Screen Real Estate Ownership Based Mechanism for Negotiating Advertisement Display

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ABSTRACT

As popularity of online video grows, a number of models of advertising are emerging. It is typically the brokers – usually the operators of websites – who maintain the balance between content and advertising. Existing approaches focus primarily on personalizing advertisements for viewer segments, with minimal decision-making capacity for individual viewers.

We take a resource ownership view on this problem. We view consumers' attention space, which can be abstracted as a display screen for an engaged viewer, as precious resource owned by the viewer. Viewers pay for the content they wish to view in dollars, as well as in terms of their attention. Specifically, advertisers may make partial payment for a viewer's content, in return for receiving the viewer's attention to their advertising. Our approach, named "FlexAdSense", is based on CyberOrgs model, which encapsulates distributed owned resources for multi-agent computations. We build a market of viewers' attention space in which advertisers can trade, just as viewers can trade in a market of content. We have developed key mechanisms to give viewers flexible control over the display of advertisements in real time. Specific policies needed for automated negotiations can be plugged-in. This approach relaxes the exclusivity of the relationship between advertisers and brokers, and empowers viewers, enhancing their viewing experience.

This thesis presents the rationale, design, implementation, and evaluation of FlexAdSense. Feature comparison with existing advertising mechanisms shows how FlexAdSense enables viewers to control with fine-grained flexibility. Experimental results demonstrate the scalability of the approach, as the number of viewers increases. A preliminary analysis of user overhead illustrates minimal attention overhead for viewers as they customize their policies.

ACKNOWLEDGEMENTS

This thesis is dedicated to my wonderful parents.

CONTENTS

LIST OF TABLES

List of Figures

List of Abbreviations

IPTV	Internet Protocol Television
PPV	Pay Per View
STB	Set Top Box
FF/FR/RW	Fast Forward/Fast Reverse/Rewind
iMEDIA	Intelligent Mediation Environment for Digital Interactive Advertising
AA	Actor Architecture
DM	Directory Manager
UAN	Universal Actor Name
VoD	Video on Demand
QoS	Quality of Service
DVR	Digital Video Recorder
iTV	Internet TV
SMIL	Synchronized Multimedia Integration Language
GUI	Graphical User Interface

Chapter 1

Introduction

The purpose of this chapter is to provide a preamble to the thesis by motivating this research topic. Section 1.1 contextualizes this work by providing an overview of the research scope in the advertising industry. Section 1.2 describes the gap in advertising mechanisms for multimedia delivery which leads to the research opportunity. The problem and the motivation of this research are presented in Section 1.3. Section 1.4 identifies the specific aims and objectives of this thesis. To conclude, Section 1.5 will provide the overall thesis structure.

1.1 An Overview of the Advertising Industry

According to a recent U.S. ad spending report from eMarketer [26], U.S. spending on Internet advertising will surpass 25 billion US dollars this year, and will reach up to 42 billion US dollars by 2013, as more money moves away from traditional media like television and newspapers (Figure 1.1(a)). For reasons of the rapid expansion of video content availability on the web, analysts predict a rise in spending on video advertising on the web. As shown in Figure 1.1(b), eMarketer estimates that U.S. TV ad spending will decline, because new features such as skip-over capability of TV recorders makes it difficult for advertisers to reach audiences. As traditional business models are threatened, advertisers and publishers are expected to consider alternative business models.

US Online Advertising Spending, by Format, 2008-2013 (millions)

	2008	2009	2010	2011	2012	2013
Search	$10,691	$12,285	$13,880	$15,552	$17,686	$19,530
Display ads	$4,629	$4,933	$5,448	$6,182	$7,175	$7,956
Video	$587	$850	$1,250	$1,850	$3,000	$4,600
Rich media	$1,888	$2,030	$2,252	$2,560	$2,960	$3,360
Classifieds	$3,139	$2,956	$2,936	$2,944	$2,960	$3,360
Lead generation	$1,605	$1,645	$1,682	$1,792	$1,998	$2,268
Sponsorships	$590	$514	$542	$576	$629	$672
E-mail	$472	$448	$513	$544	$592	$630
Total	**$23,600**	**$25,700**	**$28,500**	**$32,000**	**$37,000**	**$42,000**

Source: eMarketer, November 2008

99566   www.eMarketer.com

(a)

US TV Advertising Spending. 2007-2010 (billion and % change)

2007 $67.8 (2.4%)

2008 $69.80 (2.9%)

2009 $66.9 (-4.2%)

2010 $67.2 (0.55%)

Note: Includes broadcast networks, cable, spot, syndication

Source: eMarketer, November 2008 and local TV advertising

99297   www.eMarketer.com

(b)

Figure 1.1: Online advertising spending vs. TV advertising spending (U.S.).

1

Internet advertising is a large and fast growing industry and plays an important role in subsidizing the cost of content delivery. For example, *Youtube*, the most popular online video website, brings visitors enormous entertainment without any charge, and all its revenue comes from advertising. A variety of advertisement models are emerging. Especially with the growth of Wide World Web, advertising has not been confined to newspapers, television, or radio. It has been revolutionized by the new way of reaching potential customers. Various new web–based advertising opportunities, such as popup, flash, banner, and email advertisements, are now commonplace.

1.2 Existing Multimedia Delivery Mechanisms

Interaction between multimedia content publishers and consumers is typically mediated by cable operators, satellite companies and multimedia websites. These intermediaries are called brokers. In current multimedia delivery, it is these brokers who maintain the balance between content and advertising. According to the infrastructures, we roughly classify the multimedia content delivery mechanisms into three categories: television based mechanisms, web based mechanisms and mobile device based mechanisms.

1.2.1 Television Based Mechanisms

Under the category of broadcasting TV–based mechanisms, three platforms of multimedia content delivery exist: traditional television, television with digital video recorders and Internet Protocol Television (IPTV).

Traditional Television

In this thesis, terrestrial TV, cable TV and satellite TV are all classified as traditional TV. Each of them uses its own delivery medium: aerial, cable, satellite dish and set-top box. Research on each medium has focused on providing larger numbers of channels and better quality of picture and sound. However, in traditional TV broadcasting, all audiences have the same schedule of programs and the number of channels is limited (Table 1.1), though this number is steadily increasing with the development of new techniques such as cable and satellite. Each channel operates its own schedule, which often consists of both multimedia content and advertisements ranging in length from a few seconds to several minutes. The final stream chosen by a viewer often looks like Figure 1.2. In this mechanism, missing one program means missing it forever as long as it is not rebroadcast. If a viewer does not like a program's content or comes across an advertisement that they dislike, the only choice they have is to switch to a different channel. In other words, granularity of viewer control over both the content and advertisement viewed is coarse.
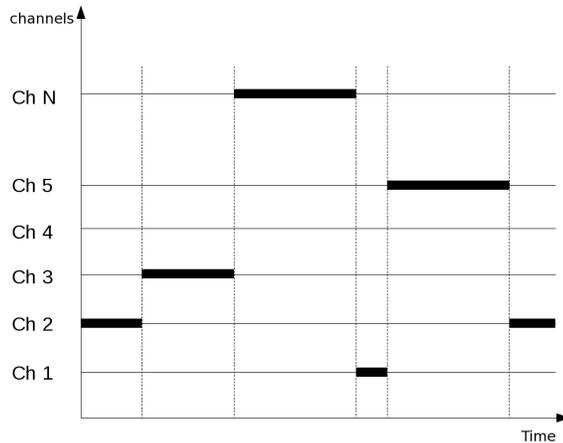
Figure 1.2: Schedules of existing TV channels. (Some of the chosen stream may contain advertisements.)

Television with Digital Video Recorders (DVRs)

With the development of Digital Video Recorders (DVR) in 2001, viewers are now able to record the desired content at the desired time for future viewing, as well as to skip over ads typically using a 30 seconds fast-forward button. As shown in Table 1.1, DVRs normally provide playback functions such as fast forward, fast reverse and rewind. Viewers have relatively fine-grained control over content viewing and some control over advertisements. Recently, DVRs have been designed with two or even three tuners. For example, TiVo, which has a dual tuner, allows recording of a live program while the viewer watches another live program simultaneously. Alternatively, two programs can be recorded at the same time while the viewer watches a previously recorded one. However, in both cases, viewers can only eliminate ads for recorded video content rather than live TV. Viewers can eliminate some ads if they are watching buffered content, as long as they are behind the current broadcast feed.

ReplayTV, one of the two early DVRs (the other one is TiVo), offered automatic elimination of commercial advertising, but were forced out of business (ended up filing for bankruptcy) because the elimination of advertising is said to have "riled hollywood" [59]. The complete elimination of advertisements, which is too coarse-grained, irritated both advertisers and content publishers, by eliminating the significant source of revenue.

Internet Protocol Television (IPTV)

With the rapid development of broadband technologies and infrastructures, IPTV is drawing significant attention from researchers. IPTV refers to the system using Internet protocol network to deliver digital television. This platform enables the possibility of the **Video on Demand** service, often short as *VoD*, which is a mechanism that enables viewers to purchase video content on de-

mand, for live viewing or download for future viewing. Not only are viewers able to view content at a time of their choosing, there is often a large selection of content to choose from. Viewers have fine-grained control over viewing of the content. Unlike common television broadcasts, VoD content is paid for and free of commercials. Viewers do not have the choice of viewing ads to cover their cost; consequently, they have no control over advertising at all.

1.2.2 Web Based Mechanisms

Internet TV (iTV) and multimedia websites are both web based. Viewers choose multimedia content from a library or a channel directory. This platform differs from the above ones in the destination device. Content are delivered to personal computers instead of TV sets or set–top boxes. Video on Demand services become natural with the interactive nature of web. A number of cable companies are also migrating their service into the Internet. Shaw Communication Inc is a famous cable company in Canada, for example, and in 2005 [68], Shaw Cable systems announced that they were the first cable company to sign the Video On Demand agreement with *Paramount Pictures*, one of the world's biggest entertainment companies. Shaw started providing viewers with unprecedented choices of content viewing. Video on demand enables customers to conveniently order desired programs and control playback either using the remote control or through a website which provides search capabilities. Hulu, Movielink and CinemaNow are all influential content providers in the web domain.

1.2.3 Mobile Device Based Mechanisms

Mobile devices (cell phones and PDAs) have transcended its original role as a means of communication by serving multiple purposes. Although many people prefer a bigger screen to consume media content, a majority of people are still in favour of the capability of watching TV through mobile devices [43]. One of the most famous mobile TV providers is MobiTV[1], which is an end–to–end platform, delivering live television, video-on-demand, satellite and digital music services from the top broadcast and cable television networks. The portability nature of these devices allows consumers to access multimedia service anywhere, introducing location flexibility to users, in spite of some limitations such as low quality and extra cost of a "smart phone data plan".

1.2.4 Granularity Summary

In this section, we first analyze the supported features of the above mechanisms in Table 1.1 and summarize their control granularities over content and advertisements respectively in Figure 1.3. We can see that more and more mechanisms offer fine-grained control over content, but none offers

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[1]http://www.mobitv.com

fine-grained control over advertising. There is a big gap in enabling users with flexibility control over advertising. Therefore, a mechanism which has fine-grained control over both content and advertisement is desired.

Control over		Content Selection		Content Viewing		Ad Selection	Ad Viewing
Mechanisms		# of Channels	Personalized Schedule	FF/FR/RW	Quality Control	Attributes Configuration	Skip-over ability
TV	Terrestrial TV	Small	No	No	No	No	No
	Cable / Satellite	Large	No	No	No	No	No
	DVR	Large	Yes	Yes	No	No	Yes
	internet TV	Large	Yes	Depends	Yes	No	Depends
Web	Video on Demand	Extra large	Yes	Depends	Yes	No	Depends
	IPTV	Extra large	Yes	Depends	No	No	Depends
Mobile Device	Mobile TV, etc.	Depends	Yes	Depends	No	No	Depends

Table 1.1: Features of control over content and advertisements of existing platforms. "Depends" means the feature's applicability depends on the models adopted in these mechanisms.

1.3 Problem Statement

We identify the problems from the perspective of each party as follows:

1.3.1 Viewers' Problems

As highlighted by Czepiel et al. [24] consumers satisfaction is important to the market. Viewers are facing the following problems:

- ***Problem One: Limited decision making capacity over advertisements.***

  Viewers are not involved in the negotiation of advertisement display in existing mechanisms. Although some mechanisms allows viewers to select the content of ads, but the control is limited. If the TV program or website contains too many unexpected commercial advertisements, the only thing viewers are able to do is switching to another channel or publisher.

- ***Problem Two: Viewers' privacy.***

  Significant research efforts have been directed toward making targeted advertisements; however, most of them are investigating viewers' interests implicitly, without the acknowledgement of viewers [40, 17, 41]. These personalization techniques obtain users' preferences by tracing their historic interaction behaviours, which invades viewers' privacy.
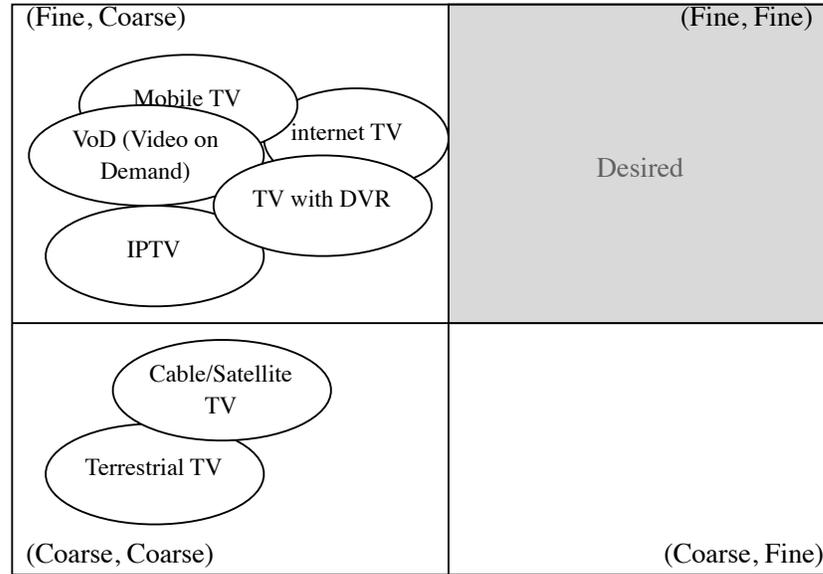
Figure 1.3: Granularity of control for existing platforms. Values in the parentheses refer to the granularities of control over multimedia content and advertising respectively.

1.3.2 Advertisers' Problems

Advertisers' objective is to draw the attention of desired consumers who potentially make purchases. They face the following challenges:

- **Problem One: Poor advertisement effectiveness.**

  Although advertisements become more targeting than before, advertising are still delivered to a large number of people who are not interested in the product or service offered from the ads [45]. Existing techniques are only conjecturing viewers' interests by analyzing their interaction behaviours or contextual texts. The effectiveness of advertisements is still poor.

- **Problem Two: Difficulty in estimating advertising expenditure.**

  The advertising industry was taken as the poorest quality-assurance system and the most inconsistent product in [61]. There is no strict guideline for advertisers to determine how much to invest on advertising. Because ad effectiveness is difficult to measure, the estimation for advertising expenditure in future plans becomes a problem.

- **Problem Three: Complicated negotiation processes in publishing ads.**

  Posting an advertisement is a time consuming task [55]. As an example, some advertisers would like to publish a banner ad. They have to keep track of several popular web sites and negotiate the issues about the expenses and display schedules before making the final decision.

1.3.3 Brokers' Problems

As the intermediary between multimedia publisher, multimedia consumer and advertiser, a broker is the vital party.

- **Problem: Dilemma of advertising decisions.**

  Currently, there are two primary models for multimedia brokers. One supplies paid high-quality services without any advertisement such as *iTunes*, and the other is advertisement-supported model which provides free content viewing but at the cost of embedded advertisements such as *YouTube* and *Hulu.com*[2]. Some approaches try to mix these two, In all these cases, the broker makes the decisions about whether or not to display advertisements; if yes, they also have to determine the amount and types of advertisements to display and when to display them. Additionally, it is a challenge for brokers to maintain the balance between content and advertising, because too much advertising may annoy viewers, and too little advertising may require viewers to pay more, which also takes the risk of losing audience.

1.4 Thesis Objective

The objectives of this research are as follows:

- Conduct a comprehensive literature review in the research addressing advertising mechanisms, especially in the area of multimedia delivery.

- Treat viewers' attention as precious owned resources, and build a market of the attention spaces in which advertisers can trade, just as viewers can trade in a content market.

- Develop key mechanisms to provide viewers with fine-grained control over both advertising and content displayed on their screens in real time.

- Design and implement a flexible prototype, with properties of modularity and extensibility.

- Separate mechanisms from policies. Implement examples of interactivity policies.

- Design and carry out experiments and analyze experimental results.

1.5 Thesis Organization

The remainder of this thesis is organized as follows: Chapter 2 discusses work related to this research. Chapter 3 describes the approach named FlexAdSense, which is to enable fine-grained

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[2]Hulu.com is a free online video service that offers hit TV shows (only available to U.S. viewers).

resource trade in viewers' attention space. Chapter 4 is dedicated to prototype design and implementation. Feature comparison with existing advertising solutions and performance criteria of the prototype are presented in Chapter 5. Finally, Chapter 6 presents conclusions and future work.

CHAPTER 2

RELATED WORK

Advertising mechanisms have received significant attention from the research community. In the previous chapter, we discussed advertisement display mechanisms in the industry and categorized the mechanisms according to their contexts — television, web and mobile devices. In this chapter, we explicitly introduce the concept of *attention* in Section 2.1, and analyze the mechanisms and techniques based on the consideration of different segments: public group or individuals (Section 2.2 and Section 2.3). Section 2.4 presents existing personalization techniques. A summary of these mechanisms is given in Section 2.5.

2.1 Attention

Attention, as a part of cognition in the field of psychology, has been pioneered by psychologist William James in 1890 [35]. He identified the two characteristics of attention – focalization and concentration – which continue to be studied today. Focalization means focusing on some interest or activity. Concentration means devoting mental effort to understand the information we receive.

Attention was first introduced to Computer Science by Simon in 1971 [56]. He highlighted the imbalance between the "wealth of information" and the "poverty of attention". In 1996, Simon [57] again noted that what was needed was filtering out unimportant or irrelevant information instead of providing as much information as possible, which has inspired a lot of research in Computer Science. Ma et al. [47] have developed a framework called *User Attention Model* and applied it to video summarization.[1] Their approach relies on the fact that human attention reflects information prioritizing and filtering. In another words, people pay more attention to things that interest them. Attention analysis was carried out on the visual, aural and linguistic channels. Three curves which represent the attention level from each channel are generated, based on which a final attention curve is generated for estimating the importance ranking of frames for a segment of video content, enabling viewers to get the general idea of a video content. Additionally, Simon's "information and attention imbalance" theory also inspired a variety of personalization techniques and recommender

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[1]Video summarization creates a summary of digital video content, which contains as much information as possible as the original video.

systems [62]. Nevertheless, in most personalization techniques, attention is not explicitly mentioned (i.e. [11], [51]). We will address these techniques in Section 2.4.

2.1.1 Attention Economics

Attention economics applies economic theory to solving information management problems. Bagozzi [10] proposed a model of complex circular exchange, in which attention is exchanged for entertainment or product information in the example of distributing channels.

In their distributed Competitive Attention-space System, CASy [16], Sander et al. treat a consumer's attention space as a scarce resource and makes use of adaptive software agents to allocate that resource in an electronic shopping mall. Suppliers compete with each other in an auction by bidding for the limited attention space of the consumer.

When browsing a web site, users normally seek information from a sequence of scattered web pages, which forms a meaningful path, Wang and Day [65] carried out experiments to observe directly the attention that a subject allocates to different paths with the aid of an instrument called an eye-tracker. Their results show that the amount of attention allocated to the content of a web page is different based on different phrases of depth. Their findings suggest that web advertising located in the earlier and later phases of a path should be priced higher than advertising in the middle phases, because a viewer is more sensitive to advertising embedded in web pages during the earlier and later phases.

2.2 Public Advertising Mechanisms

Advertisements on traditional TV platform are broadcast to a diverse audience, and on web platform are delivered to the site's visitors. In this thesis, we regard all advertising that does not target individuals as advertising for public groups and classify them from the perspectives of different parties.

2.2.1 Advertisers

An advertiser's success depends on the number of desirable consumers exposed to their ad. Fighting back ad elimination campaigns, investigating new advertising possibilities and improving the ad effectiveness are advertisers' main objectives.

Avoiding skip–over ad models

As mentioned in the previous chapter, the time–shifted or nonlinear viewing ways of content viewing have brought new challenges to advertisers. There is growing focus on blending ad opportunities into the multimedia content itself. Some possibilities are as listed below:

- *Product Placement Ads*: Branded goods or services are placed in the context of content. These ads can be physical objects or objects virtually added afterwards. Wan et al. [64] have developed a sports advertising insertion system, which can analyze sports content and naturally insert ads into the environment like the playground automatically or manually. For example, the blue square with a character "a" and a star in Figure 2.1 is an ad virtually added while broadcasting the sports program.

- *Overlay Ads*: Ads pop up and overlay the bottom or a corner of the TV screen, taking up 5% to 25% of the screen (e.g. Figure 2.2).

Figure 2.1: Product placement ad example (virtually added object).

Figure 2.2: Overlay ad example.

- *Ads in Encrypted Form*: Templeton [60] propose to release shows in encrypted form, which has been adopted on the copyright notice in some DVDs: the frames with the copyright notice are not allowed to fast forward.

- Pramataris [51] et al. propose an alternative solution which uses 'contact me' type of advertisements, in which the viewer can actively request further product information and requests may be responded by a company representative. Therefore, the ad actually only takes space for the tag. They also propose to use advertisements that can be bookmarked, to enable viewing at a more convenient time if desired.

These opportunities are designed to avoid ad elimination, which satisfies advertisers but denies viewers control over the advertising they watch.

Designing more effective ads

"An effective advertisement would generally refer to an advertisement that is able to interest, intrigue and inspire a viewer, persuade the consumer that a certain product is worth buying and in turn generate more sales for the manufacturer successfully. "[2]. Bayles [14] investigates the

relationship between the use of animation in ads and ability to recall and recognize banner ads. Results indicate that animation does not enhance user memory of online banner advertisements. One characteristic of effective advertising is highly targeting potential consumers, which benefits not only advertisers, but also viewers. This will be discussed at greater length when we address viewers' perspective in Section 2.2.2.

Novel advertising models

Several novel advertising models have recently sprung up, which take advantage of their performing platforms–social network and software.

- Social Network Advertising: Social network is the community connected through socially meaningful relationships, such as friendship, or information/knowledge exchange [66]. Examples are Facebook, MySpace, Linkedin, and YouTube. The benefit is that advertisers can target ads by user demographic information. A number of possibilities of advertising on social networking sites have been investigated ([22, 70, 69]). However, in these models, user's personal and interaction data are derived without the permission of users.

- Adware and Spyware [9]: Adware, defined as advertising–supported software, finds advertising space in software products, or installs additional third party components. Spyware is software that collects information about the user in order to display ads in the web browser. These approaches often violate users' rights, and are typically classified as privacy–invasive software.

2.2.2 Viewers

From the perspective of viewers, the efforts addressing advertising can be placed in these classes: (1) making more interesting, personalized, unintrusive ads; (2) eliminating unwanted ads; and (3) taking advantage of ads to guarantee quality for VoD systems.

Contextual advertising models

Contextual advertising refers to mechanisms for matching ads with the context such as web page content or frames in video content. Contextual advertising widely ranges from individual bloggers to large publishers. Contextual matching strategies cover textual relevance and visual relevance.

- Textual relevance: Yih et al. [58] have discussed how to extract advertising keywords from web pages automatically. Broder et al. [18] propose a system for contextually matching ads based on textual relevance: typically, a combination of semantic and syntactic features. Agichtein et al. [6] build models for predicting users' preferences for results of web search by learning user interaction.

- Visual relevance: vADeo [53] and VideoSense [49] are two contextual ad matching systems based on visual relevance. Specifically, VideoSense can detect the most appropriate ad insertion points based on content discontinuity and attractiveness, and relevant candidate ads can be embedded at these points, making ads less intrusive [49]. Kazienko et al. [40] try to provide a given anonymous viewer with personalized advertisement. Different agents are defined for different tasks such as web content and usage mining, click-through data exploration, user monitoring, advertisement recommendation and management.

These models enable targeted advertising, which may be a win–win for advertisers and some viewers. However, we can see that these models all use contextual data: some are driven by users' queries and some are from usage data mining, ignoring viewers' privacy.

Advertising elimination models

Covell et al. [23] propose to detect ads in video streams using acoustic and visual cues. Browser extensions provide a way to eliminate unwanted image and flash ads on web pages. For example, AdBlock[2] – one of the top ten of the most popular *extensions* to Mozillia Firefox browser – allows users to get rid of banner ads. Esfandiari and Nock [27] propose to dynamically learn to eliminate ads based on minimal interaction with the user. These models benefit viewers of websites while frustrating advertisers, and threatening to make many services unsustainable.

Advertising in Quality of Service (QoS)

In VoD (Video on Demand) Systems, QoS is normally guaranteed by the technique of *stream merging*, which is merging streams that request the same content, so as to improve resource utilization (e.g. bandwidth). Secondary content (i.e., advertisement) insertion can be a means to synchronize the streams and minimize the startup latency. Basu et al. [13] have proposed and evaluated an optimal scheduling algorithm for inserting ads. They also have investigated how QoS factors affect the price of on-demand content. Models are developed in their later work [12] to maximize the profits from both ads and content, based on the fact that the arrival rate of viewers is influenced by the amount of advertising. Hadrusi and Sarhan [7] propose a streaming media delivery framework and an associated dynamic pricing prediction model for ads, which depends on the time spent on commencing the requested content. Considering viewers' different bandwidths, these models are desirable.

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[2]http://adblockplus.org/en/

2.2.3 Publisher / Broker

The objective of a publisher or broker is to generate more revenue and attract larger audiences. Search engine based advertising enables small publishers to earn money by putting up advertising on their sites. Various optimizing ad models are also reviewed in this section.

Paid Placement

Paid placement [15] (also referred to as *Sponsored Search*), commonly used in search engines, is a bidding mechanism for ranking *attention*. It works as follows: when a search is carried out, the search engine lists the items for the searched keyword from the highest bid to lowest bids. Advertisers can choose and bid on terms that are closely related to their products. When users arrive at an advertiser's website by clicking the items from search engines, an amount equal to the bidding price is subtracted from the bidder's account. Revenue from these auctions is the main source of revenue for search engines such as Google (AdWord), Yahoo (Search Marketing) and MSN (AdCenter). Recall the U.S. online advertising spending diagram (Figure 1.1(a)). Search engine advertising spending is roughly half of the total expenditure. The secret of this model's success is its high targeting and high measurability.

- *High targeting*: Users only search when they are interested in the searched term. The rarer the term queried, the higher targeting it can reach. Take the term "compressed air pump" for instance. Users normally search for this term only when they need it or want to obtain information about it. Additionally, advertisers can target geographic regions, which increases the likelihood of conversion from searching to purchasing.

- *Measurability*: Interfaces provided by search engines enable advertisers to be knowledgeable about every penny they have spent, especially by which term, at what price and from which *IP* address. Advertisers are able to measure and control the spending flexibly. Some search engines also provide tools, such as Google Insights,[3] with which advertisers can compare search volume patterns across specific geographic regions, categories and other attributes.

Optimizing ad models

Banner advertisement placement have been investigated in a number of studies ([3, 15, 30, 8, 46, 25]). Amiri et al. [8] studied how to specify schedules to make banner advertisements more efficient: increase the chance for an ad getting displayed. They allow the advertisers to set display frequencies of advertisements and the desired number of display times. Adler [3] investigated the algorithms to find the optimal schedule for some given ads, satisfying given geometry position and given display

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[3]http://www.google.com/insights/search/

frequency. These models maximize revenues for website operators who own the advertising space because of the higher ad exposure. Langheinrich et al. [46] proposed a novel non-intrusive technique for adapting banner advertisement to users' short term interests (searched keywords), instead of collecting user-specific data. Dewan et al. [25] carried out a study on the tradeoff between the amount of advertising and its attractiveness to potential visitors, and built a model that maximizes the broker's profit.

Digital Signage

Digital signage is a form of electronic display that shows information, advertising and other messages. Figure 2.3 shows an example of digital signage. Digital signage allows advertisers to present dynamic multimedia on a display device rather than single static images on a physical board in conventional signage (Figure 2.4). Targeted to this form of attention space, Harrison et al. [32] have proposed a partially-automated intermediary for adapting an advertisement campaign in real–time, based on changing demographics. They built an efficient marketplace for purchasing and selling of multimedia display time on digital signage. This offers convenience to brokers who maintain a digital signage display.

Figure 2.3: An example of digital signage.

Figure 2.4: An example of conventional signage.

2.2.4 Summary of Public Advertising Mechanisms

In this section, we reviewed related work in public advertising mechanisms from each parties' perspective. The advertisements' characteristics of being annoying and invasive have inspired researchers in two directions: one is for viewers, such as eliminating ads; the other is for advertisers, such as investigating new possibilities to reach customers and developing new models to make ads more effective. However, complete elimination of ads seems not desirable because it is very rigid and breaks the traditional exchange paradigm in the marketing literature [10]. Novel irremovable forms

of advertising are also too strict and can irritate users. More flexible models are required. For example, adaptive advertising is reasonable when used as a means to guarantee QoS of VoD systems (Section 2.2.2). The novel advertising built on social network can target users by demographic information; however, the information is actually unauthorized. Contextual advertising models promote targeting aims; however, these models are only conjecturing people's interest in advertised items. Although paid placement (sponsored search) model raises the possibility of matchmaking with users' interests, it may have a negative impact on perceived credibility, because it may lead users to information they do not really need.

2.3 Individual Advertising Mechanisms

A number of personalized advertising mechanisms have been inspired by Simon's theory: the imbalance between the "wealth of information" and the "poverty of attention". Personalized advertising is delivered to individual users instead of a large group of people. Therefore, the personal information which contains viewer's profile and preference data is required. We classify the research that targets individuals based on different platform domains: TV and web.

2.3.1 Personalization Ad Models in TV Domain

The novel technologies such as the invention of the set–top–box (DVR) and IPTV (Internet Protocol Television) makes it possible to identify individuals and brings more interaction to the TV platform. In the TV domain, interactive TV mechanisms allow users to voluntarily interact. iMEDIA business model applied technologies exploring viewers' interactive data and empowered viewers with control on their personal information. With this model, viewers have more control over their attention space (TV screen) in selecting multimedia content and more targeted advertising. *TV-anytime Model* enables users to record multimedia content at any time at any place.

- ***Interactive Television***

  Interactive Television refers to techniques that allows viewers to interact with TV content while the program is on. Barkhuus et al. [11] observed people's television viewing experience from actual web–based television consumption data and explored new interaction possibilities around television. Currently, the interaction includes directly incorporated polls, questions, comments, and other forms of audience response back into the show. For example, TiVo, a famous brand of DVR, allows viewers to record programs based on household viewing habits, which is called *TiVo Suggestions*. TiVo Suggestions use Thumbs Up and Thumbs Down ratings to obtain the viewers' responses, which form content recommendations to other viewers with similar viewing habits.

- **iMEDIA Business Model**

  iMEDIA [1] (Intelligent Mediation Environment for Digital Interactive Advertising) is a project funded by IST (Information Societies Technology). Its architecture is shown in Figure 2.5. An iMEDIA service provider takes the functions of controlling consumer profiles and interaction information on behalf of all participating parties, and managing the distribution of interactive ads with the TV channel. iMEDIA aims to provide necessary technologies for analyzing interactive consumer behaviour for evaluating advertising, and empowering viewers with the ability to control access to their personal information. As a part of the iMEDIA project, Pramataris et al. [51] have developed an approach specifically for advertising over digital interactive TV, introducing personalization and interaction on the broadcasting TV platform. Bozio et al. [17] discuss advanced technologies under iMEDIA business model, such as how the extracted viewer behavioural rules associate with viewer segments and how related advertising are sent through the broadcast channel to viewers.
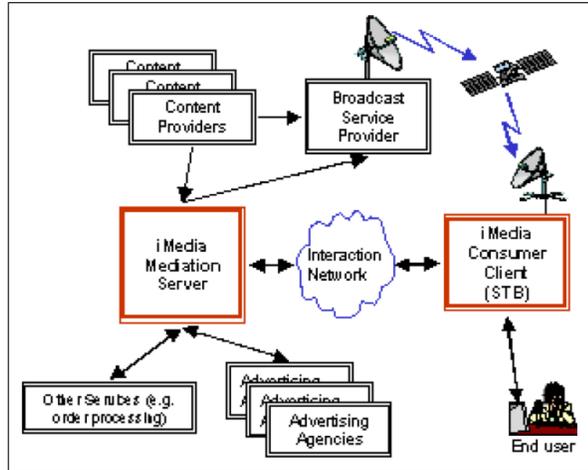
Figure 2.5: iMedia overall architecture.
Source: http://imedia.intranet.gr/main.htm

- **TV–Anytime Model**

  Yoon et al. [71] have proposed a system based on TV-Anytime standard, which provide both media library services and targeted advertisement services. Unlike recording using DVR, protocols presented in this model enable remote recording on a personal or network DVR. Recording requests can originate from PDAs, as well as DVRs and PCs. This model enables users to record multimedia content at any time at any place.

2.3.2   Personalization Ad Models in Web Domain

Typically, personalization techniques have to obtain a user's profile or extract a user's interests by tracking their browsing history and query keywords. In the web domain, editable profile models

allow users to freely edit profiles, which are used to target ads. Therefore, users now have some control by selecting desired advertising content. Streaming ad-time-control model allows brokers to control on the balance ratio of ads and content. Commercial personalization service providers, such as LikeMinds, enable advertising recommendation for online shopping sites. Krakatoa Chronicle represents a significant progress in considering consumers' interests, because it enables users to define personalized newspaper at a fine grain. Two models described for email advertising build a direct payment from advertiser to recipients, yet these models are only experimental products. Interactive advertising models and adaptive hypermedia models explore more interaction possibilities, some of which give users an amount of control over advertisements they watch.

- ***Editable Profile Models***

  Kiyomitsu et al. [42] propose a mechanism for reconfiguring the content of web pages according to users' spatio–temporal information and access histories. Different from the models described in Section 2.2, this model allows authors to explicitly define personalization rules, such as the language and the location of their preferred information. Weiß et al. [67] present an approach that integrates two tasks: generating of user profiles and recommending of content according to the profiles representing users' interests. Particularly, the profiles are editable and can be in various meta-data formats which can be converted into a uniform format to be importable and exportable.

- ***Streaming Ad–Time–control Model***

  Oshiba et al. [50] discuss inserting streaming ads into streaming content following a time-control function. They focus primarily on the issues of duration of the ads and content and aim to maintain a balanced ratio of the ads length to the content length, to avoid excessive advertising exposure. Three processes are included: ad-insertion decision, ad-length decision and real-time updating of usage data. This model allows control over the balance between content and advertising; however, the balance is determined by brokers, not viewers.

- ***LikeMinds***

  LikeMinds, one of the biggest personalization technology providers for e-Commerce [29], is a GUI application. A number of recommendation rules are executed on LikeMinds Personalization Server and LikeMinds keeps track of customer's preference information and shopping behaviours on websites, such as online bookstore.

- ***Krakatoa Chronicle***

  Krakatoa Chronicle [39] is a web–based interactive, personalized newspaper. Users are able to dynamically control the web page layout and specify personal and community interests. An interactive agent provides users with a variety of browsing options such as resizing and

the ability to "peek" at articles. A user's interests can be explicitly specified by the user or extracted by observing the user's interactions. Personal interests are integrated with community interests, which are aggregated based on similarity of interests in a group of users. Although the authors do not address advertising issues, this model enables users to define their attention space at a fine grain, which significantly empowers users.

- **Email Advertising**

  E-mail advertising uses electronic mail as a means of communicating commercial messages to an audience. The advantage of this mechanism is its short delivery time and relatively low cost: information is distributed to a wide range of specific potential customers by a mailing list. To access the service provided by some websites, consumers are required to register by providing their email addresses, which may subsequently be appended to the company's mailing list. If the consumer has consented to subscribe to newsletters such as upcoming promotion, this form of advertising is called opt-in email advertising [28]. Unsolicited emails are known as *spam*.

  In order to prevent senders from sending unlimited number of emails, Kraut et al. [44] came up with the idea of charging senders a price for the attention that may be paid to their messages by the recipients. In their work, attention is measured by the percentage of messages that get read or replied. Two experiments were carried out to explore whether the "postage" can improve social welfare by matching the communication needs of senders and recipients respectively. The results showed the usage based pricing mechanisms would cause more effective allocation of attention. Jamali and Geng [34] propose another mechanism for curbing spam, in which senders negotiate and pre-purchase sending rights. Different from the former mechanism, recipient's attention space as well as computational and network resources devoted to handling email are explicitly viewed as precious owned resources.

- **Interactive advertising**

  Hyperlinked video [37] fills the gap in creating interactive video in academic research. They make objects in the video selectable, which opens up a new possibility for interactive advertising. For example, a particular item – such as the necklace worn by an actor – can be selected by a consumer interested in obtaining its information, which may be offered by an advertiser. This technique enables the mechanism of consumer-driven advertising, which means consumers now have some control over the display of advertisements.

- **Adaptive Hypermedia**

  Adaptive hypermedia is a term introduced by Brusilovsky et al. in 1993 [20]. They built a model, combining regular hypermedia with users' goals, abilities, interests and knowledge.

Three typical adaptive hypermedia techniques are defined in [19]. These techniques are capable of:

- Selectively showing and hiding content elements and links.

- "Stretch text": Text normally appears in condensed form, and users can access additional information.

- Dimming or highlighting selected content elements and links.

- Sorting content elements and links.

2.3.3 Summary of Individual Advertising Mechanisms

In this section, we review a number of advertising mechanisms targeted at individual users, and classify them according to their executing platforms: TV and web. To summarize, individual advertising mechanisms give users more control over the advertisement display, because they normally maintain users' profiles, which could be edited by users. Based on this information, ad process can be personalized. The profile generally comes from two sources: historic behaviour and the information directly from viewers. The advertising based on these mechanisms has significantly improved effectiveness. Advertisement negotiation involves anticipation of users; however, control is still limited.

2.4 Personalization Techniques

The mechanisms described in the above two sections involved targeted advertising. In this section, we give a short introduction of common personalization techniques. The techniques can be roughly classified into four categories [50] according to the mathematical techniques adopted:

- *Data Mining* is used to extract consumers' behaviour patterns by observing and collecting users' interaction manners, such as browsing histories and purchasing histories. A number of models use data mining [40, 22, 70, 11, 51, 42, 50].

- *Decision trees* are used to allow users to define target variables so as to generate rules for advertisement selection [42].

- *Linear programming* has been used for making advertising decisions to maximize click-through rate and satisfying advertisers' obligations in the meantime [8, 21, 46].

- *Nearest-neighbour collaborative filtering algorithms*, also known as recommendation techniques, are used to recommend products by computing the similarity between consumers based on past behaviours and predicting consumers' preferences [54].

2.5   Summary

We began in this chapter by introducing the concept of *attention* and how it is related to Computer Science and Economy, and ended by introducing some popular personalization techniques. We investigated different research initiatives in advertising.

Depending on the manner of identifying targeted segments, we classified the research into two categories: public groups and individuals. The former does not identify users and delivers ads to a large group of people. In these models, users are passive and not involved in the advertisement decision making. What to display in viewers' attention space is only decided by the contracts between brokers and advertisers. In order to make ads less intrusive, some models attempt to match ads with contextual environment. A number of models have applied data mining technique to explore users' historic behaviours, based on which to match ads. However, most of the models are acquiring information without notifying users. Users have nearly no control over advertisements displayed.

The latter maintains each user's profile, which is long term data. By specifying their preferences, consumers have some control over the advertising content by existing personalization techniques. Although users have some control on what ads are displayed, the extent of control is limited. With the appearance of interactive advertisement models, users now are enjoying greater control; however, this control is coarse-grained.

The complete ad elimination functions of DVR as well are too rigid, because they remove the incentive for advertisers to subsidize delivery of multimedia content.

To conclude, none of the above models provide viewers fine–grained control of advertising display over the attention space they own.

Chapter 3

Trade in Attention Resource

Our approach to the problem of making decision about advertisement display is to enable fine-grained resource trade – in real time – between owners of attention resource and parties interested in acquiring them. Because active participation in trade negotiation can place significant additional demands on viewer attention – taking away from the viewing experience – we have separated preferences of the different parties as pluggable policies, which – in *normal* situations – enable automated negotiations on behalf of the parties. Additionally, our approach allows interaction in real time, which means that the viewers may change their mind on the fly. Therefore, the contract can possibly be re–negotiated or even broken. We build mechanisms for these situations as well, with possible penalties.

To enable these mechanisms, we specialize the CyberOrgs model [33] for resource acquisition and control for a viewer's attention resources. Cyberorgs are distributed resource encapsulations which use *eCash* to buy and sell resources from/to each other. In this thesis, we view the attention of viewers as a type of owned resource: anyone who wants this resource has to negotiate a contract with its owner. Additionally, all parties – viewers, publishers, advertisers and brokers – are distributed.

The organization of this chapter is as follows: Section 3.1 briefly introduces the CyberOrgs model. Section 3.2 describes how we specialize Cyberorgs to develop mechanisms for negotiating display of advertising on owned screen real estate. These include mechanisms for resource analysis, and contract negotiation for trade in attention resources. In Section 3.3, several scenarios are used to motivate the aims, concept and mechanisms along with our approach. Section 3.4 addresses the architecture of our approach. Section 3.5 and Section 3.6 describe details of policies and contracts. Section 3.7 presents some examples of price models. Considering that viewers may change their minds after contracts have been signed, Section 3.8 discusses some penalty options. Finally, Section 3.9 summarizes this chapter.

3.1   CyberOrgs

CyberOrgs[1] [33] is a model for resource bounded distributed systems. CyberOrgs organizes computational and communication resources as a market with ownership organized in the hierarchical structure, as shown in Figure 3.1. The design of hierarchical ownership organization is used because there is a lifespan of the ownership transfer and the object ownership must subsequently return to its original owner. Each cyberorg owns a certain amount of resources and a collection of multi-agent computations which may consume the resource. Cyberorgs use *eCash* to buy and sell resources from/to each other, and use *Ticks* and *TickRate* to represent the resource quantity and requested rate of resource availability, respectively. This allows dynamic pricing schemes to be used naturally. Negotiations lead to contracts which stipulate the types and quantities of resources that will be available to cyberorgs, and at what costs. All cyberorgs are obliged to honour their contracts. The model defines mechanisms for trading in resources, and reifying resource control.
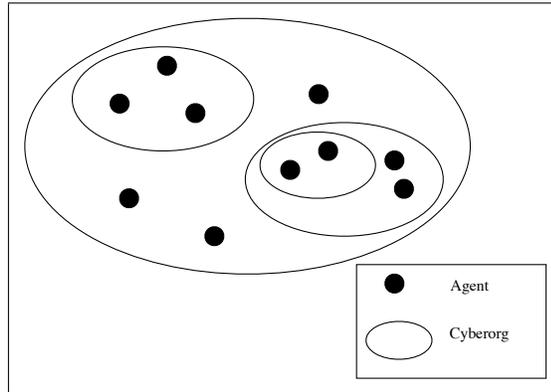
Figure 3.1: The hierarchical structure of a cyberorg.

CyberOrgs distribute resources primarily by three primitives called *isolate*, *assimilate*, and *migrate*.

- ***isolate:*** As shown in Figure 3.2, using the isolate primitive, one cyberorg can encapsulate a number of its actors, messages and an amount of eCash as a new cyberorg.

- ***assimilate:*** The exterior cyberorg dissolves the inner cyberorg by assimilate primitive (Figure 3.3). After assimilation, the content of the assimilating cyberorg belongs to its originally host cyberorg.

- ***migrate:*** As depicted in Figure 3.4, a cyberorg may migrate from one host to another. The migration of a cyberorg happens when its host cannot satisfy its resource requirement. To migrate, first, the cyberorg has to search for a host who can provide sufficient resources. After

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[1]CyberOrgs refers to the model name, and cyberorgs refer to the entities in the model.
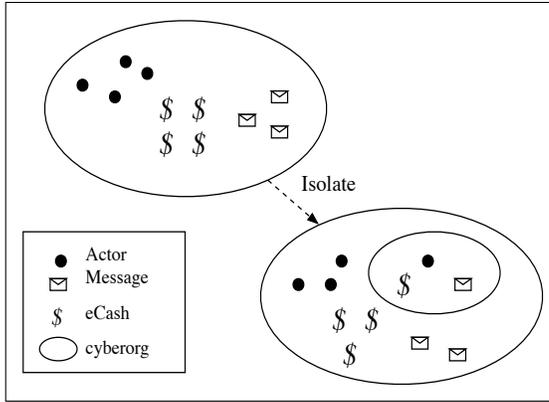
Figure 3.2: Cyberorg isolation.
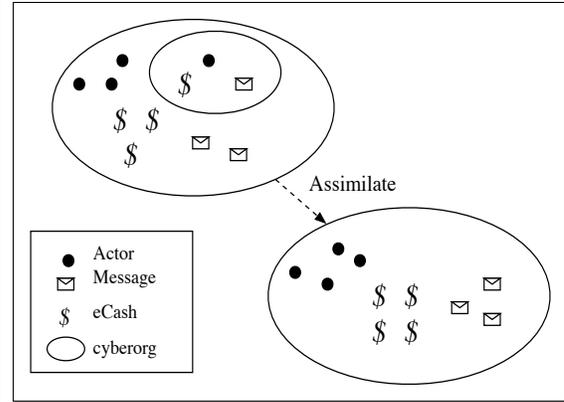
Figure 3.3: Cyberorg assimilation.

that, a negotiation between the cyberorg and this host occurs. If the negotiation succeeds, a new contract is generated. The cyberorg then migrates to this new host and begins receiving resources according to the contract.
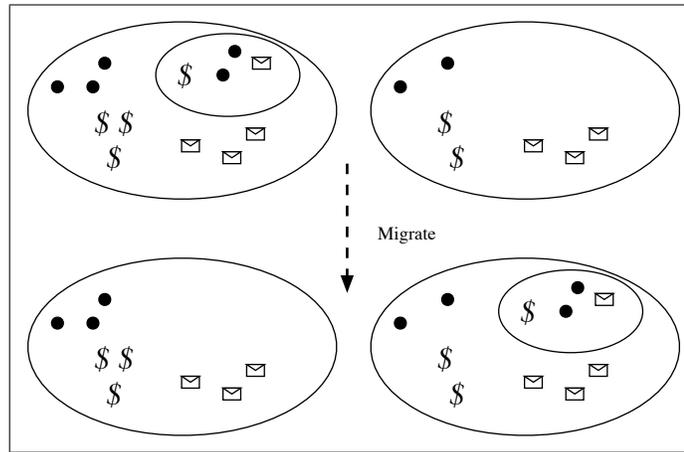
Figure 3.4: Cyberorg migration.

3.2 FlexAdSense – Specialization of CyberOrgs Model

Our approach is to specialize the CyberOrgs Model for the attention resource. Inspired by Google's *AdSense*, our approach is called FlexAdSense. In other words, the system "senses" the most appropriate advertisements for viewers based on preference data both explicitly provided by viewers or implicitly extracted by exploring viewers' historical behaviours. The term "flex" is short for flexible, which refers to the fine–grained flexible control available to viewers over the content and advertisements.

3.2.1 Resource Analysis

There are generally four parties in multimedia delivery: content publisher, content viewer (consumer), broker and advertiser. Each party owns certain resources and desires to obtain certain resources, as shown in Table 3.1. Multimedia publishers own multimedia content, which is a type of information resource. They wish to make profit by selling content resource using brokers' intermediary service. Viewers own cash and attention resource, and want to be entertained by viewing multimedia content. Brokers own delivery resources such as cables, network bandwidth and storage servers, and provide services such as the payment mechanisms and customer support modules. Advertisers own cash and are interested in viewers' attention. We focus primarily on two types of resources: **viewer attention** and **multimedia content**. *eCash* is replaced by **real cash**. We treat the display screen as an abstraction of a viewer's attention space and view attention as a type of resource owned by the viewers, having both spatial extension and temporal duration.

Party	Owned Resources	Wanted Resources
Viewer	Attention, Cash	Multimedia Content, Intermediary Service
Advertiser	Cash	Attention, Intermediary Service
Publisher	Multimedia Content	Cash, Intermediary Service
Broker	Intermediary Service	Cash

Table 3.1: Resource analysis in FlexAdSense.

3.2.2 Resource Trade

As illustrated in Figure 3.5, to be entertained, viewers pay for content resource in cash, as well as in terms of their attention. Brokers earn money by providing intermediary services: trading and delivering platform. Publishers make profits by selling content resources. Screen real estate is owned by viewers, which means advertisers do not have the right to interrupt without the viewer's permission. Advertisers are interested in viewers' attention resource. They have to purchase these resources by proposing to partially pay for the viewers' content.

As owners of their attention space, viewers are empowered to decide what to display on the space by managing access admission. For example, if a viewer does not desire paying any attention to advertisers, all attention resources go to the publisher side and the viewer has a screen free of ads, at the cost of paying the full price for the viewed multimedia content. In another case, because advertisements may also contain entertainment and useful information, such as upcoming promotions and new products, some viewers may not mind or may even like to view some ads. In such a case, viewers may subtract the value received from the compensation expected for the ad.

There can be thousands of advertisers publishing advertisements of various types. Our approach
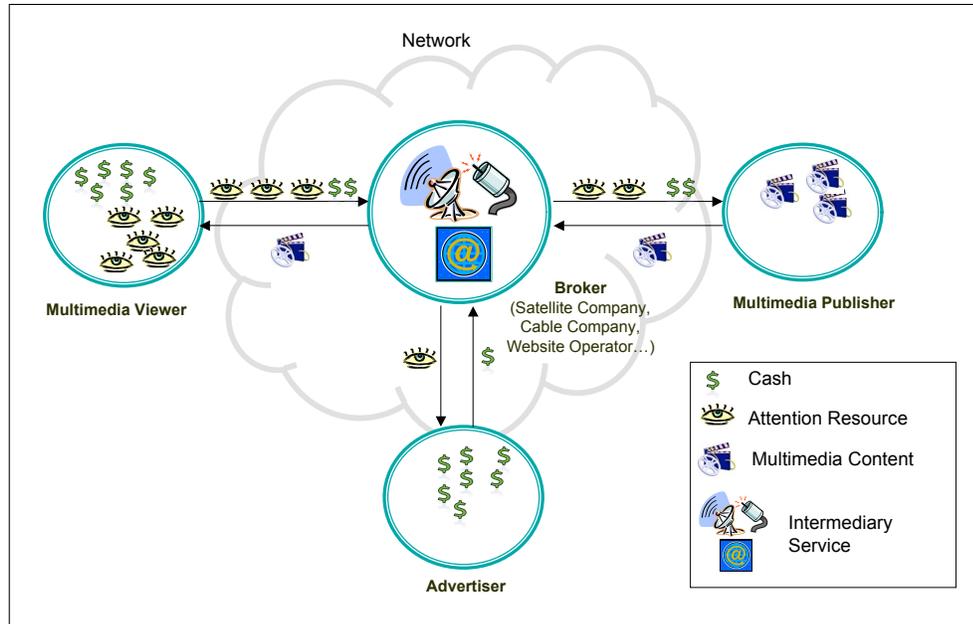
Figure 3.5: Resource trade analysis.

allows viewers to choose which advertiser can get the admission, and decide how to schedule delivery of their attention. The selected advertisers negotiate with viewers on how to consume their attention resource, such as at what time to display their ads, taking up which parts of viewers' screen space and for how long.

3.2.3 Contracts

Contracts in the CyberOrgs model stipulate the types, quantities and costs at which resources will be available to a buyer. FlexAdSense uses a number of parameters to describe availability of any type of resources in a contract. For example, for multimedia content, the quality (DVD quality, fine quality or poor quality), the capability of playback (fast forward, fast reverse, or rewind), the category of content (action, strategy, sports or romance) and some other properties can be defined. Viewers can also negotiate the payment mechanism, which can be pay-per-view, periodic payments, or a monthly flat fee for unlimited viewing. For advertisements, viewers may be able to control the type (banner, video, text-in), the category (beauty, apparel, travel, sports), and the specific configuration for each type of ad, such as font, position, duration and insertion time for text-in ads.

3.3 Scenarios

In this section, we look at several scenarios to illustrate the features of our approach. Let us consider the following scenarios involving a fictional user Jack:

1. *Suppose Jack turns on TV after a tiring day of work. He browses through existing channels. There are nearly 100 channels, and he finally finds his favorite detective show. During the show, advertisements interrupt his viewing at intervals. Jack wishes he could view his favorite content on his own schedule and wishes he could eliminate ads from this favourite content even by paying extra money. Additionally, the increasing number of channels makes it difficult to find the one he likes; he desires searching and recommendation functionalities.*

2. *Suppose Jack prefers high quality videos and does not care about the cost. However, these expensive tastes sometimes lead him to a tight budget at the end of the month. He wants to be able to set a monthly budget for himself, so that the system can automatically schedule content and advertisements for him: relatively more ads when the budget is tight and fewer ads when the budget is freer.*

3. *Suppose Jack does not mind viewing advertisements if the ads fit his interests. Additionally, he dislikes ads that pop up and overlay at the bottom of the screen. He wishes to be able to define the types of ads.*

4. *Suppose Jack has a 6-year-old daughter. He wants the screen free of adult-only content/ads, such as tobacco, alcohol and violence.*

The scenarios motivate our approach. As far as we concerned, none of existing mechanisms can satisfy the above requirements so far. FlexAdSense provides even more features besides the listed ones. The following sections will give the solutions to the above requirements and describe FlexAdSense in a systematic way.

3.4 Architecture

3.4.1 Primary Steps

FlexAdSense primarily contains five steps as shown in Figure 3.6. Depending on the specific policy, which will be addressed in Section 3.5, the third step "content/ad selection" is optional, because the selection may be carried out by the system automatically with specific policies. Moreover, with a "No Advertisement" Policy, ad list in "list generation" process may also be empty. The concepts and detailed sub-processes will be discussed shortly in the following sections.

3.4.2 Entities

FlexAdSense involves four types of entities: publisher, viewer, advertiser and broker. The typical viewer entity is depicted in Figure 3.7. Each entity maintains an account and has one agent performing various interactive operations. Besides the account, viewers maintain more information,
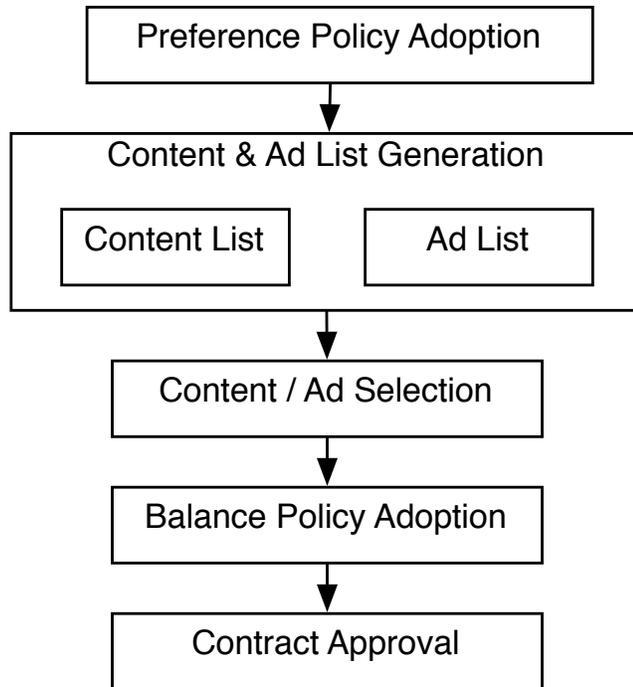
Figure 3.6: Primary steps in FlexAdSense.

which addresses the viewer's profile and policies. Depending on different platforms, the information can be stored in the database located in brokers for web based platform, or in the viewers' set–top boxes for TV based platforms. Broker entities are located on the server side and provide brokerage service for all the other entities. Publisher entities perform publishing multimedia content tasks. Advertiser entities also maintain policies stipulating how they would like to consume the attention resources.
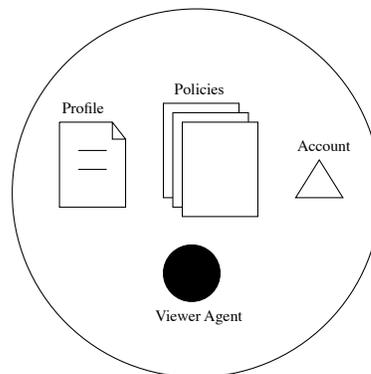
Figure 3.7: A typical viewer entity.

3.5   Policies

Fine-grained negotiation process may include a number of interactions, which call for significant additional demands on viewer attention. Therefore, we introduce policies for automated negotiations that can be used in predictable situations. Specifically, users are able to create policies or customize existing policies by overwriting them. There are default policies in place to use for users who have not created customized ones. Policies can be composed together. We have implemented three types of policies: preference policies, balance policies and privacy policies, which respectively specify policies for content/ad selection, payment and privacy.

3.5.1   Preference Policies

Preference policies are introduced to reduce the interaction complexity by specifying rules as so how to sieve out unwanted or unrelated ad/content. Viewer, advertiser and publisher can all have preference policies.

- **Viewer Preference Policies** are introduced to personalize the pattern displayed on their screen, including two parts: content and ads. Viewer preference policies provide constraints which lead to choices of display sequences with advertisements embedded in content streams. Policies can be as simple as "no advertisement" or as complex as "only sports ads of video clip type, and insert at the beginning of content". Recall Jack's wishes, he can specify the category of his interests, as well as the ad types he dislikes.

  For ad preference policies, viewers can specify price, category, date, type, language and so on. The price constraint, for example, can be defined as higher, lower or equal to a specific price. The category and type constraints can be set in two ways, like or dislike. The date constraint is before, on or after a given date. Specifically for content preference policy, viewers can specify the category, language, quality, price, performing in the same way as ad preference policies.

- **Advertiser/Publisher Policies** are owned by advertisers/publishers, specifying ad/content attributes, by which they can target their audience and ease the ad/content creation process. A lingerie advertiser will never want to waste money on males, therefore, they can confine gender to female. In addition, like the case of Jack's daughter, adult–only content/ads should not be placed in kids' contract. Local business companies can target specific locations to avoid expenditure on people who are impossible to purchase their products. Moreover, these policies can be used to ease the publishing process: for a specific advertiser/publisher, they have relatively fixed type of products, and they do not have to specify the same attributes every time. Take a lingerie advertiser for example, most of their products should be under the

apparel category. Therefore, when they publish new ads, the category can be automatically set as "apparel", which simplifies the publishing process.

3.5.2 Balance Policies

Because ads can subsidize the cost of content and viewers are empowered by the fine-grained control over content and ads, dynamic pricing becomes an issue depending on the context. Consider the advertiser's budget in advertising and viewer's budget in content viewing, we discuss the balance policies in the following two categories.

- Advertiser Balance Policies

  Advertiser balance policies can be defined by specifying price models or setting monthly or daily budgets.

  - *Price Model*:

    For the same advertisement, fine-grained control over ads may result in different effectiveness. For example, the viewer can define video ads at any insertion point and it is more possible that they prefer the ads to be displayed at the beginning or ending of the multimedia content instead of the middle. Obviously, the ads at the end may not be as effective as the beginning ones and it is not fair for advertisers to pay the same price. Therefore, we allow advertisers to define price models based on different attributes. We will discuss more examples of the price model in Section 3.7.2.

  - *Budget Setting*:

    Advertisers usually have a daily/monthly/annual budget in advertising investment. We allow advertisers to set the budget, so as to avoid unexpected spending. For example, if the advertiser has set a daily budget as 20 dollars, when the cost on their advertisement reaches up to 20 dollars during the day, the ads become invisible to viewers. Compared with traditional costly TV advertisements, this function allows small companies to get involved. This model is quite similar to the *paid placement (sponsored search)* model [15], which has been discussed in the previous chapter (Section 2.2.3). We can also make a reference to Google's AdSense[2], which gives advertisers various controls about where the ads place and how much to spend for that placement. Users can also choose Google's kinds of optimizing tools, such as budget optimizer, to manage bids and attract most clicks, though its decision generally benefits Google the most.

- Viewer Balance Policies

  Instead of choosing content and content ad every time, it is easier for viewers to set rules to

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[2]https://www.google.com/adsense

automatically generate the content/ad lists corresponding to their expected budgets. Flex-AdSense allows the following three types of balance settings.

- *Coverage Percentage*:

  Viewers are allowed to have policies which give preferential rates to viewer if they have advertising balance. "free content" practically equals to 100 percent coverage and "no advertisement" equals to 0 coverage percentage. We denote P as the price, P_{bill} as the price invoiced on the bill, p as the coverage percentage, and $P_{content}$ as the price of selected content. Equation 3.1 shows the relationship. Note that the formulation is based on the assumption that content has been selected.

$$P_{bill} = P_{content} * (1 - p) \qquad (3.1)$$

- *Monthly Budget*:

  Back to the scenarios, Jack wishes to view high quality multimedia content and has set a monthly budget. We need a model to assign the budget evenly to avoid the imbalanced case: start with high quality content viewing without any ads and end with poor quality with plenty of ads. We assume the viewer has set the approximate frequency of content viewing as f (days per content) and today is the ith day of this month. We denote current balance as $P_{balance}$ and assume there are 30 days this month. Thus there are $\frac{30-i}{f}$ remaining viewing days of this month. Today's budget $P_{BudgetToday}$ can be calculated by Equation 3.2.

$$P_{BudgetToday} = \frac{P_{balance} * f}{30 - i} \qquad (3.2)$$

  A content list will be generated after adopting preference policies, Jack's list should be a high quality content list. Jack will select one content or the system will select a random content from the list. If the price of the selected content is higher than the calculated $P_{BudgetToday}$, then advertisements will be added into play list. Of course, these options can all be changeable. If Jack still does not want to view any ad in spite of a tight budget, he can freely select cheaper content or content higher than $P_{BudgetToday}$, which means he may have a smaller $P_{BudgetToday}$ for the remaining days or he may have to deposit more money for future high quality content viewing.

- *Ad Number Per Video*:

  When watching movies, people are more likely to select one instead of many at a time. They may prefer configuring the ads based on one video. We define a variable n_{ads} as the number of ads per video, which allows viewers to specify a fixed number of ads per video. The total price has to be paid will be

$$P_{bill} = P_{content} - \sum_{i=1}^{n_{ads}} P_{ad_i} \qquad (3.3)$$

Take Jack for example, he is willing to view some ads but there should be no more than three, thus $n_{ads} = 3$. As regards the price for each ad, we can apply the random strategy to select n_{ads} ads out from the generated ad list.

3.5.3 Privacy Policies

Privacy issues have been addressed in the literature [38]. Different from the manner of obtaining sensitive data used by other technologies, in our approach, personal information is directly from viewers with transparent communication. Viewers are empowered with control their private personal information and define Privacy policies on how their data can be used. Particularly, viewers' personal information can also be viewed as a type of resource with commercial value. Similar to owned attention resources, as the owner, viewers can trade in their personal information in the marketplace with advertisers at a fine grain, rather than unacknowledged or arbitrarily used. For example, the information can be set as "absolutely private", or "only used for targeting", or "would like to subscribe to newsletters", or "sell to specific advertisers under certain conditions and terms."

3.5.4 Summary of Policies

Policies are introduced for automated negotiations for predictable situations. Figure 3.8 summarizes all kinds of policies. Note that policies are designed for easy subscribing procedures and if the content or ad are not expected, viewers are capable of making changes.
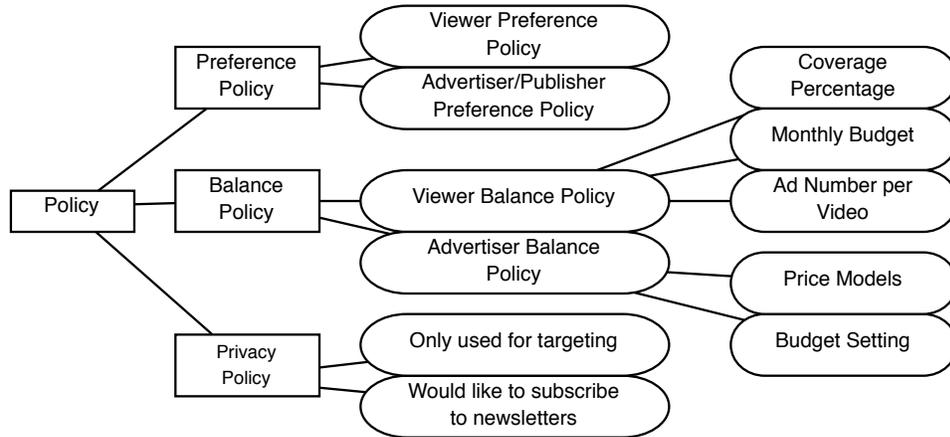
Figure 3.8: Summary of policies.

3.6 Contracts

After the content has been selected, a list of ads will be generated. This process can either be carried out automatically after the adoption of policies, or be selected manually by viewers. Generated ads will be added into a contract. Viewers have the capability to configure them at a fine grain, which will possibly cause conflicts. Therefore, we need a **conflict checking** process. Contracts cannot be negotiated successfully if conflict occurs. A sample streaming of contract with no conflict is illustrated in Figure 3.9.
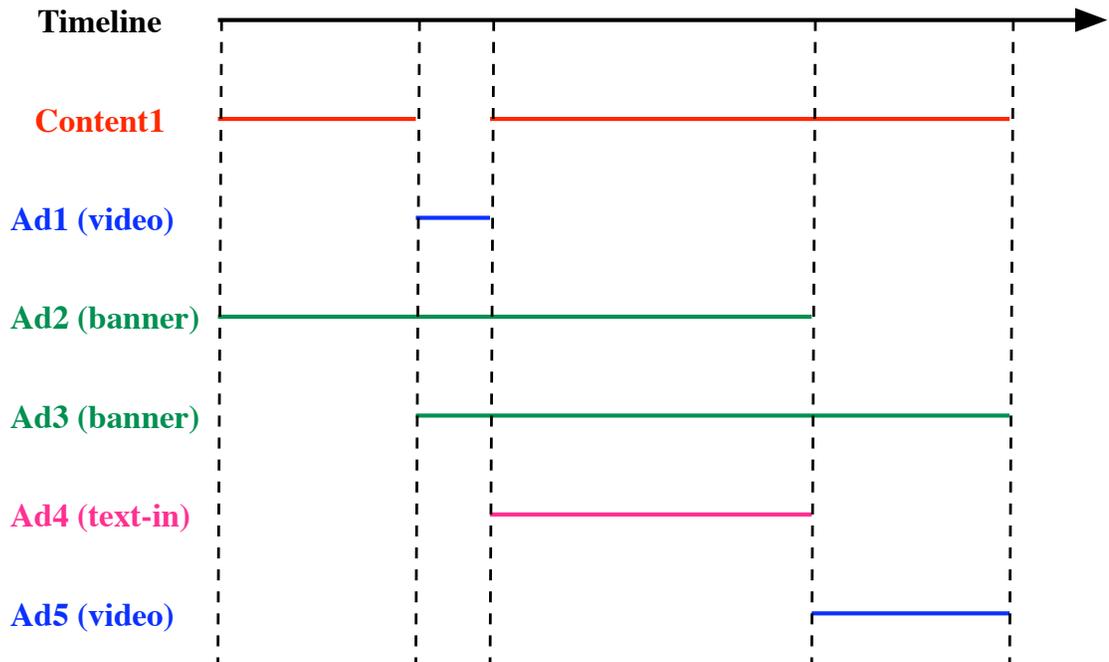
Figure 3.9: A sample streaming of contract with no conflict.

3.6.1 Conflict Checking

The checking process addresses time conflicts, type conflicts, category conflicts, insertion point conflicts, size conflicts, position conflicts and any other conflict that possibly occurs. Conflicts can either occur between content and ads, or between two ads. Several rules are listed as below:

1. The insertion point of advertisements cannot exceed the duration of the content plus the previous ads.

2. Two advertisements cannot be overlapped geometrically if they have overlap in time. For example, Ad2 and Ad3 in Figure 3.9 cannot overlap geometrically with each other, because they have overlap in time.

3. Content and video ads[3] are allowed to play concurrently only when ads are far smaller than content, like the Picture–in–Picture technique (Figure 3.10).

Figure 3.10: Video ads play concurrently with content (Picture in Picture). The figure on the right is the extraction of ads with corresponding type and position.

3.6.2 Contract Approval

If any conflict occurs, viewers will be notified to modify the conflicting configuration or change to other ads. Contracts require the approval from viewers, after which the promised content with selected advertisements in the promised format will be delivered strictly in accordance with the contract.

3.7 Price Models

Constraints or formulations about prices for content and ads can be defined by publishers and advertisers respectively. In this section, we first propose two possible payment means for content. Then, as mentioned in Section 3.5.2, ad prices are dynamically determined depending on specific configurations. We present several examples of ad price models in Section 3.7.2.

3.7.1 Content Price Models

Depending on delivery facilities, viewers may want to select different content qualities. They may also want to select content delivery methods such as streaming or download. Content price is normally determined by publishers. From the perspective of viewers, there are two conceivable content payment mechanisms:

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[3]Nowadays, video ads are not limited to streaming ads. Popup and banner ads can all be made in video forms, thus video ads here refer to all streaming ads.

1. *Pay–As–You–Go*: similar to the service of cellular phone charged by airtime. Viewers can pay periodically, which can be every one, five or ten minutes' viewing. This mechanism can avoid viewers being over-charged if they cannot or do not want to finish the rest of the video that has been ordered.

2. *Pay–Per–View*: viewers purchase the whole video at once, like purchasing a DVD. Pay–per–view often abbreviated PPV, is a common payment mechanism applied in Video–on–Demand Systems.

3.7.2 Dynamic Price Models

FlexAdSense allows advertisers to either define static prices or dynamic prices. Static prices are unchangeable unless updated by advertisers. Dynamic prices means prices float with different attribute values, because different settings may influence ad effectiveness greatly. We present several sample models as below, from which many other models can extend.

- *Insertion Point (Video Ads)*:
  By specifying an acceptable price range (a basic price and a maximum price), the final price for the video ad can follow:

$$P_{ad} = P_{adMax} - InsertionPoint_{ad} * (P_{adMax} - P_{AdBasic})/D_{content} \qquad (3.4)$$

  where P refers to price and D is the duration of the content. This linear model can also be used for other attributes: font size of text-in ads and image size of banner ads.

- *Matching Degree*
  Matching degree refers to how ads match viewers' habits. The higher this value is, the more targeting the ads are and the advertisers may be happy to pay more. A number of existing recommendation algorithms can be used to compute this matching degree, such as *Collaborative Filtering Algorithm* [48, 52].

3.8 Penalties

Our approach allows interaction in real time, which means that viewers may change their mind on the fly. Therefore, a contract can possibly be broken or re–negotiated, with possible penalties. Pay-as-you go payment mechanisms may not require penalties. In the circumstance of using pay–per–view payment mechanism, we can borrow ideas from the telephone companies involving cell phone leasing. Telephone companies usually provide from one to three year contracts. If a consumer wants to withdraw, even though they do not need to pay for all the remaining months, a penalty fee will be applied. The penalty policies described in [31] used for curbing spam can also be borrowed.

3.9 Summary

This chapter presents an approach – FlexAdSense – to empower viewers with advertisement decision-making. This approach is constructed by specializing the CyberOrgs model. Viewers' attention is traded as a type of precious owned resource. We build a market of the attention spaces in which attention resources can be traded for multimedia content, with the participation of viewers. Contracts are the products of negotiation and stipulates the content and ads displayed at a fine grain. Specifically, viewer can define not only what ads and content to display, but also how, when and where to display. Various policies are proposed for automated negotiations that can be used in predictable situations. The cases breaking up contracts are also discussed.

Chapter 4

Prototype Design and Implementation

In this chapter, we provide a proof-of concept prototype implementation of *FlexAdSense*. In the prototype, each party is implemented as an agent. The broker agent acts as a server maintaining the database, which stores information including users' profiles, policies and information of all published content and ads. One special agent named *Directory Manager* (DM), offers a *Yellow Pages* service. Each agent is implemented with functionalities to negotiate resource trading between different parties at a fine grain.

The organization of this chapter is as follows: Section 4.1 gives a short introduction of the Actor Architecture (AA) [36], on which the prototype is built. In Section 4.2, we provide the design of the system, including the architecture, actors, actor communication, interface design, as well as design of policies. Section 4.3 is dedicated to presenting the customized attention space. Presentation architecture, the technique and streaming server applied in the prototype are discussed here. Section 4.4 summarizes this chapter.

4.1 Actor Model and Actor Architecture

Using agents to model online trading and some other social structure problems has become increasingly popular. Actors [4] provide a formal model for building distributed systems, with a built-in notion of encapsulation and interaction. The dynamic reconfiguration feature of the actor model provides considerable flexibility in organizing concurrent activity and representing coordination between interconnected components. An actor encapsulates a state, a thread of control, a number of methods and messages. Actors can be viewed as independent processes that execute concurrently on one or more hosts. Figure 4.1 illustrates the structure of an actor.

Actor Architecture (AA) [36], a distributed implementation of the Actor model, provides an actor execution environment. The AA platform provides asynchronous communication (primitive **send**) as well as synchronous communication (primitive **call**), which is built upon asynchronous communication. Each type of actor can extend the base class *Actor* by defining methods which can be invoked as a result of receiving messages from other actors. Messages received by an actor are stored in its message queue until it is ready to process them. Actors are identified by globally
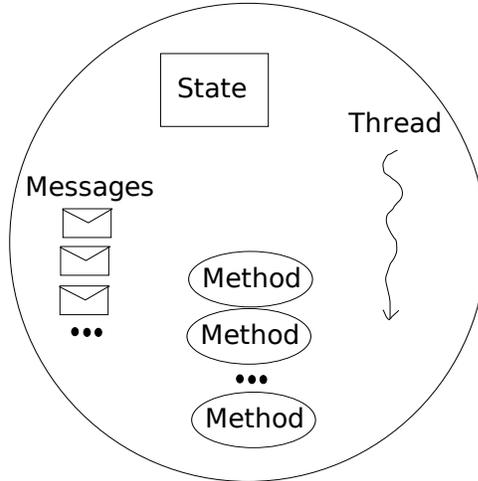
Figure 4.1: The structure of an Actor.

unique names called Universal Actor Names (*UAN*), such as `uan://128.233.104.144:3`. An actor is created by by an existing actor or an AA platform using the **create** primitive locally or the **createRemote** primitive remotely. The return value of the actor creation process is of ActorName type, which refers to the new actor's *UAN*.

4.2   Prototype Design

Because of Actors' natural support for distributed computations, it was a natural choice to implement FlexAdSense. Section 4.2.1 introduces the distributed architecture of the prototype. Section 4.2.2 defines four types of actors with their specific responsibilities. The communication between actors is described in Section 4.2.3. The interface of our prototype is presented in Section 4.2.4.

4.2.1   Distributed System Architecture

The structure of our system is as shown in Figure 4.2. Different from the agents defined by tasks in AdROSA [40], agents in FlexAdSense are designed according to their roles. We use a client-server model, in which brokers are taken as servers providing service, such as processing database queries and communicating with requesting users. Advertisers, publishers and viewers are client agents responsible for interacting with users and sending users' requests to brokers, trading resources, displaying response results and so on.

4.2.2   Actors

Agents in FlexAdSense are implemented as actors in the AA platform.
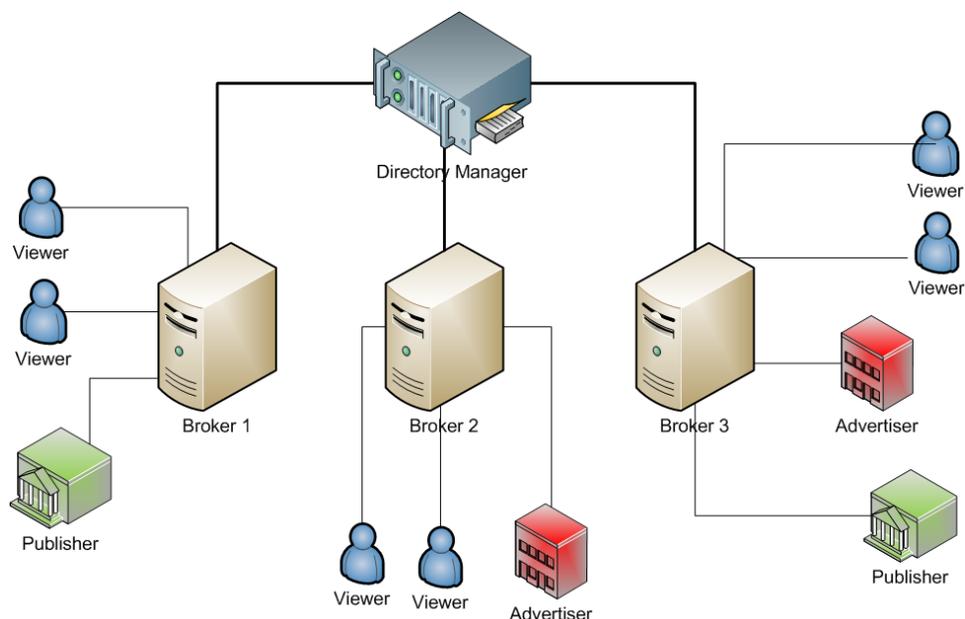
Figure 4.2: The distributed structure of FlexAdSense.

- The Directory Manager (DM) offers *Yellow Pages* service, maintaining the names of all brokers. When a new client agent is created, DM is responsible for rendezvous with a server, which subsequently takes care of requests from the agent. Because each broker maintains a replication of the database, DM also takes the charge of sychnronizing databases on brokers. Specifically, when the database in any broker is modified, DM has to instruct all brokers to update the database.

- Brokers maintain the database which stores information about all users,[1] including users' account information, viewers' profiles, various customized policies, advertisement information and content information. There can be more than one brokers. We use a load balance based scheduling policy: the broker with the lightest load balance is selected to serve a new client agents. New brokers have to register with DM and replicate the database before going online. Figure 4.2 shows two brokers, Broker 1 and Broker 3, serving four agents. Broker 2 is already serving three agents, any newly created agents will be served by Broker 2. When an agent leaves the system, workload information of its broker is updated.

- Advertiser agents represent advertisers in interacting with brokers and DM, and manages their advertisements, policies and accounts, as well as investigates viewers' informations if applicable and necessary.

- Publisher agents represent publishers in managing their multimedia content resources and

---

[1]In this chapter, users refer to all parties, which can be advertisers, publishers or viewers.

accounts.

- Viewer agents represent viewers in managing their attention space by searching for and selecting contents, selling attention resources at a fine grain, as well as managing their profiles, policies and accounts.

4.2.3 Communication

Two main types of communications are required: communication between agents and communication between agents and the GUI.

Communication between agents

We classify the requests into two types: query requests and modification requests.

- *Query requests:* Query requests refer to requests between users and their designated brokers. These requests can either be for searching or for subscribing to content/ad, or retrieving users' personal information. Thes types of requests are implemented by sending a message to the relevant broker. As the example shown in Program 1, a viewer's profile can be obtained using a synchronous message and content can be searched by an asynchronous message. Note that *searchViewerFormByID* and *searchContentByName* are two methods defined in broker actor class and used to retrieve data from the database. The former requires a ViewerForm return value; the latter does not require a return value and sends results back by sending a message, because it sends its own *UAN* by *getActorName()*.

- *Modification requests:* Modification requests refer to requests that change the database. Because each broker maintains a copy of the database, modification requests trigger an update procedure on all brokers. These requests include requests to publish a new ad/content, to register a new user or to change preference information. For this type of requests, we use attribute–based communication [5] between actors, which means that an actor does not need to know the recipient actor's name, just some characteristics. To enable this, a Directory Manager maintains a public tuple space, which stores tuples with specific patterns, and offers the "deliverAll" service, using which a viewer actor can tell DM to send a request to all brokers. If there exists a corresponding method at which the receiver matches the given arguments, the method is invoked. Program 2 illustrates registering of viewer's profile with brokers. Viewers do not have to know brokers' *UANs* or communicate with them individually. Instead, they simply send messages to "brokers."

Program 1 Retrieve a viewer's profile and retrieve content by a given name.

```
/**
* Retrieve a viewer's profile.
* @param loginID the login ID of the viewer.
* @return viewerForm the profile encapsulated as an object of ViewerForm
*/
public ViewerForm getViewer(String loginID){
    try{
     //myBroker is the broker's ActorName.
     viewerForm = (ViewerForm)call(myBroker, "searchViewerFormByID", loginID);
    }
    catch (CommunicationException e) {
        System.err.println("Please check getViewer method: " + e);
    }
    return viewerForm;
}


/**
* Search content by content name.
* @param content_Name the String content name
*/
public void searchContentByName(String content_Name){
    send(myBroker, "searchContentByName", content_Name, getActorName());
}
```

Communication between actors and GUI

Even though information can be exchanged between actors, the return values of those methods are still located inside actor encapsulations and cannot be observed outside the actors. Let us take a viewer's query for example. After the viewer's broker has received the request, it searches through the database, and then sends the results back to this viewer. How to make these results visible to viewers becomes a problem. To solve this problem, we encapsulate the user interface into an actor, as shown in Figure 4.3.

Except for the login user interface, all other GUI components are embedded inside user agents. Advertiser, publisher and viewer have different GUIs, which can be initialized when they have successfully signed into the system.

4.2.4   Interface Design

A user enters the system using the login panel, which triggers the initialization of the AA platform and creation of a user actor. After successfully signing in, users are brought to the interfaces corresponding to their roles. What is displayed in the interface depends on each user's preferences.

Program 2 Register a viewer's profile to brokers.

```
/**
* Register a viewer's profile to brokers.
* @param viewerform is the profile encapsulated as an object of ViewerForm.
* anDM is the UAN of the Directory Manager.
*/
public void registerProfile(ViewerForm viewerform){

//Extract all brokers in a tuple.
ActorTuple tuple = new ActorTuple(null, "broker");

//"addViewer" is a method located in brokers to insert a new entry
//to Table "viewers" in the database.
send(anDM, "deliverAll", tuple, "addViewer", viewerform);
}
```
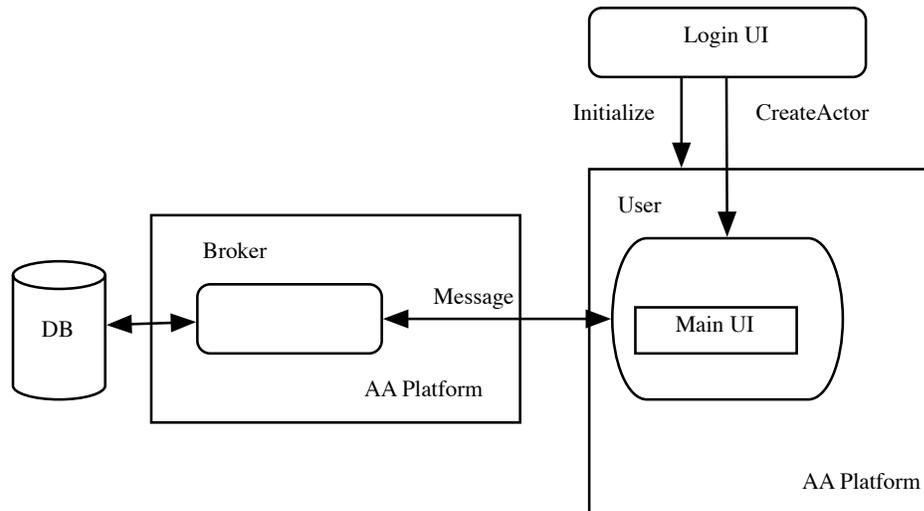

Figure 4.3: The interaction between user and broker.

Viewer

As described in the previous chapter, there are four primary processes: policy adoption, content/ad list generation, content/ad selection (optional), and contract approval. Before viewers define their customized policies, the system uses a default policy: list all available contents and advertisements. Figure 4.4 shows a viewer's interface with the default policy.

From the main panel, viewers select content/ad from lists. Selected content/ad are displayed on the Mylist panel (on the right). Items in the list are implicitly added into a contract. As discussed in the previous chapter, the conflict checking mechanism is triggered whenever an item is added into the contract. If there is a conflict, an alert results.

In the example shown in Figure 4.4, we can see that ad prices are all negative. This means
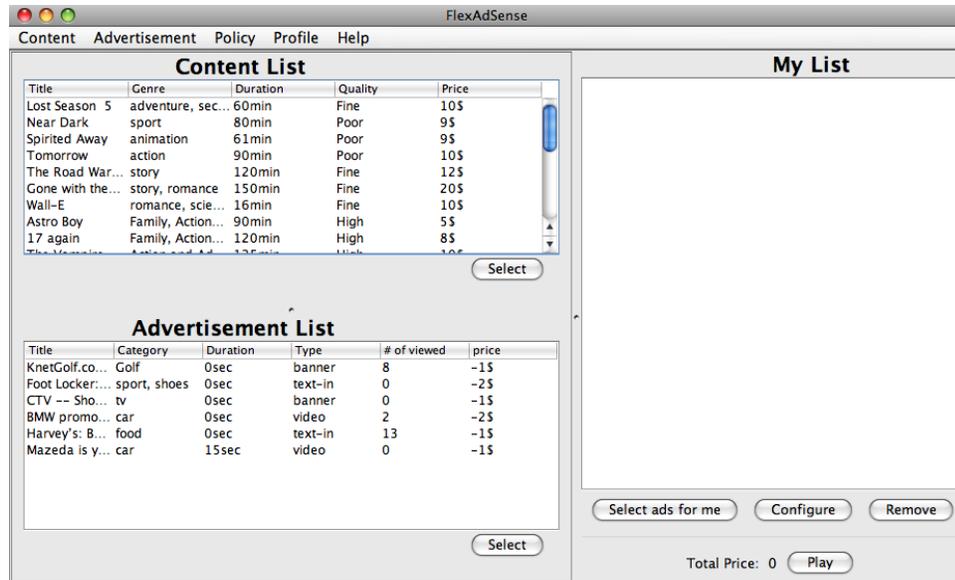
Figure 4.4: The main user interface for viewers.

that they subsidize the cost of content. The total price of selected content is shown at the bottom. The *configure* button is for configuring one selected ad, whose attributes can be specified (e.g. insertion point, duration and so on). Viewers can remove the selected content/ad from the list. If there is no conflict in the contract and the viewer's account has sufficient balance, the contract is negotiated successfully. The *Play* button instructs the media player to play the list in the specified form. Particularly, the *Select ads for me* button triggers the adoption of balance policies, which automatically generate the desired ads. Viewer customized policies will be discussed in Section 4.2.5.

Figure 4.5 shows how viewers can search content or ads by inputting attribute values such as title, category, type, price and so on. Viewers can manage their accounts, and edit their policies and profiles.

Figure 4.5: Functionality of viewers' menu.

Advertiser

Each advertiser has an account, which allows them to publish advertisements on their own. Figure 4.6 shows the advertisers' interface, through which advertisers can manage their existing advertisements. Besides the attributes visible to viewers, advertisers can monitor each ad's viewed times and the total amount paid to displaying each ad. This information can be used for optimizing policies. For example, if one ad has an unexpectedly high cost, the advertiser can set the ad to be unavailable temporarily, or set a daily or monthly budget. Advertisers can also publish new advertisement, and upload their images or video content through the interface.
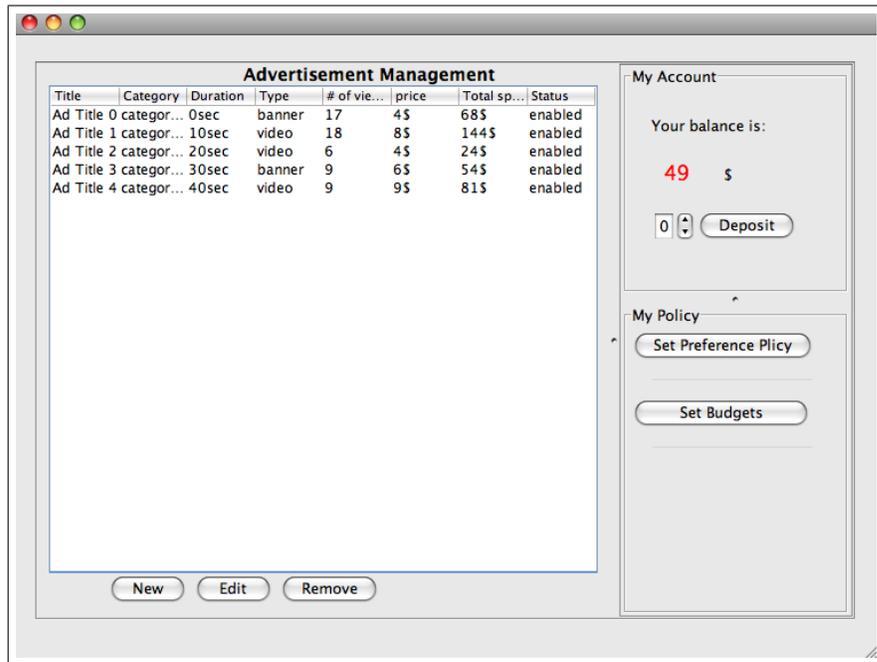
Figure 4.6: Advertisers' interface.

Publisher

Publishers' interface provides the functionalities of publishing new content, as well as managing accounts and existing content.

4.2.5   Policy Design

This section discusses how we have implemented policies in the prototype for different parties.

Viewer Policy

Figure 4.7 shows viewers' policy management panel, integrating support of setting up three types of policies.

44

Figure 4.7: Policy panel for viewers.

- Privacy Policy: The prototype provides two options – "Only used for targeting" and "Would like to subscribe to newsletters related to my interests". The former activates matchmaking between viewers' interests and the content/ad list displayed on the list panel previously shown in Figure 4.4. The latter can make the viewer's email visible to those advertisers whose products match viewers' interests. This functionality for now is implemented by setting a flag in the database. Brokers simply use as a filter: advertisers can obtain their potential viewers' email information only if the flag has been set. The default privacy policy is the first one: only used for targeting.

- Preference Policy: Preference policies are stored in two tables in the database, and are used for filtering out unwanted content/ad and generating targeted content/ad lists. Preference policies are adopted before balance policies (discussed next), and they contribute to the generation of candidate content/ad list that is used for the adoption of balance policies.

- Balance Policy: Three types of balance policies have been implemented. They differ from each other in the parameters they take: coverage percentage, monthly budget, and limit ad

number. Algorithm 1 shows how preference policies and balance policies are adopted.

Algorithm 1 The algorithm of policy adoption.

---

0. *//Adopting preference policies for content and advertisement separately, if any.*

1.   if(contentPrefPolicy != null){

2.   Adopt contentPrefPolicy to generate a content list.

3.   while(next(contentPrefPolicy)){

4.   Adopt contentPrefPolicy on content list to generate a sub list;

5.   }

6.   else   Generate a content list containing all content;

7.   if(adPrefPolicy != null){

8.   Adopt adPrefPolicy to generate an ad list.

9.   while(next(adPrefPolicy)){

10.   Adopt adPrefPolicy on ad list to generate a sub list;

11. }

12.   else   Generate an ad list containing all ads;

13. *//Adopting balance policies, if any.*

14.   if(balancePolicy != null){

15.   if(balancePolicy.type == CoveragePercentagePolicy)

16.   Randomly select one content from content list;

17.   Randomly select ads from ad list one by one until reach $P_{content} * p$;

18.   if(balancePolicy.type == MonthlyBudgetPolicy){

19.   Apply model to calculate $P_{BudgetToday}$;

20.   Randomly select one content from content list;

21.   if($P_{content} > P_{BudgetToday}$)

22.   Randomly select ads from ad list one by one until reach ($P_{content}$ - $P_{BudgetToday}$);

23.   }

24.   if(balancePolicy.type == AdNumberPolicy)

25.   randomly select *nads* ads from ad list;

26.   }

Advertiser & Publisher Policy

In the current version of the prototype, specifically for advertisers, monthly budget balance policy has been implemented. The functionality to define preference policies, which are used for simplifying publishing process as described in the previous chapter, has been implemented for both advertisers and publishers.

4.3   Multimedia Presentation

The presentation architecture of this prototype is discussed in Section 4.3.1. SMIL (Synchronized Multimedia Integration Language) enables bringing multimedia assets together into a complete presentation as well as hyperlinking. Section 4.3.2 gives more information about SMIL. QuickTime streaming server is used for storing and delivering published content and advertisements.

4.3.1   Presentation Architecture

The architecture for multimedia presentation is shown in Figure 4.8. The approval of a contract triggers the generation a SMIL file and pressing of the *play* button instructs the media player to play the SMIL file. Links to multimedia content and advertisements are embedded in SMIL markups, which request servers to stream the specified media. Elements in SMIL files control the sequence and layout the of the final stream.
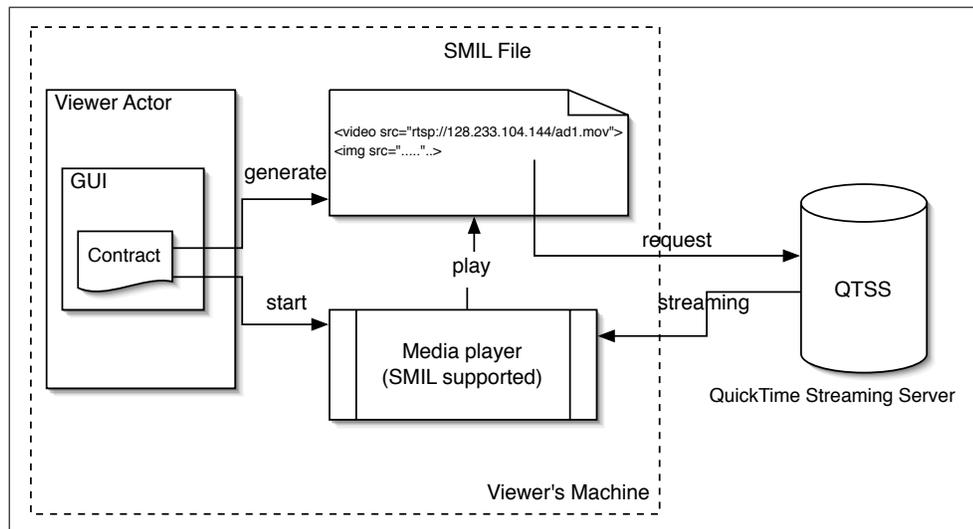
Figure 4.8: The architecture of multimedia presentation.

4.3.2   Synchronized Multimedia Integration Language (SMIL)

The Synchronized Multimedia Integration Language (SMIL, pronounced "smile") [63] developed by the World-Wide Web Consortium (W3C) provides a standard for scripting multimedia presentations. It defines markups for timing, layout, media embedding among other things. The term "media" here covers both video content and various advertisement forms, including still images, text, as well as continuous media types that are intrinsically time-based, such as video, audio and animation.

SMIL Timing defines elements and attributes to coordinate and synchronize presentation of

47

media over time. For example, it is possible to specify that a video ad begins at a given absolute time or relative to the time when the movie begins. The *LinkingAttributes* module of SMIL provides a basic but important click-able feature, through which users can be guided to advertiser's websites by clicking ads appearing in the environment. Program 3 shows one example of a SMIL presentation file with content video embedded with a banner ad and a text-in ad. Figure 4.9 shows the screen shot of the given program.
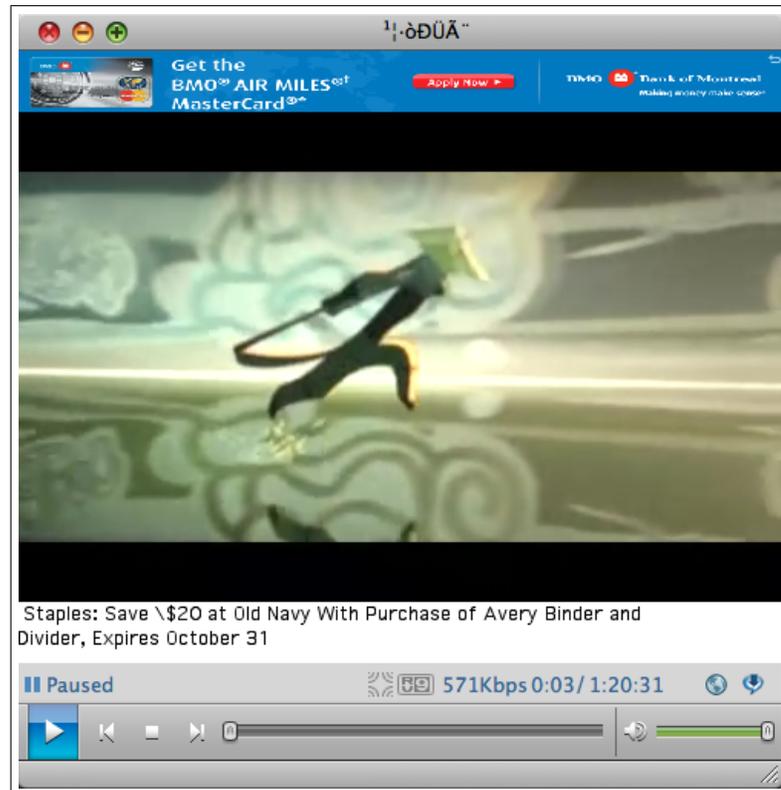
Figure 4.9: The screen shot of the presentation example: a movie with a banner ad, a video ad and a text-in ad. At the point of 100s, the main panel will play the video "BMW" ad. Afterwards, the movie will resume.

4.3.3   Streaming Server

The QuickTime Streaming Server (QTSS) is used as the streaming server in the current version of our prototype because it supports SMIL streaming. In the prototype, publishers and advertisers are able to upload their content either to the server provided in brokers or any other existing streaming server as long as content/ad links are available. Note that viewers media player has to be SMIL supported. Currently, Realplayer, QuickTime player and many other open source players such as AMBULANT from CWI support SMIL 2.0.

Program 3 A content video embedded with a banner ad and line–in ad. Layout element defines three regions for specific purposes. Objects inside a par element will be played in parallel and inside a seq element will be played sequentially.

```
<smil>
<head>
<layout>
<root-layout width="500" height="400"/>
<region id="video_region" left="0" top="40" width="500" height="320" z-index="0"/>
<region id="text_region" left="0" top="360" width="500" height="40" z-index="1"/>
<region id="banner_region" left="0" top="0" width="500" height="40" z-index="2"/>
</layout>
</head>

<body>
  <par>
    <a href="http://BMO.com/Mastercard" >
    <img src="ads/BMO_MasterCard.png" region="banner_region" duration="25s"/>
    </a>
    <seq>
        <video src="contents/KongfuPanda.mov" region="video_region" clip-begin="0"

        <video src="ads/BMW.mov" region="video_region"/>
        <video src="contents/KongfuPanda.mov" region="video_region" clip-begin="100"/>
    </seq>
    <text src="data:, Staples: Save \$20 at Old Navy With Purchase of Avery Binder and
                Divider, Expires October 31" region="text_region" textAlign="center"/>
  </par>
</body>
</smil>
```

4.4 Summary

This chapter describes a prototype implementation of *FlexAdSense*. The prototype is implemented over the Actor Architecture (AA) [36]. Each party is implemented as an agent. Functions defined in each agent enable fine-grained negotiation about consumption of resources. The prototype is designed as a distributed client-server system. Broker agents act as servers providing services. Directory Manager maintains the directory of brokers, and load balances between brokers. Several example policies are implemented and user interfaces are designed implementing key mechanism as required for a functioning system.

Algorithm 2 Algorithm for inserting video ads.

1. Sort videoAdList by insertionPoint in ascend order.

2. int clipBegin=0, clipEnd=Duration(content), point = 0;

3.   for(i from 0 to size(videoAdList)) {

4.   point = insertionPoint(videoAdList[i]);

5.   if(point is 0)

6.   Play video ad[i];

7.   else {

8.   Play content video clip between clipBegin and clipEnd;

9.   clipBegin = point;

10.   clipEnd = insertionPoint(videoAdList[i+1]);

11.   }

12.   Play the rest of content video, if any.

13.   }

CHAPTER 5

EVALUATION

FlexAdSense can be evaluated along multiple dimensions. The key among these is the level of flexible fine-grained control afforded all involved parties. Section 5.1 compares FlexAdSense to existing solutions. Two other interesting metrics of evaluation are server scalability and the additional demand on viewer attention resulting from interactions with the system. Among these, we have decided to focus primarily on the former in Section 5.2. Section 5.3 includes a very preliminary evaluation of additional viewer attention demands.

5.1   Approach Feature Evaluation

Recall the problems regarding different parties stated in Chapter 1, we evaluate our distinguished features by comparing existing models with FlexAdSense in solving those problems from each party's perspective.

5.1.1   Viewers' Perspective

Privacy concern:

Because of the intrusive nature of advertisements, a number of personalization models are proposed to make ads more relevant to viewers' interests; however, many models trace viewers' behaviour and collect data without viewers' permission. Mechanism design is supposed to alleviate these concerns. Table 5.1 compares the models regarding the means of obtaining user profiles, the author of personalization rules and personalization segmentations. "The author of personalization rules" refers to the party who defines the rules about how personalizing should be carried out. "Personalization segmentations" refers to the target segmentation, which can be an aggregation (or say "public"), or ans individual.

Note that FlexAdSense does not allow implicit viewer profile investigation unless viewers authorize to do so. Aggregation personalization refers to viewers who have not provided any personal information and do not mind their behaviour history to be investigated. FlexAdSense distinguishes between other models in the author of personalization rules: viewers are capable to negotiate personalization rules.

Models		Way to obtain viewers' profile	Author of personalization rules	Personalization segmentation
TV	iTV	explicit	broker	Individual
	iMEDIA	explicit / implicit	broker	Individual& Aggregation
	TV any time	explicit	broker	Individual
Web	Ad-duration control model	implicit	broker	Aggregation
	Contextual Advertising	implicit	broker	Aggregation
FlexAdSense		**explicit / implicit**	**broker / viewer**	**Individual& Aggregation**

Table 5.1: The comparison of personalization models.

Granularity of control over content and advertising:

Viewers have limited decision making capacity over the advertisements in existing multimedia delivery mechanisms. We add information about FlexAdSense to Table 1.1 (in Chapter 1) to obtain Table 5.2. Additionally, Table 5.3 shows the attributes that can be configured in FlexAdSense.

Control over		Content Selection		Content Viewing		Control Granularity of content	Ad Selection	Ad Viewing	**Control Granularity of ads**
Mechanisms		# of Channels	Personalized Schedule	FF/FR/RW	Quality Control		Attributes Configuration	Skip-over ability	
TV	Terrestrial TV	Small	No	No	No	Coarse	**No**	No	**Coarse**
	Cable / Satellite	Large	No	No	No	Coarse	**No**	No	**Coarse**
	DVR	Large	Yes	Yes	No	Fine	**No**	Yes	**Coarse**
	interactive TV	Large	Yes	Depends	Yes	Fine	**No**	Depends	**Coarse**
Web	Video on Demand	Extra large	Yes	Depends	Yes	Fine	**No**	Depends	**Coarse**
	IPTV	Extra large	Yes	Depends	No	Fine	**No**	Depends	**Coarse**
Mobile Device	Mobile TV, etc.	Depends	Yes	Depends	No	Fine	**No**	Depends	**Coarse**
FlexAdSense		Extra large	Yes	Depends	Yes	Fine	**Yes**	Yes	**Fine**

Table 5.2: Comparison of existing mechanisms on control granularity over content and advertising.

5.1.2 Advertiser's Perspective

Advertisers' problems can be summarized as: ads are not precisely targeted, so it is hard to measure their effectiveness; moreover, the negotiation for publishing ads on some platforms is a complex and time-consuming procedure. Considering these concerns, we compare FlexAdSense with existing

Control over	Attributes	Selections
Content	Quality	DVD quality, fine quality or poor quality
	Playback capability	Fast forward, fast reverse, or rewind
	Genre	Action, strategy, sports, family, animation, adventure, etc
	Payment method	Pay per view, or pay periodically (by minute), or a monthly flat fee for unlimited viewing
Advertisement	Category	DVD quality, fine quality or poor quality
	Type	Banner, video, text-in, pop-up, etc.
	Other properties	Position, font of text-in ads, insertion point, duration, etc.

Table 5.3: FlexAdSense's granularity of control over content and advertising.

advertising mechanisms in Table 5.4. In the table, "targeting" refers to how ads can be related to viewers' interests. "Measurability" refers to the ability of measuring the cost on advertising and evaluating their effectiveness. The term "Possible" in the table means availability of the feature depends on the model used in these mechanisms. We can see that FlexAdSense is comparable with several models: providing high targeting, easy to estimate spending and effectiveness. Additionally, FlexAdSense makes advertisers easy for negotiation ascribed to the capability of policy designs.

5.1.3 Brokers/Publishers' Perspective

Brokers are the intermediary between publishers, viewers and advertisers. On the one hand, they have to satisfy advertisers' variant requirements; on the other hand, it is a challenge for brokers to maintain the balance between content and advertising. Table 5.5 compares related models regarding these problems. We can see that most of them can only perform on one type of advertisements and FlexAdSense can function on various ad types. Additionally, FlexAdSense allows viewers to explicitly define the ratio of advertising, which relieves the brokers' concerns. Specifically for paid placement models, note that it is brokers who define the ad ratio in some models. Brokers define a fixed number of bidders whose ads can be displayed as wishes. For example, *Baidu.com*, the biggest Chinese search engine, regulates that only the first two pages are for advertised items, the rest of bidding items will be listed as the first two item placements scattered in subsequent pages.

Models / Mechanisms	Targeting	Measurability
Traditional TV Mechanism	No	No
interactive TV	Possible	Possible
Email Advertising	Yes	Yes
Web Contextual Advertising	Yes	No
Paid Placement	Yes	Yes
iMEDIA	Yes	Yes
Adware & Spyware	No	No
Digital Signage	No	No
Social Network Advertising	Yes	Possible
FlexAdSense	**Yes**	**Yes**

Table 5.4: The comparison between existing advertising models regarding advertisers' intentions.

5.1.4 Overall Comparison for Different Parties

This section discusses the comparison between FlexAdSense and existing mechanisms, considering overall intentions of all parties. We categorize the existing mechanisms in several groups according to their characteristics.

- Some models (Krakatoa Chronicle model, email advertising models, avoiding skip-over ad models, digital signage models, optimal banner models, complete ad elimination models and adware& Spyware models) are only relevant to some parties. These models are not desirable because they ignore the other parties' intentions.

- Traditional TV, TV with DVRs, iTV mechanism, TV anytime models, Adaptive hypermedia models and Social network advertising models are comparable. They differentiate each other with some distinguished features, such as bringing more interaction, or time/space independent feature by TV anytime model, skip-over ability of DVRs, recommendation features and some other features.

- Contextual advertising have directed significant research efforts. These models are delicate to displaying the most appropriate advertisements to viewers. Technically, most of these models can be applied to our approach. Because not every viewer would bother to define their attention space explicitly, some of them may prefer automated personalizing.

Models	Applicable ad types	Who define ad ratio	Features & Liminations
Paid Placement Models	Search engine ads	Depends on # of bidders(advertisers)	High targeting, measurability, but may have a negative impact on viewers' perceived credibility.
Streaming Ad-Time Control Model	video	Brokers (by a ratio function)	Balanced ad ratio, but brokers still have to define the ratio.
Optimal Banner Model	banner	Brokers (by algorithms)	Satisfy diverse advertisers' requirements on ad sizes, locations & frequencies.
Krakatoa Chronicle Model	banner, text	Viewers	Viewers define web content, but advertisers' intention is ignored.
Advertising model for QoS of VoD	video	Viewers' bandwidth	Synchronize the streams and minimize the startup latency.
FlexAdSense	**video, banner, text**	**Viewers/brokers, depending on viewers' choices**	**Viewers are allowed to define ad ratio in various ways: by coverage percentage/ ad#/budget. Brokers have to define ad ratio, if viewers do not.**

Table 5.5: The comparison of personalization models.

- Advertising models for QoS in VoD systems consider different viewers' network bandwidth, and propose to use the start latency to display ads, which is desirable. LikeMinds model, as an example of online personalization service providers, supports efficient advertising recommendation. However, viewers in these two models provide very limited control over advertising.

- iMEDIA model is a promising and comparable model with our approach. It takes all parties' intention into consideration. In iMEDIA, viewers are allowed to take part in the advertisement negotiation, but the control is not as fine-grained as our approach. Moreover, advertisers in our approach can define some constraints on targeting viewers, which is not featured in iMEDIA.

5.2 Prototype Performance Evaluation

The prototype is implemented over the Actor Model. We carried out a number of experiments to assess the performance of the prototype in terms of the scalability. Section 5.2.1 introduces the environment of these experiments. Section 5.2.2 discusses the experimental design in several aspects of scalability. Section 5.2.3 interprets experimental results.

5.2.1 Experiment Environment

Experiments were carried out using six Mac OS X Servers each running an actor platform of AA. Each server has a 2×2.8 GHz Quad-Core Intel Xeon CPU and 8 GB memory.

5.2.2 Experiment Design

The scalability of the system is determined by how well the system scales as the number of users or request frequency increases.

1. We designed the first set of experiments to evaluate the performance as viewer number grows from 1 to 3000 to determine the number of viewers that could be handled by our system. We assumed each viewer sends requests at the same frequency. Because there can be multiple brokers, we carried out the experiments for the cases when there were one, two or three brokers in the system.

2. Request rate, which is a factor influencing the capacity of the system (the number of viewers that can be served per second). We carried out a second set of experiments aimed at finding the relationship between the frequency of requests and the capacity of the system with different number of brokers.

3. Because modification requests change the database, Directory Manager has to instruct all brokers to update their local database. Our third set of experiments is for measuring the synchronization time among multiple brokers.

4. We considered to place multiple brokers on one server machine, so that brokers located on the same server do not need to update the database for every modification request. However, locating multiple brokers requires additional system resources, such as memory. We carried out experiments to find the best number of brokers to locate in one server among different number of viewers in the system.

5. Multiple brokers can be located on multiple servers as well. Another set of experiments concerned the performance of system when there are one, two, or three servers located, and each server evenly maintains multiple brokers.

6. This set of experiments compares the execution time for the cases when DM and brokers are located on the same server or not. We designed the Directory Manager on a separate server machine in Chapter 4, because the DM is the vital agent maintaining the directory of all brokers. Considering the communication between brokers and DM, we carried experiments to evaluate the proper location of DM.

5.2.3 Results Interpretation

1. **Execution Time vs. Viewer Number**

   We simulated the time taken to process requests as 10 milliseconds and each viewer sent one request every ten seconds. 3000 viewers were distributed on three servers and sent requests

at the same frequency. Brokers are located on separate servers. Figure 5.1 shows the effect of increasing the number of viewers on the average execution time per request. Results show the cases when there were one, two or three brokers in the system. We can see that if there is only one broker, as the number of viewers grows, the execution time increases before stabilizing. There are orders of magnitude improvident when the load is divided between 2 or 3 brokers. The Y values in the graph are the results from logarithmic function. The actual values are in linear aggregation.
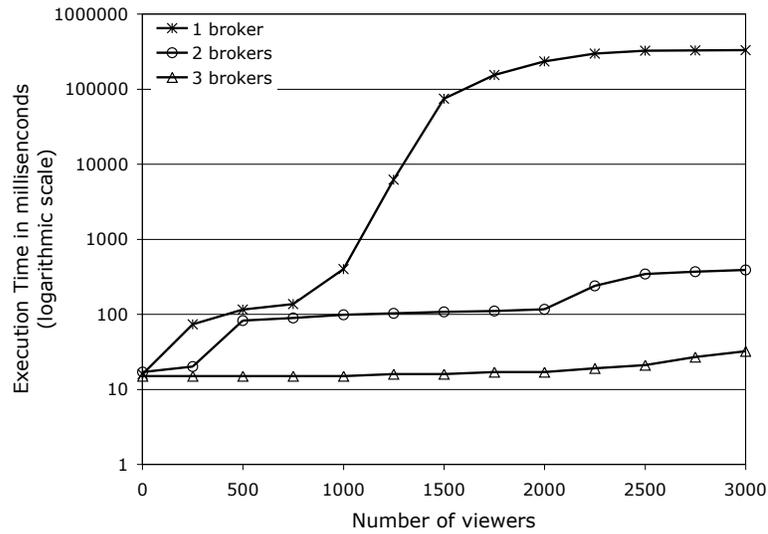
Figure 5.1: Execution Time for Different Number of Viewers.

2. **Request Frequency vs. Broker Capacity**

The second set of experiments aimed to find the relationship between the frequency of requests and the capacity of brokers. The requests in this experiment were to search for specific content and the average time taken for the operation was determined to be 100ms. We tested the response time with various rates under different number of brokers. Response time is recorded as the time period from request sending time to result receiving time. The results are shown in Figure 5.2.

Because each request takes 100ms, the maximum number of requests completed per second is ten. The figure shows that the request frequency is inversely proportional to the capacity of brokers. When there is only one broker, the capacity decreases drastically when the request frequency is 10 req/sec. For the two and three broker cases, this happens at 20 req/sec and 25 req/sec for two and three brokers respectively. Therefore, if the frequency of requests is
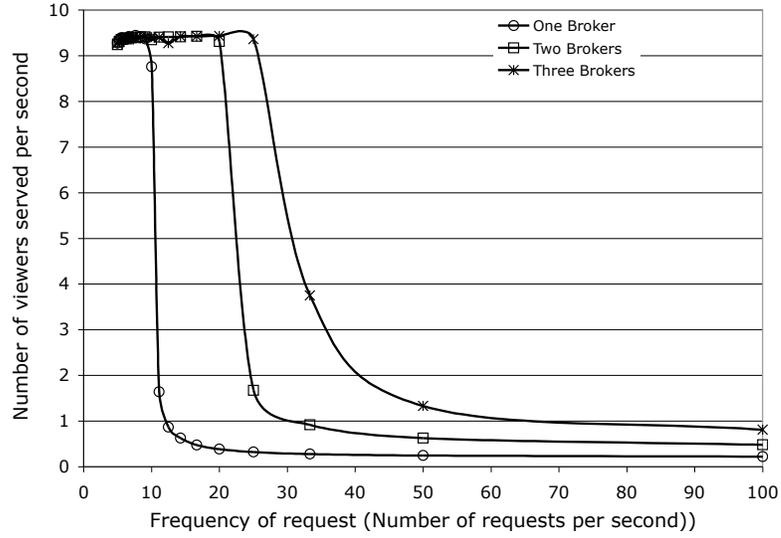
Figure 5.2: Executing time with different frequencies of request.

lower than 10 req/sec, one broker is good enough to handle theoretically.

3. **Synchronization Time**

Considering the working mode of modification requests, our third set of experiments is to measure the synchronization time among multiple brokers. We simulated each database operation time as 100ms, three brokers were located. Table 5.6 shows the synchronization time for different request rates, from one request per second to ten thousand requests per second. Synchronization time refers to the maximum difference between the amounts of time taken before a request is received by a broker. For example, when the Directory Manager sends a modification request to all brokers, if Broker 1 is the first to receive it at time t1 and Broker 2 is the last to receive it at time t2, then the synchronization time is t2 - t1.

Request Rate	Synchronization Time
1 req/sec	1ms
10 req/sec	18ms
100 req/sec	27ms
10000 req/sec	40ms

Table 5.6: Synchronization time for different request rates.

4. **Average Execution Time vs. Number of Brokers**

This set of experiments considered multiple brokers on one server. We simulated each viewer sent one 100 requests in total, and each request was sent every 100ms and took 100ms of computation. The y axis refers to the average execution time per viewer for the cases when there were 100, 200, 300, 400 and 1000 viewers sending requests. The Directory Manager is located in one of the servers together with brokers. Results are shown in Figure 5.3.
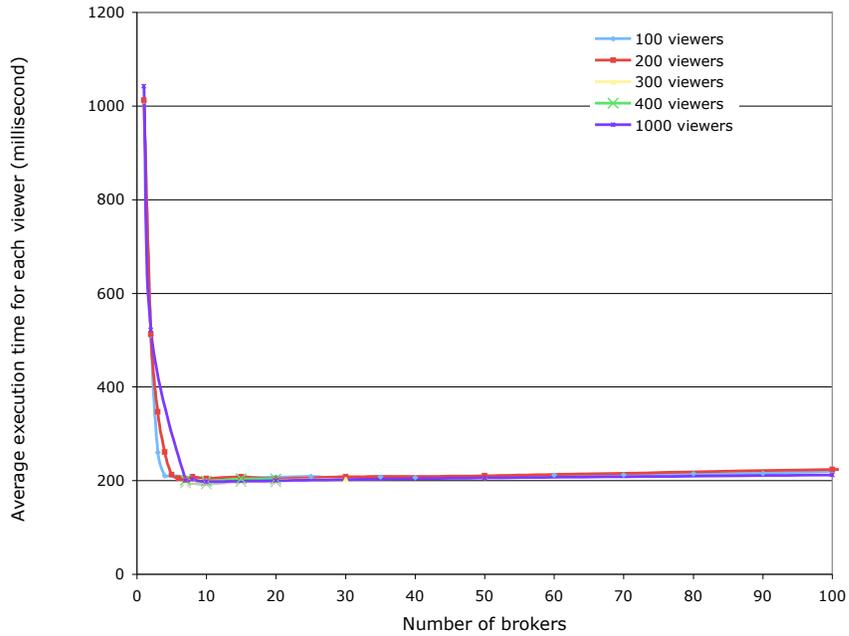
Figure 5.3: Average executing time per viewer with the number of brokers increases for cases with different number of viewers.

We can see that the average execution time is stable and not changing with the number of viewers increases. The system performed the best when there were about eight brokers, which may be because there are eight cores in each server and eight threads can execute concurrently. As the number of brokers increases, the average execution time slightly grows, which is probably caused by the overhead of resource allocation and scheduling multiple threads.

5. **Server Number vs. Broker Number**

The fifth set of experiments considered the case when there were multiple servers, each of which maintains multiple brokers. We simulated 1000 viewers and each of them set the same

parameters as the fourth set of experiments. Brokers were evenly distributed on one, two, or three servers. For instance, if the total number of brokers is 60 and there are 3 brokers, then each server has 20 brokers. Figure 5.4 shows the results.
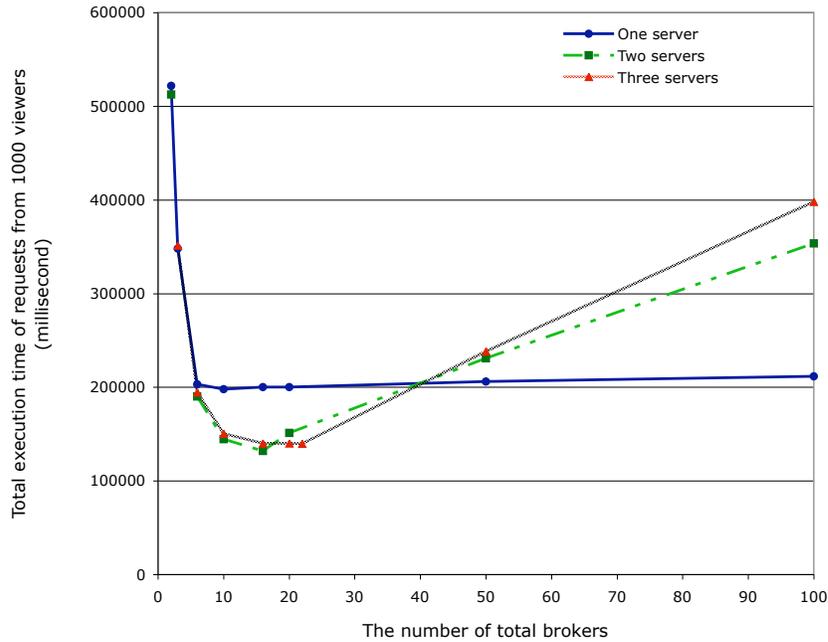
Figure 5.4: Total executing time for 1000 viewers with increasing number of brokers located on one, two or three servers.

When there is only one server, the system performs the best (about 20000ms to finish all requests) when there are 8 brokers. If two servers are located and each of them has about 16 brokers, the total execution time can reduce to about 13000ms. However, the involvement of the third server does not help the performance if the workload is not high. It is probably because of the communication overhead between servers. Additionally, when there are more than one server, the execution time grows faster as the number of broker increases. Therefore, if the system requires the best performance, about 16 brokers distributed on two servers will be the best choice.

6. **Location of the Directory Manager**

The Directory Manager in the above experiments was embedded with broker servers. This set of experiments used the same settings as the fifth experiment. Figure 5.5 compares the results for cases when the DM and brokers are on the same server or not.
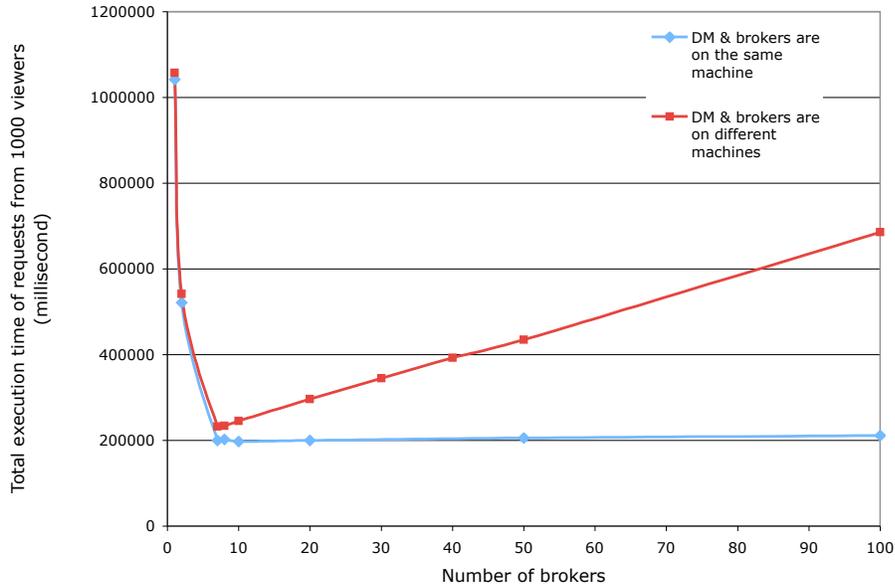
Figure 5.5: The comparison for cases when the Directory Manager and brokers are on the same server or not.

We can see that the execution time is quite close before the broker number reaches 10, but grows much faster for the case when they are on different servers. The results suggest that if the DM and broker are on the same server, the system performs better; however, the DM should be actively replicated for fault tolerance. If there is an available server specifically for the DM, the system performs the best when there are 8 brokers.

5.3 Attention Overhead

Because active interaction itself calls for viewers' attention, we carried out experiments to assess the attention overhead of using our approach. We preliminarily evaluated the amount of this attention resource as the number of clicks viewers have to make, for specific tasks. Regarding Jack's scenarios in Chapter 3, we give some examples in Table 5.7.

Because some attributes can be configured by the same interface, the overall number of clicks can reduce when setting multiple attributes together. Additionally, some click numbers are illustrated as a range, because the attribute setting may vary depending on the way they are set, such as using spinners or typing in the value. We measured the number of mouse clicks after viewer's

The tasks to realize Jack's scenarios:	Number of clicks required
1. Define the ads to his interests	4 -- 6
2. Search specific high quality content	2 -- 6
3. Set a monthly budget, relatively more ads when the budget is tight and fewer ads when the budget is freer.	6
4. Define the type and content of ads	4 -- 6
5. Keep the screen free of adult-only content/ads	4 -- 6
Set all the above tasks at a time	12 -- 20

Table 5.7: The overhead of using the prototype for realizing Jack's scenarios.

successful signing in. As long as the policies have been set, viewers can even make fewer clicks for future viewing. Therefore, communication involving negotiation with policies has minimal attention overhead.

5.4 Summary

This chapter discusses the evaluation along three dimensions: fine-grained flexibilities afforded all involved parties, scalability of the prototype and attention overhead of using FlexAdSense. Regarding the problems faced by each party, we analyze the distinguished features of FlexAdSense, compared with existing models/mechanisms. We evaluated performance of the prototype by carrying out a series of experiments. Experimental results demonstrate its scalability. Attention overhead – the amount of attention resource ascribe to negotiation – of the system was preliminarily evaluated by measuring the number of clicks for various tasks.

Chapter 6

Conclusion and Future Work

This chapter concludes the thesis and discusses future directions for this research. Section 6.1 describes the contribution of the thesis, including the innovation of FlexAdSense: taking a resource ownership view on advertising negotiation and enabling viewers to fine-grained control their attention space in real time. Future work is explored in Section 6.2, addressing both design and implementation.

6.1 Conclusion

This thesis is concluded by analyzing its innovations and summarizing how the stated problems have been solved by FlexAdSense.

6.1.1 Innovation

- A key innovation in our approach is the mechanism providing flexibility of control over advertisement display; any contribution related to marketing are incidental. We consider viewers' attention as a type of precious resource, and enable fine-grained resource negotiation between the parties. Any contribution related to marketing are incidental. Viewers are allowed to take part in this negotiation, and explicitly define their attention space. Because active participation itself can cost extra attention, we have separated preferences as pluggable policies for predictable situations, enabling automated negotiations on behalf of the parties.

- Additionally, our approach allows interaction in real time, which means that the viewers may change their mind on the fly. Therefore, the contract can possibly be re–negotiated or even broken. We build mechanisms for these situations as well, with possible penalties.

6.1.2 Dimensions of Flexible Control

In this section, we discuss specific examples of how the approach described in this thesis offers enhanced and more flexible control to the different parties involved in making advertising decisions.

Viewers

- ***Limited decision making capacity over the advertisements.***

  Viewers are not involved in the negotiation of advertisement display in existing mechanisms. FlexAdSense allows viewer-anticipated negotiation at a fine grain: viewers can decide whether or not to view advertisements to subtract the cost of multimedia content viewing; if yes, they are allowed to decide which, when, where and how to display advertisements.

- ***Viewers' privacy.***

  A number of existing personalization techniques obtain viewers' preferences by tracing their historic interaction behaviours, which invades viewers' privacy. FlexAdSense alleviates this concern by allowing viewers to explicitly define access policies.

Advertisers

- ***Advertisement effectiveness.***

  Most advertisements cannot reach the right people and existing techniques exploit personalizing advertisements by analyzing viewers' behaviours. FlexAdSense can encapsulate these techniques when viewers do not want to make explicit negotiations. Ad effectiveness can be even higher when viewers explicitly select ads, as they normally choose ads that interest them.

- ***Difficulty in estimating advertising expenditure.***

  Because ad effectiveness is difficult to measure, the estimation for advertising expenditure in future plans becomes a problem. FlexAdSense enables viewers to explicitly choose and configure their favourite advertisements, which allows advertisers to have knowledge of each ad's spending and viewers' preferences according to their selections and configurations. Advertisers can make future based on these information.

- ***Complicated negotiation process in publishing ads.***

  Posting an advertisement is a time consuming task [55]. FlexAdSense enables viewers to define the schedule, position and many other attributes, which relieves the burden for both brokers and advertisers. Of course, advertisers are also allowed to declare their intentions by setting attribute constraints.

Brokers

- ***Dilemma of advertising decisions.***

  In existing mechanisms, brokers have to make the decision about whether or not to introduce advertising; if yes, they have to maintain the balance between content and advertising. This

problem is solved in FlexAdSense by enabling viewers to make the decision. Brokers can propose options in the circumstance of no applicable decision from viewers.

6.2 Future Work

In this section, we explore the opportunities for improving FlexAdSense and enhancing the functionality of the prototype.

6.2.1 Approach Design

1. Advertisers have traditionally played an active part in targeting advertisements to viewers; however, in FlexAdSense, they are relatively passive. One possibility is to introduce auction mechanisms, like paid placement models, where advertisers can place bids on advertising to be embedded in content selected by viewers.

2. Although we have focused on an individual viewer, an interesting direction of future exploration can be to extend the idea to dynamically changing groups of viewers. Imagine viewers entering a room with their personal agents carrying their preferences on mobile devices. Viewer agents could negotiate with each other before group preferences can be negotiated with advertisers.

3. We have considered dynamic price models for advertisements; however, they all depend on their own attributes and we did not consider the case that ads can influence other ads. Normally, the more ads displayed, the less each individual ad will be worth. Such factors can be investigated in the future. Additionally, payment to the broker may be tied to the complexity of requests received from viewers and advertisers.

6.2.2 Implementation

1. In the current version of the prototype, matchmaking is implemented coarsely as comparing two Strings. Existing personalization techniques can be planned to be investigated and combined into the prototype.

2. We carried out an admittedly preliminary analysis of the additional demand on viewer attention resulting from interacting with the system; this should be followed with a more detailed user study in the future.

3. As the performance evaluation addressing multiple brokers on one server suggested, multiple brokers can be located on one machine. It cannot only improve the rate of request being processed, but also relieve the burden of updating database. In that case, there should be

one special broker taking the responsibility of updating the database on their server. The other brokers only care about retrieving database. Another obvious opportunity for improving efficiency of our prototype lies in making updates to the replicated databases lazy. A further evaluation using more realistic workloads is desirable.

4. The current interface is built using JAVA Swing components. It is expected to implement using the structure of Browser/Server to replace Client/Server, so that viewers can enjoy these services through browsers without installing client software. Moreover, the interface can be designed in a more user friendly manner. For example, pictures of content/ads should be provided, as well as some free movie trailers.

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