT	√	√		Shared
Social work	√	√		Shared

Some of the clinical disciplines have access to computer terminals that allow them to access an information system called GARMAN. GARMAN is primarily used by the C3s—they use it to create assessment documents, care plans, and to write case notes that describe changes in patients' status or changes in services. The dietician also uses GARMAN regularly to support documentation practices. Other disciplines have limited access to GARMAN. OT, PT, and social work can access it through two shared terminals in Community Services. These disciplines primarily use the system to check on a patient's status by reading electronic versions of the C3's case notes. For example, when a new patient is assigned to an OT, PT, or social worker, the patient may have been on the discipline's waiting list for a week or two. These workers often check GARMAN before visiting the patient so that they can see if the patient's status has changed since the care plan and assessment document were created by the C3.



Date: 11/06/2001
Time: 11:05 am

Employee Schedule
SDH - Home Care
From: Nov 7/01 05:01 To Nov 9/01 23:59

User: SYSTEM
Page: 1

Report Options: Department: (Home Care), From (Wed Nov 07,2001 05:01 To Fri Nov 09,2001 23:59) (Including overlapping visits) Reference Numbers ('PHN'), Area(1), Report Options(Include Regular Visits, Include Client Address, Use A Seperate Page For Each Employee, Include Visit Comments, Include Client Phone Number, Include One Time Visits,)

EMPLOYEE: [redacted]
No Code
Phone: NONE
Area: 1

Area / Client Name / Client Phone	Visit Comments	PHN Address	Start - Stop	Type
[redacted]	SHOWER - TIME SPECIFIC	[redacted]	7:00 am - 7:45 am	Every 2 Weeks
[redacted]	A.E.S. - Clt leaves for Day Program at 0845 on MON , WED, & FRI	[redacted]	8:00 am - 8:15 am	Onetime Visit
[redacted]	AMCARE/ BRKFST/ ADV.LUNCH/ LEAVE OUT SUPPER - BATH ON THURS	[redacted]	9:00 am - 10:00 am	Onetime Visit
[redacted]	Bath	[redacted]	10:15 am - 10:45 am	Onetime Visit
[redacted]			11:00 am - 11:30 am	Every 1 Weeks
[redacted]			12:45 pm - 1:00 pm	Every 1 Weeks
[redacted]	get up	[redacted]	1:00 pm - 1:15 pm	Onetime Visit
[redacted]	TIME SPECIFIC - HM	[redacted]	1:30 pm - 3:00 pm	Onetime Visit
[redacted]	tioleting	[redacted]	3:15 pm - 3:30 pm	Onetime Visit

Figure 3.7. Home health aide schedule generated through Procura

Two administrative information systems also play a role in the work of home care clinicians. First, Home Care uses a system called Procura to generate home health aides' schedules. The system generates printed schedules for each aide. Schedules contain patients' names and addresses, visit times, and annotations that have been added to the system by the nursing supervisors (e.g. "beware of dog"). Home health aides pick up the printed schedules that are generated by Procura twice a week. Figure 3.7 shows a home health aide schedule that was generated through Procura.

A second system plays a role in managing the workload of OTs, PTs, and social workers. The seniors in Community Services have access to an information system (built on Microsoft Excel) that they use to manage the waiting list for each discipline. The data base is used to manage the queue, and when the patient is removed from the waiting list, the system is used to track which patient is assigned to which clinician.

3.4.7 The work environment

The home care work environment places a number of demands on community-based workers and influences the way workers' organize their daily activities. Home care workers function in an uncertain work environment where they often have little control over events that can shape their workday. Unexpected events occur regularly, and workers need local autonomy and flexibility in order to adapt to changing demands. This flexibility requires loose coupling with other collaborators, since it is not practical to consult with others when local situations force changes in schedules and activities.

Community-based workers spend most of their time delivering treatments to patients in their homes. The home environment is often chaotic, and they have minimal control over the home setting. They must contend with a number of potential distracters, which can include pets, children, family members, and visitors. They are usually able to work around people and events in the home, but at times these distractions can disrupt treatments, and can cause them to be cut short or to take longer than anticipated. For example, an unexpected guest can interrupt an exercise session with an OT or a PT, and the therapist may be unable to resume the session until the patient has dispensed with social niceties. The unpredictability seen in the home can force workers to shuffle their schedules to accommodate variations in treatment times and durations.

Variability in road conditions can also add uncertainty to the work day, since workers rely on their cars for transport between treatments. Workers can get caught in traffic, or they can be delayed by road construction, accidents, or weather conditions.

In questionnaires administered during the second field trial (described in Chapter 8), workers list several occurrences that force them to revise their schedules: “crisis situations, <patient’s> families come to city”, “unforeseen health emergencies with clients, clients not home or not ready for visit”, “client calls to say they won’t be home at a planned time due to an appointment.”

3.5 Management and the treatment team

A worker’s relationship with management is determined by their discipline, and members of professional disciplines are afforded greater autonomy than members of quasi-professional disciplines. Home health aides and LPNs are more tightly coupled with management than the professional disciplines, and must consult with managers before making changes to the services that they provide a patient.

3.5.1 Management and home health aides

Home health aides have limited autonomy and are closely supervised by the nursing supervisors. They have limited training, do not hold a license, and are not sanctioned by an external professional association. Their work duties require limited autonomy and decision-making. In a questionnaire administered to home health aide during the second field trial (discussed in Chapter 8), a home health aide described the limited autonomy that aide have: “We do what we are told/no more/no less.” Home health aides’ schedules are centrally generated, and the services that they provide to patients are determined by others. Initially, home health aide services (e.g. laundry, cooking, bathing, etc.) are determined by the C3 who creates a patient’s initial care plan. If the patient requests changes, or if the home health aide thinks changes are needed, they must first consult the nursing supervisor to get their approval.

3.5.2 Management and LPNs

LPNs are supervised by RNs and have more autonomy than home health aides. LPNs have more training than home health aides, and hold licenses that show that they are competent at carrying out basic nursing tasks. They can set their own daily schedules, and are autonomous in planning and arranging their days. However, the treatments that they provide to patients must adhere to treatment plans that have been established by supervising RNs.

When a new nursing patient is admitted, they are assigned to an RN. When the RN has formally evaluated that patient and established a nursing treatment plan, they may choose to assign them to an LPN if they feel that the services that are required fall within the scope of LPN expertise. At this point, the LPN receives the chart from the RN and assumes responsibility for the treatments. However, if the LPN feels that the treatments need modification, they must consult with the RN first and get their approval. In practice, LPNs often have significant input in decisions, and RNs often rely on their discretion and expertise in guiding a patient's care.

3.5.3 Management and professional disciplines

Professional workers are autonomous – they plan their workdays and determine the content of their treatments without consulting others. In the professional disciplines, management plays a minor role in shaping work. Managerial oversight is minimal, and supervisors do not inspect treatments or the paperwork that is created by these workers. The autonomy seen in the professional disciplines is partially the result of the professionalism and knowledge specialization of the workers. Professionals are perceived as having the expertise and competency needed to make decisions about their patients, and supervisory intrusion into professional-patient relationships is generally unwelcome.

3.6 Relationships between workers of the same discipline

Workers regularly consult with other workers from their discipline for social and professional support. Since these workers have office sites that keep them in close proximity with each other, they have more opportunities for informal conversations, and when problems arise they can consult others to get advice. This close proximity also allows workers to arrange coverage for patients when a worker is away (e.g. holiday, sick leave, continuing education, etc.).

At times, two or more members of the same discipline treat the same patient. This situation usually occurs for one of two reasons. First, home health aides and nurses provide some patients with services that span two shifts. In these cases, at least two workers from the same discipline are involved in providing services to the patient. Second, some workers work part time, usually only on specific days of the week. When these workers have patients that require services on days outside of their scheduled work days, they must share the patient with another worker.

When more than one person from the same professional discipline (i.e. all disciplines except home health aides) share a patient, the relationship between workers is more tightly coupled relative to the shared patient. Variations in the services provided by one worker directly impact those that are provided by the other, and they must mutually adjust to accommodate the other's actions. These workers must work together to guarantee that a common schedule is maintained for the patient's services, and to direct the patient's care in a way that is mutually agreed upon by both workers. They must keep the patient's chart up to date, and then must make sure it is accessible to the other workers when they treat the shared patient.

In the next two sections, I discuss shared patients for two disciplines: home health aides and nursing. Two factors make sharing more common for these disciplines. First, both disciplines tend to visit patients with greater frequency than others, and second they provide services across two shifts. Other disciplines (OT, PT, social work, dietician, and C3) tend to visit the patient less frequently (e.g. as frequently as 1-5 times a week to as intermittently as once every month or two) and only provide services in a single shift. This reduced frequency means that workers who are part time can carry patients with visitation frequencies that match their work schedules, so that sharing (which generally increases overhead) can be avoided.

3.6.1 Home health aides

Home health aides who share the same patient do not have to deal with many of the issues that must be handled by the professional disciplines. The central scheduling that takes place at the Home Care office assigns visit times to workers, so home health aides do not have to worry about directly managing schedules. Also, the use of the communication binder makes it easier for patients to exchange a patient's chart. Since all documentation stays in the patient's home, extra steps are not needed to pass the documentation on to another worker. Figure 3.8 shows a communication binder and the internal dividers.

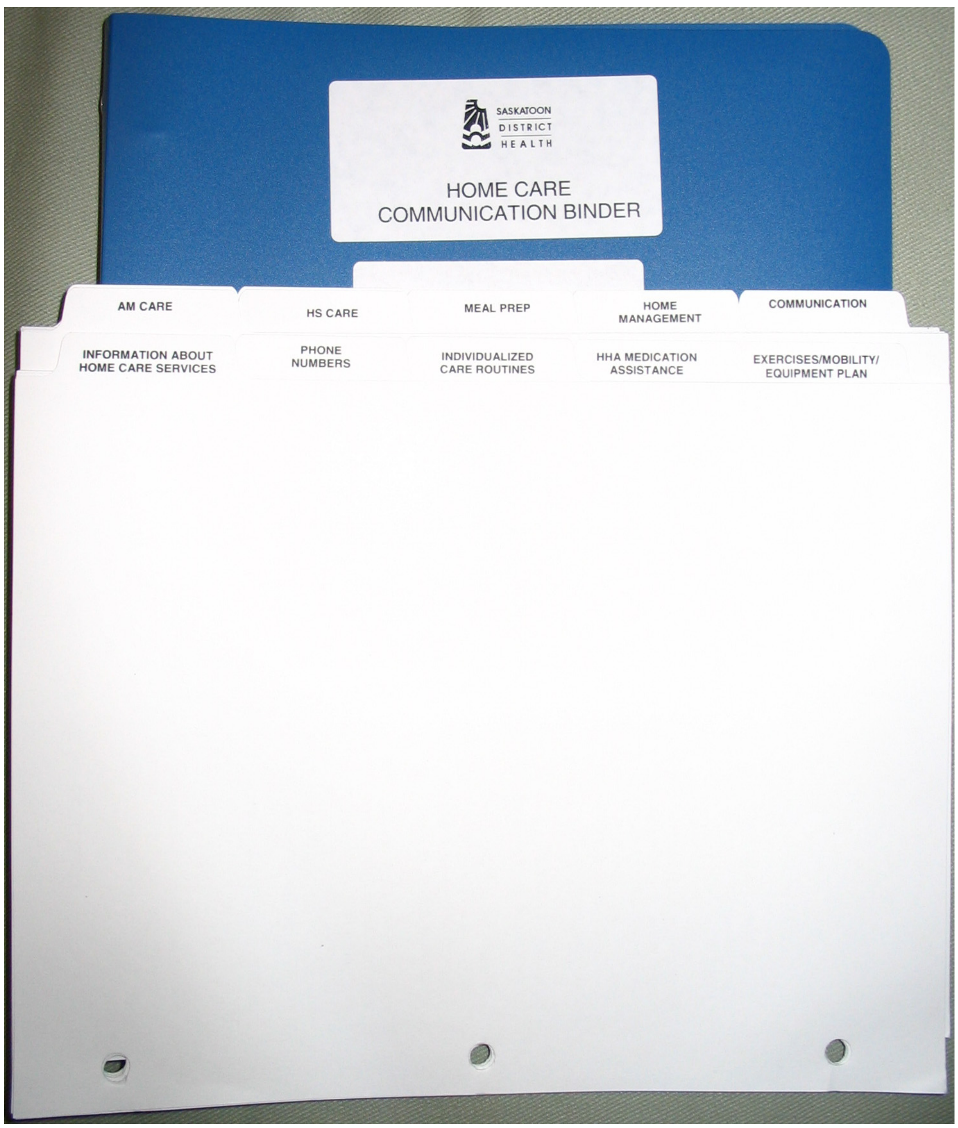


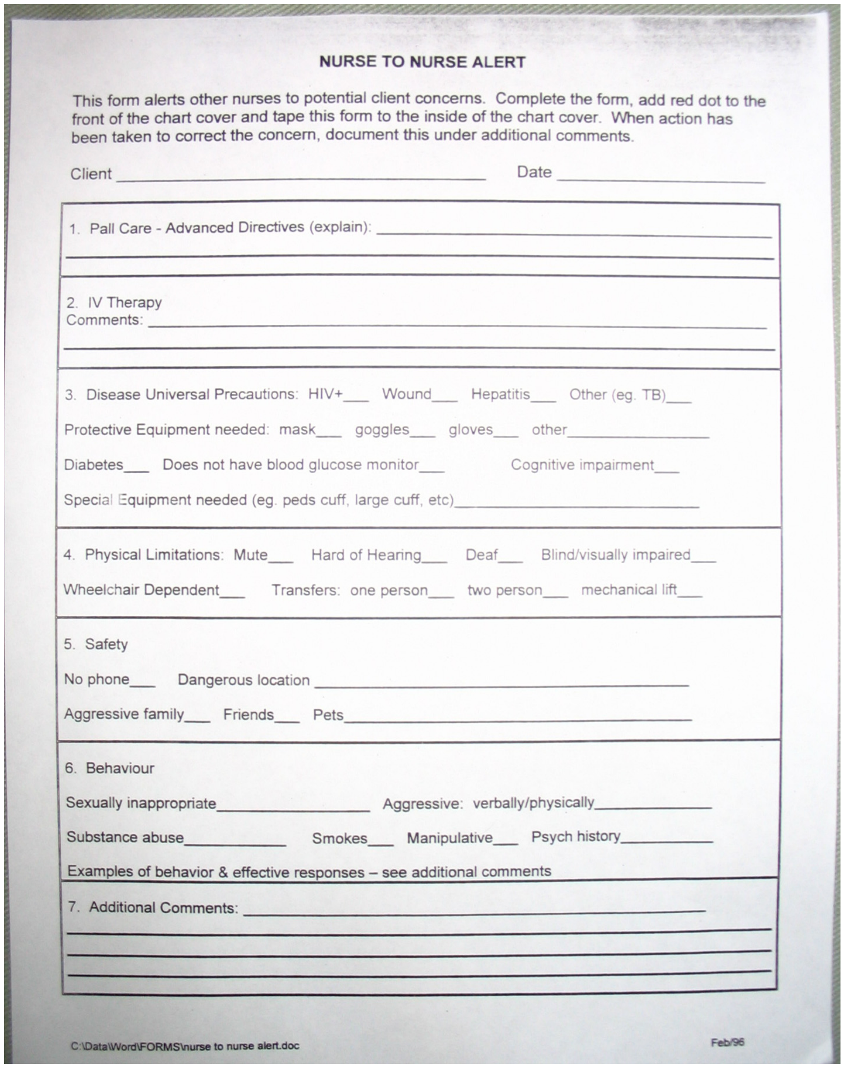
Figure 3.8. Home care communication binder

Home health aides that share patients generally do not directly communicate about their care. Direct communication is generally not needed, given the routine nature of the services that these workers provide. They do not have the autonomy to revise services without the consent of the nursing supervisors, so variations in services are usually minimal across visits. In the event that information does need to be passed on to other home health aides, two mechanisms are usually used. First, they can leave notes for others' in the communication binder. Second, they can notify the nursing supervisor, and the nursing supervisor can add annotations in Procura, the computerized schedule system for home health aides, that are printed on the schedules of all aides that treat the patient.

3.6.2 Nurses

Nurses who share a common patient must work together in a tightly coupled fashion to manage the patient's care. Unlike home health aide services, nursing treatments are more likely to vary across visits since they are often based on changes in the patient's status over time. For example, as a patient's wound changes (heals or regresses), nurses may use different dressings and techniques in wound care treatments. It is important that this information is passed on to other nurses who treat the patient so that a unified approach can be followed.

In nursing, work is arranged to facilitate communication between shift workers who share a patient. The first and second shifts both have scheduled overlaps in their office times—the first shift returns to the office at the end of their shift, and the second shift begins their day in the office. This overlap, which usually lasts approximately 30 minutes, allows nurses to discuss shared patients face-to-face so that treatment approaches can be discussed and consensus can be reached on how treatments will proceed. Nurses from the first shift also use this time to pass on charts to workers on the second shift.



NURSE TO NURSE ALERT

This form alerts other nurses to potential client concerns. Complete the form, add red dot to the front of the chart cover and tape this form to the inside of the chart cover. When action has been taken to correct the concern, document this under additional comments.

Client ______________________ Date ______________

1. Pall Care - Advanced Directives (explain): ______________________

2. IV Therapy
Comments: ______________________

3. Disease Universal Precautions: HIV+___ Wound___ Hepatitis___ Other (eg. TB)___

Protective Equipment needed: mask___ goggles___ gloves___ other__________

Diabetes___ Does not have blood glucose monitor___ Cognitive impairment___

Special Equipment needed (eg. peds cuff, large cuff, etc)______________

4. Physical Limitations: Mute___ Hard of Hearing___ Deaf___ Blind/visually impaired___

Wheelchair Dependent___ Transfers: one person___ two person___ mechanical lift___

5. Safety

No phone___ Dangerous location ______________________

Aggressive family___ Friends___ Pets______________________

6. Behaviour

Sexually inappropriate__________ Aggressive: verbally/physically________

Substance abuse________ Smokes___ Manipulative___ Psych history________

Examples of behavior & effective responses – see additional comments

7. Additional Comments: ______________________

C:\Data\Word\FORMS\nurse to nurse alert.doc Feb/96

Figure 3.9. Nurse to nurse alert form

When a nurse shares a patient with another nurse who works on a different day (e.g. two part time nurses), they are not usually able to meet face-to-face and must make use of asynchronous communication channels. This communication is often facilitated by the nursing chart, which is usually placed on one of the worker's desks so that it can be retrieved on the next day. Since the nursing chart is central to the treatment of nursing patients, and since every nurse who treats a patient will access the chart prior to carrying out a treatment, nurses often leave messages for each other in the chart. They do this using "communication cards" that are placed in the front of the clear plastic sleeve that holds the chart's contents. This location makes the card highly visible, and since nurses feel confident that others will read the cards, this is one of nursing's preferred communication channels since it can be used for both urgent and mundane messages. Nurses also use a “nurse to nurse alert” form when there are important issues that all nurses who treat a patient need be aware of. This form covers safety precautions and other issues that are relevant to treatments, and it is placed in the front of patients’ charts so that all nurses will see it before visiting the patient. A sample form is shown in Figure 3.9.

3.7 Loose coupling in treatment teams

Treatment teams are made up of workers from several home care disciplines who work together in a loosely coupled fashion. Since treatment team members share a common patient, their work is interdependent. However, workers are mobile, maintain different schedules, and work out of different locations, and it is often difficult for them to collaborate with each other. Communication within treatment teams is usually infrequent, and workers usually carry out their work activities without a full awareness of others’ activities.

In multidisciplinary teams, each worker is recognized as the expert in their discipline’s practice domain, and it is acknowledged by others that they are the best suited to make decisions that fall within that area. This professionalism and knowledge specialization effectively partitions the work that takes place in home care, since each worker is usually able to focus on their separate concerns and leave other areas to workers from other disciplines. This arrangement allows workers to function with minimal knowledge of others’ activities.

Even though collaboration and information sharing can be difficult, the reduced interdependence seen in home care has some benefits. For example, the mobile work environment seen in home care is unpredictable—workers may be delayed while driving between patients’ homes or while delivering treatments. Loose coupling gives workers the flexibility that they need to handle this uncertainty, since they do not need to consult others when plans and schedules need to be revised.

In the next sections, I discuss patterns of loose coupling in multidisciplinary home care treatment teams in more detail. The discussion is divided into the following sections:

- Information buffers
- Flexible group organization
- Discretionary collaboration
- Implicitly shared information
- Asynchronous collaboration
- Barriers to synchrony
- Difficulties coordinating services

3.7.1 Information buffers

In SHR, workers need access to information in the field to support their treatments and to help organize their day. Each worker carries their discipline's version of clients' charts with them in the field, along with their daily schedule and any other notes that might be used to help organize the work day. These documents contain information that potentially could improve coordination and mutual awareness within treatment teams. However, this information is maintained as separate "information buffers" that are not accessible to other team members (Kmetz 1984). These information buffers represent a fragmentation of the information that is available within the organization about patients' and their care. This point is illustrated through an LPNs response during an interview. She indicated that she did not have access to home health aide's schedules, even though they are maintained in the office:

LPN: "I can phone in and say so-and-so [i.e. a patient] hasn't been fed today. Is anyone supposed to be here? And then they would check their schedule—I mean, we have no way of checking schedules to see who is supposed to be where or at what time."

One of the advantages to information buffers is that "they are used at the discretion of those having access to them, and their very existence can be denied, if necessary" (Kmetz 1984, p. 272). The privacy that is afforded by information buffers is an important part of work practice in SHR. For example, social workers provide counseling services to patients, and the sensitive nature of their written notes makes them unwilling to share them with other workers. Additionally, workers from other disciplines often maintain handwritten notes that are not part of the legal medical chart. These notes are generally for their own use, and they are not willing to share them with others. For example, during observations an OT who was considering a patient's equipment needs (e.g. shower chair, lift, dressing equipment, etc.) maintained informal written notes about possible options prior to making formal equipment recommendations.

3.7.2 Flexible group organization

Members of a home care team have varying levels of participation in the group, and members reorganize the team to ensure that participation is appropriate for addressing the patient's needs. Each worker's level of participation usually changes over time, and based on this level of participation, workers may have up to date knowledge of the patient's status or minimal knowledge of the patient's status. Depending on their level of knowledge, workers employ different strategies to guarantee that group makeup and organization—including the level of participation by members—is appropriate.

C3s make initial decisions about who treats a patient, but once individual clinicians have been assigned, they are able to determine their level of participation with the patient and with the team. Each worker's level of involvement is usually based on the changing needs of the patient and the appropriateness of their expertise for addressing those needs. In home care, the level of worker involvement is usually determined by the frequency with which a worker treats or interacts with a patient. This was described by an RN during an interview:

RN: "They [the C3s] are in charge of making up the care plans. We basically are in charge of how much nursing time is required but they will say this is what they need, the meals on wheels, they do need nursing and… but they actually do the coordinating of the client—all of the services. Sometimes there is a little bit of—I call it conflict. It seems, and we are told to do that, if we want to do any referrals to any other discipline we are supposed to go through the client care coordinator. And I find that is almost two times the work, so what is the point of me phoning them and then they have to phone the other discipline."

Each worker may utilize their knowledge of others' involvement with a patient to reorganize the group and to help guarantee that the patient's needs are being met. This is seen in the example above, where the nurse discusses the need to make referrals to other disciplines. When a worker treats a patient frequently they are likely to have up to date knowledge of the patient's condition and of the activities of other group members. These workers play a more active role in organizing the group by recommending changes in the level of participation of others and by identifying when new team members need to be added. When a worker sees a patient infrequently, it is more difficult for them to have an up to date knowledge of recent events that may have a bearing on their treatments. They may need to rely on information and advice from workers who see the patient regularly to help them stay informed and to determine their ongoing level of participation.

When new workers are added to a group, it is usually to fulfill a specific role that was identified by the referring healthcare worker. Referrals specify disciplines but do not specify the individual worker that should treat a patient, so for example, a nursing or social work referral might be issued. It does not matter which particular worker fills the role, since all members of a discipline are qualified to provide the service. This provides flexibility in determining group membership since no single group member is irreplaceable. If a group member misses work for health or holiday, other members of their discipline are able to step in and replace them. The worker's discipline-specific documentation facilitates this type of shift, along with communication between the original member and their replacement. For example, nurses may exchange patients in the morning before beginning their daily visits in order to provide adequate coverage when a nurse is away.

3.7.3 Discretionary collaboration

The autonomy of individual workers in SHR means that collaboration with others is (in most cases) not strictly required; instead, workers engage in collaboration when they decide that it is valuable to do so. The fact that collaboration is for the most part discretionary implies that in each instance of potential engagement the worker must assess the tradeoff between the effort required to collaborate and the benefit that could be realized either for the worker or for the shared work focus. Therefore, there is a threshold of effort under which workers may decide not to collaborate – since they can usually get by without sharing information or seeking consultation, there will be situations where working together is not worth the overhead costs.

This style of collaboration means that workers will know more about their own activities relative to shared patients than is actually passed on to others. Again, the barrier to this sharing is the level of effort required to explicitly communicate information to others, and information that is seemingly mundane is typically not shared. In SHR, workers usually know a great deal more about the patient, their situation, and the services they provide to the patient (e.g. why, how, when, etc.) than they communicate to others. While much of this information may be relevant to others, in many cases the person who holds that information may not know how relevant it is due to his/her lack of knowledge about others' work situations. In the following example, a PT points out the differences between information that gets communicated, and information that would be useful for a worker to access:

PT: "We do a lot of messaging back and forth on voice mail. Here is my question—call me back with the answer. You know, that type of thing. Communicating with the nurses wouldn't be something that we do on a really regular basis, but when we need to do it, it is really important.

"A lot of times too it may not be something that we would even call the nurse about, but, gee, I would like to know what this guy's diabetes is doing right now just because that might explain this or that. It is not something important enough to track down the nurse to find out today anything new on the client [i.e. patient], but if we were able to sort of read what was happening with nursing and sort of the client's response to the nurses visits and that, it would certainly complete the picture better for us. But because communication is difficult and always a challenge in the community, that we pick and

choose what we communicate about. But if we had better access, we would know a lot more about our client."

As seen in this example, communication usually occurs with other team members when "it is really important." In observations, communication was usually restricted to those workers whose participation is necessary to see an issue through to successful resolution. This is done as a means of minimizing effort, since collaboration becomes more time consuming as the number of individuals involved increases. However, it also means that in many cases, some team members are unaware of problems that are considered urgent by others, but that are not communicated to them.

Three common approaches are used by home care workers for communicating and coordinating work, and workers usually try to select the method that requires the lowest possible amount of overhead. In order of increasing effort, these approaches are: maintaining peripheral awareness by gathering implicitly shared information about others activities; explicit communication using asynchronous channels; and synchronous communication. I discuss each of these approaches in the next sections.

3.7.4 Implicitly shared information

In home care, the only work site all team members usually have in common is the shared patient's home, and this location provides an opportunity for the informal exchange of information between team members. Workers are not usually co-present in patients' homes at the same time, but during the course of their work activities they may leave evidence of their activities that persists and is available to others during their visits. For example, OTs and PTs usually leave printed handouts that describe exercise programs, and nurses often leave supplies in patients' homes for the next visit. These clues provide evidence that a visit has occurred recently, and some indication of the type of treatment that was given. This form of information can be easily retrieved, and allows workers to maintain a limited awareness of others' activities with little overhead.

During an interview, a nurse described how workers utilize clues in patients' homes to learn about others' activities:

A nurse states that it is difficult "to know who's involved [in a patient's care] and when they [other team members] generally see them or how often they generally see them or what they are working on. For example, OTs, what kind of equipment they may be looking into getting for that person. We never know that kind of thing until it appears or the client says the OT has been here and I am going to be getting this or that."

In this example, the nurse points out that it is difficult to maintain a basic awareness of the makeup of the treatment team, and the level of participation that others have in a patient's care. This is largely due to the autonomy of workers and their ability to determine their own level of involvement. This has implications for more explicit forms of communication since it may be difficult to know who should be involved when communicating about or coordinating work activities relative to a given patient.

The nurse indicates two sources of awareness information: the physical evidence in the patient's home and information that is provided by the patient. The patient represents the single shared resource that receives the focus of the team's efforts, so the patient is aware (assuming that they are not cognitively impaired, as is sometimes the case) of all interactions they have had with members of the treatment team. Because of this, workers regularly talk with the patient and attempt to learn about others' activities and level of participation. During an interview, a home health aide described how she gathers this information from patients:

HHA: "Clients sometimes tell me somebody is supposed to come this morning at such-and-such time. Without that, I don't always know who is coming in or what they are doing or what. But some of these people can't tell you. If the clients were totally reliable, they probably wouldn't need our help."

Even though the shared patient and the shared work location can provide workers with access to information about others' activities, this type of information does not provide a full account of others' activities. Since workers usually leave physical evidence unintentionally, they do not usually attempt to make sure the information is complete. Even when obvious evidence has been left, the patient or their caregivers may clean the home, and remove the evidence. Additionally, as seen in the example above, problems arise with using the patient as an information source. At times, patients do not understand the treatment activities provided by workers, and they may have difficulties explaining the treatment to others in a way that is understandable.

3.7.5 Asynchronous collaboration

Asynchronous communication does not allow for the efficiency seen in the rapid exchanges that occur when people are synchronous, but in SHR it is often favored over synchrony since it allows team members to deal with their lack of awareness of others' locations, availabilities, and schedules. Messages that are left asynchronously persist, and can be retrieved by the recipient when they are able to read or listen to them.

In SHR, the work activities and the work setting impose constraints on workers that sometimes make asynchronous communication channels preferable to synchrony. Many workers state that it is unprofessional to talk on the phone in front of a patient. In addition to this, many treatments cannot be easily interrupted to communicate synchronously with others (e.g. wound care, bathing). Time in patients' homes, along with time spent driving, account for the majority of a home care worker's day. So, in this case, the nature of the work strongly favors asynchrony since each worker can find the best time in their schedule to retrieve and deal with messages.

Most asynchronous messages are passed on using voice mail, handwritten notes, and messages passed through the office staff. The flexibility of asynchrony and its ability to accommodate each individual worker's schedule and availability was seen during observations of the daily activities an OT:

An OT leaves the office and spends the morning in the community treating patients. Around noon, she stops at a café for lunch. After finishing lunch, she uses the pay phone in the café to phone in to check her messages. She writes down the important points from a message [in this case, the message conveys information about the changing status of a *patient]. She then looks up the phone number for the PT that treats one of her patients. She phones the PT and leaves a message on her voice mail telling her that the shared patient's wife reported that he had fallen twice in the past week.*

In this example, the OT uses downtime in her schedule to retrieve her messages. In home care, this strategy is common—workers seek out a quiet place where they can take notes and return calls before checking their messages. SHR does not provide workers with mobile phones (although workers report that a modest number of SHR home care employees carry their personal mobile phones with them), and most workers do this from the office, gas stations, or restaurants. This strategy is flexible, and it accommodates the autonomous nature of loosely coupled collaboration—workers check and respond to messages when they are able. This example also shows the typical use of asynchrony to address specific issues rather than to pass on routine information. In this case, the repeated falls of the patient were worrisome, so the OT phoned the PT, who is the expert on mobility issues, and is the most qualified to address the problem.

The intent of asynchronous messages is usually to resolve a specific issue—to pass on information, to get a pressing question answered, or to coordinate activities. So, these asynchronous interactions are typically shaped by need, and with a specific goal. This asynchronous, need-driven interaction style limits the range of information that workers are exposed to. Unlike the mobile workers discussed by Perry et al. (2001) who regularly become synchronous with mobile phones to check up on projects and developments in the office, the asynchrony seen in SHR often precludes the type of rapid back and forth that is required to pass on often seemingly inconsequential information that is needed to maintain an awareness of others.

3.7.6 Barriers to synchrony

Even though asynchrony is more common in SHR, some work situations require full synchrony. However, when synchrony is required, workers must overcome the barriers that make synchrony less frequent in the first place. The difficulty of becoming synchronous is primarily the result of two factors. First, work is not organized to facilitate regular synchrony with others. For example, workers do not have formal meetings with other team members, and different disciplines work at different office sites. Second, limited awareness of others' locations, availabilities, and schedules makes it difficult to become synchronous for face-to-face conversations and using the phone.

When synchronous communication requires negotiation to set up, it usually requires a higher level of effort than asynchronous communication. Synchrony is usually only sought out when back-and-forth discussion is needed to resolve an issue, which generally indicates a more complex work situation. So, for example, in SHR synchronous communication may occur because of changes in a patient's needs, unexpected events involving a patient, or a need to coordinate treatments more closely. In one case, a nurse and an occupational therapist used synchronous communication to coordinate their treatments for a patient:

A nurse visits a patient in the afternoon [The patient has a longstanding history of skin breakdown over the sacrum as the result of sensory loss and poor positioning when sitting in his wheelchair]. She changes the dressing that covers the wound on the tissues overlying the patient's sacrum. After changing the dressing, she tells the patient that the wound has worsened. When she returns to the office later that afternoon, she phones the OT who also treats the patient, and leaves a voicemail message telling the OT about the condition of the wound and recommending that the OT may want to revisit the patient's sitting schedule [i.e. the amount of time he sits, lies down during the day] and the positioning devices he uses when he sits in the wheelchair. The nurse asks the OT to call her back at the office. The OT calls back approximately 45 minutes later, and they discuss the situation and jointly develop a new sitting schedule, and the OT agrees to investigate new positioning devices for the patient.

In this case, synchronous communication was necessary to coordinate activities in order to resolve the patient's needs, needs which required the joint expertise of both disciplines. During field observations, when synchronous communication was used as a means of coordinating work as is seen in the example, workers attempted to minimize the need for ongoing synchrony as much as possible by developing plans for future action so that further negotiation would not be needed.

This example also illustrates how shifts are typically made to synchronous communication. In most cases, workers use asynchronous communication to facilitate these shifts, usually by leaving messages such as, "Call me in the office—I will be in from 2:00 to 3:00." This strategy, however, is not always very effective, and some workers report that it is not unusual for it to take a few days before they are able to talk with another team member on the phone. This delay is often the result of delays in receiving and responding to asynchronous messages. Since workers are autonomous, it is possible that they may not have an opportunity to retrieve and respond to asynchronous messages until hours after a message was actually sent. Therefore, there is a delay in the response time, so the message sender may not be available when the recipient tries to reach them. These difficulties, and the difficulties that arise from a lack of information about others' locations, availabilities, and schedules can be seen in comments from a physiotherapist:

PT: "We can actually call the nurse directly [nurses have phones at their desks], but they are tough to get a hold of. They are in very early—in and out usually before we are even in. And then at the end of the day they may be in but we are usually out, and do not come in at the end of the day. And it is hard to call a nurse from a client's home and discuss another client over the phone, so sometimes we have to make a point of coming back in here so that we can call a nurse, you know, that type of thing. And sometimes the nurse can get a message to call us, and they may be able to find a place to call us during the middle of the day, but will we be at our desk? I don't know."

In addition to phone-based communication, SHR workers occasionally utilize face-to-face meetings to exchange information with others. These meetings may be opportunistic and unplanned. However, the physical separation between workers' office sites makes meetings between workers from certain disciplines rare. Even when workers have offices in the same site, the schedule variability between workers reduces opportunities for these meetings to occur, as described below by the physiotherapist:

Interviewer: "You share the same office site with social work and occupational therapy. How does this affect your communication with members of those disciplines?"

PT: "It isn't always as easy as that because everybody is always coming and going at different times. You are certainly more apt to bump into them than you would, say, nursing because they are not on site here, but we still do leave a lot of voice mail messages for each other and that kind of thing. Normally we are mostly in for the first couple of hours in the morning and we don't usually return at the end of the day—some people will, but that is not our usual pattern. Usually the OTs and the social workers are in in the morning, but we don't have set rules about that. So you might want to talk to an OT and they have gone out on an early a.m. dressing kind of visit and they are back in and you are gone, so it's not a set thing."

This example shows that in SHR, work is not organized to facilitate synchrony, and when synchrony is needed, this lack of organization makes it difficult. The work group is not centralized, and a common hub is not regularly utilized to facilitate co-present meetings. This lack of opportunity for regular face-to-face, agenda-free and casual conversations prevents explicit communication from being used to regularly convey mundane information about others' work activities.

3.7.7 Difficulties coordinating services

Home care workers usually have limited information about the services that others provide to a shared patient. Usually this does not interfere with their abilities to carry out their work activities successfully since they are autonomous and the level of interdependence in teams is often low. However, on occasion workers need to coordinate services more closely, and to do this they need to know when other treatments occur and the specific services that are provided. Since this information is not usually shared (i.e. it is split into separate, unshared information buffers), workers often have limited awareness of others' activities, and can have difficulties coordinating services with other team members.

Limited awareness of others' services can give rise to four coordination problems. First, the services a worker carries out with a patient can negatively impact the patient's ability to participate in treatment-related activities with a worker from another discipline. When workers do not have adequate information, it can be difficult for them to avoid these situations. For example, some disciplines may not want to visit a patient after a physical therapist has carried out gait training with him or her, since the patient may be fatigued. Second, some services are closely aligned, and services can be needlessly replicated by different disciplines when they have a limited awareness of others' treatment activities. For example, occupational and physical therapists may both include upper extremity exercises in their daily treatments, and they may be unaware of the overlap. Third, some combinations of treatments may be counterproductive or contraindicated, and limited awareness can make it difficult to know when these situations arise. For example, if an occupational therapist is attempting to teach a patient to dress his or her lower body, it is counterproductive for the home health aide to dress the patient without encouraging their participation. Fourth, dependencies may exist between two services, and workers may prefer to link their visit with the visit of another worker. However, limited information about others can make it difficult to manage these dependencies. For example, some disciplines may prefer to visit a patient with Parkinson's disease after the nurse has given them their medications.

A coordination problem that was caused by service replication was seen during field observations:

A PT is in a patient's living room and is instructing her through an exercise program. The patient states that she becomes very fatigued when the PT and the OT both visit her on the same day, and that they both ask her to do upper body exercises. The PT states that she was unaware of the treatment overlap and that she will begin focusing on lower body and trunk exercises in the future, and will allow the OT to handle the upper body.

In this case, the PT was not aware that there was an overlap in treatments with the OT (i.e. both were carrying out upper body exercises). The patient informed her of this, and she adjusted her treatments to accommodate this new information.

Another coordination problem that occasionally occurs is a schedule conflict where more than one worker attempts to visit a patient at the same time. Since workers maintain their own schedules (with the exception of home health aides), and since they are not shared with other team members, they usually have limited awareness of others' treatment times. Furthermore, schedules for professional disciplines are not always precise. Variations in caseloads and the unpredictability of treatments and travel lead to daily revisions of schedules. When schedule conflicts occur, two workers' visit times overlap, and one must either wait while the other finishes their treatment or leave and try to give the treatment at a later time. Either way, a significant amount of time can be wasted, and workers can be forced to rearrange their schedules to accommodate the delay. When asked about schedule conflicts during an interview, a registered nurse provided a recent example:

RN: "I just ran into this last week, but as it turned out I had to make a couple of phone calls to the doctors to verify the orders and to actually fill her docette, otherwise it would have been a problem. But in this case I was able to keep busy while she was working with the client."

4 Framework part 1: Contextual model

Groupware Design Process
1. Understand work practice in context
2. Analyze data and organize into useful forms
3. Design system to support work practice

This is the first of three chapters that present the design framework. The next section briefly discusses the intent and composition of the design framework. The rest of the chapter presents the contextual model, the first part of the framework.

4.1 Overview of the design framework

Groupware design for loosely coupled workgroups is difficult because the design process is underspecified. To address this problem, I developed a design framework to improve the groupware design process for loosely coupled workgroups. The framework has three main parts that add a new layer of support to each of the three stages in the general groupware design process: data collection, analysis, and system design. The framework was developed to provide designers with support during each of these stages so that they can consider important characteristics of loosely coupled work practice while carrying out design for the target group. The design framework is based on information from CSCW and organizational research, and on real-world design experiences with one type of loosely coupled workgroup—home care treatment teams.

The framework attempts to improve the groupware design process for loosely coupled groups by:

- clearly defining *loose coupling* and *loosely coupled groups* for groupware designers
- providing a vocabulary for discussing loosely coupled situations

- providing a set of concepts that designers can look for when approaching a new work setting
- providing a description of collaboration patterns, work patterns, reasons, and outcomes seen in loosely coupled settings to help designers understand loosely coupled work situations
- providing a technique for analyzing key features of loosely coupled work in preparation for groupware design
- providing a set of approaches for designing groupware systems that are appropriate for work practice in loosely coupled groups

The framework has three main parts, each of which supports a different step in the design process: a contextual model, an analysis technique, and a set of design approaches. The contextual model acts as a theoretical foundation for the rest of the framework and helps designers understand loose coupling in real world settings. The analysis technique helps designers to recognize and specify important features of loosely coupled work settings, and to organize that information in a way that makes it usable during the design process. The design approaches translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups.

4.2 Overview of the contextual model

The first part of the framework is a contextual model that describes loose coupling in real world settings. The intent of the contextual model is to help designers to understand work and collaboration patterns that are seen in loosely coupled groups. Improving the understanding of loosely coupled situations is important to the CSCW design process, since the first step in design is to develop and understanding of work practice in context. The contextual model was developed by synthesizing existing information on loose coupling in CSCW and organizational research, which includes research in education, human service organizations, administration, and sociology. The model forms the theoretical foundation for the other two parts of the framework.

In order to build groupware that supports loosely coupled groups, it is first necessary to understand loosely coupled work and collaboration patterns in detail. Loose coupling work practice has not been considered in detail in CSCW, and the contextual model was developed to address the lack of knowledge. It provides definitions for loose coupling for groupware designers, a discussion of coordination and communication patterns in loosely coupled groups, a list of reasons and outcomes of loose coupling, and a discussion of work domains where loose coupling seems to be common.

The contextual model has six parts:

- Operational definitions of loose coupling
- Levels of organization in loosely coupled systems
- Patterns of interaction between loosely coupled elements
- Reasons for loose coupling
- Outcomes associated with loose coupling
- Loose coupling and work domains

4.3 Operational definitions of loose coupling

Several definitions for loose coupling have been proposed in CSCW and organizational research (e.g. Glassman 1973; Weick 1976; Orton and Weick 1990; Begole et al. 1999; Olson and Teasley 1996, discussed in detail in Chapter 2). The focus and clarity of these definitions vary, but in general they do not provide a clear standard for determining whether persons, groups, or organizations are loosely coupled. These definitions are either ambiguous or lacking in objective criteria that can be used to determine whether social systems are loosely coupled. This can make it is difficult for designers to consistently recognize loose coupling in the real world and can make it difficult for them to learn from others' design experiences.

In this section, I attempt to establish an operational definition for loose coupling that is useful to groupware designers. This is done by providing three criteria for determining whether loose coupling exists in social systems. As much as possible, the criteria remove ambiguities and provide objective standards for identifying loose coupling in real world settings.

In the next two sections, I propose a series of definitions. In the first section, I establish definitions for "loose coupling", and "tight coupling." In the second section, I establish definitions for "loosely coupled groups" and "tightly coupled groups."

4.3.1 Loose coupling defined

The definitions established in this section are based on a systems model. This dissertation focuses on social systems, which are composed of people; however, systems theory allows flexibility in determining how people are grouped in system elements. Depending on the focus of the system being studied, the elements that constitute the system can be individuals, groups, departments, or organizations. Systems theory is discussed in more detail in Section 4.4.

Interdependence is an important concept in loose coupling since it describes the strength of linkages between system elements. Interdependence refers to "the extent to which the items or elements upon which work is performed or the work processes themselves are interrelated so that changes in the state of one element affect the state of others" (Scott 1987, p.214). In loose coupling, interdependence is weak since system elements that are loosely coupled share few or weak "variables" (Glassman 1973; Weick 1976).

The definitions for loose and tight coupling that are established here are partially based on definitions by Orton and Weick (1990). They define different levels of coupling using two dimensions: responsiveness and distinctiveness. In their definition, responsiveness indicates interdependence between elements. Distinctiveness indicates that elements are well defined and semi-autonomous. According to Orton and Weick (1990):

> If there is neither responsiveness nor distinctiveness, the system is not really a system, and it can be defined as a noncoupled system. If there is responsiveness without distinctiveness, the system is tightly coupled. If there is distinctiveness without responsiveness, the system is decoupled.

> If there is both distinctiveness and responsiveness, the system is loosely coupled. (p. 205)

Orton and Weick's definitions for loose and tight coupling are limited since they do not address another important dimension—the level of integration seen between elements. According to Bertrand (1972, pp. 26), integration indicates coordination of interaction patterns. Weick (1982, p.381) describes loose coupling as high differentiation—low integration, and he indicates that these two dimensions are independent of each other. For example, he discusses (p. 381) the work or Lawrence and Lorsch (1969) who are interested in high differentiation-high integration groups. He also indicates that high differentiation can produce tightly coupled or loosely coupled work units (p. 382).

The definitions established here incorporate three dimensions: interdependence (i.e. responsiveness), distinctiveness, and integration. Both loose and tight coupling are defined using these dimensions since it is difficult to discuss one without contrasting it with the other. As with Orton and Weick's (1990) definition, these are based on a systems model so that they are generalizable and can be applied to a range of social structures including organizations, groups, and individuals. The underlying intent in establishing these definitions is to, as much as possible, describe concrete and observable criteria that can be used in determining the level of coupling in social systems. The definitions follow:

Loose coupling. Loose coupling exists between two or more elements when:

1) *Low interdependence.* Each element's actions affect the other elements weakly and/or infrequently.
2) *High differentiation.* Elements are distinct, logically separate, and self-contained.
3) *Low integration*. Interaction to manage interdependence does not take place regularly between elements.

Tight coupling. Tight coupling exists between two or more elements when:

1) *High interdependence.* Each element's actions affect the other elements significantly and regularly.
2) *Low differentiation.* Elements are not self-contained or distinct.

3) *High integration.* Interaction to manage interdependence takes place regularly between elements.

The differentiation described in these definitions can operate at different levels. For example, when the elements are two people, differentiation can indicate well-defined roles that give a logical separation to the work of each individual. When elements are groups, high differentiation can indicate separation of function or purpose between the groups.

The low interdependence described in the loose coupling definition indicates that elements' actions will not strongly impact other elements. This is described in detail by Weick (1982), who characterizes interdependence in loosely coupled systems:

> Loose coupling exists if A affects B (1) suddenly (rather than continuously), (2) occasionally (rather than constantly), (3) negligibly (rather than significantly), (4) indirectly (rather than directly), and (5) eventually (rather than immediately). Connections may appear *suddenly*, as in the case of a threshold function; may occur *occasionally*, as in the case of partial reinforcement; may be *negligible*, as when there is a damping down of response between A and B due to a constant variable; may be *indirect*, as when a superintendent can affect a teacher only by first affecting a principal; and may occur *eventually*, as when there is a lag between legislator voting behavior and response by his or her electorate. (p. 380)

4.3.2 Loosely coupled groups defined

In this section, I propose a definition for "loosely coupled groups." The focus of this dissertation is on workgroups (as contrasted with other types of groups such as clubs, families, or social groups). According to Arrow et al. (2000, p. 82), the primary purpose of workgroups is to complete group projects. This shared purpose indicates interdependence between group members.

The definition for loosely coupled groups characterizes relationships between group members using the three criteria for loose coupling: interdependence, differentiation, and integration. First, weak interdependence is seen between group members. Group members' activities only impact other members' minimally. Second, high differentiation is seen within the group. In relationships between individuals, this implies distinctiveness in the roles of each member of the group. Having well-defined and mutually understood roles means that workers have awareness of others' responsibilities and of their own responsibilities in working toward shared goals. Third, low integration is found between workers in the group. This indicates that group members do no interact regularly to manage interdependence.

The three criteria for loose coupling outline a basis for defining loosely coupled groups. However, given differences in work patterns over time and differences in relationships between different group members, it can be difficult to classify a group as a "loosely coupled group" in an absolute sense. This type of classification seems most appropriate when loose coupling represents the primary relationship pattern between members of the group, and when the coupling patterns are relatively stable over time. Given this qualifier, occasional and brief shifts to tight coupling do not prevent a group from being "loosely coupled", since work will settle back into a loose pattern. The definitions follow:

Loosely coupled groups. Loosely coupled groups meet the following criteria:

1) *Low interdependence*. Each group member's actions affect the other members weakly and/or infrequently.
2) *High differentiation.* Each group member has a distinct and mutually understood role. Roles may be defined by professional disciplines, job descriptions, skills, knowledge specialization, or through periodic planning.
3) *Low integration*. Members do not interact regularly to manage interdependence.
4) *Stability*. In spite of brief and intermittent shifts in coupling style, the high differentiation—low integration patterns remain stable over time.

Tightly coupled groups. Tightly coupled groups meet the following criteria:

1) *High interdependence*. Each member's actions affect the other members significantly and regularly.
2) *Low differentiation.* Each group member may or may not have a distinct role.
3) *High integration.* Members interact regularly to manage interdependence.

4) *Stability.* In spite of brief and intermittent shifts in coupling style, the low differentiation—high integration patterns remain stable over time.

Some workgroups do not fit into either of these classifications. In some groups, one coupling style may not be clearly preferred, or coupling styles may vary significantly over time.

4.4 Levels of organization in loosely coupled systems

Literature on loose coupling in groups and organizations is based on an open systems model (e.g. Weick 1976; Glassman 1973; Orton and Weick 1990; Foster 1983). Systems theory is based on the notion of a system, which Scott (1987) describes as, "an assemblage or combination of parts whose relations make them interdependent" (p. 76), and systems theory is usually used to characterize the structure, relationship, and processes seen in systems and their parts (Hassard 1993, p. 30-31). The flexibility of the system definition allows for wide variation in the types of systems that can be studied, which can be seen through the application of systems theory in several dissimilar fields such as biology, physics, and sociology (Hassard 1993, p. 30).

The systems foundation provides flexibility to loose coupling concepts, since systems theory does not place constraints on the size and composition of system elements. For example, loose coupling theory is frequently used to describe relationships at different levels of granularity in social systems, including: between individuals (Orton and Weick 1990; DiTomaso 2001), between organizational subunits (Meyer and Rowan 1977; Weick 1976), and between organizations (Brusoni et al. 2001). These different levels are shown in Figure 4.1. In a survey of loose coupling literature, Orton and Weick (1990) expand on this notion and describe eight types of elements that have been studied in loosely coupled systems: individuals, subunits, organizations, hierarchical levels, organizations and environments, activities, ideas, and intentions and actions.

Loose coupling research is based on an *open* systems model (Scott 1985; Scott 1987; Lei et al. 1996). Open systems theory differs from closed systems theory (which is often used to describe mechanical systems) since it accounts for systems' interactions with their external environments (Boulding 1956; Katz and Kahn 1978; Thompson 1967). This interaction allows systems to act to prevent deterioration and disruption, and to restore equilibrium. Scott (1985) points out that open systems “are capable of adaptive upgrading, becoming more differentiated and elaborate in their structures and processes over time” (p. 601).

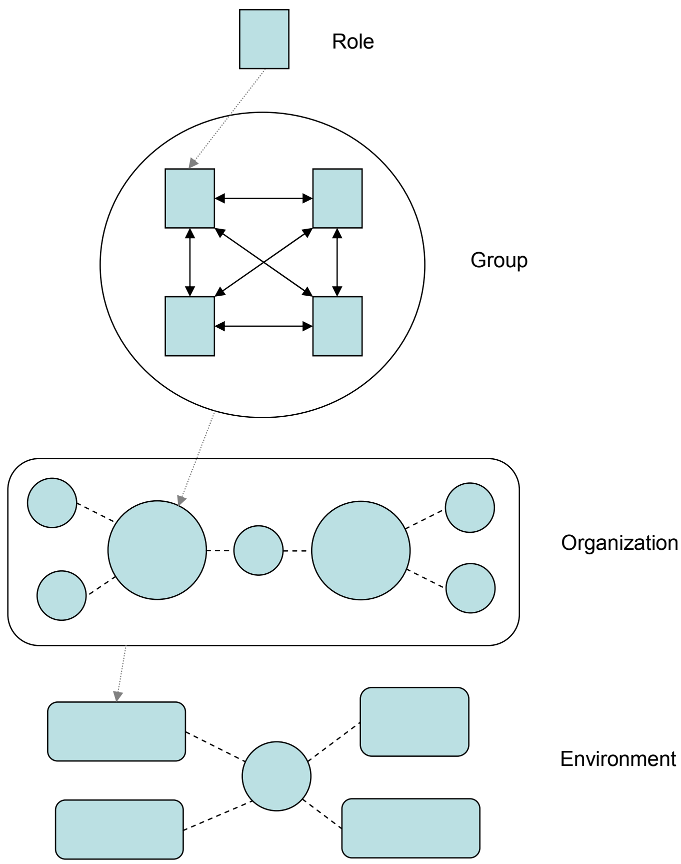


Figure 4.1. Four levels of analysis in social systems: role, group, organization, and environment. Adapted from Bertrand (1972, p. 189).

Katz and Kahn (1978) define the environment as “everything in the universe, except the organization under study” (p. 122). However, they qualify this by stating that it is more productive to focus on those aspects of the environment that interact directly with organizations. They identify five environmental sectors that strongly influence organizations: the cultural environment, the political environment, the economic environment, the technological environment, and the ecological environment (p. 124).

The characteristics of an organization's environment place pressures on the organization, and to be successful, the organization must adopt behaviors and structures that allow it to handle those demands (Georgopoulos 1973, p. 102). Lorsch (1973) argues that "there must be a fit between internal organizational characteristics and external environmental requirements if an organization is to perform effectively in dealing with its environment" (p. 132).

Since organizations respond to their environment, specific environmental characteristics can lead to the adoption of structural and behavioral patterns in organizations. For example, unpredictable and changing work environments have often been described as one of the primary causes of loose coupling between an organization's elements (Orton and Weick 1990; Meyer and Rowan 1977; Lei et al. 1996). Lorsch (1973) illustrates this point:

> We would predict that in effective units involved in more uncertain parts of the environment, members would perceive less structure, would feel that they have high influence over their own work and would perceive egalitarian influence distribution in general, and that supervisory styles would be seen as participative. The opposite set of conditions would fit a unit effectively dealing with a more certain environment. (pp. 135-136)

4.5 Patterns of interaction between loosely coupled elements

Loose coupling implies that system elements "respond to each other in a circumscribed, infrequent, slow, or unimportant manner" (Hasenfeld 1983, p. 150). In organizations, Hasenfeld (1983) states that loose coupling results in weakly connected and weakly coordinated tasks and activities, and in a weak system of administrative control over activities. Staber and Sydow (2002) point out that in loosely coupled organizations, "control is decentralized and information travels slowly and unevenly" (p. 417).

Beekun and Glick (2001; 2001) characterize the interactions between coupling elements in more concrete terms. According to them, organizational elements can be coupled by work related communication; informal, social communication; mutual participation in work tasks; and resource exchange. The quality of coupling relationships can be described by the level of interdependence between elements and by the strength, directness, and consistency of interactions.

In the next two sections, I discuss how loosely coupled relationships shape coordination and communication patterns in groups and organizations.

4.5.1 Loose coupling and coordination

Since interdependence is weak in loose coupling, few coordination mechanisms may be in place between system elements, and when more intense coordination is needed, it can require extra effort. March and Simon (1993, pp. 180-182) consider the effort that is required to coordinate work, and they focus on the relationship between coordination mechanisms and the predictability of work situations (loose coupling is usually associated with unpredictable work situations, e.g. Orton and Weick 1990; Meyer and Rowan 1977; Lei et al. 1996). They argue that when work situations are predictable and repetitive, organizational subunits can structure themselves so that they can account for interdependencies with other subunits. This predictability gives subunits a high tolerance for interdependence, since the subunit is organized to accommodate expected work patterns. Interdependencies in these settings can be managed by "coordination by plan", where schedules and plans are established in advance. However, as variability and unpredictability increase in the work situation, the burden of coordinating work and managing interdependencies increases as well. In these situations, "coordination by feedback" is usually required, where new information is transferred between organizational subunits.

Litterer (1965, pp. 223-224) considers the autonomy that individuals have in coordinating work and identifies two strategies for managing coordination: voluntary and directed. He defines these by stating that in voluntary coordination, "the individual or group of individuals sees a need, finds a program, and applies it when deemed necessary. Contrasted with this is the directed method where individuals are told what to do and when" (p. 224).

When work must be coordinated between loosely coupled workers or units, both types of coordination might be seen, but given the discretion that is characteristically seen in these relationships, it is likely that voluntary coordination will be more prevalent. According to Litterer (1965), however, voluntary coordination is only effective when workers have some knowledge of their role, shared goals, and the conditions that must be accommodated. He also states that individuals are more likely to be motivated to carry out voluntary coordination when they identify closely with the organization and its values and goals.

One type of voluntary coordination discussed by Litterer (1965) provides workers with guidance in their decision making but still leaves them significant discretion. Litterer calls this mechanism "preformed decisions" (p. 226). These are most often seen in organizational policies, and they provide general guidance to workers and "enhance the likelihood of coordinative action" (p. 226). Since policies do not usually provide detailed guidance, workers are still left with latitude in starting and directing coordinative actions.

One mechanism that enables low-effort coordination between loosely coupled individuals is the common socialization of workers (Weick 1980). Members of organizations may have common training, socialization, and work experiences "which influence their perceptions about the goals…and about the means through which these goals ought to be attained" (Hasenfeld 1983, p. 156). These shared perceptions provide workers with an understanding of the actions that others who have similar training and socialization are likely to take, and of the rules associated with fulfilling specific roles within the organization. This knowledge frees workers from the need for ongoing coordination with others who are similarly socialized, since they are able to anticipate others' actions.

Weick's claim is supported by the work of Gamoran et al. (2000) who suggest that common socialization allows workers to operate on *unexamined assumptions* about the actions of others. They illustrate this by providing an example from an educational setting:

> …fourth grade teachers may assume that third-grade teachers are introducing concepts on which they will build when they teach the same students in the following year. Similarly, teachers teaching the same subject area in different grades share a common disciplinary socialization that yields a coherent approach to teaching despite the absence of formal mechanisms of coordination. (pp. 43-44)

Figure 4.2 summarizes coordination strategies in loosely coupled groups and organizations. In the figure, coordination strategies are grouped according to the level of time and effort required to utilize them. Since work in loosely coupled systems is primarily autonomous, low cost strategies will be generally preferred (e.g. task partitioning, unexamined assumptions). However, it is likely that most systems will utilize a range of strategies over time to meet the demands of changing work situations.

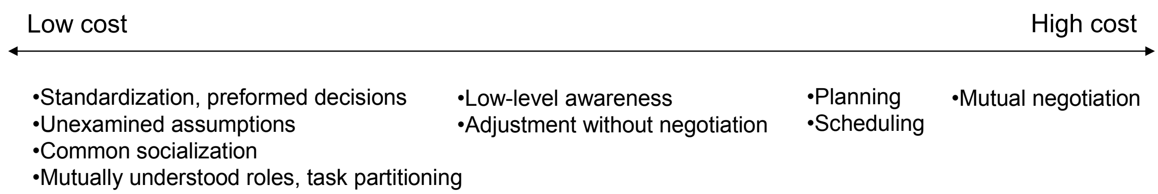


Figure 4.2. Coordination in loosely coupled systems. Strategies are displayed according to the level of time and effort required to utilize each strategy

4.5.2 Loose coupling and communication

Since loose coupling is characterized by weak interdependencies and increased autonomy, communication between loosely coupled elements can be minimal. Communication and information flow has been described as "slow" (Staber and Sydow 2002, p. 417), "infrequent" (Hasenfeld 1983, p. 150), "uneven" (Staber and Sydow 2002, p. 417), "indirect" (Weick 1982, p. 380), and "occasional" (Weick 1982, p. 380).

The reduced information flow seen in loose coupling can make it difficult to initiate and manage communication since channels between system elements are not necessarily well established. March and Simon (1993) argue that an organization's ability to handle a high level of interdependence is tied to its ability to manage communication. They state that "the greater the efficiency of communication within the organization, the greater the tolerance for interdependence" (p. 183-184). They also hypothesize that "the greater the communication efficiency of the channel, the greater the communication channel usage" (p. 189).

Since interdependence is decreased in loose coupling, workers are more tolerant of non-rich communication channels. According to Daft and Lengel (1986), rich communication transactions "can overcome different frames of reference or clarify ambiguous issues to change understanding *in a timely manner*" (p. 560). They list communication media in order of decreasing richness: fact-to-face, telephone, personal documents (e.g. letters or memos), impersonal written documents, and numeric documents. They suggest that when interdependence is low, non-rich media is sufficient, but as interdependence increases, rich media is needed.

Another dimension of communication in loose coupling that has been mentioned but not discussed in detail is the indirectness and unevenness of communications between loosely coupled elements (e.g. Staber and Sydow 2002; Weick 1982). These concepts can be illustrated using simple communication networks that illustrate the flow of messages between people in groups or organization (Goldhaber 1999, p. 39-40). Communication networks show the paths that messages normally follow between people, and the more people a message must pass through before reaching a recipient, the more inefficient the network (Brown 2000, pp. 117-118). In loose coupling, since communication requirements are often minimal, networks with uneven, indirect, and inefficient flows can be adequate for meeting the needs of the organization or group. Figure 4.3 shows several networks. Of these, the wheel and cross are both fairly even and direct in the paths that messages must take to reach others. For example, in the wheel, all messages pass through a central hub with a maximum of two pathways needed to reach any recipient, and in the cross messages require at maximum one pathway to reach recipients. In the other networks, the number of pathways involved in communications and the distance between different recipients can vary significantly.

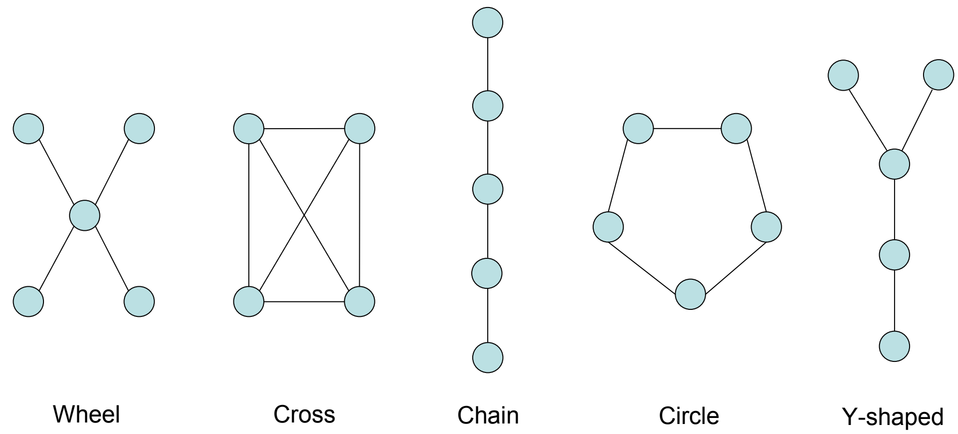


Figure 4.3. Simple communication networks (Adapted from Brown 2000, p. 118)

4.6 Reasons for loose coupling

Several different reasons can lead to the adoption of loose coupling. These reasons can occur at different levels—at the organizational level, at the group level, at the interpersonal level, or in the external environment. Since these reasons help to shape work practice in loosely coupled groups, they are relevant to groupware design since designers must consider how their decisions will impact work in context.

In this section, I review the underlying reasons that can lead to the adoption of loose coupling. The discussion is organized around characteristics that have been identified in organizational research, CSCW research, and small group research. While each of the reasons listed here can lead to loose coupling, it has also been pointed out that some conditions may be the result of loose coupling (e.g. Foster 1983, p. 13). In compiling this section, I attempted to include characteristics that fit more logically as underlying contributors to the adoption of loose coupling; the outcomes associated with loose coupling are discussed in detail in Section 4.7.

In the next sections, I discuss the following reasons:

- *Ambiguous evaluation criteria.* The criteria for evaluating worker or unit performance are unclear and poorly defined.
- *Cryptic surveillance*. Inspection of organization members' activities is weak and undemanding.

- *Environmental uncertainty and complexity*. The organization operates in an uncertain and/or complex environment.
- *Non-routine and unpredictable tasks*. The tasks required to carry out work in the organization are not routine and are difficult to plan and predict.
- *Organization / group size and complexity*. The social system is large and complex.
- *Incompatible external expectations*. Environmental expectations for organizational behavior are incompatible with operational demands.
- *Internal conflicts*. Workers have personality conflicts or incompatible values and opinions.
- *Professionalism*. The organization has professional employees.
- *Specialized knowledge, expertise*. Employees have specialized knowledge and/or expertise.
- *Limited opportunities for interaction.* Group or organization members have limited opportunities to interact.
    - *Physical distribution.* Group members work out of different locations.
    - *Schedule variability.* Group members maintain different schedules.
    - *Mobility.* Groups member are mobile.
    - *Physical environment.* Characteristics of the physical work environment interfere with interaction.

4.6.1 Ambiguous evaluation criteria

When there are not clear criteria for evaluating work performance, it can be difficult for managers and administrators to exercise authority over workers. This can occur when tasks are unpredictable or when they do not produce concrete, measurable outcomes, making it difficult to gauge success or failure. Ambiguous evaluation criteria can weaken the authority structure in the organization and can lead to loose coupling between management and workers or between administrators and work units. According to Hasenfeld (1983, p. 155), ambiguous evaluation criteria are common in human service organizations. He discusses several reasons why evaluation is difficult in these organizations, including the uncertainty of outcomes, difficulties identifying success and failure, the instability and variability of clients, difficulties determining an appropriate sampling of staff activities to monitor, and difficulties in monitoring staff-client encounters.

4.6.2 Cryptic surveillance

Another condition that can facilitate loose coupling is limited monitoring and awareness of others' activities. Weick (1980) calls this "cryptic surveillance" and states that, "this occurs when the inspection of members' activities, of funds spent, or of programs implemented, is weak and undemanding." Cryptic surveillance can occur between administrators and subordinates, or can occur laterally between peers (e.g. Scheid-Cook 1990, pp.191-192). Cryptic surveillance is frequently seen in conjunction with other conditions that facilitate loose coupling such as prior socialization (e.g. Gamoran et al. 2000) or incompatible external expectations (e.g. Meyer and Rowan 1977). However, it can also stand alone as a cause of loose coupling, as Hasenfeld (1983) shows when discussing administrators' abilities to monitor the services that staff members provide to clients in human service organizations (e.g. health care, education):

> With few exceptions, their content is not readily open to inspection for several reasons: (1) numerous legal and ethical restrictions protect the confidentiality of the information exchanged between client and worker; (2) human service practitioners strongly believe that the quality of the relationship and the trust between them and the client will be adversely affected by any external intrusion; (3) the lack of reliable and valid performance evaluation criteria makes the direct observation of staff-client relations a highly volatile supervisory tool that may cause serious conflicts over interpretations of observations; (4) administrative costs of direct monitoring of staff-client relations are exceedingly high because the organization cannot fully anticipate or control their initiation and because direct monitoring requires a substantial commitment of personnel and time. (pp. 156-157)

In this case, cryptic surveillance causes loose coupling between administrators and front-line staff, since administrators are not able to monitor the tasks and outcomes that are part of service delivery.

4.6.3 Environmental uncertainty and complexity

Orton and Weick (1990) suggest that a fragmented external environment that exposes the organization to complex and diverse stimuli can cause loose coupling. Loose coupling is seen as a response to environmental complexity and uncertainty since, as Scott (1985) argues, "loosely joined structural elements are seen as highly adaptive to systems confronting heterogeneous, conflicting, and changing environments" (p. 603). A loosely coupled structure may be effective at dealing with uncertainty and complexity since individual subunits are more autonomous and are free to rapidly adjust to changes in their specific circumstances (Aldrich 1979). Lei et al. (1996, p. 502) illustrate this point by discussing how advanced manufacturing technologies can transform organizations, but that a loosely coupled organizational structure is needed in order to quickly adapt to complex and changing market pressures.

Hasenfeld (1983) points out the relationship between organizational structure and environmental stability when discussing task perceptions, which he relates to environmental factors in human service organizations. "In general, the greater the clarity, predictability, and efficacy of the task perceptions, the greater the ability of the organization to develop tightly coupled work arrangements—that is, standardized and routinized procedures, explicit evaluation and monitoring mechanisms, and hierarchical authority" (pp. 154-155). However, when task perceptions are unclear and unpredictable, "it is not surprising to find that work arrangements are loosely structured" (p. 155).

4.6.4 Non-routine and unpredictable tasks

When work tasks are unpredictable, organizations are unable to provide clear behavioral directives for workers, so loose coupling may be adopted so that workers have the discretion to manage their work activities. Hasenfeld (1983, pp. 154-155) states that these tasks are often carried out with incomplete knowledge and with uncertain consequences. This unpredictability requires that workers have the freedom to exercise their own judgment so that they can alter tasks using feedback from their work. Hasenfeld points out that unpredictable tasks are common in human service organizations, since client interactions are difficult to control, and knowledge about clients is often incomplete.

4.6.5 Organization / group size and complexity

When the size of social systems increases, they become more complex, and this is often managed through increased differentiation and autonomy in the subsystems (Weick 1982, p. 382). This suggests that increased size and complexity in systems can lead to loose coupling between organizational subunits and between individuals in groups. Monane (1967) supports this hypothesis:

> The smaller the social system, the more frequent its internal communication and the higher its organization are apt to be... As a social system increases in size, its components become more independent. The less does the action of one mean for any of the others and for the system as a whole. The less 'concerned' similarly, will the system be regarding the action of one component and the more 'tolerant' will it seem; components and system will 'care' less about one another and about system inflow and outflow. (pp. 24-25)

Monane suggests that there is a direct correlation between system size and coupling style, with tight coupling being more common in smaller systems, and loose coupling being more common in large systems.

4.6.6 Incompatible external expectations

Some organizations must reconcile incompatibilities between environmental expectations for organizational behavior and the need to carry out work activities in a competitive and rational manner. These conflicting pressures can lead to the adoption of loose coupling. Meyer and Rowan (1977) state that many organizations rely on adherence to external "myths" for legitimacy, such as public opinion and expectations, laws, standards, and rules. These myths influence organizational structure, since adherence to them is essential for legitimacy and survival. However, strict adherence to these externally established myths can be detrimental to an organization's ability to carry out work efficiently and effectively, since they may be ambiguous and do not necessarily promote rational work practices. For example, "a governmentally mandated curriculum may be inappropriate for the students at hand, a conventional medical treatment may make little sense given the characteristics of a patient" (p. 355).

Meyer and Rowan argue that some organizations reconcile the need to adhere to myths with the incompatible need to carry out work practices that are rational, efficient, and effective by reducing the level of coupling between formal structures and structures that work at the operational level. This allows the formal structures to project an image of compliance with myths, avoids conflicts that can lead to the loss of legitimacy, and frees operational structures to direct their own activities without oversight. Operational work units become more autonomous, and are not subjected to formal inspection and evaluation by the formal structures, and coordination among units is handled informally. Hasenfeld (1983) supports Meyer and Rowan’s claim by stating that human service organizations operate in task environments that are subject to changing pressures from regulatory agencies, interest groups, and service beneficiaries, and that these external pressures are expressed within organizations so that they can demonstrate responsiveness to these constituencies.

> It does this by pursuing multiple goals and by allocating resources to distinctly bounded clusters of activities that respond to particular interests of demands. Furthermore, the links and ties among these clusters of activities are purposefully made weak and tenuous because of the potential incompatibilities and contradictions among the interests and demands expressed through them. That is, the integrity of the organization and the minimization of conflict among disparate goals is achieved precisely through the loose coupling of the various internal work units. (p. 152)

4.6.7 Internal conflicts

Loose coupling may be adopted to minimize internal conflicts in the organization. Since loose coupling allows increased autonomy, often with minimal inspection of work activities and with reduced interaction with others, it can lead to fewer conflicts between workers, supervisors, and work units. For example, Cockburn and Jones (1995) suggest that when personality clashes occur between workers, further collaboration may be reduced between those workers, presumably to minimize future conflicts. Hasenfeld (1983) considers the importance of loose coupling in human service organizations since it allows the organization to accommodate different and incompatible “moral and ideological systems” (p. 156) that are seen between staff members. According to

Hasenfeld, these incompatibilities are often seen between different professional groups who are socialized differently and have different views of the means that should be used to achieve goals. Weick (1982) supports this claim: "Loosely coupled systems are often characterized as systems in which there is low agreement about preferences and causes-effect linkages. When people see things differently, their efforts will be only loosely coordinated and they will share few variables" (p. 384).

4.6.8 Professionalism

Professionalism can facilitate loose coupling since professional employees have power to demand increased autonomy from bureaucratic structures. Kouzes and Mico (1979) state that "after years of schooling, professionals consider themselves capable of self-governance and believe that they have the expertise to respond to the demands of clients" (p. 457). According to DiTomaso (2001, p. 255), the power of professionals comes from being able to keep others from doing the work that they do through links to the environment such as state licensing, professional organizations, and credentials. These environmental links legitimize the status of professionals and determine normative professional behavior. According to Scheid-Cook (1990), these environmental links make it difficult for the organization to control the work activities of professionals, so loose coupling is adopted between bureaucratic structures and professionals. This loose coupling gives professionals increased autonomy and discretion in carrying out work tasks.

4.6.9 Specialized knowledge, expertise

As pointed out by Brusoni et al. (2001), "knowledge specialization *per se* plays a major role in explaining the emergence of loose coupling" (p. 610). DiTomaso (2001) shows that when workers have knowledge and expertise that are highly specialized, supervisors may not have enough knowledge to direct their activities. Knowledge specialization differs from professionalism, since it does not imply sanctioning of work by external professional organizations. Instead, work becomes loosely coupled (i.e. between worker and administration) because the tasks that must be carried out by the knowledge worker are autonomously decided since they are considered to be the one with the expertise needed to make that determination.

4.6.10 Limited opportunities for interaction

In order to work in a tightly coupled fashion, workers need to interact with each other to share information and to coordinate work. When opportunities for interaction are limited, workers are likely to adopt a more autonomous and loosely coupled style of work. Several factors have been identified that can make it difficult for workers to interact: physical distribution, schedule variability, worker mobility, and physical environment.

4.6.10.1 Physical distribution

When collaborators are physically distributed, interaction becomes more difficult and loose coupling is often adopted. This is illustrated by Kraut et al. (1988) in a study of collaboration practices between researchers. Their findings show that physical proximity increases the likelihood of collaboration between researchers, in part due to increased opportunities for unconstrained and opportunistic communication. They also point out that proximity allows face-to-face interactions that use multiple sensory channels, which result in high quality and more intense collaboration. Finally, they suggest that a significant amount of the communication that occurs between co-present researchers is not planned, and would not occur if it had to be planned.

The decreased collaboration that is associated with physical distribution can lead to loose coupling between workers. Olson and Teasley (1996) point out that when remote work is difficult to coordinate, it is often restructured to be loosely coupled. They describe an instance where a worker who was physically separated from the rest of the team was allowed to pick his work assignments. The worker selected work that was “cleanly partitionable” (p. 425), since this minimized ongoing coordination demands. In a discussion of organizational structure in research and development (R&D) work, Grinter et al. (1999) equate co-location with tight coupling and high communication requirements, and physical distribution with a loose coupling and reduced communication requirements.

4.6.10.2 Schedule variability

When workers maintain different work schedules, it can be difficult for them to collaborate in real-time. This schedule variability can lead to loose coupling, since workers may have to expend extra effort to communicate and to coordinate work. While it still may be possible to overcome schedule variations with formal appointments and meetings, the extra coordination costs can discourage the routine flow of information between workers (Bellotti and Bly 1996).

Three major types of schedule variability have been discussed in CSCW literature. First, workers may have different "work rhythms", and they may carry out different tasks at different times (Begole et al. 2002; Reddy and Dourish 2002). These variations can make it difficult to establish common times when workers can collaborate (Begole et al. 2002). Second, workers may work in shifts, and one worker may begin the work day when another worker ends his or her work day (Kaplan 1997). Third, workers may work out of different time zones, and may not work during the same hours (Begole et al. 2002).

4.6.10.3 Mobility

When workers are mobile over a wide area, variations in workers' physical locations and schedules can introduce collaborative difficulties that facilitate loose coupling between workers. For example, Fagrell et al. (2000) point out that mobile teamwork requires autonomy to deal with local situations, but that work interdependencies may exist that require collaboration.

Several collaboration difficulties can contribute to loose coupling between mobile workers. Since physical location is a changing dimension in mobile work, it is difficult for workers to stay aware of others' locations and availabilities (Fagrell et al. 2000; Belotti and Bly 1996), which makes it difficult for workers to communicate and coordinate work (Belotti and Bly 1996). In mobile groups, workers may have more opportunities to see each other face-to-face since they do not work out of distributed fixed locations. However, the variability in time and location seen when workers are mobile over a wide area can make it difficult to establish any type of intentional synchrony, even when technologies are utilized (Brown and O'Hara 2003).

4.6.10.4 Physical environment

The characteristics of the physical environments where work is carried out can interfere with interaction, and can lead to a more loosely coupled style of work. There are a number of possible factors that can interfere with interaction between workers. Three of these have been identified from related literature. First, Smith (1973) suggests that loud noises in the workplace can limit verbal communication, thus restricting the level of cooperation in groups. Second, Smith states that the physical layout of the workplace can decrease workers' accessibility to others. Third, Mikalachki (1969, p. 21) suggests that factors that limit workers' ability to change their work position on their own initiative can restrict interaction.

4.7 Outcomes associated with loose coupling

The adoption of loose coupling in social systems can lead to a number of potential outcomes. Loose coupling influences the work, coordination, and communication patterns seen in social systems, and as with the factors discussed in 4.4, these outcomes can occur at the organizational level, the group level, or the interpersonal level. They can be central to the work practice in workgroups, and therefore, they are important factors to consider in groupware design.

In this section, I review the outcomes associated with the adoption of loose coupling. The discussion is organized around outcomes that have been identified in organizational research, CSCW research, and small group research. It should be noted that the outcomes I discuss in this section are not wholly good and are not wholly bad (Firestone 1985, p.5; Weick 1976). Instead, the utility of each outcome depends on the specific circumstances confronted in the work situation (Scott 1987, p. 254).

In the next sections, I discuss the following outcomes:

- *Buffering.* Since loosely coupled elements function autonomously, problems in one element do not impact other elements.
- *Information buffers.* Loosely coupled elements maintain local information repositories to support autonomous work.

- *Partitioning of tasks*. Work is partitioned so that the need for ongoing negotiation and task allocation activities is minimized.
- *Autonomy and behavioral discretion*. Loosely coupled elements are free to use their own discretion in determining their behavior.
- *Sensitivity to environmental stimuli*. Since loosely coupled systems have several distinct "sensors", they are sensitive to environmental stimuli.
- *Adaptability*. Loosely coupled elements are able to adapt to the environments that they encounter locally.
- *Persistence*. Since loosely coupled elements are distinct and autonomous, it can be difficult to institute changes to the system.
- *Weak authority structure.* Authority structures are limited in their ability to sanction subordinates.

4.7.1 Buffering

In loosely coupled systems, the weak connections that link system elements protect or "buffer" the system from problems in individual subunits. According to Weick (1976), "if there is a breakdown in one portion of a loosely coupled system then this breakdown is sealed off and does not affect other portions of the organization" (p. 7). Perrow (1999) has a slightly different view of buffering. He focuses on the flexibility and adaptability that loose coupling affords systems and how those qualities can help circumvent catastrophic accidents:

> In tightly coupled systems the buffers and redundancies and substitutions must be designed in; they must be thought of in advance. In loosely coupled systems there is a better chance that expedient, spur-of-the-moment buffers and redundancies and substitutions can be found, even though they were not planned ahead of time. (pp. 94-95)

Since individual subunits are free to adjust to local circumstances, the subunits are able to recognize and respond to stressors in a way that "buffers" the system as a whole.

4.7.2 Information buffers

Kmetz (1984) describes information buffering, a different type of buffering that can occur as the result of loose coupling. When work is loosely coupled, and parts of the organization operate in an autonomous, modular fashion, they may develop information buffers, or local repositories of information that support autonomous work. Information buffers are not shared with the rest of the organization. In Kmetz's study of workflows on U.S. Navy aircraft carriers, he states, "buffers can be specific to processes in the workflow or to members of the organizations" (p. 272). He also points out that information buffers, "are used at the discretion of those having access to them, and their very existence can be denied, if necessary" (p. 272).

4.7.3 Partitioning of tasks

When workers collaborate in a loosely coupled fashion, tasks are often strongly partitioned between workers. This partitioning minimizes coordination demands and allows workers to work autonomously and in parallel (Olson and Teasley 1996). Hasenfeld (1983, p. 150) describes this partitioning by stating the tasks and activities in loosely coupled systems are weakly connected and weakly coordinated. The use of well defined and mutually understood roles allows loosely coupled workers to partition work in order to minimize ongoing consultation, but to still work toward shared outcomes.

4.7.4 Autonomy and behavioral discretion

In loosely coupled systems, the elements are autonomous and have discretion in determining their own behavior (Aldrich 1979, p. 326). Horne (1992, p. 90) quotes Tyler (1987) who claims that in loose coupling, "organization is approached through the loose connections between 'stable sub-assemblies' which retain their identity and a good deal of autonomy at all times." Perrow (1999) elaborates on this idea by stating that loose coupling "allows certain parts of the system to express themselves according to their own logic or interests. Tight coupling restricts this" (p. 92).

Weick (1976, p. 7-8) suggests that the behavioral discretional that is seen in loose coupling can lead to an increased sense of efficacy in workers, and Orton and Weick (1990, p. 215) suggest that this leads to satisfaction with the work setting. However, other findings contradict these claims. For example, Lorsch (1973) suggests that "individuals in a less formalized organization with more influence over decisions and working for a participatory leader would work more effectively if they preferred more autonomy and did not prefer strong authority relationships. Persons in more highly formalized organizations, where influence was more centralized and leadership more directive, would be more likely to feel competent only if they felt comfortable with more dependent authority relationships" (p. 141). Similarly, DiTomaso (2001) outlines a number of problems that are encountered by autonomous knowledge workers, such as reduced socialization.

4.7.5 Sensitivity to environmental stimuli

Weick (1976) indicates that one of the major advantages of loosely coupled systems is that they have a "sensitive sensing mechanism" (p. 6). Loosely coupled systems are able to "know" the environment better than more tightly coupled systems since they have a higher number of diversified and autonomous elements that can serve as "sensors." Staber (2002) argues that this benefit is often seen when loosely coupled systems operate in uncertain environments: "When knowledge is tacit and the application possibilities of new knowledge are unclear, loose coupling raises the chance that at least one organizational element is exposed to the environment in ways that contribute to system adaptation" (p. 418). Brusoni and Prencipe (2001) support this claim by showing that in companies that manufacture complex, multi-technology products, loose coupling within the organization allows organizational elements to focus on new innovations and advances in knowledge (available through exposure to the environment) in their area of expertise.

4.7.6 Adaptability

One of the effects of the flexibility seen in loosely coupled systems is that each autonomous element is able to adapt to the situation that it encounters locally. Rubin (1979) equates flexibility with "loose structure" (p. 212), and Horne (1992) points out that "adaptability requires loosening" (p. 97). Lutz (1982) supports this claim by stating that several conceptual models of organizations indicate that, "organizations that permit considerable flexibility in the behavior of their subsystems are better able to adapt and survive" (p. 653). Weick (1976, p. 6) suggest that the autonomy of elements in a loosely coupled system allows individual elements to adapt to local contingencies, and the loose coupling between elements allows this to occur without affecting the system as a whole.

Scott (1987) points out that this allows “simultaneous adaptation to conflicting demands” (p. 254). However, Scott (1987) also cautions that “whether looser or tighter coordination or coupling is adaptive for the organization depends on the specific circumstances confronted, and is also a matter for investigation, not prejudgment” (p. 254).

4.7.7 Persistence

Persistence, which refers to stability and resistance to change, has been identified as a common outcome of loose coupling (Orton and Weick 1990; Weick 1976; Glassman 1973). Since administrative elements may be loosely coupled with operational elements (e.g. Meyer and Rowan 1977; Scheid-Cook 1990), it is often difficult to institute changes throughout a loosely coupled system from the administrative level (Horne 1992). Spender and Grinyer (1995) contend that changes are possible in loosely coupled systems, but they tend to be adopted slowly: “tight coupling leads to punctuated changes while loose coupling makes for more gradual changes” (p. 909). March (1978) takes a more extreme view of administrators’ abilities to change loosely coupled educational systems. Firestone (1985, p.4) quotes March (1978) who states that, “changing education by changing educational administration is like changing the course of the Mississippi by spitting into the Allegheny” (March 1978, p. 219).

4.7.8 Weak authority structure

Authority structures in loosely coupled systems are often weak and allow workers to function in an autonomous fashion. Workers and units in loosely coupled systems may be insulated from those structures that have formal authority over them. Hasenfeld (1983, pp. 150-151) states that even when formal lines of authority exist, authority structures may be weakened by their inability to effectively sanction subordinates. Staber and Sydow (2002) describe authority in loosely coupled organizations as “decentralized”, and Lorsch (1973) suggests that these organizations are more “egalitarian” (p. 135). Weak authority structure is often tied directly to cryptic surveillance of workers’ activities (Weick 1980), ambiguous evaluation criteria for assessing workers’ performance (Hasenfeld 1983), and to worker professionalism (Kouzes and Mico 1979; DiTomaso 2001) and expertise (Brusoni et al. 2001).

4.8 Loose coupling and work domains

In organizational research, loose coupling has been studied in a relatively limited number of work domains. This may indicate that the shared contextual factors that are found in these domains make the adoption of loose coupling more likely. This suggests that identifying the domains where loose coupling commonly occurs can make it easier to identify it in other similar settings.

In this section, I provide a brief overview of the domains and organization types where loose coupling has been studied in organizational research. I discuss three: human service organizations, knowledge work, and mobile service work.

4.8.1 Human service organizations

Hasenfeld (1983) defines human service organizations as the "set of organizations whose principal function is to protect, maintain, or enhance the personal well-being of individuals by defining, shaping, or altering their personal attributes" (p. 1). He points out that two characteristics distinguish human service organizations from others: 1) people are the "raw material" of the organization, and the organization's purpose is to shape their attributes; and 2) the organizations are mandated to promote the welfare of the people that they serve. Examples of human service organizations include hospitals, medical centers, mental health centers, social service agencies, public health agencies, public schools, universities, nursing homes, police departments, correctional institutions, employment services, and probation departments (Kouzes and Mico 1979, p. 453).

Workers in human service organizations tend to operate in a loosely coupled fashion. According to Kouzes and Mico (1979), this is the result of client staff relationships. Work is focused around transforming or serving a client in some way, which leads to "ambiguous and problematic" goals, and unclear and intangible outputs that are difficult to observe and evaluate. According to Meyer and Rowan (1977), another potential cause of loose coupling is the need to adhere to external "myths" for legitimacy (such as a government mandate, as is the case in many human service organizations). Since external myths often are ambiguous and do not promote rational work practice, the operational units are loosely coupled to administrative units. This allows work to proceed in a rational fashion in operational units with minimal inspection by administration, and allows administration to project the adherence to myths to external parties.

Patterns of loose coupling have been studied in two types of human service organizations: health care and education. Loose coupling in health care domains is defined primarily by the relationships between clients and healthcare professionals, and by the professionalism of workers (Hasenfeld 1983; Meyer and Rowan 1977; Scott 1985; Scheid-Cook 1990). Several factors can lead to the adoption of loose coupling in health care including: the professional status of workers; ambiguous evaluation criteria; cryptic surveillance of client-professional relationships; non-routine, unpredictable tasks; incompatible external expectations; and the need to minimize internal conflicts between professionals with different perspectives.

In education, the relationships between management (e.g. principals, department heads), administration, and teachers/professors are often characterized as being loosely coupled (this has been described at elementary, secondary, and postsecondary levels). These units function relatively autonomously, and in spite of organizational hierarchy, are only able to exert minimal influence on other units (Weick 1976; Gamoran et al. 2000; March 1978; Firestone 1985; Foster 1983; Horne 1992; Lutz 1982; Rubin 1979). Several factors can lead to the adoption of loose coupling in education including: uncertainty, unpredictability of tasks; physical distribution (e.g. time spent in separate classrooms and offices); ambiguous evaluation criteria; cryptic surveillance; non-routine tasks; professionalism, expertise of workers; and the need to minimize internal conflicts.

4.8.2 Knowledge work

The term "knowledge worker" was coined by Drucker (Drucker 1999) to describe workers who create and manipulate information (rather than physical products) as part of their jobs. Some examples of knowledge workers include "market analysts, engineers, product developers, resource planners, researchers, and legal counselors" (UC Berkeley 2004). These workers are usually highly trained, often professional, employees that have the expertise needed to succeed at their work tasks. According to Drucker

(1999), knowledge workers need to work autonomously in order to maximize their productivity.

The autonomy, expertise, and professionalism of knowledge workers makes them more likely to work in a loosely coupled fashion (Brusoni et al. 2001). This loose coupling can operate in vertical relationships with supervisors and in horizontal relationships with peers. For example, DiTomaso (2001) shows that when workers have knowledge and expertise that are highly specialized, supervisors may not have enough knowledge to direct their activities. DiTomaso (2001) also states that the autonomy seen in knowledge workers often leads to reduced interaction with their peers.

4.8.3 Mobile service work

Mobile service work, where workers travel to different physical locations to carry out their work tasks, often leads to loose coupling since workers need the flexibility to adjust to local circumstances, and since variable locations and schedules can make it difficult to collaborate with others (Fagrell et al. 2000; Fagrell et al. 1999). Several factors can lead to the adoption of loose coupling in mobile service work including: mobility; physical distribution; schedule variability; cryptic surveillance; and environmental uncertainty.

4.9 Summary of contextual model

Table 4.1 provides a summary of the contextual model.

Table 4.1. Summary of the contextual model

Definitions	
Factors in coupling	Interdependence Differentiation Integration
Loose coupling	Low interdependence High differentiation Low integration
Loosely coupled groups	Low interdependence between members High role differentiation Low integration Stability of patterns over time
Levels of organization	
Open systems theory	Role Group Organization Environment

Patterns of interaction	
Coordination	Voluntary coordination Low-cost coordination strategies
Communication	Tolerance for low efficiency Tolerance for “non-rich” media Can be uneven and indirect
Reasons	
Ambiguous evaluation criteria	Evaluation criteria are unclear and poorly defined
Cryptic surveillance	Inspection of elements’ activities is weak and undemanding
Environmental uncertainty and complexity	The system operates in an uncertain and/or complex environment
Non-routine and unpredictable tasks	Tasks are not routine and are difficult to plan and predict
Organization / group size and complexity	The system is large and complex
Incompatible external expectations	Environmental expectations for behavior are incompatible with operational demands
Internal conflicts	Workers have personality conflicts or incompatible values and opinions
Professionalism	Organization has professional employees
Specialized knowledge, expertise	Employees have specialized knowledge
Limited opportunities for interaction	Physical distribution, schedule variability, worker mobility, physical environment constraints
Outcomes	
Buffering	Problems in one element do not impact other elements
Information buffers	Elements maintain local information repositories
Partitioning of tasks	Work is partitioned so that the need for ongoing negotiation is minimized
Autonomy and behavioral discretion	Elements are free to use their own discretion in determining their behavior
Sensitivity to environmental stimuli	The system has several distinct sensors, so it is sensitive to environmental stimuli
Adaptability	Elements are able to adapt to the environments that they encounter locally
Persistence	It can be difficult to institute changes to loosely coupled systems
Weak authority structure	Authority structures are limited in their ability to sanction subordinates
Work domains	
Human service organizations	e.g. healthcare, education
Knowledge work	e.g. market analysts, engineers
Mobile service work	e.g. repair work

5 Framework part 2: Analysis technique

Groupware Design Process
1. Understand work practice in context
2. Analyze data and organize into useful forms
3. Design system to support work practice

The second part of the framework is a technique for analyzing work practice in loosely coupled groups in preparation for design. The intent of the analysis technique is to help designers to recognize and specify important features of the work setting, and to organize that information in a way that makes it usable during the design process.

The raw data that are generated in investigations of work practice are unwieldy, and even when that information is presented as an ethnographic report, it is often still difficult to utilize by designers. Hughes et al. (1994) discuss the problem of communicating ethnographic findings to designers, and they state that, "the output of ethnographic analyses are typically discursive and lengthy, looking nothing like the blueprint diagrams that are *de rigeur* in systems engineering" (p. 431). One approach to simplifying findings from work settings is to create models or diagrams of important work patterns and characteristics. This allows complex data to be presented in a way that is easy to interpret, and that facilitates communication within the design team. This is seen most notably in Contextual Design, where work models are used to analyze and represent work patterns and relationships (Beyer and Holtzblatt 1998).

The analysis technique that is presented in this chapter consists of a set of diagramming conventions that organize contextual information from the loosely coupled work setting in preparation for system design. The diagrams that are created during this step are intended to provide an overview of important features of the work setting (e.g. details on coupling patterns, work patterns, collaboration patterns, and causes and outcomes of loose coupling) and to abstract away unwieldy details that are seen in raw observational data so that designers are better able to incorporate that information into the design process.

The analysis technique was developed from the approaches that were used to analyze data from home care in preparation for designing Mohoc, a groupware system for treatment teams (this analysis is described in Chapter 7). The technique is based on the contextual model, and incorporates several existing analysis methods including Contextual Design work models, Collaboration Usability Analysis, and sociograms. Contextual Design (Beyer and Holtzblatt 1998) is a technique for incorporating information about workers and the way that they carry out their work into the design process. Collaboration Usability Analysis (Pinelle, Gutwin, and Greenberg 2003) is a task analysis technique that analyzes collaborative aspects of group work in preparation for designing groupware systems. Sociograms (Garton et al. 1997; Wigand 1988, p. 321; Monane 1967) are diagrams that are used to represent interaction between elements in social systems.

In the next sections, I present the analysis technique. I begin by discussing the requirements of an analysis technique for loose coupling. Next, I discuss existing analysis and design techniques that incorporate contextual information into the design process. Finally, I present the analysis technique and provide examples of the modeling approaches.

5.1 Requirements for analyzing loose coupling

An analysis technique for loosely coupled work settings needs to help identify and organize key pieces of information about work and collaboration practice in loosely coupled groups in preparation for groupware design. The contextual model provides a foundation for carrying out this type of analysis—it addresses communication and coordination patterns between loosely coupled elements, and it identifies reasons and outcomes of loose coupling. The model also considers different organizational levels that influence work practice including interpersonal relationships, inter-group relationships, intra-group relationships, supervisor-subordinate relationships, and relationships with the external environment.

Some of the factors that are important to designing groupware for loosely coupled workgroups are covered by existing analytical and design methodologies (e.g. Contextual Design, Collaboration Usability Analysis). However, many others are not. In the rest of this section, I define a set of requirements for analyzing loose coupling in preparation for groupware design. The requirements discussed here are based on the contextual model and on work with home care teams. They are organized into four categories: coupling patterns; work patterns; communication, coordination, information utilization patterns; and causes and outcomes. Figure 5.1 provides an overview of the requirements.

Coupling patterns. An analysis technique for loose coupling should capture the level of integration and interdependence between elements in organizations at different levels. Since the relationships that can influence worker behavior are often external to the workgroup (e.g. relationships with other peers, relationships between supervisor and subordinate, relationships with other members of the organization), analysis techniques should have the flexibility to incorporate information about all significant relationships, regardless of their placement in the organization.

Work patterns. An analysis technique for loose coupling should capture the work patterns that are seen in target workgroups so that software systems can be tailored to support workflows. This requires an analysis of individual and collaborative tasks, along with the points of interdependence that must be managed during collaborative work. Other factors that shape the way that work is carried out are relevant here as well, including the locations where work is carried out and the artifacts that are used by workers.

Communication, coordination, information utilization patterns. An analysis technique for loose coupling needs to capture the current collaboration patterns seen in workgroups so that those patterns can be supported and augmented according to the needs of the workers. Communication and coordination methods should be analyzed, along with the preferred frequency, directness, and richness of channels that support them. Communication and coordination breakdowns should also be considered, along with the circumstances that lead to breakdowns. Workers' level of awareness of others' activities, locations, and availabilities should be addressed, as should information utilization by individual group members and by the group as a whole.

Coupling patterns – across different organizational levels

- Coupling patterns between workers
- Coupling patterns within the group
- Coupling patterns between group members and supervisors
- Coupling patterns between group members and other members of the organization

Work patterns

- Point of interdependence – shared work focus
- Individual tasks and collaborative tasks
- Causes and frequencies of shifts between different coupling styles
- Work locations
- Work artifacts

Communication, coordination, information utilization patterns

- Communication methods
- Frequency, directness, richness of communication between individuals
- Coordination methods, voluntary vs. directed
- Frequency of coordination activities
- Approaches used by group members to stay aware of others
- Information utilization patterns, including shared and unshared information
- Communication and coordination breakdowns

Causes and outcomes

- Environmental influences on coupling patterns
- Organizational influences on coupling patterns
- Spatial and temporal factors that impact coupling patterns
- Other reasons for loose coupling
- Outcomes associated with loose coupling

Figure 5.1. Requirements for analyzing contextual features in loosely coupled groups

Causes and outcomes. An analysis technique for loose coupling should capture the reasons for loose coupling and the outcomes associated with the adoption of loose coupling so that designers can consider the impact that proposed design decisions will have on the workgroup and on the organization. Environmental, organizational, supervisory, spatial, and temporal reasons for loose coupling should be analyzed, and the outcomes associated with the adoption of loose coupling should be analyzed across different organizational levels.

5.2 Foundations for analyzing loose coupling

The analysis techniques that are outlined in this chapter are partially based on three existing analysis and representation approaches: Contextual Design, Collaboration Usability Analysis (CUA), and sociograms. In the next three sections, I briefly discuss each approach. For each, approach, I discuss how well it meets the requirements discussed in Section 5.1.

5.2.1 Contextual design work models

Contextual Design is a method for designing software systems based on information collected from the target users. It is based on data from the work setting, and the design process focuses on supporting workers and their activities. According to Beyer and Holtzblatt (1998), "it makes deciding how customers will work in the future the core design problem and uses those decisions to drive the use of technology" (p. 3).

One of the main parts of the Contextual Design methodology is the use of work models to capture and analyze information about the target work setting prior to beginning design work. Contextual Design models organize contextual information for system design, and provide broad coverage of different aspects of real world work. In Contextual Design, five different modeling approaches are used (Beyer and Holtzblatt 1998):

> Each of the five types of work models has its own concepts and symbols representing one aspect of work for design. The five models were developed over time to meet the needs of the design problems we encountered. They represent the key aspects of work that design teams need

to account for in their designs. We have found these five to be necessary to almost every problem and sufficient for most. (p. 89)

A brief description of each model type follows:

- *The flow model* describes workflow – (Beyer and Holtzblatt 1998) "how work is broken up across people and how people coordinate to get the whole job done" (p. 90). A sample flow model from the home care domain is shown in Figure 5.2.
- *The sequence model* is similar to a set of task analysis results (e.g. Annett and Duncan 1967; Pinelle, Gutwin, and Greenberg 2003)—it presents a series of steps that are required to reach a desired outcome. A sample sequence model is shown in Figure 5.12.
- *The artifact model* includes copies or drawing of artifacts, such as "to-do lists, forms, documents, spreadsheets, or physical objects under construction (circuit boards, cars, airplanes)" (Beyer and Holtzblatt 1998, p. 102-103), along with a written analysis of artifacts' parts, structures, and uses.
- *The physical model* is used to capture the important elements of the physical work environment, and it consists of drawings of the physical spaces where work is carried out, and of information about how people are grouped and how space is used by workers.
- *The culture model* provides a diagramming convention for describing the cultural context by showing the factors that influence workers, which can include other workers, other work units, or environmental factors.

The Contextual Design work models are useful for incorporating many of the key issues that are discussed in Section 5.1 into an analysis of the work setting. For example, the flow models consider how workers interact with each other at a basic level, and show how information and artifacts flow between workers. The physical models consider the role that physical spaces play in shaping interaction. However, the work models do not address several issues that are central to CSCW: How is work coordinated? How do users stay aware of each others' actions? How are tasks partitioned between workers?

Also, other issues that are central to coupling are not addressed, such as frequency of interaction and underlying factors that lead to the adoption of loose coupling.

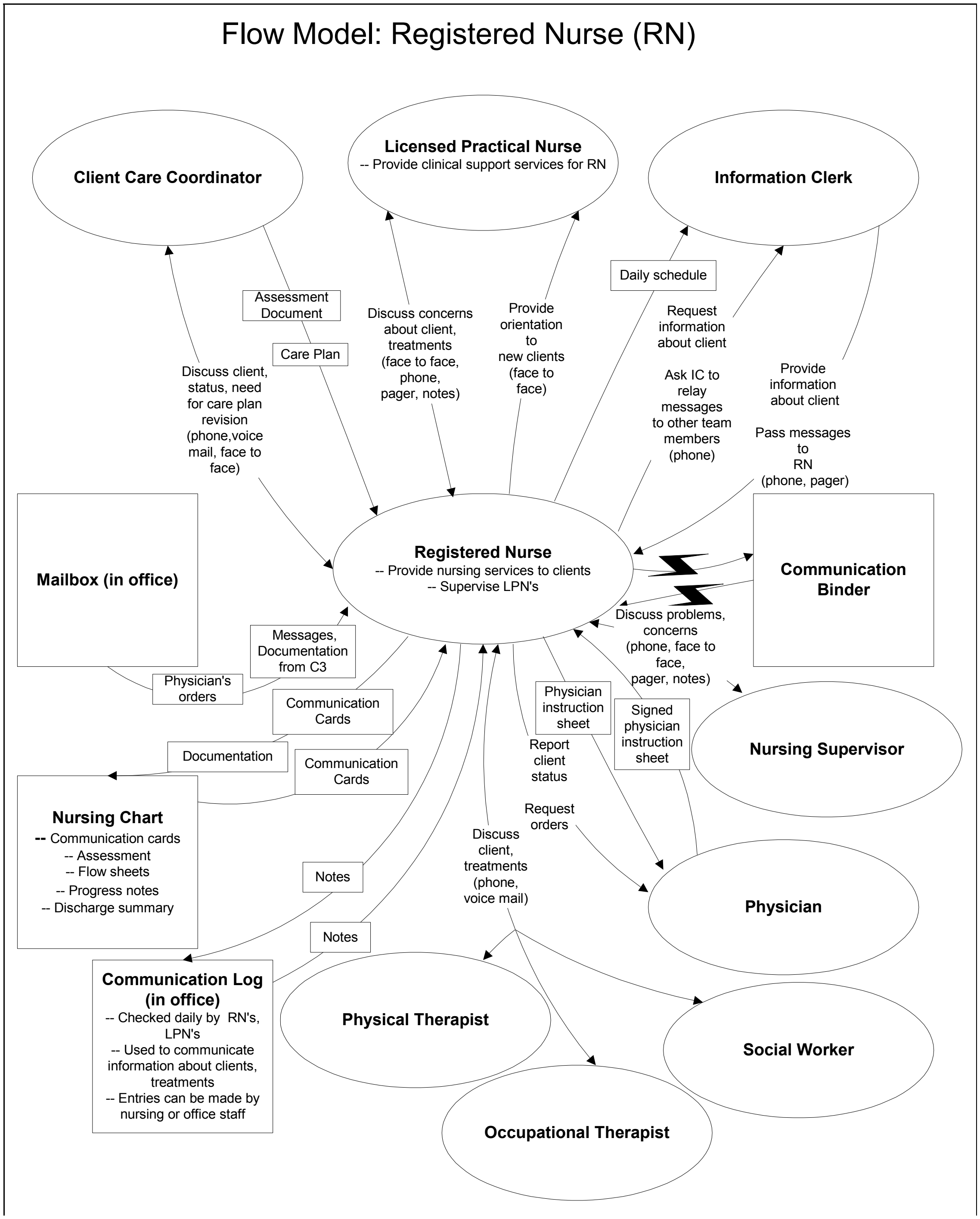


Figure 5.2. Flow model for Registered Nurses. Arrows indicate workflow, ovals represent workers, boxes indicate work artifacts, and lightning indicates breakdowns in workflow

5.2.2 Collaboration usability analysis

Collaboration Usability Analysis (CUA) is a task analysis technique that represents collaboration in shared tasks for the purpose of designing groupware systems (Pinelle, Gutwin, and Greenberg 2003). CUA is focused on the teamwork aspects of a collaborative situation. It provides representations of the collaborative situation and the shared task, and provides representations for multiple actors and the interactions between them in shared work. To represent the range of ways that a group task can be carried out, CUA allows variable paths through the execution of a task, and allows alternate paths and optional tasks to be modeled (see Figure 5.3).

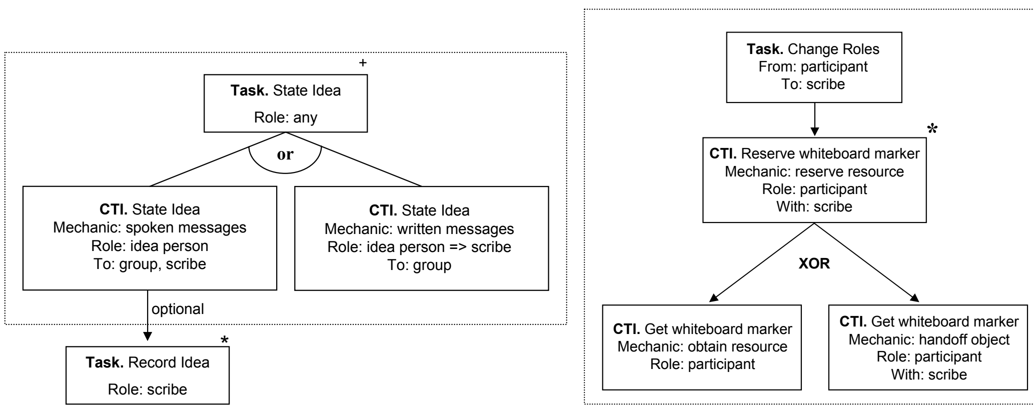


Figure 5.3. Sample CUA task diagrams for a brainstorming scenario.

CUA grounds each collaborative action in a set of group work primitives called the mechanics of collaboration (Gutwin and Greenberg 2000). The mechanics of collaboration are the basic operations of teamwork—the small-scale actions and interactions that group members must carry out in order to get a task done in a collaborative fashion. They are the things that will be common to a shared task even with a variety of social and organizational factors, such as communicating with other members of the group, keeping track of what others are doing, negotiating access to shared tools or empty spaces in the workspace, and transferring objects and tools to others. The mechanics are a useful level of analysis for task models because they provide a fine-grained view of teamwork; and since the mechanics are observable, collaboration can be analyzed and broken down into specific actions that groupware designers can consider one at a time.

Unlike many other task analysis techniques, CUA is appropriate for analyzing multi-person tasks, making it well-suited to groupware design in general. Since it can help to understand how tasks are partitioned between group members, it is useful when considering coupling between collaborators. The models break tasks into collaborative task instantiations, which roughly correspond with tightly coupled work, and individual task instantiations, which are more likely to represent loosely coupled work.

CUA provides a fine-grained view of task and collaboration, but it does not consider high-level aspects of the work situation. It does not consider organizational issues such as supervisor-subordinate relationships, environmental factors, and intra-group relationships. It also does not model general patterns in social systems such as interaction patterns, workflow patterns, and interaction frequency.

5.2.3 Social network analysis and sociograms

Social network analysis is a social science technique that is concerned with investigating interactions within social systems. The social network itself consists of the pattern of relations in social systems, including the flow of information and resources between system elements (Garton et al. 1997), and analyzing networks can provide “descriptions and characterizations of the system’s structure” (Wigand 1988, p. 321). Wigand (1988) points out the generalizability of network analysis: “Network analysis techniques are appropriate to many forms of social systems, such as organizations, villages, classrooms, entire industries, interorganizational analysis, and others” (p. 321).

According to Garton et al. (1997), the relations that are investigated through social network analysis can be characterized in terms of content, direction and strength. Content indicates the things that are exchanged, such as different kinds of information or work artifacts. Direction indicates symmetry of the relation; for example, a relation can be one-sided where one individual sends memos to the other, or it can be mutual, where two individuals participate equally in a discussion. Strength indicates the frequency of communication or the importance of the information that is exchanged. Garton et al. (1997) indicate that multiple relationships can exist between social actors.

The sociogram is a type of diagram that is commonly used to represent social networks. Usability First (2004) defines a sociogram as, “a diagram that shows interaction patterns between people.” Sociograms usually consist of nodes which are used to indicate elements in the social system (e.g. departments, individuals, groups, etc.) and lines or edges between those nodes, which indicate the relations between social system elements. Information can be embedded in the sociogram to indicate content, direction, and strength of a relation. For example, Wigand (1988, p. 328) suggest using arrows to indicate direction. Figure 5.4 shows a simple sociogram.

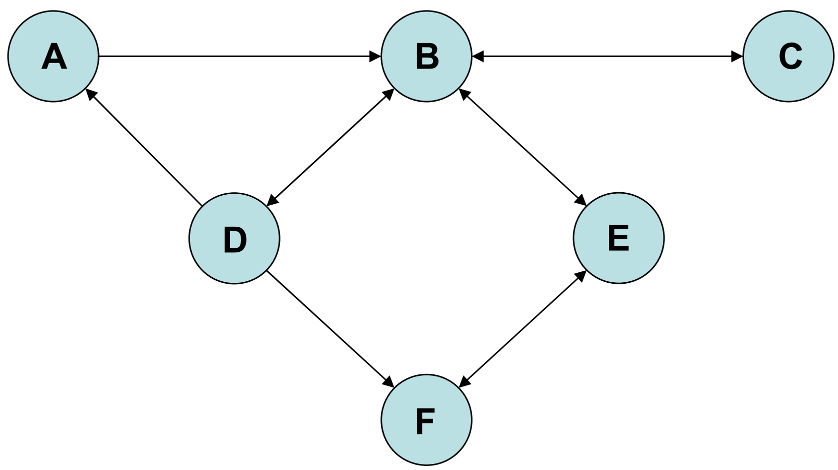


Figure 5.4. A simple sociogram. Arrows indicate directional communication patterns between system elements. Adapted from Wigand (1988, p. 329) and Monane (1967, p. 8)

Wigand (1988) discusses several limitations of sociograms. He points out that sociograms are limited when social systems grow large, since large two dimensional spatial representations are difficult to draw and interpret. He also indicates that there are few criteria for conveying the meaning of a given link—whether it indicates amount, duration, or frequency of communication.

In spite of the limitations discussed by Wigand, the sociogram provides a useful representation when analyzing coupling in workgroups. First, it can be applied at different organizational levels. For example, it can be used to model organizational units, workgroups, or individuals. Second, notation for linkages can be specified within the scope of an analysis technique, so that information about content, direction, and strength of relations can be represented. Third, the sociogram representation is simple and relatively flexible, so it can be easily adapted to meet a range of analysis and design needs.

5.3 Analysis technique for loose coupling

The analysis technique consists of five modeling approaches that organize contextual information from loosely coupled work settings in preparation for system design. The models that are created using the technique are intended to provide an overview of important features of the work setting and to abstract away unwieldy details that are seen in raw observational data so that designers are better able to incorporate that information into the design process.

Each model covers a different aspect of work and collaboration in loosely coupled situations. The modeling approaches are not prescriptive. Rather, they are intended to provide the designer with tools for capturing those aspects of work that are relevant to groupware design. Each modeling approach is intended to be flexible enough to be used in a variety of social systems, and to be able to bridge organizational boundaries when needed.

The analysis technique was developed from the approaches that were used to analyze data from home care in preparation for designing Mohoc, a groupware system for treatment teams (this analysis is described in Chapter 7). The technique is based on the contextual model, and incorporates existing analysis methods including sociograms, Contextual Design work models, and Collaboration Usability Analysis.

In the next sections, I discuss the five parts of the analysis technique:

- Interaction model
- Awareness model
- Coordination model

- Task model
- Loose coupling checklist

5.3.1 Interaction models

Analyzing interaction patterns in social systems can provide a strong indication of the coupling patterns seen between system elements. When interaction occurs regularly to manage interdependence, the elements are highly integrated, which can indicate tight coupling; when interaction is intermittent or rare, the elements are minimally integrated, which can indicate loose coupling. Analyzing and understanding these interaction patterns is important in designing groupware since they can suggest the required frequency, richness, and directness that is needed in communication support.

Interaction patterns that can influence the actions of workers and workgroups can span different levels in organizations. These can take place at the interpersonal level, at the group level, or at the organizational level. Therefore, an analysis technique for analyzing interaction needs to have the flexibility to consider these different levels.

The technique presented in this section uses sociograms to model interaction between social system elements. Figure 5.5 shows a sample interaction model along with a set of diagramming conventions. Each node in the sociogram represents a different social system element and patterns of interaction are shown using arrows that link the nodes. Arrows can indicate one or two directional flow of information between nodes. The arrow paths shown in the figure convey the frequency of interaction between the workers—the broken path indicates rare interactions, and the solid paths indicate more frequent interactions. Lightning bolts that are shown along the path indicate breakdowns where the current channels do not meet workers' needs. Paths can be annotated to describe the media that are used to interact (e.g. phone, voice mail, email, etc.), the level of control in initiating interaction (voluntary or obligatory), and the structure of interactions (structured or unstructured).

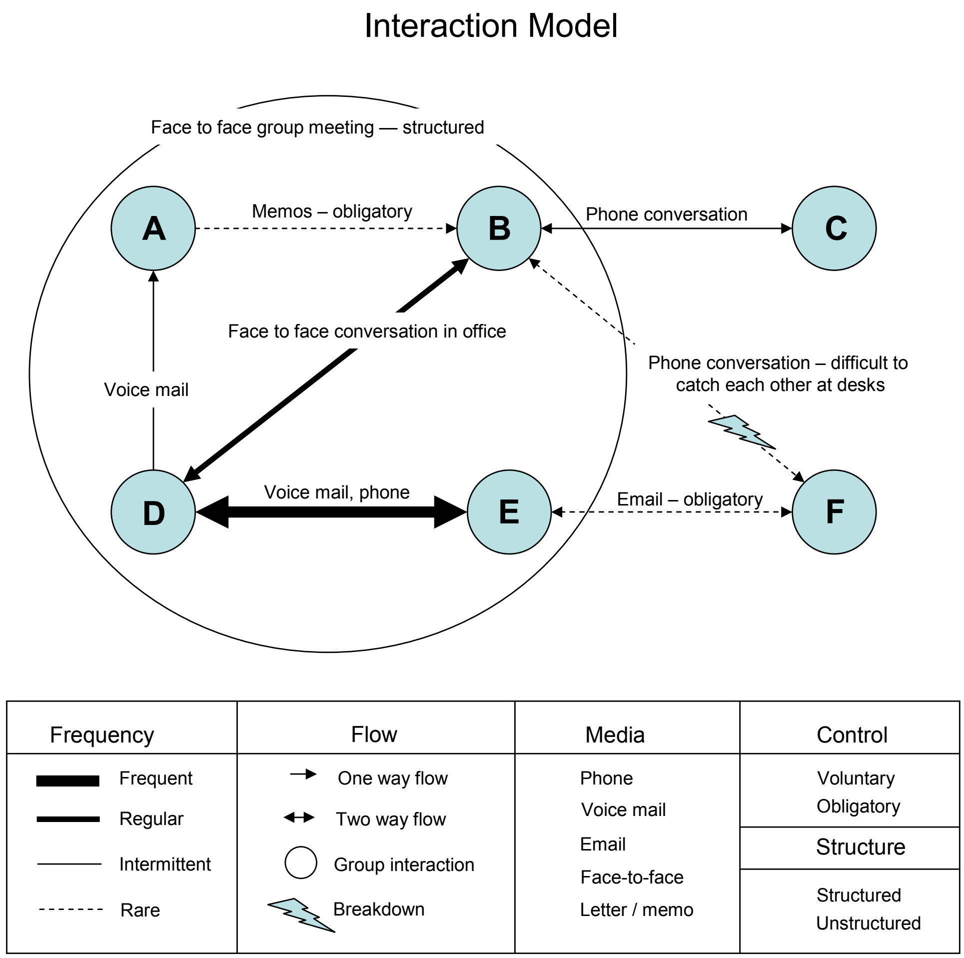


Figure 5.5. Sample interaction model and modeling conventions.

Figure 5.6 shows a sociogram for a home care treatment team. The team works in a loosely coupled fashion, and the interaction frequencies are rare or intermittent. This figure illustrates one of Wigand's (1988) criticisms of sociograms—they do not scale well when the number of nodes becomes large. In this figure, little room is left to annotate the arrow paths between nodes in order to describe the content of the interaction between workers.

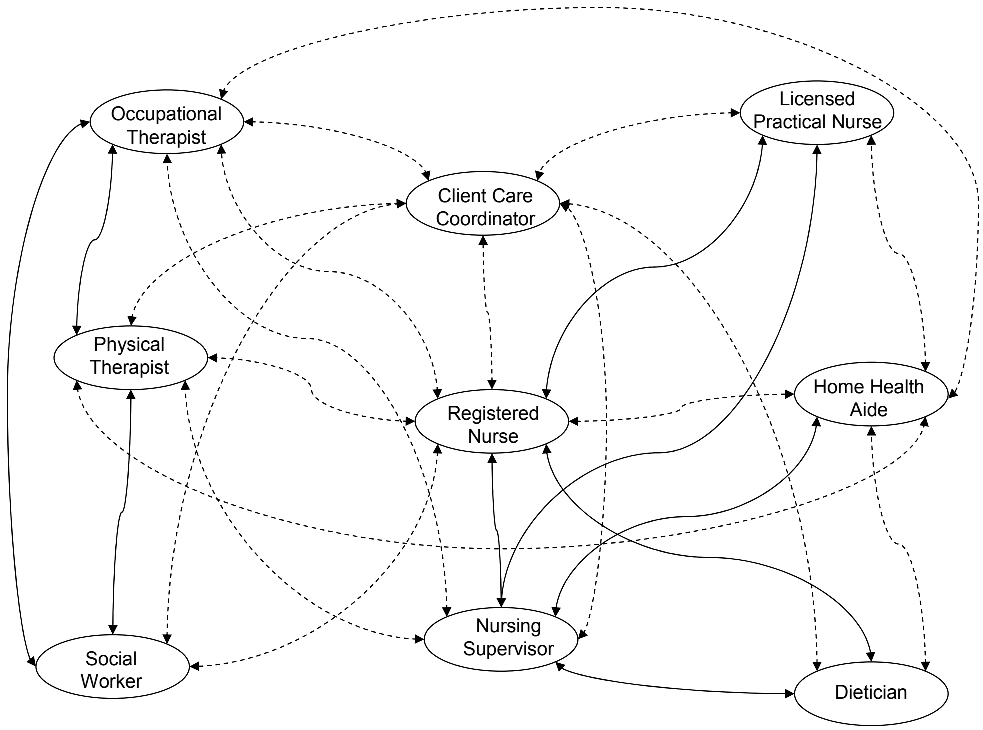


Figure 5.6 Interaction model for home care treatment teams. Nodes indicate roles and arrows indicate interaction between workers who fill the roles.

An alternate means of showing interaction between social system elements is by showing interaction patterns for only a single element at a time. This is shown in Figure 5.7 where a flow diagram from Contextual Design is shown. The diagram makes better use of two-dimensional space since it does not consider interaction patterns between a large number of nodes—instead it uses a single element (i.e. worker or role) as a central hub, and shows how that element interacts with others in the organization. This reduces the number of pathways that must be shown (n instead of (n x n - 1) / 2) and allows room for annotation of the arrow pathways so that the flow of information and artifacts between nodes can be shown.

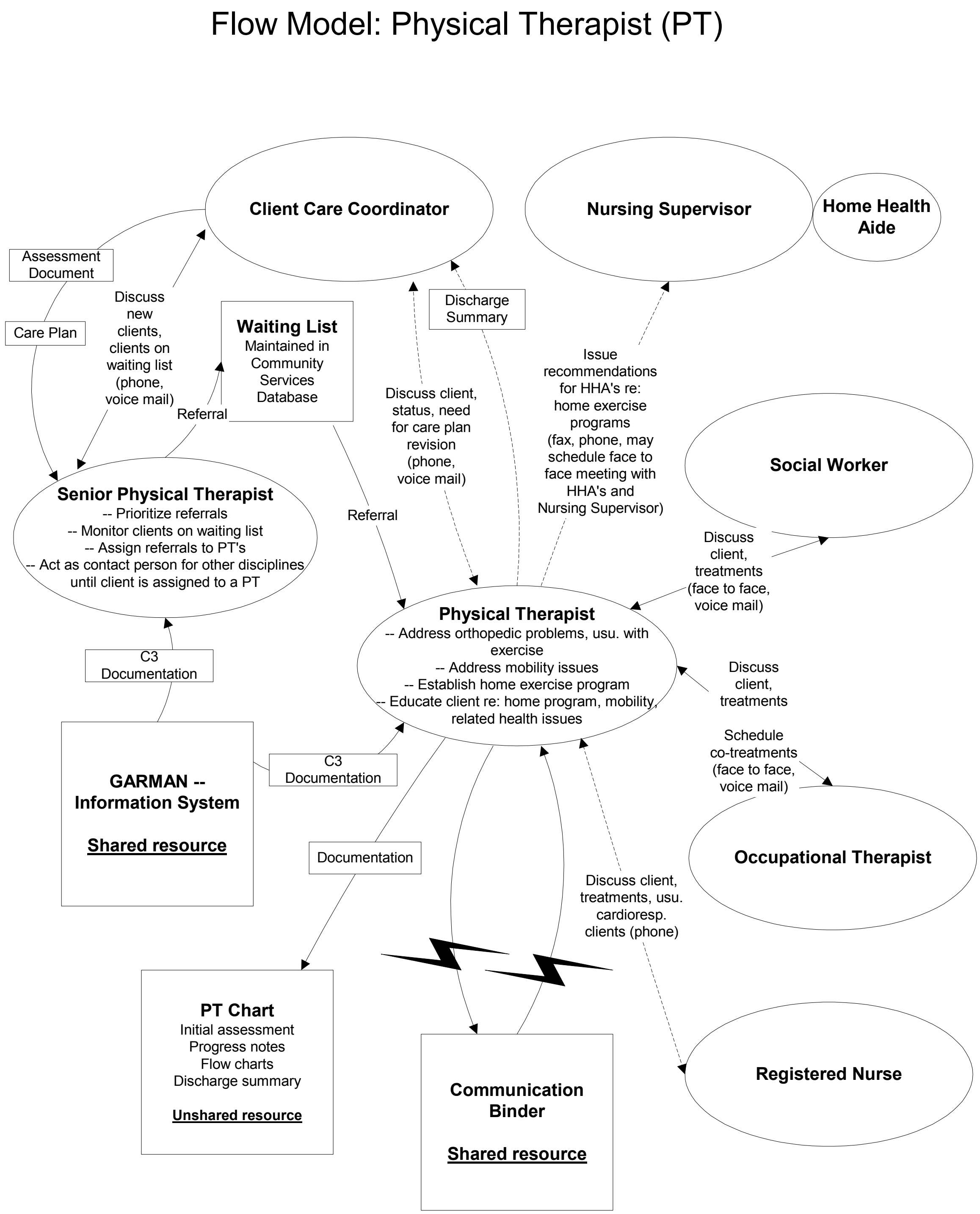


Figure 5.7. Modified Contextual Design flow model for a home care Physical Therapist. Arrows indicate workflow, ovals represent workers, boxes indicate work artifacts, and lightning indicates breakdowns in workflow

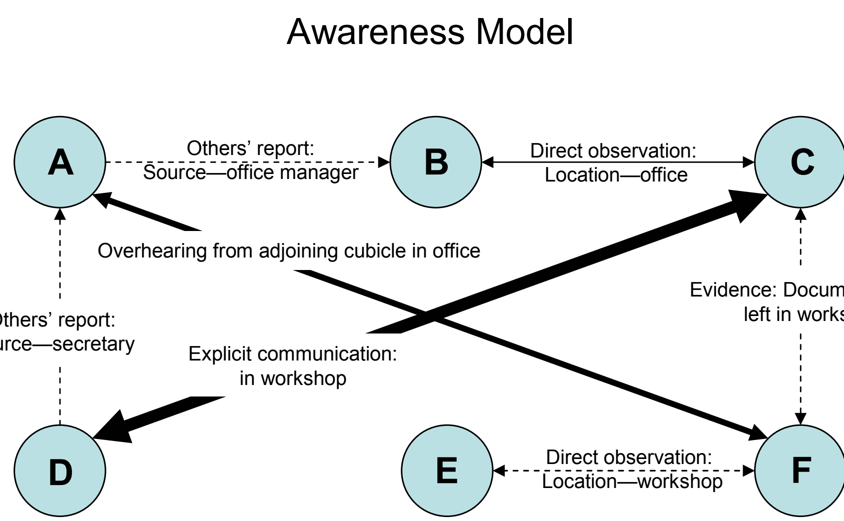
Figure 5.7 shows a Contextual Design flow model that has been slightly modified to meet some of the needs outlined in Section 5.1. The flow of artifacts are shown along the pathways using boxes, and descriptions of interaction “content” are provided along each of the other pathways along with the type of media that is used for communication (e.g. phone, voice mail, face to face, pager). Two modifications have been made. First, the flow model incorporates information about interaction frequency into the arrow paths using the coding scheme described for Figure 5.5. Second, the information resources that are shown in the figure (GARMAN information system, PT chart, communication binder) are annotated to indicate whether they are shared or unshared (i.e. information buffers) information sources.

These two modeling approaches (i.e. sociogram and flow model) both serve different purposes. The sociogram provides a good overview of interaction patterns between system elements. It can be adequate on its own when the number of nodes and pathways is small enough to allow room for annotation. When occlusion becomes a problem, the diagrams can be constructed in a similar fashion to that seen in the flow models—interaction patterns can be shown for a single element in each diagram. Flow models provide a wider range of features. Shared resources and artifacts are shown—however, these can create new occlusion problems. One technique is not clearly preferable to the other—the usefulness of each depends on the needs of the designer.

5.3.2 Awareness models

Arranging communication and coordinating work often relies heavily on maintaining an awareness of others’ activities, locations, and schedules. Since awareness is central to collaboration, the level of awareness that is seen in workgroups can impact coupling patterns between workers. For example, limited awareness that arises as the result of mobility and physical distribution can interfere with interaction and can lead to loose coupling. Similarly, significant awareness of others can enable more collaboration and more tightly coupled work patterns. Analyzing and understanding awareness patterns in groups can provide insight into how groupware can be designed to enhance awareness.

The modeling technique presented in this section uses sociograms to model awareness patterns in social systems. Figure 5.8 shows a sample awareness model along with a set of diagramming conventions for tracking how awareness is maintained. Two types of awareness are considered here: direct and indirect. Direct awareness comes from direct knowledge of others' activities. This can occur through observation of another worker, through overhearing their activities, or through explicit communication. Indirect awareness comes from sources other than first hand observation. This can include evidence of another worker's past activities (e.g. artifacts that provide evidence of recent activity) or second hand reports about another worker's activities. The diagram also specifies the source or location of awareness information when it is appropriate. For example, if a worker is observed in the office, this represent the "location" where awareness information is gathered, or if a secretary provides a worker with information about another's activities, the secretary is the "source."



Frequency	Flow	Type	Location or Source
Frequent	One way flow	*Direct*	<Specify>
Regular	Two way flow	Observation	
Intermittent	Breakdown	Overhearing	
Rare		Explicit comm.	
		Indirect	
		Evidence	
		Others' reports	

Figure 5.8. Sample awareness model and modeling conventions.

Figure 5.9 shows an awareness model for home care treatment teams. The model in the figure uses a registered nurse's perspective rather than showing all awareness patterns between all workers in the team. This is to accommodate the limited space and the problems with occlusion that would occur if all relationships were shown concurrently in the diagram. The diagram shows that nurses typically have limited awareness of others' activities, with most information being collected rarely or intermittently. Since this portrays a loosely coupled work arrangement, this is not necessarily a problem, but the diagram suggests that a groupware application could play a role in improving awareness within treatment teams.

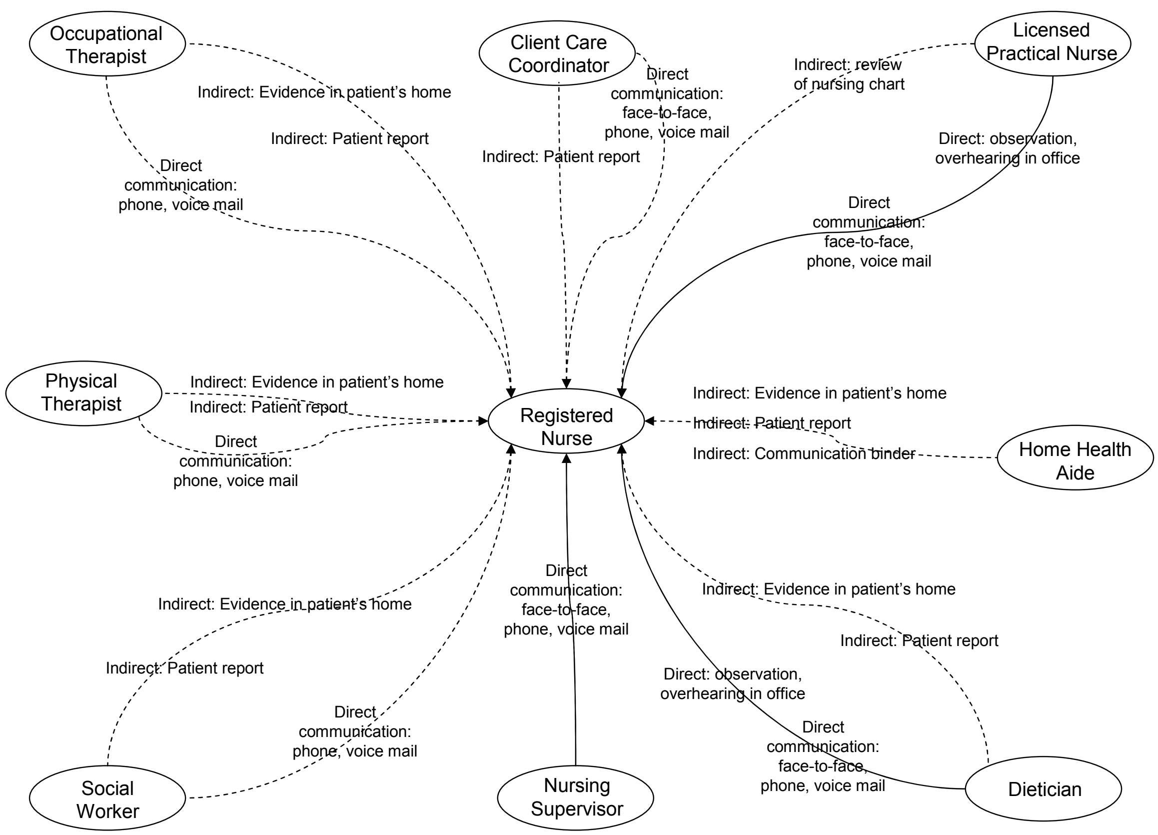


Figure 5.9. Awareness model for Registered Nurse. Nodes indicate roles and arrows indicate strategies that are used to maintain awareness of others.

5.3.3 Coordination models

In workgroups, coordination is necessary to manage interdependence between workers. However, the level of coordination that is needed often varies greatly with the strength of interdependence and with the level of coupling seen between workers. When work is loosely coupled, coordination may be managed in a way that minimizes effort and direct negotiation between workers. When it is tightly coupled, direct negotiation may be more common out of necessity. Since a group's preferences for coordination approaches may vary with coupling levels, it is important to analyze and understand coordination patterns in order to determine how groupware can be designed to meet the group's needs.

The analysis technique presented in this section uses sociograms to model coordination in social systems. Figure 5.10 shows a sample coordination model along with a set of diagramming conventions for tracking how work is coordinated. In the diagrams, coordination type is considered along with the level of effort needed to coordinate work with others. Three types of coordination are shown in the diagram. They are listed here, in order of increasing level of effort: unexamined assumption / mutually understood roles; adjustment without negotiation; and mutual negotiation. Mutual negotiation, which requires effort on the part of all participating parties, has several sub-types which include: planning, task allocation, scheduling, and explicit role delineation. The diagram also specifies the level of control and the circumstances surrounding coordination activities when appropriate. Control specifies whether coordination actions are voluntary (initiated by the individual) or are directed (initiated by directive).

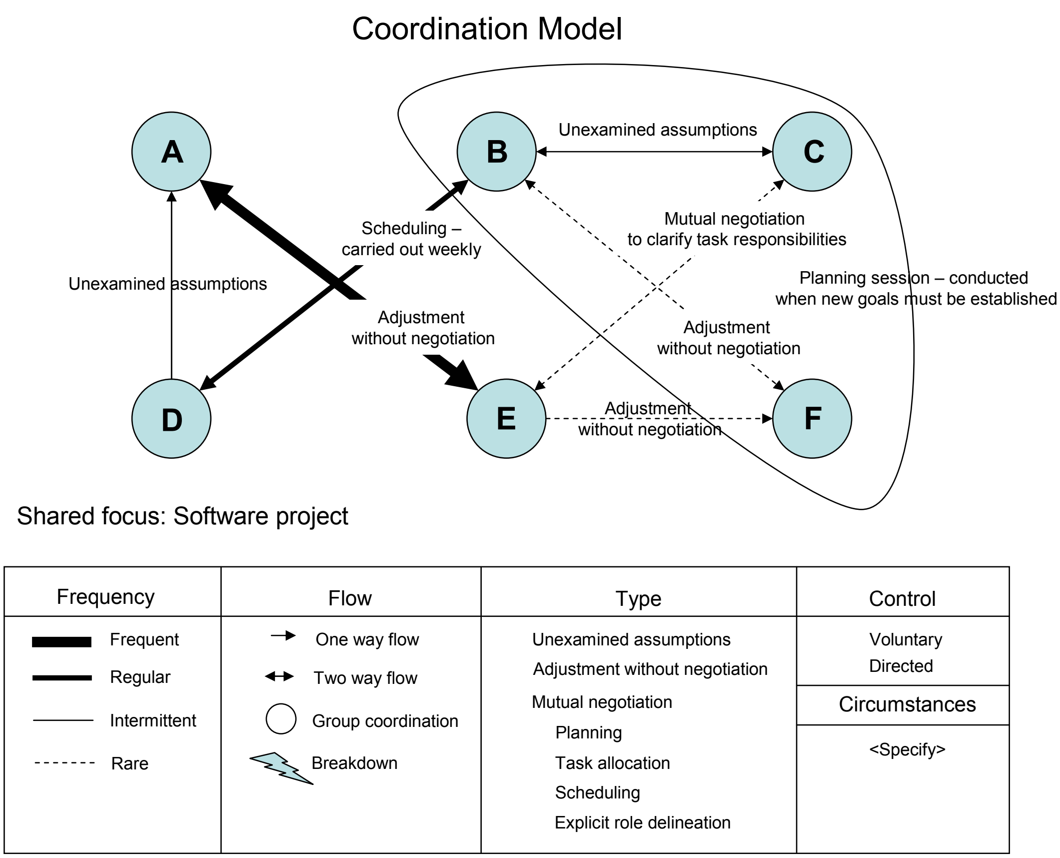


Figure 5.10. Sample coordination model and modeling conventions.

Figure 5.11 shows a home care coordination model shown from a registered nurse's perspective. The diagram shows that most coordination uses low-cost approaches, including unexamined assumptions and adjustment without negotiation. The mutual negotiation that does take place occurs rarely or intermittently.

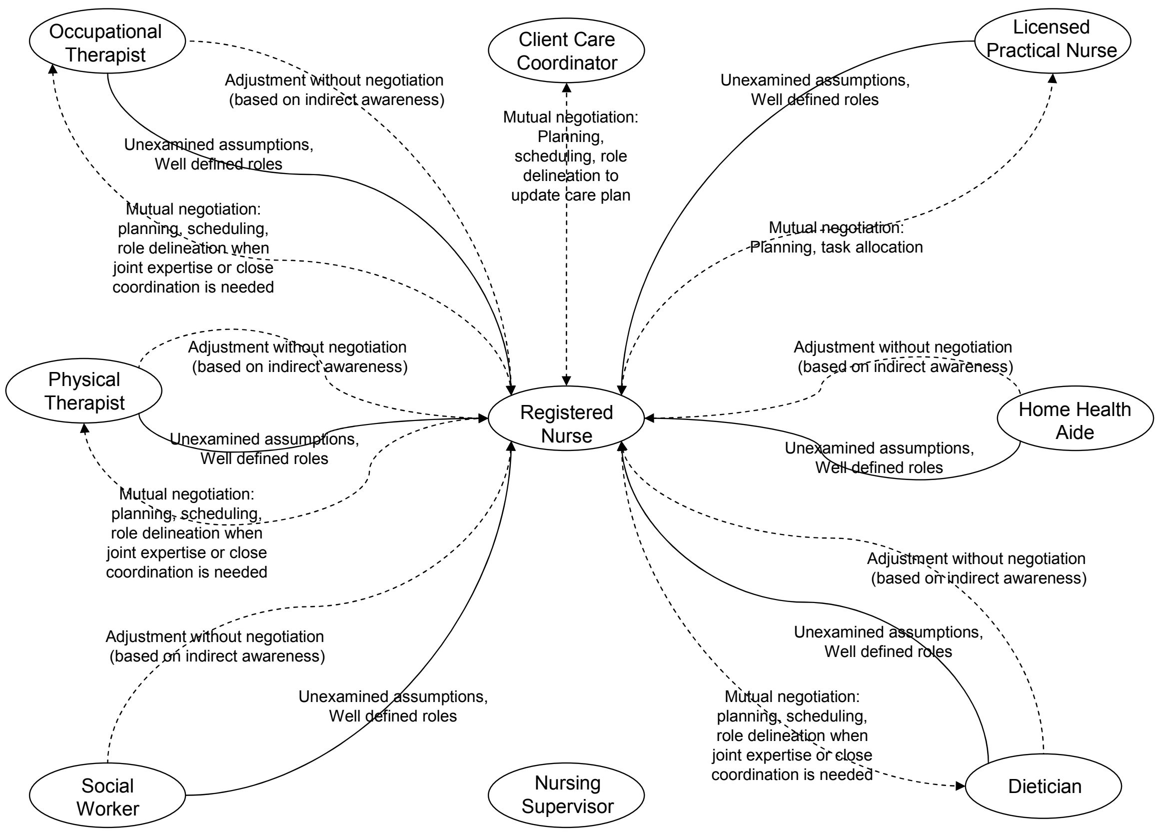


Figure 5.11. Coordination model for Registered Nurse. Each arrow shows a coordination strategy. Origin of the arrow indicates the role initiating coordination, and the arrow head points to role with which work is being coordinated.

5.3.4 Group task models

To develop software systems to support specific work processes, it is necessary to understand how real world tasks are sequenced so that appropriate design decisions can be made. Several researchers have considered how task analysis should be carried out to support system design (e.g. Diaper 1989; Richardson et al. 1998). However, most existing task analysis approaches are not appropriate for collaborative work situations, where work is divided between several individuals and is carried out in parallel. In loosely coupled situations this is not always a significant problem since much of the work that is carried out may in fact be handled individually rather than in close coordination with others.

The analysis approach outlined in this section does not propose a new technique for modeling tasks for design; rather, it suggests which existing task analysis approaches are appropriate in different situations. The two approaches discussed here are the Contextual Design sequence model (Beyer and Holtzblatt 1998) and Collaboration Usability Analysis (Pinelle, Gutwin, and Greenberg 2003).

Community C3 resources:
Voice mail, Office space, No email, Garman (information system) access

Intent: Assess a new client

Trigger: New client admitted to community (not from hospital)
↓
Call client and set up appointment
↓
Visit client in home
↓
Interview client / caregiver
↓
Record information on blank assessment form
↓
Discuss the need for community-based services
↓
Return to office
↓
Enter assessment into Garman (information system)
↓
Enter care plan into Garman
↓
Print assessment and care plan
↓
Enter case note into Garman
↓
Fax care plan / assessment to disciplines at RUH (OT, PT, SW) if necessary
↓
In Garman, forward care plan, assessment to home care if needed
(for Nursing, dietetics, HHA)
↓
Call to set up external services if needed (e.g. meals on wheels, adult day care)

Figure 5.12. Sequence model for home care Client Care Coordinator (C3) task: assess a new client. Arrows indicate the sequence of steps in the task.

The Contextual Design sequence model provides a high-level view of steps in tasks. The sequence begins with a trigger, which indicates the precipitating event that begins the task sequence, and is followed by a chain of steps that are needed to achieve the intended outcome. Figure 5.12 shows a sequence model for a client care coordinator in home care. The view shown in 5.12 represents individual work with little collaboration. In many cases, this level of analysis may be adequate for design needs since it gives a reasonable indication of how work is sequenced. However, when work is collaborative in nature, it is difficult to represent multi-person work using a sequence model approach. Notation is not included in the sequence model for collaborative aspects of work, and it is not clear how multiple workers' task sequences should be managed when tasks intertwine.

Collaboration Usability Analysis (CUA) is able to handle the cases that are not adequately addressed by the Contextual Design sequence model. CUA provides notation for modeling collaborative tasks and for showing how tasks are divided between different workers. The diagramming conventions are relatively extensive and are not discussed in detail here, but Figure 5.13 shows a sample CUA model for a collaborative home care task. Tasks are divided between two workers: a nurse and a case manager. In the diagram, a scenario is shown where a nurse discusses a patient and related documents with a case manager in an office setting. In the diagram, tasks are divided into collaborative task instantiations (CTI's) that specify how collaborative parts of the task are carried out, and individual task instantiations (ITI's) that specify how the individual parts of the task are carried out.

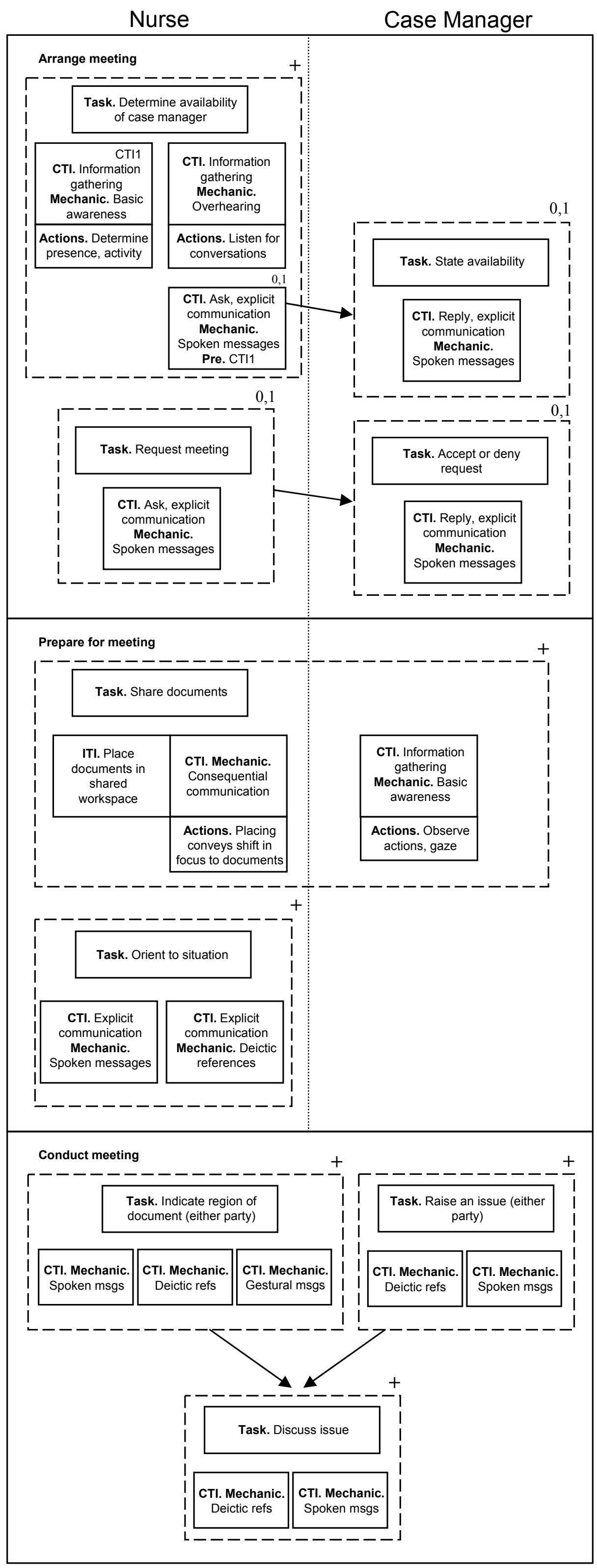


Figure 5.13. CUA results for “Discuss patient and document” scenario. CTI = collaborative task instantiation, ITI = individual task instantiation.

The level of effort, the level of needed detail, and the collaborative nature of tasks to be modeled will largely determine which analysis technique is most appropriate. Since loosely coupled work is often divided more cleanly between workers than is tightly coupled work, the sequence model may be appropriate for handling many of the task analysis needs. Collaboration Usability Analysis is likely more appropriate when collaborative aspects of work must be considered in detail. Table 5.1 provides a comparison between sequence models and CUA for modeling tasks in groups. The appropriateness of each technique will be dictated by the demands placed on designers, the task type, and the needed level of detail.

Table 5.1. Comparison between Contextual Design sequence models and CUA.

	Sequence model	CUA
Effort	Low	High
Detail	Low	High
Emphasis on collaboration	Low	High

5.3.5 Loose coupling checklist

Many of the factors that are important to groupware design for loose coupling are not easily diagrammed using modeling techniques. These factors are often complex and qualitative in nature, and span multiple levels in the organization. Analyzing and conveying these factors requires written descriptions of real world work and organizational features to understand how they will interact with a groupware design.

This section does not present a modeling technique per se, but instead it presents a "checklist" to help organize observational findings. The checklist is intended to be used in situations where loose coupling has been identified in a target workgroup. It is meant to guide ongoing observations and to help organize the interpretation of observational findings. Since factors that may be important to groupware design are not always readily apparent, it is meant to help draw the attention of designers to those areas that have been previously shown to be important in shaping loose coupling in social systems so that they will not be overlooked.

The checklist is based on the contextual model and is divided into two halves: reasons and outcomes (see Table 5.2). The reasons section covers underlying reasons that can lead to the adoption of loose coupling. The outcomes section covers outcomes that are associated with the adoption of loose coupling. Each of the sections is divided into sub-sections that indicate a particular organizational level. For example, the reasons section is divided into the following subsections: environment, organization, supervision, group, and worker. Each subsection in the checklist has a set of factors that are seen at that organizational level. For example, in the environment subsection of the reasons section, "incompatible external expectations" and "environmental uncertainty" are listed.

Table 5.2. Loose coupling checklist.

	Reasons	
Environment		
	Incompatible external expectations	
	Environmental uncertainty, complexity	
Organization		
	Size, complexity	
Supervision		
	Ambiguous evaluation criteria	
	Cryptic surveillance	
	Barriers to interaction	
Group		
	Internal conflicts	
	Size, complexity	
	Cryptic surveillance	
	Barriers to interaction	
	• Physical distribution	
	• Schedule variability	
	• Mobility	
	• Physical environment	
Worker		
	Professionalism	
	Knowledge specialization, expertise	
	Non-routine, unpredictable tasks	
	Outcomes	
Environment		
	Adaptability	
	Sensitivity to environmental stimuli	
Organization		
	Persistence	
	Buffering	
Supervision		
	Weak authority structure	
	Persistence	
Group		
	Partitioning of tasks	
	Information buffers	
	Buffering	
Performance		
	Effectiveness	
	Disjointed work processes	

5.4 Conclusion

The analysis technique is intended to act as a guide for designers so that the features of loosely coupled work will be considered in the design process. The models provide representations for presenting that information in a way that removes the complexities of raw data and ethnographic reports so that it can be more easily considered during the design process. The technique was developed from analysis and design work that was carried out in home care to develop the Mohoc groupware system, and it still needs to be evaluated in other loosely coupled work situations.

The technique is not intended to address all of the analysis needs of groupware designers. It focuses on areas of analysis that are relevant to loose coupling in social systems, so other more generic analysis techniques may be needed. For example, Contextual Design artifact models, physical models, and cultural models are useful in analyzing information from target work settings, but they are not covered here.

5.5 Summary of analysis technique

Table 5.3 provides a summary of the analysis technique.

Table 5.3. Summary of analysis technique

Model type	Purpose	Structure
Interaction model	Identify interaction patterns.	Frequency, flow, media, control, structure
Awareness model	Identify awareness patterns.	Frequency, flow, type, location or source
Coordination model	Identify coordination patterns.	Frequency, flow, type, control, circumstances
Group task model	Identify task sequences in collaborative and individual work.	Contextual Design sequence models, CUA models
Loose coupling checklist	Identify reasons and outcomes of loose coupled work practice.	Reasons: environment, organization, supervision, group, worker Outcomes: environment, organization, supervision, group, performance

6 Framework part 3: Design approaches

Groupware Design Process
1. Understand work practice in context
2. Analyze data and organize into useful forms
3. Design system to support work practice

The third and final part of the framework is a set of design approaches for developing groupware applications for loosely coupled groups. The underlying intent of this part is to help designers to translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups. The material presented in this chapter is based on CSCW and organizational research and on observations from home care.

The approaches presented in this chapter were developed to provide guidance in designing user-interface and interaction in groupware systems for loosely coupled situations. The approaches have implications for groupware system architectures, but technical issues are not explicitly addressed in the design approaches. Rather, they focus on supporting loosely coupled work in context, and on how support for individual and collaborative work should be provided to the target users. The design approaches are appropriate for design work on all versions of groupware systems, from low-fidelity prototypes to full implementations, and the approaches were developed with the assumption that they will be used after some analysis of the work setting has been completed.

The design approaches do not provide rigid guidelines for how design should be carried out for loosely coupled groups. Instead, each approach highlights a loose coupling characteristic outlined in both the contextual model and the analysis step, and presents a design recommendation that suggests how groupware systems should be designed to accommodate the characteristic. Each approach discusses the considerations and tradeoffs associated with using the approach and how variations in contextual factors can change how it should be implemented.

This chapter is divided into two main sections: general design strategies and specific design approaches. The general design strategies cover the general approaches that can be used in designing groupware for loosely coupled groups. These strategies only deal with high-level design issues and address whether groupware applications should support current loosely coupled work practices, or whether applications should support tighter coupling between group members. The second part of this chapter presents a series of design approaches that address user interface and interaction design issues that are central to design for loosely coupled groups. Nine approaches are presented, and each approach highlights a design issue that addresses a loose coupling characteristic outlined in both the contextual model and the analysis step.

6.1 General design strategies

The benefits and drawbacks associated with loose coupling in a given setting help determine the design strategies that are likely to be successful in supporting a workgroup. When significant benefits are realized through the adoption of loose coupling, systems that support the current collaboration patterns are likely to be well received. However, when loose coupling is adopted as the result of barriers to interaction and few benefits are gained, designs that shift the interaction style to a more tightly coupled arrangement may be more appropriate.

In the next sections, I discuss the implications that the issues outlined in the contextual model (and highlighted through the analysis step) can have in shaping the general design strategies used in developing groupware. These strategies refer to high level decisions that have implications for the system architecture and user interface design, but they do not provide a detailed discussion of how specific features should be designed in the system. First I discuss factors that make loose coupling a “good” or “bad” fit for a given group or organization, and then I discuss three general design strategies: 1) support tight coupling, 2) support loose coupling, and 3) support mixed coupling.

6.1.1 Is loose coupling "good" or "bad"?

The utility of the outcomes associated with the adoption of loose coupling depends on the specific circumstances confronted in a work situation (Scott 1987, p. 254). In some work settings, loose coupling may be well suited to the needs of workers, groups, and the organization (i.e. it is "good"). However, in other settings, it may not be conducive to meeting goals in an efficient and effective manner (i.e. it is "bad"). The mere presence of loose coupling, then, does not necessarily mean that designers should attempt to preserve that coupling style. When loose coupling is "bad", designs that partially or significantly shift to a more tightly coupled style of interaction may be most effective for supporting the workgroup.

One of the main advantages of loose coupling is that under certain circumstances, it allows social systems to achieve certain desired outcomes more effectively than more tightly coupled work arrangements. Loose coupling has been identified as an effective approach for achieving five types of outcomes. First, it is useful in reconciling incompatible expectations between external myths and operational units (Meyer and Rowan 1977; Scheid-Cook 1990). Second, it can help reconcile internal conflicts between administrative units and professionals who expect to function with significant autonomy (Kouzes and Mico 1979; DiTomaso 2001). Third, it is considered an effective approach for dealing with complex and unpredictable environments (Perrow 1999; Aldrich 1979). Fourth, since coordination, communication, and administrative oversight are usually minimized, it reduces the costs and difficulties required to coordinate work (Sanchez and Mahoney 1996; Scott 1987, p. 254; Weick 1976, p. 8). Fifth, recent research suggests that loosely coupling may foster innovation at the operational level (Damonpour 1987; Brusoni and Prencipe 2001).

While loose coupling can be beneficial in some organizations and in specific contexts, it can also lead to uncoordinated and disjointed work processes (Hasenfeld 1983, p. 158). Since coordination is often voluntary and at workers' discretion, interdependencies may not be managed effectively since organizational practices are not in place to guarantee strict cooperation between workers. Jones and Hinds (2002, pp.372-373) point out that when the level of interaction between collaborators is not adequate to address interdependence (as is seen in distributed work), work processes can be disjointed, and collaborators can fail to meet their goals. The relative benefits and drawbacks of loose coupling are largely determined by the organization, environment, tasks, and people that are found in any given work setting (Weick 1982).

To determine whether loose coupling is “bad”, designers must attempt to ascertain whether it is mismatched with the needs of the workers, the group, and the organization. Several factors have been identified in related literature that can indicate the need for a change in coupling style:

- The level of interdependence between workers demands more interaction than is currently seen (Jones and Hinds 2002).
- Work processes are disjoint and uncoordinated (Hasenfeld 1983, p. 158).
- Few beneficial outcomes result from the adoption of loose coupling (Weick 1976).

In Section 6.1.2, I briefly discuss how groupware applications can be designed to address these mismatches by changing group patterns to a more tightly coupled style of interaction.

When loose coupling is “good”, it enables workers, the group, and the organization to address their needs and to meet their goals in a reasonably effective and efficient manner. This compatibility between collaboration style and need can be seen through the following observations:

- Interdependence is minimal, and more interaction is not needed
- Workers are effective at carrying out their work activities
- Beneficial outcomes are gained through the adoption of loose coupling

In Section 6.1.3, I discuss how groupware applications can be designed to support loosely coupled work patterns. In Section 6.2, I discuss more specific design considerations.

In some workgroups, members carry out their work in a loosely coupled fashion but occasionally must shift to a more tightly coupled collaboration style. Edwards and Mynatt (1997) call this style of work “autonomous collaboration”, and they describe several scenarios where loosely coupled groups must work together more closely for brief periods. In Section 6.1.4, I briefly discuss how groupware applications can be designed for groups that need support for mixed coupling styles.

6.1.2 Support tight coupling

When loose coupling leads to undesirable outcomes and few significant benefits, or when interdependence demands more direct interaction, a groupware strategy that supports tighter coupling may be most appropriate. Shifting to a tightly coupled collaboration style means that the system will need to support the management of tighter interdependence along with more tightly integrated work processes. Managing increased integration and interdependence demands more extensive collaboration support than systems that are designed to support (rather than change) loosely coupled work styles.

Supporting tight coupling requires support for both tighter coordination and tighter communication. Communication channels should allow rapid response and should provide enough clarity for workers to manage a high level of interdependence (e.g. possibly voice or video rather than text messaging). Coordination support should enable a range of approaches, including planning, scheduling, mutual adjustment and negotiation. This may require the provision of detailed “awareness information” so that members can manage shared tasks, such as concurrent editing of shared documents or artifacts. Since rapid response times are often needed in managing higher levels interdependence, most groupware systems that facilitate tight coupling are synchronous (e.g. Rodenstein and Donath 2000; Streitz et al. 1994; Olson et al. 1993), but this is not necessarily a strict requirement.

6.1.3 Support loose coupling

When loose coupling allows the group and organization to meet their goals in an effective and efficient manner, a groupware strategy that supports loose coupling is most appropriate. Supporting loose coupling means supporting and augmenting current work processes through groupware design, but doing so in a way that does not significantly increase interdependence or integration. Designers should also carefully consider how the system will impact the benefits that are realized through the adoption of loose coupling. For example, will design decisions foster autonomy and flexibility, or will they compromise these?

Supporting loose coupling requires support for both loose coordination and loose communication. Communication channels do not necessarily need the level of richness required by tightly coupled groups, and there is usually a higher tolerance for communication delays. Coordination support should not increase interdependence and should not force additional effortful negotiation on the users. Groupware applications can support mutual adjustment without negotiation by providing each worker with information about other workers' activities that they can utilize in their own decision making processes. Since loosely coupled workers usually do not orient their schedules around each other, most communication and coordination support in these systems is usually asynchronous (e.g. Roseman and Greenberg 1996; Fuchs et al. 1995). In Section 6.2, I discuss design to support loose coupling in more detail.

6.1.4 Support mixed coupling

In some instances, it may be desirable to support combinations of tight and loose coupling to support variations in work style over time. Loosely coupled teams may need to work together in a tightly coupled fashion on occasion, and tightly coupled teams may partition work at times and carry out tasks autonomously. One of the more common ways this has been addressed is through supporting a tight and loose collaboration mode in applications (Schuckmann et al. 1999; Baecker et al. 1994). However, another potential means of achieving mixed support is to provide users with a variety of communication and coordination tools so that they can choose the ones that are most appropriate for a given situation.

In some instances, the type of mixed support that is needed may be dictated by that tasks that workers carry out. For example, Edwards and Mynatt (1997) describe scenarios where workers carry out work in a loosely coupled fashion, but occasionally work closely together to "integrate the disparate work done by collaborators" (p. 218). In this instance, a design that primarily supports loose coupling would be most appropriate, since this represents the predominant collaboration style. Support for the tightly coupled could focus on supporting those tasks that are required to allow successful completion of the integration step.

6.2 Specific design approaches

The work patterns seen in loosely coupled workgroups have implication for how groupware systems should be designed to support workers. Unlike more tightly coupled groups, work is primarily autonomous, and communication and coordination occur less often. These patterns suggest that designs should place more of an emphasis on features that support autonomous work, and should support direct collaboration, but only at the workers' discretion.

In this section, I consider how groupware applications should be designed to support loosely coupled groups. Unlike Section 6.1, this section presents specific design approaches that suggest how user interface design and interaction design should be handled. This section assumes that it is not the intent of designers to change the current loosely coupled work situation, but to support and augment the current style of work.

The approaches presented in this section were developed to provide guidance in designing user-interface and interaction in groupware systems for loosely coupled situations. They focus on supporting loosely coupled work in context, and on how support for individual and collaborative work should be provided to the target users. The design approaches are appropriate for design work on all versions of groupware systems, from low-fidelity prototypes to full implementations, and the approaches were developed with the assumption that they will be used after some analysis of the work setting has been completed.

The design approaches are intended to provide guidance in moving from the analysis phase to the design phase. They are not prescriptive in nature. Instead, each approach highlights a loose coupling characteristic outlined in both the contextual model and the analysis step, and presents a design recommendation that suggests how groupware systems should be designed to accommodate the characteristic. Each approach discusses the considerations and tradeoffs associated with using the approach and how variations in contextual factors can change how it should be implemented.

The design approaches were used in the design of Mohoc, a groupware system that was developed for home care treatment teams. Mohoc is discussed in detail in Chapter 7. Examples of how each design approach was implemented in the system are presented in Chapter 9.

In the next sections, I present the following nine approaches:

- Support autonomy and flexibility
- Consolidate information buffers
- Support individual workspaces and discretionary sharing
- Integrate collaboration with features for individual work
- Facilitate asynchronous awareness
- Support loose coordination
- Support loose communication channels
- Support shifts to tighter coupling
- Support flexible group organization

6.2.1 Support autonomy and flexibility

Since loosely coupled workers are autonomous, groupware designs should preserve that autonomy and the flexibility that it affords workers. Scott (1985) argues that "loosely joined structural elements are seen as highly adaptive to systems confronting heterogeneous, conflicting, and changing environments" (p. 603). Similarly, Orton and Weick (1990) see a fragmented external environment as a cause of loose coupling, and adaptability, which they describe as assimilation and accommodation of change, as one of the direct effects of loose coupling. Loose coupling is seen as affording more adaptability and flexibility in changing environments because individual subunits are more autonomous and are free to rapidly adjust to changes in their specific circumstances (Aldrich 1979), presumably without consulting others. Groupware systems designed for loose coupling should support current work practices without tightening interdependencies between workers, since this can reduce autonomy, professional discretion, and flexibility.

Supporting autonomy and flexibility in groupware means that the design should not constrain the current levels of discretion that are seen in work practice. Workers should be able to exercise autonomy in decision making without being forced into *explicit* collaboration with others. For example, designs that provide information that enhances autonomous decision making do not reduce autonomy, but extra steps that force negotiation can compromise autonomy.

When matching support for autonomy with the work patterns seen in a target group, the level of interdependence between workers must be evaluated along with any benefits that are gained through autonomy. If work interdependence demands more collaboration, workers may be more accepting of designs that force direct negotiation, although it is probably best left to the users to decide when tools that provide direct communication are needed. Also, when few beneficial outcomes are seen through autonomous work practices, more support for direct negotiation may be tolerated. However, in these cases, it is also possible that these designs may be seen as a threat to professional autonomy, and may be rejected.

6.2.2 Consolidate information buffers

As pointed out by Kmetz (1984), loosely coupled work can cause fragmentation of the information needed to support work activities across the locations where the work is carried out. These separate "information buffers" support the autonomous work activities that are carried out by each worker, so they are not usually accessible by others. For example, SHR workers maintain clinical notes, schedules, treatments plans, and other miscellanea such as phone numbers in paper folders that are not shared with other disciplines.

Since maintaining information buffers is part of work patterns seen in loose coupling, groupware systems can have a role in supporting these practices. These information maintenance practices provide a design opportunity to consolidate information that is fragmented across multiple locations, and to make it visible to other team members. Shifting select pieces of information from locally maintained information buffers to a merged repository has the potential to lower the threshold for maintaining awareness and coordinating work within teams.

Merging information buffers means that a groupware system should be designed to support individual information maintenance practices, but in a way that makes that select pieces of information accessible to others. Support for activities such as scheduling, maintaining documents, and tracking individual progress in tasks are all relevant here, since they support current individual work practice. Information from each worker's activities can be collected and automatically shared with others. This allows work practice to proceed without the addition of new tasks (i.e. workers already maintain the information), and increases mutual awareness without the need for direct interaction (i.e. workers can view others' information buffers or can choose to ignore them—direct negotiation is not forced by the design).

When information buffers are merged, workers may lose the ability to protect information that they are unwilling to share with the rest of the team. Therefore, the pieces of information that are shared by a groupware system need to be considered carefully since forced sharing may intrude unnecessarily on worker autonomy. For example, workers may be unwilling to share certain types of information since it may threaten their professional autonomy by making their work activities more transparent to others. Similarly, other types of information that are informally maintained (e.g. reminders, notes) may not be meant to viewed by others. Designers should carefully consider each piece of information in the workflow to decide whether it should be included in a merged information repository. This decision should also consider the benefit of sharing information—that is, whether placing a piece of information in the merged information repository will improve mutual awareness in a meaningful way, or whether it will clutter the shared space.

6.2.3 Support individual workspaces and discretionary sharing

Loosely coupled work is most often carried out autonomously, and with limited inspection from others. This lack of inspection can make it difficult for a worker to maintain an awareness of others' activities and to gauge progress toward goals. However, it can also have several benefits such as preserving professional discretion, enabling flexibility in managing the workday, and avoiding internal and external conflicts that arise from different priorities and perspectives.

When direct benefits are realized through reduced inspection, groupware applications designed for loosely coupled groups should allow workers to maintain portions of their work in individual workspaces. Individual workspaces enable work to be carried out locally, and the information maintained in the workspace is inaccessible to others. This allows workers to protect information that they are unwilling to share, such as personal annotations or incomplete results. When information maintained by a worker is shared with the rest of the team (into a "merged information buffer"), the sharing should be at the worker's discretion so that they can selectively protect information.

Providing workers with individual workspaces means that the groupware application supports different views of the global information space. Some information is fragmented and accessible only to the person who creates and maintains it (the individual workspace). Other information is in a shared space and accessible to the entire team (or possibly even to subsets of the team). At the design level, each user must be able to differentiate between these spaces, and functions need to be provided to allow workers to move information between them. For example, an incomplete report maintained in the individual space should be able to be moved into the shared space when it has been completed.

To implement a combination of shared and individual workspaces, decisions must be made about which pieces of information can be protected in an individual space and which pieces can be automatically shared. If sharing certain pieces of information compromises autonomy and discretion, that information should be maintained in an individual workspace, and workers should be given the option to share it if they feel it is appropriate. Workers may be more willing to share other less sensitive pieces of information with others. In these cases, the system can automatically move that information into the shared workspace.

6.2.4 Integrate collaboration with features for individual work

Since loosely coupled work is often organized to reduce collaboration, groupware designers should not overemphasize the importance of communication and coordination features in design. Grudin (1994) states that when organizations are structured to reduce collaboration, collaborative features will be better received if they are integrated with features that support individual work. Furthermore, he suggests that when collaborative features are added, they should be unobtrusive and should not interfere with workers' abilities to utilize other more frequently used features.

Several approaches can be taken in unobtrusively integrating collaboration features with individual work tools. First, information to support mutual awareness of others' activities can be discretely visualized in individual work tools. This information can help to augment individual work by allowing workers to consider others' actions in their decision making processes. Second, explicit communication and coordination tools can be physically placed next to the artifacts where the collaboration will take place. This physical closeness can enable what Fitzpatrick (2000) calls "conversations about the work at the point of work" so that the context can be preserved. Third, interaction techniques for collaborative features can be unobtrusive so that workers can selectively use or ignore them.

6.2.5 Facilitate asynchronous awareness

Loosely coupled workers need to stay aware of others' activities so that they can identify situations where tighter coupling (i.e. more communication, coordination) is needed (Baker 2002; Olson and Teasley 1996). Much of the research on the provision of awareness information focuses on awareness in synchronous applications (e.g. Dourish and Belotti 1992; Gutwin and Greenberg 1999; Dourish and Bly 1992; Gutwin et al. 1996). However, Edwards and Mynatt (1997) argue that synchronous awareness techniques are not appropriate for loose coupling. Instead, they suggest using asynchronous awareness approaches. Asynchronous awareness has been described as awareness information that persists over time so that it is available to accommodate varied schedules and autonomous work patterns (Neuwirth et al. 1998; Pankoke-Babatz and Syri 1997; Fuchs et al. 1995; Preguiça et al. 2000).

Asynchronous awareness can be supported by tracking each user's interactions with the shared workspace and then making that information available to other team members. Since this information is asynchronous, information about others' actions may be stored and displayed as interaction histories so that each user can interpret others' activities (Edwards and Mynatt 1997). Examples of the types of information that might be maintained are histories of artifact accesses, histories of artifact modifications, or histories of system logins.

Since asynchronous awareness support is limited to work done in the groupware application, it does not necessarily impact real-world work practices significantly. However, when important tasks from the real world are supported in the application, and awareness is available about progress on completing work, the implications of increased surveillance and evaluation need to be considered. For example, the addition of asynchronous awareness information may allow supervisors to monitor work in ways that they were unable to prior to introduction of the technology, which may not be well received by autonomous workers.

6.2.6 Support loose coordination

Since regular communication channels are not always present in loosely coupled work, and since workers may have limited awareness of others, coordinating work can be difficult. While the general autonomy of workers means tight coordination is not usually necessary, even loose interdependencies may make it necessary for group members to coordinate their activities at times. Groupware systems can help support this loose coordination, where minimal effort and minimal direct negotiation is needed by the users.

In groupware designs, coordination mechanisms for loose coupling ideally will require little effort on the part of users. Perhaps the best way of accomplishing this is by allowing workers to mutually adjust to others' activities without the need for direct negotiation. This type of support requires that the system provide information about the points of interdependence between the team members. For example, several pieces of relevant information might be: the status of the shared project, progress made toward goals, current plans, and expected timelines. If this information is already maintained by each worker, it can be shared in the application to allow workers to adjust to others' actions without the need for explicit communication.

The considerations in the type of coordination supported in a groupware application and the level of effort required by workers are similar to those seen in the real-world. Figure 6.1, previously introduced in Chapter 4, provides an overview of coordination techniques by level of effort required. Coordination that relies on unexamined assumptions requires no support at all in a groupware application. Low level awareness of others' activities is the lowest cost representation that can be supported, with support for planning, scheduling, and mutual negotiation requiring more effort on the part of the users. It should be noted, however, that even though higher cost coordination mechanisms may not be used regularly, there may be instances where this type of support may be needed (see Section 6.2.8 for more detail).

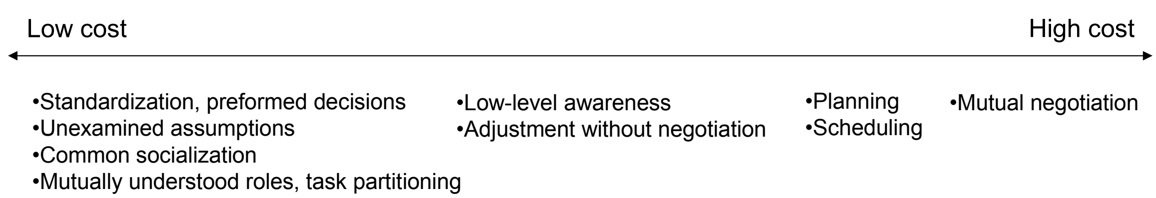


Figure 6.1. Coordination strategies

6.2.7 Support loose communication channels

One of the side effects of loose coupling is that workers may not have well-established communication channels, and purposeful explicit communication can be difficult to initiate. The decreased incidence of communication is not necessarily a problem given the reduced interdependence seen between workers. However, the level of effort required to initiate communication when it is needed can be a problem, since workers may have to deal with uncertainty about others' locations, availabilities, and schedules. Therefore, when designing groupware systems the goal should not necessarily be to increase the amount of communication that occurs between loosely coupled workers, but to lower the amount of effort that is required to initiate communication when it is needed.

Communication support for loosely coupled groups should consider the required timeliness of responses by collaborators and the degree of richness that is needed in communication channels to effectively convey meaning and repair ambiguities. According to the contextual model, requirements for timely response are often relaxed in loose coupling, so asynchronous communication tools may be well suited to users' needs, and can afford needed flexibility in managing divergent schedules between sender and receiver. The level of required communication richness may also be more minimal in the groups, so text communication channels may be appropriate for meeting workers' needs (contrasted with, e.g. audio and video channels).

Asynchronous communication tools can enable a relatively loose style of communication in groupware applications. Asynchronous messaging, such as is seen in email and voice mail, allows the sender to leave a message for a recipient, and the recipient can retrieve the message whenever it suits their schedule. This has a low cost to the sender and recipient alike. The sender does not have to determine the recipient's location, and the expectation for an immediate response is relaxed, so the recipient is not forced to alter their schedule to attend to the message. In groupware systems, asynchronous communication can be varied, and can consist of video, audio, or text messages presented in different user interface representations and using a range of interaction techniques.

6.2.8 Support shifts to tighter coupling

Even when workers work together in a loosely coupled fashion, situations may arise that require temporary shifts to tight coupling, and groupware systems should support these shifts. For example, Olson and Teasley (1996, p. 422) report that in their observations of a design team, when conflicts surfaced, loosely coupled work would become more tightly coupled to enable negotiation, clarification, discussion, and agreement. Sakamoto and Kuwana (1993) argue more generally that both types of communication channels are important in cooperative work, and that group tools should support both modes of collaboration. Mandviwalla and Olfman (1994, p. 256) suggest that groupware should support periods of interaction and periods of no interaction.

Support for tighter coupling can be handled in two ways: support for direct collaboration within the application or support for arranging direct collaboration in the real world. Support for direct tightly coupled collaboration in groupware is usually synchronous, with real-time feedback about others' activities and real-time communication channels (e.g. Olson et al. 1993; Streitz et al. 1994). While this style may work well on some occasions in loosely coupled groups, it constrains users' schedules since they have to be present at their computers at the same time to collaborate, and usually opens their work to fine-grained inspection by others, which may impinge on their autonomy. In some cases, it may be more useful to support a smaller subset of "tight collaboration" in an application. For example, a real-time communication tool could be used only when needed and without dramatically altering normal work practices. Other task-specific tools may fit the expected needs of groups without negatively impacting workflow, such as a tightly coupled tool for planning and allocating tasks.

Groupware can also play a role in helping to arrange direct collaboration through other media. By making information available to team members about others' schedules, locations, and availabilities, it becomes possible to determine when face-to-face meetings can occur and when others' are reachable by phone. However, sharing this information makes work open to more inspection by others, and its impact on worker autonomy must be carefully assessed.

6.2.9 Preserve flexible group organization

Loosely coupled workers are often able to decide their level of involvement in collaborative situations. For example, in home care, workers' determine their own levels of involvement with each patient, and that level often changes over time. When participation levels are self-directed, it can be difficult to have knowledge of others' level of involvement in the group. However, this knowledge is needed in many collaborative activities in order for workers to determine with whom they should communicate and coordinate activities.

Groupware designs for loose coupling should allow workers to determine their level of involvement in collaborative situations. Workers should have the flexibility to determine how involved they want to be in a given group. When different levels of involvement require different types of support from the system, it should be provided (e.g. home care workers have three different types of team involvement: active member, inactive members, and past members). Additionally, systems should provide group members with information about others' level of involvement with the group so that they can coordinate their activities more effectively.

Groupware systems that are designed to support flexible group organization should allow workers the flexibility to determine how involved they will be in a group, and should convey that level of involvement to others. For example, if workers are only involved at a low-level, support for monitoring should be provided where they do not need to interact with others using the system. If there are well-defined levels of participation seen in the group, explicit support for those levels in the system may be warranted. Otherwise the best approach may be to allow workers complete flexibility in determining which system-supported tasks they engage in. The system should convey the level of involvement to others. It may be valuable for group members to know, for example, who is in the group, who has been a previous member of the group, how involved current group members are in the group, and when a group member last accessed the system.

6.3 Summary of design approaches

Table 6.1 provides a summary of the design approaches.

Table 6.1. Summary of design approaches

Design approach	Description
Support autonomy and flexibility	Support current work practices without tightening interdependence between workers since this can reduce autonomy, professional discretion, and flexibility
Consolidate information buffers	Shift select pieces of information from locally maintained information buffers to a merged repository to help improve coordination and awareness of real-world activities.
Support individual workspaces and discretionary sharing	When information maintained by a worker is shared with the rest of the team, the sharing should be at the worker's discretion so that they can selectively protect information.
Integrate collaboration with features for individual work	Support for collaboration should be integrated with features that support individual work. Collaborative features should be unobtrusive and should not interfere with workers' abilities to utilize other more frequently used features.
Facilitate asynchronous awareness	Support awareness of the activities that others carry out in the groupware system. Awareness representations should persist over time to accommodate varied schedules and autonomous work patterns.
Support loose coordination	Support loose coordination, where minimal effort and minimal direct negotiation is needed by the users.
Support loose communication	Provide support that lowers the amount of effort that is required to initiate communication.
Support shifts to tighter coupling	Support periods of direct interaction and periods of no interaction. Support for tighter coupling can be handled in two ways: support for direct communication within the application and//or support for arranging direct communication in the real world.
Preserve flexible group organization	Allow workers to determine their level of involvement in collaborative situations. They should have the flexibility to determine how involved they want to be in a given group, and involvement levels should be conveyed to others.

7 Prototypes and groupware system

The framework was used to design a groupware system to support home care treatment teams in Saskatoon Health Region. The design work progressed through several phases, beginning with observing and analyzing real world work patterns in SHR, and progressing to a low-fidelity prototyping stage. The prototypes were evaluated by carrying out walkthroughs with home care workers, and were then implemented as Mohoc, a groupware system that uses laptop clients. Later, Pocket Mohoc, a Pocket PC client for home health aides, was designed and implemented.

In the next sections, the different stages of design work will be discussed. The chapter is divided into the following sections:

- General design strategy
- Analysis of home care work practice
- Low-fidelity prototypes
- Mohoc: a laptop-based groupware system
- Pocket Mohoc: a pocket-pc groupware client

7.1 General design strategy

The introduction of groupware systems changes users' work patterns. These changes are usually intended to provide some type of benefit to the target groups in order to make their investment in the new technology worthwhile, such as improved efficiency or effectiveness in carrying out work tasks. However, if the system changes work patterns too significantly, the design may be rejected. According to Beyer and Holtzblatt (1998),

> A good design provides an optimal match between the users' current way of working and the work practice introduced by the new system; it changes the work enough to make it more efficient but not so much that people cannot make the transition. Innovative designs that succeed are those that offer new ways of

> working and new advantages while maintaining enough continuity with people's existing work that they can make the transition. (p. 8)

Mohoc was designed to improve collaboration in treatment teams. It was intended to improve communication and work coordination by allowing users to exchange information along channels that do not currently exist in the home care setting.

Rather than forcing a significant revision in work practice, Mohoc was designed to support the current loosely coupled work style seen in home care teams. Chapter 6 provides a discussion of whether designs should attempt to change coupling styles in groups. The Mohoc design supported loose coupling because of several factors found in treatment teams:

- Interdependence is low and does not require ongoing communication
- Workers are usually effective at carrying out their work activities, although work processes are occasionally uncoordinated
- Beneficial outcomes are realized as a result of loose coupling (e.g. flexibility, preservation of professional autonomy)

The design process considers how work practice can be improved by introducing software, but it is also worth considering what improvements can be made in existing work practices *prior to* the introduction of software. In home care, many of the breakdowns that are seen are also found in other home care settings (Warner 1996; Neal 1997; Benefield 1996), and are the result of the constraints of the domain, and therefore are not easily changed. For example, all home care workers are mobile, most are professionals, and they usually maintain significant discretion in managing their work due to factors such as environmental uncertainty and the confidentiality of the professional-patient relationship.

Some of the collaboration breakdowns that were found in observations are partially the result of the current work arrangement in SHR. For example, since workers are divided between separate office sites, opportunities for communication between team members are reduced. It is likely that moving all departments that deliver home care services into a single shared building would increase opportunities for collaboration within teams. However, this would only be a partial solution to the collaboration breakdowns since mobility and schedule variability still make it difficult for team members to communicate and coordinate work.

7.2 Analysis of home care work practice

The data from home care observations and interviews (discussed in Chapter 3) were analyzed in preparation for system design. Several design methods were used including Contextual Design work models (Beyer and Holtzblatt, 1998), Collaboration Usability Analysis (Pinelle, Gutwin, and Greenberg 2003), and the contextual model.

Contextual Design work models were used to model task sequences, workflows, collaboration patterns, and breakdowns in the treatment teams (see Chapter 5 for a discussion of Contextual Design). The following models were used: sequence models, flow models, and artifact models. Sample sequence models and flow models are included in Appendix A.

Collaboration Usability Analysis was used to analyze a small number of the home care tasks. CUA models collaborative tasks at a fine level of granularity, and it was only needed in a few instances. Chapter 5 discusses CUA in detail and provides a sample CUA model from home care.

The contextual model was used to help organize the findings from home care, and to identify aspects of loosely coupled work that should be considered in design. It was used to help incorporate consideration of factors outlined in the model into the analysis and design process. These included: reasons for loose coupling, outcomes of loose coupling, communication patterns, coordination patterns, and information utilization patterns.

The analysis technique was developed from the approaches that were used to analyze home care work practice. The technique was based on Contextual Design work models, Collaboration Usability Analysis, and the contextual model. It also includes consideration for other factors that were shown to be important during design work in home care, including coordination, communication, and awareness patterns. The analysis technique is discussed in detail in Chapter 5.

7.3 Low-fidelity prototypes

Low-fidelity prototypes of a groupware system for home care teams were developed using the design approaches (reported in Chapter 6) and the results of the analysis step (Section 7.2). Early prototype work focused on developing designs that would support the major home care tasks, and that would arrange those tasks in a logical way that would fit into workers' daily workflows. The design needed to be general enough to accommodate all treatment team members in a reasonable way, regardless of their discipline. Design work was based on the models that were developed in the analysis step, and focused on matching support with real-world work patterns, with developing low-cost support for coordination between team members, and with providing opportunities for communication between team members.

Once prototypes progressed to the point that the major features had been defined, walkthroughs of the prototypes were carried out with home care clinicians. Eight different walkthrough sessions were carried out, one with a member of each discipline. During each walkthrough session, the participant was presented with the paper prototypes and was oriented to the user interface and to the tasks that were supported by the design. Each participant was then asked to simulate common home care tasks using the prototypes (e.g. "How would you use the prototype to set an appointment with this patient?", "How would you create a progress note using the prototype?"). As participants indicated their actions, the interviewer placed dialogs and other indicators on the prototype to provide feedback on how the system would react to their actions (see Figure 7.1). When participants had difficulties carrying out tasks with the system, the interviewer discussed the problems with the participant in an effort to identify how the design could be improved so that it would be more intuitive for the target users. Appendix B provides a list of tasks that were used during the walkthroughs.

After each walkthrough, prototypes were revised to resolve design problems. There was a total of eight walkthrough sessions, and each lasted from 1 to 1 ½ hours and was conducted at the participant's desk or in a meeting room at the downtown home care office. Sessions were audiotaped for later analysis. Participants were selected by CAU and Home Care managers, and by seniors from Social Work, Occupational Therapy, and Physical Therapy.

After carrying out walkthroughs with the clinicians, the prototypes were reviewed with home care managers in an effort to address larger organizational considerations. The final result of this step was a set of prototypes that were ready to be implemented as a full groupware system.

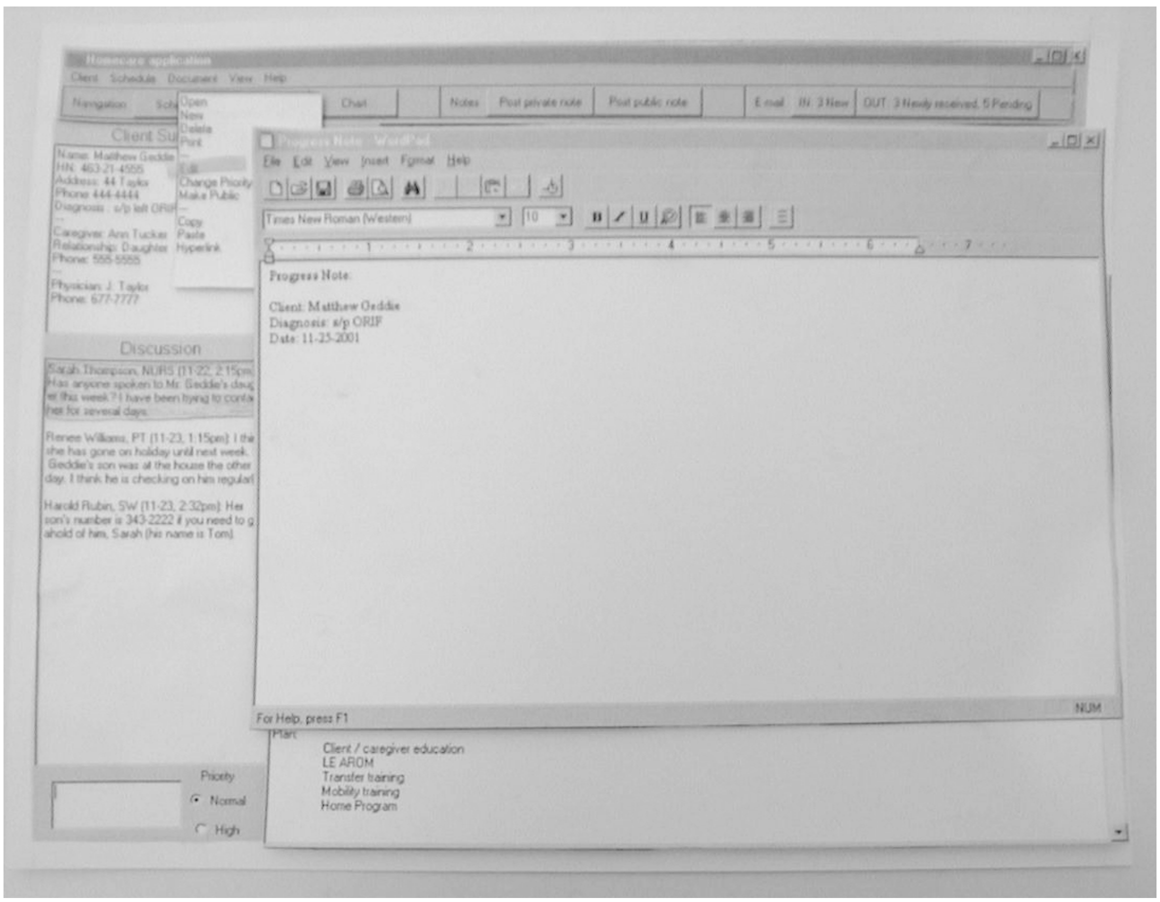


Figure 7.1. Paper prototype

7.4 Mohoc: a laptop-based groupware system

The low fidelity prototypes were implemented as a full groupware system. The system, called Mohoc, is a mobile groupware application that was developed to support community-based home care workers. The system was developed to be deployed on laptops that workers carry with them in the field so that the system is accessible in a variety of locations such as patients' homes, the office, and workers' cars. It supports workers in carrying out common work activities, including scheduling, paperwork, and treatment planning. Each worker enters information into the system during the day and that information is automatically routed through a central server and to other members of the treatment team. This approach allows workers to maintain an awareness of others' activities and to pass explicitly created communications to other members of treatment teams.

7.4.1 Technical overview

Since home care workers are mobile and maintain different schedules, the Mohoc system was developed to support asynchronous distributed collaboration. The system utilizes the wide area wireless network technologies that were available at the time of development. The system uses a client-server model (see Figure 7.2), and client-server communication relies on a low bandwidth CDPD (cellular digital packet data) network (19.2 kb/sec max; 11kb/sec max observed) that has frequent and unpredictable disconnections.

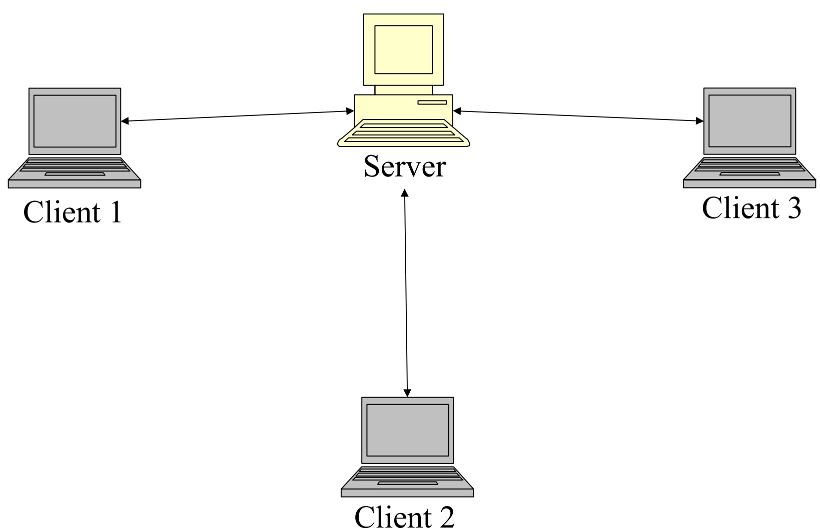


Figure 7.2. Mohoc client server model. All transactions between clients pass through a central server.

The client platforms are laptops that home care workers carry with them during the workday. Each laptop has a Sierra Wireless Aircard modem that enables access the

CDPD network, 1024 by 768 screen resolution, a 20 megabyte hard drive, 1 gigahertz processor speed, and 128 megabyte RAM memory.

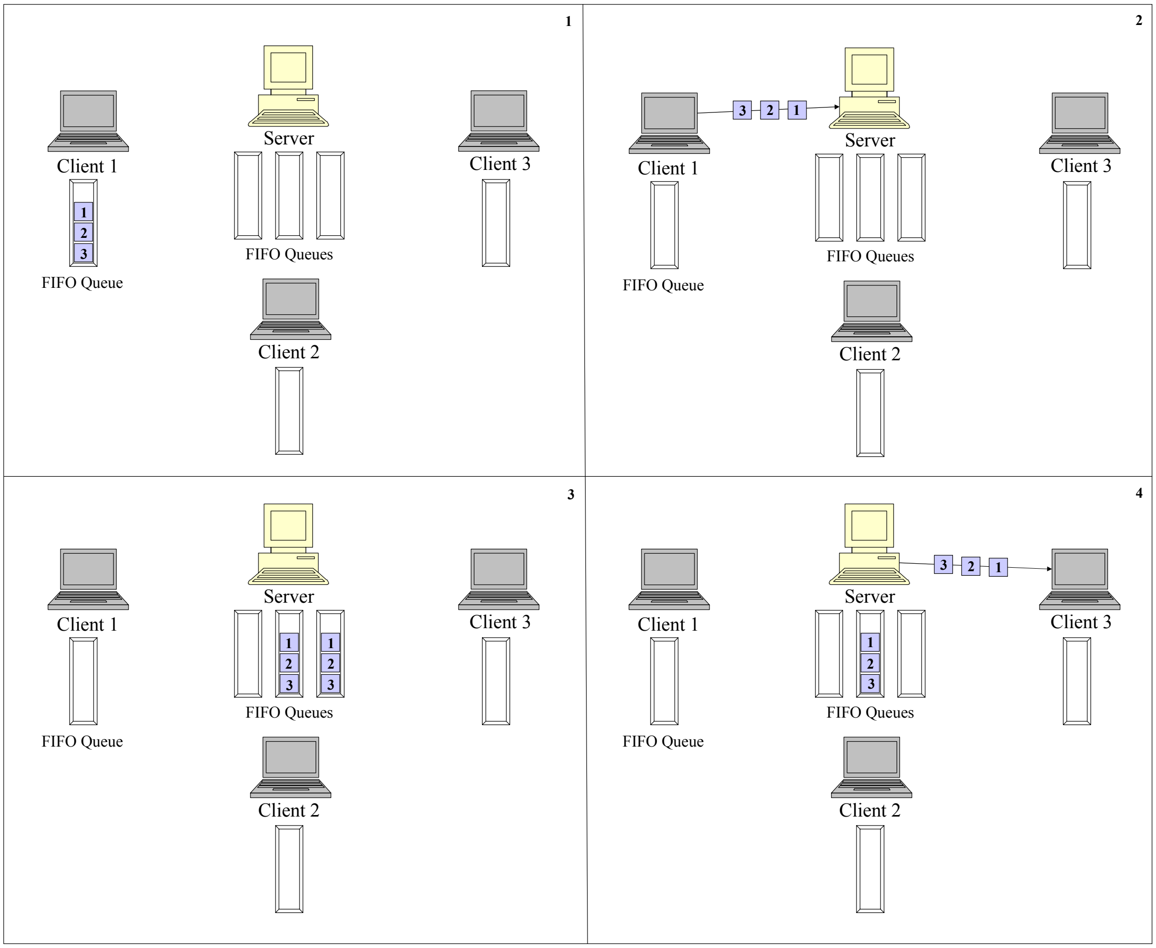


Figure 7.3. Mohoc store and forward approach. Panel 1: Client 1 creates transactions while not connected to Server and transactions are enqueued. Panel 2: A network connection becomes available and transactions are forwarded to Server. Panel 3: Server enqueues transactions in FIFO queues for Client 2 and Client 3. Panel 4: A network connection becomes available to Client 3, and Server dequeues and sends messages. Note: the figure does not show the confirmation transactions that are used to guarantee that messages arrive.

The Mohoc server maintains a master copy of all data in the system, and replicated data views are stored locally on laptops for use by each worker. All messages sent between workers are sent through the server (see Figure 7.2), which reduces the effects of disconnections by allowing messages to be sent between workers even though they might not be online at the same time. When a worker's actions require a message to be sent, it cannot be assumed that a connection to the server will be available. To handle this, outgoing messages are stored in a reliable message queue on the laptop's hard drive and are not dequeued until they are confirmed as received by the server. This allows workers' laptops to maintain outgoing messages if the system is turned off or in the event of a system crash, and the queue is FIFO (first in, first out), so it guarantees that transactions are transmitted to the server in the order that they are carried out. The server uses the same queuing method to send messages to workers' laptops (see Figure 7.3).

Mohoc was developed using Java 1.4.0, and took over a year of development work. It has a complex data model that mirrors real-world home care work arrangements, and that incorporates data items to support work practices from all disciplines (see Figures 7.4, 7.5). The data model was specified using XML DTDs that map to Java business logic classes. All data generated during patient treatments are stored on client and server machines as XML files.

The GUI is implemented using standard Java API's and interaction techniques. Most of the interface is implemented using Java Swing and AWT toolkits, with standard GUI widgets. Java drag and drop support is also utilized, as are customized, transparent widgets.

7.4.2 Data model

The Mohoc data model was based on the work patterns and information requirements of home care clinicians. The model is specified using twelve XML DTDs that include information about home care workers, clients, documents, and communications pertaining to specific clients. The model has three core DTDs: worker, client, and chart. The remaining nine accessory DTDs specify content that is contained in them. In the next two sections, I briefly discuss the core and accessory DTDs. Appendix A provides detailed diagrams that show the relationships between DTDs and the data elements that are contained in them.

7.4.2.1 Core DTDs

The worker DTD specifies the profile of a home care clinician. Each home care clinician typically has a number of clients that they regularly treat. This group of clients is part of a worker's caseload, and the worker is responsible for monitoring developments concerning each client's health, functional status, and home situation. Figure 7.4 (left) shows the relationship between the worker and client DTDs. In the figure, the worker has four clients on their caseload.

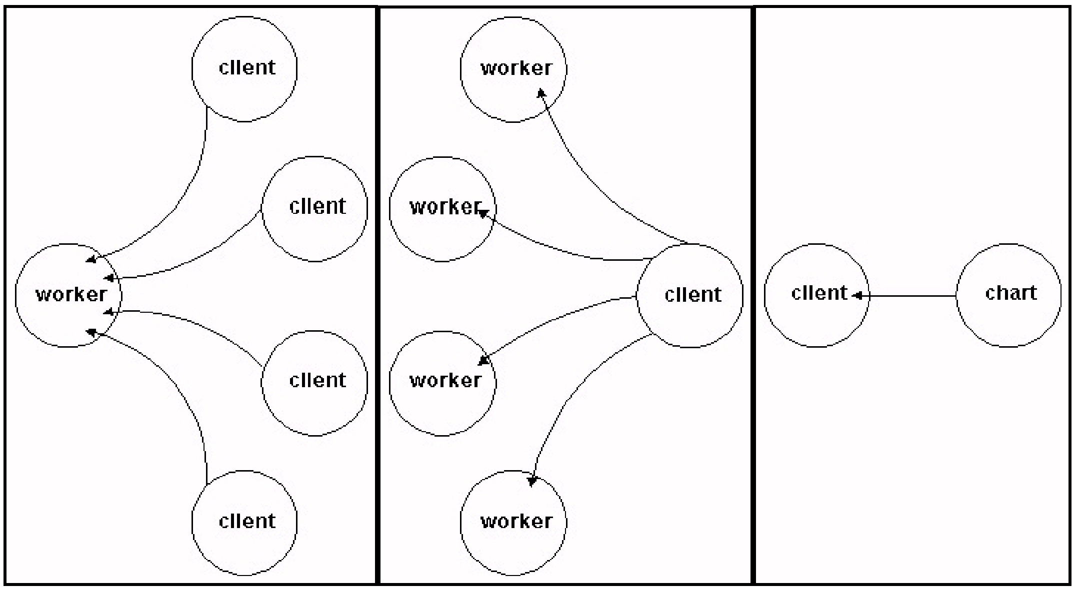


Figure 7.4. Relationships between core DTDs

More than one worker can have a given client on their caseload. This typically occurs when a client receives services from several disciplines. For example, a client might receive services from a nurse, an occupational therapist, and a home health aide, all of whom have the client on their individual caseloads. These workers represent the client's treatment team. This relationship is seen in Figure 7.4 (center). In the figure, four workers have the client on their caseload.

The collection of information that is maintained in the system for a given patient represents that patient's chart. In current home care work practice, that information is fragmented into separate information buffers. However, this information can be maintained in a single repository within the data model. The chart in the data model contains all of the documents that are supported by the system, and it also includes data elements to support collaboration within the treatment team. It contains explicit communication structures as well as awareness structures to log workers' interactions with the chart so that each team member will have knowledge of others' activities. Figure 7.4 (right) shows the one-to-one relationship between the client and chart DTDs.

7.4.2.2 Accessory DTDs

Figure 7.5 shows the relationships between the twelve DTDs in the model. The nine DTDs that are not part of the model's core are children of the core DTD.

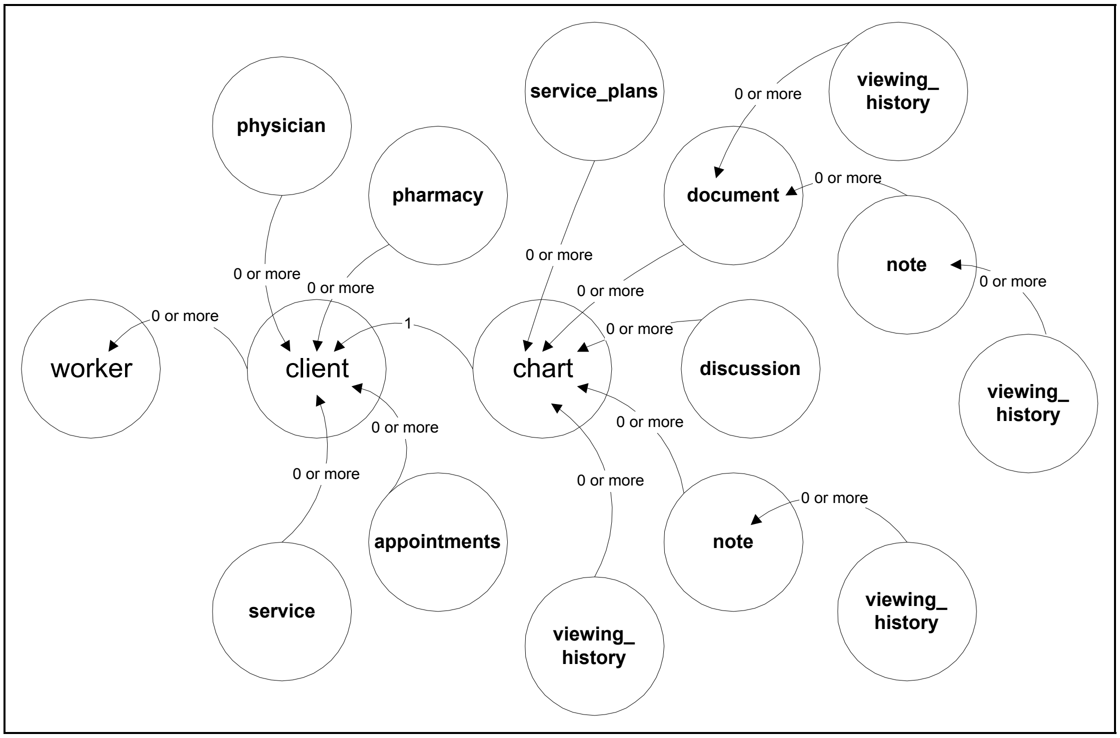


Figure 7.5. Overview of the Mohoc data model

The worker DTD specifies a profile for a home care clinician. It contains elements that specify the worker's name, profession (discipline and professional designation), and contact information (phone number, voicemail number, pager number, and email address). The DTD also specifies the worker's caseload, which contains IDs for clients.

The data elements in the client DTD provide general information about a home care client including name, birth date, sex, marital status, and diagnoses. The DTD also includes elements that describe the locations where the client receives home care services, including the address, phone numbers, neighborhood, and driving directions to the location.

The client DTD has five accessory DTDs: physician, pharmacy, service, appointments, and chart. The physician DTD contains basic information about a physician that treats the client. The pharmacy DTD has information about a pharmacy that is used by the client. The appointments DTD specifies all appointments a client has with a given home care worker. The service DTD includes information about a single type of home care service a client is receiving or has received. The chart DTD holds documents, communications, and awareness information related to a client.

The chart DTD has five accessory DTDs: document, note, discussion, service plan, and viewing history. The document DTD defines a single clinical document such as an assessment, progress note, or discharge summary. The note DTD defines a sticky note (i.e. a text message) that can be attached to clinical documents and to charts. The discussion DTD defines a single entry in an ongoing multi-person discussion. The service plan DTD contains information about the services that a clinical discipline provides to the client. The viewing history DTD contains information about when specific users have accessed shared artifacts. In the data model, viewing histories are attached to documents, notes, and charts.

7.4.3 Data policies

Mohoc's data management policies are based on the work practices of home care treatment teams. In the next sections, four policies are discussed: data and replication transparency, artifact ownership, asynchronous awareness transactions, and transaction guarantees.

7.4.3.1 Transparency

Mohoc uses connection and data replication transparency (e.g. Ebling et al. 2002; Terry et al. 1998). The workers are not aware of the status of their connection or of the status of other workers' connections. They are also unaware of the messages in the queues and of how up-to-date the information is that is stored on their laptop. Since the system automatically attempts to negotiate a network connection, and since the client and server automatically transmit messages when a connection is available, providing this information is not required. Also, it was felt that information about network status and data replication was not central to the concepts being investigated in this research, and adding that information to the user interface would force technical details on the workers, most of whom have limited experience with computers, networks, and client/server architectures.

7.4.3.2 Artifact ownership

Home care team members have clear ownership of the artifacts that they use in their work. Each worker "owns" their schedules, paperwork, and treatment plans—they maintain them in separate information buffers, and do not have to share them with other treatment team members. This means that others do not have permission to edit those artifacts unless the patient is shared by two workers from the same discipline. Even when this is the case, that sharing takes place sequentially—workers work opposite shifts, or on different days. This makes concurrent editing highly unlikely.

The clear ownership of artifacts seen in home care allowed editing and access privileges to be handled using simple permission policies in Mohoc. Unlike other types of groupware (as discussed in Munson and Dewan 1996), real-time updates were not needed to the shared workspace and strategies such as locking for editing were not necessary. Each worker has exclusive privileges for editing their appointments and their worker profile. Other editable items such as documents and service plans are editable by members of the author's discipline. Since parallel editing does not normally occur in practice, no special policies were needed to protect against divergent versions.

7.4.3.3 Asynchronous awareness transactions

Mohoc automatically collects information about users' interactions with the system and shares that information with other treatment team members. This does not require explicit intent on the part of the user to share information—the system tracks when a user views a shared artifact and when they modify a shared artifact and transparently passes that information on to other treatment team members. This information is intended to improve users' awareness of others' activities, but since the system is asynchronous, these updates do not normally occur in real time. Instead, the system tracks modification *histories* and viewing *histories* so that others can determine when and where others' actions occurred in the system since they are not usually able to see them unfold in the user interface.

7.4.3.4 Transaction guarantees

In the Mohoc data model, dependencies exist between data elements. For example, viewing histories are attached to documents that are contained in a chart that is associated with a client. These dependencies make the order of transaction and transaction guarantees important in the system design. For example, if a note is attached to a specific clinical document, it is essential that the clinical document arrive prior to the arrival of the note. In Mohoc, dependencies are handled using FIFO message queues and message acknowledgements. Since the message queues are first-in-first-out, all messages cross the network in the order that they were carried out, so artifacts will not be able to precede their parent in crossing the network. Data dependencies are also handled using acknowledgements that are sent by machines when they receive a transaction. A message is not dequeued from the sending machine until it has first been acknowledged by the receiving machine.

7.4.4 Interaction and user interface design

Mohoc was designed to support the work activities that are commonly carried out by community-based home care workers. The user interface supports several distinct activities. First, it supports the worker in planning their daily visits. Second, it supports the worker during their workday by presenting a detailed daily agenda that can be revised as the workday unfolds. Third, it supports paperwork activities related to treating patients. Collaboration support is provided as an adjunct to these autonomous work activities.

In the next sections, I provide an overview of the three major user-interface screens that are available in Mohoc: the schedule view, the daily agenda view, and the chart view. Home care workers can navigate between these screens to select the one that suits their current work activities. Additionally, I discuss two other areas of support—sticky notes, and awareness indicators. Sticky notes allow workers to leave messages for each other in shared workspaces, and awareness indicators help facilitate low-cost awareness of others' activities.

7.4.4.1 Schedule view

The schedule view supports workers in planning their workday and workweek. It supports current scheduling activities, which include: specifying appointments with a given patient; specifying the services that will be delivered during a given appointment; and modifying time, date, duration, and services. The top half of the screen (marked "Caseload") shows a list of all of the patients that the worker currently treats. The bottom half of the screen, marked "Schedule", shows the worker's weekly schedule (see Figure 7.6).

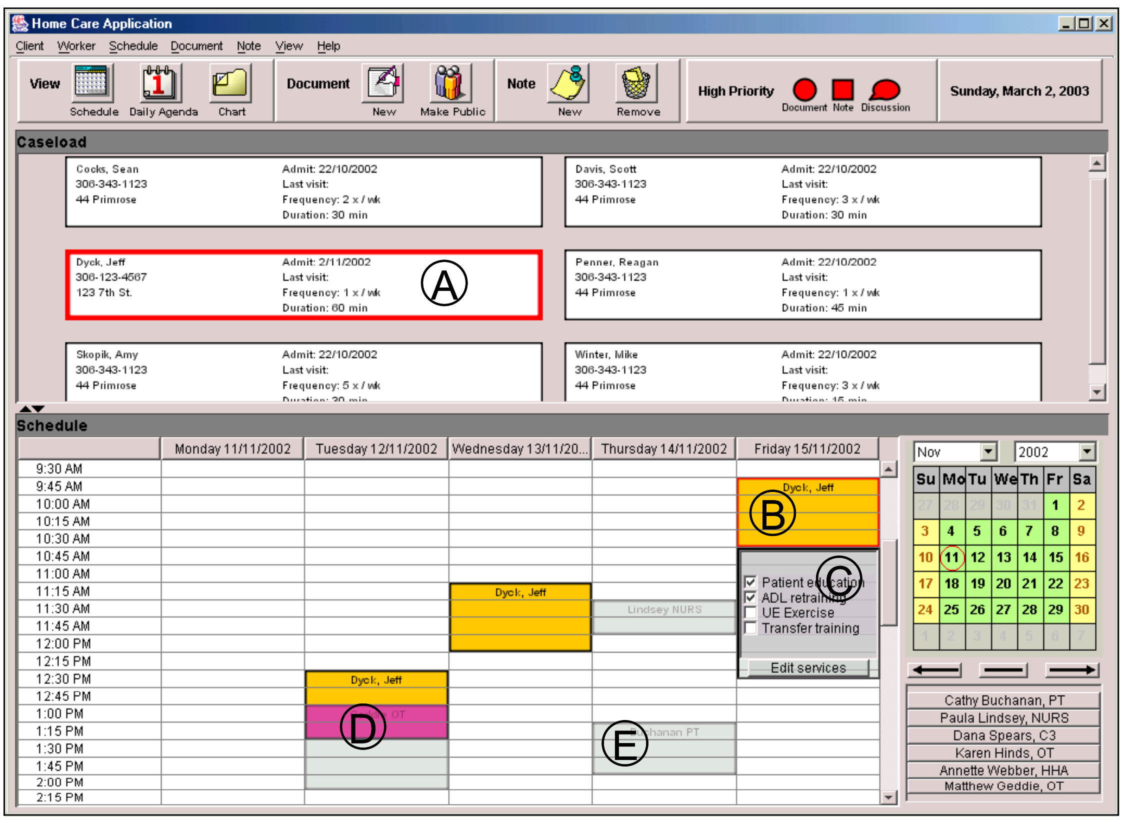


Figure 7.6. Mohoc schedule screen. A-Patient record; B-Appointment; C-Service plan; D-Schedule conflict; E-Other worker's appointment.

Workers can create and modify appointments using drag and drop interaction techniques. To create an appointment, a worker selects a patient in the caseload region at the top of the screen (A on Figure 7.6) and drags the patient's rectangle to the proper timeslot in the schedule region at the bottom of the screen (B). This creates a new appointment tile in the schedule region. When a new appointment is created, a popup window appears and allows workers to specify the services that they will deliver during that appointment (C). The popup window displays the "service plan" for the workers' discipline (the service plan is a list of services that the discipline provides to the patient—discussed further in Section 7.4.4.2.3), and the worker can select the services that they will deliver by clicking on the checkboxes next to the desired services. The information entered through these features is then automatically pushed out through the network so that it is available to other treatment team members.

The schedule view was designed to improve awareness and to facilitate low-cost coordination by making information about schedules and treatments available to workers who share common patients. This information is embedded into the scheduling tools, so when workers carry out their autonomous work activities, they can better consider the activities of other workers. This information is represented in the user interface so that workers can:

- View others' appointments with a shared patient
- Identify scheduling overlaps with others who visit a shared patient
- View the services that will be delivered by other workers during visits

When a worker selects a patient in the caseload region of the screen, all appointments that others have made with that patient are shown in the worker's schedule as transparent overlays. This can be seen in Figure 7.6, where Jeff Dyck is selected in the caseload region of the screen (A). The tiles that are shown more prominently represent the appointments that have been made by the worker that is using the system (B). The overlays that represent others' appointments with John Doe are also visible. For example, on Thursday at 1:15, an appointment that was set by Buchanan, a physical therapist, is shown (E).

The system also helps workers identify schedule conflicts with other workers. This can be seen in Figure 7.6 (D), where an appointment that was set by the worker that is using the system overlaps with an appointment set by Geddie, an occupational therapist. In the user interface, the timeslot where the collision occurs is flagged in red, so that workers can resolve the overlap if it is a problem.

Finally, Mohoc provides a view of all appointments that have been set with a given patient. This view is shown in Figure 7.7, and it displays all appointments that have been set with a patient, and the services that will be provided during those appointments. This view is included as part of the chart view (discussed in Section 7.4.4.2).

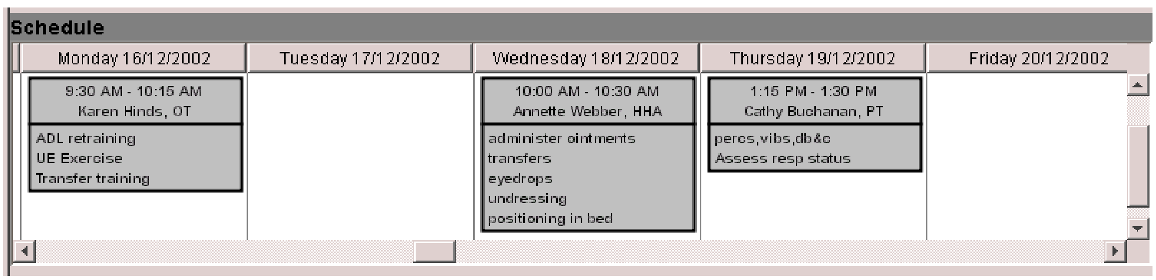


Figure 7.7. Alternate schedule view. Appointments are shown, along with time/date; worker and discipline; services for each appointment.

7.4.4.2 Chart view

The Chart View contains all clinical documents that have been created for a specific patient, as well as tools for sharing information and communicating with other workers who treat the patient (see Figure 7.8). The chart view merges the separate information buffers that are used to maintain clinical documents into a shared information repository. It also allows workers to choose to maintain select documents in separate private workspaces. The chart view is divided into four regions: the client summary region, the discussion tool, the timeline region, and the document viewing region (see Figure 7.8). The timeline region and the document viewing regions are tightly integrated, and are used for interacting with clinical document and with the chart view's cover page. This section discusses the following features: client summary region, discussion tool, cover page, and clinical document support.

7.4.4.2.1 Client summary region

The client summary region (A on Figure 7.8) provides an overview of basic client information. The client's name is displayed at the top of this region in a white rectangular text field. Clicking on the client's name will display a drop-down list of clients that are in the worker's caseload. The worker can switch between charts for different clients by clicking on another client's name in that list.

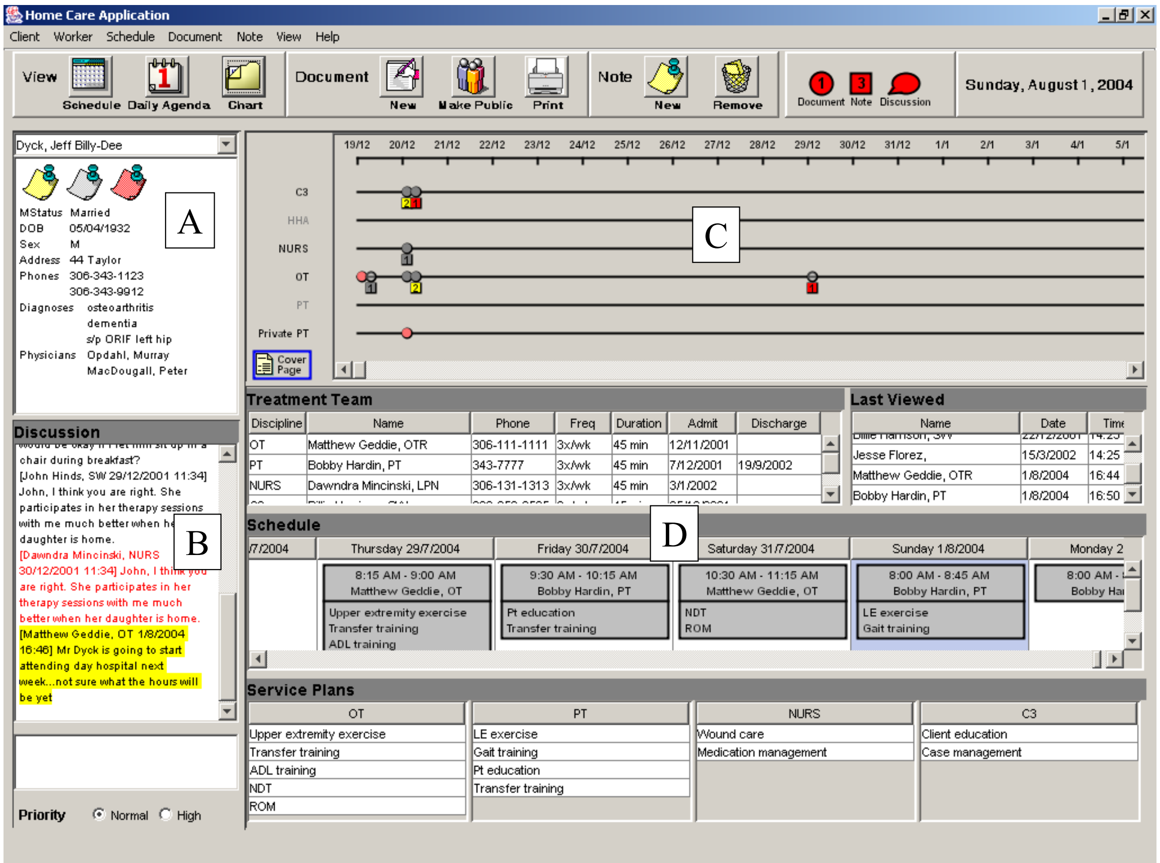


Figure 7.8. Chart view with cover page selected. A: Client summary region. B: Discussion tool. C: Timeline region. D: Document viewing region with cover page selected.

7.4.4.2.2 Discussion tool

The discussion tool (B on Figure 7.8) allows all home care workers that treat a client to carry on a group discussion using persistent text messages. When a worker enters a message into the discussion tool, the system automatically appends the worker's name, discipline, and the time and date of composition to the message. The message is then routed to all other treatment team members.

The discussion tool consists of two text panes, a large one above a smaller one. The bottom text pane is used for message composition. The top text pane displays the content of the group discussion, and it contains all of the messages that have been left by workers who treat the client. Messages are persistent and are sorted chronologically with the most recent messages appearing at the bottom of the pane. Messages can take on one of three appearances: red highlight, yellow highlight, or black on white. Messages with red highlights have been designated as high priority by their author. Messages with yellow highlights are normal priority messages that the worker logged into the system has not previously viewed. Finally, black on white messages are normal priority messages that the worker has previously had the opportunity to read.

7.4.4.2.3 Cover page

The cover page is a collection of information about other workers who treat the selected client, and about the services they provide to the client. By default, it is displayed in the document viewing region (D on Figure 7.8) when a user enters the chart view. The cover page can be activated and deactivated by clicking on the button labeled "Cover Page" in the lower left corner of the timeline region (C on Figure 7.8). When the button is highlighted in blue, the cover page is selected and is visible. The cover page is divided into four sections: the treatment team region, the last viewed region, the schedule region, and the service plans region (see Figure 7.8).

The treatment team region shows summary information about treatment team members for the selected client including: worker discipline, name, phone number, treatment frequency, typical treatment duration, admission date, and discharge date.

The last viewed region shows the last time each treatment team member accessed the chart view for the selected client. This information can be used to determine whether or not another team member has had an opportunity to view a piece of information. For example, a worker can determine whether or not another team member has had an opportunity to read a discussion entry that is particularly relevant to them.

The schedule region shows the schedule for the selected client (as opposed to the schedule view which shows the worker's schedule). Every entry in this region, then, is an appointment with this client. Appointments that are displayed here show the name of the worker, their discipline, and appointment times. Additionally, if services have been specified for the appointment, they are displayed as well.

The service plan region displays the service plans for each discipline that currently treat the selected client. A service plan is a list of services that a discipline provides to the client. For example, an occupational therapy treatment plan might be: upper extremity exercise, activities of daily living training, transfer training, and patient/family education. The service plans that are displayed in the cover page provide a mechanism for facilitating low cost coordination within the team since workers can tailor their services based on those of others. The system allows users to add, delete, and edit service plan entries. Revisions to the service plan are reflected in the services that can be specified for appointments on the schedule screen (C on Figure 7.6).

7.4.4.2.4 Clinical document support

Many of the features found in the chart view support the current paperwork practices that are seen in home care. Each discipline uses its own set of paperwork, and some disciplines have a large set of forms that can be used (e.g. nursing has approximately 100 different forms they can utilize). Mohoc supports the most commonly used forms for each clinical discipline. Computerized versions of current paper-based forms were created in the system, for a total of 72 different forms. The system allows workers to enter data into form templates so that support mirrors current documentation practices as closely as possible.

Support for paperwork is provided in the chart view using two screen regions: the timeline and the document viewing region. The timeline is a long, narrow region in the top right corner of the chart view. It provides a visualization of the documents that have been created for the currently selected client. The document viewing region is found in the lower right corner of the chart view. The content of a document that is selected on the timeline is displayed here.

In the next section, I discuss the clinical documentation support that is provided in the Mohoc chart view. The discussion is organized around the following topics:

- Timeline region
- Document viewing region
- Composing a document
- Editing a document
- Deleting a document
- Changing a document's priority level
- Making a document public

Timeline region

The timeline region is found in the top right corner of the chart view (C on Figure 7.8). It provides a visualization of the documents (e.g. progress note, assessment, care plan, flowsheet, etc.) that treatment team members have created for the selected client. A timeline spans the top of this region, and a vertical hashmark is shown for each day on the timeline, beginning with the date of the first document posted and ending with the current date (see Figures 7.9, 7.10).

A horizontal line is displayed for each discipline that treats the client, and labels are placed to the left of these lines to indicate the discipline. Circles are positioned along these lines to represent documents that have been created by workers from that discipline. The line that a circle is positioned on indicates the discipline that created the document (e.g. a circle positioned on the OT line represents a document was created by an occupational therapist), and the horizontal position of the circle indicates the date that the document was created or was last modified. For example, a document posted under 31/10 on the timeline was created or modified on October 31st.

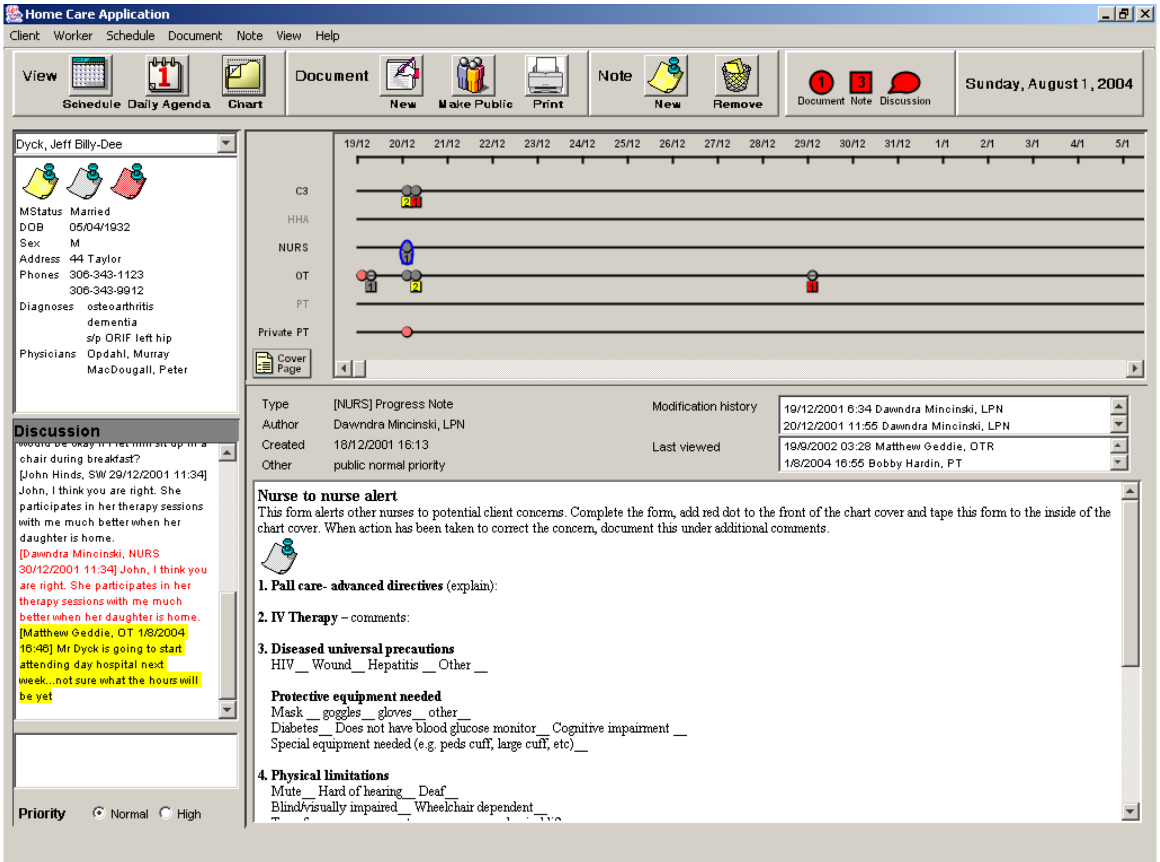


Figure 7.9. Timeline region showing a variety of document and note icon types. A text document is selected in the document viewing region and modification and viewing histories are visible.

The timeline region provides access to a private workspace that is only accessible to the user and to other members of their discipline who have the selected patient on their caseload. This private space is shown using a horizontal line at the bottom of the timeline region, and it is labeled with the word "Private" followed by the name of the worker's discipline. For example, if a nurse is logged into the system, the label will be, "Private NURS." This space can be used to store documents that are incomplete or that the worker is unwilling to share with other treatment team members. The sharing level can be set on documents when a document is first composed (see Figures 7.13, 7.15). For example, if a document is only partially filled out, the worker may want to keep it in their private space, and once they have completed it they can share it with the rest of the treatment team.

The circles that are used to represent documents on the timeline convey additional information using their colors. There are five document colors: clear, yellow, bright red, faded red, and gray, each of which is discussed below (all showing in Figure 7.9 and 7.10):

- *Colorless* circles are private documents that were created by another discipline. If the worker clicks on them, they will be informed that the document is private and that they cannot view the content.
- *Yellow* circles represent normal priority documents that the user has not yet viewed.
- *Bright red* circles represent high priority documents that the user has not read.
- *Faded red* circles represent high priority documents that the user has read.
- *Gray* circles represent normal priority documents that the user has read.

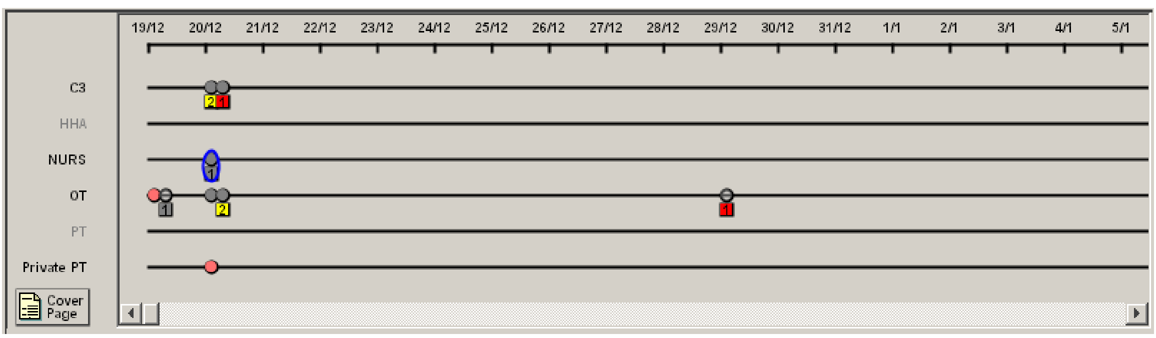


Figure 7.10. Close up of timeline region.

In addition to circles, the timeline also shows sticky notes that have been attached to documents (see Figures 7.9 and 7.10). If a circle has a small square attached beneath it, this means that the document has a sticky note in it. The square will contain a number that indicates the number of sticky notes that the document contains. Color-coding on the squares is similar to the color-coding used on documents (i.e. yellow indicates unread; gray read; etc.).

Document viewing region

To view a document, the worker can click on its circle representation on the timeline. The system will then display the document content in the document viewing region (D in Figure 7.8). Three types of documents can be displayed in this section: the cover page (discussed in 7.3.4.2.3), flowsheets (shown in Figure 7.11), and text documents (shown in Figure 7.9).

Composing a document

When a worker creates a new document (by clicking on the "New" button in the document region of the toolbar at the top of the screen), the system uses the worker's profile to determine their discipline, and then presents them with a list of discipline-specific document templates. Document templates reflect the content of current paper-based forms, and can have a wide range of uses, such as progress notes, assessments, care plans, or discharge summaries. When a document template is selected, an editor dialog loads the appropriate template, and then the worker can add new content to the dialog.

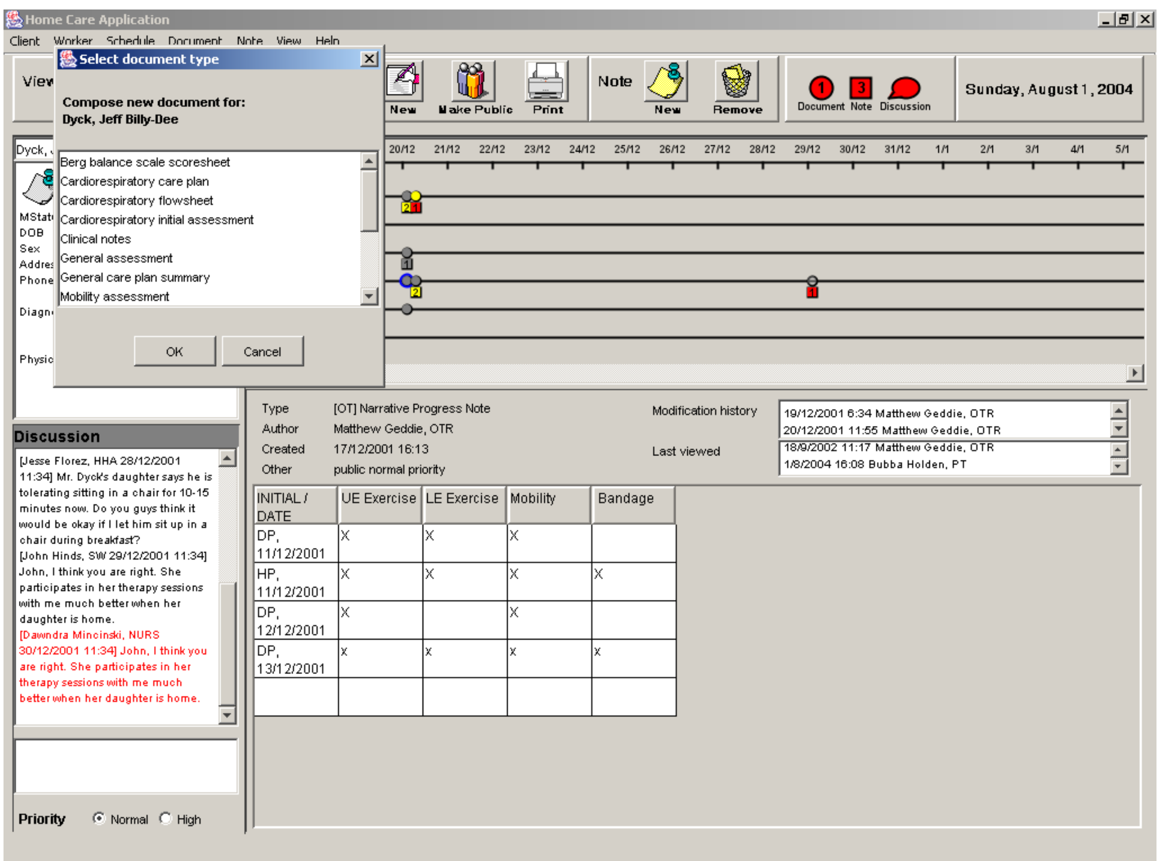
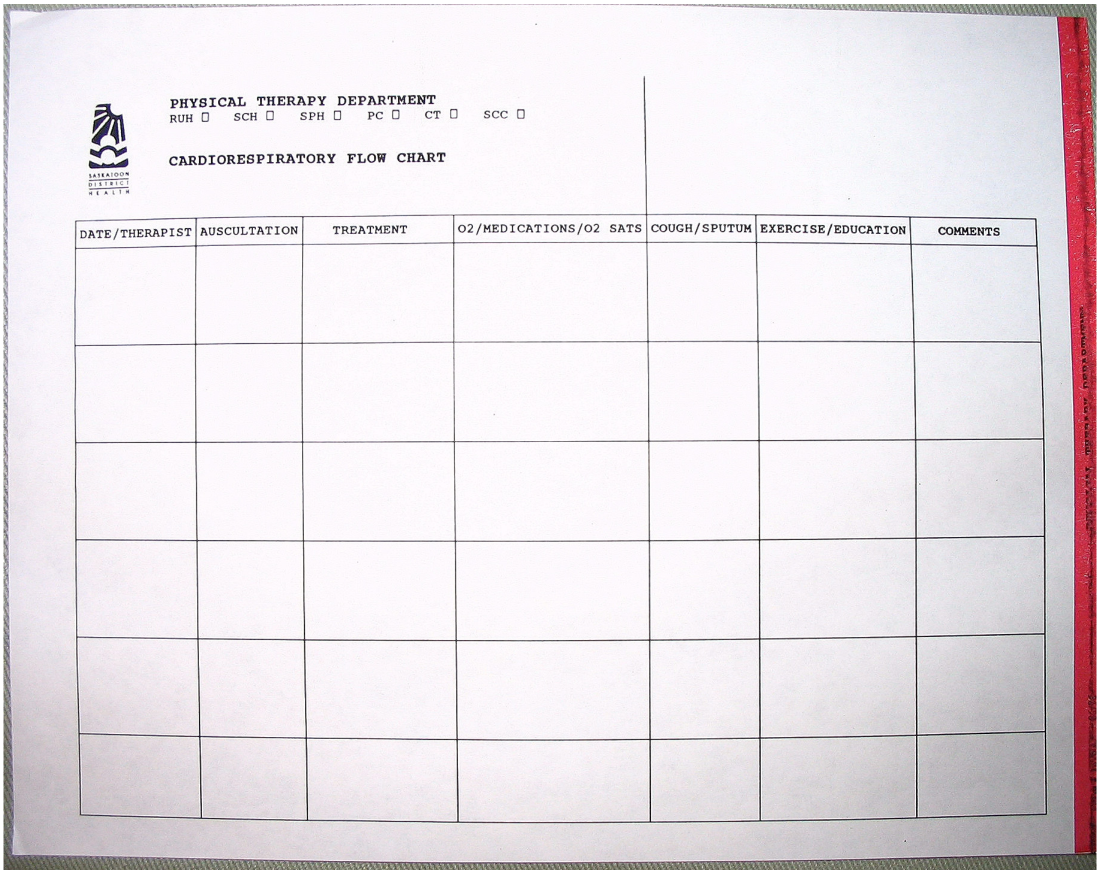


Figure 7.11. Dialog to select template type for document composition. Flowsheet is displayed in document viewing area along with modification and viewing histories.



PHYSICAL THERAPY DEPARTMENT
RUH ☐ SCH ☐ SPH ☐ PC ☐ CT ☐ SCC ☐

CARDIORESPIRATORY FLOW CHART

DATE/THERAPIST	AUSCULTATION	TREATMENT	O2/MEDICATIONS/O2 SATS	COUGH/SPUTUM	EXERCISE/EDUCATION	COMMENTS

Figure 7.12. SHR physiotherapy flowsheet.

The system supports two types of documents: flowsheets and text documents. The appropriate editor type will appear depending on the type of template that is chosen. Flowsheets are grid based documents, and workers typically fill in a list of services in the column headings. For each subsequent visit, the worker will check off the services they provided to the patient on a row of the flowsheet, and will add any annotations to the flowsheet cells that are needed to qualify the entry. A sample physiotherapy cardiorespiratory flowsheet is shown in Figure 7.12. In the figure, a list of observations and interventions is shown in the column headings (e.g. auscultation, treatment, O2/medication/O2 sats). The flowsheet editor in Mohoc provides workers with editable grids, and workers can annotate grid cells by typing text into the cells (see Figure 7.13). Cells expand vertically to accommodate long entries.

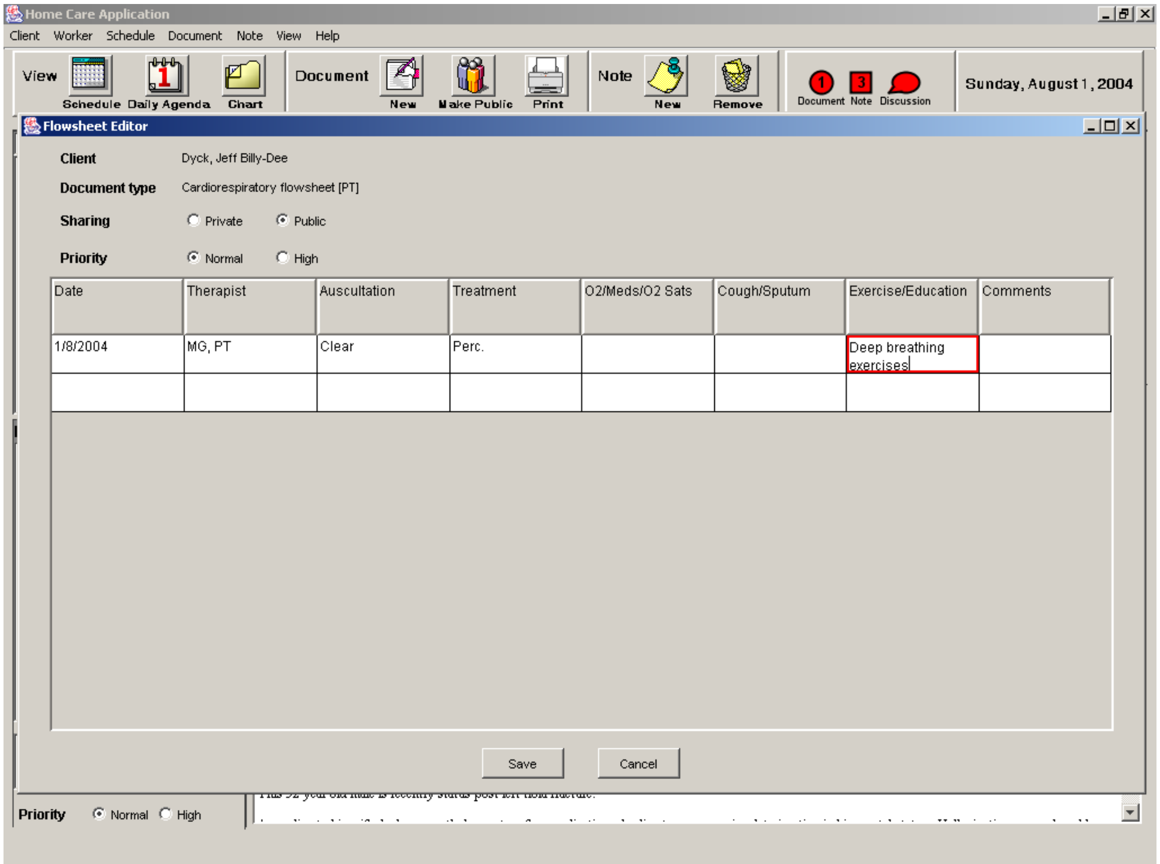
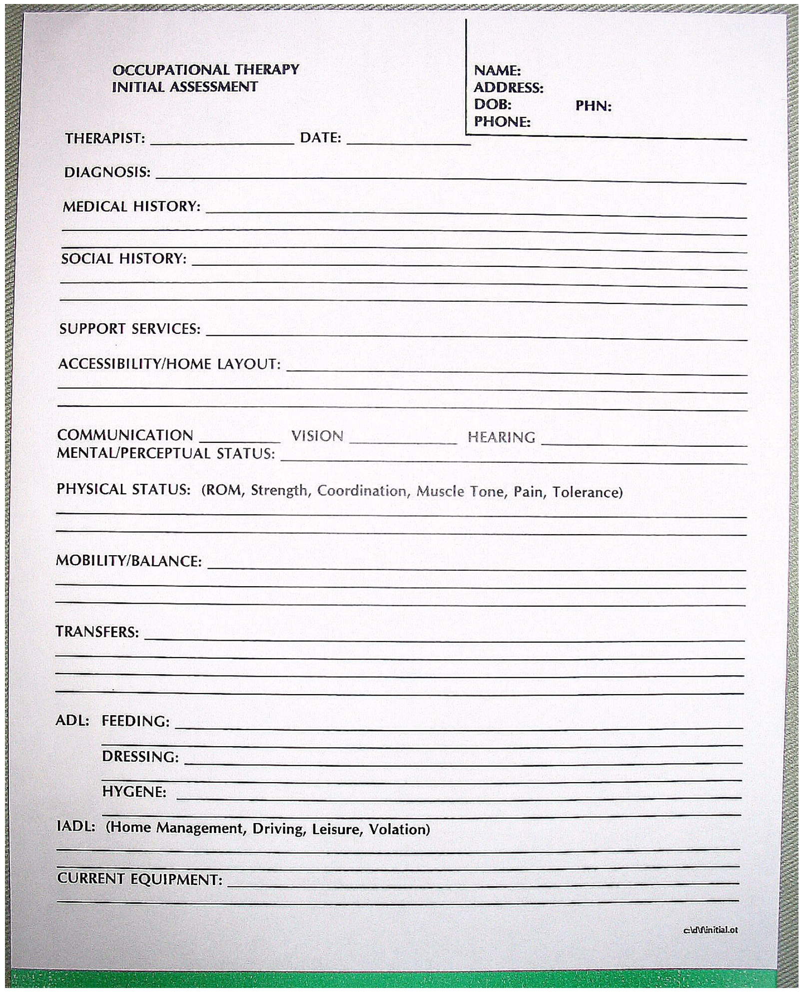


Figure 7.13. Flowsheet editor.

Text documents differ from flowsheets because data is not recorded on a grid. Text documents can be structured with fixed headings and or can be entirely freeform. Figure 7.14 shows a sample occupational therapy initial assessment form. The form provides headings to organize entries and allows more flexibility in recording data than flowsheet forms.

Text documents are supported in Mohoc using a text editor (see Figure 7.15). The templates for these documents are stored in rich text format so that styles (e.g. bold, italic, variable font sizes) can be applied to make them more readable. The templates contain the headings and organization that are seen in the original forms. The editor provides workers with basic functionality, including cut/paste, copy, variable font sizes, bold text, and italic text. The worker is able to add as much text as they need to the template, and can selectively delete portions of the form.



OCCUPATIONAL THERAPY
INITIAL ASSESSMENT

NAME:
ADDRESS:
DOB: PHN:
PHONE:

THERAPIST: ____ DATE: ____

DIAGNOSIS: ____

MEDICAL HISTORY: ____

SOCIAL HISTORY: ____

SUPPORT SERVICES: ____

ACCESSIBILITY/HOME LAYOUT: ____

COMMUNICATION ____ VISION ____ HEARING ____
MENTAL/PERCEPTUAL STATUS: ____

PHYSICAL STATUS: (ROM, Strength, Coordination, Muscle Tone, Pain, Tolerance)

MOBILITY/BALANCE: ____

TRANSFERS: ____

ADL: FEEDING: ____
DRESSING: ____
HYGENE: ____

IADL: (Home Management, Driving, Leisure, Volation)

CURRENT EQUIPMENT: ____

c:\d\f\initial.ot

Figure 7.14. SHR occupational therapy assessment form. This form provides an example of a “text document.”

Both types of editors allow the worker to set sharing level for the document they are composing. Buttons labeled “Private” and “Public” can be found at the top of the dialogs. These buttons determine whether or not the content of the document will be shared with team members from other disciplines. Private documents are only shared with members of the author’s discipline that treat the selected client, but are not shared with anyone else. Public documents are shared with all treatment team members regardless of their discipline.

The editor dialogs also allow the worker to set the priority level of the document. Buttons labeled “High” and “Normal” can be found at the top of the dialogs. By setting a document's priority to high, a worker can indicate that its content is important to other team members.

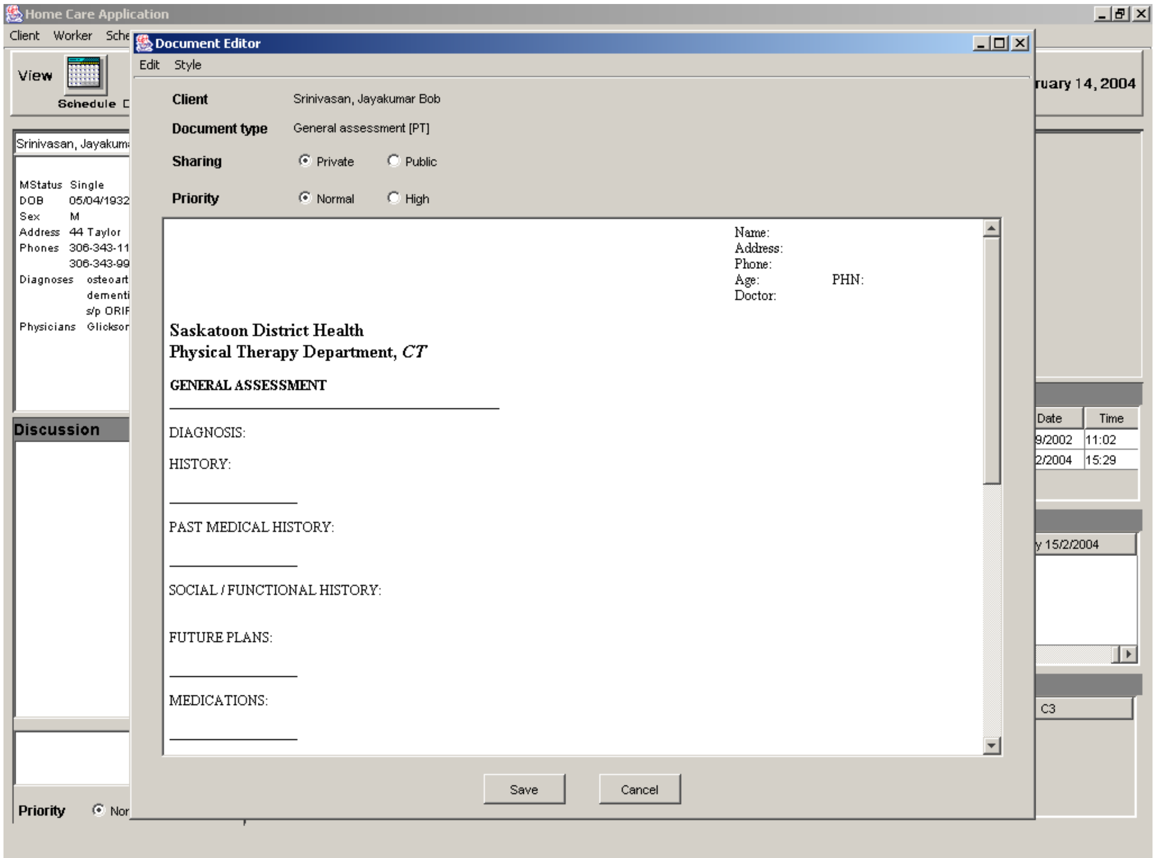


Figure 7.15 Editor for text documents.

Editing a document

A worker can edit existing documents if they were created by a member of the worker's discipline. The flowsheet editor will let workers append a new row to the bottom of the flowsheet, but it will not let them edit previous rows (see Figure 7.16). The editor for text documents will allow them to revise all content in the document. When a document has been edited, it is advanced on the timeline to the modification date. For example, if a document was created on May 1st, and was then edited on May 4th, the icon for the document will move on the timeline to May 4th, the modification date.

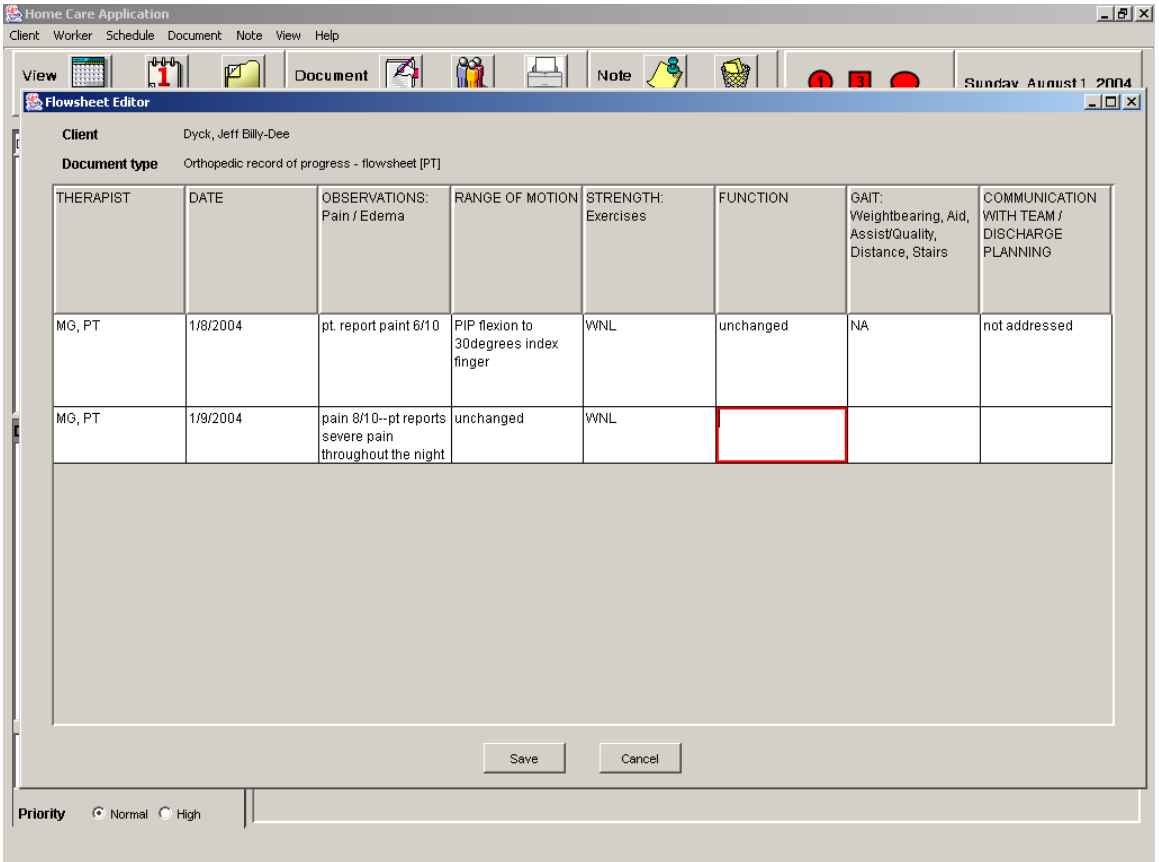


Figure 7.16. Dialog for editing a flowsheet.

Deleting a document

A worker can delete documents that were created by their discipline and that are in their private space. Deleting a document permanently removes it from the system. The worker can also delete a document within the first five minutes of making it public, but after that, it cannot be deleted.

Changing a document's priority level

Workers can change the priority of an existing document. This allows them to flag existing documents that seemed routine at composition, but that are more important in light of new events. It also allows them to remove high priority flags from documents when the underlying reasons for the flag have been resolved.

Making a document public

Existing documents that are in a worker's private space can be made public. Once this is done, the document will move from the worker's private line to the public line, and the system will send the content of that document to members of other disciplines that treat the client. Workers can make a private document public, but cannot make a public document private.

7.4.4.3 Daily agenda view

The daily agenda view is intended to help the worker manage their workday by presenting a detailed daily agenda that can be revised as the workday unfolds (see Figure 7.17). The daily agenda merges information and interaction techniques from the caseload and schedule regions of the screen in the schedule view, but presents it in a way that supports work patterns when the worker is in the car or in patients' homes. It provides the worker with schedule information for visits; the patient's name, address, neighborhood, and phone number; and with flags that indicate whether paperwork has been filled out for the patient on the displayed date. Workers can also modify and delete appointments and revise services using the daily agenda view.

Figure 7.17 shows several appointment tiles in the daily agenda view, and two of the appointments display flags that indicate that the worker has created clinical documents to record the outcome of the visit. On the right side of these tiles, labels are displayed that indicate the type of form that has been filled out ("Cardiorespiratory care plan" and "General assessment"), and a red checkbox icon is displayed to show that the paperwork has been completed for that visit.

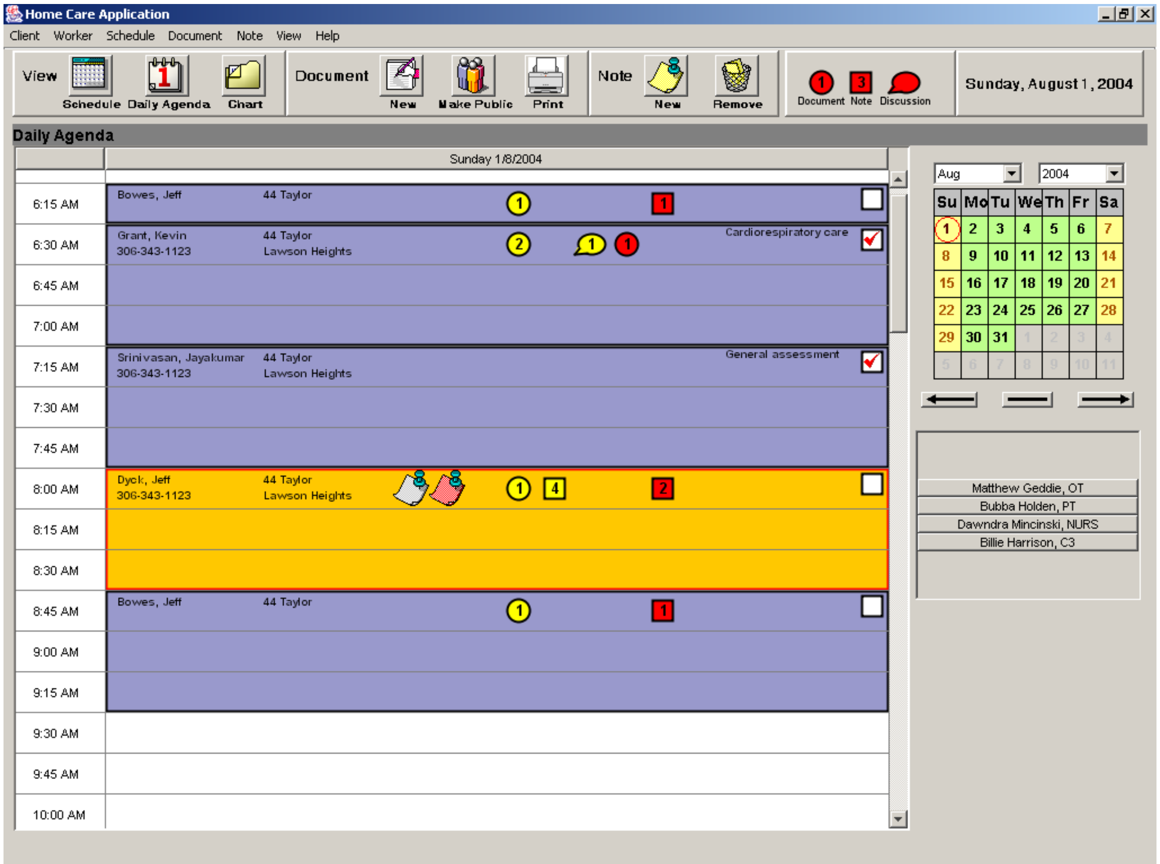


Figure 7.17. Daily agenda view. Appointment tiles are visible, as are sticky notes and documentation indicators.

7.4.4.4 Sticky notes

Sticky notes allow workers to leave messages for specific treatment team disciplines or for the entire treatment team. Sticky notes can be attached to a client's chart or to clinical documents. When notes are left on a patient's chart, they are highly visible and easily accessible. When notes are left on documents, the context of the message can be preserved since it can be attached to a specific location in the target document.

A new note can be created by clicking on the "New" button in the note region of the toolbar at the top of the screen. The mouse pointer then turns into a note icon, and the user can position the pointer on a target location to place the new note. Valid note targets for leaving notes on the chart cover are: (a) the white tiles in the caseload region of the screen in the schedule view (Figure 7.19), (b) the appointment tiles in the daily agenda view (Figure 7.17), and (c) the client summary area in the upper left corner of the chart view (Figure 7.18). Once a note is left in one of these locations, it is visible across all three views. Notes can also be attached to clinical documents (Figure 7.18) by opening the target document (by selecting it on the timeline in the chart view) and then moving the pointer to the location in the document where the note should be placed.

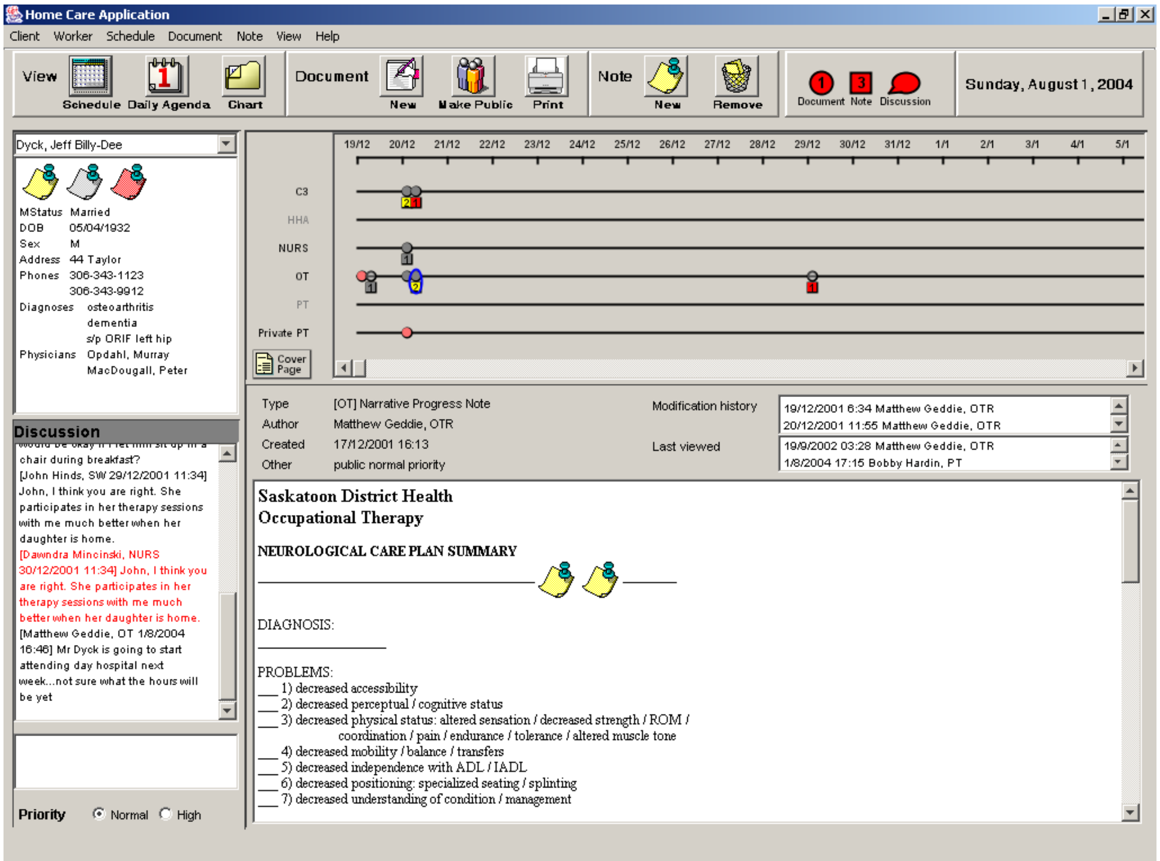


Figure 7.18. Chart view showing three sticky notes on the chart in the upper left and two sticky notes in a text document.

Once the pointer is positioned over a valid note target, the note can be created by clicking the left mouse button. This causes a note editor dialog to appear on the screen (see Figure 7.20). The editor allows the user to specify note content, specify the recipients, and set the priority of the note. By default, a note is sent to the entire treatment team, but the sender can choose to restrict the disciplines to which a note will be sent. The user can also specify the priority of a note. By default, notes have normal priority, but the user can change the priority to high.

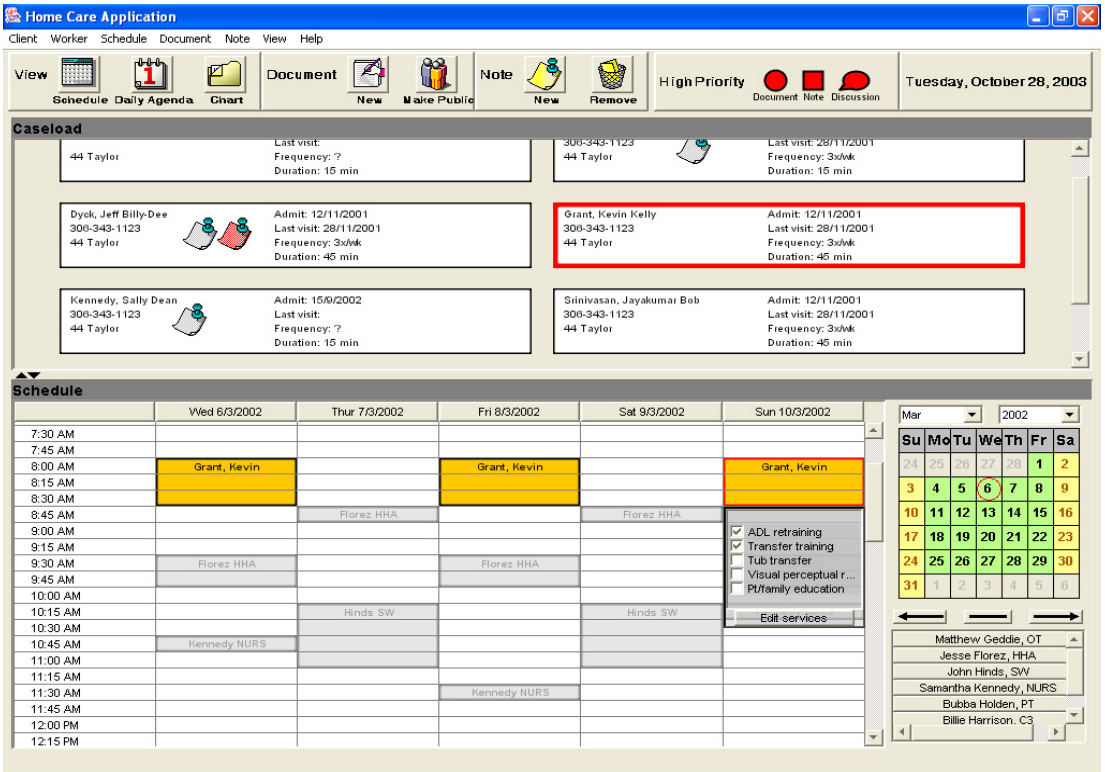


Figure 7.19. Schedule view showing sticky notes on white caseload tiles.

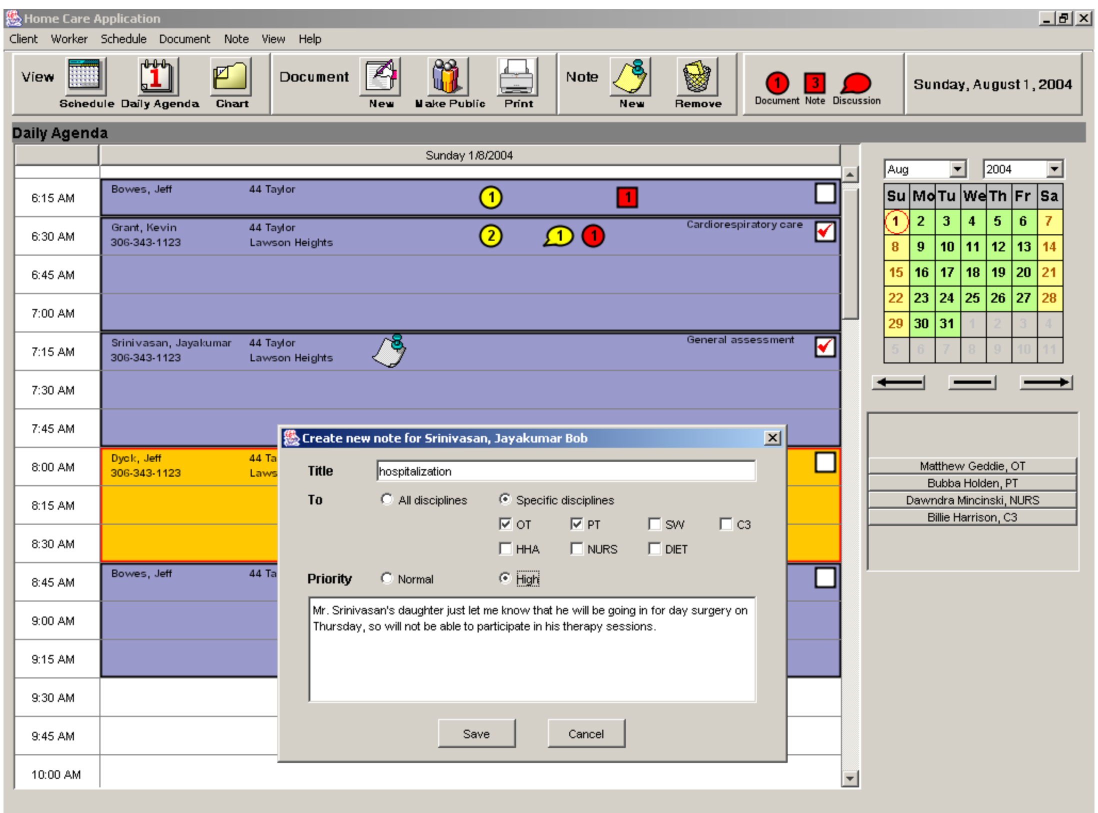


Figure 7.20. Note editor dialog.

Note icons that are shown on the chart and in documents use the same color coding scheme that is used on the timeline (see Figure 7.18). Unread high priority notes are bright red, and high priority notes the user has read are faded red. Unread normal priority notes are yellow, and normal priority notes that the user has read are shown in white.

A note can be viewed by positioning the pointer over it and then clicking the left mouse button. The note icon will turn blue, and a dialog will appear that shows the note content. The top of the dialog shows the name of the author, the title of the note, a list of recipients, and the time/date the note was created. The bottom of the dialog shows the text that is contained in the note (see Figure 7.21).

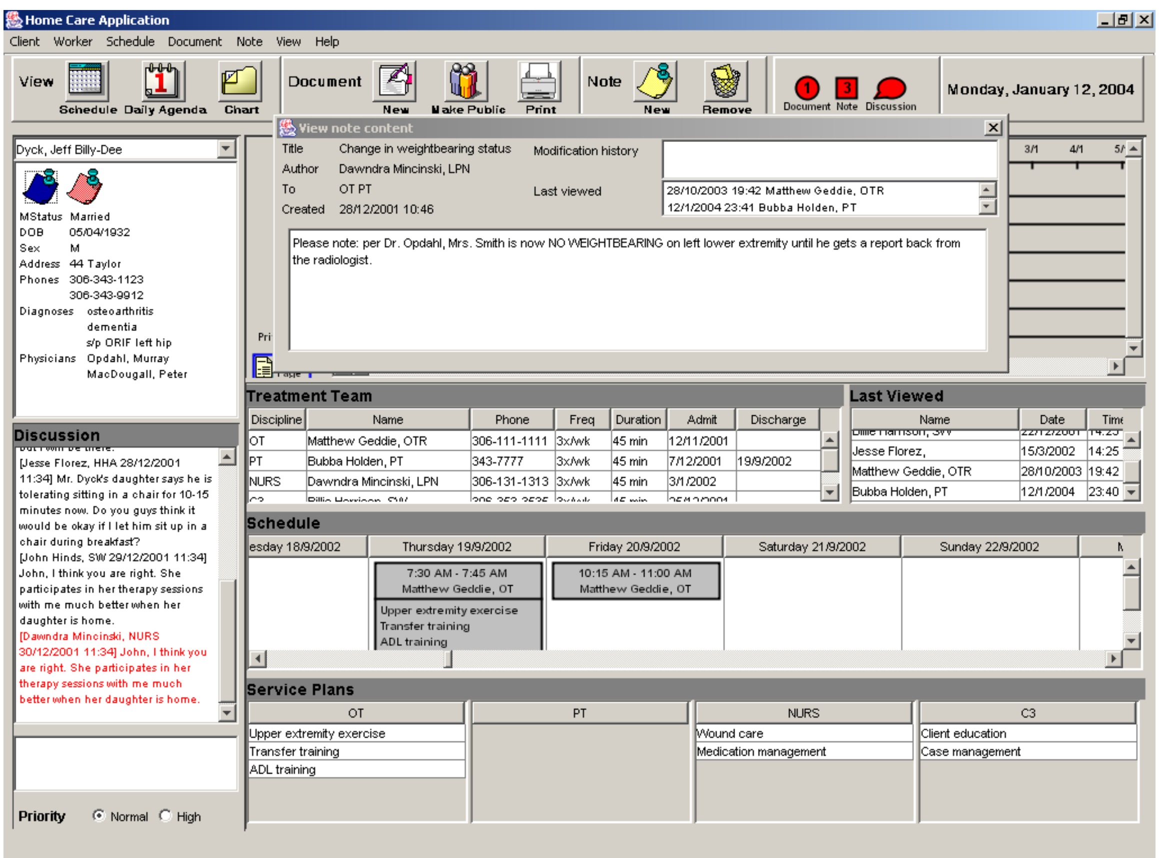


Figure 7.21. Note viewing dialog. The note's viewing history is visible.

7.4.4.5 Awareness indicators

Mohoc has several features that are intended to facilitate awareness of others' recent activities in the system. As a user carries out work activities using the system, others' activities can lead to new content being added to the system. Mohoc uses several flags and indicators to help users to identify new content when it is added to the system and to help users to know when others have viewed or modified existing content. In the next section, I discuss four system features: the high priority monitor; flags on caseload tiles; flags on documents, discussion entries, and notes; and viewing and modification histories.

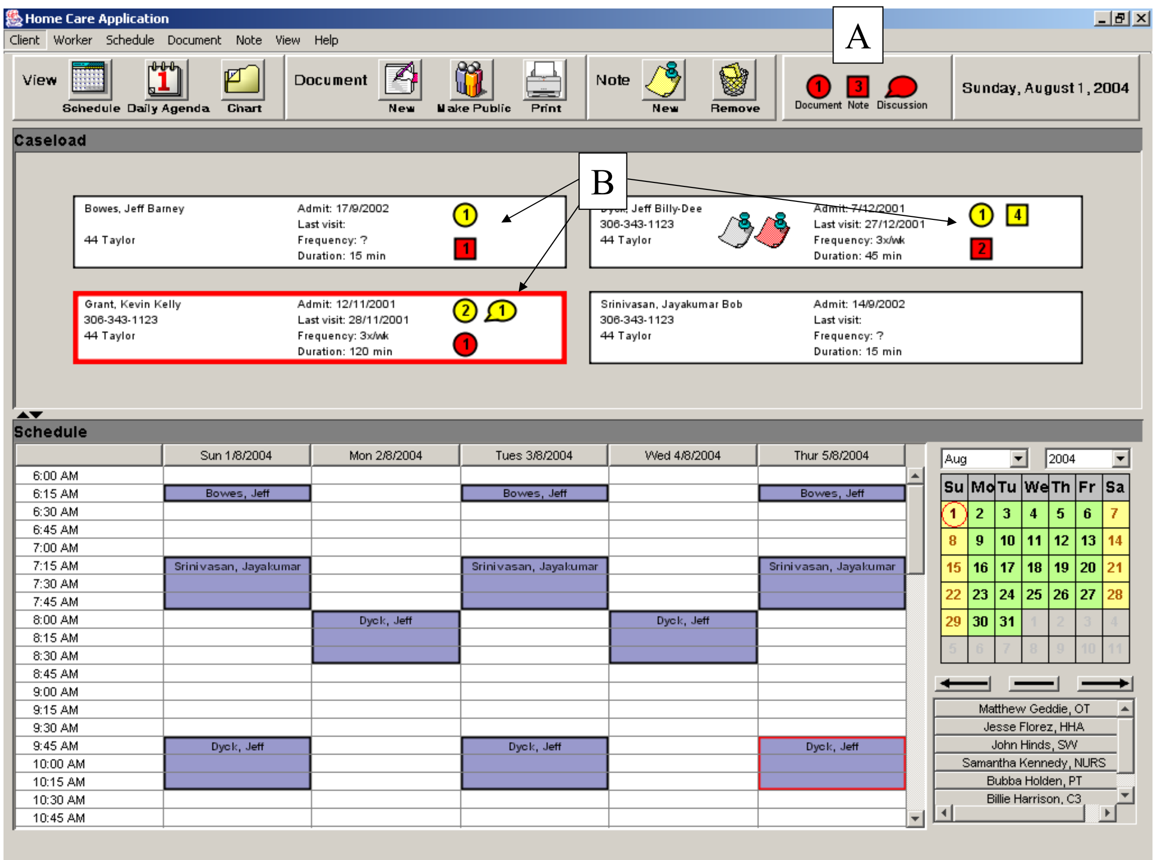


Figure 7.22. Awareness flags in schedule view. A: The high priority monitor, with flags indicating 1 document and 3 sticky notes. B: Flags on caseload tiles indicate unread and unread high priority content in each patient's chart.

7.4.4.5.1 The high priority monitor

The high priority monitor is displayed in the upper right corner of the screen (see Figure 7.22 A). This monitor tracks high priority chart content that the user has not read. For each content type (e.g. note, discussion, document) the monitor shows a number that indicates the total number of unread high priority items of that type for all clients in your caseload (i.e. the number is the sum of all unread high priority items of that content type for all of a workers' clients). Numbers are shown on top of the icon that represents the content type. If a number is not displayed, then there are no unread high priority items of that content type in the system. For example, the high priority monitor in Figure 7.22(A) indicates that 1 unread high priority document and 3 unread high priority sticky notes are in the system. Since the discussion icon does not have a number in it, there are no unread high priority discussion entries.

7.4.4.5.2 Flags on caseload tiles

The caseload region of the Schedule view contains a white tile for each client in a worker's caseload. The right side of each tile can contain icons that alert the user of unread content in the client's chart (see Figure 7.22 B). These icons use the same shapes to represent content that are used in the high priority monitor: a circle represents documents; a square represents sticky notes; a dialog bubble represents discussion entries. The icons on the caseload tiles only appear when there is unread content in the client's chart. These icons are color-coded: red icons represent unread high priority content; and yellow icons represent unread normal priority content. As with the high priority monitor, a number is placed on each icon to indicate the number of entries that can be found in the patient's chart for that content type.

7.4.4.5.3 Flags on documents, discussion entries, and notes

As discussed in previous sections, color-coding is used to track whether or not the user has read content in the system. These awareness flags are used on three types of content: documents, discussion entries, and notes. While color-coding varies somewhat between each type, two colors are used consistently in the system. Bright red indicates high priority content, and yellow indicates normal priority content that the user has not yet viewed.

7.4.4.5.4 Viewing and modification histories

The system maintains information about when workers have viewed or modified shared artifacts so that users can stay aware of the activities that others carry out using the system. Each note and document in the system has an associated modification history list. The modification histories track when an artifact was modified and by whom, and the list is displayed at the top of the dialog that appears when a user views that artifact (see Figures 7.9, 7.11, and 7.21). Each note, document, and patient's chart has an associated viewing history. Viewing histories track the last time that an individual accessed an artifact. For notes and documents, viewing histories are displayed at the top of the viewing dialogs (see Figures 7.9, 7.11, and 7.21). For charts, the viewing history is displayed in the last viewed region of the cover page (see Figure 7.8 D).

7.5 Pocket Mohoc: a pocket-pc groupware client

Home health aides' workflows differ from those of the professional home care disciplines. They have decreased autonomy—they are centrally scheduled and cannot revise the services that they deliver to patients without first consulting nursing supervisors. Their document utilization practices are also different than those of other disciplines. They maintain their documents in the communication binders that are kept in patients' homes, and all of their paperwork uses checkbox based flowsheets. They also do not spend time in the office, which limits their opportunities to communicate with others face-to-face.

The differences seen in home health aide workflows mean that many of the features found in the laptop Mohoc client are not well suited for home health aides. To accommodate these differences, I designed Pocket Mohoc, a handheld Mohoc client that is tailored to meet the needs of home health aides. Pocket Mohoc provides a subset of the functionality that is found in the Mohoc laptop client, but it is still interoperable with the Mohoc server and allows workers to communicate with treatment team members from other disciplines.

7.5.1 Technical overview

Pocket Mohoc was implemented in C# for Audiovox Thera Pocket PC devices with integrated 1X wireless modems. Pocket Mohoc is interoperable with the Mohoc laptop client, and home health aides using Pocket Mohoc can still collaborate with workers from other disciplines. However, each application offers slightly different functionality based on the needs of the target user group.

Both client versions (i.e. Pocket Mohoc and the laptop version) communicate with the Java server using text messages that have identical syntax. This messaging approach allows flexibility in choosing platform and implementation languages on the client side. Since Pocket Mohoc offers limited functionality, the server does not send it all of the transactions that are sent to the laptop clients. For example, since home health aides do not have discretion in managing their schedules, Pocket Mohoc does not provide a shared scheduling tool. In this case, the server filters schedule transactions and does not send them to Pocket Mohoc clients.

7.5.2 Interaction and user interface design

Pocket Mohoc was designed to support the work activities of home health aides. As previously discussed, it provides a limited subset of the features that are found in the Mohoc laptop client. The changes in system features reflect differences between the tasks of home health aides and professional workers and the limited autonomy that home health aides have in managing their workday.

Pocket Mohoc provides several of the core features found in the laptop client, including:

- Access to sticky notes and the discussion tool so that home health aides can be involved in communication with other team members.
- Support for home health aide documentation so that multiple aides can manage paperwork for a shared patient.
- Sharing of artifacts and awareness information with the rest of the treatment team so that other disciplines can coordinate their activities with the home health aides.

The major differences between the laptop client and Pocket Mohoc are:

- Pocket Mohoc only allows home health aides to view home health aide documents. Access to other disciplines' paperwork is not provided since little direct benefit is gained due to aides' limited autonomy and since some workers voiced concern about allowing aides to access their documents since they are not professional workers.

- Pocket Mohoc does not show others’ appointments since home health aides do not have discretion in setting their schedules.
- Pocket Mohoc does not show other disciplines’ service plans since home health aides are not able to revise services in order to coordinate with others.
- Pocket Mohoc provides limited awareness information to home health aides.

The user interface and interaction design were shaped by the limitations of the handheld device. Since the screen space was limited, the functions that are supported by the system are divided across several user interface views (5 total). Interaction support is provided using a stylus and an on-screen keyboard. The stylus serves as the pointing and input device on the Audiovox Thera. When options are selected that allow data entry, the application automatically displays an on-screen keyboard, and the stylus can be used to type on the screen.

Navigation between the different views in the system is provided using a navigation bar at the bottom of the screen. Buttons that are labeled “<Back” and “Next>” are used to cycle between the five screen views. The action options for each screen are listed on the navigation bar next to the navigation buttons. These options allow users to add new content to the system and include: “New Sticky”, “New Appointment”, “New Entry”, and “New Flowsheet.” Users can switch between the clients on their caseload using a drop-down menu at the top of each view.

In the next sections, I provide an overview of the five major user-interface screens that are available in Pocket Mohoc. These are:

- Client summary
- Appointments
- Discussion
- Service plan
- Flow sheets

7.5.2.1 Client summary

The client summary screen shows basic information about the patient that is currently selected in the system. Figure 7.23 shows a sample summary screen where "John Doe" is selected in the drop down menu at the top of the screen. The screen also shows the treatment team for the selected patient at the bottom of the screen along with contact information.

The sticky note feature on the Mohoc laptop client is supported on this screen. A small button that is labeled "N" provides access to notes that are attached to the active patient's chart. Figure 7.24 shows a dropdown menu that appears when that button is selected, and it lists a single note that has been attached to the chart. Selecting a note from this list will display the content of the note, as is shown in Figure 7.25. Composition of a new sticky note can be initiated along the navigation bar, and, as with the laptop version, notes can be sent to all or specific disciplines, and can be designated as high or low priority (illustrated in Figure 7.26).

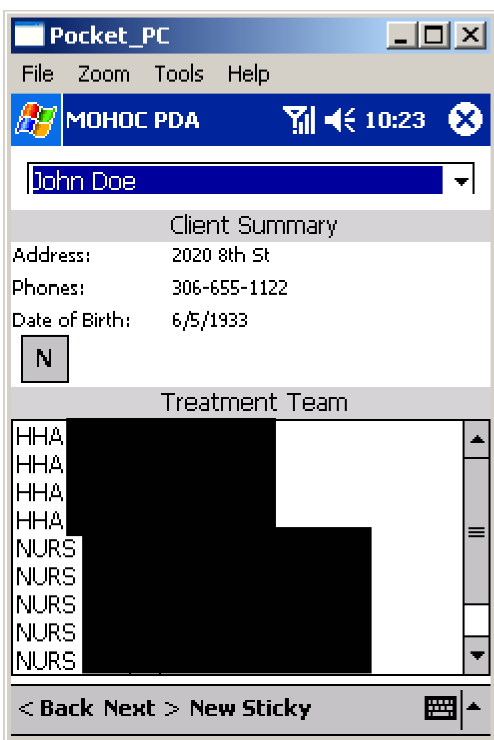


Figure 7.23. Pocket Mohoc client summary screen

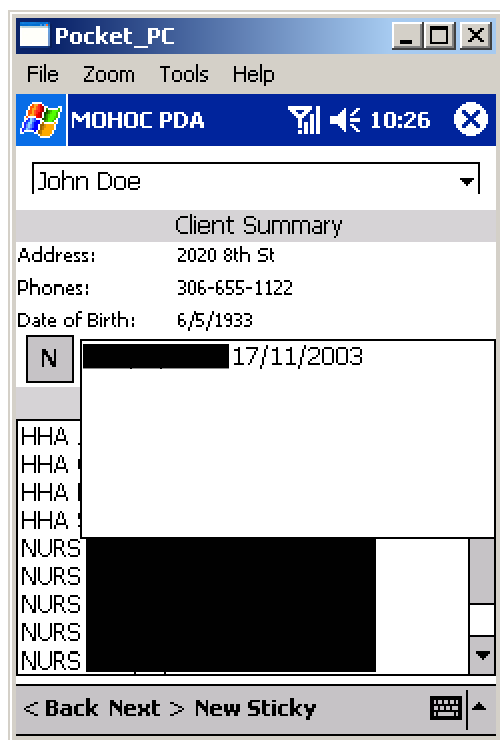
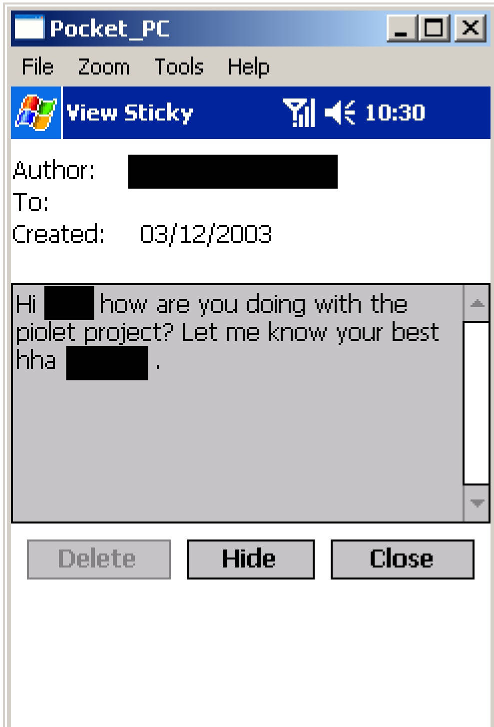


Figure 7.24. Popup showing list of sticky notes



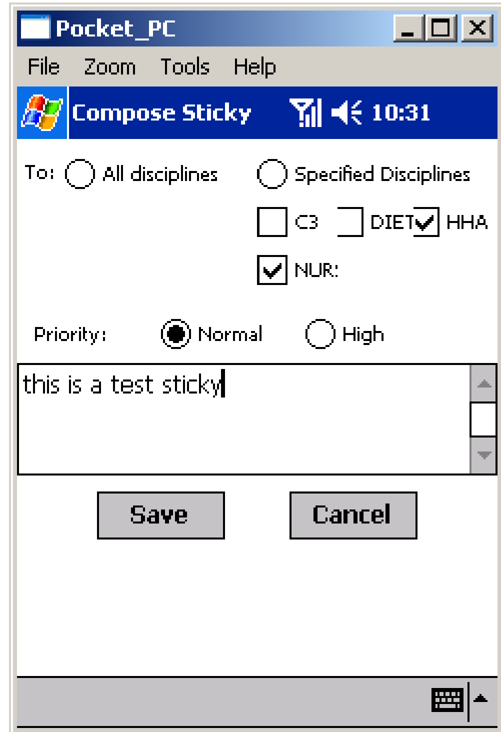


Figure 7.25. Screen displaying content of a sticky note

Figure 7.26. Sticky note editor

7.5.2.2 Appointments

The appointments screen allows workers to enter their appointment times with clients and to specify the services that they will deliver during a given appointment. Figure 7.27 shows the main appointments screen. It displays a list of appointments that the worker has set with the selected patient. In this figure, three appointments are displayed, and the listing indicates the date, time, and duration of an appointment.

When an appointment is selected from the list or when the new appointment option is selected on the navigation bar, an appointment editor is displayed. Figure 7.28 shows the appointment editor which allows the user to specify the details of an appointment using drop down menus. At the bottom of the editor, a list of services that the worker provides to the patient is displayed, and the services for the appointment can be specified using checkboxes.

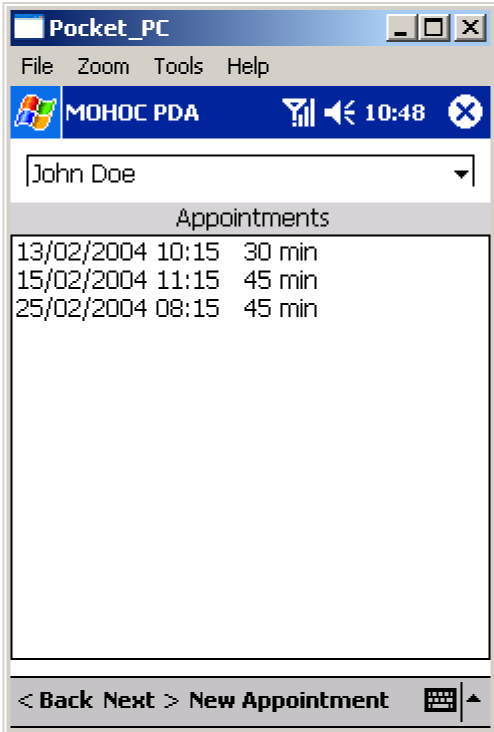


Figure 7.27. Pocket Mohoc appointments screen

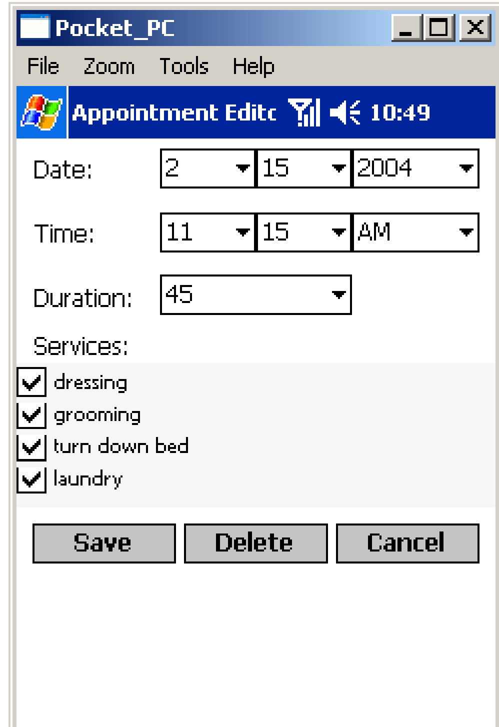


Figure 7.28. Appointment editor

7.5.2.3 Discussion

The Pocket Mohoc discussion screen is similar to the discussion feature on the PC version of the Mohoc client (see Figure 7.29). The screen allows all members of the treatment team to communicate using persistent text messages. New entries can be initiated by selected the new entry option at the bottom of the screen. Figure 7.30 shows a discussion editor screen where a new entry is being composed. The on-screen keyboard is shown at the bottom of the figure.

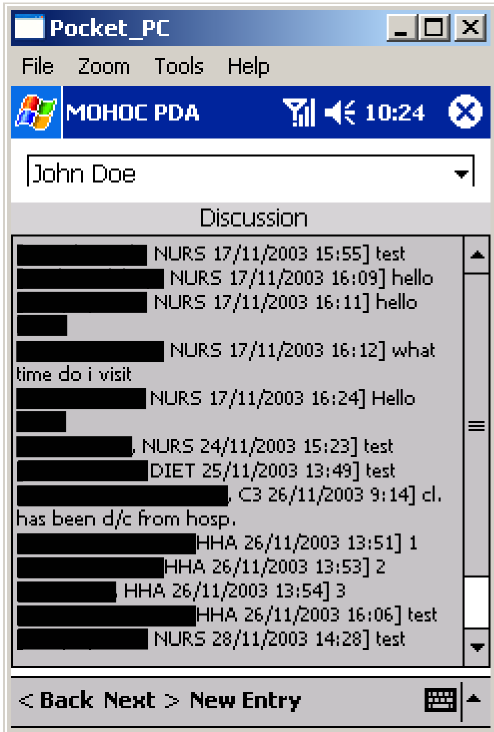


Figure 7.29. Pocket Mohoc discussion screen

Figure 7.30. Discussion editor

7.5.2.4 Service plan

The service plan screen allows workers to set and maintain the home health aide service plan for the selected patient. Figure 7.31 shows the service plan for John Doe. Each cell in the service plan is editable. When the stylus is used to click in a cell, the on-screen keyboard automatically appears to as is shown in Figure 7.32. Revisions to the service plan are reflected in the services that can be specified using the appointment editor (Figure 7.28).

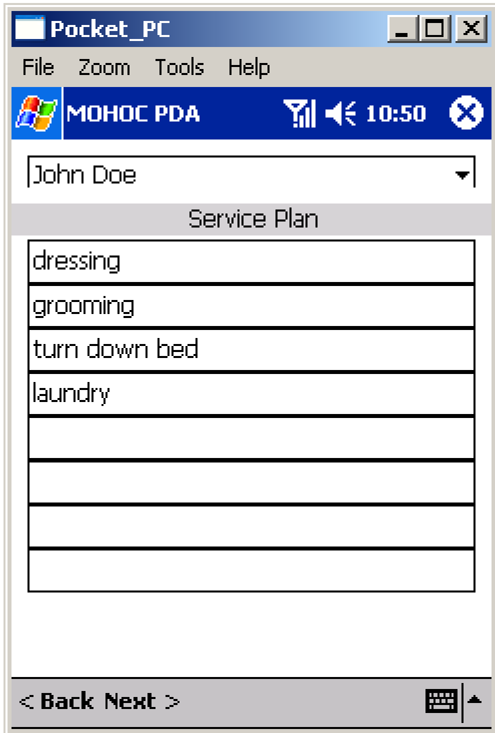


Figure 7.31. Pocket Mohoc service plan screen

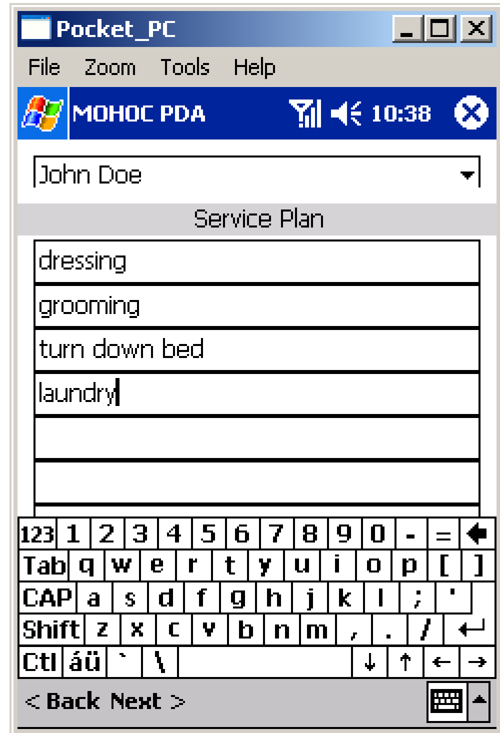


Figure 7.32. Service plan editor

7.5.2.5 Flow sheets

The flow sheets screen supports the clinical documentation practices of home health aides. Home health aide documentation uses flowsheets. The content of a flowsheet is laid out along a grid. The top of each column details a specific service (e.g. grooming, bathing, meal preparation, etc.). When a home health aide visits a patient, they complete a row on the flowsheet. They date and initial the row, and then check off the cells on the row that correspond with the services that they performed during the visit. Paper-based flowsheets have enough rows to document 15-20 visits.

The flow sheet screen shows all flowsheets that have been created for the selected patient. Figure 7.33 shows a list of flowsheets for John Doe. For each flowsheet, the flowsheet type, date, and time is displayed. Flowsheet type indicates the template that is used to create a flowsheet. Each flowsheet template contains a different set of column headings to reflect the type of services that the home health aide delivers during a visit. The system supports four flowsheet templates: AM Care, HS Care (i.e. evening care), Meal Prep, and Home Management.

When the “New Flowsheet” option is selected from the navigation bar, a list of flowsheet templates is displayed (see Figure 7.34). When the use selects a template, it is loaded into an editor, and the flowsheet editor is displayed so that the user can make the first entry in the new flowsheet (see Figure 7.35). To edit a cell, the user must click on it with the stylus and then the on-screen keyboard will appear.

New entries can also be added to existing flowsheets. If one of the flowsheets shown on the screen in Figure 7.33 is clicked on, the flowsheet will load into the editor and a new row will be appended to the bottom of that flowsheet so that a new visit can be added. Figure 7.36 shows a flowsheet with two entries. This shows how two home health aides can share a single flowsheet. In the figure, two home health aides have made entries to the flowsheet.

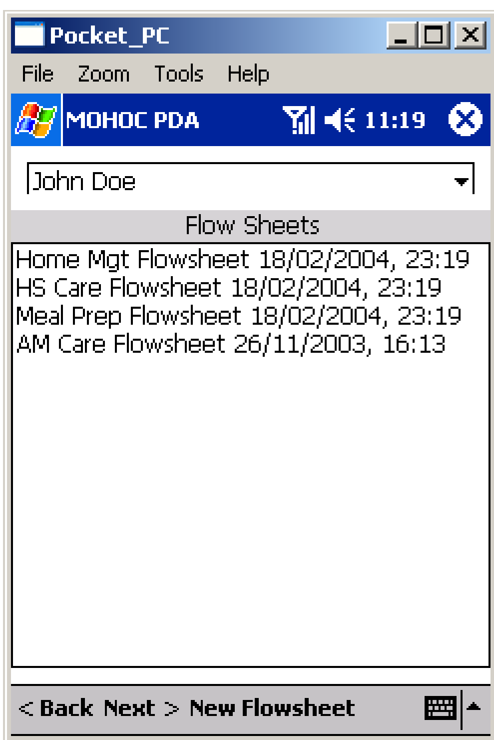


Figure 7.33. Pocket Mohoc flow sheets screen

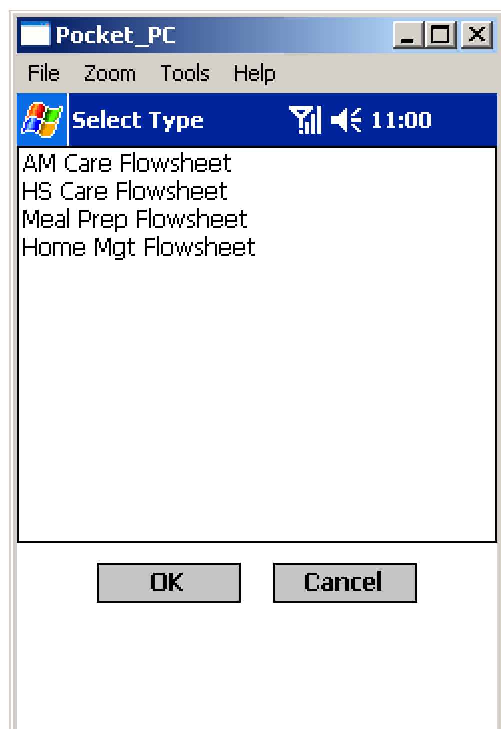


Figure 7.34. Screen to select template type for new flowsheet

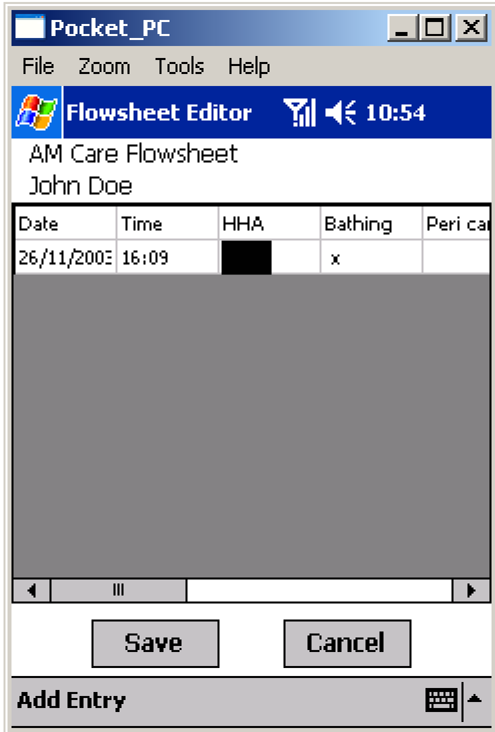


Figure 7.35. Flowsheet editor showing new flowsheet.

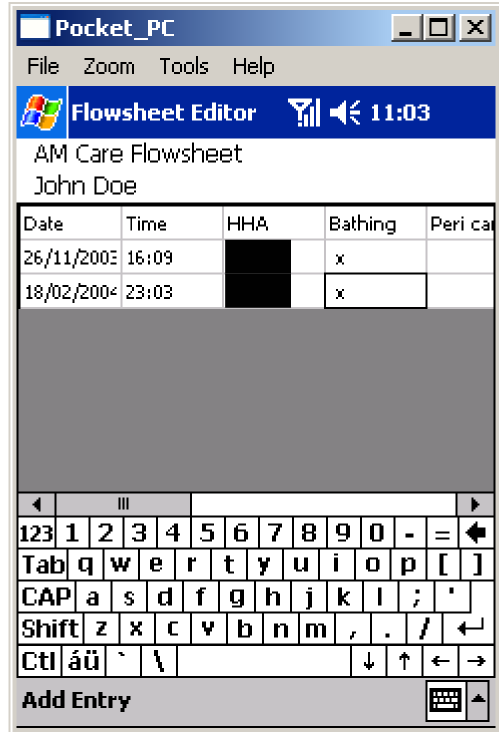


Figure 7.36. Flowsheet editor showing addition to existing flowsheet

8 Field trials

As part of the evaluation of the design framework, I carried out two field trials where the groupware system was used by home care teams to support team members' daily activities. The field trials allowed the groupware system and the underlying design framework to be evaluated to determine how well each part of the framework fulfilled its role in the design process.

In this chapter, I discuss the field trial methodologies and provide a general discussion of the events that unfolded during each trial. I discuss how the findings of the field trial were used to evaluate the framework in Chapter 9. The chapter is arranged as follows:

- Field trial 1
- Preliminary analysis and revision
- Field trial 2
- Validity of field trial methods
- Reliability of field trial methods
- Analysis and interpretation

8.1 Field trial 1

I carried out a 2 ½ month field trial of Mohoc to evaluate the system and to gather information to assist with evaluating the design framework. During the field trial, Mohoc was used by a treatment team of six home care workers from five different disciplines. Each team member was given a laptop with a wireless modem, and the team used the application to support the treatments that they provided to a single shared patient. In the next sections, I discuss the field trial methodology in detail and arrange the discussion around the following themes: planning and preparation, managing the trial, data collection, and general observations.

8.1.1 Planning and preparation

The first field trial was planned with the involvement of several departments and units in Saskatoon Health Region. The plan was developed over an extended period of time through meetings, emails, and phone conversations with supervisors from each of the home care departments (e.g. Home Care, Coordinated Assessment Unit, Occupational Therapy, Physical Therapy, and Social Work) and with administrators from other SHR departments including Client and Patient Information Services, Information Systems and Telecommunications, and Research Services. This process involved discussions about research goals and how the research process should be tailored to address the needs and concerns of each interested party in the health region. This took place over approximately 9 months and culminated in the project being granted approval from the University of Saskatchewan's Advisory Committee on Ethics in Behavioural Science Research, and soon thereafter, in the project being granted operational approval by the Health Region.

Later, once observations, design, and implementation had progressed sufficiently, more concrete plans were developed. A group meeting was held with supervisors and seniors from each home care department. During the meeting, a plan of action was developed for the first field trial. The SHR supervisors agreed to work together to select a single client for the field trial that they felt was stable enough to stay on workers' caseloads for a 2-3 month period. They also agreed to identify the workers who treated that patient and to make the workers available for interviews, training sessions, and other involvement in the trial. A nursing supervisor was designated as the primary liaison for coordinating field trial activities.

Once a patient was identified and informed consent was obtained, the nursing supervisor forwarded the names and phone numbers of the workers that treated that patient to the researchers. The treatment team that participated in the field trial consisted of six workers from five disciplines:

- 1 occupational therapist
- 1 physiotherapist

- 1 registered nurse
- 1 case manager
- 2 home health aides (working in two different shifts)

Prior to the trial, each worker participated in two training sessions. Each session lasted between 1 and 1 ½ hours. First, each participant was trained on the care and maintenance of the laptop and CDPD modem, and on the Windows XP operating system. Each worker also received preliminary training on Mohoc. Workers were given the laptops and modems, and encouraged to use them so that they could become more familiar with them and with the software. A second training session was scheduled with each worker approximately 2 weeks after the first session. During the second training session, workers were given in-depth training on the Mohoc application, and on the logistics of the field trial. Appendix B includes rough training scripts.

The level of technical expertise varied within the treatment team. Three workers were familiar with using machines with a Windows operating system, and the other three had limited prior exposure to computers. Participants' typing skills also varied, but all were familiar enough with keyboard layout that they were able to use the system during training sessions without significant problems.

8.1.2 Managing the trial

Once the trial began, ongoing efforts were made to ensure that the system was performing properly, that home care workers were using the system, and that they were not having difficulties. Several provisions were made to allow this. Foremost among these was that the workers were given the cellular phone number of a researcher who was available during business hours to take their calls, and they were encouraged to phone if they had any questions or problems.

The status of the system and users' participation was monitored remotely using an administrative laptop that ran the Mohoc client application. This laptop, which accessed the server using an administrative account, allowed researchers to log into the system so that communications and artifacts could by monitored to determine the patterns of system use and to ascertain whether workers appeared to be having any problems with the system. The administrative account allowed researchers to log into the system without leaving a footprint that would potentially interfere with the trial. For example, it did not place viewing history indicators on artifacts when they were accessed.

Participation and patterns of use were also monitored using system logs that were generated on the server. The logs tracked all transactions that were generated by workers' interactions with their client laptops. Figure 8.1 shows sample content from a server log. Five transactions are shown in the figure, and the content is extensive enough to give a detailed understanding of the activities that were carried out by a worker.

```
date=2003-12-03   time=16:15:08     op=addDoc   name=WOR000005
      id=DOC_CLI000001_WOR000005_000011   discipline=NURS
      contentPath=data/Document/DOC_CLI000001_WOR000005_000011.rtf
      author=WOR000005  clientID=CLI000001      creationTime=16:12
      creationDate=3/12/2003  op=addDoc   priority=normal   mid=126
      description=Narrative progress notes
      publicOrPrivate=private
date=2003-12-03   time=16:15:08     op=addViewingHistory
      name=WOR000005
      id=VHX_(DOC_CLI000001_WOR000005_000011)_WOR000005
      visible=true      lastViewTime=16:13
      lastViewDate=3/12/2003  clientID=CLI000001
      op=addViewingHistory    workerID=WOR000005      mid=127
date=2003-12-03   time=16:15:54     op=modifyDoc
      publicOrPrivate=public  toPublicTime=16:13      mid=130
      name=WOR000005    toPublicDate=3/12/2003  op=modifyDoc
      id=DOC_CLI000001_WOR000005_000011   clientID=CLI000001
date=2003-12-03   time=16:22:10     op=logon    name=WOR000005
      objPort=4448      tcpipPort=4447    op=logon    id=131
date=2003-12-03   time=16:22:49     op=addViewingHistory
      name=WOR000005    id=VHX_(CHT_CLI000001)_WOR000005
      visible=true      lastViewTime=16:20
      lastViewDate=3/12/2003  clientID=CLI000001
      op=addViewingHistory    workerID=WOR000005      mid=132
```

Figure 8.1 Sample content from a server log. The log shows 5 transactions.

An effort was made to maintain ongoing contact with the participants throughout the study. The workers were contacted every 3-4 weeks to check to see if they were having any problems with the system. Some of these interactions were part of the formal data collection process for the field trial (see Section 8.1.3), and others were initiated by the workers themselves by way of the cellular phone.

When technical problems were identified in the client application, they were usually addressed remotely using an FTP-based patching utility. Since there were six laptops in the trial, and since it was often difficult to meet with workers due to their mobility, the patching utility was developed to allow problems to be fixed without physical access to the client laptops. When workers started the application, the patching utility would automatically search for updates. If they existed on the server, the client laptop would download them, unzip them, and then start the application with the updates in place. The utility was used twice in the first two weeks of the trial to fix unexpected technical problems.

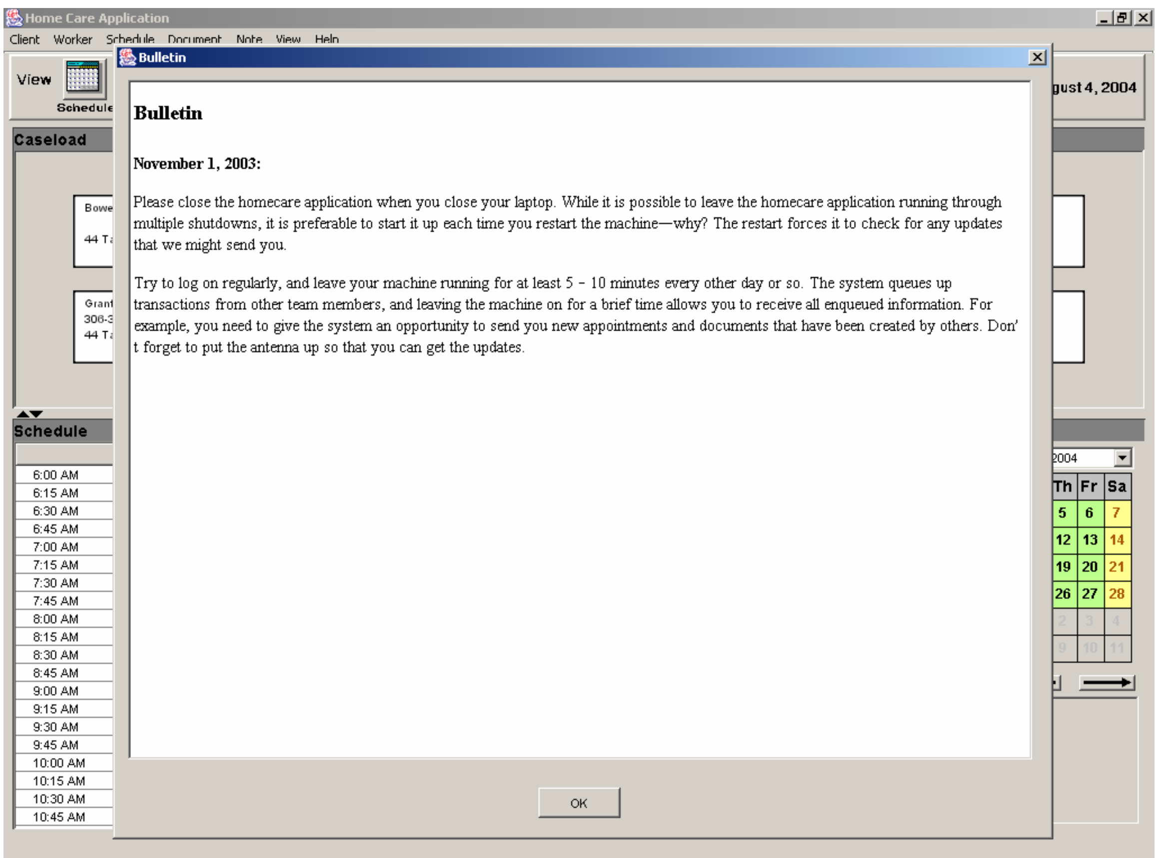


Figure 8.2. Bulletin file from Mohoc.

The patching utility also provided a means of communicating with the workers in the field. Mohoc has four HTML help files, which include a Mohoc tutorial, a series of frequently asked questions and answers, a bulletin, and contact information for researchers (the cellular phone number). The patching utility allowed these files to be updated throughout the trial so that new information could be sent to the workers. Figure 8.2 shows a bulletin file that was sent to workers using the patching utility early in the second field trial.

8.1.3 Data collection

During the field trial, two types of data collection procedures were carried out. First, data was collected though interviews with home care workers. Second, data was collected using system logs and using the shared workspaces that are shown in the user interface of the groupware system.

Two rounds of interviews were carried out with each participant. Each interview session lasted between 1 and 1½ hours. Interviews with the occupational therapist, physical therapist, and client care coordinator were conducted at the participant's desk. Interviews with the nurse and home health aides were conducted in private meeting rooms in the home care office. The first interview was conducted midway through the trial, and the second interview was conducted at the end of the trial. All interviews were audio recorded for later analysis. The interviews were semi-structured, and focused on gathering information about how features were utilized by participants and about participants' opinions of features. They were also intended to provide an initial look at how the system impacted work practice.

Workers' interactions with the system were recorded using system logs to provide an objective measure of how the application was used by the participants. System logs contained timestamps and information about the specific interactions that workers carried out with the application (see Figure 8.1). Access to the system using the administrative account allowed the shared workspaces to be examined, which provided additional context for interpreting users' actions. For example, documents, appended notes, and modification and viewing histories were easier to interpret at the user interface level than they were through examining system logs.

8.1.4 General observations

The focus of the first field trial was primarily on collecting data to evaluate the design framework, but since this was the first time the full Mohoc application was introduced to real users, it also provided an opportunity to identify and address technical problems. During the first training session, each participant was given a laptop. The laptops were set up to allow workers to explore the Mohoc system using a “John Doe” patient that had been added to all of their caseloads. Workers had access to the system for approximately two weeks before the field trial formally began. During this time, several technical problems were identified. The first was an oversight in the way that XML data was stored and retrieved on the client platforms, and the second was a user-interface bug that interfered with the display of treatment plans. These problems were corrected once they were identified, and a patch was sent to the client machines using the patching utility.

Once the second round of training had been conducted, the field trial formally began. Workers were notified that the trial would be initiated on a specific date, and it was initiated by pushing the “real” client’s profile to all study participants. This was done using a feature in the Mohoc server application which allows the system administrator to add patients to workers’ caseloads. When this is done, updates are sent to each laptop to update the worker’s profile, and the data that is associated with that client is “pushed” to the worker’s laptop so that they can begin using the system to support the care of that patient.

Once the trial started, the server, system logs, and the administrative laptop were used regularly to guarantee that the system was working properly and to monitor workers’ level of participation. This allowed small technical issues to be identified, and early in the trial, a second patch was issued to address three minor user interface problems. The patch also included new document templates and an updated tutorial file. Once this patch was added, the client applications and the server remained stable for the duration of the trial. Further patches were not needed, and there were no complaints about technical problems from the trial participants.

Usage patterns in the system varied with participants' level of involvement in the patient's care. Predictably, the workers that visited the patient more frequently tended to use the system more regularly. Figure 8.3 illustrates this by showing the number of times participants from each discipline logged in to the Mohoc system during the field trial. The figure shows that home health aides, physiotherapy, and nursing had the most logins, and this reflects the frequency of each discipline's visits to the patient. Home health aides visited the patient daily, and nursing and physiotherapy visited several times a week. The occupational therapist and case manager visited the patient only occasionally (frequency varied somewhat over the course of the trial), and the intermittent nature of these visits was reflected in their level of participation in the trial.

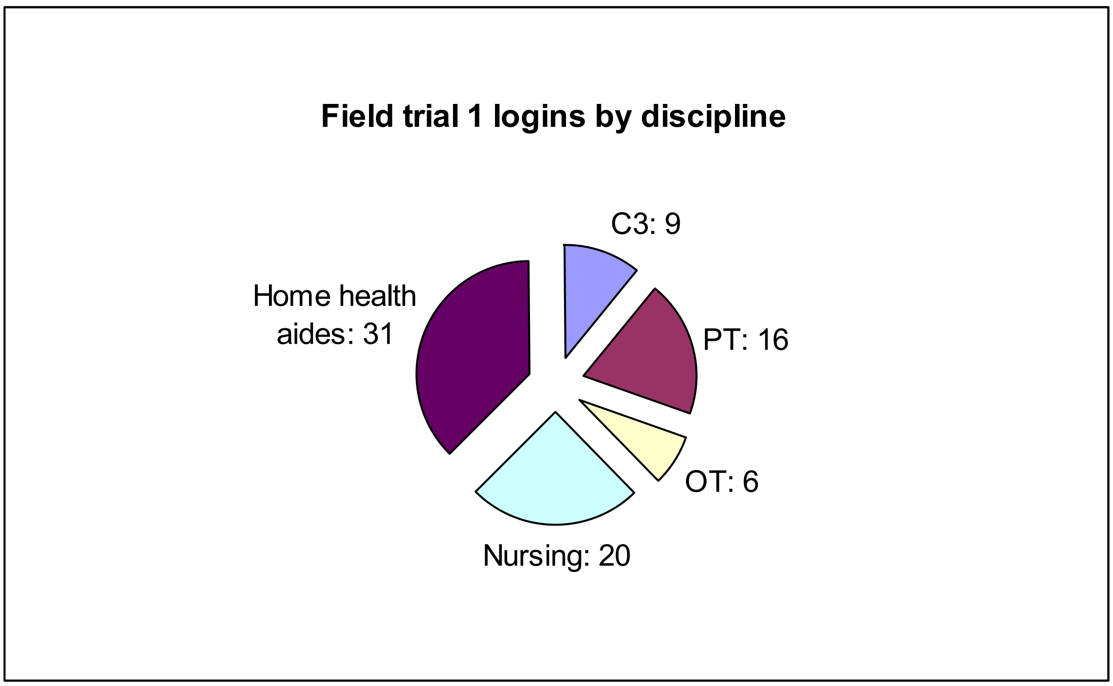


Figure 8.3. Field trial 1 logins by discipline. Discipline type and total number of logins are indicated next to each pie slice.

The home health aides accessed the system more regularly than the professional disciplines. Since home health aides are not professionals and are tightly coupled to their supervisors, they felt more compelled to participate than the professional disciplines since they felt that the nursing supervisors expected them to use the system. This was confirmed during interviews at the end of the trial. Professionals used the system more intermittently, which seems to be a reflection of their professional autonomy and their ability to determine their own work activities. These deployment issues are discussed in more detail in Chapter 10.

The first round of interviews was conducted half way through the field trial. During this time, half of the workers stated that they did not carry their laptops with them in the field, but rather kept them in the office or at their homes. They were concerned that carrying the laptop would make them targets for theft, so instead they chose to access the system after their visits. Additionally, four of the workers stated that using the system was extra work since they were only using it to support a single patient.

The latter half of the field trial had several events that led to periods of low system use by the participants. In the weeks surrounding Christmas and New Years Day, many of the participants were on holiday, and their use of the system decreased significantly (roughly days 55-65 in Figure 8.4). Also, the patient was hospitalized briefly mid-way through the trial, and system use was minimal at that time.

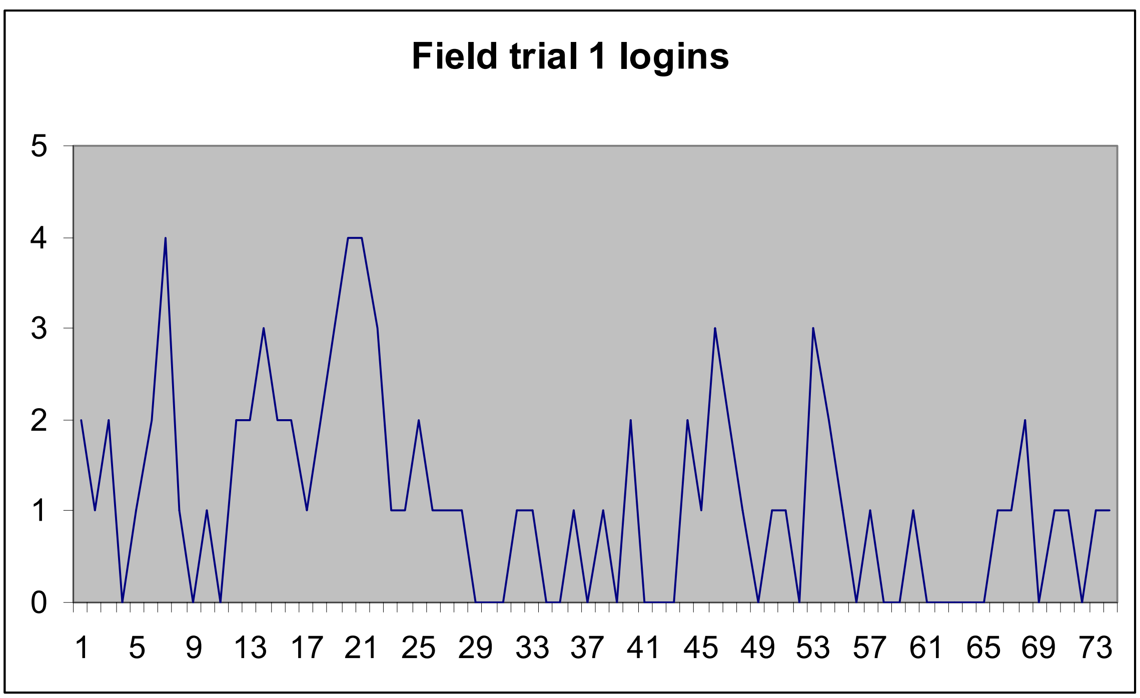


Figure 8.4. Field trial 1 logins. Vertical axis indicates number of logins per day, horizontal axis indicates day of the field trial.

At the end of the trial, exit interviews were conducted. During the interviews, three of the workers stated that they felt the system would have been more valuable to them if it had been used with all of their patients instead of with only a single patient. When asked for general comments on the system, workers felt that the system provided several features that were valuable to them, including the shared document repository and communication features. However, three of the participants indicated that the stability of the patient and the predictability of the treatments that they provided meant that there was often very little to collaborate about. Several workers suggested including patients of varied acuity in the second field trial so that the system could be used in more varied work scenarios.

Overall, the system performed well during the trial. When data from the laptops were reviewed, all transactions appeared to be routed to the proper recipients and data loss was not seen. After the initial patches, the system was stable, and participants did not complain of technical problems during the interviews during and after the trial.

The field trial was overall successful. Participation was good but limited at times due varying levels of involvement by different team members. At times, some participants accessed the system sporadically, but the field trial duration enabled enough data to be collected from each user so that a reasonable evaluation could be carried out. Additionally, a range of system features were used by the participants over the course of the trial, which provided data on each of the major features (and underlying design approaches) so that they could be evaluated (see Section 8.6 for more details).

8.2 Preliminary analysis and revision

I carried out a brief preliminary analysis of the system logs and the interview data from field trial 1 to help determine the direction of the second field trial, and to identify design and implementation problems with the Mohoc system. The analysis identified several minor technical problems, and the client and server applications were revised to resolve those problems.

Preliminary field trial results indicated that the Mohoc system was not well-suited to the needs of home health aides. Home health aides have decreased autonomy—they are centrally scheduled, and they cannot revise the services that they deliver to patients without consulting nursing supervisors. Also, they have different document utilization practices and do not spend time in the office. These differences meant that many of the features found in the Mohoc system were not useful to home health aides, and were underutilized by the home health aides who participated in the first trial.

To accommodate these differences, I designed Pocket Mohoc, a new application that is tailored to meet the needs of home health aides. Pocket Mohoc provides a subset of the functionality that is seen in Mohoc. For example, since home health aides do not self-schedule, many of the collaborative scheduling features were removed in the new version. Pocket Mohoc is discussed in detail in Chapter 7.

8.3 Field trial 2

I carried out a second field trial using Mohoc and Pocket Mohoc to further evaluate the design framework. The second trial was larger in scope—it lasted 3 months and included 3 patients and 10 participants. The underlying intent of the second trial was to expand on the investigation started in the first, but with patients with varying levels of acuity. This variance, it was hoped, would provide an opportunity to examine different levels of interdependence within treatment teams so that a more varied set of work patterns could be considered.

In the next sections, I discuss the field trial methodology in detail and arrange the discussion around the following themes: planning and preparation, managing the trial, data collection, and general observations.

8.3.1 Planning and preparation

Planning and initiating the second field trial required less time than the first trial since administrative hurdles had already been cleared with the health region. Preliminary planning took place at a meeting with managers from the Home Care unit. During the meeting, the goals of the second field trial were discussed which were to include patients with different levels of acuity and stability, and to increase the size of the worker participant pool. The home care managers agreed to identify three patients for the trial. They also agreed to identify the workers who treat those patients and to make them available for interviews, training sessions, and other involvement in the trial. A nursing supervisor was designated as the primary liaison for coordinating field trial activities.

Once the patients were identified and informed consent was obtained, the nursing supervisor forwarded the names and phone numbers of the workers that treated the patients. There were ten participants from five disciplines:

- 3 home health aides
- 2 office-based nursing supervisors
- 3 registered nurses
- 1 case manager
- 1 dietician

None of the participants in the second trial took part in the first trial. Technical expertise varied within the participant pool. Typing skills varied as well, but all participants' demonstrated some familiarity with keyboard layout during training sessions and none reported problems with data entry after the trial.

Prior to the trial, each worker participated in two training sessions. Each session lasted between 45 minutes and 1 ½ hours. The length of the session varied depending on each participant's level of technical expertise. Training sessions were different for some of the participating disciplines. Home health aides were trained to use the Audiovox Thera devices and the Pocket Mohoc application. Professional participants were trained to use laptops, CDPD modems, and the Mohoc application. During the first session, participants were trained on basics of the operating system, on the care of the hardware, an on the basics of the client application. During the second session, workers were provided with more in-depth training on the client application, and were instructed on the logistics of the field trial. Appendix B includes rough training scripts for the laptop and handheld versions of the application.

8.3.2 Managing the trial

The management of the second field trial was similar to the first. Workers were given the cellular phone number of a researcher who was available to answer questions and provide technical support, and this support was provided during the day and evening home care work shifts. The status of the system and users' participation was again monitored using the administrative account. The patching utility was used to send bulletins and to add new document templates to participants' client machines.

8.3.3 Data collection

During the second field trial, three types of data collection procedures were used. First, data was collected through interviews with home care workers. Second, data was collected using system logs and using the shared workspaces that are shown in the user interface of the groupware system. Third, questionnaires were administered to participants at the end of the trial.

Two rounds of interviews were carried out with each participant. Each interview session lasted between 1 and 1½ hours. Interviews with the nursing supervisors and client care coordinator were conducted at the participant's desk. Interviews with the dietician, nurses, and home health aides were conducted in private meeting rooms in the home care office. The first interview was conducted midway through the trial, and the second interview was conducted at the end of the trial. All interviews were audio recorded for later analysis. The interviews were semi-structured, and focused on gathering information about how features were utilized by participants and about participants' opinions of features. They were also intended to provide an initial look at how the system impacted work practice. Appendix B contains rough interview scripts.

Questionnaires were administered near the end of the trial to gather information about workers' views on work and collaboration in the team. The questionnaire was intended to add information that was needed for the evaluation of some of the key areas of the design framework (see Appendix B for copies of the questionnaire).

8.3.4 General observations

An initial round of training was provided to the participants, and they were given the devices (laptop of handheld) so that they could explore the features using a “John Doe” patient. The initial training session uncovered several issues that needed to be addressed in the interim period before the second round of training began. In the first round of training, the nurses stated that they felt that the system would add significant work for them since they would have to document their visits for the current paper-based record keeping system, and then would have to duplicate the documentation in the Mohoc system. To address this, printing features were added to the system so that the flowsheets and narrative notes could be printed and then added to the paper-based chart.

During the second round of training, two nurses indicated that using printouts from the system would add too many extra sheets of paper to patients’ charts and would make them prohibitively thick. In their current work practice, they did not create a new form for each entry, but instead they sequentially added new entries to the bottom of existing forms. Printing in the Mohoc system would require that they print a new document after each entry so that the paper-based chart could be kept up-to-date. A compromise was eventually reached with the two nurses—they agreed to enter progress notes (narrative notes that describe the patient’s status and response to treatments) into the system, but not their medication flowsheets. This would allow important observations to be recorded in the system and would significantly reduce the number of printouts that would need to be added to the paper chart. The third nurse participant did not feel that printouts would add significant paper to her chart, and she agreed to use the system to support all documentation for her two patients that were in the trial.

Once the second round of training had been conducted, the field trial formally began. Workers were notified that the trial would be initiated on a specific date, and it was initiated by pushing the “real” clients’ profile to all study participants. This was done using a feature in the Mohoc server application which allows the system administrator to add patients to workers’ caseloads. Each participant treated different subsets of the three patients who participated in the trial, and they were only sent the profiles for the patients that were in their caseload.

Early in the trial, a patch was released. The patch added new document templates for the dietician, and two new templates for nursing. The technology was stable throughout the trial. Participants did not report any technical problems, and further patches were not needed.

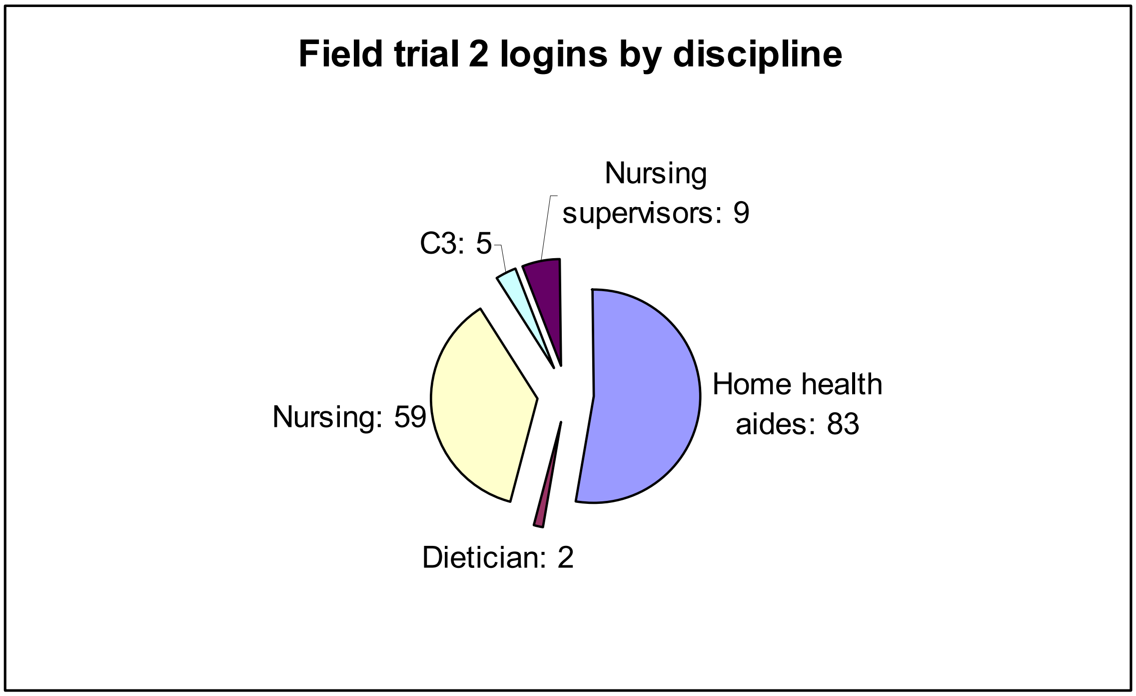


Figure 8.5. Field trial 2 logins by discipline. Discipline type and total number of logins are indicated next to each pie slice.

As seen in the first trial, usage patterns were largely a function of workers' level of involvement in patients' care, and workers who visited patients frequently accessed the system more frequently. Figure 8.5 illustrates this by showing the number of times participants from each discipline logged in to the Mohoc system during the field trial. The nurses and home health aides visited the patients more frequently than the other disciplines, and system logs indicated that they accessed the system more frequently. The case manager visited the patients infrequently, and this was mirrored in the access patterns for the system. The nursing supervisors rarely accessed the system during the trial, and in exit interviews they indicated that it did not fit into their workflows (i.e. they are office-based workers that do not visit patients), and that their workload was significant and did not leave extra time to access the system. The dietician kept a patient on her caseload for a short time at the beginning of the trial before discharging him/her, which led to a low level of participation in the trial.

The home health aides accessed the system more frequently than the professional disciplines. Nurses generally accessed the system once or twice a week, even though their treatment frequencies were more frequent (3 times a week, daily, and twice a day). Home health aides visited participating patients daily and twice a day, and they usually accessed the system daily. As previously discussed, this seems to be partially a function of the limited autonomy that home health aides have, and their perceptions that their supervisors expected them to participate in the trial (this is discussed in more detail in Chapter 10). However, the home health aides had different platforms (Audiovox Thera) and different client applications which could potentially contribute to differences in participation levels.

The patients that were included in the trial had conditions that were acute and unpredictable, and this led to differences in patterns of collaboration and system use. Workers used the system to notify others of unexpected events that occurred such as changes in a patient's status or hospitalizations. For example, a home health aide left a message using the discussion tool: "<name> on the floor this evening. got <him/her> on bed , called office. both knees bruised, daughter coming over." However, one unintended consequence was that the instability of patients' conditions led to increased instances where the patients were hospitalized, and this caused periodic down-times in the trial where little activity occurred for those patients. Participants reported that two of the three clients spent time in the hospital.

Other events led to slowdowns or limited participation by some of the workers involved in the trial. As seen in the first trial, participation was limited in the weeks around Christmas and New Years Day since many of the workers took time off (approximately days 55 to 70 in Figure 8.6). Two of the participants unexpectedly were forced to take time off during the trial due to illness, and they did not participate in the trial during those periods. The workers who replaced them for those times did not participate in the trial due to the significant time investment that would be needed to schedule and conduct training sessions, and the uncertainty of how long the participants would be out from work.

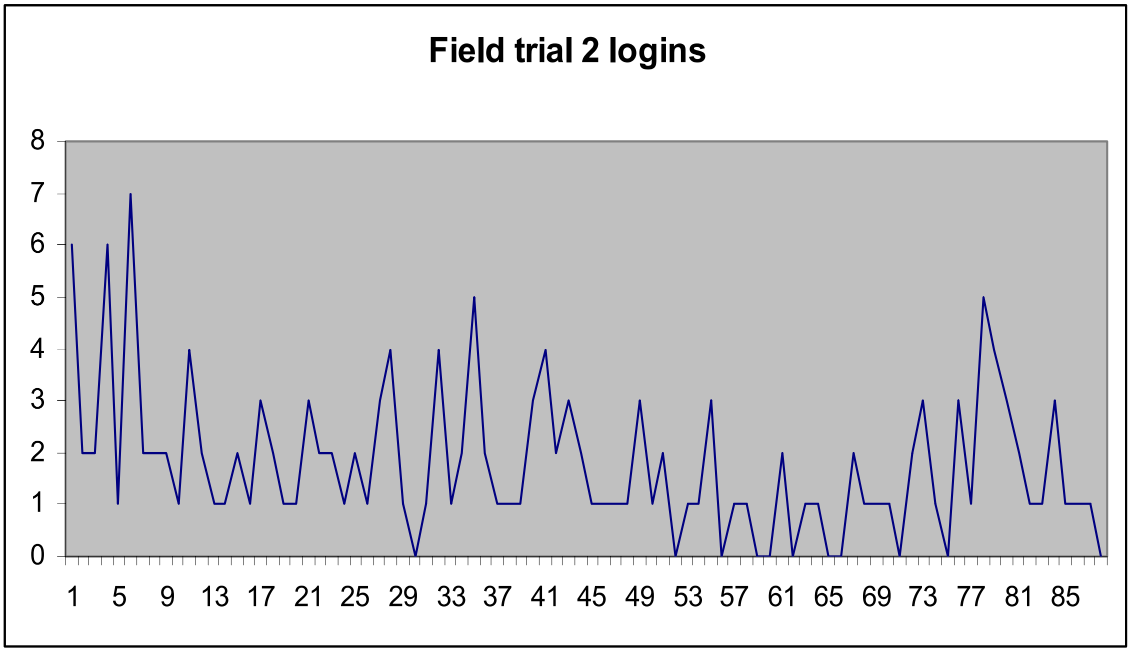


Figure 8.6. Field trial 2 logins. Vertical axis indicates number of logins per day, horizontal axis indicates day of the field trial.

Most (6/7) of the participants who used laptops (i.e. all participants except the home health aides) reported not carrying the laptops with them in the field. They reported two concerns. First, they were worried about potential theft of the laptop. Second, they felt that the laptop was bulky and heavy, and since they already had to carry their paperwork and supplies with them on their visits, they could not manage to carry the laptop as well. As was seen in the first field trial, these participants either kept the laptop in their office or at their homes.

All home health aide participants reported carrying the AudioVox Thera devices with them during the workday. They were able to conceal the devices in the cars or in their satchels, and they did not express any concerns about theft of the devices.

Overall, the server and both versions of the client application were stable during the trial and performed well. A brief review of data from the client machines did not identify any problems with routing data through the system, and data loss was not seen. Participants did not identify any technical problems during the trial. All support provided during the trial either provided clarification on operating system issues or on how tasks should be carried out in the application.

The field trial was overall successful, although the level of participation was limited for some of the disciplines. Fortunately, the nurses' and home health aides' levels of involvement with the patients were relatively stable. Also, in some cases two workers from the same discipline shared patients, and collaboration took place both between team members of the same discipline and between team members of different disciplines. A range of system features were used by the participants over the course of the trial, which provided data on each of the major features (and underlying design approaches) so that they could be evaluated.

8.4 Validity of field trial methods

In this section, I discuss the validity of the field trial methods. In this dissertation, validity is defined as "the extent to which the research findings or concepts correspond to empirical reality" (Marvasti 2004, p. 148).

During the trials, there were a total of 16 participants from six different disciplines, and participants from the first trial did not take part in the second trial. A substantial number of the participants were nurses (4) and home health aides (5). This is partially due to the staffing levels seen for each of the clinical disciplines—there are more nurses and home health aides working in the health district than there are workers from the other disciplines. However, this means that some of the disciplines were under-represented (e.g. one participant each for occupational therapy, physical therapy, and dietetics), which could possibly introduce bias in the results.

The system logs provided objective data about usage patterns during the trial—they indicated the frequency and distribution of features used in the system. The logs were automatically generated by the system, and they included all data that was transmitted across the network between client and server machines. Therefore, they accurately reflected the activities of workers during the trial.

There were two rounds of interviews per trial. Participants brought their laptops with them to interviews, and the results of their activities in the system were reviewed with them in the user interface. They were asked questions about usage patterns and about how the system impacted their work practice.

The combination of interview data and system log data provided two views of the work situation. The interviews provided information about the impact the system had on work practice and on workers' perceptions of the system and of its features and the underlying design choices. System logs provided an objective measure of usage patterns during the trials.

8.5 Reliability of field trial methods

In this section, I discuss the reliability of the field trial methods. In this dissertation, reliability is defined as "the extent to which research findings can be replicated over time and / or by other investigators" (Marvasti 2004, p. 147).

Data collection was carried out by a single researcher, and it is unclear whether the results and conclusions that were reached would show significant variance if they were carried out by others. Scripts were used during the interviews, but the line of questioning often deviated from the script in order to get clarification on participants' responses. Since the interviews were not standardized, it is possible that different results would be obtained if other researchers conducted the interviews.

The logs were automatically generated by the system, so they were not subject to methodological bias. However, it is difficult to ascertain whether the same results would be obtained over time, since variation in patient status or in makeup of the participant pool could possibly lead to different usage patterns.

8.6 Analysis and interpretation

Once the field trials were completed, data were analyzed to determine the impact that the groupware system and the underlying framework had on home care teams. The transcripts, questionnaires, and logs were analyzed to determine the system's impact on work and collaboration patterns. The results were used in an evaluation of each of the main parts of the design framework. These results are reported in Chapter 9.

Workers' interactions with the system were recorded in the system logs, which provide a partial indication of how the system impacted work practice in the participating treatment teams. In the rest of this section, I briefly summarize the usage patterns that were seen in the system logs. During the trials, there were a total of 240 system logins by participants over the course of 162 days. There were a total of 5153 transactions during the trials. A transaction is an action taken by a user that generates a network message that is sent to the server. On average, participants carried out 21.47 transactions per session.

Table 8.1 presents a list of transaction types and the total number of transactions that occurred for each type during the two field trials. The table is partitioned into sub-sections so that transactions are grouped by the objects that they manipulate (e.g. clinical document, sticky notes, appointments, etc.).

Table 8.1. Field trial transactions. First column describes transaction type, second column indicates sum of transactions for both trials, and third column indicates percentage of total transactions

Transaction type	# transactions	% total
CLINICAL DOCUMENT		
Create new clinical document	136	2.6%
Initially set as public	62	1.2%

Initially set as private	74	1.4%
Modify document content	230	4.5%
Change private document to public	46	.9%
Delete document	17	.3%
View a document	1482	28.8%
STICKY NOTES		
Create a new note	92	1.8%
Placed on patient's chart	68	1.3%
Placed in clinical document	24	.5%
Private notes	31	.6%
Public notes	61	1.2%
Delete note	12	.2%
View a note	485	9.4%
View note on chart	413	8.0%
View note in clinical document	72	1.4%
APPOINTMENTS		
Create a new appointment	263	5.1%
Modify an appointment	173	3.4%
Delete an appointment	28	.5%
Specify a service for an appointment	374	7.3%
Delete a service from an appointment	61	1.2%
SERVICE PLANS		
Add or modify an entry in the service plan	340	6.6%
Delete a service plan entry	25	.5%
DISCUSSION TOOL		
Add a new discussion entry	118	2.3%
SERVICES		
Change the treatment frequency or duration	10	.2%
WORKER PROFILE		
Modify worker profile (e.g. phone, pager #)	8	.2%
CHART		
Open (view) a patient's chart	1253	24.3%

All transaction types were utilized during the trials, but the usage patterns varied significantly. The transactions that occurred most frequently were object "views", which occur when a user opens a note, document, or patient's chart. In all, document (28.8%), note (9.4%), and chart (24.3%) views accounted for a total of 62.5% of the transactions in the system. This suggests that participants were interested in reviewing others' clinical documents and in reading sticky notes left by others.

Tools that support current autonomous work practices were used regularly. A total of 136 clinical documents were created in the system, and the contents of many of the documents were later modified (230 total modifications). A total of 263 appointments were set in the system, and the appointments were often modified over the course of the trial. Service plans were regularly updated, and a total of 340 additions and modifications were made to workers' service plans.

Communication features were used less frequently. A total of 92 sticky notes were left in the system—68 on patients' charts and 24 in clinical documents. Of those, 31 were sent to private recipients, and the remaining 61 were public. A total of 118 entries were left using the discussion tool.

9 Evaluation

In this chapter, I present the results of a qualitative evaluation of the design framework. The home care setting at SHR was used to explore three questions about the framework:

1. Whether the contextual model identified organizational, work, and collaboration patterns that are important for understanding loose coupling in the home care setting,
2. Whether the analysis technique captured and organized important contextual features of the home care setting in preparation for design, and
3. Whether the design approaches enabled important aspects of the work situation to be mapped to the design of system features.

The evaluation was based on home care interviews and observations (discussed in Chapter 3), and on field trial findings. The contextual model was evaluated using the interview and observational data that is discussed in Chapter 3. The analysis technique and the design approaches were evaluated using field trial findings.

The chapter is divided into four main sections:

- Scope and goals of the evaluation
- Evaluation of the contextual model
- Evaluation of the analysis technique
- Evaluation of the design approaches

9.1 Scope and goals of the evaluation

The design framework is the first CSCW framework that brings together information about work patterns in loosely coupled work situations, and therefore, the evaluation was oriented towards gaining initial experience with the principles in real use. The overall goal of the evaluation was to determine whether the elements, tools, and approaches in the framework actually assisted the groupware design process in a real-world work setting.

The design framework is based on a general CSCW design process that includes data collection from the target work setting, analysis of the data, and system design based on the analysis results. The framework organizes and guides this process for loosely coupled groups, and the evaluation is organized around the parts of the model and the design phase that they support.

9.2 Evaluation of the contextual model

The contextual model is intended to help designers to understand and identify key factors that shape work and collaboration patterns seen in loosely coupled settings. It was evaluated by assessing how well it predicted the factors that were important for understanding loose coupling in home care at SHR. The evaluation was qualitative and was based primarily on the home care observations reported in Chapter 3, but also relied partly on findings from the field trials.

Since the evaluation is limited to a single work setting, it is not possible to conclusively determine the coverage and precision of the contextual model. First, the model was developed in parallel with observational work in the field, and so it is possible that some aspects of the home care setting are over-fitted to the model. Nevertheless, because observational work at SHR was for the most part carried out separately from the creation of the contextual model, the evaluation is able to compare predictions made by the model with reasonably independent observations of the work setting. Second, the presence or absence of evidence for different items in the model in the home care setting does not rule out the usefulness of those items in describing work in other types of loosely coupled groups. It is clear that further assessments of the model in other domains will be required in future; however, the goal here was to gather initial data about whether the model was useful for design, and the home care setting was sufficient for that purpose.

The next sections discuss the major parts of the contextual model, and how successful each part was at predicting the patterns that were observed in treatment teams. The sections are organized according to the following outline:

- Coordination
- Communication
- Reasons for loose coupling
  - Limited opportunities for interaction
  - Professionalism; specialized knowledge, expertise
  - Ambiguous evaluation criteria; cryptic surveillance
  - Environmental uncertainty; non-routine and unpredictable tasks
  - Organization / group size and complexity
  - Incompatible external expectations
  - Internal conflicts
- Outcomes associated with loose coupling
  - Information buffers
  - Partitioning of tasks
  - Adaptability
  - Weak authority structures
  - Persistence
  - Sensitivity to environmental stimuli
  - Buffering
- Summary of findings
- Validity of evaluation and conclusions

9.2.1 Coordination

Prediction. Loosely coupled workers use coordination mechanisms that minimize time, effort, and direct negotiation (Section 4.5.1).

Results

The information in the contextual model did successfully cover the majority of the coordination methods seen in the home care setting. Home care workers at SHR have a strong preference for low cost coordination methods that minimize the need for direct negotiation; this preference played a significant role in the organization of work in treatment teams. Coordination methods observed in home care included several that were included in the model: unexamined assumptions, mutually understood roles and task partitioning, awareness, and adjustment without negotiation. For example, since each worker serves in a well-understood role in treatment teams, others can usually make assumptions about the services that the worker will provide to a patient. These assumptions are usually adequate to allow the group to function effectively. When more detailed coordination is needed, home care workers often ask patients about others' treatment activities, or they rely on evidence of others' activities in patients' homes (e.g. handouts, equipment). Direct communication, which requires more effort, is generally used only when other mechanisms fail. This is largely due to the cost inherent in communicating since workers have limited awareness of others' locations, schedules, and availabilities. It is worth noting that one coordination mechanism seen in home care was not part of the model: the idea of coordinating activity through the patient themselves or another intermediary. This type of coordination is possible when there is a person, a resource, or a location that everyone in the loosely-coupled group contacts or visits on a regular basis. This mechanism is discussed further in Sections 9.2.5.2 and 10.5.3.

9.2.2 Communication

Prediction. Loosely coupled workers are tolerant of sparse communication channels and of information flow that is slow, infrequent, uneven, and indirect (Section 4.5.2).

Results

This part of the model accurately described the communication patterns that were observed in home care treatment teams. In home care, work is not arranged specifically to facilitate communication within teams, and workers usually only initiate communication when opportunities arise (e.g., when they unexpectedly meet another team member face-to-face) or when a work situation demands it. When communication is required, the channels that are usually used are normally slow and sparse: in particular, asynchronous channels such as voice mail, written messages, or messages passed through office staff. These asynchronous techniques allow workers to communicate without the need to arrange a time for synchronous communication. When synchronous communication is needed, workers often rely on phones, or if they work out of the same office, on face to face discussions. However, synchronous communication can take considerable time to arrange since each worker sets their own schedule, and office hours are often unpredictable. At times, this schedule variability leads to extended conversations through voice mail that can span several days, where each person takes turns leaving a message for the other until an issue is resolved.

9.2.3 Reasons for loose coupling

The contextual model contains a set of reasons that describe why social systems adopt loose coupling. In the next sections, I assess the degree to which each reason was useful in understanding loose coupling in home care.

9.2.3.1 Limited opportunities for interaction

Prediction. Loose coupling can occur because of factors that limit interaction; these include physical distribution, schedule variability, mobility, and constraints in the physical environment (Section 4.6.10).

Results

Three factors from the model – mobility, schedule variability, and physical distribution – were obvious characteristics of the home care setting, and these contributed substantially to the loose coupling seen in this situation. Since most workers set their own schedules and visit many different locations each day, there are very few opportunities for casual or planned interactions during the normal working day. Lack of face-to-face interaction makes it difficult for workers to communicate regularly and coordinate work, which contributes to a more autonomous, loosely coupled style of work. These factors also make it difficult for workers to interact using common distributed communication technology such as fixed or mobile telephones. However, the lack of access to technologies such as mobile phones is an additional factor that was not originally part of the model – SHR workers do not currently carry mobiles, and although these would not make interaction radically more frequent, they would allow for a higher level of contact than is currently seen.

9.2.3.2 Professionalism; specialized knowledge, expertise

Prediction. Professional status and expertise allow workers to operate autonomously of other group members (Section 4.6.8, 4.6.9).

Results

This part of the contextual model was extremely useful in explaining loose coupling in home care teams. The professional status of workers provides them with significant autonomy, and plays a crucial role in the way that treatment teams organize work and collaboration. Most of the disciplines in home care are professionals, with the exception of home health aides and licensed practical nurses. As professionals and experts in their discipline, they are given a high level of responsibility for their working day, their treatment decisions, and their interactions with other staff. The supervisors of the professional workers serve primarily as advisors, and only intervene in day-to-day activities when problems arise. For example, the supervisory duties of the senior therapist in Physiotherapy, Occupational Therapy, and Social Work are limited to managing of the waiting list, assigning new patients to different workers, and interacting with other departments and departmental administration.

The role that professionalism plays in shaping loose coupling in vertical relationships is best illustrated by contrasting it with home health aides' vertical relationships, which are tightly coupled. Home health aides are not professional employees—they have minimal training, and are not sanctioned by external licensing agencies. Supervisory oversight is more rigorous—they do not set their own schedules and do not have discretion in managing their work day. Managers may page them during the day and assign them additional patients to treat. They are not free to modify their treatments without first checking with the nursing supervisors.

9.2.3.3 Ambiguous evaluation criteria; cryptic surveillance

Prediction. When evaluation criteria are ambiguous, and when it is difficult to monitor others' activities (i.e., cryptic surveillance), worker autonomy increases, and knowledge of others' activities decreases (Sections 4.6.1, 4.6.2).

Results

Observations in home care indicate that these factors play a role in the loose coupling that is seen in treatment teams, but are partly a consequence of professionalism. In vertical relationships (i.e., between worker and supervisor), surveillance of workers' actions is minimal, in part due to the mobility of workers and the sensitivity of the patient-worker relationship, and evaluation criteria are ambiguous since outcomes are not easily measured given the range of factors that can impact patients' progress (e.g. patient compliance, prognosis, home situation, etc.). In home care, these factors mean that supervisors have limited ability to monitor and sanction workers based on their performance, and they also free workers to perform work activities more autonomously and without the need for ongoing negotiation with supervisors.

In horizontal relationships (i.e. between treatment team members), workers also have limited ability to monitor others' activities. Most team members do not see each other face-to-face regularly, and they often have limited awareness of others' activities. This contributes to a less integrated, more autonomous style of work within the team.

9.2.3.4 Environmental uncertainty; non-routine and unpredictable tasks

Prediction. An unpredictable external environment makes it necessary for work units to be autonomous so that they can adjust to unexpected circumstances, and non-routine tasks make it difficult for organizations to provide clear behavioral directives (Sections 4.6.3, 4.6.4).

Results

Both parts of the model significantly contribute to worker autonomy in home care. Home care workers operate in unpredictable work environments, and they have limited control over the patients' homes where they deliver treatments. As discussed in Chapter 3, pets, family members, neighbors, and friends can interrupt treatments, and workers have to adjust their activities to accommodate these factors, at times to the point of shuffling the entire day's schedule to accommodate a single event in a patient's home. This unpredictability makes autonomy necessary in home care since it provides workers with the flexibility to adapt to work situations.

Home care observations suggest that task unpredictability plays a role in loose coupling as well. This is seen in the work of home health aides whose tasks are predictable, and the professional staff whose tasks are usually unpredictable. Home health aides' tasks are routine and are often not directly linked to variations in the patient's health and functional status. Common tasks include meal preparation, bathing the patient, and cleaning the patient's home. The tasks that are provided during visits are set by the case manager and the nursing supervisors, and they remain the same for every visit. Since tasks are routine, the supervisors are able to provide behavioral directive that limit the aides' autonomy and decision making.

The tasks that are carried out by professional disciplines are linked more closely to patients' functional and health statuses, and workers must adjust their activities to address variations in those factors from visit to visit. This makes professionals' tasks more unpredictable, and workers must exercise considerable discretion in tailoring their tasks to current circumstances. For example, during observations a nurse found that a patient's wound had worsened considerably, and she was forced to adopt a wound care technique that was different than the one she had used previously. This task unpredictability means that supervisors are not able to provide behavioral directives to the professional staff, which contributes to the autonomy that workers have in routine decision making.

9.2.3.5 Organization / group size and complexity

Prediction. When size and complexity increases, social systems are more likely to divide into separate subunits that operate in a loosely coupled fashion (Sections 4.6.5).

Results

This reason was difficult to operationalize, and no evidence was found in home care to support this part of the model. At the organizational level, it was difficult to determine why the departments involved in home care delivery are loosely coupled and what role departmental and organizational size and complexity play in shaping coupling patterns. Furthermore, it was difficult to quantify size and complexity, and to interpret when a threshold would be reached that could bring these factors into play. At the group level, no evidence was found that would indicate that size and complexity plays a role in the adoption of loose coupling. Even when treatment team size was small and of limited complexity (e.g. two workers from different disciplines), workers still worked together in a loosely coupled fashion. This does not conclusively show that organization and group size/complexity cannot play a role in the adoption of loose coupling, but in home care no evidence was found that would indicate that such a relationship exists.

9.2.3.6 Incompatible external expectations

Prediction. When environmental expectations for organizational behavior are incompatible with operational demands, loose coupling may be adopted between administrative and operational units (Section 4.6.6).

Results

No evidence was found in home care to support this part of the model. The study focused on treatment teams and on relationships that shape their work and coupling patterns, and the scope of the study precluded direct observation of the linkages between administrative units and operational units (e.g. Home Care, Community Services, and Coordinated Assessment Unit). Even if observations were possible in administrative units, it is unclear whether direct evidence of “incompatible external expectations” would be found given the abstract nature of the concept. Furthermore, if an administrator had knowledge of a policy of loosened oversight, they likely would not divulge it in interviews since such a confession could have negative implications for the organization’s legitimacy.

9.2.3.7 Internal conflicts

Prediction. Loose coupling may be adopted to reduce internal conflicts arising from incompatible values and opinions (Section 4.6.7).

Results

No evidence was found in home care to support this part of the model. If, as the model states, loose coupling reduces internal conflicts, then observable evidence of those conflicts should be reduced as well. In home care observations and interviews, evidence of a link between internal conflicts and loose coupling was not found. While it seems unlikely that such a link ever existed, conclusive evidence was not found to warrant entirely discounting it either.

9.2.4 Outcomes associated with loose coupling

The contextual model contains a set of possible outcomes associated with the adoption of loose coupling. In the next sections, I assess the degree to which each outcome was useful in understanding loose coupling in home care.

9.2.4.1 Information buffers

Prediction. Loosely coupled workers may maintain local unshared information repositories to support autonomous work (Section 4.7.2).

Results

This part of the model describes a central part of work practice in home care, where workers maintain the information that supports their work practice in separate and unshared buffers. Each worker carries their paperwork and other supporting documents with them in the field to support local work activities. Information buffers in home care contain workers' schedules, patients' discipline-specific charts, and miscellanea such as other workers' phone numbers. Since workers are mobile, this information is inaccessible to others. Formal channels do not exist for passing this information to other treatment team members, and it is usually only shared at the worker's discretion. One part of information buffer practices in home care that was not included in the model was that occasionally workers transfer buffers to other workers from their discipline. For example, if a worker is out on sick leave or holiday, they pass the patient's chart to another worker who will treat the patient while they are away.

9.2.4.2 Partitioning of tasks

Prediction. Loosely coupled groups partition work so that the need for ongoing negotiation and task allocation activities is minimized (Section 4.7.3).

Results

This part of the model accurately characterizes the way that tasks are allocated in home care. Each worker's professional discipline indicates the treatment activities that they are able to carry out with patients. This effectively partitions the task-space within teams, since there is minimal overlap in the treatments that are provided by different disciplines. Physiotherapists carry out tasks to address patients' gait and strength deficits, and occupational therapists carry out tasks to address patients' problems with activities of daily living. Treatment team members understand the role that each professional discipline plays in a patient's care, so in many cases, information about others' activities does not need to be communicated. One part of this partitioning that was seen in home care, but that was not described in the model is the role that unexamined assumptions play in the partitioning of tasks. Since workers serve in mutually understood roles, workers operate on unexamined assumptions about the activities that others carry out, which is adequate in most cases for managing work practice.

9.2.4.3 Adaptability

Prediction. Loosely coupled elements are able to adapt to the environments that they encounter locally (Section 4.7.6).

Results

This part of the model accurately describes the flexibility that home care workers have in adjusting to unpredictable local work environments. They are able to adjust to local circumstances without first consulting others, which allows them to rapidly respond to unexpected circumstances in patients' homes or on the road. Adaptability will not be addressed here since it is closely associated with environmental uncertainty, which was previously discussed in Section 9.2.3.4.

9.2.4.4 Weak authority structures

Prediction. In loosely coupled systems, authority structures are limited in their ability to direct activities and sanction subordinates (Section 4.7.8).

Results

This part of the model accurately describes the authority structures for the professional disciplines in home care. Authority structures for the professional disciplines are weak, but nursing supervisors exercise significant authority over home health aides. Weak authority structures will not be addressed here since they are closely associated with professionalism, ambiguous evaluation criteria, and cryptic surveillance each of which was previously discussed in Section 9.2.3.

9.2.4.5 Persistence

Prediction. Since loosely coupled elements are distinct and autonomous, it can be difficult for management to institute changes to the system (Section 4.7.7).

Results

The model accurately characterizes the difficulties that were seen in introducing the Mohoc system to treatment teams during the field trials. The introduction of the Mohoc system represented a change to the system. When Mohoc was introduced during the field trials, compliance varied depending on the coupling style seen between worker and supervisor. These differences were seen when comparing compliance between home health aides, who are tightly coupled to the nursing supervisors, and the professional workers, who are loosely coupled to their supervisors. During both field trials, home health aides were more compliant because they felt that the nursing supervisors wanted them to use the system during the work day (per participant report during interviews). Since the supervisors are able to issue directives to the home health aides, they considered using the Mohoc system to be part of the job duties that were assigned to them and they required little prompting to use the system. In contrast, some of the professional workers required periodic reminders to continue to use the system. Since supervisors could not compel their participation, they had a more active role in determining the direction of the trial, and significant time had to be spent to secure their buy-in to the research process. Unlike home health aides, accommodations had to be made to secure some workers' participation. This issue is discussed further in section 10.5.2.

9.2.4.6 Sensitivity to environmental stimuli

Prediction. Since loosely coupled systems have several distinct "sensors", they are sensitive to environmental stimuli (Section 4.7.5).

Results

This part of the contextual model describes a work outcome that is found in home care, but that is only apparent when explicit communication takes place between team members. The mobility and autonomy of home care workers means that they will visit shared patients at different times, and during those visits will have access to information that may not be available to others during their visits. This increases the sensitivity of the group as a whole, even though much of that information is not routinely shared. However, this "sensitivity" is important since group members are able to alert others when significant events occur that may require their attention. For example, a patient's daughter may be in the home during a workers' visit and may be able to share information with them that would not be passed on to other workers. Since the cost of communication is high, novel information that might be acquired by one worker is unlikely to be shared with others unless the perceived need to share is great. Therefore, the benefit of having a number of autonomous "sensors" only is seen when the level of urgency reaches a certain threshold. This threshold function was not part of the model, but it is important to work practice in home care since it helps to guarantee that the treatment team is able to adjust to vital information, such as patient hospitalizations or unexpected changes in a patient's status.

9.2.4.7 Buffering

Prediction. Since loosely coupled elements function autonomously, problems in one element do not impact other elements (Section 4.7.1).

Results

This outcome was difficult to operationalize, and no evidence was found in home care to support this part of the model. Problems were not found that would pose a threat to treatment teams or to the departments that deliver home care services. In fact, given the nature of home care work (i.e. non-competitive government funded human-service organization), it is difficult to imagine any type of problem that would require buffering.

9.2.5 Summary of findings

In the next two sections, I summarize the findings of the evaluation. I begin by synthesizing the findings from the preceding sections in order to determine how useful the contextual model was at identifying important organization, work, and collaboration patterns in home care prior to design. Then, I discuss how the contextual model should be revised to address the issues that were identified during the evaluation.

9.2.5.1 Evaluating the contextual model

The contextual model predicted many of the organizational, work, and collaboration patterns in home care treatment teams. Most of the items described in the model were observed in home care (12/16 or 75% of the evaluated items), but a smaller number were not (4/16 or 25%). Those items that were observed played a significant role in shaping the way work was carried out in treatment teams.

The contextual model was used to develop the analysis technique and design approaches, and the successes and failures of those parts of the framework provide an indication of the value of the contextual model as a theoretical basis for design techniques. For example, the collaboration features in Mohoc were based on the contextual model's characterization of communication and coordination between loosely coupled elements. Sections 9.3 and 9.4 present evaluations of these parts of the model.

9.2.5.2 Revisions to the contextual model

The field trial results suggest that the stability of the interdependence between workers can act as a partial determinant of the coupling level seen in treatment teams. A review of the literature showed that this characteristic has been identified as a reason for loose coupling in other work settings. Given these findings, this new reason, which is referred to here as "constant interdependence", will be added to the contextual model. It is discussed briefly below and in more detail in section 10.5.1.

Constant interdependence. Findings from the field trials suggest that the stability of the interdependence between group members can impact the coupling patterns seen between workers. As interdependence becomes more stable, work becomes more autonomous since little coordination is needed. However, when interdependence is unstable, more coordination is needed to manage interdependence. In the first field trial, the patient was at times very stable, and there was little need for workers to explicitly coordinate their activities. They had treated the patient over a long period of time, and had a basic understanding of the activities that others provided based on that long involvement. In the second field trial, the patients were more unstable. Workers had to revise their treatments regularly to address changes in patients' statuses, and coordination became more important. While workers still worked in a loosely coupled fashion, there were more instances of direct communication between workers to address the variability in patients' statuses. This reason is discussed in more detail in section 10.5.1.

One of the primary difficulties in using the contextual model was the difficulty of determining causation and outcome. The partitioning of factors into "reasons" and "outcomes" was at times meaningless in observations. The observations only provided a snapshot of the group and organization at a specific time, so they were not able to account for the historical evolution of the organization and of work practice. Therefore, it was at times difficult to ascertain whether observations were "reasons" for loose coupling, when in fact an equal argument could often be made that they were "outcomes" of loose coupling. However, it does not entirely make sense to remove this classification altogether, since some "reasons" are clearly not "outcomes" and vice-versa. For example, environmental uncertainty and incompatible external expectations are clearly not outcomes of loose coupling since they refer to external factors that the organization has little control over.

I propose a reclassification of the "reasons" and "outcomes" that are presented in the contextual model. The reclassification is based on the following observations:

- Certain work factors are invariant, regardless of the coupling style seen in groups, and therefore are unlikely to be outcomes of loose coupling. These factors are classified as reasons for loose coupling.
- Certain characteristics that are seen in groups and organizations cannot be directly adopted without changes to underlying work and organization patterns. These factors are classified as outcomes of loose coupling.

- Some characteristics of work can be directly adopted by organizations without the need to significantly change underlying work and organization patterns. These factors are classified as *either* reasons or outcomes.

Reasons
- Environmental uncertainty, complexity
- Non-routine and unpredictable tasks
- Organization / group size, complexity
- Incompatible external expectations
- Internal conflicts
- Professionalism
- Specialized knowledge, expertise
- Constant interdependence

Outcomes
- Buffering
- Sensitivity to environmental stimuli
- Adaptability
- Persistence

Either
- Ambiguous evaluation criteria [formerly a reason]
- Cryptic surveillance [formerly a reason]
- Limited opportunities for interaction [formerly a reason]
- Weak authority structure [formerly an outcome]
- Partitioning of tasks [formerly an outcome]
- Information buffers [formerly an outcome]

Figure 9.1. New classification scheme for contextual model

Figure 9.1 presents the new classification scheme. The new *reasons* category includes the following invariant factors: environmental characteristics, unpredictability of tasks, organization / group size, internal conflicts, professionalism of workers, and constant interdependence between workers. The new *outcomes* category includes characteristics that are not easily adopted by organizations without changes to underlying work and organization patterns, and include buffering, sensitivity to environmental stimuli, adaptability, and persistence. The *either* category includes factors that were formerly in the reasons or outcomes categories. These factors can be either causes or outcomes of loose coupling—they can be intentionally or unintentionally adopted by organizations.

For example, limited opportunities for interaction such as worker mobility can lead to loose coupling, or opportunities can be limited as the result of loose coupling, such as when work units are intentionally distributed across different physical locations since they are only minimally interdependent.

Some of the factors outlined in the model were not observed in home care, or were difficult to operationalize. In the next paragraphs, I briefly discuss four factors: incompatible external expectations; organization / group size and complexity; internal conflicts; and buffering.

Incompatible external expectations. In the contextual model, incompatible external expectations are identified as a potential reason for loose coupling. Since this reason primarily takes place at the organizational and administrative levels, it is difficult to operationalize when designing systems to support workgroups. In home care, observations and analysis did not include administrators who would be responsible for adherence to “external myths”, and at the group level, it was difficult to find evidence of these pressures. The usefulness of this factor in groupware design is debatable; however, there is potential value in understanding that the reasons for loose coupling may not be immediately apparent at the group level, and may in fact come from administrative levels external to the group members and their direct supervisors (Meyer and Rowan 1977; Hasenfeld 1983, p. 152). Therefore, until further work can be done to investigate the usefulness of this factor in other work settings, it will remain in the model.

Organization / group size and complexity. In the contextual model, organization and/or group size and complexity are identified as a potential reason for loose coupling. This was difficult to operationalize at the organizational level. At the group level, group size was not a significant determinant of coupling style. However, in groups where size increases significantly, it is possible that it may influence the coupling style. In home care, treatment teams rarely are larger than six participants, and are often smaller (e.g. 2-3 members). Since evidence was not found to prove that size and complexity cannot act as a determinant of coupling style, and since others have suggested that it is (Weick 1982; Monane 1967), this factor will remain in the contextual model.

Internal conflicts. In the contextual model, internal conflicts are identified as a potential source of loose coupling. However, the adoption of loose coupling is supposed to lessen or eliminate these conflicts, and evidence of these conflicts was not found in home care. Again, absence of proof does not indicate that this is not a valid reason for loose coupling in some cases, and others' observations indicate that it is a potential cause (e.g. Cockburn and Jones 1995; Hasenfeld 1983, pp. 155-156; Weick 1982). Therefore, this factor will remain in the model as a potential reason for loose coupling.

Buffering. In the contextual model, buffering—or protection of the system from problems in its subunits—is identified as a potential outcome of loose coupling. In home care, buffering was not observed, and the concept was difficult to operationalize. During observations, problems were not observed that would pose a threat to treatment teams or to the departments that deliver community healthcare services. In fact, given the nature of home care work, it is difficult to imagine any type of threat that would require buffering. It is possible that this might be a bias introduced by the work setting, and that buffering may be more valuable in competitive work industries or in safety-critical settings (e.g. Perrow's 1999 study of nuclear power plants). As with the other factors that were not directly observed in home care, direct evidence was not provided to indicate that this is not, in some cases, an outcome of loose coupling. Others have reported on buffering in other types of loosely coupled organizations (Weick 1976; Perrow 1999). This factor will remain in the model as a potential outcome of loose coupling.

9.2.6 Validity of evaluation and conclusions

Establishing the validity of the conclusions that were drawn from the evaluation of the contextual model and of other parts of the framework relies on the claim that home care is a loosely coupled work setting. This claim is supported in the works of Hasenfeld (1983) and Kouzes and Mico (1979) who state that the nature of human service organizations causes work practice to be carried out in a loosely coupled fashion.

Similarly, the observational findings from home care establish that work practice is organized in a loosely coupled fashion (described in Chapter 3), and that the work practice meets the criteria established in organizational research definitions, (e.g. Weick 1976; Glassman 1973; Orton and Weick 1990), in CSCW definitions (Olson and Teasley 1996), and in this dissertation (in Chapter 4).

The model is based on information from organizational research, CSCW research, and small group research, which provides it with some, albeit limited, credibility. However, since the model was developed in parallel with home care activities, it is possible that involvement in those activities could have inadvertently influenced the way that the model was organized. This raises the possibility that the model reflects work practice in home care more strongly than it reflects work practice in loosely coupled groups in general.

The findings from home care were used to evaluate the contextual model by comparing each part of the model with the data from home care to determine whether evidence was found to support the claims made in the model. Since the model is intended to describe work practice in loose coupling in general, the absence of evidence did not necessarily indicate that an element is incorrect and needed to be removed from the model. The evaluation was based on interviews and observations that were reported in Chapter 3. Interview results were relatively stable over time, and exhibited a high level of test-retest reliability. There were few outliers in the results, and most workers reported arranging their work practice in a similar fashion. Similar findings were seen in the observations, and this suggests that the results are representative of real-world work practices.

The external validity (i.e. generalizability) of the model has yet to be determined. It is unclear at this point whether the model will generalize to other loosely coupled settings. Again, the model is based on information from other research, which suggests that it may generalize, but in the absence of further evidence, it is impossible to draw strong conclusions.

9.3 Evaluation of the analysis technique

In this section, I present an evaluation of the analysis technique. The analysis technique was developed to help designers to recognize and specify important features of loosely coupled work settings, and to organize that information in a way that makes it usable during the design process. It was developed from the processes that were used to analyze data from home care in preparation for designing the Mohoc system. The technique is partially based on existing analysis methods including sociograms, Contextual Design work models, and Collaboration Usability Analysis.

The analysis technique was evaluated to determine how effective it was at identifying and organizing important contextual features in the home care work setting in preparation for design. The formal models that are included in the technique were not used in home care, but they were based on the analysis and modeling process that was used to design Mohoc (e.g. Contextual Design work models, Collaboration Usability Analysis, and incorporation of the contextual model into the analysis). This made it possible carry out a limited, indirect evaluation that considers whether the information that was emphasized in the analysis process adequately captured those aspects of loosely coupled work in home care that should be addressed in groupware systems. This was done by reviewing the findings of the field trials in order to determine instances where the design did not reflect an adequate understanding of work and collaboration patterns in home care, and then by reviewing the analysis technique in order to determine areas where improvements could be made. The evaluation used field trial data including: opinions of participants, patterns of system use, and participants' reports on how the system impacted their real-world work patterns.

The next sections present an evaluation of the analysis technique. The sections are organized according to the following outline:

- Interaction model, awareness model, and coordination model
- Task model
- Loose coupling checklist
- Summary of findings
- Validity of evaluation and conclusions

9.3.1 Interaction model, awareness model, and coordination model

Model. The interaction model, awareness model, and coordination model use sociograms to model interaction and information flow between social system elements.

Results

Information that is addressed in the three sociogram-based models was analyzed and incorporated into the Mohoc design using Contextual Design flow models and notes from home care observations and interviews (e.g. Pinelle and Gutwin 2002). This was useful in highlighting information flow within the group, and at identifying the support that was needed by workers. However, the field trial results suggest that there were two shortcomings in the analysis process. First, the analysis technique needs to emphasize awareness and coordination breakdowns more extensively. Providing support so that workers can avoid coordination breakdowns was widely perceived as one of the main benefit of the system by home care managers, administrators, and workers. However, the formal modeling approaches do not provide enough detail on breakdowns to guarantee that they will be adequately addressed in groupware designs. Second, the analysis technique needs to consider the role that locations play in shaping the collaboration that takes place between workers. The interaction and coordination models do not provide notation to indicate the locations where interaction takes place between workers. Evidence of the importance of location was found during the field trials. The schedule support provided by the Mohoc system did not include information about the time that workers planned to spend in the office. These times represent the point in the day when workers are most available for face-to-face meetings and phone conversations, and since other team members were not aware of this during the field trial, this communication was inadequately supported (see Section 9.4 for a further discussion).

9.3.2 Task model

Model. The task model does not propose a new technique for modeling tasks for design; rather, it suggests which existing task analysis approaches are appropriate in different situations. Two approaches are considered: the Contextual Design sequence model and Collaboration Usability Analysis.

Results

Most home care tasks were analyzed using Contextual Design sequence models, and a small number of tasks were analyzed using CUA. These two approaches provided different levels of granularity for analyzing home care tasks, and they were able to cover the range of situations that needed to be considered when designing the Mohoc system. This model was well-suited to the task analysis needs in home care, and there were no problems in using either of the two approaches.

9.3.3 Loose coupling checklist

Model. The loose coupling checklist is meant to help designers with the interpretation of data from loosely coupled groups by drawing their attention to important characteristics that could be easily overlooked.

Results

The contextual model was used in the analysis of home care data. During design work for the home care project, the full checklist had not yet been developed. However, the categories that are outlined in the contextual model were used to help interpret and organize home care findings. Section 9.2 discusses how the model characterized work practice in the home care setting, and using the contextual model categories in analysis allowed the patterns that are discussed in 9.2 to be considered during the design process. Since the evaluation of the contextual model has already been presented, and since the design approaches are partially based on the contextual model, the checklist will not be evaluated further here.

9.3.4 Summary of findings

In the next two sections, I summarize the findings of the evaluation. I begin by synthesizing the findings from the preceding sections in order to determine whether the analysis technique was effective at modeling relevant aspects of loose coupling in preparation for design. Then, I discuss how the analysis technique should be revised to address the issues that were identified during the evaluation.

9.3.4.1 Evaluating the analysis technique

The approaches used to analyze home care work and to design Mohoc ultimately led to the design of a system that was well received by participants during the study. This suggests that the analysis provided a reasonable approach for analyzing loose coupling in real-world workgroups. The analysis technique is based on these approaches and provides similar coverage and consideration for work practice, and in a similar fashion, and therefore it has the potential to address issues that are important to design for loosely coupled situations. However, the limitations of the evaluation mean that further research is needed before definitive conclusions can be reached about its usefulness.

The analysis technique highlights characteristics of work that are important to design, but that are not fully considered in other techniques. Current groupware analysis and design techniques do not provide a systematic approach for considering coordination, awareness, and communication patterns, and for highlighting those aspects of group collaboration that are important to design for loose coupling. Similarly, existing techniques do not attempt to tie outcomes and reasons for loose coupling into the observation and analysis process as is seen in the loose coupling checklist. Therefore, the analysis technique provides coverage of several important issues, even if the technique has not been evaluated rigorously.

9.3.4.2 Revisions to the analysis technique

The field trial results suggest that there are a number of areas where the analysis technique can be improved. In the next paragraphs, I discuss 3 improvements.

Awareness and coordination breakdowns. The analysis technique focuses primarily on existing collaboration patterns in target groups but makes few provisions for identifying awareness and coordination breakdowns. For example, the coordination model reflects when workers operate on unexamined assumptions, but places little emphasis on the breakdowns that occur when those assumptions are incorrect, which, in home care, can lead to schedule conflicts and poorly coordinated services. In home care, these issues were identified through observations and interviews (Chapter 3) and were addressed in the Mohoc implementation. The awareness and coordination models should be revised to reflect the importance of breakdowns in the groupware design process. The following information needs to be added to these models:

- *Type of breakdown.* Breakdown types should be identified in the models, and should include schedule conflicts, inadequate awareness information, and uncoordinated tasks.
- *Circumstances that cause breakdowns*. The circumstances that typically cause breakdowns should be specified.
- *Consequences of breakdowns*. The consequences of a breakdown should be specified. For example, in home care, the consequences of schedule conflicts are wasted time and unexpected schedule revisions.

Location and collaboration. One of the main oversights in the analysis technique is the need to account for the locations where collaboration takes place. In Mohoc, this led to office hours being excluded from the shared schedule. This oversight meant that workers were unable to determine when others were in the office and available for phone conversations and face-to-face meetings (this is discussed further in Section 9.4). Physical location is explicitly addressed in the awareness model, but not in the interaction and coordination models. The coordination and interaction models should be revised to include location information along the arcs that link the nodes so that the role of location can be more easily considered in groupware designs.

Reasons and outcomes. The loose coupling checklist is divided into causes and outcomes that mirror those that are outlined in the contextual model. The checklist should be revised to reflect the changes that were made to the outcomes and reasons classification scheme, as discussed in Section 9.2.5.2.

9.3.5 Validity of evaluation and conclusions

It is difficult to directly evaluate the analysis technique for three reasons: 1) the results of an analysis technique are not easy to measure and its overall impact on the final design can be difficult to gauge; 2) the value of an analysis technique partially hinges on designers' opinions of its effectiveness and efficiency; 3) there is not a strong basis for comparison with other existing techniques. In this research, the analysis technique was based on the techniques that were used to analyze home care work, but the formal technique was not used in the development of the Mohoc system.

The limitations of the evaluation of the analysis technique make it difficult to make strong arguments for its validity. The technique does provide an initial foundation for analyzing loose coupling, and the technique was based on modifications to existing analysis approaches that I developed while attempting to analyze home care findings and to incorporate consideration for loosely coupled work practice into the Mohoc system. This gives the technique some limited validity from a designer's perspective. Similarly, since the technique is roughly equivalent to the approaches that were used in analyzing work in context from home care, field trial findings provide a rough indication of how effective the technique is. However, these findings should not be overstated since the rigor of this approach is limited. At best, the evaluation provides an initial indication of whether the technique is able to 1) capture important information about loose coupling, and 2) whether the support for loosely coupled work practice that was implemented in Mohoc (based on the analysis) was a good match for home care support needs.

9.4 Evaluation of the design approaches

In this section, I present an evaluation of the design approaches. The design approaches are intended to help designers to translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups. Each of the nine approaches highlights a design issue that addresses a loose coupling characteristic outlined in the contextual model, and each approach suggests how user interface design and interaction design should be handled. The approaches were based on CSCW and organizational research and on findings from home care.

Each design approach was instantiated in features found in the Mohoc system, and this mapping was used to evaluate the design approaches using field trial results. Each approach was evaluated to determine how successful system features were at supporting work and collaboration during the field trial. The evaluation was qualitative and was based on findings from the two field trials (described in Chapter 8), and it includes information from system logs, interviews, and questionnaires. The determination of success and failure of each approach was based on: 1) *how extensively* features were utilized by field trial participants; 2) *how* features were utilized by participants; 3) participants' reported likes or dislikes of features; 4) participants' reports on the impact that the system had on their work practice.

The next sections present an evaluation of each of the nine design approaches. The sections are organized according to the following outline:

- Support autonomy and flexibility
- Consolidate information buffers
- Support individual workspaces and discretionary sharing
- Integrate collaboration with features for individual work
- Facilitate asynchronous awareness
- Support loose coordination
- Support loose communication channels
- Support shifts to tighter coupling
- Support flexible group organization
- Summary of findings
- Validity of evaluation and conclusions

9.4.1 Support autonomy and flexibility

Design approach

The Mohoc system supports the autonomy of treatment team members and does not compromise workers' flexibility by forcing explicit collaboration with others. It supports current autonomous workflows, including scheduling visits with patients, managing the daily agenda, documenting visits, and maintaining patients' treatment plans. The system does automatically collect information about workers' activities to improve awareness within the team—however, support for *explicit* collaboration is not forced, and workers can choose to use or ignore communication features (e.g. sticky notes and the discussion tool).

Results

During the field trials, workers used the system primarily to support current autonomous work activities. Participants used the system to document their visits, and periodically updated their schedules when typical visit times were revised. Most participants also maintained treatment plans for their patients to reflect the services that they deliver. The system did not change the coupling style within the team—each worker continued to operate in a loosely coupled fashion, and during interviews, none of them indicated that they felt that the system intruded on the flexibility they needed to revise their daily activities. Even though they shared their schedules and plans with others, they did not feel that entering information into the system limited their ability to change their plans if circumstances warranted it.

Workers' feelings that sharing information in the system did not negatively impact their ability to carry out their autonomous work activities is seen in the answers they provided to a questionnaire administered at the end of the second field trial. In the questionnaires, most workers stated that they were "comfortable" or "very comfortable" with letting other team members access their schedules and clinical documents. Only a single participant reported reservations. She felt that different levels of confidentiality were an issue in sharing documents, and that home health aides should not be able to view professionals' clinical documents. She also stated that she was "somewhat uncomfortable" sharing her appointments since she does a significant number of patient consultations by phone, and those consultations are often unscheduled.

Summary

Overall, the field trial findings indicate that support for autonomy was well received by workers. Support that was designed to match their current autonomous workflows was used regularly, and workers stated that they liked the scheduling, documentation, and treatment plan features during interviews. The Mohoc design did not attempt to shift work patterns to a more tightly coupled style, and the design fit existing workflows well enough that workers were able to use it without compromising the autonomy and flexibility that they currently have. For example, workers can have appointments that overlap others if they choose—the system does not constrain their activity in any way, and it does not force them to explicitly communicate or take part in coordination activities. They were comfortable sharing the information about their autonomous work activities that the system tracked and transmitted to others. Acts of explicit communication (i.e. sending messages to others) were used but more intermittently.

9.4.2 Consolidate information buffers

Design approach

The Mohoc system merges information buffers by moving the clinical documents that are maintained by each worker into a shared document repository. The system supports current clinical documentation practices by providing workers with templates that are based on the paper forms that are used by each clinical discipline. When documents are created in the system, they are stored in a shared repository so that they are viewable by other workers who treat the patient to whom they refer. This merging allows workers to access information that is inaccessible to them under normal circumstances.

Results

During the field trials, workers regularly used the system to browse others' clinical documents. The system allowed them to differentiate between those documents that they had previously viewed and those that they had not viewed. The system logs indicated that when workers logged into the system, they frequently browsed through the new clinical documents that others had added. During interviews, most participants indicated that this was one of the primary benefits of the system, and that they felt they had a better understanding of what was going on with their patients. For example, a participant discussed her feelings about the shared document repository, and how she was able to use it to track the activities of another worker:

Interviewer: How does the system compare to your normal paper based approach of documenting?

Participant: Certainly the benefit is, anybody else who has been involved, you could pick up what they're doing. Because we generally don't have that contact with them at all. So that was sort of one of the pluses right from the beginning. Even though we are supposed to be this team, we all have our own paper trail that really doesn't get shared with anybody else, it's only through the C3s. So we don't get any information from the OTs *or physios or whatever unless it comes in the case note from the C3s. That's the biggest advantage that you can see sort of right away.*

Most workers indicated that they could not recall specific incidences where they revised their services due to documents that were available in the information buffers. However, a participant cited one particular incident that led to service revisions. According to the participant, she had temporarily put off visiting a patient since his/her pain and nausea interfered with the services that she provided. She read the following nurse's clinical document in the system:

> SOAP Narrative Notes:
> **S**: "I feel much better today. I only have about a 3/10 for pain in my arm and a 2/10 for pain in my back. I'm not nauseated any more, either. I even ordered fish and chips last night and ate about a third of it. I just push the food to the right side of my mouth and it goes down. I didn't need to suction my self and I just cough a bit after I drink" **O**: Client much happier today. Appears stronger walking with cane. Agreeable to having 3 cans of jevity today. **A**: resolving nausea related to narcotics. **P**: Cont to visit bid.

The document indicated that the patient's pain had decreased and that his/her nausea had improved. After reading the document, the worker resumed treatments.

Summary

Overall, merging information buffers into a shared repository was well received by the participants. In interviews, it was the feature that they discussed most frequently, and most participants felt that shared access to documents was beneficial. System logs supported this, and showed that workers spent a significant portion of their time using the system to support their clinical documentation practices and to read others' documents. However, as is discussed in the next section, discretionary sharing was an important part of this support.

9.4.3 Support individual workspaces and discretionary sharing

Design approach

The Mohoc system supports the consolidation of information buffers into a shared repository; however, workers are able to protect certain pieces of information from the rest of the team. They are able to exercise discretion in sharing, and maintain information that they are unwilling to share with others in individual workspaces. In the Mohoc system, this includes two types of artifacts: clinical documents and personal communication. For clinical documents, workers can maintain partial results or private information in a shared space for their discipline. For personal communications, workers can leave sticky notes on the workspace that are viewable by their discipline only. This allows them to leave informal reminders for themselves that are not viewable by others.

Results

During the field trials, workers regularly made use of their private workspace to manage their clinical documents. This was seen in both field trials, and by workers of most disciplines. In many cases, workers used the private workspace to practice using the system, and several workers created blank documents and left them in the workspace to explore the documentation features. Several other workers created "fake" documents to test the system features. For example, one such document contained the text: "the goose is white." The private space was also used by workers when they did not finish a clinical document in a single session with the system. This pattern was observed in system logs and through incomplete documents left in the system at the end of the trial. This was seen primarily in nurse and physiotherapy work patterns, presumably since both disciplines tend to write long narrative documents. The typical pattern was for them to leave the document in the private space until the document was completed, and then to move it to the shared space so that others' could view it.

Most participants did not normally use sticky notes to leave messages for themselves. This feature was regarded as an interpersonal communication tool by most participants. However, three participants did use the sticky note feature to leave reminders for themselves. A total of 16 personal sticky notes were used during the trials. For example, one of these was a reminder to drop by a patient's home during another worker's treatment: "check schedule to see if I could go at the same time to watch transfer." Another was a reminder to send forms to the patient's physician: "send dr's order to Dr. <doctor's name>."

During an interview, a nurse described how she used sticky notes to leave reminders for herself. The interviewer was reviewing user interface features, and the nurse mentioned that she had left reminders for herself. The interviewer followed up on this comment:

Interviewer: "You left sticky notes for yourself? How did you use them?"

Nurse: "I put things in there to remind myself to pass on messages to other people. Like, for example, an LPN. Or I left a message to myself to pick up a particular type of supply. Something that I may would have written in my own calendar book or something, or put a nurse to nurse memo on the front of our file, so instead of...put it on there as a reminder to me to do something in particular, so I used it that way."

Summary

Overall, the use of individual workspaces and discretionary sharing was valuable as a design approach. Many workers were uneasy with the system initially, and this approach seemed to make them more comfortable since their work was not immediately transparent to others. If they felt that they had made a mistake, they could correct or delete it without others knowing and without losing face. Similarly, although this was not observed during the trial, several workers did indicate that there are times that their documents contain observations that are not appropriate to share with others. For example, social workers serve in a counseling role and deal with sensitive family and mental health issues. During interviews, they expressed concerns about making their documents transparent to other team members—a discretionary approach that allows individual workspaces addresses these needs.

Sticky notes were used by workers to leave reminders to themselves. This was not included in the training, and the feature was initially intended to be an interpersonal communication tool. However, some of the participants used the feature several times over the course of the trial to leave reminders to themselves. This suggests that support for reminders could have been provided more explicitly in the user interface, that this type of support is important in workflow, and that it should have been incorporated into training sessions.

9.4.4 Integrate collaboration support with features for individual work

Design approach

Mohoc features primarily support current autonomous home care workflows and integrate collaboration support into those features so that workers can consider others' activities when managing their workday. In some instances, collaborative information is actually embedded into individual work tools. For example, the scheduling tool includes transparent overlays of other treatment team members' schedules, and awareness flags are placed in the individual workspace to help workers interpret others' actions. In other instances, collaborative tools are tied closely to the screen location of the individual tools that they reference. For example, the discussion tool is placed in the workers' chart, and sticky notes can be placed inside the clinical documents that they reference.

Results

During the field trials, workers primarily used the system to support current workflows, but the close proximity of collaboration information allowed workers to selectively choose to communicate and coordinate work with others. Sections 9.4.5 and 9.4.6 evaluate awareness and coordination features that are integrated with features that support individual work. In the rest of this section, I discuss the role that the close physical proximity of communication tools to the artifacts (that support individual work) that they refer to played during the field trials.

Interviews and system logs indicate that workers made use of sticky notes to append messages to clinical documents and to workers' charts. The notes that were attached to clinical documents provided a way of adding collaboration about artifacts that are typically used to support individual work. In one instance, an occupational therapist added a clinical document to the system to indicate that a ceiling lift system had been installed in a patient's home:

> Client contacted O.T. on <date> to inform O.T. that funding had been secured from <funding source> for the ceiling track lift. The lift has been

> installed as per the O.T. recommendation and the home-health-aides are currently learning how to use same. O.T. follow-up visit is set with <patient’s name> for <date> at 1:00pm to review the client's transfer using the lift and any outstanding concerns.

At a later date, a home health aide placed a sticky note on the document to inform others of the technique that worked best for her for using the lift with the patient: “<Name>’s lift works better when <he/she> is sitting upright.” The next month, the patient got a remote control for <his/her> lift. At that time, another home health aide added another sticky note to communicate problems she was having with securing the remote: “<name> IS PLEASED TO HAVE <his/her> NEW REMOTE CONTOL FOR THE CEILING LIFT; IT DOES NOT STAY PUT; WE WILL NEED TO COME UP WITH A BETTER WAY TO SECURE THE REMOTE TO THE LIFT.”

Summary

Overall, the field trial findings indicate that design to support loose coupling (rather than to force more tight coupling) was well received by the workers. Workers did not use collaborative features as often as they did those that support current work activities, although they did utilize low cost coordination mechanisms available in the system in order to augment autonomous work practices, and did use communication support when work circumstances required it.

9.4.5 Facilitate asynchronous awareness

Design approach

The Mohoc system tracks and displays information about other workers’ interactions with shared artifacts and with the shared workspace. This awareness information is asynchronous—it is persistent so that workers can interpret others’ activities even though they may not be online at the same time. Asynchronous awareness information is handled by tracking “viewing histories” and “modification histories” for shared artifacts, which include clinical documents, sticky notes, and patient’s charts. Viewing histories track the last time that an individual accessed an artifact, and modification histories track when an artifact was modified and by whom. The system also flags new content that is added to the system by others so that the worker can identify content that they have and have not read.

Results

In interviews conducted during and after the field trials, some workers indicated that they made use of asynchronous awareness information that was embedded in the system in order to interpret others' actions. Two participants reported using viewing histories to determine who had read the sticky notes that they sent. In these instances, they had sent messages to specific recipients, and wanted to guarantee that those recipients had read the messages. Home health aides who participated in the study reported making use of modification history information that was provided for clinical documents. In both trials, multiple aides shared the same patients, and they modified the same clinical documents. According to the aides, this information allowed them to interpret the activities of other home health aides, and helped them to manage shared access of the documents. During an interview, a home health aide described how she used modification histories:

Interviewer: <reviewing system feature with participant> Did you use these modification histories <on the clinical documents>?

HHA: I used them to help keep up with <name of other home health aide> and what she was doing with <patient name>. It told me when she was on last, and I could see the extra line at the bottom that shows her visit <i.e. the new entry at the bottom of a flowsheet>.

Three workers in the second field trial stated that they made use of the viewing history information that is displayed on the chart view. This information indicates when a worker last accessed the patient's chart. Workers indicated that they used the information to know how often others were accessing the system. One participant stated, "I looked at it sometimes when I first would get on. It let me know who had been on and if they were using their computer too."

The awareness flags were used by workers to identify new content that had been added to the system by other workers. System logs indicate that most workers would read new notes and new documents when they logged into the system. During interviews, most participants confirmed that these flags helped them to track what they had read and what they had not, and helped to guarantee that they had read all content that might be relevant to them. According to a nurse, “I always clicked the red and yellow post-it’s and dots <documents on the timeline> to make sure I read everything.”

Summary

Overall, it is difficult to gauge the impact of awareness information on workers’ work patterns. Two types of awareness information were evaluated. First, viewing and modification histories were considered, and they seem to be useful to workers in some instances. However, they do not seem to be used on a regular basis. This, in part, may be due to the loose coupling between workers, and workers’ concern primarily with carrying out autonomous work activities. The histories were primarily used, as the examples show, when work circumstances forced collaboration on workers (e.g. sharing document modifications, or tracking receipt of messages). Second, awareness flags were considered. The awareness flags were used frequently by participants, and were widely seen as a valuable way of managing artifacts in the system.

9.4.6 Support loose coordination

Design approach

The Mohoc system provides several features to facilitate low cost, loose coordination in the team. These features include a shared scheduling tool that allows workers to utilize information about others’ schedules when selecting their own treatment times; a schedule that indicates the treatments that others’ plan to provide during their visits with a shared patient; a shared display that shows the treatment plans of all treatment team members; a shared repository for clinical documents; and features to facilitate awareness of others’ interactions with the system. These features are low cost since workers do not have to expend significant effort to use them, and since they do not constrain workers’ activities in any way.

Results

During the field trials, Mohoc appeared to increase awareness of others' schedules, and an analysis of system logs did not show any evidence of schedule conflicts. During interviews, participants confirmed this and stated that there were no unintentional schedule conflicts during the trials. Four of the participants in the trials indicated that they reviewed others' schedules when planning their own visits (home health aides do not self-schedule, and nursing supervisors do not visit patients). Of those who did utilize schedule information, three indicated that they felt that it helped them to avoid schedule conflicts with other workers. Additionally, two participants stated that since they had more information about others' appointments, they felt that they had greater flexibility in revising treatment times since they had enough information to avoid collisions.

Workers also reported more specific instances of coordination that occurred as a result of the introduction of Mohoc. In one instance, a participant, who often saw the patient early in the morning, wanted to guarantee that the patient was awake and out of bed before she visited. She was able to make use of information available in the scheduling tools to guarantee that the home health aide had the patient up and dressed prior to visiting. In a separate instance, the nurse and the physical therapist monitored the services that were provided by the other since they were both providing treatments focused on improving the patient's respiratory status. The nurse described this during an interview:

Nurse: Last week <patient name>'s chest was bad so <worker's name> was in there every day, and I mean, I could pick up on that, that I wouldn't normally pick up on. So that is probably the biggest advantage, that you can see what the other people are doing and what they've…noticed any changes in <him/her> or whatever.

Summary

Support for loose coordination is one of the primary benefits that can be realized through introducing groupware systems to loosely coupled groups. In the case of home care, since workers already maintain much of the information needed to make coordination possible in their daily workflow, new information did not need to be entered to support coordination. Merging this information, and presenting it in a way that augments users' abilities to utilize it with minimal effort in their decision making, and without compromising workers' flexibility, allowed workers to make use of that information in their decision making.

9.4.7 Support loose communication channels

Design approach

The Mohoc system supports low-cost communication within treatment teams. The system lowers the threshold for initiating communication by helping workers to communicate in spite of differences in schedules. All communication tools in the system are asynchronous and messages persist so that workers can access them even though senders and recipients access the system at different times. Workers are able to direct messages to specific recipients using sticky notes, or can send messages to the entire treatment team using the discussion tool or sticky notes.

Results

During the field trial, the asynchronous communication features were used regularly to pass on private (i.e. to subsets of the team) and public information to other team members. Most messages did not require immediate attention or response, and during interviews, workers expressed that when timeliness was required, face-to-face or phone based communication would be preferred over a computer-based approach (see Section 9.4.8 for a further discussion of this).

Communication channels served five main purposes during the field trial. First, the system was often used to pass on general information that was relevant to the entire team. For example, during the second field trial, two patients were in and out of the hospital, and when a worker found out about a pending hospitalization, they would post it to the discussion tool, such as: "daughter came called EMS went to hospital." Second, three workers used the system to leave sticky notes as reminders for themselves. For example, one participant left a message to remind herself to drop by during another worker's treatment: "check schedule to see if I could go at the same time to watch transfer." Third, some workers used the system for informal communication. For example: "Hi <name>. It was good to catch up to you today. I hope you get this note." Fourth, workers left messages in an attempt to coordinate services with others. For example, a home health aide left a message for a nurse: "<name> takes [2] sleeping pills -- <he/she> still does not sleep well." Fifth, on three occasions, workers used the system to ask others for information that they needed to carry out their work activities. For example, a nurse sent a sticky to another worker to try to learn whether a patient had returned home from the hospital: "did you find out how <patient's name> is today?" The recipient sent a sticky note back the next day, stating: "no, I don't know when <patient's name> is coming home."

During an interview, a nurse described her opinion of the communication support found in the system and the potential it has for her work practice:

Interviewer: How did the communication support, like the discussion and the sticky notes, impact your work?

Nurse: Yeah, that's not something we had the sort of ability to do anyway before. You know, a message or something. And we really need it. Because there's no connection. Even with the home health aides, they're never in the office at the same time that we are, so there is never an opportunity to pass on a little message. It's always got to be second hand through the supervisor to them kind of thing, so it's always a three way system. So this let me talk to them without going through the supervisor first.

Summary

Overall, the findings indicate that when workers were provided with flexible, low effort communication channels they communicated information that likely would not have been shared otherwise. In unsupported work, communication usually only occurs when a situation is urgent enough to warrant the effort. However, during the field trial, much of the communication that took place was not particularly urgent. During interviews, participants indicated that the system made it easier to initiate communication since they did not need to identify which workers treat a patient since the system tracks it and they did not need to look up workers' contact information. They also indicated that it was much easier for them to pass information on to multiple recipients since they do not have to make several different phone calls.

9.4.8 Support shifts to tighter coupling

Design approach

The Mohoc system helps to facilitate shifts to tighter coupling by providing team members with information about others' locations and activities so that they can determine when others are available for phone calls and meetings. The system provides common scheduling tools that indicate when others visit shared patients, and the treatment activities they will carry out during their visits. This information can allow workers to determine others' availabilities since they can determine whether or not certain services can be interrupted for direct communication. For example, a home health aide who visits a patient to do meal preparation can probably receive a phone call, but if the home health aide is bathing the patient, they probably cannot.

Results

During the field trials, these features were not used extensively to facilitate tighter coupling, but workers did report using them on a few occasions. For example, a participant reported that she wanted to train a home health aide on using a new piece of equipment with the shared patient. The participant utilized the scheduling information to determine when the home health aide would be in the patient's home and dropped by during that time. Without this information, she would have been forced to expend extra effort to arrange the meeting.

During interviews, three workers suggested that more could have done more to facilitate temporary shifts to tighter coupling. Mohoc did not represent office times on the schedule, but instead only handled appointments with patients. Workers reported that information about office hours would have been valuable, since this represents a point when they are more available so that others can contact them. During an interview, a C3 pointed out the need for office hours in the schedule features so that workers could contact others more easily:

Interviewer: How useful were the schedule features to you?

C3: I spend a lot of time calling clients from the office and setting up services for them and that sort of thing. My schedule doesn't always match the way this is set up because a big part of my day isn't spent, you know, isn't spent going to visit clients. I can't show my office and meeting times here. Sometimes I want to know other people's office times too so I can call them when they are in the office, but this doesn't show it.

Summary

Overall, the field trials suggest that this design approach is valuable. Even though tight coupling is not needed frequently, groupware systems can play an important role in facilitating it when it is needed. The Mohoc system was only partially successful here. This suggests that even though these shifts do not fit into the normal workflows seen in a work setting, the instances where they do occur need to play an important role in shaping the design. If, for example, more emphasis had been placed on supporting phone conversations for workers while they were in the office, the design would have likely included office hours in the schedule.

9.4.9 Support flexible group organization

Design approach

The Mohoc system supports awareness of others' level of involvement in the group. The scheduling and daily agenda screens show a list of team members and their disciplines for the currently selected patient. While there is no explicit indication of others' level of involvement, this information can be derived by scrolling through the schedule and viewing others' treatment frequencies. In the chart view this information is made more explicit. Each member of the team is listed along with their discipline and the frequency with which they treat the patient. This view also tracks past members of the team along with their contact information.

Results

During the field trials, workers' levels of involvement in patients' care were relatively stable. Unfortunately, this stability made it difficult to evaluate support for flexible group organization fully. However, there was one worker who shifted her level of participation midway through the first field trial, and this provides some limited feedback on these features.

In the first field trial, the occupational therapist's role in the patients' care was to order new equipment for the patient as his/her status changed. During the field trial, she ordered a ceiling lift system for the patient, and after she was satisfied that the home health aides were comfortable with transferring the patient using the lift, she stopped visiting the patient. At that point, she attempted to monitor the patients' status to determine whether changes occurred that would require her to become more involved again. While the OT did use the Mohoc system to monitor the patient's status, her participation was minimal at that point and she only logged in intermittently and for brief periods of time.

Summary

These findings suggest that a better understanding of participation levels in home care could have led to better support for workers who monitor patients' status, but that do not actively visit the patient. In the case of the occupational therapist, it would have been useful to provide a "monitoring mode" in the system so that she could convey her level of participation to others. This would have allowed her to indicate to other treatment team members that she should be informed of changes in the patient's status so that she could better determine when she should take a more active role in the patient's care. It also would have lessened the need to expend time checking on the patient's status, since others could send her messages to alert her to significant developments.

9.4.10 Summary of findings

In the next two sections, I summarize the findings of the evaluation. I begin by synthesizing the findings from the preceding sections in order to determine how successful the design approaches were at mapping contextual characteristics of work to appropriate design decisions. Then, I discuss how the design approaches should be revised to address the issues that were identified during the evaluation.

9.4.10.1 Evaluation of the design approaches

Most of the features that implement the design approaches were well received during the field trials. The Mohoc system was used regularly by the participants, and the features that support autonomous work activities were used most frequently. Features that support explicit collaboration were used more intermittently. However, the frequency of communication that did take place between disciplines was greater than was seen during observations of unsupported work.

The design approaches provided guidance in tailoring groupware systems to the work and collaboration patterns of loosely coupled groups. The approaches were based on the contextual model, and provided a means of bridging theoretical concepts to specific design decisions. This was useful in conducting design work, and the designs were well-received by home care participants. Currently, existing design techniques do not address the issues that are seen in the design approaches, so this provides a new and useful way of carrying out groupware design for loosely coupled groups.

9.4.10.2 Revisions to the design approaches

Some of the design approaches could not be fully evaluated due to oversights in the implementation or due to limited utilization of some features by trial participants. In the next paragraphs, I briefly discuss two approaches that were difficult to evaluate: support shifts to tighter coupling and support flexible group organization.

Support shifts to tighter coupling. The field trial results suggest that supporting shifts to tighter coupling may be valuable, but the Mohoc system missed opportunities for supporting this approach fully, and as a result, it was not evaluated as extensively as it could have been. The Mohoc system did not record information about workers' office hours, which would have helped facilitate meetings and phone conversations in the office. Participants recommended the addition of this information in exit interviews during the trials. While this approach does not need to be revised given the evidence available from the trial, it would benefit from further validation in other settings.

Support flexible group organization. The field trial results suggest that it is useful to provide explicit support for the different levels of participation that are seen in groups, but the Mohoc system did not provide different participation modes, making it difficult to fully evaluate this approach. For example, the system did not allow workers to indicate to others that they are less involved with a patient, so that more involved members can notify them when increased involvement may be needed. Since support for this approach was only minimally provided, it was not possible to fully evaluate its usefulness to team members. In the future, further work is needed to evaluate this approach.

The field trials also suggest two additions to the design approaches. The first approach deals with deployment of groupware in loosely coupled groups, and while it does not deal directly with design, it warrants inclusion in the framework nevertheless. The second approach addresses characteristics of loose coupling where workers are mobile and asynchronously work out of shared locations. I discuss each approach in the next paragraphs.

Deployment strategies. Field trial findings suggest that deployment strategies in loosely coupled groups should be based around the level of coupling seen between group members and their supervisors. When members are loosely coupled with their supervisors, it is difficult for supervisors to ensure that members will use the system since they are limited in their ability to issue and enforce directives. In these cases, more attention must be dedicated toward gaining the “buy in” of group members, and a bottom-up deployment strategy is needed. When members are tightly coupled with their supervisors, the supervisor can guarantee compliance through directive, and a top-down deployment strategy is possible. These strategies are discussed in more detail in Section 10.5.2.

Augment shared physical spaces. Observational findings suggest that when group members are mobile and asynchronously share common work sites, those locations can play a central role in sharing information within the group. For example, home care members make use of evidence that is available in patients' homes to maintain a low-level awareness of others' activities. In mobile loose coupling, these physical locations can be augmented using systems that allow information to be attached to physical sites and retrieved with mobile computing devices. This approach is discussed in more detail in Section 10.5.3.

9.4.11 Validity of evaluation and conclusions

The Mohoc features that were used to evaluate each approach clearly implemented the approach, and had minimal overlap with other design approaches. For example, "support asynchronous awareness" was evaluated using viewing histories, modification histories, and awareness flags. These features instantiate the approach, and are cleanly separable from the other design approaches.

The conclusions that were drawn from the evaluation were based on field trial results. The field trials provided data from a total of 5 ½ months of system use, and participants were encouraged to utilize the system according to their own needs or inclinations. However, since the system was only used to support a small part of each worker's case load, it is unclear whether field trial findings provide a true indication of patterns of use that would be seen if the system were utilized more extensively and over a longer period of time.

While there is no evidence of this, a possible bias in the evaluation is that workers may have given positive feedback on system features since they knew that the researcher conducting the interviews was involved in implementing the system. However, most of the conclusions from the evaluation were also based on system logs, and on reported incidents of how the system impacted work practice.

Since the evaluation is limited to a single work setting, there are no guarantees that the findings will generalize to other loosely coupled work settings. Also, the evaluation of each design approach is somewhat dependent on the user interface and interaction approaches used in the Mohoc system. Since the design approaches are high-level design guidelines, they do not specify in detail how features should be designed. Therefore, if a bad job was done realizing the design approaches in the system, then a specific design approach is unlikely to be well received.

10 Discussion

In this chapter, I present a discussion of the results of this research. The discussion synthesizes findings presented in other chapters and considers unexpected results that were not covered in Chapter 9. The chapter is organized according to the following high-level headings:

- Summary of results
- Comparing the framework with other methods
- Coupling as a design dimension
- Levels of analysis in groupware design
- Other findings
- Limitations of research

10.1 Summary of results

The main goal of the design framework was to improve groupware design for loosely coupled groups. The framework has three parts, each of which supports a different stage of groupware development. The contextual model acts as a theoretical foundation for the rest of the framework and helps designers understand loose coupling in real world settings. The analysis technique helps designers to recognize important characteristics of loosely coupled work, and to organize that information in a way that makes it usable during the design process. The design approaches help translate analysis results into designs that address the needs of target workgroups.

While some items in the design framework need revisions, overall each part filled its role in specializing the general groupware design process for loosely coupled workgroups. Since the framework was only evaluated in a single setting, however, further research is needed to determine how well it will generalize to other loosely coupled work settings.

Since the Mohoc system was based on the framework, its acceptance and use by study participants provides an indicator of how well each part of the model functioned during the observation, analysis, and system design phases. The system was generally well-received by participants during the trials, and, as Chapter 9 indicates, it helped participants to stay informed about others' activities, to carry out low-cost coordination of work activities, and to communicate with other members of the team. The design did not force workers to collaborate, and none of the participants reported feeling that the system interfered with their ability to carry out their autonomous work activities.

The contextual model was developed to help designers to understand factors that shape the work and collaboration patterns that are seen in loosely coupled groups. It was developed by synthesizing existing information on loose coupling in CSCW and organizational research, which includes literature on education, human service organizations, administration, and sociology. The model described many of the work and collaboration patterns that were identified through home care observations. While all of the elements in the model were not found, the majority of them were, and they played a significant role in home care work practice.

The analysis technique was based on the processes that were used to analyze data from home care in preparation for designing the Mohoc system. The technique incorporates existing analysis methods including sociograms, Contextual Design work models, and Collaboration Usability Analysis, and it helps to recognize and specify important features in loosely coupled work settings, and to organize that information in a way that makes it usable during the design process. While the formal models that are included in the technique were not used to design Mohoc, it was possible to loosely evaluate the technique using the results of the field trials. The findings of the evaluation suggest that the technique has promise, but it failed to address coordination and awareness breakdowns adequately, and it did not address the role that location plays in communication.

The design approaches were based on the contextual model, on information from CSCW and organizational research, and on home care observations. They were instantiated in the Mohoc system, and the results of the field trials showed that most of the features were well-suited to the workflows of study participants. A range of features were used during the trials, including those that support autonomous and collaborative work. However, some of the approaches could not be fully evaluated due to oversights in the implementation or due to limited utilization of some features during the field trials.

10.2 Comparing the framework with other methods

The design framework enables designers to consider factors that are not addressed in other design and analysis approaches. The framework addresses the need for greater understanding of loosely coupled work settings in groupware design, and provides techniques for bridging that understanding into the design process. Factors that are included in the framework, but that are rarely considered by other groupware approaches include the role environment plays in determining work style; the role supervisors/administrators play in shaping work styles; the role that shared interdependencies play in shaping collaboration patterns; the role the organization plays in determining coupling style; and the different levels of coordination and their impact on worker autonomy.

Evidence suggests that if the framework had not been used to design the Mohoc system, the design would have been significantly different. Early observation work in this project (prior to the development of the framework) led to an emphasis on collaboration "problems" in the home care setting (Pinelle and Gutwin 2002). While these issues are important, failure to consider other easily overlooked factors—such as the uncertainty of the work environment and autonomy of the workers—would have likely led to a system that forced workers to operate in a more tightly coupled fashion by making collaborative features the focal point of the design.

Existing approaches for groupware analysis and evaluation do not address the range of factors that need to be considered when designing for loose coupling. Groupware walkthrough (Pinelle and Gutwin 2002; Pinelle and Gutwin 2001) and groupware task analysis (van der Veer and van Welie 2002; van der Veer et al. 1996) focus on group task and group collaboration sequences, and how systems can be designed to support common workflows in groups. However, they do not consider organizational issues that shape work practice. Also, little consideration is given to the circumstances in the workplace that shape the way work is carried out, such as work locations, variations in interdependence, and factors that constrain and enable collaboration.

Other techniques focus on improving groupware systems' usability using inspection-based usability evaluations. Heuristic evaluation for groupware (Baker et al. 2002) provides a set of usability heuristics that can be used to identify usability problems in a groupware system. However, the technique does not attempt to tie judgments of usability to the target work setting, but instead uses a set of generic "rules of thumb" that evaluators can use to identify usability problems. Collaboration usability analysis (Pinelle, Gutwin, and Greenberg 2003) considers the work setting in more detail. It attempts to analyze information from target work settings in preparation for design. It provides group task analysis techniques, scenario descriptions, and descriptions of group members. However, one of the limitations of the technique that was identified by the researchers is that it does not address organizational and social issues that are seen in the target work setting, and little guidance is provided in organizing information about the circumstances that shape work practice.

Some techniques that are also used in designing single user applications are appropriate for groupware design. These include contextual design (Beyer and Holtzblatt 1998; Holtzblatt and Beyer 1993) and participatory design (Greenbaum and Kyng 1991; Muller 1991). Participatory design approaches are useful in developing groupware, and some of the approaches (e.g. low fidelity prototyping, prototype walkthroughs) were used in designing the Mohoc system. However, it does not present a cohesive approach for analyzing and making sense of features in the target setting, and does not provide significant guidance on how the design should be tailored to specific work and organizational patterns. Contextual Design is fairly comprehensive in providing tools for analyzing the work setting, and was utilized in this project as a starting point for designing the Mohoc system. However, as is discussed in Chapter 5, it does not consider several collaboration issues such as awareness and coordination; it does not provide modeling approaches for collaborative tasks; and it only minimally addresses organizational issues.

10.3 Coupling as a design dimension

This study suggests that coupling is an important dimension in groupware design. All groups may not operate according to a fixed coupling style, but in those that do, the group's coupling style can provide significant guidance on how analysis and design should be approached. In this dissertation, I have defined a framework for designing groupware applications for loosely coupled groups. While the framework needs to be evaluated in other settings, it provides a starting point for supporting a loosely coupled style of work. Addressing tight coupling needs to be explored in future research, but it is likely that the design requirements vary significantly.

In spite of coupling's usefulness as a design dimension, it still has its limitations. It is only a single dimension of work, and is not the only guide to how design and deployment should be approached. Other factors such as tasks, work artifacts, work culture, and physical work spaces all play a role in shaping work and support requirements. The limitations of coupling as a design dimension can be addressed by incorporating general-purpose design approaches into the design process, such as participatory design and Contextual Design.

There is still room for significant exploration of coupling as a design dimension. Tight coupling has not been investigated in detail, and different aspects of tightly coupled work likely deserve consideration, such as co-present and distributed tight coupling. Churchill and Wakeford (2001) also describe, but do not rigorously investigate, two types of coupling in mobile work, which they call tight mobility and loose mobility. In tight mobility, mobile collaborators need real-time synchrony with others in order to communicate and coordinate work. In loose mobility, mobile workers asynchronously access documents or information – while they still co-operate with others, the collaborative requirements are reduced.

10.4 Levels of analysis in groupware design

Groupware evaluation and analysis methods usually focus on tasks and group interaction, but most do not account for other important factors that can shape the needs of the target groups. Factors such as environment, organizational issues, and supervisory relationships are often overlooked. However, the findings of this study suggest that these factors are important and should be addressed in the design process.

The findings of this study suggest that existing methods should be expanded to address issues that extend beyond the workgroup. For example, findings from home care suggest that issues such as adaptability, persistence, weak authority structures, and ambiguous evaluation criteria all play an important role in the way work is carried out, and influence the support that is needed by workgroups. Each of these issues extends beyond narrowly drawn borders that may define the workgroup in some analyses—they connect the group to other parts of the organization, to the environment, and to authority structures.

The variation seen in workgroups and in organizations makes it difficult to develop systematic analysis and design techniques that account for all possible situations. However, all work does have some common characteristics. For example, all workers interact with external environments, which can be characterized along different dimensions—such as predictable vs. unpredictable or complex vs. simple. These dimensions can, at the very least, be used as a sensitizing mechanism to help add consideration for overlooked aspects of work during observational studies and design work. Applying open systems approaches during analysis may be one way to partially address these needs since the theory is flexible enough to accommodate a range of work situations, and it can account for relationships that cross organizational and environmental boundaries.

It may be possible to develop more comprehensive design methods for groups that share certain characteristics. In this research, I have presented a design framework based on one such characteristic, and the results of the study suggest that loosely coupled workgroups share many of the same organizational characteristics, and many of the same support requirements. Other potential group types that may warrant consideration are mobile groups, co-present groups, and tightly coupled groups. It may also be possible to develop design approaches for specific work domains. For example, Chapter 4 discusses several domains that seem to have high incidences of loose coupling including health care, education, knowledge work, and mobile service work. Since work in certain domains is often organized in a similar fashion across a range of settings, it may be possible to identify those domains that share common characteristics so that designers can learn from others' experiences.

Regardless of the focus of groupware design methods, whether they are general techniques or for specific group types or domains, the range of issues that should be addressed goes beyond what has been considered in existing techniques. The "loose coupling checklist" presented in the analysis technique suggests levels of analysis that should be explored in developing new groupware design techniques. They are based on organizational research from a number of fields, and include:

- *Environment*: characteristics of the group's and the organization's external environments that influence the way work is carried out in the workgroup
- *Organization*: characteristics of the organization that influence the way that work is carried out in the workgroup
- *Supervision*: characteristics of the relationships between supervisors and group members, and between group members and their subordinates
- *Group*: shared tasks, shared interdependencies, communication patterns, coordination practices, awareness patterns, coupling patterns, other characteristics of the group
- *Worker*: individual tasks, roles, other characteristics of group members

The contextual model, analysis technique, and design approaches presented in this dissertation provide a starting point for considering how these factors can be incorporated into other design methods.

10.5 Other findings

In this section, I discuss several unexpected findings from the field trials and from home care observations. These findings have implications for the framework, but were not included in the initial version of the framework presented in Chapters 4, 5, and 6. The discussion is arranged around four themes: constant interdependence; deployment strategies; shared physical spaces and loosely coupled mobility; and home care and medical informatics.

10.5.1 Constant interdependence

The stability and variability seen in the shared interdependence in treatment teams played a key role in determining the level of coordination that was needed. The shared interdependency in home care teams arises through the common patient that all team members treat. In the first field trial, the patient was at times very stable, and there was little need for workers to explicitly coordinate their activities. They had treated the patient over a long period of time, and had a basic understanding of the activities that others provided based on that long involvement. In the second field trial, the patients were more unstable, and had not been on the treatment team members' caseloads for an extended period. Workers had to revise their treatments regularly to address changes in patients' statuses, and coordination became more important. While workers still worked in a loosely coupled fashion, there were more instances of direct communication between workers to address the variability in patients' statuses.

Weick (1982) describes constant interdependence as a potential cause of loose coupling. According to Weick, when the variables that connect system elements show little variation, the need to coordinate work is minimal, and they are more likely to work together in a loosely coupled fashion. The term "variables" indicates the point of interdependence between the system elements—whether it is a project or a client, it represents the focus of collaborative activities. According to Weick (1982), constant variables can construct a "wall of constancies" (p. 400) between subsystems, causing them to be severed and loosely coupled. Weick indicates that (1982) "variables with restricted variation do not tighten systems; they loosen them. Only when variation is restored do interactions increase and systems become more tightly coupled" (p. 401).

10.5.2 Deployment strategies

Field trial findings suggest that the level of coupling seen between supervisor and subordinate influences the strategies that should be used when deploying a groupware application. When tight coupling is seen between supervisors and workers, it is much easier to deploy a system since directives can be issued from above and workers feel more compelled to comply. However, when loose coupling is seen between supervisors and workers, workers have much more autonomy in deciding their level of participation, and it can be more difficult to successfully deploy the system. These findings are supported by Weick (1982, p. 387) who describes organizational change in a loosely coupled system: “If major change becomes necessary, however, it is much harder to diffuse it among systems that are loosely coupled. Loosely coupled systems reduce the necessity for large-scale change but also make it much more difficult to achieve it if it is needed.”

During the field trials, these differences were seen when comparing compliance between home health aides, who are tightly coupled to the nursing supervisors, and the professional workers, who are loosely coupled to their supervisors. In both field trials, home health aides required few reminders and few accommodations to secure their participation because they felt that the nursing supervisors wanted them to use the system during the work day. Since the supervisors are able to issue directives to the home health aides, they considered using the Mohoc system to be part of the job duties that were assigned to them. In contrast, many of the professional workers required periodic reminders to continue to use the system. Since supervisors could not compel their participation, they had a more active role in determining the direction of the trial, and extra time had to be spent to secure their buy-in to the research process.

In the next sections, I discuss deployment strategies for introducing groupware systems to loosely coupled groups. The strategies are based on experiences with introducing the Mohoc system to home care treatment teams during the two field trials. I discuss two strategies: bottom-up deployment and top-down deployment.

10.5.2.1 Bottom-up deployment

When the vertical relationships between group members and their supervisors are loosely coupled, it can be difficult to introduce groupware systems by mandate. Workers have significant discretion in carrying out work practices, and new technologies will not necessarily be adopted unless the worker believes that there is a direct benefit to them. The role of the loosely coupled vertical relationship in deployment is to initiate and legitimize the introduction of the groupware system, but in the absence of other changes (e.g. increased inspection and evaluation of system use), the success or failure of the deployment rests more firmly on the buy-in of the group members.

To address the need for worker "buy in", a bottom up deployment strategy is needed. This strategy focuses on tailoring and directing the deployment to the workers, rather than through the supervisors. Ongoing training and support is needed to address each individual's concerns, and to help them understand how the system can fit their work processes.

In the field trials, some professional workers were more willing to participate than others. Those that were more willing to participate were either interested in computers and information technologies or felt that their involvement would be beneficial to them, to their department, or to the health region. Others expressed concerns that their participation would interfere with their existing workflow and would lead to extra work. During training sessions for the field trials, extra sessions had to be scheduled with those professional participants (four participants total) to try to address their concerns. One of the primary concerns that workers had was that paperwork would be duplicated in the paper chart and the groupware system. Since workers still had to comply with the standard documentation practices in their departments, they still had to fill out paper-based forms for the patients that were supported in the trials. Entering documentation into the groupware system, then, represented duplication of work. To allay this concern, printing features were added to the system, and a laser printer with a USB cable was set up at the Home Care / CAU office site so that workers could plug in and print out their paperwork. In other cases, some workers asked that the documents be printed out by the researchers and dropped off at the office. The documents were printed off for these workers and delivered at the end of the week.

Some of the professional participants needed to be reassured about different technical aspects of the system. Some were concerned about encryption, and they were reassured that 128-bit encryption was sufficient for safeguarding patient information. Nursing supervisor participants were concerned about logistics and the burden the trial would place on staff members, and these concerns were addressed through explaining the logistics of the trial in detail and the steps that had already been taken to ease the burden that the trial would place on participants.

The field trials suggest that loose coupling between supervisors and workers introduces a significant deployment challenge, particularly when several individuals' needs must be addressed. These difficulties, however, may be able to be managed more easily through using a focus-group strategy to deployment in order to build consensus among workers so that the task of addressing and consolidating differing opinions is not so onerous. The potential value of this approach was seen during a training session for the second field trial. The session had been set up for a single nurse, but two other nurses dropped by since they were going to participate in the trial and wanted to learn more about the system. During the session, one nurse expressed concerns about the printing features that were included in the system. She felt that using printouts from the system would add too many extra sheets of paper to patients' charts and would make them prohibitively thick. This led to approximately 20 minutes of discussion. Two nurses agreed that this would be a problem during the trial, but the third nurse did not feel that it would be a problem for the two patients that she treated. A compromise was eventually reached with the two nurses—they agreed to enter progress notes (narrative notes that describe the patient's status and response to treatments) into the system, but not their medication flowsheets. Since all nurse participants were present at the time, the solution addressed all of their concerns, and it minimized the need for ongoing "horse-trading" with the participants.

10.5.2.2 Top-down deployment

When vertical relationships between group members and their supervisors are tightly coupled, it is much easier to introduce a groupware system by mandate. Since workers' autonomy is limited, they have little discretion in deciding whether to integrate a new groupware system into their work practices. Deployment strategies do not have to focus strongly on getting workers to buy into the system, and supervisors can play a larger role in ensuring that the deployment is a success.

When tightly coupled relationships are seen between group members and their supervisors, a top-down deployment strategy can be used. The design still needs to be tailored to the needs of the workers, but the deployment itself can be directed by supervisors. The need to negotiate with workers and to address their individual concerns is decreased.

During the field trials, the home health aides were more willing to use the system than the professionals. These differences were seen in training sessions and during the trials. In training sessions, they were willing to use the system without requesting revisions in the way the system was deployed. During the trial, they used the system with more regularity than the other disciplines even though the visitation frequency did not always vary significantly from some of the other disciplines.

10.5.3 Shared physical spaces and loosely coupled mobile work

In home care, workers are mobile over a wide area and do not see each other face-to-face regularly. The mobile aspect of loose coupling in home care means that workers' use of work sites varies from the patterns seen in situated loosely coupled groups. Unlike situated groups, a home care team shares the same work site (e.g. the patient's home), but usually at different times. This asynchronously shared worksite acts as an "information repository" for sharing information within the team. Home health aides keep the communication binder in the patient's home, and they use the binder to maintain shared documents and to leave messages for each other. Workers also try to stay aware of others' activities through making use of evidence that has been left in the patient's home such as equipment, handouts, or supplies (see Chapter 3).

The patterns seen in home care have implications for groupware design for other types of loosely coupled mobile groups. Home care findings suggest that when workers asynchronously share common spaces, those spaces can play an important role as an awareness and communication resource. These common spaces can provide access to information that cannot be found through other means, and require very little effort both for the person who leaves the information and for the person who gathers it. However, common workspaces for mobile groups may be public or belong to someone else, and they do not always provide sufficient information for workers to maintain reasonable awareness. It is possible that the information-holding capacity of these real-world shared spaces themselves can be augmented to overcome some of these limitations, and to allow workers to be more aware of others' activities and more able to share information.

For example, GeoNotes (Espinoza et al. 2001) allows users to leave virtual notes that are attached to real world locations. The notes can be accessed at that location with mobile phones and PDAs, and workers can be alerted when they come into close physical proximity with a note. While this technique seems to be a promising way of contextualizing messages by attaching them to a site, the need to explicitly compose and attach messages limits this technique to intentional communication only. However, an approach like GeoNotes that implicitly gathers and shares information such as who has recently visited a location, when, and the duration of time in the location has the potential to improve awareness and coordination using real world common space and without significantly increasing the amount of effort that is needed by workers.

10.5.4 Home care and medical informatics

The findings from observations and interviews (Chapter 3) and from the field trials (Chapter 8) provide insights that are relevant to clinical information system design for home care. The primary finding is that the support needed by home care teams goes beyond the level of support that is available through shared access to a simple electronic health record (EHR). Electronic health records are often viewed as a simple replacement for the paper record, or as a slightly augmented version of that record (e.g. Raghupathi 1997). In the Mohoc implementation, a shared document repository was provided that was based on workers' current paperwork practices. However, while workers benefited from access to this repository, the support alone was insufficient for addressing many of the collaboration needs that were identified through this research.

As discussed in Chapter 6, even though workers work in a loosely coupled fashion, "loose" communication and coordination channels can enable low-cost collaboration without negatively impacting worker autonomy. Support for collaboration can be built into system that provides access to Electronic Health Records so that organizational objectives are met (i.e. a unified EHR that adheres to the organization's standards), but so that workflow needs are also addressed. Observations from home care identified several collaboration difficulties that fall outside the scope of the traditional EHR. While these are not always significant problems since workers are primarily autonomous, at times they are significant, particularly when treatment interdependence increases within subsets of the treatment team. These happen when:

- It is difficult for home care workers to stay aware of other treatment team members' activities, even when they have direct relevance to their own treatments.
- It is difficult for home care workers to coordinate treatments with each other so that the treatments are complimentary.
- It is difficult for home care workers to coordinate their schedules so that unwanted conflicts are avoided, and so that desired meetings are possible.
- It is difficult for home care workers to disseminate information to other members of the treatment team.
- It is difficult for home care workers to obtain information from other team members.

The Mohoc implementation addressed these issues, largely by augmenting the visualization of the shared document repository with collaborative features. The system was organized around a chart metaphor, and the document repository was central to the system. Other features were built around the document repository, such as a chart "cover page" that included a list of treatment team members, the patient's schedule, treatment plans, and viewing histories. Awareness and communication features were associated with individual documents—viewing histories and modification histories were tracked for each document, and sticky notes could be placed on documents to allow communication about document content.

The field trial suggested that this approach was useful in addressing the needs of home care teams. For example, the system facilitated communication within the treatment team that would likely not have occurred without groupware support. Similarly, participants reported being more aware of others' treatment activities, and reported incidences where they used the system to coordinate treatments with others (see Chapter 9). This suggests that clinical information systems should be based on the workflows of the workers that they support, and not on the data models (EHRs) that they provide access to. This study did show benefit in providing a shared document repository, but only as a partial solution to addressing the collaboration and information needs of workers.

10.6 Limitations of research

This research has four main limitations: questionable external validity, limited scope, limited basis for comparing the framework, and limited evaluation of the analysis technique.

10.6.1 Questionable external validity

One of the main limitations of this study is that it considers a single work setting, so it is unclear whether the findings from home care will generalize to other loosely coupled settings. The framework was developed concurrently with home care data collection activities, and was evaluated in the home care setting. This means that there is a possibility that the framework may be tailored to the home care setting rather than to loosely coupled groups in general, and that evaluation results may also reflect this bias. In the future, the framework needs to be evaluated in other loosely coupled groups in order to determine its external validity.

10.6.2 Limited scope

Another significant limitation is the limited scope of this project. A total of four patients were included in the two field trials—one patient in the first, and three in the second. Each home care worker typically treats anywhere from 6-12 patients a day, so the patients that were supported during the trials represented a small portion of each participant's daily workload. Additionally, the visit frequency often varied between disciplines, with some workers treating a patient once a week, others 3 times a week, and others daily.

Since the patients supported in the trial represented a small part of each worker's daily work activities, using the system did not fit into workers' workflows. The system represented a deviation from their normal unsupported work style. This raises questions about how the system would be used if the majority of workers' patients were supported using the system, and the impact that design decisions would have with this level of adoption. However, personnel and monetary limitations precluded covering workers' full caseloads, since expanding the number of patients included would also expand the number of clinicians involved. This would lead to a corresponding increase in the number of devices needed to support the trial, as well as an increase in the number of personnel needed to support the trial and data collection/analysis activities.

This dissertation evaluated each part of the framework, but did not focus significantly on the system's overall impact on work and collaboration patterns in teams. This was partly due to the overall focus of the research, but the scope of the trials also precluded considering these issues in detail since the system played a minor role in most workers' daily work activities. While the evaluation does provide some details on these issues, it was not possible to draw strong conclusions due to the scope limitations.

10.6.3 Limited basis for comparing framework

The Mohoc system was well received by study participants during the field trials, which suggests that the underlying design framework was useful at helping to tailor the design to the needs of the target users. However, since a single design process was used and a single groupware system was deployed during the trials, it is not possible to directly compare Mohoc and the design framework with other systems and processes. For example, if two systems were designed and deployed using different design methods, a more direct comparison could be made in order to determine whether the design framework led to a design that is better suited to users' needs. Since this type of study design was not possible, conclusions about the framework must rely on indirect comparisons with existing techniques.

10.6.4 Limited evaluation of analysis technique

The analysis technique was based on the methods that were used to analyze home care work, but the formal technique was not used in the development of the Mohoc system. The technique was based on modifications to existing analysis approaches that were made in order to incorporate consideration for loosely coupled work practice into the Mohoc system. This gives the technique some limited validity from a designer's perspective. Similarly, since the technique is roughly equivalent to the approaches that were used in analyzing work in context from home care, field trial findings provide a rough indication of its effectiveness. The technique provides an initial foundation for analyzing loose coupling, but the limitations of the evaluation make it difficult to make strong arguments for its validity.

11 Conclusions

This chapter concludes the dissertation and has three parts. First, I summarize the dissertation. Second, I summarize the major and minor contributions this research has made to Computer-Supported Cooperative Work, Medical Informatics, and Human Computer Interaction research. Third, I discuss future directions for research based on this dissertation.

11.1 Summary of research

Loosely coupled workgroups are common in the real world, and workers in these groups are autonomous and weakly interdependent. They have patterns of work and collaboration that distinguish them from other types of groups, and groupware systems that are designed to support loose coupling must address these differences. However, they have not been studied in detail in Computer-Supported Cooperative Work (CSCW), and the design process for these groups is currently underspecified. This forces designers to start from scratch each time they develop a system for loosely coupled groups, and they must approach new work settings with little information about how work practices are organized.

In this dissertation, I present a design framework to improve the groupware design process for loosely coupled workgroups. The framework has three main parts that add a new layer of support to each of the three stages in the general groupware design process: data collection about the target work setting, analysis of the data, and system design based on the analysis results. The framework was developed to provide designers with support during each of these stages so that they can consider important characteristics of loosely coupled work practice while carrying out design for the target group. The design framework is based on information from CSCW and organizational research, and on real-world design experiences with one type of loosely coupled workgroup—home care treatment teams.

The design framework has three parts: a contextual model, an analysis technique, and a set of design approaches. The contextual model acts as a theoretical foundation for the rest of the framework and helps designers understand loose coupling in real world settings. The analysis technique helps designers to recognize and specify important features of loosely coupled work settings, and to organize that information in a way that makes it usable during the design process. The design approaches help translate real world characteristics of loose coupling identified in the analysis step into designs that address the needs of target workgroups.

The framework was evaluated using observations, interviews, and field trials that were carried out with multidisciplinary home care treatment teams in Saskatoon Health Region. Home care teams provide a working example of loose coupled workgroups—workers are interdependent, but only minimally—they carry out their work autonomously, and collaborate with each other infrequently. I carried out a series of field observations and interviews with team members from each of the home care disciplines. I then used the framework to develop Mohoc, a groupware system that supports loosely coupled work practice in home care. Two field trials were carried out where the system was used by teams to support members' daily activities.

Results were analyzed to determine how well each part of the design framework performed in the design process. The results suggest that the framework was able to fill its role in specializing the general CSCW design process for loosely coupled groups by adding consideration for work and collaboration patterns that are seen in loosely coupled settings. However, further research is needed to determine whether these findings generalize to other loosely coupled workgroups.

11.2 Contributions

The main contribution of this dissertation is a design framework that improves the design process for groupware developed for loosely coupled workgroups. The design framework is based on a general CSCW design process that includes data collection from the target work setting, analysis of the data, and system design based on the analysis results. It is the first design framework based on work patterns in loosely coupled work situations, and it improves the ability of a designer to see the important characteristics of a loosely coupled work situation, assists them in organizing data gathered from the domain, and provides them with a set of approaches for translating their analysis into system features.

There are also minor contributions to both the CSCW and medical informatics communities. There are two minor contributions related to the design and implementation of groupware systems. First, since the Mohoc system is a full implementation of a mobile groupware system in a real-world work setting, it is a novel contribution to CSCW research. Unlike other mobile groupware systems that have been studied in CSCW, the Mohoc system is more than a partial prototype, and the deployment and evaluation of the system over an extended period of time produced findings that are new to CSCW research. These include:

- The success of the store and forward approach used in the system for supporting mobile and disconnected work
- The tolerance that mobile home care workers had for delays in communication
- The success of the simple permissions policy for managing modifications to artifacts (see Section 7.4.3.2)
- The usefulness of asynchronous awareness information in managing weak interdependence in mobile work

Second, the prototyping and implementation work that was carried out to develop Mohoc led to the development of novel user interface representations and interaction techniques. These include:

- Transparent overlays that show information about others' activities without interfering with individual work
- A timeline-based visualization of a shared health record repository that includes embedded awareness information

- Asynchronous awareness representations including viewing histories, modification histories, and flags for interpreting others' recent activities in the system
- Chart, daily agenda, and schedule metaphors for arranging user interface and interaction support for home care teams
- User interface and interaction approaches for supporting clinical documentation practices on PC and handheld devices

These design techniques provide new options for designing groupware systems for other workgroups.

There are three minor contributions that are relevant to the home care and medical informatics communities. First, the analysis of loose coupling in home care work provides a detailed understanding of organizational issues that are relevant to designing applications for community-based healthcare workers. Second, the design and prototyping work in home care provides insight into how technologies can address homecare workflows. Third, the field trial results provide insight into how groupware technologies can support work and augment communication and coordination in home care teams.

11.3 Future work

This research raises several new questions. In the next sections, I discuss five areas where future research is needed:

- Further evaluation of the framework
- Increase the scope of the evaluation
- Further investigation of coupling and deployment patterns
- Develop design frameworks for other types of groups
- Investigate implications for general populations

11.3.1 Further evaluation of the framework

One of the main limitations of this study is that it considers a single work setting, so it is unclear whether the findings from home care will generalize to other loosely coupled settings. The primary research activity that needs to be carried out in the future is to evaluate the design framework in other loosely coupled workgroups. Potential settings can include human service organizations (e.g. healthcare, education), knowledge work, and mobile service work.

Future work should focus on evaluating two aspects of the framework. First, the contextual model should be evaluated through further observational studies. Observational studies can be used to evaluate each of the items in the model, as was done in this dissertation, in order to determine whether the model accurately characterizes work practice in other loosely coupled groups. Second, the analysis and design approaches should be evaluated through future design and implementation work in loosely coupled settings. Investigating these parts of the framework will require the development and deployment of groupware applications so that the framework can be evaluated in context.

11.3.2 Increase the scope of the evaluation

The scope of the field trials that were carried out in this research was limited (see 10.6.2). Only a small number of patients were included in the trial, and the system was used to support a small part of each participant's caseload. In the future, new home care field trials can be carried out that increase the number of patients that are included and that support a larger percentage of each participant's caseload. This will provide data that is more representative of how the Mohoc system would be used under normal conditions (i.e. a full deployment), and of how the design impacts work practice.

11.3.3 Further investigation of deployment and coupling patterns

One of the unexpected findings during the field trials was the influence that vertical coupling patterns had on groupware deployment. In Chapter 10, I present these observations and two strategies for deploying groupware based on these patterns. I propose a top-down approach for tightly coupled vertical relationships, and a bottom-up approach for loosely coupled vertical relationships. These findings are somewhat preliminary, and warrant further investigation in a range of work settings. Investigating coupling and deployment issues does not necessarily require the development of custom software, which makes this a much easier issue to investigate than analysis and design concepts. The merit of different deployment strategies can be evaluated through introducing new groupware applications within an organization. The general strategies that are proposed in Chapter 10 can be expanded significantly, and specific deployment methods can be investigated, such as the use of focus groups.

11.3.4 Develop design frameworks for other group types

The framework presented in this research improves groupware design for loosely coupled workgroups by providing support for common design activities (e.g. observation, analysis, system design). In the future, the general approach that was used in this research can be used to develop design frameworks for other group types. That is, other types of groups can be examined in detail in order to determine how an additional layer of support can be added to the design process to address the characteristics of those groups. Several group types that may warrant further consideration are:

- Tightly coupled co-present groups
- Tightly coupled distributed groups
- Loosely coupled mobile groups
- Tightly coupled mobile groups

11.3.5 Investigate implications for general populations

The design framework considers levels of organization that are overlooked in existing groupware analysis and evaluation methods. For example, vertical relationships, work environment, and organizational characteristics are considered in the framework, and were important in design for home care teams. However, consideration for these issues has not been incorporated into design techniques for general populations. It may be possible to develop a general analytical framework so that organizational levels can be considered in the groupware design process. Possible levels of analysis that can be incorporated into groupware design techniques for general populations include:

- *Environment*: characteristics of the group's and the organization's external environments that influence the way work is carried out in the workgroup
- *Organization*: characteristics of the organization that influence the way that work is carried out in the workgroup

- *Supervision*: characteristics of the relationships between supervisors and group members, and between group members and their subordinates
- *Group*: shared tasks, shared interdependencies, communication patterns, coordination practices, awareness patterns, coupling patterns, other characteristics of the group
- *Worker*: individual tasks, roles, other characteristics of group members

11.4 Conclusion

Groupware design for loosely coupled workgroups is difficult because the design process is underspecified. This dissertation addresses this problem by presenting a framework that improves the design process for groupware developed for loosely coupled groups. The framework has three main parts that add a new layer of support to each of the three stages in the general groupware design process: data collection about the target work setting, analysis of the data, and system design based on the analysis results.

The framework enables designers to develop systems that consider the complexities of work in context in loosely coupled groups. It allows designers to begin the design process with access to information about how work is commonly organized, how work settings can be analyzed, and how user interface and interaction support can be designed for common work practices. This allows designers to approach new settings without being forced to start from scratch every time, and allows them to consider others' design experiences when building their own systems.

This dissertation opens a new area of research in groupware and user-interface design. It represents a first step in considering how work practice in loosely coupled groups shapes the support needs of group members. It also provides a general approach for improving design for other types of groups. Since the groupware design process is underspecified in general, it is possible to develop similar design frameworks that are based on the characteristics and work practices seen in other group types.

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Appendix A: home care models

Data model diagrams

Sample flow models

Sample sequence models

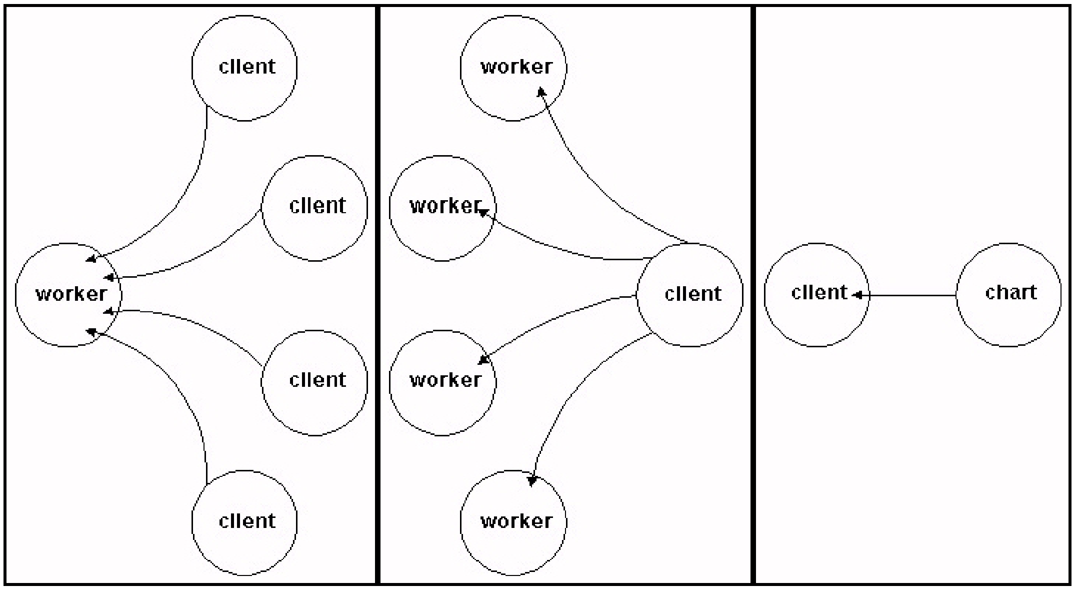

Figure A.1. Relationships between core DTDs.

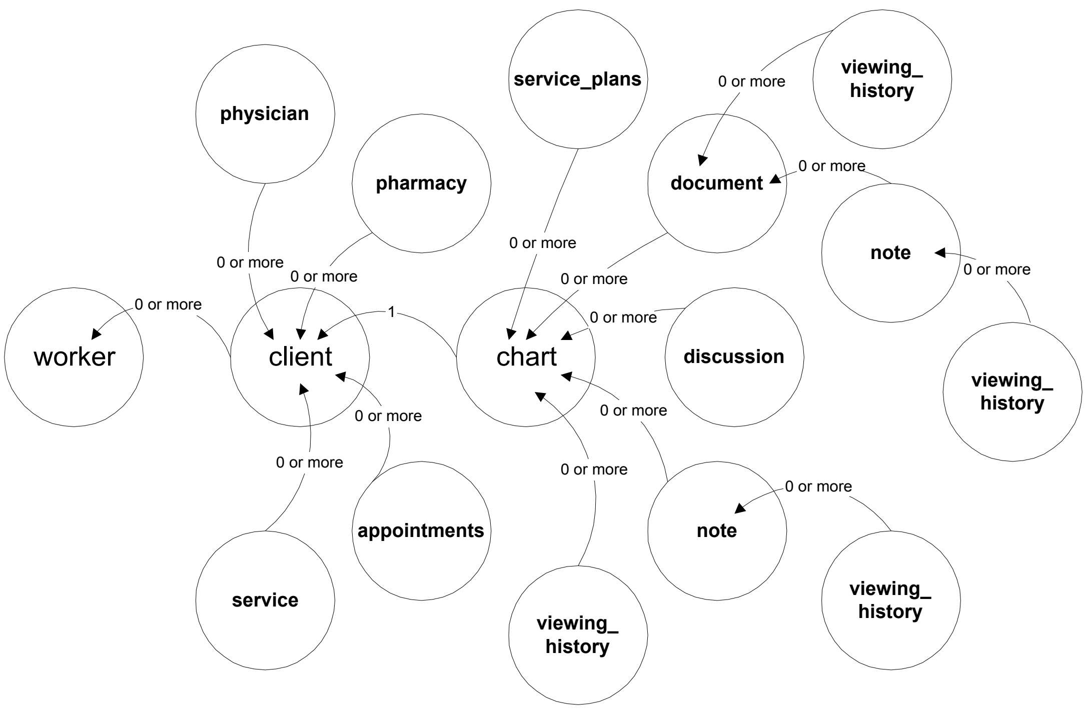

Figure A.2. Overview of twelve DTDs and their relationships.

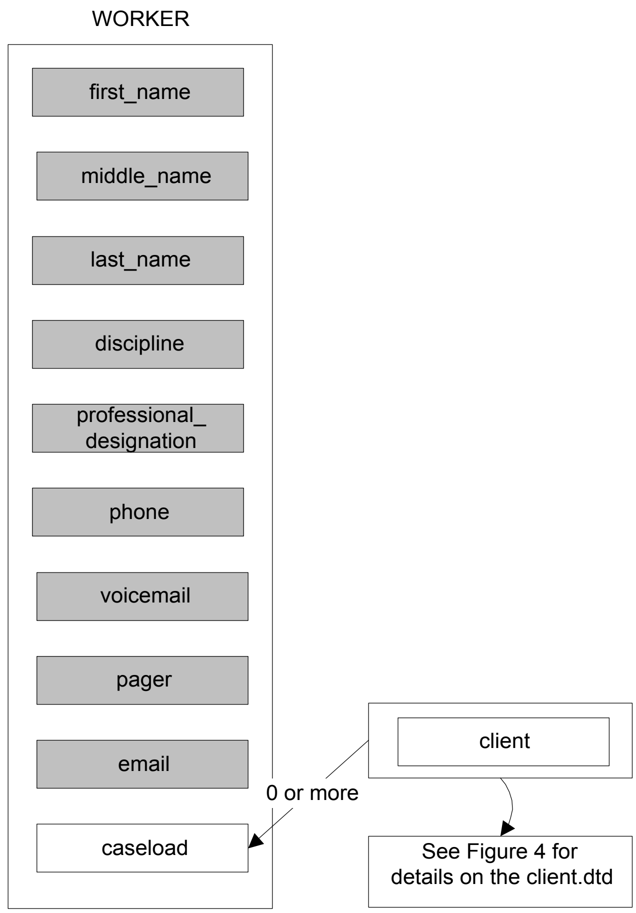

Figure A.3. Worker.dtd fully expanded except for client. Gray cells are atomic data elements.

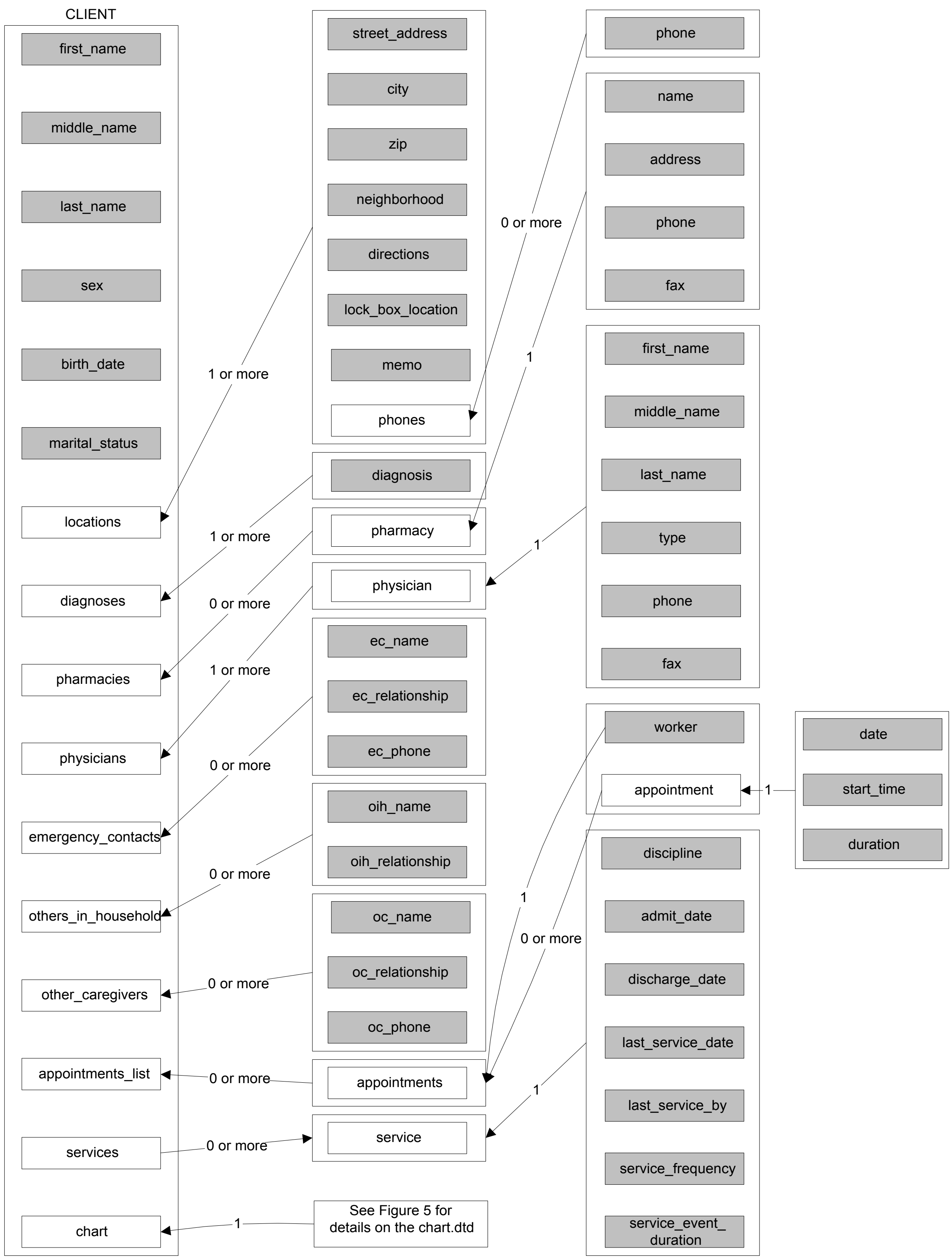

Figure A.4. Client.dtd fully expanded except for chart.

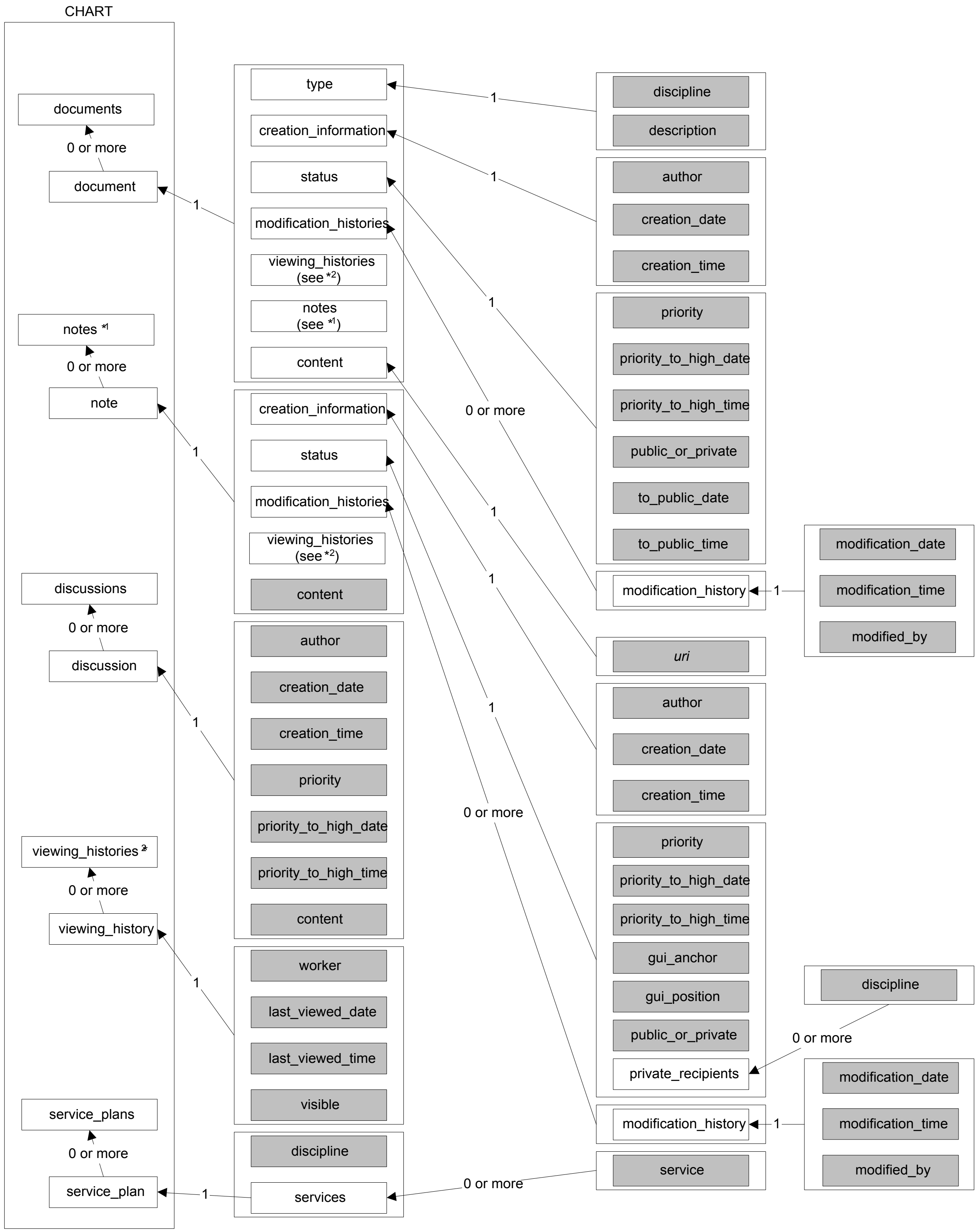

Figure A.5. Chart.dtd fully expanded.

Flow Model: Occupational Therapist (OT)

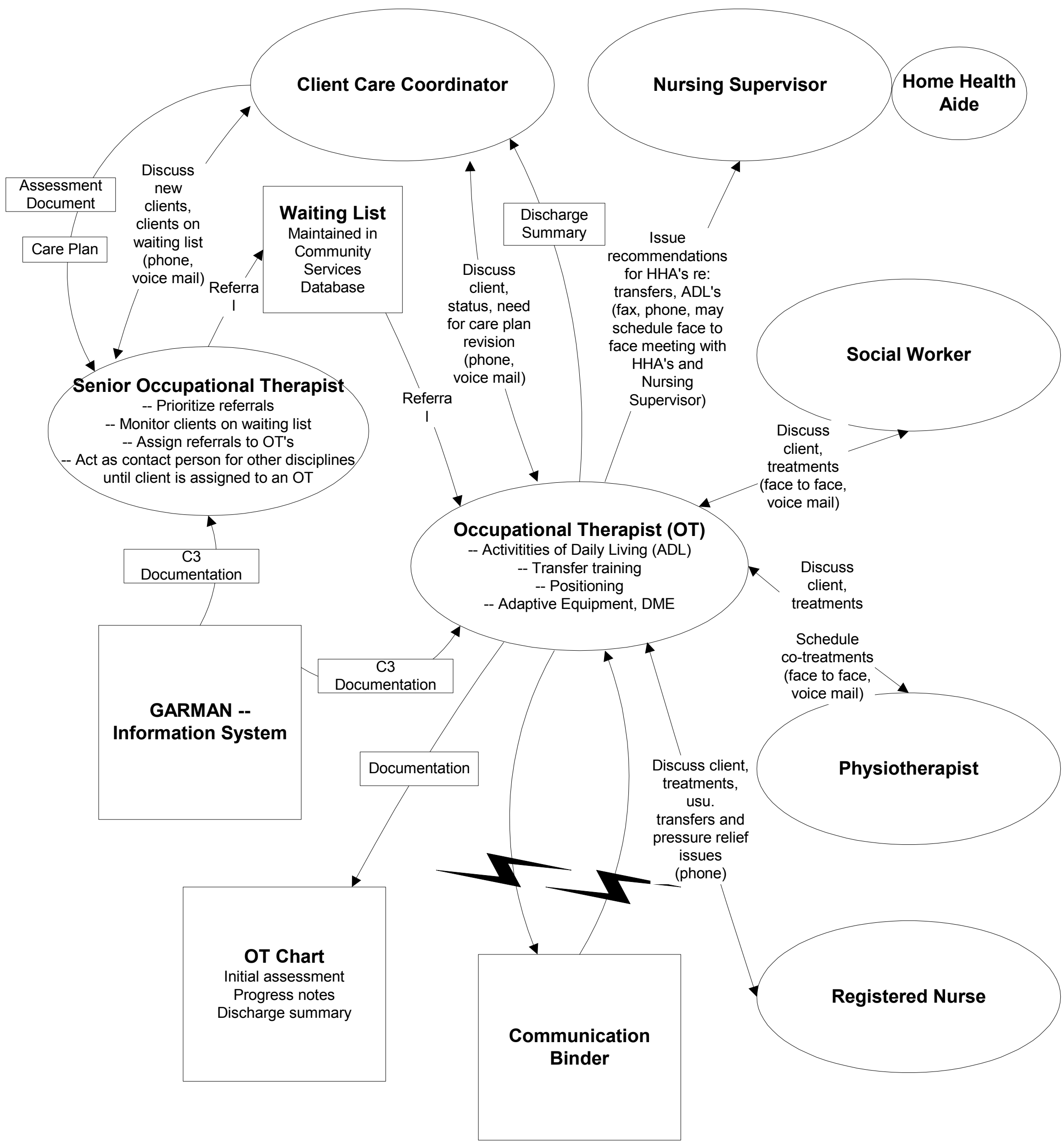

Figure A.6. Contextual design flow model for occupational therapists

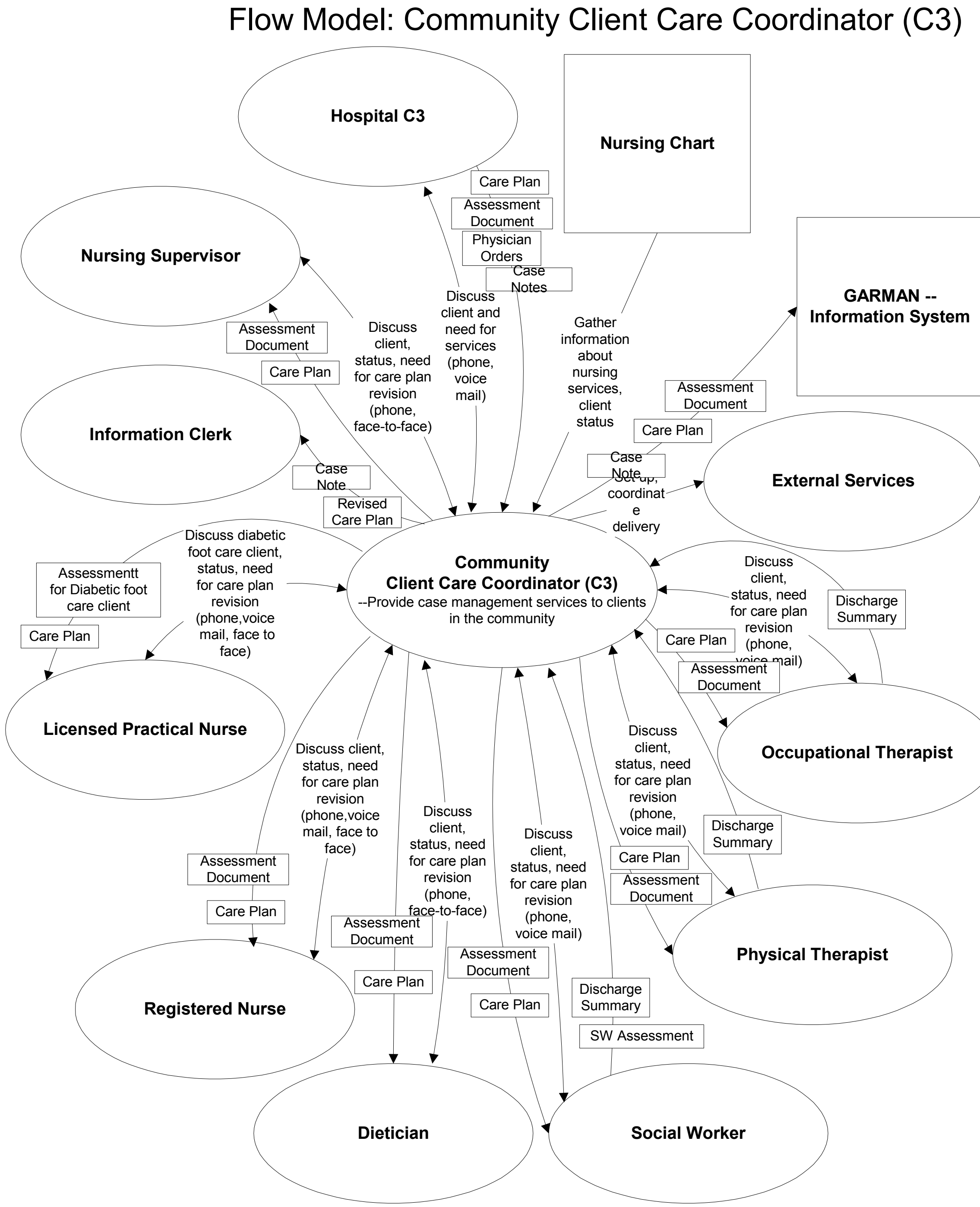

Figure A.7. Contextual Design flow model for C3s

Flow Model: Home Health Aide (HHA)

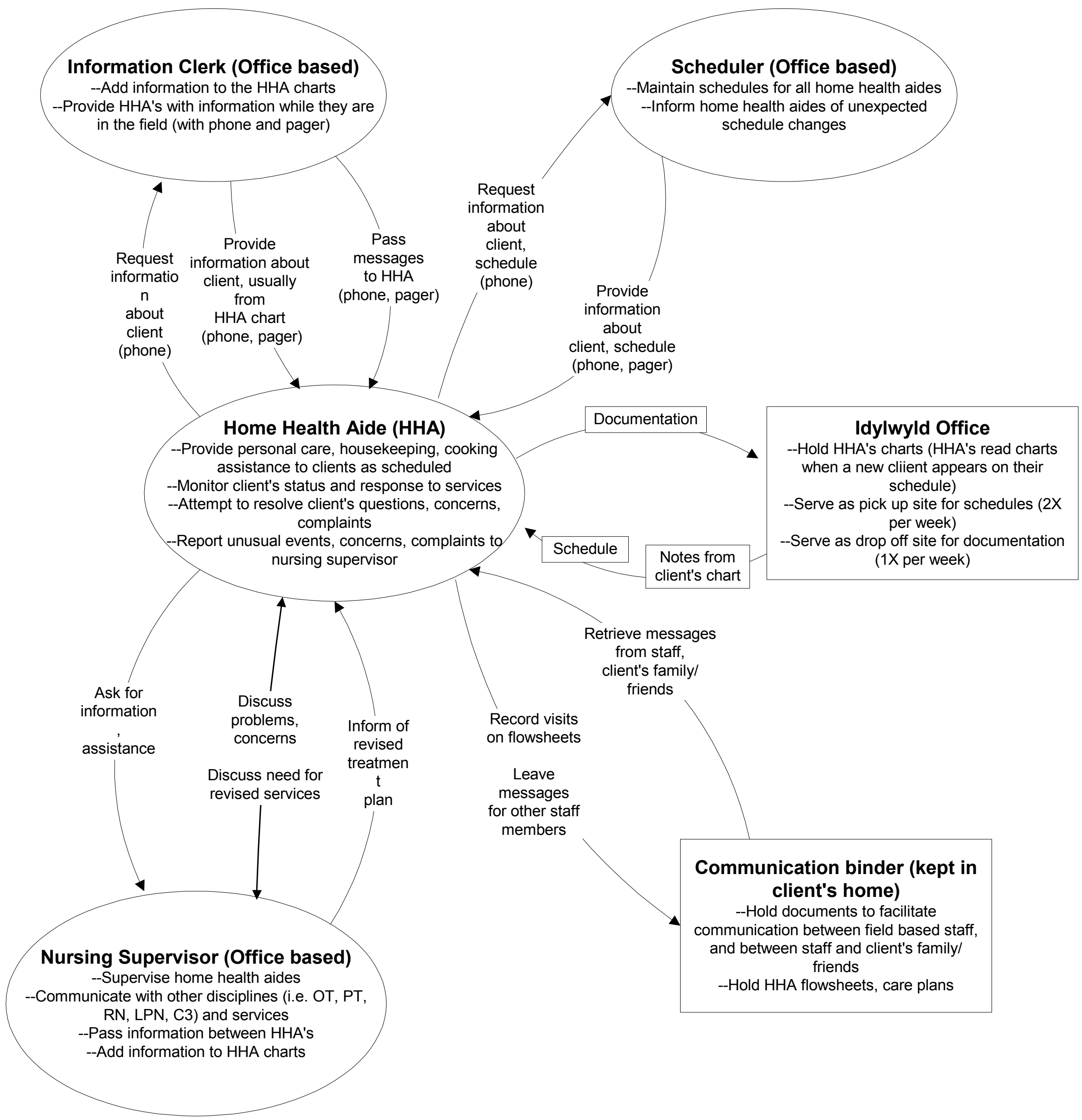

Figure A.8. Contextual Design flow model for home health aides

[Sample sequence model for dietician– 1 page]

Dietician resources:
Personal office space, pager, access to Garman. No voice mail

Intent: Document a client visit

Trigger: Visit a client
↓
Return to office
↓
Enter case note into Garman
↓
Read case notes written by C3s pertaining to the client

Intent: Gather information about a new client (admitting after hospitalization)

Trigger: A new client is admitted after recent hospital discharge. Additional information is needed about the client and their diet in the hospital.
↓
Call hospital dietician
↓
Request that they look up documentation on client's hospital stay
↓
Retrieve information by fax or phone

Intent: Communicate dietary recommendations to home health aides involved in meal preparation.

Trigger: Client has specific dietary needs that must be shared with home health aides who provide meal preparation services
↓
Contact nursing supervisor (usually face to face, possibly phone)
↓
Tell nursing supervisor about dietary recommendations
↓
Provide nursing supervisor with a written copy of the diet
↓
(Nursing supervisor will pass information to all home health aides)

Intent: Discuss client with nursing or C3

Trigger: An issue arises in which client information must be passed on to, collected from, or discussed with a nursing or a C3.
↓
Using general knowledge of schedules, attempt to contact nurse or C3 in the office
↓
If unable to establish face-to-face contact, leave written messages on their desk (if necessary, can ask them to meet at a certain time). With C3, may contact with voice mail.

[Sample sequence models for C3s – 2 pages]

Community C3 resources:
Voice mail, Office space, No email, Garman access

Intent: Assess a new client

Trigger: New client admitted to community (not from hospital)
↓
Call client and set up appointment
↓
Visit client in home
↓
Interview client / caregiver
↓
Record information on blank assessment form
↓
Discuss the need for community-based services
↓
Return to office
↓
Enter assessment into Garman
↓
Enter care plan into Garman
↓
Print assessment and care plan
↓
Enter case note into Garman
↓
Fax care plan / assessment to disciplines at RUH (OT, PT, SW) if necessary
↓
In Garman, forward care plan, assessment to home care if needed
(for Nursing, dietetics, HHA)
↓
Call to set up external services if needed (i.e. meals on wheels, adult day care)

Intent: Initiate community based services for client who recently discharged from hospital

Trigger: Receive care plan, assessment document, case notes, and possibly
physician's orders / hospital documentation from hospital C3
↓
Call hospital based C3 (before or after visit) if additional information is needed
↓
If cannot reach hospital C3, leave voice mail or page
↓
Call client and set up appointment (within 48 hours of hospital discharge)
↓
Visit client in home
↓
Interview client / caregiver
↓
Complete assessment if needed (if hospital C3 has not yet done so)
↓
Discuss the need for community-based services

↓
Return to office
↓
If needed, complete assessment in Garman
↓
If needed, revise care plan in Garman
↓
Print assessment and care plan
↓
Enter case note into Garman
↓
Fax care plan / assessment to disciplines at RUH (OT, PT, SW) if necessary
↓
In Garman, forward care plan, assessment to home care if needed
(for Nursing, dietetics, HHA)
↓
Call to set up external services if needed (i.e. meals on wheels, adult day care)

Intent: Visit client to determine the need for care plan revisions

Trigger: Client, home care discipline, care giver, or external service reports change in client's status or feel a service should be added or discharged from care plan
↓
Call client and set up appointment
↓
Visit client in home
↓
Interview client / caregiver
↓
Record information on printed copy of assessment document
↓
Discuss the need for care plan revision
↓
Return to office
↓
Enter assessment revisions into Garman
↓
Enter care plan revisions into Garman
↓
Print revised assessment and care plan
↓
Enter case note into Garman
↓
Phone discipline at RUH (OT, PT, SW) if necessary to inform of care plan changes
↓
In Garman, forward revised care plan, revised assessment, and case note
to home care if needed (for Nursing, dietetics, HHA)
↓
Call to revise external services if needed (i.e. meals on wheels, adult day care)

Appendix B: field trial materials

Script from first round of interviews

Tasks for prototype walkthroughs

Rough training script for laptop client for field trial 1 and 2

Rough training script for handheld client for field trial 2

Rough script for first interview, field trial 1

Rough script for second interview, field trial 2

Questionnaire for field trial 2

[Script from first round of interviews with home care clinicians – 2 pages]

ORIENTATION TO PROJECT:

We are interested in building a computer system to make it easier for home care workers to access others' documentation and to improve communication between members of the different disciplines.

Our current idea is pretty rough at this time. Our expectations are that home care workers will carry laptop computers with them in the field and enter their documentation directly into a system that we will build. At the end of the day, each worker will connect the computer to a phone line and send all of the documentation to a central computer. This would also give that worker access to the notes of the other home care workers who treat the same clients.

In addition to documentation sharing, we are considering other functions for the system. We can add the ability to send personal messages and group messages. We can clearly mark new chart entries so it is obvious what has been recently added.

The purpose of this interview is to get your feedback on how you work as a member of your discipline. Specifically, I am interested in how you gather and share information with other home care workers. I am interested in how you do this using written documentation, pagers, phones, voice mail, and meetings. Gathering this information will help us to understand the needs of home care workers in the district. One of our goals in building this system is to tailor it to the needs of home care workers. Interview results will be used to develop a set of initial system requirements, and the computer system will evolve out of this.

I. General

What are your sources for client information initially?
After treatment has begun?

II. Scheduling

How do you determine visit times (i.e., day of week, time of day) and coordinate this with other disciplines?
How long do you typically provide service to a client?
How frequent are your visits (i.e., once a week, three times a week)?
Do you typically share responsibility for treating clients with other members of your discipline? If so, how do you share client information?

III. Documentation

A. Formal documentation

Paperwork used by your discipline?
When and how often is each piece of paperwork filled out?

B. Informal documentation (i.e., communication log)

Paperwork used by your discipline?

When and how often is each piece of paperwork filled out?

Of the information that you feel you need to convey to members of other disciplines, how much of it do you typically capture in your documentation?

Do you feel it would be valuable to you to have easy access to the documentation of other disciplines? If yes, which disciplines?

Is it difficult to maintain your paperwork in a mobile setting?

IV. Communication

A. Formal communication

How often do you have regularly scheduled contact with members of your discipline?

Other disciplines?

B. Informal communication

How and how often do you currently communicate with members of other disciplines?

How do they communicate with you?

Is communication inconvenient? If so, how? Does this restrict the quality and quantity of communications?

Which disciplines do you communicate with most commonly?

Which disciplines do you NEED to communicate with more commonly?

In what cases would it be useful to be able to easily communicate with members of other disciplines?

Are there any pieces of information from other disciplines that you frequently do not have access to or find yourself having to go out of your way to retrieve?

V. System Recommendations

In this project, we want to attempt to improve communication between home care workers who are treating a given client—are there common pieces of information that you find you would like to have?

Given what we have told you about our current goals for a system, is there any functionality that you can think of that would be particularly useful to you?

To help us develop a system that works well with the way you work, what are some problems you foresee with implementing a system such as this?

[Tasks for prototype walkthroughs – 1 page]

Tasks for prototype walkthroughs: October 2001

Test these features: Screen transitions, workflows, representations, and other functionality

Screen 1

1. Generate a progress note for Judy Day.
2. Write a private note to yourself and attach it to Randy Apodaca's chart (i.e. remember to bring equipment for client X).
3. Schedule Christi Carpenter on Tuesday at 4pm and Thursday at 9am. Make sure you do not schedule her at the same time as another discipline.
4. Add Dawndra Meers to your client list (case load).
5. Discharge Jesse Florez.
6. Begin your day – i.e. move to daily agenda screen
7. Read the public note attached to Sarah Brooks' chart.

Screen 2

1. You just treated John Hinds. Who do you plan to visit next?
2. Identify which charts contain new documents
3. View the contents of the chart for Wanna Smith.
4. Revise the schedule – reschedule Scott Draper for Monday November 26th.
5. View the schedule for Monday November 26th.
6. Write an evaluation for Wanna Smith.

Screen 3

1. Identify which documents have been newly added since you last viewed this chart
2. Make a new entry in the discussion window, and set the priority to high
3. Read the newest physiotherapy document
4. Which disciplines have visited Matthew Geddie today and what treatments were delivered?
5. Create a new progress note
6. Open the chart for Wanna Smith (another client)
7. Place a public note on the oldest physiotherapy document
8. Edit the newest document for your discipline
9. Go back to the agenda for today
10. Read the new public note attached to a C3 document.

[Rough training script for laptop client for field trial 1 and 2 – 1 page]

First laptop / application orientation session

Project

Overview of project
The coming field trial
[you will have laptop probably till <month>]

Laptop

Login / password
Power on / power off

Power supply

Battery life—charging it [battery monitor]
Spare battery (about 3 hr to charge one that is depleted)

CDPD modem

Careful of antenna
Watcher

Other

DVD player
[I can get you a floppy drive if you want one]
Mouse & Other pointing devices
Tutorials

Application

Give an overview of the application
Help / Tutorials
Make sure you close application

HOW SHOULD I CONTACT YOU IN THE FUTURE!?!
[Contacting me -- <cellular phone #, email>]

[Rough training script for handheld client for field trial 2 – 1 page]

First handheld / application orientation session

Project
Overview of project
The coming field trial
[you will have handheld probably till late Feb]

Gear overview
Power cord
Car charger
Case and clip

Audiovox Thera
Charging the device…orange light when charging, green light when charged
Power on / power off
Using the stylus
Clicking
Click and hold
Battery life—charging it [battery monitor]
Accessing applications — the home button, the home button region
THE SOFT RESET — If it starts acting up, soft reset

1x modem
The button
The watcher

Application
Give an overview of the application

HOW SHOULD I CONTACT YOU IN THE FUTURE!?!
[Contacting me -- <cellular phone #, email>]

[Rough script for first interview, field trial 1 – 2 pages]

General questions

Miscellaneous

1. Have you had any problems with the laptop?
2. Have you had any problems with logging into the system?
3. Have you had any general problems with using the system?
4. How does this approach compare with your normal paper-based approach to work?
5. Are there any benefits to using the computer-based system? Any drawbacks?
6. Is the general layout of the system understandable? Can you interpret the information in the system?
7. What is your opinion of the way the system partitions the workspace into separate charts for each client? Is this a useful approach?
8. Do you have any suggestions for how existing features can be improved?
9. Do you have any suggestions for features you would like to see in this system?

Awareness / collaboration

1. Without the system, do you know who else treats a client?
2. With the system, do you know who else treats a client?
3. Which are you usually aware of: the disciplines that treat a client or the individuals that treat a client? Which is most important?
4. With the system, do you know more about others that treat the client than you would otherwise? Specify. Has this impacted the way you carry out your work activities?
5. Would the system change your knowledge of the activities of others that treat as shared client if you used it more extensively?
6. During the trial, have you communicated with others that treat a shared client? Have you communicated with others using the system?
7. Does the system change the way you interact with others? If so, how?
8. The system shares information about your appointments, activities, and documentation. How do you feel this approach impacts your privacy?
9. Does the system impact the job flexibility you normally have when you are not using the system?
10. Do you feel the system gives you opportunities to communicate more closely with others who treat a shared client?

Features

Ask these questions for features on the feature list:

Usability

Usefulness of feature? Problems with using feature?

Workflow
Did you use feature? Why or why not?

Collaboration / awareness
Did you look at what others did?
Did this change what you did?
What was the impact on privacy / flexibility?

Feature list

Schedule view
- Awareness flags on caseload tiles
- Shared schedule [overlays, collisions]

Chart view
- Discussion
  - Use of color – high priority, new
- Notes, on chart
  - Use of color – high priority, new
- Notes, on docs
  - Use of color – high priority, new
- Timeline
  - Timeline icons – docs, notes
  - Private docs
  - Use of color – high priority, new
- Doc content
  - Rtf
  - Flowsheets
- Chart cover
  - Service plans
  - Schedule / Services in appointments
  - Lists of who is on the team
  - Viewing Histories
- Modification histories

[Rough script for second interview, field trial 2 – 2 pages]

1. Have you had any general problems with using the system?

2. Do you have any suggestions for features you would like to see in this system?

3. With the system, do you know who else treats a client?

4. Which are you usually aware of: the disciplines that treat a client or the individuals that treat a client? Which is most important?

5. With the system, do you know more about others that treat the client than you would otherwise? Specify. Did this impact your work practice during the trial?

6. Would the system change your knowledge of the activities of others that treat as shared client if you used it more extensively?

7. Does the system impact the job flexibility you normally have when you are not using the system? E.g. sharing schedules, plans

8. Do you feel the system gives you opportunities to communicate more closely with others who treat a shared client?

9. How important is it for you to be able to protect information from others? Explain.

10. What role could a system like this play in helping you communicate with your supervisor? With people you supervise?

11. How useful is it to have information about others' plans and schedules?

12. Do you think that a system like this can play a role in helping you contact others for face-to-face discussions or phone calls?

Additional questions for home health aides, who used Audiovox Thera handhelds:

How did you use the device? How did you carry it, use it in the field?

Feature inspection — step through each screen and ask how it was used, if it is useful, suggested improvements

Why did you use it?? Form factor? Pressure from supervisors? Was the system useful?

Do you feel it is easier to communicate with others using the system?

How did it work when you shared clients with other workers? How did you manage documents, etc.?

Any problems with device??

[Questionnaire for field trial 2 – 2 pages]

Questionnaire: January 2004

Your name will not be associated with this questionnaire, so please be candid in your responses.

For each question, please circle the response that best answers the question.

Your discipline: **Nursing** **Home health aide** **C3** **Dietician**

1. How much experience do you have using computers?
None **Very little** **Some** **Considerable**

2. How much experience do you have using the Internet and the World Wide Web?
None **Very little** **Some** **Considerable**

3. How much experience do you have using handheld devices (e.g. Palm Pilots, or other similar devices)?
None **Very little** **Some** **Considerable**

4. How would you rate your overall level of comfort with using computer technologies?
Very uncomfortable **Somewhat uncomfortable** **Comfortable** **Very comfortable**

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5. In general, how often do you know which community-based disciplines treat your clients?
Never **Rarely** **Occasionally** **Regularly** **Always**

6. In general, how much do you usually know about the treatments that other disciplines provide to your clients?
Nothing **Very little** **Some** **Considerable**

How useful do you think it would be to have more information about the treatment activities of other workers who treat your clients?
Not useful **Barely useful** **Somewhat useful** **Very useful**

7. In general, how would you rate the level of effort needed to communicate with members of other disciplines who treat your clients?
No effort **Very little** **Some** **Considerable**

What methods do you use to communicate with other home care workers? Please specify.

If you have experienced problems in sharing information with other disciplines or in getting information from other disciplines, what were those problems?

8. How often do you need to work closely with other disciplines?
Never Rarely Occasionally Regularly Always

If you do work closely with other disciplines, is it difficult to sustain this level of cooperation?
Yes No

If you answered *Yes*, why is it difficult? Please specify.

9. How comfortable would you be letting other workers (from your discipline and from other disciplines) see your *daily schedule*?
Very uncomfortable Somewhat uncomfortable Comfortable Very comfortable

If you are uncomfortable or have reservations, please specify why.

10. How comfortable would you be letting other workers (from your discipline and from other disciplines) see your *paperwork*?
Very uncomfortable Somewhat uncomfortable Comfortable Very comfortable

If you are uncomfortable or have reservations, please specify why.

11. How often do you unexpectedly have to revise your schedule and plans during the workday?
Never Rarely Occasionally Regularly Always

If you do make revisions, please specify some events that might lead to these changes.

How often do you need to consult with your supervisor when you change your schedule or treatments?
Never Rarely Occasionally Regularly Always