The Right Format of Web Advertisement: Case Study in Iran
Payam Hanafizadeh, Mehdi Behboudi

Insights into Online Auction Market Structure of eBay in 2006-2007: A Historical Perspective
Yanbin Tu, Steven R. Clinton, Adora Holstein

Data Hiding Technique Based on LSB Matching towards High Imperceptibility
Marghny H. Mohamed, Naziha M. Al-Aidroos, Mohamed A. Bamatraf

Key Management Scheme for Cumulative Member Removal and Bursty Behavior in Secure Group Communication Using *m-ary* Tree
R. Aparna, B.B. Amberker

airiti press

GPN 2007800019
ISSN 1018-1393

MIS REVIEW Volume 18 Number 1 September 2012

MIS REVIEW
An International Journal

Vol.18 No.1 September 2012

MIS Review **Vol. 18, No. 1** Published in September 2012

Publisher: Samuel Chuen-Lung Chen

Published by: National Chengchi University, Department of Management Information Systems & Airiti Press Inc.

Editor-in-Chief: Eldon Y. Li

Executive Editor: Shari S.C. Shang

Assistant Editor: Li-Zhih Yu, Ting-Yu Chen

Printed by: Sincere Digital Printing, Co.

Cover Designer: Thomes Chen

Typesetting: Hsiao-Hsuan Wang

Publication Office:

National Chengchi University, Department of Management Information Systems
No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 116, Taiwan

Airiti Press Inc.
18F., No. 80, Sec. 1, Chenggong Rd., Yonghe District, New Taipei City 23452, Taiwan

Order Information:

Airiti Press Inc.
18F., No. 80, Sec. 1, Chenggong Rd., Yonghe District, New Taipei City 23452, Taiwan
Tel: +886-2-29266006
Fax: +886-2-22317711
E-mail: press@airiti.com

Price: NT$ 400

e-Journal: http://www.airitilibary.com

ISSN: 1018-1393

GPN: 2007800019

Printed in Taiwan

Editorial Board

Editor's Introduction

In this *MISR* issue, we are delighted to present four research papers concerning the following issues: selecting the right format of Web advertisement, insights into online auction market structure of eBay in 2006-2007, technique of data-hiding based on LSB (least-significant bit) matching towards high imperceptibility, and schemes for handling cumulative member removal and bursty behavior. The summaries of the four papers are as follows.

Payam Hanafizadeh and Mehdi Behboudi in their paper "The Right Format of Web Advertisement: Case study in Iran" develop a solution for selecting the right format of web advertisement in Iran. The study designed a new methodology based on TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) philosophy, and have defined two ideal frameworks; one for advertisement and the other one for alternatives. Accordingly, the right format of web advertisement is the advertisement that its ideal has a more similarity with the ideal of alternative. To test this methodology, the study selected 150 Iranian high-ranked websites and found that the model is working properly. The report of websites analysis is placed at the appendix.

Yanbin Tu, Steven R. Clinton and Adora Holstein in their paper "Insights into Online Auction Market Structure of eBay in 2006-2007: A Historical Perspective" extend existing research by using eBay's auction data for the Xbox game console to understand the evolution and characteristics of eBay users, and to investigate the nature of competition in this market in 2006-2007. Among others, the study finds that the Xbox game console market could be best categorized as a mix market with a dominant C2C (Consumer to Consumer) segment because it had many individual sellers. The study also discusses the theoretical contributions and managerial implications of our findings regarding three dimensions of online auction market structure, and identify future research directions.

Marghny H. Mohamed, Naziha M. Al-Aidroos, and Mohamed A. Bamatraf in their paper "Data Hiding Technique Based on LSB Matching towards High Imperceptibility" propose an efficient steganographic scheme which provides high capacity of secret data as well as imperceptibility of stego image. Using fixed number (i.e., max) as the upper limit criteria for embedding, the target pixels selected for embedding are based on the number of bits which matches between the secret data bits and the cover pixel bits. As an indicator to determine which pixel is used for embedding, the first bit is reversed (negated). The experimental results over greyscale images showed, the ability of embedding high data capacity with preserving stego image quality. Efficiency of the model is evaluated using two metrics, the PSNR (Peak-Signal-to-Noise Ratio) value as one of the evaluation

metrics, and the visual effects over the cover image as the second. Results are drawn and compared with one of the most common techniques (Classic LSB) and accordingly showed significant advancement.

R. Aparna and B.B. Amberker in their paper "Key Management Scheme for Cumulative Member Removal and Bursty Behavior in Secure Group Communication Using *m-ary* Tree" propose schemes for handling cumulative member removal and bursty behavior. The study uses *m-ary* key tree for managing the secure group and maintain only m keys at each level of the key tree. It starts with a scheme for cumulative member removal and then handles all the possible bursty behavior scenarios. It further analyzes the communication and computation costs for worst cases, and compares the costs of their scheme with the schemes proposed by Li et al. (2001) and binary key tree scheme of Zou, Magliveras, and Ramamurthy (2002). The result shows that in their scheme the number of new keys generated and encryptions performed are less compared to Li et al. (2001) and Zou, Magliveras, and Ramamurthy (2002) schemes.

We would like to thank all the authors and reviewers for their collaborative efforts to make this issue possible. Please note that the Chinese version of a paper, if any, is available online at the Airiti company website. We believe the bilingual format of paper submission would allow Chinese authors to better focus on their research process rather than being hindered by language barrier. It is our sincere wish that this journal become an attractive knowledge exchange platform for both Chinese and non-Chinese authors. Please provide your continuous support and submit your papers to *MISR*. Finally, to our loyal readers around the world, we hope you find the contents of the papers useful to your work or research.

Dr. Eldon Y. Li
Editor-in-Chief and Professor

Dr. Shari S.C. Shang
Managing Editor and Associate Professor

Department of Management Information Systems
College of Commerce
National Chengchi University
Taipei, Taiwan
Fall 2012

MIS Review

September 2012 Vol.18 No.1

Contents

Research Articles

MIS Review Vol. 18, No. 1, September (2012), pp. 1-30

The Right Format of Web Advertisement: Case Study in Iran

Payam Hanafizadeh[1], Mehdi Behboudi[2]
[1]*Department of Industrial Management, Allameh Tabataba'i University*
[2]*Department of Business Management, Qazvin Branch, Islamic Azad University*

ABSTRACT: *The purpose of this paper was to develop a solution for selecting the right format of web advertisement in Iran. The paper is conducted based on a review of the literature and scrutinizing among more than forty scholarly papers. By reviewing the literature, and developing a theoretical framework, a conceptual model was designed to examine factors explaining right format of advertisement on the internet. Expert's opinion was used to test the conceptual model and using T-student examination, have discovered that seven critical factors affect selection of the right format of the web advertisement. In order to implement the model, we designed a new methodology based on TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) philosophy. In this way, we have defined two ideal frameworks; one for advertisement and the other one for alternatives. Accordingly, the right format of web advertisement is the advertisement that its ideal has a more similarity with the ideal of alternative. To test this methodology, we select 150 Iranian high-ranked websites and found that the model is working properly. The report of websites analysis is placed at the appendix.*

KEYWORDS: *Web Advertising, Advertising Formats, Product Involvement, Advertising Classification, Advertising Audience, Advertising Strategy.*

1. Introduction

The increasing access to the Internet as an electronic media has turned it into a dynamic and user-friendly medium for advertising. As a method of marketing through communication, advertising has essentially two primary areas: Marketing whose target is communicating value to the customer (Darroch et al., 2004) and Communication which encompasses creating a united idea between a sender and receiver (Dibb & Simkin, 1991; Schramm, 1955). According to Sepstrup (1991), the ideal advertisement is the one with the highest possibility of access to a wide range of well-defined audiences (selectivity) that provides a good feedback at a low cost (reviewed by Thomsen, 1996). However, mass communication often forces the advertisers to accept a wide range of ill-defined audiences that does not provide a proper feedback for achieving a reasonable cost-effectiveness (Thomsen, 1996). This definition raises a question in the advertisers' minds: which medium has the potential to provide the advertisers with the ideal type of advertisement?

According to the The Interactive Advertising Bureau (2011), "internet advertising revenues in the U.S. hit $7.3 billion for the first quarter of 2011, representing a 23 percent increase over the same period in 2010." The share of the four major types of Internet advertising studied in this research from the total incomes was 34 percent at the end of 2008. The four major Internet advertising types are as following: (1) Display Ads (21%) including Banners, Hypertexts, and Skyscrapers; (2) Rich Media (7%) including Pop Up and Pop Under, and Interstitials; (3) Sent Emails (2%); and (4) Digital Video (3%).

Although large investments are made on Internet advertising, the advertisers and marketers are not yet aware of the effectiveness of various formats of Internet Advertisement and do not know the appropriate audience of each form. On the other hand, the great variety of Internet advertisement formats and insufficient knowledge of the advertisers have added to the complexity of online advertising activities. It is useless to recommend an advertiser to use the right format (Heinz, 2004) when he does not have an idea about right format (Burns & Lutz, 2006).

This study aims at finding the appropriate answers to the following questions:

(1) What advertising format should be developed by advertisers for different goods and services?

(2) Which ad formats do meet the needs of marketers and advertisers of a product or service?

(3) What criteria and features should be considered for advertising a certain product or service?

(4) How can we define the right Internet advertising format for a certain good or service?

By considering the report of Internet World Stats (2012), which states: the number of Iranian users has been reached to 37 million users at the second quarter of 2011, this research intends to develop a general framework to illustrate the factors determining the proper format of Internet advertising in Iran. In sum, the present study embarks on classifying various possible scenarios and selecting the most appropriate Internet advertisement format from each group.

2. Literature review

A few conceptual and qualitative Internet advertising models have been proposed such as Interactive Advertising Model (IAM) (Rodgers & Thorson, 2000), internet advertising avoidance model of Cho and Cheon (2004), the structural equation model Ko, Chang, and Roberts (2005), and avoidance from social networks advertising

Kelly, Kerr, and Drennan (2010). IAM introduces the motivations and initial reasons of entering into the Internet with the framework of two areas of user and advertiser, and then explains factors influential on processing information by the users and the output resulting from information processing. Based on the previous studies on uses and gratifications theory and Internet interaction, the structure equation model (Ko et al., 2005) tries to show the relationships among motivation of using the Internet, duration of time at a website, interactivity, attitudes, and purchase intention of online customers in a structural framework. Whereas in the IAM, the general assumptions are based on the merit of information processing in an interactive environment and are related to functional structure; this model tries to classify the different types of online advertising and recognize their features. It also attempts at finding the effective factors which shape and influence the user's attention, memory, and attitude.

The distinction between the study conducted by Rodgers and Thorson (2000) and the present study is the fact that while Rogers and Thorson have done the information processing from a customer's viewpoint, this study investigates the issue from an advertiser's viewpoint in an attempt to provide the right model for Internet advertising based on the earlier studies and investigations. The other model (Ko et al., 2005) is trying to examine the interactivity construct in terms of its antecedent and consequent and is an attempt to illustrate the interaction between the user and the advertisement. Previous investigations mostly reflect the general attitude toward Internet ads (Ducoffe, 1996; Previte, 1998; Scholsser, Shavitt, & Kanfer, 1999) different types of Internet advertising (Burns & Lutz, 2006), and differentiation between pleasant and objectionable products advertising methods (Heidarzadeh, Behboudi, & Sadr, 2011). Li and Leckenby (2004) introduced the relation between the content of a website and Internet advertising while Sundar and Kalyanaraman (2004) investigated the effects of animated banners' speed and found fast-animations to be more attractive. According to these two studies, fast animations can elicit greater psychological arousal compared to slow-animations.

Most of the researches conducted on the effectiveness of Internet advertising are concerned with step(s) taken after selecting an Internet advertising format. In other words, the assumption is that users are already exposed to an advertisement. The question is: how should the impact of advertising be enhanced to yield a higher click-through rate (Burns & Lutz, 2006; Sundar & Kalyanaraman, 2004). The present study, however, takes some neglected aspects of Internet advertising formation into account. It is believed that the specifications of a given product or service shall be considered a priori to decide about a proper advertising format and the next step is the study of ad impact and it effectiveness in increasing the click rates. Hence, it will be tried to identify the main actors in the context of advertising development so that marketers can select the right advertisement format.

3. Theoretical framework

3.1 Product involvement

Product involvement means "how the product fits into that person's life (Cushing & Douglas-Tate, 1985, p. 243)." From an information processing perspective, involvement is related to the accuracy of elaboration and the amount of attention dedicated to advertising messages (Gardner, Mitchell, & Russo, 1985). Involvement is also influential on processing, keeping, and retrieving information (Salmon, 1986).

Involvement, particularly product involvement, has been proven to be a major determinant of the consumer's behavior and response to a certain ad (cf. Celsi & Olson, 1988; Laurent & Kapferer, 1985; Zaichkowsky, 1985). When product involvement and complexity are high, consumers process advertisements more actively (Warrington & Shim, 2000), devote more time and cognitive effort to the advertisements (Celsi & Olson, 1988) and focus more on the product-related information of the ads (Celsi & Olson, 1988; Petty, Cacioppo, & Schumann, 1983). This is also reported by (Cacioppo & Petty, 1984; Petty et al., 1983).

When product involvement is low, consumers are less likely to process brand written message claims than advertisement execution cues (Chattopadhyay, 1998). This is due to the fact that brand written message claims require more cognitive efforts to be processed compared to the advertisement execution elements (Chattopadhyay, 1998) and consumers are not motivated to devote much cognitive effort to low-involvement products (Warrington & Shim, 2000). Consumers are more willing to devote their cognitive effort to high-involvement products and are then more likely to process brand message claims of advertisements (Dahlén, Malcolm, & Nordenstam, 2004).

Moreover, product involvement affects the design of advertising messages. Advertisements of low or high-involvement products differ in advertising appeals. Research findings also support the idea that rational advertising appeals can help marketing high involvement products, whereas advertising of emotional appeal has been proved to be good for low-involvement products (Wills, Samli, & Jacobs, 1991). In his study, Vaughn (1980) takes four types of involvement into account and believes them to be the determining features of a given product or service to be considered when selecting the right advertising. Our first hypothesis is based on this viewpoint.

Hypothesis 1: Grouping products based on four types of involvement has a positive impact on determining the right Internet advertising format.

3.2 Audiences

The way the Internet is used has a considerable effect on the users' interest and excitement to follow online ads and shopping. Furthermore, the type of responses users provide to an advertisement is, to a large extent, based on their beliefs and attitudes towards the Internet (Bruner & Kumar, 2000). The time users spend on Internet is a determining factor in forming such beliefs and perceptions. In this respect, Internet users are divided into three groups; namely, Heavy users, Medium users, and Light users (Korgaonkar & Wolin, 2002). Heavy users include PC owners using Internet at their homes or offices, as well as well-educated people using Internet at the universities (Anderson et al., 1995), men (Sheehan, 1999) who earn higher income, (Katz & Aspden, 1997) and people who use Internet excessively for their occupational purposes (Korgaonkar & Wolin, 2002). A heavy user spends up to five hours per day on the Web and usually visits three websites in an hour. The heavy users believe Web advertising to be amusing, enjoyable, informative, trustable, and helpful. They also feel that internet advertising decreases expenses and are necessary. They have a very positive attitude toward Internet advertisement. The medium users are among the most educated and the highest income users of internet. Compared to the heavy users, they are less likely to believe that web advertising is informative, amusing, enjoyable, informative, trustable, and helpful; rather, they believe that it is boring. The medium users spend up to three hours per day on the Web, mostly visit websites of their own interest and visit 2 or 3 websites in an hour (Korgaonkar & Wolin, 2002).

The time spent by the light users on the web is about an hour and no clear-cut usage pattern exists for this group in terms of the time they spend each day on the web. The light users are placed in the second position in terms of both income and education (Korgaonkar & Wolin, 2002). Classifying users into 3 groups have been confirmed by other studies, too. For example, Bruner (2006) conducted a study in which users were divided into three groups of heavy, medium, and light according to the number of times they used internet monthly. Heavy users were those who used internet 19 times, those using internet 11 to 19 times were the medium users, and those using internet less than 11 times were classified as light users. When releasing an online advertising, the advertiser should be mindful of the users' motivations of going online because users have distinctive motivations in surfing a given website. In fact, people use Internet not only to retrieve information, but also to entertain themselves (Ko et al., 2005; Korgaonkar & Wolin, 2002). Marketers' task is recognizing the right audience, because each audience has a unique behavioral reaction to Internet (Ko et al., 2005). Therefore, regarding the distinctive perceptual backgrounds of the Internet users and audience, providing one same Internet advertising format is likely to have different impacts on these groups. A hypothesis was developed on this basis as follows:

Hypothesis 2: Segmenting and targeting audiences based on three types of audiences has a positive impact on determining the right Internet advertising format.

3.3 Advertising type

According to Thorson (1996), all advertisements can be classified into one of the five basic categories, including: product/service, public service announcement (PSA), issue, corporate and political. Each of these ad types represents the general structure in which an ad is seen; that is, the ad type itself provides an indicator of the types of possible consumer responses. Ad type will often determine the types and the extent of the cognitive tools, as outlined earlier, that audiences will use. For example, attention may be heightened by ads that promote a political candidate who is strongly favored by the consumer. In the same vein, memory for an issue ad may be poor in instances where the ad promotes a health or public message that is irrelevant to the user. It is known from traditional advertising research that PSAs outperform other types of ads in terms of credibility and perceptions of social responsibility (Haley & Wilkinson, 1994). The general ad type will predict whether and how much cognitive effort is devoted to the task of processing online ads. Ad type will also interact with the user's motives to influence outcomes, or consumer responses. Based on this point, the third hypothesis is suggested as follows:

Hypothesis 3: Grouping advertisements based on five types of advertising has a positive impact on determining the right Internet advertising format.

3.4 Pull or push strategy

A pull strategy involves those manufacturers who use advertising and consumer promotion as a means to persuade the intermediaries to order the product. This is especially appropriate when there is a high brand-loyalty and a high-involvement in the category; people understand brand differences and choose before they go to the store (Kotler, 2001, p. 279). When users have high level of loyalty, they tend to look for the corporate product. Therefore, the only thing a manufacturer needs in such occasions is to design a website and wait for its users (Turban et al., 2006, pp. 172-173). According to this strategy, websites or other properly designed ads await customers' visit. Depending on their tendency toward the products and services, customers search through the internet to find relevant information (Turban et al., 2006, p. 171). However, when companies provide products or services that are rather unknown to the customers, or when customers are not motivated enough to follow the ads, push strategy is used to attract customers by the companies. In a push strategy, the manufacturer uses sales force and trade promotion to induce intermediaries to carry, promote, and sell the product to end users. In this situation, various tools are applied to push the users toward a company's website. On this basis, another hypothesis is formed:

Hypothesis 4: Selecting appropriate type of advertising strategy has a positive impact on determining the right Internet advertising format.

3.5 The status of audience's ICT condition

In some countries, like developing ones, the level of users' access to Internet is not the same as Western countries. According to the report of Iranian Ministry of Telecommunication and Information Technology (ICT.com, 2007), in this country the low-rate connection with the transfer rate of 56 kbps is mostly suitable for home connections and high-rate connection with the transfer rate of 128 kbps is mostly used by organizations and institutions. Since copper wires are used for the connections in this country, faster rate of data transfer is not achievable. The fifth hypothesis mentioned below is based on the fact that different types of advertisements require different bandwidth:

Hypothesis 5: The ICT status of target market is determinant in the selection of the right Internet advertising format.

In this study, the data transfer at the rate of 128 kbps is referred to as "high Internet speed" which is shown by "H," while data transfer at the rate of 56 kbps is referred to as "low Internet speed" illustrated by "L." However, recently higher rates of data transfer have been achieved in these countries as a result of using fiber-optic cables and sometimes data can be transferred at the rate of several mega bytes per second. They were not included in this study for two reasons: first, it is not cost-effective to develop and expand fiber-optic networks for home users. Second, in the universities and organizations using fiber-optic networks, the high number of users reduces the rate to less than 100 kbps.

3.6 Advertising features

So far, the effects of external features on the Internet advertising formats have been discussed. Nevertheless, the advertisement itself has some features that seem to affect the selection of the right Internet advertising format (Holbrook & Lehmann, 1980). These features or specifications are divided into 2 categories; subjective features and objective ones. Subjective features include Typeface, Appeal Type, Number of Sentences, Movement and Interactivity, Sound Level, Sound Clarity, Telepresence, Realism, and Number of Choices. Objective Features, on the other hand, include Excitement, Flow, Current Information, Attitude toward Ad, Friendly Navigation (Thorson & Leavitt, 1986, reviewed by Rodgers & Thorson, 2000). On this basis, the following hypotheses are formed:

Hypothesis 6: Subjective features of advertising are determinant in the selection of the right Internet advertising format.

Hypothesis 7: Objective features of advertising are determinant in the selection of the right Internet advertising format.

In this study, objective features such as typeface, appeal type, movement and interactivity, as well as subjective features such as attitude toward Ads are considered. Although Thorson and Leavitt (1986) included more features under both subjective and objective categories (reviewed by Rodgers & Thorson, 2000), they are not covered in this study as they are very stylistic and subject to variation based on either the advertising company, or the advertiser's ideas.

4. Conceptual model

Based on the literature review, leading to the development of the seven mentioned hypotheses, the conceptual model is designed for the selection of the right format of web advertisement (Figure 1). The model is a scoring process. In other words, it is initiated with the product or service intended to be advertised. The first influential factor in this regard is the product or service intended to be advertised. The next steps are determination

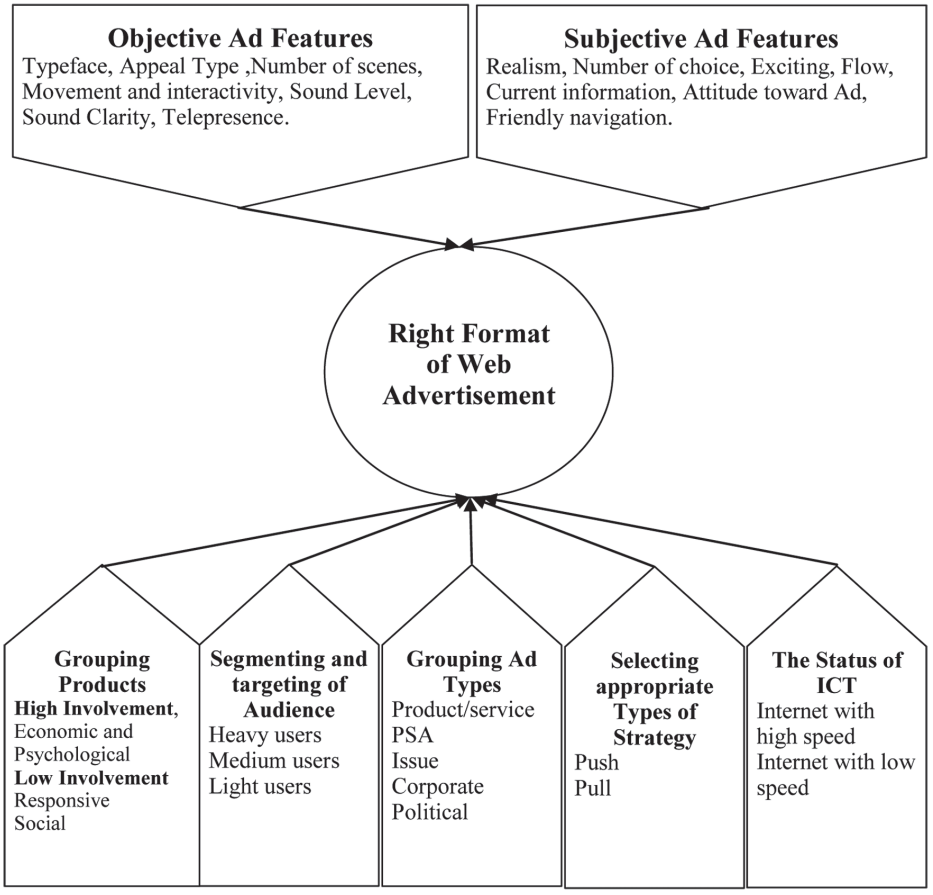


Figure 1 Right Format of Web Advertisement

of the target audience, the type of product/service to be advertised, the most proper advertising strategy, the ICT status, and finding out the audience's Internet connection speed. After calculating the scores allocated to the external variables, the process focuses on two internal advertising variables. This study deals with the type of online ad suitable for a given product/service.

5. Methodology

5.1 Participants

The participants of this study included the websites and businesses of Iran. There were two reasons for selecting Iran for this purpose. First, so far, no study has been conducted on the area of Internet advertisement and it is a new field of research in the world, and particularly, in Iran and its data can be useful for future studies. The second reason related to the research team and its research record in Iran. Since this team is active for a long time in the area of e-commerce and on-line advertisement in Iran, they have comprehensive information on the situation of e-business in this country, which is an advantage for selecting Iran for this study.

5.2 Sample and data collection

Non-random sampling method was utilized for this purpose (Behboudi, Jalili, & Mousakhani, 2011). Efforts were made in a widespread manner to find email IDs of Marketing, DBA (Doctorate of Business Administration), MBA, IS (Information System) and E-commerce experts. Most of the experts selected were either jury members of various journals or faculty members teaching at universities. Ultimately, more than 1,500 IDs belonging to international experts and 200 IDs belonging to some Iranian experts were identified (which itself deemed a valuable asset for future studies). On the other hand, a questionnaire was designed in the form of a website (IARFM.COM) and email invitations including a hypertext were sent to the mentioned experts to motivate them to participate in the survey. From 1,700 experts receiving the invitations, 370 replied by filling the questionnaires. This shows a responding rate of about 0.217. The reason for this low rate of answering is the design of questionnaire website, because it was designed in a way so that each IP address could only take part in the poll just for one time in order to avoid repetitive replies. Thus, from among the experts of the same university who used one IP address, only one could inevitably express his opinion. This research limitation resulted in the low reply rate. Since 6 out of the 7 hypotheses of this article are based on international studies performed in other domains, and the study was performed in Iran at that time, the opinions of the Iranian experts were regarded weightier, to help aggregate their views in the study. As to the third hypothesis referring to the users' type, since the

classification presented was specifically in line with the American society, a parallel survey was developed to study and classify the Iranian users. Encompassing all conditions ruling Korgaonkar and Wolin Study (2002), this survey enquired as to the number of weekly visits paid to the web. The study revealed the same results as those of Korgaonkar and Wolin Study (2002). Based on these results, the Iranian users like users of other parts of the world are divided into three groups: heavy users, medium users, and light users. The finding was included in the questionnaire so the experts could assess it as true or false.

5.3 Validity and reliability

Initially, a 5-item questionnaire was developed and piloted, using small groups of experts who volunteered to provide feedback. For the final instrument several questions were revised for clarity. Internal consistency using Cronbach's alpha resulted in a reliability estimate of 0.84 for the total 7-item scale, where 0.70 is considered adequate. All relevant documentations are accessible for future researchers. After collecting the questionnaires -- as illustrated in Tables 1 and 2 -- although a strict assessment was selected ($\mu \geq 4$), all experts confirmed the research. After confirmation of the features, a core ideal framework was designed based on TOPSIS (Technique for Order Preference by

Table 1 Product Student's T test Statistical Computing

	x	f	fx	$(x - \bar{x})^2$	$f(x - \bar{x})^2$	Statistics
	1	7	7	11.2225	78.557	$\bar{x} = 4.35$
	2	4	8	5.5225	22.09	Sx = 0.85
Product/Service Types	3	37	111	1.8225	67.432	Critical value = -1.65
	4	124	496	0.1225	15.19	T = 7.92
	5	198	990	0.4225	83.655	
		370	1,612		266.925	

Table 2 Hypotheses Validity and Reliability

$\mu \geq 4$	Examination Statistics: $t_{student}$					
Hypothesis	N	M	Sx	Critical Value	Examination Statistic	Results
Product/Service Types	370	4.35	0.85	-1.65	7.92	Accept
Advertising Types	370	4.165	0.89	-1.65	3.574	Accept
Audience Types	370	4.3	0.815	-1.65	7.08	Accept
Strategy Types	370	4.03	1.08	-1.65	0.53	Accept
Situation of ICT	370	3.96	1.125	-1.65	-0.68	Accept
Ad Subjective Features	370	3.93	1.19	-1.65	-1.113	Accept
Ad Objective Features	370	4.11	0.945	-1.65	2.24	Accept

Similarity to Ideal Solution) to compare the alternatives intended to be used as a tool for the selection of the right Internet advertising format. TOPSIS method is a multi-criteria decision making approach based on farness from and closeness to the ideal. It ranks the solutions by defining the main and subsidiary ideals. According to TOPSIS philosophy, a solution is considered proper if it is closest to the main ideal solution and furthest from the subsidiary solution. The authenticity of these findings has been verified in previous studies (Hanafizadeh, Moosakhani, & Bakhshi, 2009).

6. Defining methodology

In order to select the right Internet advertising format, first, the advertising core ideal framework should be designed according to the confirmed features; i.e., the features of the product or service, and the features of the advertisement itself. This framework serves as a criterion to evaluate the features of the occurred scenario and the possible advertising alternatives. It is noteworthy that the term "Scenario" here refers to a product/service about which the advertiser tends to send information to his potential customers (i.e., to advertise). To advertise a scenario, it is first located within this framework to identify its ideals. On the other hand, this framework serves as a criterion to show the ideal scenario of any given advertising alternative (Table 3). In fact, it identifies the appropriate type of advertising for a given scenario (product or service). Later, this scenario is compared to the ideals of the main advertising alternative and the closest advertising type is selected as the right Internet advertising format.

6.1 Elements of the core ideal framework

You may find the details of the five features (involvement, audience, ad type, strategy, and ICT status) in the "Hypotheses" section. The advertising features include five features, four of which (appeal, interaction, movement, and size) are categorized under objective features, while "attitude toward ads" belongs to the subjective category. These features are set as the base of making distinction among various types of Internet advertising. Therefore, each has been elaborated in detail under different Internet advertising type. This study solely deals with the appeal type, because it is directly related to the customers' type of involvement with the product or service. Appeal is basically

Table 3 Core Ideal Framework

Other Features					**Ad Features**					**Product**
ICT	Strategy	Ad Type	Audience	Invol-vement	Attitude	size	Intera-ctive	Anim-ation	Appeal Type	
										Ideal

divided into two groups: emotional factors, represented here by "E," and rational factors represented by "R." As mentioned earlier, by advertising products and services of low involvement, customers can be affected through applying emotional factors; while by advertising products/services of high involvement advertisers may influence their audience through applying rational appeals.

7. Internet advertising formats

As mentioned earlier, the four types of Internet advertising discussed here are Display Ads (including banners, skyscrapers, and hypertexts), Rich Media (including Pop Ups and interstitials), Sent E-mails, and Digital Video. This section elaborates each type explaining the distinctive features of each. Furthermore, each advertising type is evaluated based on the advertising criteria including the Appeal Type, Movement and interactivity, Typeface, Attitude toward Ad, Strategy, audience, involvement, ICT status, and the type of advertisement, which have already been mentioned under the "Main Framework Elements."

7.1 Banners

A banner typically appears as rectangular-shaped box located at the top, either side, or foot of the page (Faber, Lee, & Nan, 2004). It enables consumers to connect to the advertiser's website by clicking on it (Briones, 1999). At present, two major banner formats exist: the static and the rich media (The Interactive Advertising Bureau, 2000). The static banners are interactive but stationary and generally appear in the size of 2.5 cm × 12.5 cm or smaller. Rich media banners, on the other hands, are more interactive (Briones, 1999). Banner advertisements aim at evoking click-through at least for high-involvement (Dahlén, 2002; Dahlén & Bergendahl, 2001; Dahlén, Ekborn, & Mörner, 2000). Banner is the smallest Internet advertising format (usually 468 × 60 pixels). Efforts made to tempt people to click on such ads by sending misleading messages have raised a sense of dislike in the consumers toward this format. Although the information included in a banner is usually limited to the brand name and a brief slogan, it can serve as a mean to improve brand awareness and reminder (Briggs & Hollis, 1997; Faber et al., 2004). However, audiences cannot interact with it and, hence a banner is neutral from this point of view. Therefore, banners seem to be effective for those products whose owners apply pull strategy and try to enhance their customers' awareness by using banners (Bruner, 2006; Dahlén et al., 2004). Due to their low file size, banners do not require a high bandwidth; the available bandwidth of 56 kbps seems proper to display and view these ads (Table 4).

7.2 Pop ups

Pop-ups usually appear on a separate window at the top of the page content. The pop-

Table 4 Banner and Pop up Core Ideal Framework

Other Features					Ad Features					Features / Alternatives
ICT	Strategy	Ad Type	Audience	Involvement	Attitude	size	Interactive	Animation	Appeal Type	
L	Pull	ALL	H, M, L	H_1, H_2	-	□	□	□	R	Banner
H	Push	ALL	L	L_1, L_2	-	+	□	+	E	Pop up

up window does not disappear before the user closes it voluntarily. A more recent study reveals that pop-up ads are irritating and annoying to the users (Edwards, Li, & Lee, 2002; Faber et al., 2004). Negative sentiments raised in this regard are due to the disruption that such ads cause for the users when they are engaged in a specific activity on the web.

Since pop-ups have a high rate of movement, they are categorized under the category of large Internet advertising types because the smallest pop-up is 250 × 250 pixels, while the largest one may be 550 × 480 pixels (The Interactive Advertising Bureau [IAB], 2007). Pop-up size and movement are so important because bigger size and higher rate of movement result in higher number of clicks. From an interaction point of view, a pop-up is designed to lead the audiences to a certain website, without providing explanation about the target product/service. In fact, pop-ups provide their audiences with no interactive information.

Pop-ups appeal mostly to light users, first because such users have little information about the advertising types, and second because they get online basically for entertainment. Such audiences do not have any particular query (Bruner & Kumar, 2000), thus they react to appealing objects and are more influenced by emotional appeals rather than rational ones (Korgaonkar & Wolin, 2002).

7.3 Interstitials

Interstitials are considered annoying (Cho, Lee, & Tharp, 2000). They cover the whole page (Rodgers & Thorson, 2000) and users have a little control over them because unlike pop-ups, there is no "exit" option to stop or delete an interstitial. However, customers show a more positive attitude towards such ads because they are bigger than pop-ups and provide customers with more information and are thus easier to interact with.

Just like pop-ups, interstitials can effectively advertise products and services which are unknown to users and push strategy is applied to provide the required information. Interstitials, just like pop-ups, have a lot of movements due to employing rich media technology. They also apply numerous appealing and emotional factors to influence the users. Audiences of an Interstitial, as mentioned above, are primarily light users because this group is more prone to emotional appeals. Moreover, this type of advertising suits

those users who have access to a connection speed of 100 kbps.

7.4 Skyscrapers

Skyscrapers are the most popular Internet advertising format (IAB, 2007). They are considered as big Internet advertisements (600 × 120 pixels). Skyscrapers are especially effective for advertising products and services of high customer involvement. Since they sit on the right side of the webpage, the information they provide mostly include the companies' brands and logos. Because customers look for products and services of high involvement rate, they interact with skyscrapers properly. A skyscraper contains a lot of GIF files and animations, and its background color constantly changes to attract the users' attention. Skyscrapers are more appealing to heavy and medium users who use Internet due to highly rational and emotional motives. These people surf the Internet to find their targets. Skyscrapers are effective for advertising familiar brands. Advertisers with such products should use pull strategy in their advertisements. Internet connectivity rate of 56 kbps seems to be enough for users exposed to skyscrapers.

7.5 Hypertexts

Hypertexts come under the oldest and cheapest category of Internet advertising formats. They appear within the content of WebPages in the form of a highlighted text. Hypertexts are interactively neutral because most of the time they include only one or two words, or a relatively short phrase. Since the only things that users see are a number of words possibly related to the search option, a hypertext is not interactive (Hanafizadeh & Behboudi, 2012, p. 81). Hypertexts are neutral from the typeface and movement points of view, as they are offered in the form of a text and might be ignored by some users. The required speed, from the ICT point of view, is 56 kbps. Heavy users and high involvement products are potentially the best targets (Hanafizadeh & Behboudi, 2012, p. 78; Salmon, 1986). Through employing an inexpensive pull strategy and locating the hypertexts in frequently visited websites, the product owner may facilitate the users' access to their websites. Eventually, since hypertexts play an important role in decreasing the advertising expenses and do not appear to be disruptive, users have a very positive attitude toward them (Hanafizadeh & Behboudi, 2012, p. 78).

7.6 Email advertising

Advertising through E-mail is one of the major instruments of push strategy. The targets of this method are mainly middle users and heavy users because light users rarely tend to check their mailboxes (Hanafizadeh & Behboudi, 2012, p. 81). The lowest connectivity speed, 56 kbps, seems to be enough for this method. Movement and size has nothing to do with emails because these two are specified for those ads which occupy some spaces of the web. Email advertising is appropriate for push strategy. However,

the follow up emails trigger user's emotional, and not rational, involvement, first, due to the large number of spam letters and lack of trust on the emails, and second, because of the effectiveness of appeal factors. In e-mail advertising, the emotional motives play a determining role. Therefore, once appealing, they persuade users to follow up e-mails, otherwise they will be easily ignored by the user. Therefore, this method provides a very low level of rational interaction. The attitude toward e-mails is positive and E-mails are very popular with users (International Data Corporation, 2002). Moreover, studies reveal that Internet users are keen on receiving e-mails and being informed (Intermarket Group, 2004) and hence, tend to fill application forms on the web quite often.

7.7 Digital video

This method has successfully shifted from TV to the Net. However, both the advertisers and the consumers contribute to controlling it (Hanafizadeh et al., 2012). Digital video has a very high interaction rate as they can be recalled and analyzed as long as the maneuvers carried on the logo of the advertising company. Customers have a very positive attitude toward this method due to its dynamism and appealing images. According to a study carried out by Jupiter Systems (2005), compared with text-type advertising, video advertising has a deeper effect on the customers' attitude. Video advertising is more influential on light and medium users than heavy users due to the emotional appeals. High-speed Internet connections are required for this type of advertising and it is appropriate for unknown products and services. Video advertising is used both for pull and push strategies.

7.8 The variables of the model

The model includes two groups of features presented below (Table 5):

The "R" representing "rational appeal" is related to those products with which the customer has a high rate of mental involvement and gathers a lot of information to buy them.

The "E" representing the "emotional appeal" is related to those products with which the customer has a low rate of rational involvement and purchases only due to emotional motives.

The "□" stands for those features that do not apply to the option or have a zero value.

The "-" sign stands for features of negative value.

The "+" sign stands for features of positive value.

H_1 and H_2 stand for high customer-product involvements. H_1 stands for those ration-based purchases (like buying furniture), while H_2 represents emotion-based purchases

Table 5 Core Ideal Framework Based on 10 Features and 7 Alternatives

Features / Alternatives	Ad Features					Other Features				
	Appeal Type	Anima-tion	Interac-tive	Size	Attitude	Involve-ment	Audi-ence	Ad Type	Strategy	ICT
Banner	R	□	□	□	-	H_1, H_2	H, M, L	ALL	Pull	L
Pop up	E	+	□	+	-	L_1, L_2	L	ALL	Push	H
Interstitial	E	+	+	+	-	L_1, L_2	L	ALL	Push	H
Skyscraper	R	+	+	+	+	H_1, H_2	H	ALL	Pull	L
Hypertext	R	□	□	□	+	H_1, H_2	H	ALL	Pull	L
Email Ad	E	□	□	□	+	L_1, L_2	H, M	ALL	Push	L
Digital Video	E	+	+	+	+	L_1, L_2	H, M	ALL	Push, Pull	H

(like buying jewelry or cosmetics).

L_1 and L_2 stand for low customer-product involvements both from a logical and an emotional point of view.

H, M, L stands for "Heavy" user, "Middle" user, and "Light" users, respectively.

In ICT section, L represents "low connection speed" and H represents "high speed."

When the ideal framework for each advertising alternative is defined (Table 3), a comparison is made between the scenario and each individual alternative to choose the most appropriate framework for the product.

8. Case study

Here "Job search" was the study case. Job search ads are categorized under "issue ads (Devlin, 1995)."

(1) Involvement: high

(2) Appeals: rational and logical

(3) Audience type: all users

(4) Ad type: issue

(5) Strategy: pull

(6) ICT: lowest connection

(7) Attitude: negative

(8) Interactivity: positive and high

(9) Size and animation: neutral

The scenario presented in Table 6 is considered as the core ideal framework for job search based on 10 variables. At this moment, this ideal framework is compared to the individual ideals of all advertising items (Table 5), and the alternative, having the most corresponding ideals with the scenario ideal, will be selected as the right Internet advertising format for the job search.

As illustrated in Table 7, banner advertisements are closest to job search scenario with only one difference. According to this model, banners proved to be the most effective type of Internet advertising methods for job searches. To evaluate and assess the accuracy of the model, a content analysis was performed on the Persian weblogs and websites to observe and record the job search ads. Eventually, the proposed model was strongly confirmed because the majority of job search ads were in form of banners.

Considering the fact that banner may be the most common format of Internet advertising and since relying merely on one advertising format may not be reliable to prove it as an efficient format, another case study was developed. Just as with the most right banner scenarios, an assumption emerged. According to this assumption, the skyscrapers were assumed to be the best solutions for advertising a film due to customers' high emotional involvement. The proper strategy to be used is Pull strategy because users look for it. In this case, customer-product interaction is high, because users scrutinize the ad looking for the names of the actors and the director. They may even refer to the website to seek additional information. As to ICT status, minimum speed can satisfy the demand. To apply the model, an approach was defined. First, a visit was paid to *Webgozar.com*, an Iranian source of statistics providing monthly reports introducing websites most-visited by

Table 6 Core Ideal Framework for Job Search

Other Features					**Ad Features**					**Job Search**
ICT	Strategy	Ad Type	Audi-ence	Involve-ment	Attitude	size	Interac-tive	Anima-tion	Appeal Type	
L	Pull	Issue	H, M, L	H_1, H_2	-	□	+	□	R	Ideal

Table 7 Core Ideal Framework for Banner

Other Features					**Ad Features**					**Banner**
ICT	Strategy	Ad Type	Audi-ence	Involve-ment	Attitude	size	Interac-tive	Anima-tion	Appeal Type	
L	**Pull**	**ALL**	**H, M, L**	**H_1, H_2**	-	□	□	□	R	Ideal

users within the past month. It also provides a list of most-visited websites by users within a year. Then, a list included 150 most-visited websites within the past year. Next, entering into each URL, the relevant data were collected (as stated in Appendix). First, the website was checked to make sure whether it accepts the ad or not, next the type of product to be advertised and the advertising format were checked. The findings revealed that from 150 websites, there were 111 accepted ads. 65 had already accepted film advertising, 45 of which accepted ads of skyscraper format, 20 displayed ads of banner format, and the remaining were as follow: (1) filtered and damaged ones = 14, (2) Skyscraper = 6; Banner = 21; and Bottom = 5 which displayed ads of some other products. According to the content analysis, the skyscraper is the most frequently used format (the right format) of film advertising, thus it can be concluded that the model is functionally efficient. Because according to Enabz.com (2010) one of the five top rank industries in the context of e-commerce is film selling.

9. Discussion

The objective of this study was to provide some insights on Internet advertising formats in Iran. In pursuing this goal, we developed a conceptual model by scrutinizing previous research in the marketing and advertising fields. A questionnaire was performed to validate identified factors. By this work, we found seven factors including product involvement, advertising types, audience types, strategy types, situation of ICT, ad subjective features, and ad objective feature which successfully explain the right format of web advertisement.

The present study introduces a potential framework that helps to classifying the possible scenarios for different alternatives. In other words, based on the main ideal framework, decisions can be made on what advertising format suits which scenario best. Advertisement likelihood scenario is the closest answer to reality. For instance, in the above-mentioned case study, banners seen to be the best advertising method once the ideal framework was defined. On this basis, one classification may be as follows:

Banner is the right format of web advertisement for scenarios (products that are supposed to advertise) that have following requirements:

(1) Have a high involvement and need to high information processing.

(2) Need to use pull strategy in advertising.

(3) Banner can be used for all type of advertisements (product/service, issue, public service announcement, corporate and political).

(4) Banner can be used for all types of users (heavy, medium, and light users).

(5) Banner is more appropriate for those products that consumers have a negative attitude toward them.

(6) Banner is appropriate for those products that their advertising do not need to have interaction, big size and animation.

(7) Banner is good choice when marketers want to use rational appeals.

Banner is the appropriate advertising alternative for those scenarios identified with these features. Actually, this classification can be equally applied to six other types of Internet advertising formats. Each Internet advertising method has its specific characteristics that make it the best advertising alternative for the scenarios categorized in this group.

10. Conclusions and recommendations

The study provides a framework to illustrate the right Internet advertising format. To identify the right Internet advertising format, this study proposed a general framework using the TOPSIS approach. Applying the proposed model, the likelihood of ideal group of advertising format for different types of products/services was determined. The hypotheses were evaluated by international and Iranian experts. In order to complete and extend this research, further researches can be performed on the ad types and the way they contribute to choose the right Internet advertising format.

In order to answer to question; who can enjoy the achievements of this study? It can be concluded that the study consolidates the findings of previous studies and introduces the main pillars of making decision about the selection of the right Internet advertising format. This text opens a window for researchers through which they may observe the various branches of subjective features model (ICT situation, strategy type, audience type, ad type, product type, and ad and subjective objective features) effective on making decisions as to Internet advertising, and develop the required delves. It is noteworthy that the main criteria included in this text were extracted from 40 sources. Business firms tend to use Internet as an advertising medium and Internet may use this model to select an advertising format that suits their product/service best. They may also develop their advertising activities based on the defined criteria to improve the efficiency of their ads. Although, this study provide the main foundation of internet advertising in Iran, more comprehensive studies seem to be required to assess the effect of advertising method on the selection of the right Internet advertising format.

References

Anderson, R.H., Bickson, T.K., Law, S.A., & Mitchell, B.M. (1995) *Universal Access to Email: Feasibility and Societal Implications*, Rand, Santa Monica, CA.

Behboudi, M., Jalili, N., & Mousakhani, M. (2011) 'Examine the commercialization research outcomes in Iran a structural equation model', *International Journal of Business and Management*, Vol. 6, No. 7, pp. 261-276.

Briggs, R. & Hollis, N. (1997) 'Advertising on the web: Is there response before click-through?', *Journal of Advertising Research*, Vol. 37, No. 2, pp. 33-45.

Briones, M. (1999) 'Rich media may be too rich for your blood', *Marketing News*, Vol. 33, No. 7, pp. 4-5.

Bruner, G.C. & Kumar, A. (2000) 'Web commercials and advertising hierarchy-of-effects', *Journal of Advertising Research*, Vol. 40, Nos. 1/2, pp. 35-42.

Bruner, R.E. (2006) 'Best practices for optimizing Web advertising effectiveness', available at http://www.Doubleclick.Com/Insight/Pdfs/Dc_Bpwp_0605.Pdf (accessed 21 March 2012).

Burns, K.S. & Lutz, R.J. (2006) 'The function of format: consumer responses to six on-line advertising formats', *Journal of Advertising*, Vol. 35, No. 1, pp. 53-63.

Cacioppo, J.T. & Petty, R.E. (1984) 'The elaboration likelihood model of persuasion', in Kinnear, T.C. (Ed.), *Advances in Consumer Research Volume 11*, Association for Consumer Research, Atlanta, GA, pp. 673-675.

Celsi, R.L. & Olson, J.C. (1988) 'The role of involvement in attention and comprehension processes', *Journal of Consumer Research*, Vol. 15, No. 2, pp. 210-224.

Chattopadhyay, A. (1998) 'When does comparative advertising influence brand attitude? The role of delay and market position', *Psychology and Marketing*, Vol. 15, No. 5, pp. 461-475.

Cho, C.-H. & Cheon, H.J. (2004) 'Why do people avoid advertising on the internet', *Journal of Advertising*, Vol. 33, No. 4, pp. 89-97.

Cho, C.H., Lee, J.G., & Tharp, M. (2000) 'Advertising responses to different forced exposure levels on the www', in Shaver (Ed.), *The Proceedings of the 2000 Conference of the American Academy of Advertising*, American Academy of Advertising, East Lansing, MI, p. 148.

Cushing, P. & Douglas-Tate, M. (1985) 'The effect of people product relationships on advertising processing', in Alwitt, L.F. & Mitchell, A.A. (Eds.), *Psychological Processes*

and Advertising Effects: Theory, Research, and Applications, Lawrence Erlbaum Associates, Hillsdale, NJ, pp. 241-259.

Dahlén, M. (2002) 'Thinking and feeling on the World Wide Web: the impact of product type and time on World Wide Web advertising effectiveness', *Journal of Marketing Communications*, Vol. 8, No. 2, pp. 115-125.

Dahlén, M. & Bergendahl, J. (2001) 'Informing and transforming on the Web: an empirical study of response to banner ads for functional and expressive products', *International Journal of Advertising*, Vol. 20, No. 2, pp. 189-205.

Dahlén, M., Ekborn, Y., & Mörner, N. (2000) 'To click or not to click: an empirical study of response to banner ads for high and low involvement products', *Consumption, Markets and Culture*, Vol. 4, No. 1, pp. 57-76.

Dahlén, M., Malcolm, M., & Nordenstam, S. (2004) 'An empirical study of perceptions of implicit meanings in World Wide Web advertisements versus print advertisements', *Journal of Marketing Communications*, Vol. 10, No. 1, pp. 35-47.

Darroch, J., Miles, M.P., Jardine, A., & Cooke. E.F. (2004) 'The 2004 AMA definition of marketing and its relationship to a market orientation: an extension of Cooke, Rayburn, & Abercrombie (1992)', *Journal of Marketing Theory and Practice*, Vol. 12, No. 4, pp. 29-38.

Devlin, L.P. (1995) 'Political commercials in American presidential elections', in Kaid, L.L. & Holtz-Bacha, C. (Eds.), *Political Advertising in Western Democracies: Parties and Candidates on Television*, Sage, Thousand Oaks, CA, pp. 186-205.

Dibb, S. & Simkin, L. (1991) 'Targeting, segments and positioning', *International Journal of Retail and Distribution Management*, Vol. 19, No. 3, pp. 4-10.

Ducoffe, R.H. (1996) 'Advertising value and advertising on the Web', *Journal of Advertising Research*, Vol. 36, No. 5, pp. 21-35.

Edwards, S.M., Li, H., & Lee, J.-H. (2002) 'Forced exposure and psychological reactance: antecedents and consequences of the perceived intrusiveness of pop-up ads', *Journal of Advertising*, Vol. 31, No. 3, pp. 83-96.

Enabz.com (2010) 'Why internet advertising?', *Enabz.com*, available at http://www.enabz.com/articles/art010.html (accessed 21 December 2010).

Faber, R.J., Lee, M., & Nan, X. (2004) 'Advertising and the consumer information environment online', *American Behavioral Scientist*, Vol. 48, No. 4, pp. 447-466.

Gardner, M.P., Mitchell, A.A., & Russo, J.E. (1985) 'Low involvement strategies for processing advertisements', *Journal of Advertising*, Vol. 14, No. 2, pp. 4-12.

Haley, E. & Wilkinson, J. (1994) 'And now a word from our sponsor: an exploratory concept test of PSAs vs. advocacy ads', *Proceedings of the 1994 Conference of The American Academy of Advertising*, Athens, GA, pp. 79-87, available at http://www.aaasite.org/Proceedings.html (accessed 22 March 2012).

Hanafizadeh, P. & Behboudi, M. (2012) *Online Advertising and Promotion: Modern Technologies for Marketing*, IGI-Global, Hershey, PA.

Hanafizadeh, P., Behboudi, M., Ahadi, F., & Varkani, F.G. (2012) 'Internet advertising adoption: a structural equation model for Iranian SMEs', *Internet Research*, Vol. 22, No. 4, pp. 499-526.

Hanafizadeh, P., Moosakhani, M., & Bakhshi, J. (2009) 'Selecting the best strategic practices for business process redesign', *Business Process Management Journal*, Vol. 15, No. 4, pp. 609-627.

Heidarzadeh, K., Behboudi, M., & Sadr, F. (2011) 'Emerging new concept of electronic police and its impact on the websites' sales', *Interdisciplinary Journal of Research in Business*, Vol. 1, No. 3, pp. 8-14.

Heinz, M. (2004) 'It's the massage, stupid', *imedia Connection*, available at http://www.imediaconnection.com/content/26312.asp (accessed 21 December 2012).

Holbrook, M.B. & Lehmann, D.R. (1980) 'Form versus content in predicting starch scores', *Journal of Advertising Research*, Vol. 20, No. 4 pp. 53-62.

ICT.com (2007) 'Communication ministry online report on internet bandwidth', *ICT.com*, available at http://www.ICT.com (accessed 12 September 2012).

Intermarket Group (2004) 'The internet commerce briefing: online advertising & digital marketing report', *Intermarket Group*, available at http://www.Intermarketgroup.com (accessed 21 December 2012).

International Data Corporation (2002) 'Email marketing', *IDC*, available at http://www.Idcresearch.com (accessed 21 December 2012).

Internet World Stats (2012) 'Internet usage in the Middle East', *Internet World Stats*, available at http://www.internetworldstats.com/stats5.htm (accessed 22 March 2012).

Jupiter Systems (2005) 'Digital video report', *Jupiter*, available at http://www.Jupiter.com (accessed 21 December 2012).

Katz, J. & Aspden, P. (1997) 'Motivations for and barriers to internet usage: results of a national public opinion survey', *Internet Research: Electronic Networking Applications and Policy*, Vol. 7, No. 3, pp. 170-188.

Kelly, L., Kerr, G., & Drennan, J. (2010) 'Avoidance of advertising in social networking sites: the teenage perspective', *Journal of Interactive Advertising*, Vol. 10, No. 2, pp. 16-27.

Ko, H., Chang, C.-H., & Roberts, M.S. (2005) 'Internet uses and gratifications: a structural equation model of interactive advertising', *Journal of Advertising*, Vol. 34, No. 2, pp. 57-70.

Korgaonkar, P. & Wolin, L.D. (2002) 'Web usage, advertising, and shopping: relationship patterns', *Internet Research: Electronic Networking Applications and Policy*, Vol. 12, No. 2, pp. 191-204.

Kotler, P. (2001) *Marketing Management*, Prentice-Hall, Upper Saddle River, NJ.

Laurent, G. & Kapferer, J. (1985) 'Measuring consumer involvement profiles', *Journal of Marketing Research*, Vol. 22, No. 1, pp. 41-53.

Li, H. & Leckenby, J.D. (2004) 'Internet advertising formats and effectiveness', available at http://www.sites.google.com/site/champtec/ad_format_print.pdf (accessed 25 December 2010).

Petty, R.E., Cacioppo, J.T., & Schumann, D. (1983) 'Central and peripheral routes to advertising effectiveness: the moderating role of involvement', *Journal of Consumer Research*, Vol. 10, No. 2, pp. 135-146.

Previte, J. (1998) 'Internet advertising: an assessment of consumer attitudes to advertising on the internet', paper presented at the 1998 Communication Research Forum, Canberra, Australia.

Rodgers, S. & Thorson, E. (2000) 'The interactive advertising model: how users perceive and process online ads', *Journal of Interactive Advertising*, Vol. 1, No. 1, pp. 26-50.

Salmon, C. (1986) 'Perspectives on involvement in consumer and communication research', in Dervin, B. & Voigt, M.J. (Eds.), *Progress in Communication Sciences*, Vol. 7, Ablex, Norwood, NJ, pp. 243-268.

Scholsser, A.E., Shavitt, S., & Kanfer, A. (1999) 'Survey of internet users' attitudes toward internet advertising', *Journal of Interactive Marketing*, Vol. 13, No. 3, pp. 34-54.

Schramm, W. (1955) 'How communication works', in Schramm, W. & Roberts, D.F. (Eds.), *The Process and Effects of Mass Communications*, University of Illinois Press, Urbana, IL, pp. 3-26.

Sheehan, K.B. (1999) 'An investigation of gender differences in on-line privacy concerns and results behaviors', *Journal of Interactive Marketing*, Vol. 13, No. 4, pp. 24-38.

Sundar, S.S. & Kalyanaraman, S. (2004) 'Arousal, memory, and impression-formation effects of animation speed in web advertising', *Journal of Advertising*, Vol. 33, No. 1, pp. 7-17.

The Interactive Advertising Bureau (2000) 'Internet ad revenue report', *IAB.net*, available at http://www.iab.net/media/file/IAB_PwC_004_2000.pdf (accessed 21 December 2012).

The Interactive Advertising Bureau (2007) 'Pop-up guidelines', *IAB.net,* available at http://www.iab.net/guidelines/508676/508767/1461 (accessed 22 March 2012).

The Interactive Advertising Bureau (2011) 'Internet advertising revenues hit $7.3 billion in Q1 '11 highest first-quarter revenue level on record according to IAB and PwC', *IAB*, available at http://www.iab.net/about_the_iab/recent_press_releases/press_release_archive/press_release/pr-052611 (accessed 22 March 2012).

Thomsen, M.D. (1996) 'Advertising on the internet', *Studymode*, available at http://www.oppapers.com/essays/Thompson/668536 (accessed 22 March 2012).

Thorson, E. (1996) 'Advertising', in Salwen, M.B. & Stacks, D.W. (Eds.), *An Integrated Approach to Communication Theory and Research*, Lawrence Erlbaum Associates, Mahwah, NJ, pp. 211-230.

Turban, E., King, D., Viehland, D., & Lee, J. (2006) *Electronic Commerce: A Managerial Perspective 2006*, Prentice Hall, Upper Saddle River, NJ.

Vaughn, R. (1980) 'How advertising works: a planning model', *Journal of Advertising Research*, Vol. 20, No. 5, pp. 27-33.

Warrington, P. & Shim, S. (2000) 'An empirical investigation of the relationship between product involvement and brand commitment', *Psychology and Marketing*, Vol. 17, No. 9, pp. 761-782.

Wills, J., Samli, A.C., & Jacobs, L. (1991) 'Developing global products and marketing strategies: a construct and a research agenda', *Journal of The Academy of Marketing Science*, Vol. 19, No. 1, pp. 1-10.

Zaichkowsky, J.L. (1985) 'Measuring the involvement construct', *Journal of Consumer Research*, Vol. 12, No. 3, pp. 341-352.

About the authors

Payam Hanafizadeh is an Assistant Professor at Department of Industrial Management, School of Management and Accounting (formerly Tehran Business School) at Allameh Tabataba'i University in Tehran, Iran and a member of the Design Optimization under Uncertainty

Group at the University of Waterloo, Canada. He was a Visiting Research Fellow at the Faculty of Business and Government, the University of Canberra, Australia in 2010 and a Visiting Scholar at the Department of Systems Design Engineering, the University of Waterloo, Canada in 2004. He is the co-author of Online Advertising and Promotion: Modern Technologies for Marketing published in 2012 by IGI Global, USA. He has published more than 50 articles in reputable journals such as the *Information Society, Journal of Global Information Management, Telecommunications Policy, Systemic Practice and Action Research, Electronic Commerce Research, Energy Policy, Management Decision, Journal of Information Technology Research, Higher Education Policy, Mathematical and Computer Modeling, Expert Systems with Applications, International Journal of Information Management*, among others. Dr. Hanafizadeh has also been serving on the editorial review board for *International Journal of Information Technologies and Systems Approach, International Journal of Enterprise Information Systems, Journal of Information Technology Research, Journal of Electronic Commerce in Organizations,* and *International Journal of Decision Support System Technology*.

Mehdi Behboudi is a Lecturer of Online Advertising and Interactive Marketing at Department of Business Management, School of Management and Accountancy, Qazvin Branch, Islamic Azad University, Qazvin, Iran. Mr. Behboudi is the co-author of the book entitled *Online Advertising and Promotion*; *Modern Technologies for Marketing* published by IGI-Global, USA. He is also the author of several successful books in Iran such as: *International Marketing*, *How Get Profit from eBay*, and *Successful Entrepreneurs*. Some of his articles have been appeared in leading journals, including: *Internet Research*, *Information Resources Management Journal*, *Telematics and Informatics*, *International Journal of Online Marketing*, *International Journal of Business and Management*, *International Business Research*, *International Journal of Marketing Studies*, and among others. In this regard, he is serving as member of editorial review board for *International Journal of Marketing Studies*.

Appendix: Iranian Websites Which Were Used to Analysis

Rank	Web Site Address	Product	Date	Ad Type	Rank	Web Site Address	Product	Date	Ad Type
1	http://www.java88.blogfa.com	Movie	2009/09/10	Banner	41	http://www.toop30d.com	Movie	2009/09/10	Banner
2	http://www.p30world.com	Movie	2009/09/10	Skyscraper	42	http://mersee.com	Movie	2009/09/10	Skyscraper
3	http://www.pzrocks.com	filtered	2009/09/10	filtered	43	http://www.takkhal.net	Other	2009/09/10	Banner
4	http://www.kopey.irr	No	2009/09/10	No	44	http://persianbook.ning.com	Other	2009/09/10	Banner
5	http://www.limoonat.com	Movie	2009/09/10	Skyscraper	45	http://www.free-offline.com	Movie	2009/09/10	Banner
6	http://www.patoghu.com	Movie	2009/09/10	Skyscraper	46	http://www.takmob.net	Movie	2009/09/10	Skyscraper
7	http://www.persian.3jokes.com	Movie	2009/09/10	Botton	47	http://www.ymvis.com	Movie	2009/09/10	Banner
8	http://www.pix2pix.Org	filtered	2009/09/10	filtered	48	http://www.film2movie.com	Movie	2009/09/10	Skyscraper
9	http://www.Bitaraf.com	Other	2009/09/10	Banner	49	http://www.dvb5.net	No	2009/09/10	No
10	http://www.funpatogh.com	Movie	2009/09/10	Banner	50	http://www.aryabooks.com	Movie	2009/09/10	Skyscraper
11	http://www.jadidtarin.com	Movie	2009/09/10	Banner	51	http://www.p30world.com	Movie	2009/09/10	Skyscraper
12	http://www.7gardoon.com	Other	2009/09/10	Banner	52	http://footiran.ir	Movie	2009/09/10	Skyscraper
13	http://linkboxiran.com	No	2009/09/10	No	53	http://www.topmovie.ir	Movie	2009/09/10	Skyscraper
14	http://www.downloadha.com	Movie	2009/09/10	Skyscraper	54	http://night-skin.com	Movie	2009/09/10	Skyscraper
15	http://www.pctools.ir	Damaged	2009/09/10	Damaged	55	http://www.tafrihi.com	Movie	2009/09/10	Skyscraper

16	http://www.asandownload.com	Other	2009/09/10	Bottom	56	http://www.mahsunki-rmizigul.ir	Other	2009/09/10	Banner
17	http://www.lovefor.blogfa.com	Damaged	2009/09/10	Damaged	57	http://sms-jok.royablog.ir	Movie	2009/09/10	Skyscraper
18	http://www.liga43.org	Damaged	2009/09/10	Damaged	58	http://www.mamisite.com	No	2009/09/10	No
19	http://www.miadgah.ir	Movie	2009/09/10	Skyscraper	59	http://www.yekmobile.com	Movie	2009/09/10	Skyscraper
20	http://www.yaronline.com	Damaged	2009/09/10	Damaged	60	http://www.eca.ir	No	2009/09/10	No
21	http://www.faclip.com	Movie	2009/09/10	Skyscraper	61	http://www.acclearn.com	No	2009/09/10	No
22	http://www.softgozar.com	Other	2009/09/10	Skyscraper	62	http://www.irantk.ir	No	2009/09/10	No
23	http://www.ketabeavval.ir	No	2009/09/10	No	63	http://www.23055000.ir	No	2009/09/10	No
24	http://www.farabourse.net	Other	2009/09/10	Bottom	64	http://www.far30mobile.com	Movie	2009/09/10	Skyscraper
25	http://www.rapidautodl.blogfa.com	No	2009/09/10	No	65	http://www.unp.ir	No	2009/09/10	No
26	http://agahinameh.com	Movie	2009/09/10	Bottom	66	http://www.it2.ir	No	2009/09/10	No
27	http://www.pcparsi.com	Movie	2009/09/10	Skyscraper	67	http://musicaal.com	Movie	2009/09/10	Banner
28	http://www.daneshju.ir/forum	Other	2009/09/10	Banner	68	http://www.nega.ir	Movie	2009/09/10	Banner
29	http://yahoo360iran.ning.com	Other	2009/09/10	Bottom	69	http://www.parsiland.ir	Movie	2009/09/10	Banner
30	http://www.iranhall.com	Movie	2009/09/10	Skyscraper	70	http://forum.tvshow.ir	No	2009/09/10	No
31	http://link2bux.mihanblog.com	Movie	2009/09/10	Skyscraper	71	http://www.banksat.com	Movie	2009/09/10	Banner

32	http://www.birmusic3.com	Movie	2009/09/10	Skyscraper	72	http://kashkul.com	No	2009/09/10	No
33	http://iranian.f	No	2009/09/10	No	73	http://hurrahsport.com	No	2009/09/10	No
34	http://www.iranmc.org	No	2009/09/10	No	74	http://club.parniaz.com	No	2009/09/10	No
35	http://www.footballiran.ir	Other	2009/09/10	Skyscraper	75	http://www.parsquran.com	No	2009/09/10	No
36	http://www.p30day.com	Movie	2009/09/10	Skyscraper	76	http://www.yaoo.ir	No	2009/09/10	No
37	http://www.9cd.ir	Filtered	2009/09/10	Filtered	77	http://www.mob4u.ir	Movie	2009/09/10	Skyscraper
38	http://www.100fal.com	Other	2009/09/10	Banner	78	http://iransaze.com	Other	2009/09/10	Banner
39	http://www.irpdf.com	No	2009/09/10	No	79	http://www.p30island.com	Movie	2009/09/10	Banner
40	http://blogers.ir	Other	2009/09/10	Skyscraper	80	http://www.cfon.ir	Filtered	2009/09/10	Filtered
81	http://www.pezeshk.us	Other	2009/09/10	Banner	116	http://nezamvazifeh.com	Other	2009/09/10	Banner
82	http://www.kar20.ir	Other	2009/09/10	Skyscraper	117	http://www.miadgah.org	Movie	2009/09/10	Skyscraper
83	http://www.oxin-box.co.cc	Movie	2009/09/10	Banner	118	http://www.ariamobile.net	Other	2009/09/10	Skyscraper
84	http://www.freedownload.ir	Movie	2009/09/10	Skyscraper	119	http://sshh.javanblog.com	Movie	2009/09/10	Skyscraper
85	http://www.Iranihaa.mihanblog.com	Filtered	2009/09/10	Filtered	120	http://downloadbazar.com	Damaged	2009/09/10	Damaged
86	http://www.iranselect.net	Movie	2009/09/10	Skyscraper	121	http://www.itech2.info	Other	2009/09/10	Banner
87	http://vatangig.com	Movie	2009/09/10	Skyscraper	122	http://www.pichak.net	Movie	2009/09/10	Banner
88	http://www.iranmc.org	No	2009/09/10	No	123	http://www.mashhad-shop.com	Movie	2009/09/10	Banner
89	http://www.tactools.org	No	2009/09/10	No	124	http://setarestarh.javanblog.com	Movie	2009/09/10	Skyscraper

90	http://www.irtoolz.info	Movie	2009/09/10	Skyscraper	125	http://www.arash98.com	Movie	2009/09/10	Skyscraper
91	http://www.tamashagaran.ir	Other	2009/09/10	Banner	126	http://old.taroot.ir	No	2009/09/10	No
92	http://www.cafedexign.com	No	2009/09/10	No	127	http://www.iranonlinetv.com	Other	2009/09/10	Banner
93	http://bia2clip.org/toplinks	Movie	2009/09/10	Skyscraper	128	http://www.Bo2song.ir	Damaged	2009/09/10	Damaged
94	http://www.mmdsharifnet.ir	No	2009/09/10	No	129	http://forum.p30pedia.com	No	2009/09/10	No
95	http://www.takbook.com	Movie	2009/09/10	Skyscraper	130	http://www.bia4clip.com	Movie	2009/09/10	Skyscraper
96	http://www.Taktaz.com	Other	2009/09/10	Banner	131	http://www.miladhospital.com	No	2009/09/10	No
97	http://naghola.com	Movie	2009/09/10	Skyscraper	132	http://aksetoop.dortinblog.com	Movie	2009/09/10	Skyscraper
98	http://pichak.net	Other	2009/09/10	Banner	133	http://tasetare.blogfa.com	Other	2009/09/10	Banner
99	http://www.yasinmedia.com	No	2009/09/10	No	134	http://www.bazyab.ir	Movie	2009/09/10	Banner
100	http://www.mgtsolution.com	Other	2009/09/10	Banner	135	http://sajadhosseini.javanblog.com	Movie	2009/09/10	Banner
101	http://www.tazin.blogfa.com	No	2009/09/10	No	136	http://www.karshenasi.com	No	2009/09/10	No
102	http://www.persianpet.org	No	2009/09/10	No	137	http://box1000.mihanblog.com	Movie	2009/09/10	Banner
103	http://tat-bank.blogfa.com	No	2009/09/10	No	138	http://www.fal4u.com	Movie	2009/09/10	Skyscraper
104	http://www.parsiking.com	Movie	2009/09/10	Skyscraper	139	http://10box.mihanblog.com	Movie	2009/09/10	Banner

105	http://www.clickkon.com	Movie	2009/09/10	Banner	140	http://takmahfel.com	Other	2009/09/10	Banner
106	http://www.mardomsalari.com	No	2009/09/10	No	141	http://www.irkut.ir	Movie	2009/09/10	Skyscraper
107	http://www.parniaz.com	Movie	2009/09/10	Banner	142	http://www.iranweb-shop.info	No	2009/09/10	No
108	http://www.4downloads.ir	Movie	2009/09/10	Skyscraper	143	http://www.33ir.com	No	2009/09/10	No
109	http://www.mygame.ir	Movie	2009/09/10	Banner	144	http://akse20.mahblog.com	Movie	2009/09/10	Skyscraper
110	http://www.ravazadeh.com	Other	2009/09/10	Banner	145	http://sari360.ning.com	No	2009/09/10	No
111	http://www.indexiran.ir	Other	2009/09/10	Banner	146	http://www.t-a-k-2-0.sub.ir	Damaged	2009/09/10	Damaged
112	http://www.irmob.com	Other	2009/09/10	Banner	147	http://www.webgozar.com	Other	2009/09/10	Skyscraper
113	http://i	Damaged	2009/09/10	Damaged	148	http://www.kahoo.org	Movie	2009/09/10	Skyscraper
114	http://www.paroos.com	No	2009/09/10	No	149	http://www.pooyaon-line.net	No	2009/09/10	No
115	http://www.download98.org	Movie	2009/09/10	Skyscraper	150	http://www.persiajok.com	Other	2009/09/10	Skyscraper

Total result: Without ad = 39, filtered or damaged = 14, movie ad (Skyscraper = 45; Banner = 20), other ad (Skyscraper = 6; Banner = 21; Bottom = 5),

MIS Review Vol. 18, No. 1, September (2012), pp. 31-56

Insights into Online Auction Market Structure of eBay in 2006-2007: A Historical Perspective

Yanbin Tu[1], Steven R. Clinton[1], Adora Holstein[2]
[1]*Department of Marketing, Robert Morris University*
[2]*Department of Economics and Legal Studies, Robert Morris University*

ABSTRACT: *The online auction market has experienced rapid growth in the last decade and has been playing an important role in our economy. Given the size and nature of auction markets, it is important for potential entrepreneurs and market traders to understand these markets. However, the market structure of online auctions has not been adequately examined in the literature. This study extends existing research by using eBay's auction data for the Xbox game console to understand the evolution and characteristics of eBay users, and to investigate the nature of competition in this market in 2006-2007. Among others, we find that the Xbox game console market could be best categorized as a mix market with a dominant Consumer to Consumer (C2C) segment because it had many individual sellers. We also discuss the theoretical contributions and managerial implications of our findings regarding three dimensions of online auction market structure, and identify future research directions.*

KEYWORDS: *eBay, Online Auction, Entrepreneurship, Market Structure, HHI (Herfindal-Hirschman Index) Index, Gibrat's Law.*

1. Introduction

With the advent of the Internet and information technology innovation, the online auction market has experienced rapid growth in the last decade and has been playing an important role in our economy (Barua, Whinston, & Yin, 2000). This growth has been most evident at eBay. Founded in September 1995, eBay's worldwide revenues totaled more than US$3.4 billion in the fourth quarter of 2011, with 100.4 million active users -- an increase of 35% over the fourth quarter of 2010.

Although virtual and ubiquitous, electronic marketplaces provide a place where sellers and buyers can meet, communicate, and exchange information, products and money, just like traditional markets. While offering broader markets and reduced transaction costs, transactions in cyberspace also involve greater information asymmetry about market participants and products (Bakos, 1997). In a traditional market channel, manufacturers, wholesalers and retailers reduce information asymmetry through repeated transactions, lengthy histories, and face-to-face interactions. Even when entering into a

new transaction, the traditional channel offers potential entrants information about their prospective business partners either through word-of-mouth business media, independent entities (e.g., the Better Business Bureau), and other references. These various information sources offer a measure of trust to the respective channel participants. Research shows that trust plays a crucial role in smooth functioning channels (Ba, Whinston, & Zhang, 2003; Brynjolfsson & Smith, 2000).

In contrast, the online auction market offers no such information sources. To counteract this critical shortcoming, online markets such as online auction in eBay rely upon feedback mechanisms to provide buyers and sellers with information about their respective parties. These feedback mechanisms list basic information about users, and "score" buyers and sellers. The information available from a feedback system helps eBay users build trust and conviction in conducting business transactions. Consequently, the online feedback systems are also called online reputation systems (Lin et al., 2006). Existing studies explore the roles of reputation in traditional markets (Klein & Leffler, 1981; Shapiro, 1982; 1983) and in electronic markets (Ba & Pavlou, 2002; Chiu, Huang, & Yen, 2010; Dellarocas, Fan, & Wood, 2004; Dewally & Ederington, 2006; Dewan & Hsu, 2004; Gefen, Benbasat, & Pavlou, 2008; Houser & Wooders, 2006; Li, 2010; Melnik & Alm, 2002; Pavlou & Dimoka, 2006; Resnick & Zeckhauser, 2002; Resnick et al., 2006; Wolf & Muhanna, 2011; Zhang, 2006) from the perspectives of the behavioral sciences, marketing, economics, and management information systems. As online feedback systems record the activities and profiles of eBay users, the systems contain important information about market structure.

Given the size and nature of the Business to Consumer (B2C) and Consumer to Consumer (C2C) online auction markets, it is important for potential market traders to understand such market structure. In fact, entrepreneurs and traders need to understand the basic characteristics of a market to decide whether to enter the market or not. In addition, as Lin et al. (2006) point out, understanding electronic market structure will also help entrepreneurs, business practitioners, researchers and market makers identify target markets, predict market growth trends and implement effective marketing strategies. There are existing studies addressing the market structure of online auctions from different perspectives of the market. Hou and Blodgett (2010) propose a simple theoretical framework with a two-dimensional market structure (thick vs. thin) and quality uncertainty (high vs. low) to reconcile previous findings of online auction pricing. They define the market structure from the perspective of products and product conditions: "A thin market involves items that are more heterogeneous across key attributes and are of varying quality levels; some examples are used furniture and rare antiques." They find that previous studies are not necessarily at odds. In fact, previous studies are consistent with their findings and results. Arora et al. (2007) use game theory to study the effects

of information-revelation policies under market-structure uncertainty in electronic reverse auctions. They address market-structure uncertainty as the uncertainty about the number of competitors in the market. This definition is more consistent with that in the economics literature. In the work of Alt and Klein (2011), they summarize the electronic markets research in the last twenty years and describe market structure in terms of market fragmentation, concentration, and information asymmetry. Lin et al. (2006) study market structure by investigating the characteristics of market participants in eBay. They find that seller reputation, rather than buyer reputation, is log-normally distributed. Li, Li, and Lin (2008) extend the work, and compare the market structures of eBay in the U.S.A. and of Taobao in China. They suggest that online transaction volumes of Taobao sellers demonstrate many stochastic properties similar to those on eBay with some distinguishing properties, such as a faster growth rate but a declining concentration trend. They also find that Taobao sellers held stabilized transaction volumes while market growth slowed in 2006.

However, the existing studies on online auction market structure still show certain untapped areas. First, so far no studies have been conducted to discuss the length of market participation since entry into the online auction markets. In fact, the eBay membership length can tell us some information about eBay users' seniority and how seniority is related to remaining active in the market. Second, existing studies explore the structure of the entire market without focusing on one specific product market. Lin et al. (2006) and Li et al. (2008), test *Gibrat's Law* for the entire markets in eBay and Taobao. General conclusions derived from the whole market or macro level need to be validated at the individual product or micro level. In addition, knowledge about the market structure at the product level might be more useful for market participants.

This paper extends the research into online auction market structure by addressing how the distributions of online feedback scores reflect the market structure of eBay in 2006-2007. Following the definition of market structure in the economics literature, we are particularly interested in three aspects of the market: (1) the characteristics of eBay users, (2) the extent of market competition, and (3) the evolution of eBay users. This study contributes to the literature in three ways:

(1) Existing studies do not provide information about eBay users' membership length, whereas our study takes this factor into consideration, so that we can have a complete picture of the demographics of market participants;

(2) Existing studies do not differentiate between eBay bidders and winners, in fact winners are relatively important to sellers because the winners finally buy and pay the items. We will address this differentiation in this study; and

(3) The Herfindal-Hirschman Index of market concentration and *Gibrat's Law* of market evolution were tested in the literature at the macro level. We will test these at the individual product (micro) level by using a relatively large sample size.

The rest of the paper is structured as follows: First, we describe the feedback systems at eBay. Second, we explain the research framework and data collection. Third, we demonstrate the basic characteristics of market participants, measure the extent of market competition, and study the evolution of users. Then, we discuss theoretical contributions and managerial implications of our findings. Finally, we draw conclusions.

2. eBay's feedback systems (eBay My World) and eBay users

We chose eBay to investigate the characteristics of online auction users because it is currently the largest online auction site with over 80% market share. Before we address the online auction market structure, we need to introduce eBay's feedback systems (i.e., eBay My World) because the systems contain the information about eBay users, feedback scores, and auction listing history which can be used to study market structure. Online feedback systems are critical to building online trust in electronic marketplaces. These systems record and report an online trader's feedback according to other traders' purchase and/or selling experience. Resnick and Zeckkauser (2002) estimated that there is a 52.1% probability that a buyer will give a seller a feedback score, which is lower than the 60.6% probability that a seller will give a buyer a feedback score. The feedback system, eBay My World, is the most popular and successful one. Before an auction, bidders can judge a seller by checking the seller's feedback scores, detailed seller ratings, and reviews left by previous buyers and sellers for this seller. If bidders accrue sufficient trust on the seller, they are more likely to bid and buy the items listed by the seller. After fulfillment of an auction transaction, both the buyer and the seller can provide feedback by rating each other. There are three types of ratings available: positive, neutral and negative. The overall feedback scores, positive percentage, membership starting date, and other information are published on eBay's site. Beyond summary information, eBay users can read each feedback along with detailed comments and reviews left by buyers and sellers. Therefore, we can use eBay users' feedback reputation scores as a proxy of their transaction volumes in a given period of time. These transaction volumes can be taken as an important indicator for eBay users' capacity in the market. In addition, comparing the feedback scores from buyers with those from sellers, we can measure whether an eBay user is sell-dominant or buy-dominant at eBay. Figure 1 is a representative example for one seller's feedback profile.

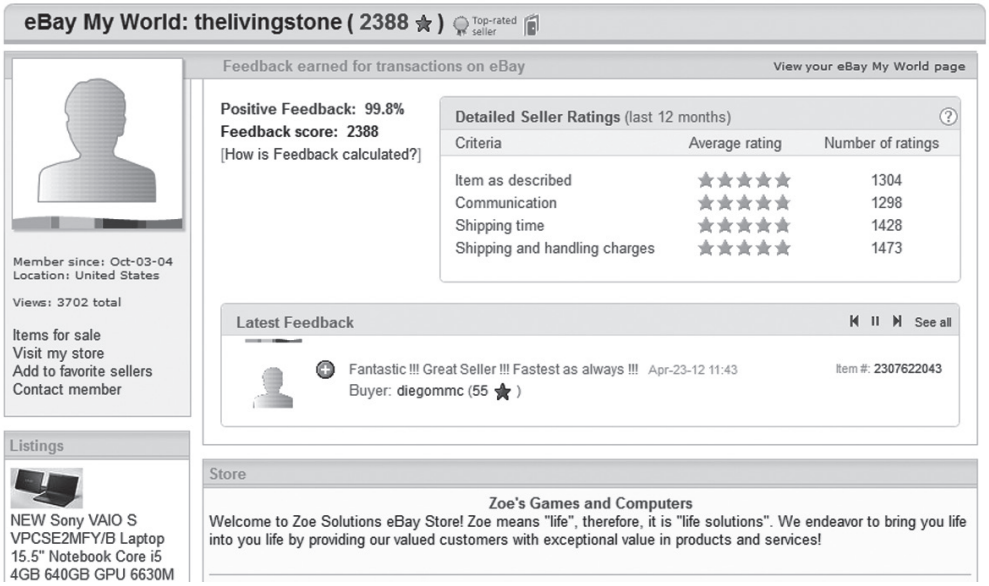


Figure 1 eBay Feedback Systems

3. Research framework and data collection

There is no common definition of market structure in the literature. As mentioned before, Hou and Blodgett (2010) define market structure from the perspective of products and product conditions. Alt and Klein (2011) describe market structure in terms of market fragmentation, concentration, and information asymmetry. Lin et al. (2006) and Li et al. (2008)'s market structure research mainly investigates the firm's growth pattern, firm's entry and exit, and market concentration. In this study, we define market structure as "the interconnected characteristics of a market, such as the number and relative strength of buyers and sellers, and degree of collusion among them, level and forms of competition, extent of product differentiation, and ease of entry into and exit from the market" (BusinessDictionary.com). This definition is consistent with the economics literature. In this study, we describe the online auction market structure according to the: (1) characteristics of *eBay users*, (2) extent of *online auction market competition*, and (3) *evolution of eBay users*. The framework we use to study the market structure is summarized in Figure 2.

First, we describe eBay users' demographics, which differ from traditional customer demographics (e.g., age, income, education, etc.). The descriptors that we call "demographics" of eBay users consist of the amount of feedback, feedback scores, eBay membership length, and stated location in the online environment. The distribution of eBay users' feedback scores and membership length, in particular, are fundamental to

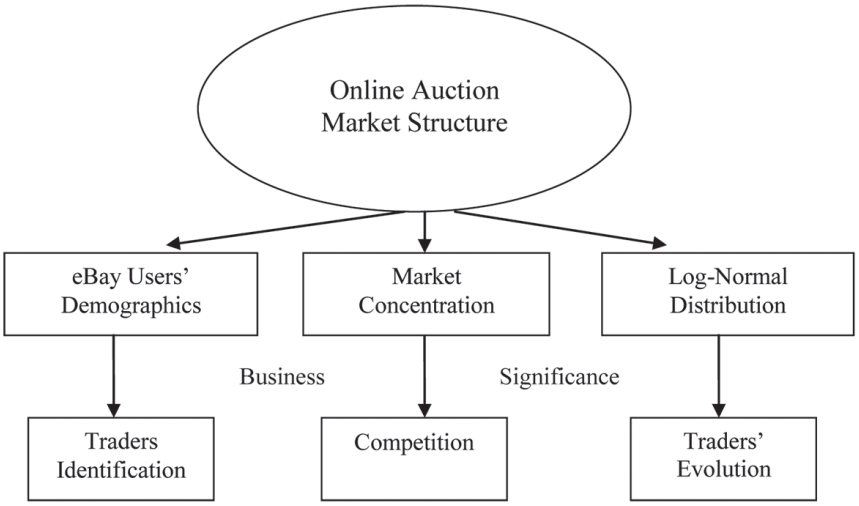


Figure 2 Research Framework

understanding the basic characteristics of eBay users. The business significance of these demographics is that they help marketers understand who eBay traders are, and identify the right business counterparts and target markets. For example, new buyers with trust concerns towards sellers might choose eBay power sellers to bid or buy as they seem to be more truthful to these buyers. Moreover, as an online auction house, eBay can better serve market participants if it understands them better.

Second, we investigate the degree of concentration of the Xbox game console market. Sellers vary from retailers of new Xbox game consoles to individuals who resell used ones. Knowledge of market concentration is very useful for possible stakeholders to make decisions on entry and exit strategy.

Third, we test whether eBay users' feedback scores are log normally distributed. *Gibrat's Law* proposes that the firm's growth rate is irrelevant to its size, thus suggesting that firm size is log normally distributed (Hart & Oulton, 1996; Lin et al., 2006). Moreover, Lin et al. (2006) find that seller reputation scores which is related to transaction volumes, rather than buyer reputation scores, is log-normally distributed. In this study, we will test the log-normal distribution on eBay data for Xbox game consoles to obtain an insight into the firm's growth pattern.

4. Demographics of eBay users

Computer programs were written to act as agents to automatically collect data from eBay. The data collection spanned over a period of three and a half months in 2006-2007.

We chose the Xbox game consoles for this study because they had a reasonable market thickness measured by the number of auction listings and active bidding everyday. All together, we collected 9,583 online auction listings for Xbox game consoles, of which 7,403 resulted in transactions. Within the 9,583 auction listings, there were 5,894 unique sellers, and 24,664 unique buyers, culminating in 6,340 unique winners (see Table 1 for a summary).

Although 5,894 eBay users acted as sellers of Xbox game consoles, a closer examination of their feedback history reveals that some sellers also participated as buyers in other auction listings. So, we further divide these sellers into "Sell Dominant" users (2,887) and "Buy Dominant" users (2,876). In the same fashion, we divide bidders and winners into these two categories. Table 2 provides a detailed breakdown of our auction participants.

Table 2 tells us that a majority of eBay users were buyers. The sellers/buyers ratio is 22.6% (2,887 + 2,375)/(2,876 + 20,408). Next, we list the feedback scores histograms for Xbox game console sellers, buyers, and winners in Figures 3-5. Half of the sellers had more than 70 feedback scores. On the other side, half of the bidders had more than 20 feedback scores, and half of the winners had more than 28 feedback scores. Overall, sellers had more feedback scores than buyers and winners. This suggests that sellers

Table 1 Summary of eBay Users

	Auction listings	Unique sellers	Unique bidders	Unique winners
	9,583	5,894	24,664	6,340
Success	7,403	5,291	23,473	6,340
Failure	2,180	1,548	3,166	N.A.

Table 2 Divisions of eBay Users

	Total	Sell Dominant	Buy Dominant
Seller	5,894	2,887 (48.98%)	2,876 (48.8%)
Average Feedback Scores	612.102	1,128.148	119.304
Average Membership Length	3.714	3.715	3.784
Bidder	24,664	2,375 (9.63%)	20,408 (82.74%)
Average Feedback Scores	98.339	449.299	65.810
Average Membership Length	2.992	3.617	3.087
Winner	6,340	642 (10.13%)	5,689 (89.73%)
Average Feedback Scores	115.260	541.889	70.764
Average Membership Length	3.190	3.735	3.226

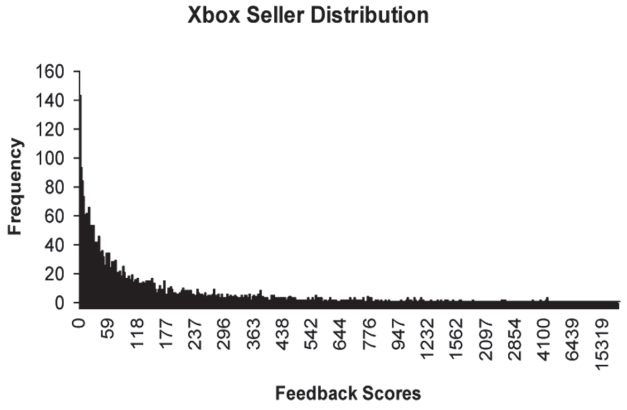


Figure 3 Seller Distribution

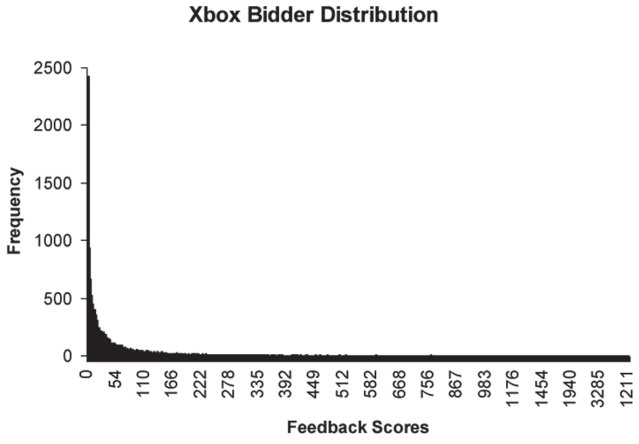


Figure 4 Bidder Distribution

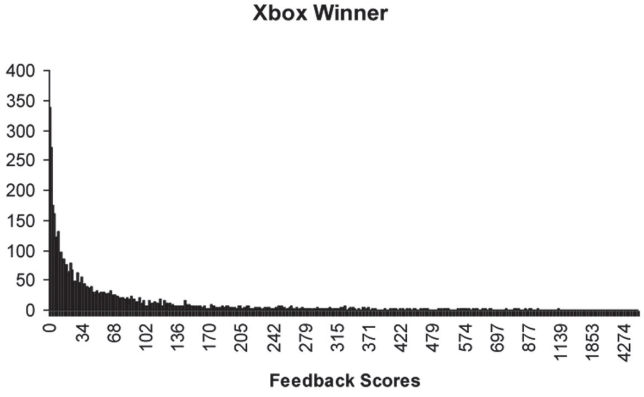


Figure 5 Winner Distribution

were generally more active than buyers in the online auction market. The histograms of the eBay membership lengths tell us that overall, sellers had a longer membership than bidders and winners. Figure 6 below illustrates the distribution of sell-dominant and buy-dominant sellers by membership length.

Table 3 lists the positive percentages for sellers and bidders with different membership lengths. It appears that sellers had a higher positive percentage of feedback scores than bidders for short membership lengths, while bidders had a higher positive

Figure 6 Proportion of Sell-Dominant and Buy-Dominant Sellers

Table 3 Positive Percentages in Membership Lengths

	Seller	Bidder	t-value
Overall	*0.953*	*0.888*	*10.858***
0 - 1 year	0.848	0.702	6.954**
1 - 2 years	0.956	0.927	2.525*
2 - 3 years	0.976	0.955	2.036*
3 - 4 years	0.976	0.962	1.387
4 - 5 years	0.977	0.964	1.253
5 - 6 years	0.983	0.979	0.440
6 - 7 years	0.976	0.988	-1.641
7 - 8 years	0.954	0.984	-1.678
8 - 9 years	0.984	0.994	-0.415
9 - 10 years	0.992	0.993	-0.015

Note: *Significance at 5% level; **Significance at 1% level.

percentage than sellers for long membership lengths. However, we find this difference not to be statistically significant. In Figures 7-10 we also list the positive percentage of feedback scores for sellers, bidders, and winners based on feedback scores and membership length. The overall average of positive percentage of feedback scores for sellers was higher than that of bidders. Differences also existed in the positive percentage of feedback scores between sellers and bidders based on different membership lengths (see Figure 11).

5. Characteristics of market competition

By studying market concentration, we can determine how competitive the Xbox game console market is. More importantly, we want to identify whether the market

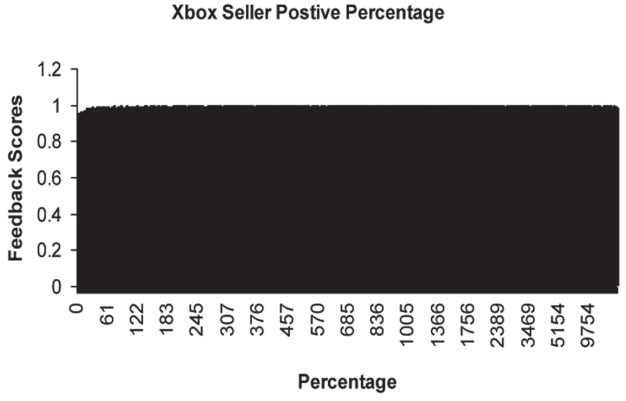


Figure 7 Seller Positive Percentage

Figure 8 Seller Positive Percentage

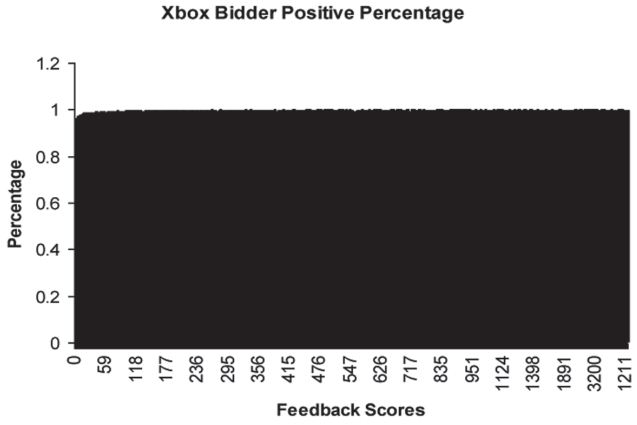


Figure 9 Bidder Positive Percentage

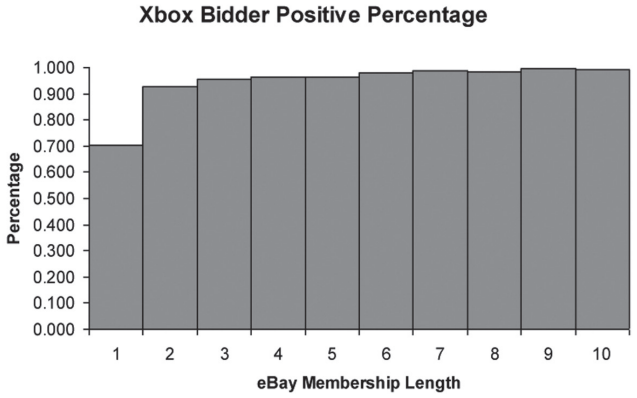


Figure 10 Bidder Positive Percentage

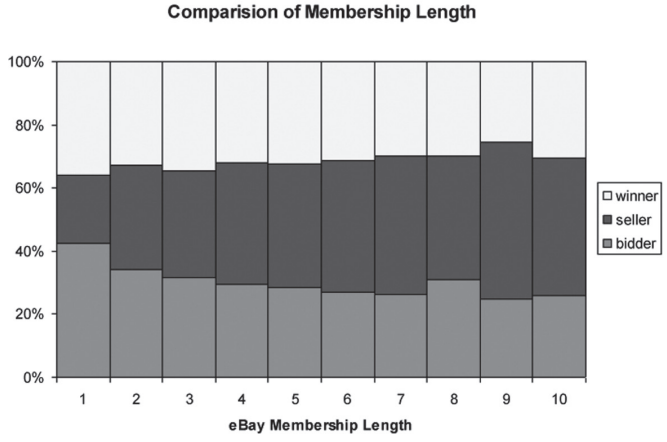


Figure 11 Comparison of Membership Length

is predominantly a B2C or C2C market. We measure the market share P_n of the top n feedback scores as:

$$P_n = \sum_{k=n}^{N} \frac{n * m_n}{T}$$

where m is the feedback score and T is the sum of feedback scores.

Table 4 lists the top 10 sellers with market shares in terms of auction listings. Table 5 lists the top 10 sellers with largest market shares in terms of auction transactions. Among 5,894 sellers, the largest market shares for both cases fell in the range of 1.4%-1.7%. For all other sellers, market share was less than 1%. The 10-seller concentration ratios were 5.4% and 6.5% for auction listings and auction success, respectively.

Table 4 Top 10 Sellers with Auction Listings

# of Listings	Seller	Market Share
136	webstore11	0.014192
83	demortdieselsouth	0.008661
48	Mobilepc	0.005009
39	auctions4aliving	0.004070
38	Sobebooay	0.003965
38	psober3449	0.003965
38	willsrealdeals	0.003965
36	Trickingitout	0.003757
30	Ponybids	0.003131
29	ckttoys	0.003026

Table 5 Top 10 Sellers with Auction Success

# of Transactions	Seller	Market Share
129	webstore11	0.017425
78	demortdieselsouth	0.010536
46	mobilepc	0.006214
38	willsrealdeals	0.005133
37	Psober3449	0.004998
36	trickingitout	0.004863
31	sobebooay	0.004187
30	ponybids	0.004052
28	megamixxer	0.003782
27	Ckttoys	0.003647

Figure 12 depicts the cumulative change of market share in terms of auction transactions starting from the sellers with largest feedback scores to sellers with 0 feedback score. From right to left, the curve increases rapidly, then smoothly. It indicates that sellers with higher feedback scores had relatively higher market shares. This trend is more obvious for sell-dominant sellers in Figure 13.

The Herfindal-Hirschman Index (HHI) has been widely used to measure the concentration level of a market (Hirschman, 1964). An HHI value of 0 indicates a perfectly competitive market and an HHI value of 10,000 suggests a monopoly market. For sampled data in the given period, we follow the literature and extend HHI to a sample-based HHI (S-HHI). Table 6 lists the HHI values for auction listings and auction transactions. Table 7 shows the

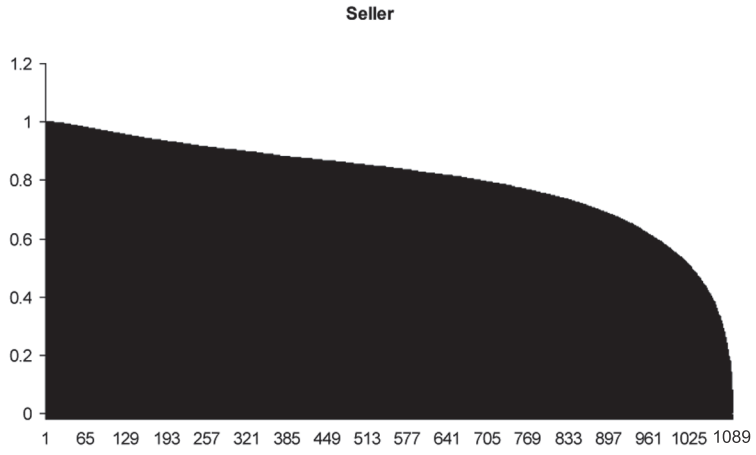


Figure 12 Cumulative Change for Sellers

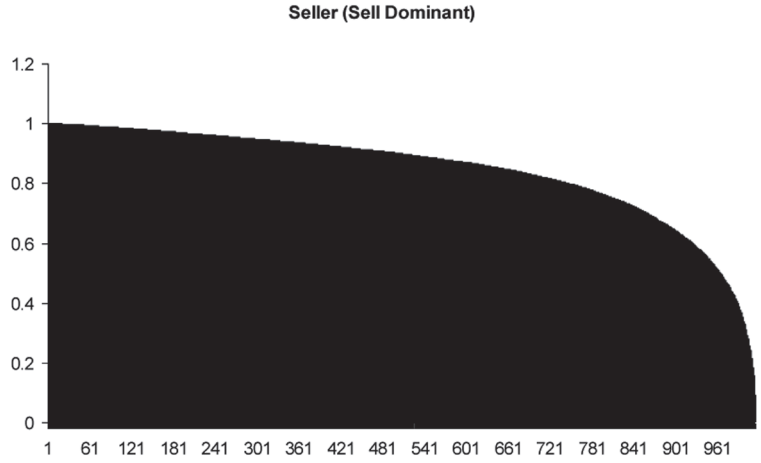


Figure 13 Cumulative Change for Sell-Dominant

Table 6 HHI for Auction Listing and Success

	Auction Listing	Auction Success
HHI	6.923	9.245
# of Sellers	5,894	5,291

Table 7 S-HHI for Sellers

	Seller	Seller (Sell Dominant)	Seller (Buy Dominant)
S-HHI	0.015	0.0370	0.090
Sample Size	5,894	2,887	2,876

S-HHI for auction listings based on types of sellers. From Tables 6 and 7, we observe the following results: (1) The HHI values for auction listings and transactions are relatively low, which indicate that the Xbox game console market was very competitive. (2) The S-HHI values for sellers, sellers with sell-dominant and sellers with buy-dominant are very low, which consistently indicate the Xbox game console market was a competitive one. These results are consistent with the findings in Lin et al. (2006) and Li et al. (2008).

From the above analysis, we can claim the Xbox game console market at eBay was very competitive in 2006-2007. Moreover, considering the market had many individual sellers, with no one enjoying any monopoly power, we can confidently characterize it as a mix market (B2C and C2C) with a dominant C2C segment.

6. Characteristics of eBay users' evolution

Using feedback scores as a proxy of transaction volumes, the histograms of logarithmic value of transaction volumes for Xbox sellers, bidders and winners are shown in Figures 14-16, respectively. For seller datasets, the graphic distributions are close to bell-shaped normal distributions. On the other hand, the shapes of the bidder and winner dataset distributions are not symmetric. A large number of bidders -- along with winners -- had reputation scores of 1. Thus, bidders' and winners' feedback distributions are more right-skewed than those of sellers. To check the differences based on types of users, in Figures 17-19 we present the histograms of sellers with sell-dominant, bidders with buy-dominant, and winners with buy-dominant, profiles. The patterns in Figures 17-19 are similar to those in Figures 14-16.

To check the type of distribution, we conduct the Wald test on sellers, bidders, and winners, the results of which are shown in Table 8. We also tested log-normality on sellers, bidders and winners each divided as sell-dominant and buy-dominant. Tables 8-9

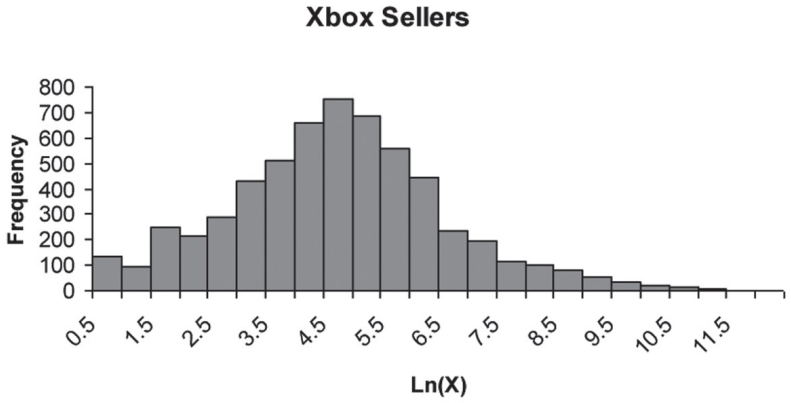


Figure 14 Seller Transaction Volumes

Figure 15 Bidder Transaction Volumes

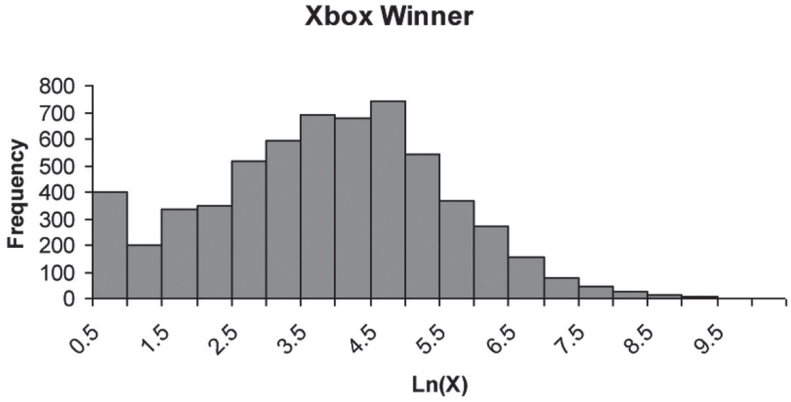


Figure 16 Winner Transaction Volumes

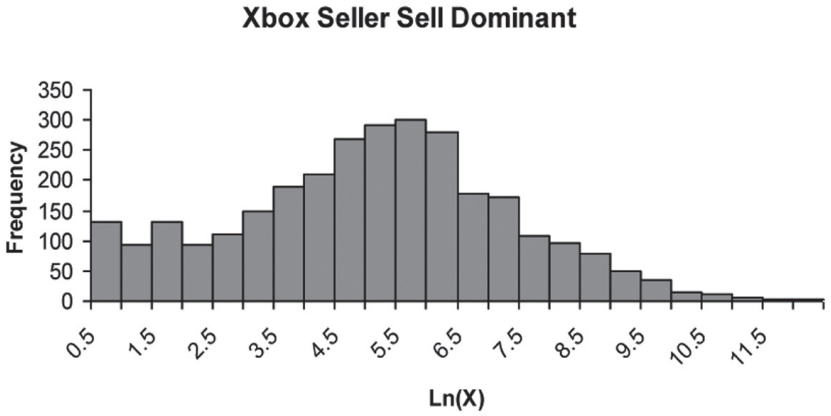


Figure 17 Sellers with Sell-Dominant

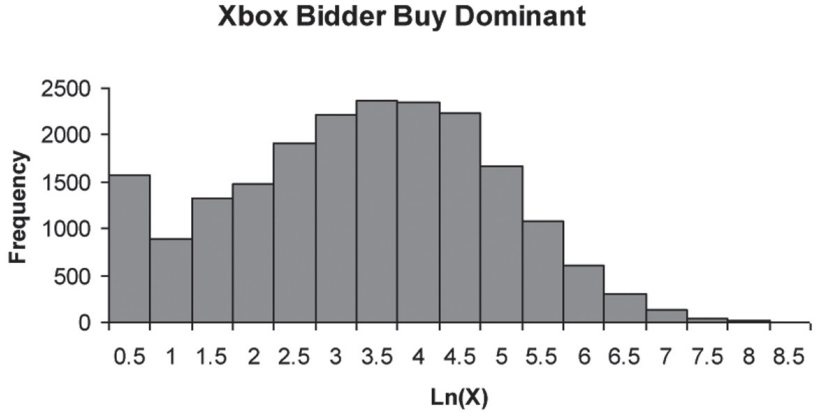


Figure 18 Bidders with Buy-Dominant

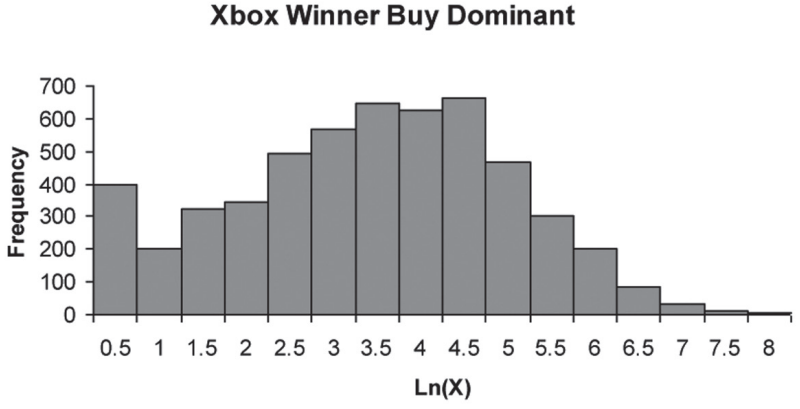


Figure 19 Winners with Buy-Dominant

Table 8 Wald Test on Sellers, Bidders, and Winners

	Seller	Bidder	Winner
Skewness	0.293	0.014	-0.011
Kurtosis	0.602	-0.238	-0.114
# of Observations	5,699	22,146	5,855
Wald-Value	167.60	52.99	3.29

Table 9 Wald Test Based on Sell-Dominant and Sell-Dominant

	Seller Sell-D	Seller Buy-D	Bidder Buy-D	Bidder Sell-D	Winner Buy-D	Winner Sell-D
Skewness	0.019	-0.231	-0.124	-0.272	-0.197	-0.157
Kurtosis	-0.019	0.559	-0.468	0.020	-0.393	-0.071
# of Observations	2,842	2,857	19,793	2,353	5,217	638
Wald-Value	0.264	62.34	231.35	29.05	67.31	2.75

summarize the following findings from the log-normality tests: (1) Sellers in total did not demonstrate a log-normal distribution of transaction volumes. However, sellers with a sell-dominant profile did exhibit a log-normal distribution. (2) The distribution of bidder transaction volumes failed to pass the log-normality test on all accounts (i.e., it did not matter if bidders were viewed in total or by sell-dominant or buy-dominant profiles). (3) Winner transaction volumes, in total, were approximately log-normally distributed. Winners with sell-dominant also showed a log-normal distribution.

We also look at the growth of transaction volumes for sellers after one year. On average, sellers more than doubled their transaction volumes from 302.93 to 608.48 within one year. Figure 20 lists the feedback score growth in number (absolute value), and Figure 21 shows the feedback growth in rate (relative value). The primary impression is that sellers with high feedback scores had more feedback ratings (more transactions) than sellers with low feedback scores. The feedback score growth rate shows a smooth spread distribution with several spikes for sellers with transaction volumes in the intervals of 0-25, 350-550, and 900-1,400. In general, sellers with the highest scores had relatively low growth rates.

We also show the growth patterns based on membership lengths in Figure 22 and Figure 23. The figures tell us that sellers with longer membership had more transaction volumes. However, sellers with shorter membership had higher growth rates in transaction volumes. One explanation is that even sellers with longer membership had higher existing transaction volumes, which dragged the growth down given the same amount of increased scores.

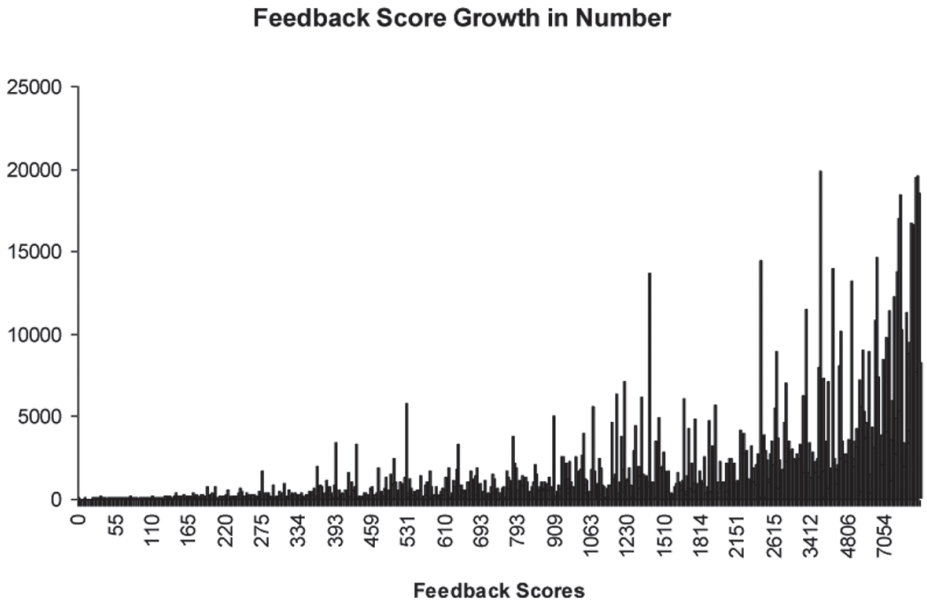


Figure 20 Growth in Number

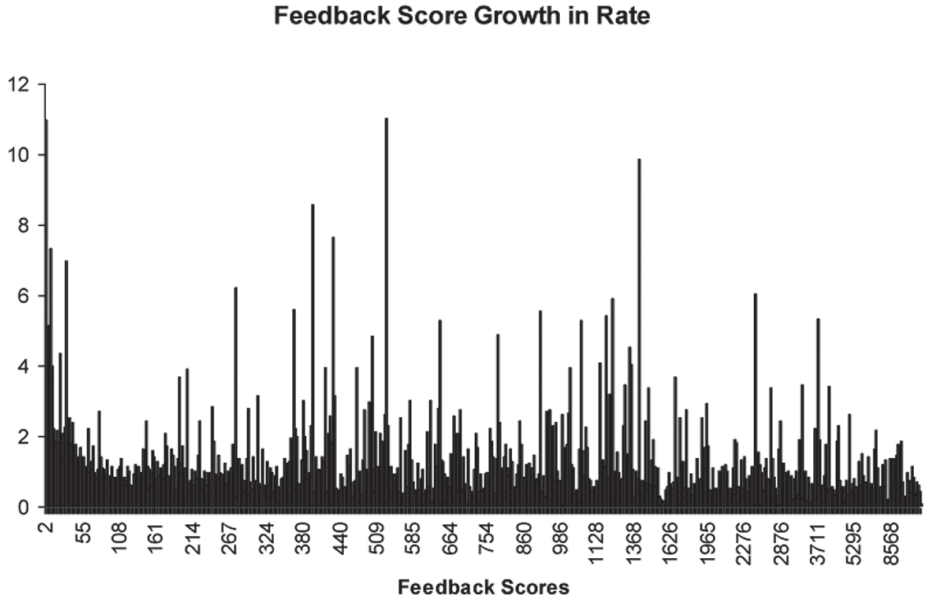


Figure 21 Growth in Rate

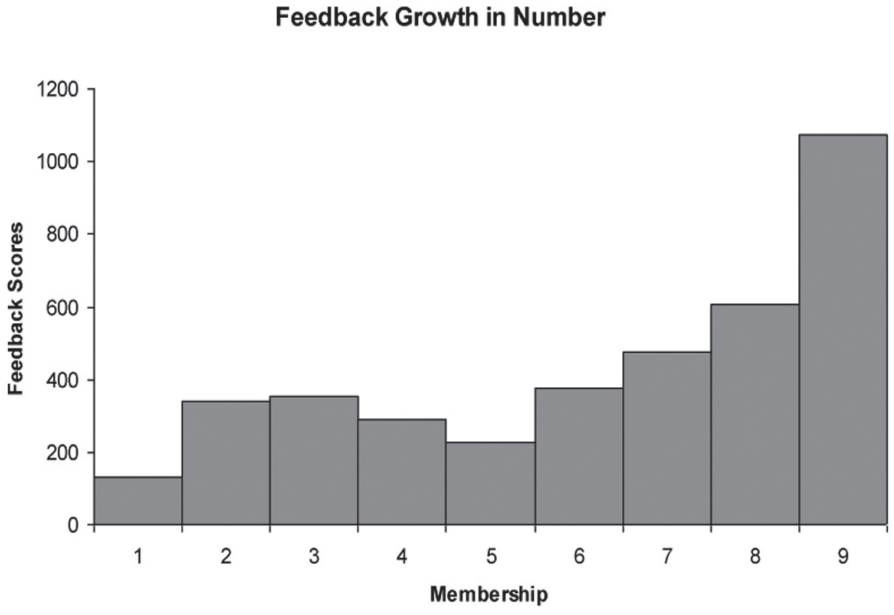


Figure 22 Growth in Number

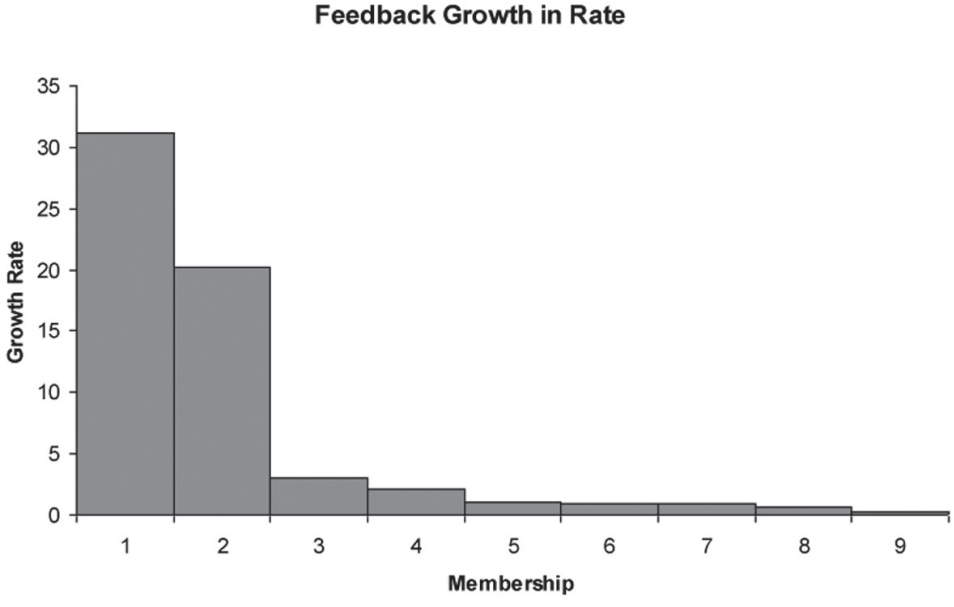


Figure 23 Growth in Rate

Gibrat's Law means that the log-normal distributions suggest firm's proportionate growth rate. That is, the expected value of the increment of firm's size over a period of time is proportional to the current size of the firm. In other words, firm growth rate is irrelevant to size. We examine the change of sellers' total feedbacks scores after a one year period. To uncover the growth pattern of seller transaction volumes, we ran the following regression: $\ln (Y (t_1)) = a + b \ln (Y (t_0))$, where $Y (t_0)$ is the feedback score at time t_0, and $Y (t_1)$ is the reputation score at time t_1. In the spirit of *Gibrat's Law*, we hypothesize b to be equal to 1, which reflects a proportionate growth. Table 10 shows the regression results. Based on the values of the coefficient estimates in a confidence interval of 95% significance, the regression results fail to support a hypothesis of a proportionate growth for three cases: sellers as whole, sellers with sell-dominant, and sellers with buy-dominant. The estimated coefficients of b for three cases are significantly below 1, which suggests that the sellers with low transaction volumes (also means that previously transacted less) grew faster than those established sellers with more transactions (along with higher transaction volumes). These findings at individual product market (micro) level are consistent with the research by Lin et al. (2006) at the entire market (macro) level, which sheds light on the limitation of *Gibrat's Law.*

Table 10 Regression Results

		Coefficients	t-value	P-value	Lower 95%	Upper 95%
Sellers	C	1.296	57.857	0	1.252	1.340
	b	0.851	157.587	0	0.841	0.862
	R^2	0.820	Adj. R^2	0.820	N	5,451
Sellers	C	1.398	41.444	0	1.332	1.464
Sell-D	b	0.860	119.857	0	0.846	0.874
	R^2	0.843	Adj. R^2	0.843	N	2,672
Sellers	C	1.427	45.739	0	1.366	1.488
Buy-D	b	0.770	87.181	0	0.753	0.787
	R^2	0.732	Adj. R^2	0.732	N	2,779

7. Theoretical contributions

In this study, we use Xbox game consoles data on eBay to analyze the market structure of online auctions in 2006-2007. By investigating three dimensions of market structure, we fill certain gaps in existing research on market structure:

First, existing studies do not provide information about eBay users' membership length. This study helps provide a complete picture of the demographics of market

participants with the analysis of membership lengths. The membership lengths combined with other measures such as feedback scores can be used to judge whether one eBay user is active and/or experienced.

Second, existing studies do not differentiate between eBay bidders and winners, even if winners are relatively important to sellers because they are willing to pay the highest prices and finally buy the items. The differentiation in this study helps us better understand the differences among bidders and winners; and

Third, we test the HHI index and *Gibrat's Law* in online auction market at the individual product (micro) level by using a relatively large sample size. Combining with existing studies that test HHI index and *Gibrat's Law* at the entire market (macro) level, this study helps enrich existing theories regarding market concentration and firm evolution.

8. Managerial implications

Understanding the characteristics of market participants and the extent of competition is of vital importance to potential entrepreneurs and traders before they decide to use the channel of online auctions. In this study, we study the market structure in 2006-2007. We believe that the market structure is stable for a long time. The findings in this study can also be used to understand the current market structure. In this study, we find many eBay users had low transaction volumes as indicated by their feedback scores. Sellers had more transaction volumes than buyers have. Sellers also typically had a longer membership than buyers. Thus, it appears that buyers had less eBay experience than sellers, and buyers were less active than sellers. Given many buyers are less experienced or inactive, sellers should carefully list their products with detailed description and instruction. In the online market, sellers need to help buyers evaluate the products, and earn their confidence and trust. At the same time, eBay, the online auction house, should also provide a variety of help and services to buyers, especially new buyers.

We also find that the Xbox game console market on eBay was very competitive. The online auction market such as eBay shows easy entry for potential sellers without high market barriers, and potential buyers might benefit lower prices from the competitive market. On the other side, sellers are under a lot of competitive pressure to survive and grow in this market. They need to study efficient and effective selling strategies. It is critical for sellers, especially newcomers, to earn competitive advantages in this online market. How to achieve these advantages is a valuable topic, but beyond the scope of this study.

We also find that eBay users' transaction volumes did not follow a log-normal distribution, which suggests that sellers with higher transaction volumes grow slower than sellers with lower transaction volumes. This suggests that it is relatively easy to start a business on eBay but achieving consistent and sustainable growth is a great challenge to sellers. Sellers need to boost their sales by winning buyers' trust and applying different marketing strategies. As they grow, sellers need to use more and more efficient and effective selling strategies to keep growing, such as becoming an eBay power seller, earning truthfulness certificates from third parties, building a good reputation, and utilizing marketing promotions.

Finally, our research also has managerial implications to buyers and online auction houses. Analysis of bidders and winners helps buyers better understand who are real competitors. The knowledge of sellers' demographics helps buyers choose the right counterparts. For example, new buyers with trust concerns towards sellers might choose eBay power sellers to bid or buy as they seem to be more truthful to inexperienced buyers. Knowledge of market structure also helps the online auction house understand the market. Thus, eBay can better serve market participants by providing tools and services that enhance trust and facilitate transactions.

9. Conclusion and limitations of the study

Using Xbox game console market data at eBay in 2006-2007, we offer insights into the market structure of online auction, particularly, the characteristics of users, the extent of market competition, and growth of transaction volumes over time. We find that many eBay users had low transaction volumes as measured by feedback scores. Sellers had more transaction volumes and longer memberships than buyers. This implies that sellers, as well as eBay, the online auction house, need to provide as much information about the products being auctioned, and a variety of services to win buyers, especially inexperienced buyers. We also find that the Xbox game console market was very competitive. To survive and succeed in this market, earning competitive advantages is very critical. We also find that sellers with higher transaction volumes grew slower than sellers with lower transaction volumes. It is relatively easy to start a business at eBay, but achieving sustainable growth poses a great challenge to sellers. Sellers need to use more and more efficient and effective selling strategies along with other marketing efforts. We discuss the theoretical contributions to the literature and managerial implications to sellers, buyers and online auction house.

There are some limitations in this study. It is possible for one seller or buyer to use different eBay user names, but we have no way of identifying them in an online

environment. Therefore, market share concentration for a single user may exceed the range noted earlier. Another limitation is that we only use data for Xbox game consoles. Our findings might be extended to similar products such as the Sony PlayStation and Nintendo game consoles, but replication studies using different products -- both within and outside the electronic game category -- can offer new insights into online market structure. Future research should examine the drivers of positive feedback scores as this appears to be critical for long-term success in the online B2C and C2C marketplace. Lastly, future studies should investigate the current market structure, and compare it with the historical one to check the market evolvement.

References

Alt, R. & Klein, S. (2011) 'Twenty years of electronic markets research -- looking backwards towards the future', *Electron Markets*, Vol. 21, No. 1, pp. 41-51.

Arora, A., Greenwald, A., Kannan, K., & Krishnan, R. (2007) 'Effects of information-revelation policies under market-structure uncertainty', *Management Science*, Vol. 53, No. 8, pp. 1234-1248.

Ba, S. & Pavlou, P. (2002) 'Evidence of the effect of trust building technology in electronic markets: price premiums and buyer behavior', *MIS Quarterly*, Vol. 26, No. 3, pp. 243-268.

Ba, S., Whinston, A.B., & Zhang, H. (2003) 'Building trust in online auction markets through an economic incentive mechanism', *Decision Support Systems*, Vol. 35, No. 3, pp. 273-286.

Bakos, J.Y. (1997) 'Reducing buyer search costs: implications for electronic marketplaces', *Management Science*, Vol. 43, No. 12, pp. 1676-1692.

Barua, A., Whinston, A.B., & Yin, F. (2000) 'Value and productivity in the Internet economy', *Computer*, Vol. 33, No. 5, pp. 102-105.

Brynjolfsson, E. & Smith, M.D. (2000) 'Frictionless commerce? a comparison of Internet and conventional retailers', *Management Science*, Vol. 46, No. 4, pp. 563-585.

Chiu, C.-M., Huang, H.-Y., & Yen, C.-H. (2010) 'Antecedents of trust in online auctions', *Electronic Commerce Research and Applications*, Vol. 9, No. 2, pp. 148-159.

Dellarocas, C., Fan, M., & Wood, C.A. (2004) 'Self-Interest, reciprocity, and participation in online reputation systems,' Working paper, MIT Sloan School of Management, Cambridge, MA, February.

Dewally, M. & Ederington, L. (2006) 'Reputation, certification, warranties, and information as remedies for seller-buyer information asymmetries: lessons from the online comic book market', *Journal of Business*, Vol. 79, No. 2, pp. 693-730.

Dewan, S & Hsu, V. (2004) 'Adverse selection in electronic markets: evidence from online stamp auctions', *Journal of Industrial Economics*, Vol. 52, No. 4, pp. 497-516.

Gefen, D., Benbasat, I., & Pavlou, P. (2008) 'A research agenda for trust in online environments', *Journal of Management Information Systems*, Vol. 24, No. 4, pp. 275-286.

Hart, P.E. & Oulton, N. (1996) 'Growth and size of firms', *The Economic Journal*, Vol. 106, No. 438, pp. 1242-1252.

Hirschman, A.O. (1964) 'The paternity of an index', *The American Economic Review*, Vol. 54, No. 5, pp. 761-762.

Hou, J. & Blodgett, J. (2010) 'Market structure and quality uncertainty: a theoretical framework for online auction research', *Electron Markets*, Vol. 20, No. 1, pp. 21-32.

Houser, D. & Wooders, J. (2006) 'Reputation in auctions: theory, and evidence from eBay', *Journal of Economics & Management Strategy*, Vol. 15, No. 2, pp. 353-369.

Klein, B. & Leffler, K.B. (1981) 'The role of market forces in assuring contractual performance', *Journal of Political Economy*, Vol. 89, No. 4, pp. 615-641.

Li, D., Li, J., & Lin, Z. (2008) 'Online consumer-to-consumer market in China -- a comparative study of Taobao and eBay', *Electronic Commerce Research and Applications*, Vol. 7, No. 1, pp. 55-67.

Li, L. (2010) 'Reputation, trust, and rebates: how online auction markets can improve their feedback mechanisms', *Journal of Economics & Management Strategy*, Vol. 19, No. 2, pp. 303-331.

Lin, Z., Li, D., Janamanchi, B., & Huang, W. (2006) 'Reputation distribution and consumer-to-consumer online auction market structure: an exploratory study', *Decision Support Systems*, Vol. 41, No. 2, pp. 435-448.

Melnik, M.I. & Alm, J. (2002) 'Does a seller's ecommerce reputation matter? evidence from eBay auctions', *The Journal of Industrial Economics*, Vol. 50, No. 3, pp. 337-349.

Pavlou, P.A. & Dimoka, A. (2006) 'The nature and role of feedback text comments in online marketplaces: implications for trust building, price premiums, and seller differentiation,' *Information Systems Research*, Vol. 17, No. 4, pp. 392-414.

Resnick, P. & Zeckhauser, R. (2002) 'Trust among strangers in Internet transactions: empirical analysis of eBay's reputation system', in Baye, M.R. (Ed.), *The Economics of the Internet and E-commerce*, Elsevier Science, Amsterdam, The Netherlands, pp. 127-157.

Resnick, P., Zeckhauser, R., Swanson, J., & Lockwood, K. (2006) 'The value of reputation on eBay: a controlled experiment,' *Experimental Economics*, Vol. 9, No. 2, pp. 79-101.

Shapiro, C. (1982) 'Consumer information, product quality, and seller reputation', *The Bell Journal of Economics*, Vol. 13, No. 1, pp. 20-35.

Shapiro, C. (1983) 'Premiums for high quality products as returns to reputations', *The Quarterly Journal of Economics*, Vol. 98, No. 4, pp. 659-680.

Wolf, J.R. & Muhanna, W.A. (2011) 'Feedback mechanisms, judgment bias, and trust formation in online auctions', *Decision Sciences*, Vol. 42, No. 1, pp. 43-68.

Zhang, J. (2006) 'The roles of players and reputation: evidence from eBay online auctions', *Decision Support Systems*, Vol. 42, No. 3, pp. 1800-1818.

About the authors

Yanbin Tu is an Associate Professor of Marketing in Department of Marketing, School of Business at Robert Morris University in Pennsylvania. He earned his Doctorate Degree from the University of Connecticut. Prior to teaching, he worked for the Bank of Shanghai in China. His research interests cover e-commerce, interactive marketing, database marketing, customer relationship management, and financial services marketing. His work has appeared in *International Journal of Electronic Commerce, International Journal of Internet Marketing and Advertising, International Journal of Electronic Business, International Journal of Technology Marketing*, and *Communications of the ACM*.

Steven R. Clinton is an Associate Professor and Department Head in Marketing at Robert Morris University. He received his Ph.D. Degree (Major: Marketing; Minor: Logistics) from Michigan State University in 1998. His research interests include international supply chain organization, customer service in logistics, and logistics strategy. He has published in *Journal of Business Logistics, Transportation Journal, International Journal of Physical Distribution and Logistics Management, Journal of Production and Inventory Management*, and *International Marketing Review* as well as numerous conference proceedings.

Adora Holstein is an Associate Professor of Economics in Department of Economics and Legal Studies, School of Business at Robert Morris University in Pennsylvania. She earned her Ph.D. in Economics from Pennsylvania State University in 1987. Her research interests

are in industrial organization, public policy in the health care and finance industries, and international trade and investments. She has published in the *Global Journal of Business Research*, *International Business and Economics Research Journal*, *Pennsylvania Economic Review*, and several proceedings of national and international academic business conferences.

MIS Review Vol. 18, No. 1, September (2012), pp. 57-69

Data Hiding Technique Based on LSB Matching towards High Imperceptibility

Marghny H. Mohamed[1], Naziha M. Al-Aidroos[2], Mohamed A. Bamatraf[3]
[1]*Department of Computer Science, Asyut University*
[2]*Department of Computer Engineering, Hadhramout University of Science and Technology*
[3]*Department of Computer Science, Hadhramout University of Science and Technology*

ABSTRACT: *Steganography is the art and science of hiding data. The secret message is hidden in such a way that the observer cannot detect any changes in the original image. In this paper, we propose an efficient steganographic scheme which provides high capacity of secret data as well as imperceptibility of stego image. Using fixed number (i.e., max) as the upper limit criteria for embedding, the target pixels selected for embedding are based on the number of bits which matches between the secret data bits and the cover pixel bits. As an indicator to determine which pixel is used for embedding, the first bit is reversed (negated). The experimental results over greyscale images showed, the ability of embedding high data capacity with preserving stego image quality. Efficiency of the model is evaluated using two metrics, the Peak-Signal-to-Noise Ratio (PSNR) value as one of the evaluation metrics, and the visual effects over the cover image as the second. Results are drawn and compared with one of the most common techniques (Classic least-significant bit, LSB) and accordingly showed significant advancement.*

KEYWORDS: *Steganography, Data Hiding, Data Security, LSB (least-significant bit) Substitution, LSB Matching.*

1. Introduction

The rapid development of the internet and the digital information revolution caused significant changes in the global society, ranging from the influence on the worldwide economy to the way people nowadays communicate. Broadband communication networks and multimedia data available in a digital format (images, audio, video) opened many challenges and opportunities for innovation.

In order to keep the security and privacy of our data from unauthorized access, variety of techniques have been proposed in the field of data security. Cryptography and Steganography are two main methods in this field.

Cryptography is the process of transforming a secret data into a form that is unreadable, except by someone who has a proper key. For any unauthorized user who does not have a key, the ciphertext will look like nothing but streams of meaningless

code. Although cryptography is a good way to secure data, it still has some weaknesses. The appearance of ciphertexts would give unauthorized user an impulse to recover them. Moreover, the unauthorized users might even simply destroy the ciphertext out of range when they have trouble recovering them so that the legal receivers cannot get the data in time.

Steganography is a branch of information hiding. It embeds the secret message in the cover media (e.g., image, audio, video, etc.) to hide the existence of the message. The word Steganography comes from the Greek words steganos and graphia, which together means "hiding writing."

Confidentiality is at the heart of what steganography does. Steganography, though, accomplishes confidentiality in a slightly different manner than cryptography. With cryptography, an unauthorized person can see the information but cannot access it. Because he or she can tell that there is information being protected, the unauthorized person may try to break the encryption. With steganography, because the data is hidden, any unauthorized party does not even know there is sensitive data there. From a confidentiality standpoint, steganography keeps the information protected at a higher level. In brief, we can say that while cryptography is about protecting the content of messages, steganography is about concealing their very existence.

The digital steganography process has three basic components:

(1) The data to be hidden (secret data).

(2) The cover file (cover-carrier), in which the secret data are to be embedded.

(3) The resulting stego-file (stego-carrier).

For the past decade, many steganographic techniques for still images have been presented. A simple and well-known approach is directly hiding secret data into the least-significant bit (LSB) of each pixel in an image. Then, based on the LSB technique, a genetic algorithm of optimal LSB substitution is available to get better stego-image quality than the simple LSB method (Wang, Lin, & Lin, 2001). In addition, Chang, Hsiao, and Chan (2003) proposed a fast and efficient optimal LSB method based on the dynamic programming strategy that improves the computation time of Wang et al.'s scheme (Wang et al., 2001).

Thien and Lin (2003) also presented a simple LSB scheme based on the modulus function to improve the stego-image quality. Besides, A novel simple LSB technique based on optimal pixel adjustment was presented to achieve the goal of improving the stego-image quality (Chan & Cheng, 2004).

Liu et al. (2004) presented a novel bit plane-wise data hiding scheme using variable-depth LSB substitution and employed post-processing to eliminate the resulting noticeable artifacts.

In order to gain a higher payload than when the 4-LSBs method is used, Wang (2005) has proposed two new schemes based on the modulo operator.

In order to enhance the security, on the other hand, Lou and Liu (2002) proposed a LSB-based steganographic method that can resist the common-cover-carrier attack by embedding variable-size secret data and redundant Gaussion noise. Lin and Tsai (2004) have proposed a new approach that integrates the concept of secret image sharing and steganographic techniques with the additional capability of image authentication.

The LSB-based methods mentioned above, directly embed the secret data into the spatial domain in an unreasonable way without taking into consideration the difference in hiding capacity between edge and smooth areas. In general, the alteration tolerance of an edge area is higher than that of a smooth area. That is to say, an edge area can conceal more secret data than a smooth area. With this concept in mind, Wu and Tsai (2003) presented steganographic scheme that offers high imperceptibility to the stego-image by selecting two consecutive pixels as the object of embedding. The payload of Wu and Tsai's scheme is determined by the difference value between the pixels. In a paper by Zhang and Wang (2004) Pixel Value Differencing (PVD) was successfully attacked. This was done through an analysis of the histogram of the stego image. Wu et al. (2005) proposed a method based on PVD which tries to increase the embedding capacity of PVD. They used LSB embedding for smooth regions and PVD embedding for edged areas. Wang et al. (2008) improved the stego-image quality by adjusting the remainder of the two consecutive pixels instead of the difference value, by using the modulus operation. Besides that, this method solved the falling-off-boundary problem also.

An Adaptive data hiding method was proposed by Yang et al. (2008). In this method pixels located in the edge areas are embedded by a k-bit LSB substitution method with a larger value than that of the pixels located in smooth areas.

An effective steganographic scheme has to be implemented that thwarts the attacker from extracting the secret information during transmission and reception (Chen, Chang, & Le, 2010).

Padmaa and Venkataramani (2010) proposed a methodology which enhances the Chang and Tseng (2004) technique by increasing the embedding capacity and improves the stego image quality using Thein and Lin (2003) algorithm by adapting Zig-Zag traversing scheme (ZZTS).

In this paper, 8-bit grayscale images are selected as the cover images. For data hiding methods, the image quality refers to the quality of the stego images. The proposed method is based on LSB substitution method and on finding a matching between the secret data bits and the cover pixels bits. To prevent illicit access of the data and to obtain better stego image quality, our method is presented.

The rest of this paper is organized as follows. Section 2 briefly describes the simple LSB substitution. In Section 3, the proposed method is presented. Experimental results with a brief discussion are given in Section 4. Finally conclusions are presented in Section 5.

2. LSB steganography

LSB insertion is a common and simple approach to embed information in a cover file: it overwrites the LSB of a pixel with an *M*'s bit. Unfortunately, modifying the cover image changes its statistical properties, so eavesdroppers can detect the distortions in the resulting stego image's statistical properties. The general operation of data hiding by using a simple LSB substitution method is described in this section.

Many steganogrphic methods embed a large amount of the secret information in the first *k* LSB's of the cover image pixels. Because of the imperfect sensibility of the human visual system, the existence of the embedded secret information can be imperceptible.

A digital image *I* can be represented by a two dimensional, with size ($N = width \times height$). Each image is composed of finite elements each of which has a definite location and amplitude. These elements are referred to as image pixels, $I = \{P_1, \ldots, P_N\}$, where every pixel P_i in the greyscale image consists of 8 bits: $|P_i| = 8$, $P_i = \{b_1, ..., b_8\}$, where: $b_i \in \{1, 0\}$.

LSB with *k* embedding factor $1 \leq k \leq 8$, for every P_i targeted for embedding data bits replaces the set of bits: $T = t_1, ..., t_k$, keeping the rest of bits $\overline{T} = (i.e., t_{k+1} .. t_8)$ without effect.

The generated set of pixels $\{P'_1, ..., P'_N\}$ represents as the stego image *I'*, where: $P'_i = \{b'_1, ...b'_8\}$, $b'_j \in \{1, 0\}$.

The following example describes how the LSB embedding happens, suppose we have the following pixels:

$P_1 = [11001011], \ldots P_2 = [00011010], \ldots P_3 = [01001100].$

And the bits want to embed it in the LSBs positions are $M = [010]$, the resulted pixels after embedding will be:

$P_1 = [1100101\underline{0}], \ldots P_2 = [0001101\underline{1}], \ldots P_3 = [0100110\underline{0}].$

The quality of the stego image produced by simple LSB substitution may not be acceptable. It means that the method degrades the image quality and probably attracts unauthorized attention. Once he/she notices the stego image, secret message can be easily extracted by simple LSB analysis. The proposed method can solve these problems, even though it is based on classic LSB, yet it is totally different as the embedding process is not a uniform in terms of what pixels are selected for embedding in the cover image. This increases the complexity of the hidden data extraction in one hand and preserves the image quality in the other hand, by minimizing the number of the modified LSB bits.

3. The proposed scheme

Any image I consists of set of pixels:

$$I = \{P_1, \ldots, P_N\}, |P_i| = 8 \text{ bits},$$
$$P_i = \{b_1, .., b_8\}, b_j \in \{1, 0\}. \quad (1)$$

The image size is computed as:

$$N = W \times H \quad (2)$$

Where W, H is the image width and height respectively. Suppose M is the secret data bits, with length n,

$$M = \{m_1, m_2, ..., m_n\}, \text{ where } m_i \in \{1, 0\}. \quad (3)$$

Like other data hiding schemes, the proposed scheme consists of two procedures; the embedding procedure and the extracting procedure. In this section the procedures steps are described in detail.

3.1 The embedding procedure

The data embedding process' steps are explained below:

Step 1: To embed secret data bits, firstly, select a number say *max*, where ($1 \leq max \leq 8$) to define the similarity threshold to be targeted for embedding.

Step 2: Scan pixel bits starting from 2nd LSB bit, to check if this pixel is valid for embedding or not based on embedding criteria (*i.e.*, *matching*) as follows:

$\forall$ cover image pixels P_i, where ($1 \leq i \leq N$),

(1) $\forall P_i[j] \in P_i$, where ($2 \leq j \leq 8$), if $P_i[j] = M_k$, so go to the next bit by increase the bit's counter (l) by 1, this step will be repeated until unmatched bit is found or until $l = max$ (*i.e.*, *max*: number of matches achieved between pixel bits and secret data bits).

(2) If $l = max$, meaning the embedding is done, so go to the next pixel.

Step 3: If the scanned pixel is valid for embedding then reverse the 1st LSB bit, else all pixel bits will remain unchanged.

$$\begin{aligned} &if\,(P_i\,[1] == 0) \\ &\quad P_i\,[1] = 1, \\ &else\,P_i\,[1] = 0 \end{aligned} \tag{4}$$

Step 4: After embedding all the secret data bits, the stego image is generating. The block diagram of the entire embedding procedure is represented in Figure 1.

3.2 The extracting procedure

This procedure is done in the other communication side to extract the hidden secret data bits, as following:

Step 1: Using the original cover image, the comparing between cover (I) and stego (I')

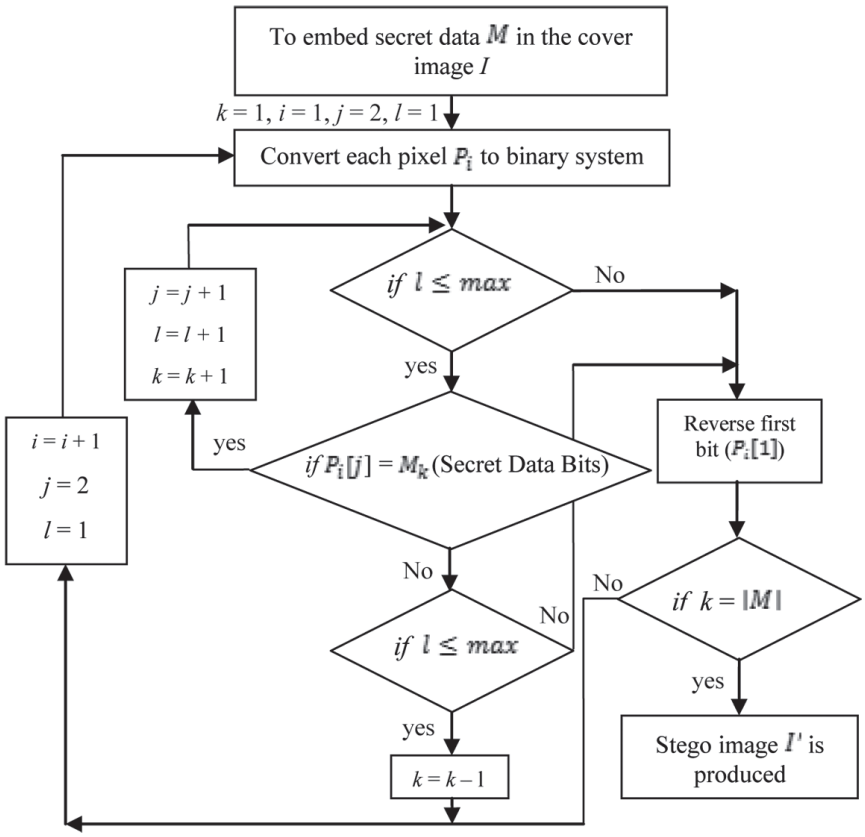


Figure 1 A Block Diagram of Embedding Steps

image pixels is done. Any pixel's value in the stego image differ from its original value, meaning it has an embedded bits.

$$\begin{aligned} &for\ (i = 1\ to\ N) \\ &\quad if\ (P_i != P'_i) \\ &P'_i\ has\ an\ embedded\ bits, \\ &\quad else\ go\ to\ next\ pixel \end{aligned} \tag{5}$$

Where P_i, P'_i is the cover, stego pixel respectively.

Step 2: If the embedded pixels are determined, the extracting is done by extracting the *max* bits from it.

$$\begin{aligned} &j = 2, k = 1, \\ &for\ (l = 1\ to\ max) \\ &\quad M'_k = P'_i\,[j], \\ &k = k + 1, j = j + 1. \end{aligned} \tag{6}$$

Where M'_k is the extracted secret message, k is the index of it, $P'_i\,[j]$ is the jth bit of the stego image pixel P'_i, and l is the counter of bits to be extracted.

Step 3: At this stage, the retrieving algorithm finishes and the embedded data has been retrieved completely. The extracting procedure steps are described in Figure 2.

4. Experimental results

The experimental results presented in this section demonstrate the performance of our proposed scheme. To conduct our experiments, we used four 128 × 128 standard grayscale images, ''Baboon," ''Lena," ''Pepper" and ''Cameraman." These images are shown in Figure 3. A series of pseudo random binary numbers are used as the secret data to be embedded into the cover images.

The well known Peak-Signal-to-Noise Ratio (PSNR) is used as performance measurement criteria, which is classified under the difference image distortion metrics. PSNR is often expressed on a logarithmic scale in decibels (*dB*), it is applied on the stego and the cover images. It is defined as:

$$PSNR = 10 \times log_{10} \frac{255^2}{MSE}\ (dB). \tag{7}$$

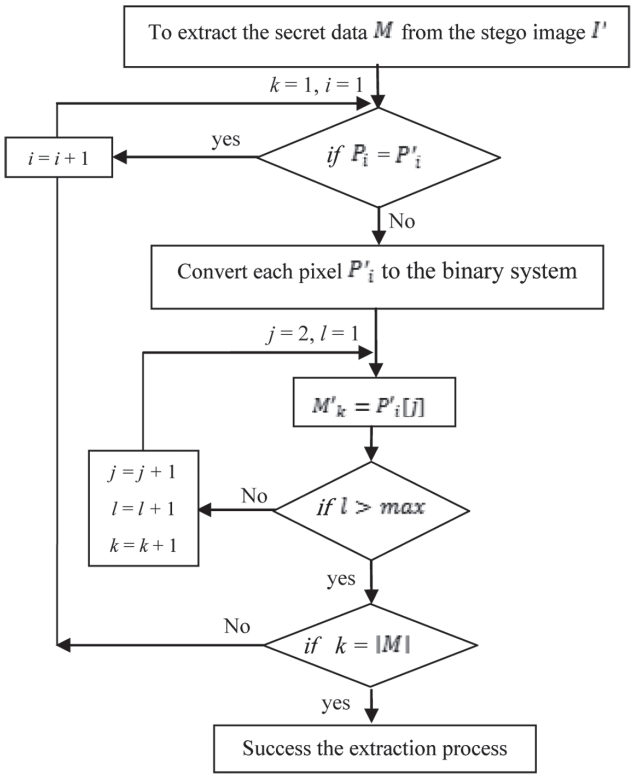
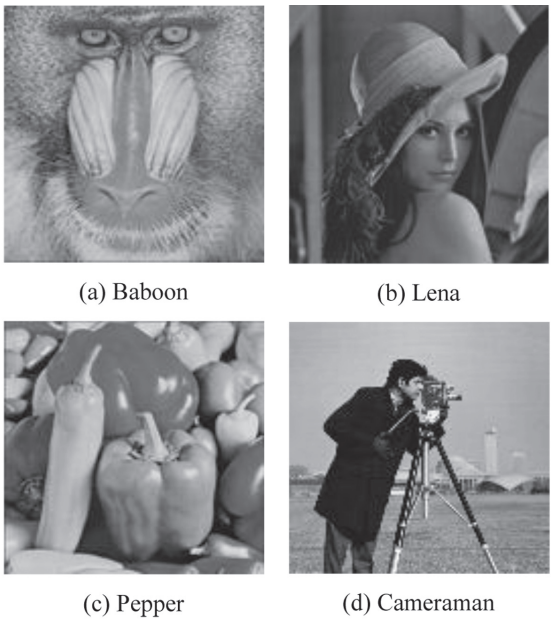


Figure 2 A Block Diagram of Extracting Steps



(a) Baboon (b) Lena

(c) Pepper (d) Cameraman

Figure 3 Four 128 × 128 Grayscale Images

Where *MSE* is the mean square error between the cover and stego images. For a cover image whose width and height are *W* and *H*, *MSE* is defined as:

$$MSE = \frac{1}{W \times H} \sum_{i=1}^{w} \sum_{j=1}^{H} (l_{ij} - l'_{ij})^2. \quad (8)$$

Where l_{ij} and l'_{ij} are the pixel values of the cover and stego images, respectively.

Note that, a large PSNR value means that the stego image is most similar to the original image and vice versa. Generally, if the PSNR value is larger than 30 *dB*, then the distortion on the stego image is hard to be detected by human eyes (Chou, Chang, & Li, 2008). Our experimental results show that the proposed method can embed a large amount of secret data while keeping a very high visual quality.

The average of PSNR values are calculated for 6 runs with different randomly selected secret data samples of different lengths. The results of the proposed method for the four grayscale images are shown in Table 1 along with the corresponding results for the classic LSB method, where the *max* value is used as the upper limit criteria for embedding in the proposed scheme, which is also used as the number of LSBs bits for embedding in each pixel in the classic LSB method as shown in Table 1.

We can clearly notice that, the PSNR value of the proposed method is constant although the embedded secret data length is variable, and the embedding criteria is variable as well, because the change in the cover image pixel's value is done only in the first least significant bit. As shown in Table 1, mostly there are significant differences

Table 1 The PSNR Values of the Proposed Method vs. Classic LSB Method

Cover Images	*max* value (no. of LSBs)	PSNR (*dB*)	
		Classic LSB Method	The Proposed Method
Baboon	2	45.11	48.13
	3	39.19	48.13
	4	33.86	48.13
Lena	2	45.13	48.13
	3	38.97	48.13
	4	31.39	48.13
Pepper	2	44.59	48.13
	3	38.84	48.13
	4	33.05	48.13
Cameraman	2	46.62	48.13
	3	37.86	48.13
	4	34.95	48.13

in the PSNR value, makes the proposed technique significantly better compared to the classical LSB.

From Tables 1 and 2, we can conclude that the proposed method performs better if compared to the classic LSB method. To explain, with the same capacity, the proposed scheme provides a higher PSNR, because the embedding targets the identical bits in the cover image pixels with the secret data bits which does not affect the original image quality. Unlike the LSB method, the embedding is done without considering the similarity between the secret data and the cover image bits which definitely will cause changes in the obtained stego image.

Table 2 The Capacity for the Proposed Method and the Classic LSB Method

x^*	Capacity	
2	2 bpp	32,768 (bits)
3	3 bpp	49,152 (bits)
4	4 bpp	65,536 (bits)

Note: $^*x$ is the number of LSBs bits, which are inserted into each pixel.

Accordingly, the advantages of the proposed scheme can be summarized as follows: The first advantage appears in the high-quality stego-image visually as well as statistically, where searching for the higher similarity rather than blindly embedding the data minimizes the change in the original image pixel's values. The second advantage is in the distribution of the hidden data, where not all the cover pixels are used for embedding data. Finally, the proposed scheme requires much less computations because its steps are so simple, easy and don't need complex computations such as some techniques which transform image in the frequency domain.

5. Conclusion

Information hiding is a technique for embedding important data into digital media. Steganography, a branch of information hiding, aims to protect important data in transmission. Message capacity and stego image quality are two important criteria in evaluating a steganogarphic method. The basic concept of the proposed method is to use simple LSB substitution. It searches for the similar properties between the secret data bits and the cover image pixels as target for embedding. Our experimental results show that the proposed method provides a stable high stego image quality visually and statistically with high message capacity compared to the classic LSB method.

References

Chan, C.K. & Cheng, L.M. (2004) 'Hiding data in images by simple LSB substitution', *Pattern Recognition*, Vol. 37, No. 3, pp. 469-474.

Chang, C.C., Hsiao, J.Y., & Chan, C.S. (2003) 'Finding optimal least-significant-bit substitution in image hiding by dynamic programming strategy', *Pattern Recognition*, Vol. 36, No. 7, pp. 1583-1595.

Chang, C.C. & Tseng, H.W. (2004) 'A steganographic method for digital images using side match', *Pattern Recognition Letters*, Vol. 25, No. 12, pp. 1431-1437.

Chen, W.J., Chang, C.C., & Le, T.H.N. (2010) 'High payload steganography mechanism using hybrid edge detector', *Expert Systems with Applications*, Vol. 37, No. 4, pp. 3292-3301.

Chou, Y.C., Chang, C.C., & Li, K.M. (2008) 'A large payload data embedding technique for color images', *Fundamenta Informaticae*, Vol. 88, Nos. 1/2, pp. 47-61.

Lin, C.C. & Tsai, W.H. (2004) 'Secret image sharing with steganography and authentication', *Journal of Systems and Software*, Vol. 73, No. 3, pp. 405-414.

Liu, S.H., Chen, T.H., Yao, H.X., & Gao, W. (2004) 'A variable depth LSB data hiding technique in images', *Proceedings of the Third International Conference on Machine Learning and Cybernetics*, Shanghai, China, August 26-29, Vol. 7, pp. 3990-3994.

Lou, D.C. & Liu, J.L. (2002) 'Steganographic method for secure communications', *Computers and Security*, Vol. 21, No. 5, pp. 449-460.

Padmaa, M. & Venkataramani, Y. (2010) 'Zig-Zag PVD -- a nontraditional approach', *International Journal of Computer Applications*, Vol. 5, No. 7, pp. 5-10.

Thien, C.C. & Lin, J.C. (2003) 'A simple and high-hiding capacity method for hiding digit-by-digit data in images based on modulus function', *Pattern Recognition*, Vol. 36, No. 12, pp. 2875-2881.

Wang, C.M., Wu, N.I., Tsai, C.S., & Hwang, M.S. (2008) 'A high quality steganographic method with pixel-value differencing and modulus function', *Journal of Systems and Software*, Vol. 81, No. 1, pp. 150-158.

Wang, R.Z., Lin, C.F., & Lin, J.C. (2001) 'Image hiding by optimal LSB substitution and genetic algorithm', *Pattern Recognition*, Vol. 34, No. 3, pp. 671-683.

Wang, S.J. (2005) 'Steganography of capacity required using modulo operator for embedding secret image', *Applied Mathematics and Computation*, Vol. 164, No. 1, pp. 99-116.

Wu, D.C. & Tsai, W.H. (2003) 'A steganographic method for images by pixel-value differencing', *Pattern Recognition Letters*, Vol. 24, Nos. 9/10, pp. 1613-1626.

Wu, H.C., Wu, N.I., Tsai, C.S., & Hwang, M.S. (2005) 'Image steganographic scheme based on pixel-value differencing and LSB replacement methods', *IEE Proceedings -- Vision, Image and Signal Processing*, Vol. 152, No. 5, pp. 611-615.

Yang, C.H., Weng, C.Y., Wang, S.J., & Sun, H.M. (2008) 'Adaptive data hiding in edge areas of images with spatial LSB domain systems', *IEEE Transactions on Information Forensics and Security*, Vol. 3, No. 3, pp. 488-497.

Zhang, X. & Wang, S. (2004) 'Vulnerability of pixel-value differencing steganography to histogram analysis and modification for enhanced security', *Pattern Recognition Letters*, Vol. 25, No. 3, pp. 331-339.

About the authors

Marghny H. Mohamed received his Ph.D. degree in computer science from the University of Kyushu, Japan, in 2001, his M.Sc. and B.Sc. from Asyut University, Asyut, Egypt, in 1993 and 1988, respectively. He is currently an Associate Professor in the Department of Computer Science, and Vice-President for Student Affairs and Education of the Faculty of Computers and Information Systems, Asyut University, Egypt. His research interests include data mining, text mining, information retrieval, Web mining, machine learning, pattern recognition, neural networks, evolutionary computation, fuzzy systems, and information security. Dr. Marghny is a member of the Egyptian Mathematical Society and Egyptian Syndicate of Scientific Professions. He is a manager of some advanced research projects in Faculty of Computers and Information Systems, University of Asyut, Egypt.

Naziha M. Al-Aidroos received her Bachelor Science degree in computer science in 2003 from Hadhramout University of Science and Technology, Yemen, got here M.Sc. degree in 2009 from Asyut University, Egypt, in computer science. She has worked teacher in Department of Computer Engineering in Faculty of Engineering and Petroleum in Hadhramout University of Science and Technology, Yemen, and she is currently a Ph.D. student in Faculty of Science, Asyut University, Egypt. Her interest subjects are networks, data security, data mining, neural networks, and image processing.

Mohamed A. Bamatraf is an Assistant Professor in Hadhramout University of Science and Technology, Yemen, Faculty of Science, Department of Computer Science. He received his B.S. degrees in Computer Science from Poona University, India, and got his M.Sc. in Computer Science from Osmania University, India, and received his Ph.D. from Asyut

University, Egypt. His Doctoral thesis was about modified data mining techniques and its application in medical diagnosis and intrusion detection. His research areas of interest includes: data and network security, medical informatics, data mining, machine learning, and bioinformatics. His research activities are currently focused on the application of bioinformatics, machine learning, and data security.

MIS Review Vol. 18, No. 1, September (2012), pp. 71-91

Key Management Scheme for Cumulative Member Removal and Bursty Behavior in Secure Group Communication Using *m-ary* Tree

R. Aparna[1], B.B. Amberker[2]
[1]*Deptartment of Computer Science and Engineering, Siddaganga Institute of Technology*
[2]*Department of Computer Science and Engineering, National Institute of Technology*

ABSTRACT: *Secure group communication is an important research area and numerous applications are relied upon secure group communication model. Since the group is dynamic in nature, rekeying must be carried out in an efficient manner. Member leave event should be handled carefully compared to member join event. In some applications like pay-per-view, periodical electronic information distribution etc., many users join and leave the group at the same moment known as bursty behavior. In this paper, we propose schemes for handling cumulative member removal and bursty behavior. We use m-ary key tree for managing the secure group and maintain only m keys at each level of the key tree. We start with a scheme for cumulative member removal and then we handle all the possible bursty behavior scenarios. We analyze the communication and computation costs for worst cases. We compare the costs of our scheme with the schemes proposed by Li et al. (2001) and binary key tree scheme of Zou, Magliveras, and Ramamurthy (2002). We show that in our scheme the number of new keys generated and encryptions performed are less compared to Li et al. (2001) and Zou, Magliveras, and Ramamurthy (2002) schemes.*

KEYWORDS: *Secure Group Communication, m-ary Key Tree, Key Distribution Center, Cumulative Member Removal, Bursty Behavior, Encryption Keys.*

1. Introduction

With the widespread availability of powerful communication networks and explosive growth of Internet technologies, group communication has become a topic of considerable interest. Secure Group Communication (SGC) deals with exchange of information securely among a set of users. Many solutions have been proposed for key management in SGC. A naive approach is to have a common key shared between each pair of users in a group of size N. This results in storing $(N - 1)$ keys with each user and performs $(N - 1)$ encryptions to send a message. This scheme is proportional to N and does not scale well for a secure group with large number of users. Therefore, a better approach for SGC is to have a common secret key known as *group key* that is shared among members of the group.

Group membership may change over time. New members may join the group and existing members may leave the group. Whenever there is a membership change, it is necessary to change the group key to provide continued privacy. The process of changing the group key and communicating it to group members securely is known as *rekeying*. When a new member joins the group, the group key must be changed to avoid the new user from accessing past communication. This is known as *backward access control*. When a member leaves the group, the group key must be changed to avoid leaving member from accessing future communication. This is known as *forward access control*. A scalable SGC model ensures that the rekeying operation is carried out with minimal computation and communication costs.

Many applications like scientific discussion, teleconferencing, real-time information services, pay-per-view, etc., are based on SGC model. In applications like pay-per-view, periodical electronic information distribution, accessing online journals etc., many users subscribe and/or unsubscribe for the service at the same time. For instance, in the pay-per-view application, users subscribe at the start of a particular show and unsubscribe after the telecast of the show (for example sports event). We can have scenarios like single user join, single user leave, multiple users join, multiple users leave and sometimes a single user may join and a single user may leave the group at the same time. Similarly multiple users join and leave scenario may occur at approximately the same moment. This scenario in which multiple users join and/or multiple users leave is termed as *bursty behavior*. Whereas the scenario in which only multiple users leave, but no user joins is termed as *cumulative member leave* or *cumulative member removal*. The above mentioned applications exhibit bursty behavior and cumulative member leave. Hence, it is important to develop an efficient key management scheme to address these issues.

Many key management schemes have been proposed to manage SGC (Blundo et al., 1993; Burmester & Desmedt, 1995, 1997; Lee, Lui, & Yau, 2002; Lin, Lai, & Lee, 2005; Perrig, 1999; Rafaeli & Hutchison, 2003; Sherman & McGrew, 2003; Wong, Gouda, & Lam, 1998). In some schemes (Blundo et al., 1993; Fiat & Naor, 1993; Lin et al., 2005; Mittra, 1997; Perrig, 1999; Rafaeli & Hutchison, 2003; Sherman & McGrew, 2003; Wallner, Harder, & Agee, 1999; Wong et al., 1998) trusted *Key Distribution Center* (KDC) may be involved which generates and distributes initial private pieces of information to users in the group. Group key may be generated and distributed by the KDC itself or group members may compute the group key either interactively or non-interactively. The other category of schemes termed as *Contributory Key Agreement schemes* (Amir, Danilov, et al., 2004; Amir, Kim, et al., 2004; Burmester & Desmedt, 1995, 1997; Diffie & Hellman, 1976; Lee et al., 2002; Perrig, 1999) do not involve KDC, instead, all the group members contribute an equal share to compute the common secret key.

But, all the above mentioned schemes concentrate on reducing the number of encryptions and rekey messages when a single member joins or leaves the group. However, in Caronni et al. (1998), Chang et al. (1999), authors try to address the problem of multiple leave operations. In Li et al. (2001), joins and leaves are accumulated for a fixed period of time and then handled all at once, thereby reducing the frequency of key distribution. This is also considered as a case of bursty behavior. In Zou, Magliveras, and Ramamurthy (2002), Zou, Magliveras, and Ramamurthy address bursty behavior by extending the key management scheme proposed by Blundo et al. (1993). Here the storage required by each user is $\binom{n+t-1}{n-1}$ and the time complexity for computing the group key is $O(t^{2n})$, where n denotes number of users in the group and t, the threshold value. In Zou, Ramamurthy, and Magliveras (2002), bursty behavior is addressed by indexing users and keys with a binary representation and using binary right shift operation. The time complexity of this scheme is logarithmic in the group size.

The scheme proposed in Chang et al. (1999) focuses on the problem of cumulative member removal and finds the minimum number of messages required to distribute new keys to the remaining members of the group. The scheme uses a binary tree structure and assigns only two keys at each level of the tree. It finds the keys required for encrypting the changed keys by using Boolean function minimization technique. In Poornima, Aparna, and Amberker (2007a, 2007b) the scheme proposed in Chang et al. (1999) has been extended to *m-ary* tree and authors propose algorithms for single leave, two members leave and multiple members leave events. It handles only simultaneous leave operations.

In this paper, we extend the scheme proposed in Poornima et al. (2007a, 2007b) to address cumulative member removal and bursty behavior in SGC. To address cumulative member removal, we find encryption keys required to convey new group key to the remaining members of the group. We compare our scheme with Chang et al. (1999) scheme and show that we reduce the storage at KDC by a factor of 4% to 12%, at users by 30% to 38% and encryption cost is reduced by 55%. For bursty behavior scenario, we compute the number of keys generated, encryptions performed and rekey messages constructed for the worst case scenario. We address equal number of join and leave events, number of joins greater than number of leaves and number of joins less than number of leaves separately. We compare our results with the batch rekeying scheme proposed in Li et al. (2001) and show that the number of new keys generated and encryptions performed are either less than or equal to the values obtained in Li et al. (2001).

Rest of the paper is organized as follows: We discuss in brief the related work in Section 2, we begin with discussing the scheme for handling cumulative member removal in Section 3. In Section 4 we analyze bursty behavior with equal number of joins and leaves, number of joins more than number of leaves, number of joins less than number of

leaves scenarios. Section 5 highlights Implications for Practices and Section 6 concludes the paper.

2. Related work

The key management scheme for managing secure group communication proposed by Wong et al. (1998), Wong and Lam (2000) is one of the efficient method which employs a logical *key tree* structure. This scheme is also termed as Key Tree scheme. A key tree is a directed acyclic graph with two types of nodes, namely *U*-nodes representing group members and *K*-nodes representing keys. In this scheme KDC maintains a key tree with degree *d*, where each node in the tree corresponds to either member's private key, or group key or an auxiliary key. Users are at the leaf level of the tree and the key nodes at leaf level correspond to private keys of the users. The key at the root node of the tree is the *group key*. Keys at the internal nodes of the tree are the *auxiliary keys*. A member *u* of *U* is given a key *k* if and only if there is a directed path from *U*-node *u* to *K*-node *k* along the path from *U*-node to root. It addresses the problem of minimizing the number of rekey messages during single join or leave event. This scheme achieves scalable rekeying, which requires $2log_dN$ rekeying overhead for user join event and $(d - 1)\ log_dN$ for user leave event, where *N* is the group size. The scheme proposed in Waldvogel et al. (1999) reduces the overhead during user join event by allowing the users to calculate new key on their own using one-way function. The scheme proposed by Sherman and McGrew (2003) uses a one-way function tree in which keys are generated using one-way functions. In both the schemes rekeying overhead is reduced to log_2N instead of $2log_2N$.

In Li et al. (2001), Li et al. accumulate joins and leaves for a fixed period of time and then handle them in a batch termed as batch rekeying, thereby reducing the frequency of key distribution. A marking algorithm has been devised to process a batch of join and leave requests and the scheme is analyzed for worst case scenarios.

Zou, Magliveras, and Ramamurthy (2002) address bursty behavior using a symmetric polynomial in *N* indeterminates with coefficients in *Zp*, where *p* is a prime and $p \geq N$. It extends the scheme proposed by Blundo et al. (1993) and provides provision for accommodating users in the range *N* to 2*N*.

Bursty behavior is addressed in Zou, Ramamurthy, and Magliveras (2002) by using a key tree structure as in Wong et al. (1998). Here, a node at level *l* in the key tree is assigned with bitstring of length *l*, $1 \leq l \leq log_2N$. Each user u_i, $i = 1, 2, \ldots, N$ in the group is also assigned with an identification number *i*. To handle bursty behavior, it first finds the common keys shared among the leaving members by performing right shift operation on the bitstrings. It changes the common keys only once thereby reducing the computation

and communication costs. The amount of storage required at each user and KDC in this scheme is same as that of Wong et al. scheme (Wong et al., 1998).

The scheme in Chang et al. (1999) is proposed to handle multiple user leave event in large groups. The scheme uses a binary key tree to manage SGC. At every level i of the binary key tree a key pair (k_i, k'_i) is maintained, $i = 1, 2, ..., [log_2 N]$. Here, k_i and k'_i are not complement to each other, but are two different values. This scheme uses Boolean Function Minimization technique to compute minimum number of encryption keys to securely distribute the changed keys to the remaining users in the group. In Poornima et al. (2007a, 2007b) *m-ary* tree is used to manage SGC. Here, m keys are used at each level of the tree. It addresses single member leave, two members leave and multiple members leave events, thus handling only simultaneous leave operations.

The scheme in Zou, Ramamurthy, and Magliveras (2002) addresses only bursty behavior, but not cumulative member removal, whereas the scheme in Chang et al. (1999) addresses only cumulative member removal, but not bursty behavior. The scheme proposed in Poornima et al. (2007a, 2007b) also addresses only cumulative member leave event. In this paper, we are extending the scheme proposed in Poornima et al. (2007a, 2007b) to address both cumulative member removal and bursty behavior efficiently. To the best of our knowledge we found no paper in the literature which addresses both cumulative member removal and bursty behavior. In this paper we are addressing both cumulative member removal and bursty behavior by considering all the possible worst case scenarios in an efficient way.

3. Cumulative member removal

Chang et al. scheme proposed in Chang et al. (1999) uses a binary key tree and two keys are maintained at each level of the tree. Here, we extend the scheme to *m-ary* key tree as in Poornima et al. (2007a, 2007b) and maintain m keys at each level of the key tree. For a key tree with degree m, the height h of the tree is $log_m N$. We use the following model in the paper.

3.1 Model

We consider a group with N users $u_1, u_2, ..., u_N$. The tree is constructed with the following features:

(1) There are $h = \lceil log_m N \rceil$ levels in the tree and are numbered from 0 to h. The root is at level 0.

(2) Each node at level l can have atmost m children nodes, $l = 0, 1, ..., h - 1$.

(3) The children of a node are numbered from 0 to $m - 1$ from left child to right child. We refer these numbers as positions of the children nodes.

(4) Leaf nodes that are rooted at level l form one subgroup, $l = 0, 1, ..., h$. Subgroups at level l are numbered from 0 to $m^l - 1$.

(5) The key at level 0 is the group key GK.

(6) At each level l of the tree, m keys are assigned and are labeled as K_l^0 to K_l^{m-1}, $l = 1, 2, ..., h$.

(7) All the m keys at level l are assigned with unique Key Identification number, KID.

(8) All the nodes at position i of level l are assigned with the common key K_l^i, $l = 1, 2, ..., h$.

(9) Nodes at level 1 which are numbered as 0 to $m - 1$ are assigned the corresponding binary value as UIDs. The length of each UID is $[log_2 m]$ bits.

(10) Each node k at level l is assigned with UID BX, where X is the binary value of k and B is the UID of its parent, $l = 2, 3, ..., h$.

KDC generates and sends a private key K_i, $i = 1, 2, ..., N$ to each user u_i. We assume that KDC establishes a secure channel with each user u_i to communicate the private key K_i, $i = 1, 2, ..., N$. To each user u_i, KDC sends the keys and their KIDs along the path from leaf to root by encrypting with the private key of u_i.

3.2 Notations

(1) GK denotes Group Key.

(2) $\{GK\}_{K_0}$ denotes GK is encrypted with the key K_0.

(3) $||$ denotes concatenation operation.

(4) $\cup$ denotes set union operation.

3.3 Advantages of using m-ary tree

For a group with N users, if binary tree is used, it results in a tree of height $log_2 N$. Each user in the group is required to store $log_2 N$ keys and the KDC is required to store $2N - 1$ keys in the scheme proposed by Wong et al. (1998). In Chang et al. (1999), the storage at the KDC is reduced by using only 2 keys at each level, thus reducing the storage to $2log_2 N$. However the storage at each user remains as $log_2 N$. In our scheme, instead of binary tree, *m-ary* tree ($m > 2$) is used which reduces the height of the tree to $log_m N$ and hence, each user is required to store $log_m N + 1$ keys and KDC is required to store $mlog_m N + 1$ keys.

3.4 Optimal value for m

For a group with N users, if h is the height of the binary tree, it results in storing $2h$ keys at the KDC in the scheme proposed by Chang et al. in Chang et al. (1999). For the same value of N, if h' is the height of the *m-ary* tree, then mh' keys are stored at the KDC. The height h of the *m-ary* tree is

$$h' = h/log_2 m$$

Number of keys at the KDC in terms of h is expressed as $m(h/log_2 m)$, which illustrates that as m increases, the storage at the KDC increases. Hence, in order to reduce the number of keys both at the KDC and users as compared to the scheme in Chang et al. (1999), following relation must be satisfied:

$$m(h/log_2 m) < 2h$$

which is true only if $m = 3$ and $m = 4$. If $m = 4$ it maintains the same storage at KDC as in Chang et al. (1999) scheme and reduces the storage at the users. However if $m = 3$, it reduces the storage both at the KDC and users as compared to Chang et al. (1999) scheme. We achieve storage savings of 4% to 12% at KDC and about 30% to 38% at the users if we use $m = 3$.

3.5 Scheme for handling cumulative member removal

Any number of users can leave the secure group from any position in the *m-ary* tree. Algorithm 1 handles the computation of encryption keys for cumulative removal of arbitrary members. We use the following notations in the algorithm.

(1) L: Number of leaving users

(2) P: Array with L elements containing UIDs of leaving users

(3) *KEK*: Set containing the keys used to encrypt the new group key

(4) S: Set of users in the group excluding leaving members

Algorithm 1 considers L leaving users and finds a set of encryption keys to convey new group key to the remaining members in the group. If there is no leave in a subgroup rooted at level l, it is termed as *non-leaving subgroup*, $l = 0, 1, ..., h - 1$. In Step 1 of the algorithm, KDC finds non-leaving subgroups in the tree and appends the keys of the non-leaving subgroups to the set *KEK*. KDC starts from level 1, if there is a non-leaving subgroup j at level 1, the key K_1^j is added to the *KEK* and the users in subgroup j are eliminated from set S. This may result in eliminating the users belonging to the subgroups at subsequent levels of the tree. This procedure is repeated for all the levels from 2 to $h - 1$ in the tree for the remaining subgroups. When we move to Step 2, we are left with the

users who do not belong to any non-leaving subgroup. We have to find encryption key individually for each remaining user in set S. We compare the keys held by each user with the keys of all leaving members and consider the combination of keys as follows:

(1) In i^{th} iteration of the loop, we compare i keys of u_i from level h to $h - i$, $i = 2, 3, ..., h - 1$ with the respective i keys of leaving members. If no leaving member shares the same set of keys, we do not proceed with the next iteration.

(2) We compute the Ex-OR of the set of keys obtained from previous step.

To convey the new group key GK' securely to the remaining members of the group, KDC performs the following operations:

Algorithm 1: Computation of Encryption Keys by KDC for Cumulative Member Leave.

Input: Set S of users in the group excluding leaving members. Array P containing UIDs of leaving users.

Output: Set KEK of Encryption Keys.

1: **Step 1:** KEK $\leftarrow \phi$

2: **for** $l \leftarrow 1$ to h **do**

3: **for** $j \leftarrow 1$ to L **do**

4: $a \leftarrow l[log_2 m]$ MS bits P[j]

5: $b \leftarrow [log_2 m]$ LS bits of a

6: H[j] $\leftarrow b$

7: **end for**

8: **for** $i \leftarrow 0$ to $m - 1$ **do**

9: $f \leftarrow 0$

10: **for** $t \leftarrow 1$ to L **do**

11: if ($i = H[t]$) **then**

12: $f \leftarrow 1$

13: end if

14: end for

15: **if** ($f = 0$) **then**

16: $KEK \leftarrow \{K_1^j\}$

17: $S \leftarrow S$ - {Users who are descendants of nodes with key K_1^j}
18: **end if**
19: **end for**
20: **end for**
21: **Step 2:** ▷ Finds combination of keys
22: **for** each user $u_i \in S$ **do**
23: $k \leftarrow 0$
24: **for** $j \leftarrow 1$ to h **do**
25: $a \leftarrow j$ [$log_2 m$] LS bits of UID of u_i
26: $b \leftarrow$ [$log_2 m$] MS bits of a
27: $k \leftarrow k \oplus K_{(h-j+1)}^b$
28: $f \leftarrow 0$
29: **for** $i \leftarrow 1$ to L **do**
30: **if** ($a = j$[$log_2 m$] bits of $P[i]$) **then**
31: $f \leftarrow 1$
32: break
33: **end if**
34: **end for**
35: **if** ($f = 0$) **then**
36: break
37: **end if**
38: **end for**
39: $KEK \leftarrow KEK \cup k$
40: **end for**
41: **Step 3:** return *KEK*

(1) Computes $C_K = \{GK'\}_K$, $K \in KEK$

(2) Broadcasts (C_K, *KID* of K), $K \in KEK$

Upon receiving the broadcast message, each remaining member of the group finds the decryption key by comparing the *KID*s of its keys with the KIDs of the received messages.

It is required to change the auxiliary keys along the path where users have left. The members of the group and KDC compute auxiliary keys on their own as follows:

(1) Each member performs exclusive-OR operation of the previous auxiliary key with the new group key *GK*'.

(2) KDC performs exclusive-OR operation of the previous auxiliary key with the new group key *GK*'.

Since all the users in the group are computing auxiliary keys on their, this reduces the communication cost required to convey auxiliary keys to appropriate members of the group. Hence, KDC only conveys the new group key to the members of the group and the members will in turn compute the auxiliary keys on their own.

3.6 Storage required

We compare the amount of storage required in our scheme with the schemes proposed by Wong et al. (1998) and Chang et al. (2004). Bursty behavior scheme addressed by Zou, Ramamurthy, and Magliveras (2002) requires same amount of storage as in Wong et al. scheme (Wong et al., 1998). Table 1 depicts the amount of storage required at KDC and at each user in the group for the above mentioned three schemes. In Table 2 we have considered some specific values for the group size, N, and theoretically estimated the amount of storage required at KDC and each user.

For instance, for a group with $N = 2{,}048$ users, the height of the key tree in Chang et al. (1999) scheme is $h = [log_2 2048] = 11$. Each user in the group stores keys along the path from leaf to root. Thus, the storage required at each user is $h + 1 = 12$. KDC has to store all the keys in the key tree. In Chang et al. (1999) scheme, since only two keys are used at each level of the key tree, KDC has to store $2h + 1 = 23$ keys. For the same value of N, for a key tree with degree 3, height of the tree is $h = [log_3 N] = 7$ and for degree 4 key tree, $h = [log_4 N] = 6$. Hence, each user in degree 3 key tree stores 8 keys and in degree 4 key tree stores 7 keys. In degree 3 key tree, 3 keys are used at each level of the key tree and 4 keys are used in key tree with degree 4. Thus, KDC stores $3h + 1 = 22$ keys in degree 3 key tree. For 2,048 users key tree with degree 4 is not a complete tree. It contains only two children at level 1 and hence only two keys are required at level 1. But, in subsequent levels 4 keys are required which results in storing $2 + 4(h - 1) + 1 = 23$ keys at the KDC. We also have calculated the percentage savings in our scheme compared to Chang et al. (1999) scheme. For instance, percentage savings for a key tree with degree 3 for $N = 2{,}048$

users is $\frac{23-22}{23} * 100 \simeq 4$. It is evident from the values in Table 2 that we are reducing the amount of storage at the KDC by a factor of 4% to 12% and at the users by 30% to 38%.

3.7 Encryptions required

We compare the performance of our scheme with Li et al. scheme (Li et al., 2001). Performance analysis of Zou, Magliveras, and Ramamurthy (2002) binary key tree scheme (Zou, Ramamurthy, & Magliveras, 2002) is same as that of Li et al. (2001). Hence it suffices if we compare the performance of our scheme with Li et al. scheme. We compare the schemes with respect to number of encryptions required to convey new group key and auxiliary keys to the remaining members of the group after the leave event. We encounter worst case if the leaves are evenly distributed. In Li et al. (2001) and Zou, Ramamurthy, and Magliveras (2002) schemes it results in worst case if there is a leave from each subgroup rooted at level ($[log_2 N] - 1$) and in our scheme if there is a leave from different positions of each subgroup rooted at level ($[log_m N] - 1$). Thus, minimum number of leaves that result in worst case in both the cases is N/m. For a key tree with degree m, maximum

Table 1 Comparison of Storage Required at KDC and Each User

	Schemes		
	Wong et al. (1998) and Zou, Ramamurthy, and Magliveras (2002)	Chang et al. (1999)	Our Scheme
Storage at KDC	$2N - 1$	$2log_2 N + 1$	$min\ \{3log_3 N + 1, 4log_4 N + 1\}$
Storage at each user	$log_2 N + 1$	$log_2 N + 1$	$min\ \{log_3 N + 1, log_4 N + 1\}$

Table 2 Percentage Savings in Storage at KDC and Each User

Storage at	N	Chang et al. (1999) Scheme	Our Scheme		Percentage Savings	
			$m = 3$	$m = 4$	$m = 3$	$m = 4$
KDC	2,048	23	22	23	4	0
User	2,048	12	8	7	33	41
KDC	2,187	25	22	25	12	0
User	2,187	13	8	7	38	46
KDC	3,000	25	22	25	12	0
User	3,000	13	8	7	38	46
KDC	8,192	27	26	27	4	0
User	8,192	14	9	8	35	42

number of encryptions required to convey new group key and auxiliary keys in case of Li et al. scheme is $\frac{m(N\text{-}1)}{m\text{-}1}$. In our scheme it requires atmost $\frac{N(m\text{-}1)}{m}$ encryptions. We compute percentage savings in encryption cost in our scheme compared to Li et al. (2001) and Zou, Ramamurthy, and Magliveras (2002) schemes as $\frac{\frac{m(N\text{-}1)}{m\text{-}1} - \frac{N(m\text{-}1)}{m}}{\frac{m(N\text{-}1)}{m\text{-}1}} * 100$. For $m = 3$, this is approximately equal to 55. Thus, for a key tree with degree 3 we achieve a saving of around 55% encryption cost as compared to Li et al. (2001) scheme.

Figure 1 shows an example key tree with $N = 16$ users, u_0 through u_{15} and the degree m of the tree is 4. The binary strings 0000 through 1111 are the *UID*s of users u_0 through u_{15} respectively. The keys K_0 through K_{15} are private keys of users u_0 through u_{15} respectively (which is not shown in the figure). Here, height h of the tree is $[log_m N] = 2$. Keys K_1^1, K_1^2, K_1^3, and K_1^4 are auxiliary keys at level 1 and keys K_2^1, K_2^2, K_2^3, and K_2^4 are auxiliary keys at level 2 and GK is the group key. User u_1 for instance, stores the keys K_2^1, K_1^0 and GK which are along the path from its position till the root of the tree along with its private key K_1.

Suppose users u_2, u_3, u_8 and u_9 leave the group at the same time. Algorithm 1 considers all the leave requests and finds out encryption keys to convey new group key to the remaining members of the group. From Algorithm 1, following keys are obtained as encryption keys: since no user is leaving from the subgroups with auxiliary keys K_1^1 and K_1^3, same keys are used as encryption keys for the respective subgroups. From the subgroup with K_1^0 as the auxiliary key, users u_2 and u_3 are leaving. Hence, to convey new group key, we cannot use K_1^0. Next possibility is to look for the keys at the next lower level i.e., K_2^0 and K_2^1. Since users u_8 and u_9 are also leaving, keys K_1^0 and K_1^1 cannot be used as encryption keys. Thus, the encryption keys for u_0 and u_1 are computed as $K_2^0 \oplus K_1^0$ and $K_2^1 \oplus K_1^0$ respectively. Similarly, for users u_{10} and u_{11}, $K_2^2 \oplus K_1^2$ and $K_2^3 \oplus K_1^2$ are the respective encryption keys.

KDC broadcasts the following message:

$$\{\{GK'\}_{K_1^1},\ \{GK'\}_{K_1^3},\ \{GK'\}_{K_2^0 \oplus K_1^0},\ \{GK'\}_{K_2^1 \oplus K_1^0},\ \{GK'\}_{K_2^2 \oplus K_1^2}\ ,\ \{GK'\}_{K_2^3 \oplus K_1^2}\}$$

Now, the auxiliary keys K_1^0 and K_1^2 must be changed by both KDC and respective users. Following are the computations performed by the users to change these auxiliary keys:

Users u_0 and u_1 compute $K_1^{0\prime} = K_1^0 \oplus GK'$

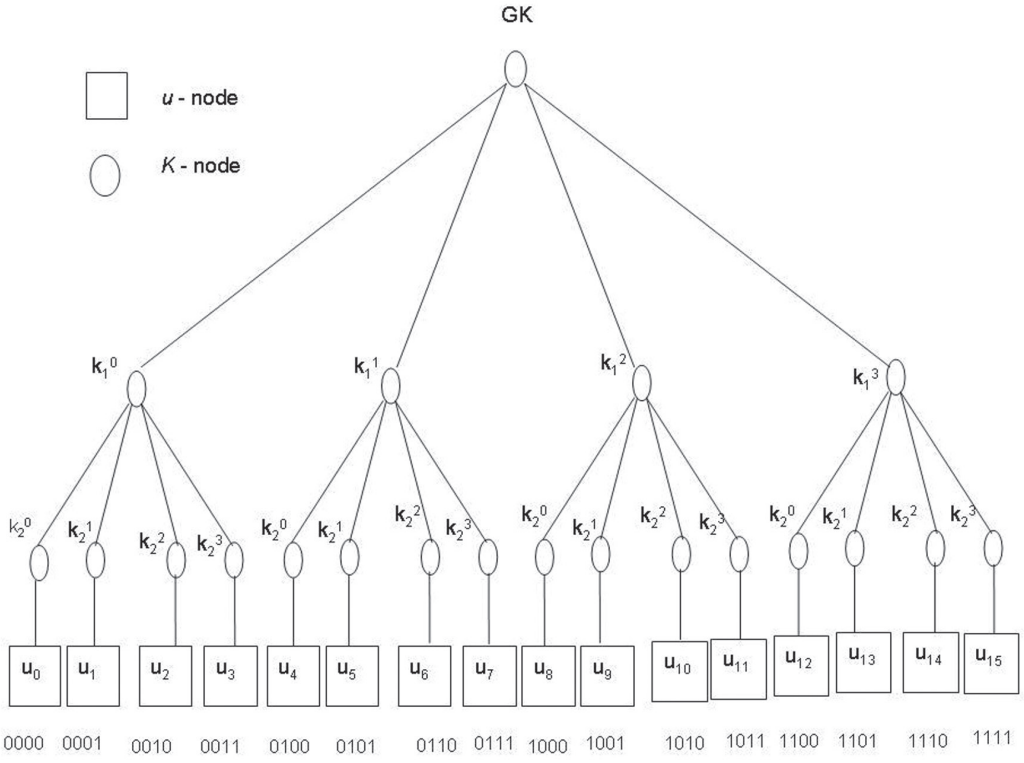


Figure 1 Key Tree Structure Showing UIDs and Keys of Users in the Group, Auxiliary Keys and Group Key

Users u_{10} and u_{11} compute $K_1^{2\prime} = K_1^2 \oplus GK'$

KDC computes $K_1^{0\prime} = K_1^0 \oplus GK'$ and $K_1^{2\prime} = K_1^2 \oplus GK'$

4. Handling bursty behavior

In this section we consider bursty behavior and analyze our scheme with respect to number of new keys generated, encryptions performed and rekey messages constructed.

4.1 Equal number of joins and leaves

We assume that initially there are N users, u_1, u_2, ..., u_N in the group. If J users join the group and L users leave the group at the same moment, where $0 \le J \le N$ and $0 \le L \le N$, then there might be a scenario in which $J = L$. In this section, we consider such a scenario and analyze with respect to the number of new keys generated, number of encryptions performed and number of rekey messages constructed.

For a group of N users, height of the key tree $h = [\log_m N]$. There are m^i nodes at

level i of the key tree, $i = 1, 2, ..., h$. It results in worst case if at least $[N/m]$ users leave the group that too each from different position of different subgroup at level $h - 1$. This scenario requires changing all the keys in the key tree. Hence for analysis purpose, we consider $L = [N/m]$. Even if more than $[N/m]$ users leave the group, the values obtained will be less than or equal to that of the values obtained in case of $[N/m]$ leaves.

Suppose L users $u_{l1}, u_{l2}, ..., u_{lL}$, $(L \leq N)$, send leave request and at the same time J users $u_{j1}, u_{j2}, ..., u_{jJ}$, send join request. Since $J = L$, joining users occupy the positions of leaving users. We first handle the leave event as in the case of cumulative member removal and then handle join event. KDC computes encryption keys required to encrypt the new group key to the remaining members of the group using Algorithm 1. Remaining users in the group find respective decryption key to decrypt the new group key by comparing the KIDs of the keys. After receiving the new group key, remaining members of the group compute the auxiliary keys on their own by performing exclusive-OR operation of the respective auxiliary keys with the new group key. For the new users, KDC encrypts the new group key and auxiliary keys using the private keys of new users and conveys the keys along with the *KID*s.

4.1.1 Number of new keys generated

For a group of N users, height of the key tree $h = [log_m N]$. Along with the group key, there are m keys at each level of the tree. Total number of keys in the key tree = $mh + 1$. Since for the worst case we have considered, all the keys must be changed, number of new keys generated = $mh + 1$.

4.1.2 Number of encryptions

We are considering worst case scenario in which at least one user leaves from each subgroup at level $h - 1$ and at least one user leaves from each position of the key tree. It requires encrypting the new group key for each remaining user in the group individually. For each new user, keys along the path from its joining point till the root are encrypted with its private key. Since $J = L = [N/m]$, there are N users in the group after handling join and leave. Thus, total number of encryptions required is N.

4.1.3 Number of rekey messages

For no two users in the group, a common rekey message is constructed. There are N users in the group after handling join and leave events. Thus, number of rekey messages required is N.

4.2 More number of joins than leaves

Suppose L users $u_{l1}, u_{l2}, ..., u_{lL}$ send leave request to leave the group and J users u_{j1},

u_{j2}, ..., u_{jJ} send join request to join the group at the same moment and $J > L$. To analyze the worst case, we are considering maximum value of L as $[N/m]$ i.e., it results in worst case if $[N/m]$ users leave the group from different positions of different subgroups at level $h - 1$. For J to be greater than L, minimum value for $J = L + 1 = [N/m] + 1$.

Among J joining users, first L users u_{j1}, u_{j2}, ..., u_{jL} occupy the positions of leaving members. We have to find either empty locations or allow the tree to grow for accommodating remaining $(J - L)$ users i.e., for users u_{jL+1}, u_{jL+2}, ..., u_{jJ}. Let the number of empty locations available in the key tree be E.

(1) If $E \geq (J - L)$, new users u_{jL+1}, u_{jL+2}, ..., u_{jJ} are inserted in the empty locations.

(2) Otherwise, if $E > 0$, first E users u_{jL+1}, u_{jL+2}, ..., u_{JL+E} are inserted in the key tree. To accommodate remaining $J - L - E$ new users, *m-ary* tree with height $h' = log_m(J - L - E)$ is constructed.

A. If $h > h'$

- the tree with height h is allowed to grow by one level in upward direction.
- the tree with height h' is allowed to grow in upward direction till h' becomes equal to $(h - 1)$.
- tree with height $h' = h - 1$ is attached as a child to the tree with height h.

B. If $h < h'$

- If the tree with height h' is complete, it is allowed to grow by one level in upward direction.
- the tree with height h is allowed to grow in upward direction till h becomes equal to $(h' - 1)$.
- tree with height $h = h' - 1$ is attached as a child to the tree with height h'.

KDC finds encryption keys using Algorithm 1, generates new group key *GK*' and broadcasts encrypted *GK*'. Remaining users in the group find decryption key by comparing the *KID*s and decrypt the new group key *GK*'. Both KDC and remaining users in the group change the auxiliary keys. For the new users, KDC encrypts the new group key and auxiliary keys using the private keys of new users and communicates the keys with their *KID*s.

4.2.1 Number of new keys generated

For a group of N users, height of the key tree $h = [log_m N]$. Along with the group key, there are m keys at each level of the key tree. Total number of keys in the key tree = $mh + 1$. Since we have considered worst case leave event, it requires changing all the keys of the

key tree. Further, to handle $J - L$ users join event, $mlog_m(J - L)$ new keys are generated. Number of new keys generated = $m(h + log_m(J - L)) + 1$.

4.2.2 Number of encryptions

We are considering worst case scenario in which at least one user leaves from each subgroup at level $h - 1$ and at least one user leaves from each position of the key tree. It requires encrypting the new group key for each remaining user in the group individually. For each new user, keys along the path from its joining point till the root are encrypted with its private key. There are $N + J - L$ users in the group after handling join and leave. Thus, total number of encryptions required is $N + J - L$.

4.2.3 Number of rekey messages

For no two users in the group, a common rekey message is constructed. There are $N + J - L$ users in the group after handling join and leave events. Thus, number of rekey messages is $N + J - L$.

4.3 Number of joins less than number of leaves

Suppose L users u_{l1}, u_{l2}, ..., u_{lL} send leave request to leave the group and J users u_{j1}, u_{j2}, ..., u_{jJ} send join request at the same moment and $J < L$. Since J is less than L, sometimes the key tree may shrink in height. We encounter worst case scenario if $L = [N/m]$ and each user leaves from different position of different subgroup at level $h - 1$. Since we are considering the case for $J < L$, the value of J can range from 0 to $L - 1$. New J users occupy the positions of first J leaving users.

KDC finds encryption keys using Algorithm 1, generates new group key *GK*' and broadcasts encrypted *GK*' along with the *KID*s of encryption keys. Remaining users in the group find decryption key by comparing the *KID*s and decrypt the new group key *GK*'. Both KDC and remaining users in the group change the auxiliary keys. For the new users, KDC encrypts the new group key and auxiliary keys using the private keys of new users and sends the keys along with the *KID*s.

4.3.1 Number of new keys generated

For a group of N users, height of the key tree $h = [log_m N]$. Along with the group key, there are m keys at each level of the key tree. Total number of keys in the key tree = $mh + 1$. Since we have considered worst case leave event, it requires changing all the keys in the key tree. Since joining users occupy the positions of some of the leaving users, join event does not require generation of new keys. Number of new keys generated = $mh + 1$.

4.3.2 Number of encryptions

We are considering worst case scenario in which at least one user leaves from each

subgroup at level $h - 1$ and at least one user leaves from each position of the subgroup. It requires encrypting the new group key for each remaining user in the group individually. For each new user, keys along the path from its joining point till the root are encrypted with its private key. There are $N + J - L$ users in the group after handling join and leave. Thus, total number of encryptions required is $N + J - L$.

4.3.3 Number of rekey messages

For no two users in the group, a common rekey message is constructed. There are $N + J - L$ users in the group after handling join and leave events. Thus, number of rekey messages is $N + J - L$.

4.4 Performance comparison

We compare the performance of our scheme with the binary key tree schemes proposed by Li et al. (2001) and Zou, Ramamurthy, and Magliveras (2002) with respect to number of new keys generated, encryptions performed and rekey messages constructed. Table 3 gives the comparison. It is observed that the number of new keys generated in the schemes of Li et al. (2001) and Zou, Magliveras, and Ramamurthy (2002) is proportional to N and in our scheme it is proportional to logarithmic in the group size. Number of encryptions performed in Li et al. (2001) and Zou, Magliveras, and Ramamurthy (2002) schemes is in terms of twice the group size, whereas in our scheme it is in terms of only the group size. Thus, number of encryptions performed and new keys generated are less as compared to the ones required in Li et al. (2001) scheme and Zou, Magliveras, and Ramamurthy (2002) scheme. Reduction in number of key generation and encryptions reduces the computation cost at the KDC. Thus, our scheme outperforms the scheme of Zou, Ramamurthy, and Magliveras (2002) in both storage and computation costs.

5. Implications for practice

We find application of this SGC model in pay-per-view, periodical electronic information distribution, on-line journal subscription and so on. In pay-per-view application, users usually subscribe for specific events which are quite interesting for them. Hence, the telecast should be made available only for the subscribed period. Usually, many users subscribe for those events which are popular and this results in many users joining and leaving the event at the same time.

In periodical electronic information distribution and on-line journal subscription, many users subscribe for a particular duration, i.e., usually for one year or two years period. It results in many users subscribing at the beginning of the year (usually during the month of January) and un-subscribing at the end of the year. We may also encounter a

Table 3 Number of New Keys, Encryptions, and Rekey Messages Required for Different Cases

	New Keys		Encryptions		Rekey messages	
	Li et al. (2001) & Zou, Magliveras, and Ramamurthy (2002) schemes	Our Scheme	Li et al. (2001) & Zou, Magliveras, and Ramamurthy (2002) schemes	Our Scheme	Li et al. (2001) & Zou, Magliveras, and Ramamurthy (2002) schemes	Our Scheme
$J = L$	$N + J - 1$	$mlog_m N + 1$	$2(N - 1)$	N	N	N
$J > L$	$N + L - 2$	$m(logmN + logm(J - L)) + 1$	$2N - 4 + 4(J - L)$	$N + J - L$	$N + J - L$	$N + J - L$
$J < L$	$N + J - 1$	$mlog_m N + 1$	$2N + J - L - 2$	$N + J - L$	$N + J - L$	$N + J - L$

situation in which when many users unsubscribe, other users may subscribe for the event resulting in bursty behavior.

In the above mentioned scenarios, if the events are considered as secure groups, *m-ary* tree is constructed with subscribing users as members of the group and these users can be provided with the keys along the path. Users can have access to the application only if proper key is entered. Once new users subscribe and existing users unsubscribe, new keys can be distributed efficiently using our scheme. Thus we find application of our scheme in day-today scenarios.

6. Conclusion

We proposed a scheme which handles both cumulative member removal and bursty behavior in a secure group. We used *m-ary* key tree with only *m* keys at each level of the tree. We showed that in our cumulative member removal scheme the encryption cost is reduced by about 55% compared to the scheme proposed by Li et al. (2001). If 4-*ary* tree is used, storage required at KDC is same as the Chang et al. (1999) scheme, but at the users it is reduced. If 3-*ary* tree is used, it reduces the storage at both KDC and users. We showed that the savings in storage at KDC ranges from 4% to 12% and with users it ranges from 30% to 38%.

We considered different bursty behavior scenarios and analyzed the scheme for worst cases. In each scenario we computed number of new keys generated, number of encryptions performed and number of rekey messages constructed. We compared our proposed scheme with the LKH (Logical Key Hierarchy) scheme and showed that our scheme performs better in terms of cost of encryption and cost of key generation, thereby reducing the computation cost overhead at the KDC.

References

Amir, Y., Danilov, C., Miskin-Amir, M., Schultz, J., & Stanton, J. (2004) 'The spread toolkit: architecture and performance', Technical report, Johns Hopkins University, Baltimore, MD.

Amir, Y., Kim, Y., Nita-Rotaru, C., Schultz, J.L., Stanton, J., & Tsudik, G. (2004) 'Secure group communication using Robust contributory key agreement', *IEEE Transactions on Parallel and Distributed Systems*, Vol. 15, No. 5, pp. 468-480.

Blundo, C., De Santis, A., Herzberg, A., Kutten, S., Vaccaro, U., & Yung, M. (1993) 'Perfectly secure key distribution for dynamic conferences', *Lecture Notes in Computer Science*, Vol. 740, pp. 471-486.

Burmester, M. & Desmedt, Y. (1995) 'A secure and efficient conference key distribution system', *Lecture Notes in Computer Science*, Vol. 950, pp. 275-286.

Burmester, M. & Desmedt, Y. (1997) 'Efficient and secure conference-key distribution', *Lecture Notes in Computer Science*, Vol. 1189, pp. 119-129.

Caronni, G., Waldvogel, K., Sun, D., & Platter, B. (1998) 'Efficient security for large and dynamic multicast groups', *Proceedings of the Seventh IEEE International Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises* (*WET ICE'98*), Palo Alto, CA, June 17-19, pp. 376-383.

Chang, I., Engel, R., Kandlur, D., Pendarakis, D., & Saha, D. (1999) 'Key management for secure Internet multicast using Boolean function minimization technique', *Proceedings of the Eighteenth Annual Joint Conference of the IEEE Computer and Communications Societies* (*INFOCOM'99*), New York, March 21-25, pp. 689-698.

Diffie, W. & Hellman, M. (1976) 'New directions in cryptography', *IEEE Transactions on Information Theory*, Vol. 22, No. 6, pp. 644-654.

Fiat, A. & Naor, M. (1993) 'Broadcast encryption', *Proceedings of the Third Annual International Cryptology Conference* (*CRYPTO'93*), Santa Barbara, CA, August 22-26, pp. 480-491.

Lee, P.P.C., Lui, J.C.S., & Yau, D.K.Y. (2002) 'Distributed collaborative key agreement protocols for dynamic peer groups', *Proceedings of the Tenth IEEE International Conference on Network Protocols* (*ICNP'02*), Hong Kong, China, November 12-15.

Li, X.S., Yang, Y.R., Gouda, M.G., & Lam, S.S. (2001) 'Batch rekeying for secure group communications', *Proceedings of the Tenth International World Wide Web Conference* (*WWW'01*), Hong Kong, China, May 1-5, pp. 525-534.

Lin, J.C., Lai, F., & Lee, H.C. (2005) 'Efficient group key management protocol with one-way key derivation', *Proceedings of the IEEE Conference on Local Computer Networks Thirtieth Anniversary* (*LCN'05*), Taipei, Taiwan, November 17, pp. 336-343.

Mittra, S. (1997) 'Iolus: a framework for scalable secure multicasting', *ACM SIGCOMM Computer Communication Review*, Vol 27, No. 4, pp. 277-288.

Perrig, A. (1999) 'Efficient collaborative key management protocols for secure autonomous group communication', paper presented at the International Workshop on Cryptographic Techniques and E-commerce (CrypTEC'99), Hong Kong, China, July 5-8.

Poornima, A.S. & Aparna, R., & Amberker, B.B. (2007a) 'Key management for cumulative member removal in secure group communication', paper presented at the International Conference on Embedded Systems, Mobile Communication and Computing, Bangalore, India, August 3-5.

Poornima, A.S., Aparna, R., & Amberker, B.B. (2007b) 'Storage and rekeying cost for cumulative member removal in secure group communication', *International Journal of Computer Science and Network Security*, Vol. 7, No. 9, pp. 212-220.

Rafaeli, S. & Hutchison, D. (2003) 'A survey of key management for secure group communication', *ACM Computing Surveys*, Vol. 35, No. 3, pp. 309-329.

Sherman, A.T. & McGrew, D.A. (2003) 'Key establishment in large dynamic groups using one-way function trees', *IEEE Transactions on Software Engineering*, Vol. 29, No. 5, pp. 444-458.

Waldvogel, M., Caronni, G., Sun, D., Weiler, N., & Platter, B. (1999) 'The Versakey framework: versatile group key management', *IEEE Journal on Selected Areas in Communications*, Vol. 17, No. 9, pp. 1614-1631.

Wallner, D., Harder, E., & Agee, R. (1999) 'Key management for multicast: issues and architectures', IETF RFC 2627, The Internet Society, Washington, DC.

Wong, C.K., Gouda, M., & Lam, S.S. (1998) 'Secure group communications using key graphs',

Proceedings of the ACM SIGCOMM'98 Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication, Vancouver, Canada, September 2-4, pp. 68-79.

Wong, C.K. & Lam, S.S. (2000) 'Keystone: a group key management service', paper presented at the International Conference on Telecommunications (ICT), Acapulco, Mexico, May 20-25.

Zou, X., Magliveras, S., & Ramamurthy, B. (2002) 'A dynamic conference scheme extension with efficient bursty operation', *Congressus Numerantium*, Vol. 158. pp. 83-92.

Zou, X., Ramamurthy, B., & Magliveras, S. (2002) 'Efficient key management for secure group communications with bursty behavior', *Proceedings of the IASTEC International Conference on Communications, Internet, and Information Technology* (*CIIT 2002*), St. Thomas, USVI, November 18-20, pp. 148-153.

About the authors

R. Aparna obtained her Ph.D. from Visvesvaraya Technological University, Belgaum, Karnataka, India. She is presently working as an Associate Professor in the Department of Computer Science and Engineering, Siddaganga Institute of Technology, Tumkur, Karnataka, India. Her research areas include cryptography and network security, security in sensor networks and database security.

B.B. Amberker is a Professor with Department of Computer Science and Engineering, National Institute of Technology, Warangal, Andhra Pradesh, India. He received his Ph.D. from the Department of Computer Science and Automation, Indian Institute of Science (IISc), Bangalore, India. His research areas include algorithmic cryptography, number theoretic algorithms, digital water marking and security in sensor networks.

CALL FOR PAPER

MIS Review: An International Journal

Published 2 Issues Annually by Airiti Press Inc.

MIS Review is a double-blind refereed academic journal published jointly by Airiti Press Inc. and Department of Management Information Systems, College of Commerce, National Chengchi University in Taiwan. The journal is published both in print and online. We welcome submissions of research papers/case studies in the areas including (but not limited to):

1. MIS Roles, Trends, and Research Methods

Roles, positioning and research methods of management information systems, and the impacts & development trends of information technology on organizations.

2. Information Management

Information infrastructure planning and implementation, information technology and organizational design, strategic applications of information systems, information system project management, knowledge management, electronic commerce, end-user computing, and service technology management.

3. Information Technologies

Database design and management, decision support systems, artificial intelligence applications (including expert systems and neural networks), software engineering, distribution systems, communication networks, multimedia systems, man-machine interface, knowledge acquisition & management, data mining, data warehouse, cooperative technology, and service science & engineering.

4. Information Applications and Innovations

The applications and innovations of business functional information systems (e.g., production, marketing, financial, human resources, and accounting information systems), enterprise resource planning, customer relationship management, supply chain management, intellectual capital, geographic information systems, and integrated information systems.

5. Information Technology Education and Society

Information education, e-learning, and information impacts on society.

6. Others

Other MIS-related topics.

INSTRUCTIONS FOR SUBMISSION

1. Papers can be prepared in either Chinese or English. If your paper is written in Chinese, it will be translated into English once it is accepted for publication.
2. There is no submission deadline for MIS Review. All papers will be double-blind reviewed by at least two reviewers, who will be recommended by the Editorial Board. The processing time for the first-round formal reviews is about six weeks. Subsequently rounds of reviews tend to be faster.
3. To simplify file conversion effort, PDF or Microsoft Word 2000/2003 (for Windows) format is advised. Then, please submit your paper via the MIS Review website (URL: http://www.icebnet.org/misr/).
4. MIS Review is an academic journal. According to international practice, once an article is accepted and published, MIS Review will not give or take any payment for the publishing. An electronic copy of the paper will be sent to the article author(s) for non-profit usage.
5. The submitted and accepted paper should follow the author guidelines for paper submission format provided on the MIS Review website.

The submitted paper should include the title page, abstract, key words, the paper body, references, and/or appendices. You must submit three files. The information of author(s) should not appear anywhere in the paper body file, including page header and footer.

1. On a separate (cover letter) file, please follow the author guidelines provided on the MIS Review website to prepare the letter.
2. On a separate (title page) file, please note the title of the paper, names of authors, affiliations, addresses, phone numbers, fax numbers, and E-mail addresses.
3. On a separate (paper body) file, please include the paper title, an abstract, a list of keywords, the paper body, the references, and/or appendices. The abstract must contain the research questions, purposes, research methods, and research findings. The abstract should not exceed 500 words and the number of keywords must be 5-10 words.
4. The submitted and accepted paper should follow the author guidelines for paper submission format provided on the MIS Review website.

CONTACT

Editorial Assistant
Department of Management Information Systems
College of Commerce, National Chengchi University
No. 64, Sec. 2, ZhiNan Road, Wenshan District,
Taipei 11605, Taiwan R.O.C.
Phone: +886-2-29393091 ext.89055
E-mail: misr@mis.nccu.edu.tw

airiti press Subscription Form

MIS Review

You may subscribe to the journals by completing this form and sending it by fax or e-mail to

Address: 18F., No. 80, Sec. 1, Chenggong Rd., Yonghe District, New Taipei City 23452, Taiwan (R.O.C.)
Tel: +886-2-29266006 ext. 8301 Fax: +886-2-22317711 E-mail: press@airiti.com Website: http://www.airitipress.com

PERSONAL				LIBRARIES / INSTITUTIONS			
	Europe	US/CA	Asian/Pacific		Europe	US/CA	Asian/Pacific
1 Issue	€ 34	US$ 41	US$ 38	1 Issue	€ 53	US$ 65	US$ 62

Vol.		No.		~	Vol.		No.		Copies		US$		Total US$	

*All Price include postage

PLEASE NOTE

- Issues will be sent in two business days after receiving your payment.
- Please note that all orders must be confirmed by fax or email.
- Prices and proposed publication dates are subject to change without notice.
- Institutions include libraries, government offices, businesses, and for individuals where the company pays for the subscription.
- Personal rates are available only to single-user personal subscribers for personal and non-commercial purposes.
- Airiti Press reserves its right to take appropriate action to recover any losses arising fromany intended or unintended misrepresentation of the term "Personal Subscriber".

BILLING INFORMATION

Name	
Company	
Tel	Fax
E-mail	
Shipping Address	

INTERNATIONAL PAYMENTS

Pay by Credit Card	
Card Type ☐JCB ☐MasterCard ☐Visa	
Card Name	
Card Number	
Expiry Date _____ / _____	CVV number
Signature	

Direct Bank Transfer	
Beneficiary	AIRITI INC.
Address	18F., No. 80, Sec. 1, Chenggong Rd., Yonghe District, New Taipei City 23452, Taiwan (R.O.C.)
Bank Name	E.Sun Commercial Bank, Ltd.Yong He Branch
Account No	0107441863017
Swift Code	ESUNTWTP
Bank Address	No.145, Zhongzheng Rd., Yonghe District, New Taipei City 23454, Taiwan (R.O.C.)