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Xiao Tong

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Why Do People Make Online Group Purchases? Risk Avoidance, Sociability, Conformity, and Perceived Playfulness
Wesley Shu

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Editorial Board

Editor's Introduction

In this *MISR* issue we are delighted to present four research papers. The summaries of the four papers are as follows.

Xiao Tong in her paper "Effect of Manufacturer Reputation, Retailer Reputation and Seller Reputation in China's Online Shopping Market" examines the effects of manufacturer brand reputation, online retailer reputation, and online seller's reputation on reducing Chinese consumers' perceived risk toward online shopping and further increasing their purchase intention in online shopping. The results of the univariate analysis of variance show the availability of information on the online seller's reputation has a significant effect on perceived risk while manufacturer brand reputation and online retailer reputation have no effect on consumers' perception of risk. The linear regression results reveal perceived risk has a negative impact on Chinese consumers' online purchase intention.

Vinay Kumar and Sunil Kumar Muttoo in their paper "A Graph Theoretic Approach to Sustainable Steganography" introduce an algorithm for steganography based on graph-theoretic approach. They take BMP file to implement the algorithm in this paper. The results show that the algorithm achieves almost 100% matching for message elements in cover elements. The embedding algorithm has been put through mathematical and statistical tests to ensure that it not only retains visual similarity in stego with cover file but also leaves other statistics of cover undistorted after embedding. Therefore it achieves sustainability.

Hamed Fazlollahtabar, Iraj Mahdavi and Nezam Mahdavi-Amiri in their paper "Assessing the Effectiveness of E-learning via User Profile Analysis: An AHP-based Dynamic Programming Approach" propose an assessment procedure by applying a dynamic programming approach to model the problem of shortest path in the user profile and using AHP (Analytical Hierarchy Process) to turn the qualitative parameters into quantitative values. A dynamic program is used to find the optimal path for the user in the E-learning environment. The validity and effectiveness of the proposed model are illustrated by two examples.

Wesley Shu in his paper "Why Do People Make Online Group Purchases? Risk Avoidance, Sociability, Conformity, and Perceived Playfulness" studies what makes online group buying (OGB) attractive to customers and how to strategically identify what customers need to effectively conduct OGB. This paper identifies five reasons why people want to engage in OGB: perceived risk avoidance, sociability, performance expectancy, effort expectancy, and social influence. This study is the first instance of academic

empirical research on OGB. The relationship between network externality and OGB is revealed. The moderating effect of conformity shows the importance of bridging persons in buying groups. The importance of role of gender is discussed.

We would like to thank all the authors and reviewers for their collaborative efforts to make this issue possible. 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 render 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 University Chair Professor

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Research Articles

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Effect of Manufacturer Reputation, Retailer Reputation and Seller Reputation in China's Online Shopping Market

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ABSTRACT: *This study examines the effectiveness of manufacturer brand reputation, online retailer reputation, and online seller's reputation in reducing Chinese consumers' perceived risk regarding online shopping and further increasing their purchase intention in online shopping. The experiment is a 2 (manufacturer reputation: well-known and unknown) × 2 (retailer reputation: strong and weak) × 2 (information on the seller's reputation: present and absent) factorial design, and 281 college students participated in this study. The results of the univariate analysis of variance show the availability of information on the online seller's reputation has a significant effect on perceived risk and manufacturer brand reputation and online retailer reputation have no effect on consumers' perception of risk. The linear regression results reveal perceived risk has a negative impact on Chinese consumers' purchase intentions on the Internet.*

KEYWORDS: *Internet, Shopping, China, Risk, Manufacturer Reputation, Retailer Reputation, Online Seller Reputation, Purchase Intention*

1. Introduction

In recent years, Internet retailing has generated an increased level of attention among marketing academicians and practitioners (Lwin & Williams, 2006). Despite the rapid growth and the apparent overall attractiveness of the industry, the uncertainties associated with online shopping contribute to the ebb of Internet retailing and its growth potential. Lack of trust is frequently the key reason why people don't make purchase online (Lee & Turban, 2001). Studies have shown that perceived risk is a critical determinant of purchase intention in an online non-store retailing context (Lwin & Williams, 2006). Shopping on the Internet has been associated with carrying multiple risks. The risk consumers perceive in electronic commerce (e-commerce) is greater than that of commerce at brick-and-mortar retail stores because of e-commerce's distribution and impersonal nature (Zhou, Dai & Zhang, 2007). Perceived risk negatively influences consumers' intention to shop online (Bhatnagar, Misra & Rao, 2000; Park, Lee & Ahn, 2004). The key point of minimizing these risks is to find a suitable way to establish trust between Ecommerce trading partners. In an environment where one has to deal with unknown parties, reputation is used to establish this trust among interacting parties (Alnemr et al., 2010).

Online shopping has increased faster in developing markets than in developed economies (ACNielsen, 2005). Concurrent with the development of the Internet are the rapid growth of the Chinese economy and the explosion of the Chinese virtual market. The number of Internet users in China reached 298 million in the end of 2008 (accounting for 22.6% of China's population), and a quarter of Chinese Internet users are active online shoppers (Anonymous, 2009). Retail websites accounted for half of China's e-commerce, with a transaction volume of online shopping estimated at 59.4 billion RMB (US$8.5 billion) in 2007, and apparel, accessories and cosmetics are among the top categories (Hoare, 2008; Yu, 2006). With China's online shopping environment maturing and offering improved service, this volume could continue to grow quickly.

Despite the importance of trust in consumer-based e-commerce and the considerable potential of China's online shopping market, there has been little empirical research examining the role and effectiveness of trust-building strategies in the Chinese online shopping market is scarce. Our intention is to close the gap by focusing on analyzing the effectiveness of three online reputation-based trust management strategies that Internet marketers could use to promote online shopping among Chinese consumers. Specifically, our study examines the effectiveness of manufacturer brand reputation, online retailer's reputation, and online seller's reputation in reducing consumers' perceived risk regarding online shopping and further increasing consumers' intentions to purchase apparel products. The rapid growth of online shopping in China underscores the importance of understanding how to build trust into e-commerce among Chinese consumers. We believe that findings of the study should help online retailers identify effective online reputation management strategies that can be used to promote trust and reduce the amount of risk Chinese consumers perceive in online shopping and further increase their purchase intention.

The apparel shopping context was selected for the present study because apparel and accessories represent one of the largest categories of online sales around the world (Cassar, 2009). Additionally, the choice of the apparel context was deemed appropriate because apparel products are likely to be products with which Chinese college students who comprise the sample for the study have some familiarity purchasing on their own.

2. Conceptual background

Trust and perceived risk determines the consumers' online transaction intentions (Jarvenpaa, Tractinsky & Saarinen, 1999). Trust is an especially important factor under conditions of uncertainty and risk. The unique virtual shopping environment associated with online shopping raises uncertainties for consumers, and the higher level of

uncertainty, would in turn, increase the overall perceived risks and untrustworthiness of online shopping (Biswas & Biswas, 2004). Many studies have indicated that credit card security, buying without touching or feeling an item, being unable to return an item, and the privacy/security of personal information remain Internet consumers' main concerns (Bellman, Lohse & Johnson, 1999; Suki & Suki, 2007). All of these issues increase risk, and influence a consumer's trust and purchasing decision in online shopping. Therefore, building consumer trust in Internet shopping is necessary for an Internet shopping transaction.

Research has suggested that consumers frequently rely on trust attributes, or risk-relieving activities (also known as extrinsic cues) to decrease uncertainties associated with Internet shopping (Chu, Choi & Song, 2005; Dowling & Staelin, 1994; Park & Stoel, 2005; Tan, 1999). These risk relievers include seeking information from formal and informal sources (e.g., obtaining information from other consumers who have used the product), limiting the set of alternatives to well-known brands, purchasing from retailers with good reputations, trying the product before purchasing, and reducing the amount that could be lost (e.g., by insisting on warranties/money-back guarantee) (Akaah & Korgaonkar, 1988; Dowling & Staelin, 1994). Lwin and Williams (2006) analyzed risk relievers based on the findings of prior studies in this field. The authors identified the most important six risk relievers, namely, "warranty/money-back guarantee," "brand/manufacturer reputation," "retailer reputation," "price," "information source/reference group," and "trial." Previous research within an online shopping context has suggested that consumers would consider online shopping to be safe and trustworthy when external cues are present versus when they are not (Barsky, 1995; Chu et al., 2005).

When consumers are unable to determine the risk before online transaction takes place, they often rely on the major source of information in E-commerce, reputation system to estimate the risk and reduce uncertainties associated with Internet shopping for products (Alnemr, et al., 2010; Chu et al., 2005; Park & Stoel, 2005; Senecal & Nantel, 2004; Tan, 1999). This study examined the effectiveness of three reputation-based trust management strategies (or risk relievers), namely manufacturer brand reputation, online retailer's reputation, and online seller's reputation in the online shopping context. We examined their effectiveness in reducing Chinese consumers' perceived risk regarding online shopping and further increasing their purchase intentions in the online market. The conceptual model of this study is summarized in Figure 1 below.

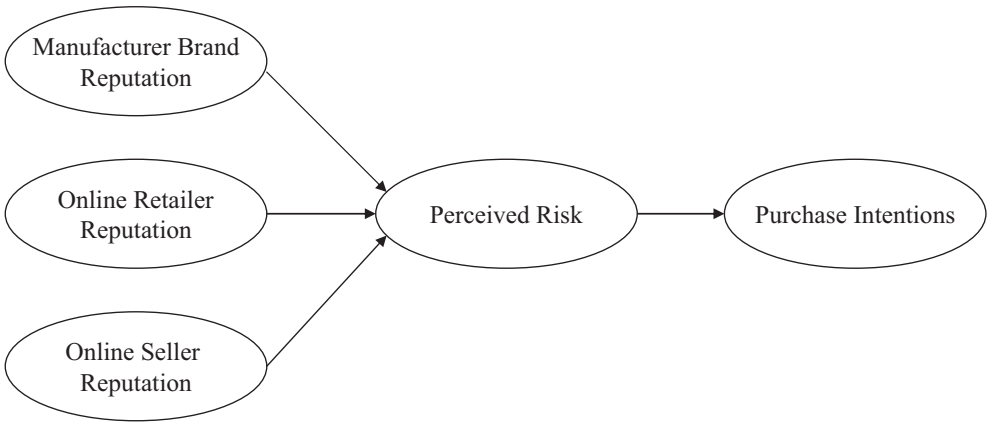

Figure 1 The Conceptual Model

3. Research hypotheses

3.1 Manufacturer brand reputation

Research shows that consumers often use brand names as risk relievers in making product choices (Chu et al., 2005; Grewal et al., 1998). Since manufacturer reputation is directly linked to the product, the manufacturer's reputation has the greatest impact on consumer perception of product quality (Grewal et al., 1998; Rao & Monroe, 1989). A well-known manufacturer brand name associated with a positive brand image creates competitive advantages in terms of increasing consumers' interest, attention, and positive evaluation of a product (Porter & Claycomb, 1997; Shen, 2001). When buying apparel products on the Internet, consumers normally cannot physically see or try on the product; thus, brand names play an important role in reducing perceived risk and assessing product quality (Moon & Millison, 2000; Park & Stoel, 2005). Therefore, a strong manufacturer brand name, a sign of quality, could reduce risk associated with product quality in the online shopping context (Vijayasarathy & Jones, 1999).

H1: Chinese online shoppers' perceived risk of online shopping will be lower when the manufacturer brand is more well-known.

3.2 Online retailer's reputation

Retailer reputation also plays an important role in many purchases, as retailers provide the interface between consumers and manufacturers (Purohit & Srivastava, 2001). Similar to manufacturer brand name, a retailer's reputation can be interpreted as the perception of quality associated with it. For example, "Nordstrom" represents an image of a luxurious store environment, high levels of customer service, and high-quality

merchandise (Grewal et al., 1998). Retailer reputations serve as a strong sign of product quality and risk reduction. Consumers' perceived purchase risk was lower for retailers who have a reputation for providing good service and quality products than for unknown retailers (Dawar & Parker, 1994; Purohit & Srivastava, 2001). The absence of a storefront in an online environment increases the uncertainty of Internet shopping, but this can be reduced by a trustworthy retailer (Biswas & Biswas, 2004; Chu et al., 2005; Vijayasarathy & Jones, 1999).

H2: Chinese online shoppers' perceived risk of online shopping will be lower when the online retailer is more well-known.

3.3 Online seller's reputation

One distinct feature of online shopping is that the buyer and seller do not meet face-to-face, and buyers transact almost entirely with new and unknown sellers on the online marketplaces (Gefen & Pavlou, 2006). Thus, there are often questions related to trust in the buyer-seller relationship. The feedback mechanism on the online retailers' websites is an essential part of the system that reduces the risk and trust associated with purchasing from sellers at an electronic marketplace (Brinkmann & Siefert, 2001). Online customer reviews provided on the Internet retailer's website have become a major information source for consumers regarding the online seller's credibility and reputation (Bickart & Schindler, 2001; Hu, Liu & Zhang, 2008). Online customer reviews, the direct, firsthand information shared by consumers who have purchased and used the product, provide specific and trustworthy information of a online seller for potential customers, which could ultimately reduce their perceived risk of online transaction with online sellers and enable them to make more informed and confident purchasing decisions (Kim, Qu & Kim, 2009; Lim et al., 2006).

H3: Chinese online shoppers' perceived risk of online shopping will be lower when customer reviews are available on a retailer's website than when they are absent.

3.4 Perceived risk and purchase intention

Uncertainties and risks associated with the Internet channel are barriers to shopping online and negatively influence consumers' purchase intention (Bhatnagar et al., 2000; Park et al., 2004). Many studies have indicated that credit card security, buying without touching or feeling an item, being unable to return an item, and the privacy/security of personal information remain Internet consumers' main concerns (Bellman et al., 1999; Suki & Suki, 2007). All of these issues increase risk, and influence consumers' decisions to shop online. Thus, the likelihood to purchase over the Internet decreases as consumers' perceptions of risk increase.

H4: Perceived risk negatively affects Chinese online shoppers' intention to purchase products online.

4. Methodology

In this study, the first three hypotheses (H1, H2, and H3) were tested using experiments in which three selected risk relievers were treated as independent variables and manipulated at two levels: 2 (retailer reputation: strong and weak) × 2 (manufacturer reputation: well-known and unknown) × 2 (information on the seller's reputation: present and absent). Linear regression was used to test the relationship between perceived risk and purchase intentions (H4).

4.1 Sample and data collection

We designed an experiment involving college students at a Chinese university located in a medium-sized city in Southwest China to test the effects of the three risk relievers on consumers' perceived risk in an online shopping context. We targeted college students mainly because college-aged consumers between the ages of 18 and 30 make the majority of online purchases (Lee & Johnson, 2002; Modahl, 2000), the consumers who make the majority of online apparel purchases in China are of college age, and these consumers' education level is higher than average (Yu, 2006).

Pretesting was carried out with 30 Chinese Internet shoppers to select the product stimuli and make sure that manipulations of the treatments were in accord with the researcher's intention. In the actual experiment, we distributed a paper questionnaire to a sample of 320 students in classes at the target university. A majority of the students participating in the survey are majoring in businesses. A small gift incentive was offered to subjects to increase the response rate, but participation was voluntary. Participants were randomly assigned to one of eight cells of the between-subject experimental conditions. The number of participants in each cell was 40 (320/8 = 40).

In the experiment task, participants were asked to imagine that they were purchasing a polo shirt on the Internet and had come across a description of a polo shirt. The description contained some generic attribute information about the polo shirt. Manufacturer reputation, online retail reputation, and the availability of information on the seller's reputation were embedded in the introduction description. After reading the description, participants are required to complete a questionnaire that collected information on the dependent measures (perceived risk and online purchase intentions), manipulation check, as well as standard demographics.

4.2 Instrument and measures

4.2.1 Product stimuli

Based on the feedback from the pre-test, a polo shirt was selected as the product category for the experiment due to the item's popularity among Chinese online shoppers. Furthermore, polo shirt is a category involving fewer changes in style and is less affected by fashion trends. Therefore, it is expected that quality and brand name will be the major factors affecting buyers' purchase decision.

4.2.2 Independent variables

We used actual brand names and Internet retailer names in our experiment, so the participants would conjure up perceptions of reputation and knowledge in their evaluation of the retailers and products (Bearden & Shimp, 1982; Dodds, Monroe & Grewal, 1991; Lwin & Williams, 2006).

There were two treatments for the manufacturer brand. The first was a new and unknown domestic brand for polo shirts -- *Chaoyue*. The second was an established and well-known international sportswear brand -- *Nike*, the number one sportswear brand in the Chinese market (Anonymous, 2006). Online retailer reputation was manipulated to distinguish between a strong reputation and a weak reputation. *Aoyun*, a new and unknown sportswear online retailer, was chosen as the retailer with a weak reputation. *Taobao*, the largest Internet retailer in China, was chosen as the retailer with a strong reputation (Li, Li & Lin, 2008). Similarly, the availability of information on the seller's reputation was manipulated at two levels: presence and absence. Phrases was included in the description section of the questionnaire to indicate that customer reviews on the seller *were or were not* provided on the retailer's website (see Table 1).

Table 1 Treatment for the Dependent Variables

Risk Relievers	Levels
1. Manufacturer brand reputation	1. ***New and unknown:*** Chaoyue 2. ***Established and well-known:*** Nike
2. Retailer brand reputation	1. ***New and unknown:*** *Aoyun* (www.buy007.com) 2. ***Established and well-known:*** *Taobao* (www.taobao.com)
3. Availability of information on the seller's reputation	1. ***Present:*** "Customer reviews on the seller are available on the retailer's website." 2. ***Absent:*** "Customer reviews on the seller are NOT available on the retailer's website."

4.2.3 Dependent variables

Perceived risk and purchase intentions were measured by existing scales. Research findings about perceived risks in product purchases (e.g., Biswas & Biswas, 2004; Lee & Huddleston, 2006) were used to develop statements related to privacy, timing, performance, and financial and social risks. We developed twelve items for perceived risk. Some of the sample items were "If I return the clothing product I bought online, I will not be able to get a full refund" and "There will be something wrong with clothing bought on the Internet, or the clothing will not fit properly." The subjects were asked to rate these statements on a 5-point Likert scale (*1 = strongly disagree to 5 = strongly agree*). Intentions to purchase via the Internet were measured using a single item, since many consumer behaviour studies have used a single-item purchase measure (Lwin & Williams, 2006; Park & Jun, 2003). The subjects were asked to indicate the likelihood of buying the product being shown in the experiment on a 5-point Likert scale (*1 = strongly unlikely to 5 = strongly likely*).

5. Data analysis and results

5.1 Sample description

Of the 320 collected questionnaires, 281 responses were considered valid and were used in the study. Most participants were between the ages of 18 and 25 (97%), and 190 respondents were women (68%). One hundred and forty respondents (51%) reported having online shopping experience, and more than 70% of the respondents who had not actually purchased anything online had frequently browsed items (including apparel items) online.

5.2 Reliability of variables and manipulation check

Cronbach's alpha was used to examine the internal consistency of the items, with a minimum criterion of approximately 0.70 (Hair et al., 1998). Items with low individual reliability were eliminated to improve the Cronbach's alpha of the scales. In the present study, only one dependent measure, perceived risks, had multiple items (12 items). The result was that two perceived risk items were excluded from the final scale due to a low item-total correlation. The value of Cronbach's alpha for "perceived risks" was 0.70. Thus, it was accepted as being reliable for the research.

Manipulation checks based on similar previous studies were conducted at the end of experiment. Subjects are asked to evaluate the manufacturer reputation (*very strong reputation and very weak reputation*), retailer reputation (*very strong reputation and very weak reputation*), and information on the online seller's reputation (*very abundant and*

very scarce) on 5-point likert scales. A 2 × 2 × 2 ANOVA showed that participants in the good-reputation condition perceived the manufacturer's reputation were significantly higher relative to the poor-reputation condition F (1, 273) = 78.62, $p < 0.0001$. The other manipulations did not affect perception of manufacturer reputation. Similarly, the result of the manipulation of retailer reputation revealed that participants in the poor-reputation condition perceived the retailer's reputation were significantly lower relative to the good-reputation condition F (1, 273) = 108.54, $p < 0.0001$. The retailer reputation ratings did not vary with any other manipulation. Finally, the result of the manipulation check of the importance of the seller's reputation information indicated a significant main effect of customer reviews F (1, 273) = 85.78, $p < 0.0001$). There were no significant main effects of the other manipulations on customer reviews. Thus, these results indicate that the independent variables were successfully manipulated.

5.3 Result of hypothesis testing

5.3.1 Univariate analysis of variance (ANOVA)

The results of the univariate analysis of variance, presented in Table 2 and Table 3, reveal that only the availability of information on the online seller's reputation (customer reviews) has a significant effect on perceived risk (F (1, 273) = 31.19, $p < 0.0001$). When customer reviews on the seller were available on a retailer's website, consumers perceived lower purchase risk compared to when customer reviews were absent (M = 12.34 vs. 13.42). Hence, the results supported H3. The results are consistent with Hu et al.'s study (2008), which found that online reviews of the seller could reduce consumers' perceived uncertainty of online transactions and influence consumers' purchase behaviour. However, in this study, both manufacturer brand reputation and online retailer reputation did not have a significant effect on consumers' perception of risk. Thus, H1 and H2 were not supported (see Table 2).

5.3.2 Regression analysis

The linear regression results ($\beta = -0.18$, t value = - 7.74, $p < 0.001$) provide evidence of the negative impact of perceived risk on consumers' purchase intentions on the Internet. Thus, H4 was supported. This is congruent with previous studies that suggested that consumers' risk perception would discourage their transaction intention in the cyber marketplace (Jarvenpaa & Todd, 1997; Kim & Ahn, 2006).

Table 2 MANOVA and Univariate Results

Independent Variables	Perceived Risk	
	***F* (1, 273)**	***Significance***
Manufacturer Brand (H1)	0.24	0.63
Retailer (H2)	0.60	0.44
Online seller (H3)	**31.19**	***0.00******
Manufacturer Brand × Retailer	0.03	0.87
Manufacturer Brand × Online seller	0.39	0.53
Retailer × Online seller	1.00	0.32
Manufacturer Brand × Retailer × Online seller	2.73	0.10

*** $p < 0.0001$

Table 3 Means and Standard Deviations for Independent Variables on Dependent Variables

	Manufacturer Brand		**Online Retailer**		**Online Seller**	
Dependent Variables	Well-known	Unknown	Well-known	Unknown	Present	Absent
	(N = 138)	*(N = 143)*	*(N = 140)*	*(N = 141)*	*(N = 141)*	*(N = 140)*
Perceived Risk	12.93 *(1.67)*	12.83 *(1.73)*	12.80 *(1.60)*	12.97 *(1.79)*	**12.34** *(1.80)*	**13.42** *(1.40)*

Note: Higher means indicate greater perceived risks.

6. Discussions, conclusions and recommendations

The main purpose of this study was to investigate the effectiveness of manufacturer brand reputation, online retailer reputation, and online seller's reputation on Chinese consumers' perception of risk associated with online shopping. Previous research has studied similar relationships using data collected mainly from the U.S. The findings of this study help not only validate previous results in a cross-culture setting but also increase Internet marketers' understanding of their target consumers in China and provide marketers with more knowledge about how reputation-based trust management strategies influence Chinese shoppers' perception of risk when they purchase products on the Internet.

Unlike the findings from most empirical studies conducted in the U.S., manufacturer brand reputation had no weakening effect on Chinese consumers' perceived risks of online shopping (M = 12.93 vs. 12.83), F (1, 273) = 0.24, p = 0.63. A possible explanation for the results is that fake and cheaply made goods are ubiquitous on e-commerce sites in China,

and the big name brands are normally the favourite target of counterfeits (Hargrave, 2005). Chinese consumers are suspicious of name brands when buying them online, even though consumers generally have a positive attitude and purchase intentions toward a well-known, high equity (Hsu, 2007). Therefore, a reputable brand does not necessarily signal good quality and a safe purchase in the Chinese online market because the product may be a fake. Brands, especially big name brands, should increase their presence and set up their own stores on the Chinese cyber market to prevent counterfeit products from hurting brand equity and sales.

Inconsistent with previous studies, we found that an online retailer's reputation could not significantly decrease Chinese consumers' perceived risk of making online purchases (M = 12.80 vs. 12.97), F (1, 273) = 0.60, p = 0.44. This may be due to two possible reasons. One is that the majority of top online retailers in China (e.g., Taobao, Paipai, and Eachnet) function as market-makers. Similar to Amazon and eBay, they create e-marketplaces that allow a large number of buyers and sellers to meet and trade with each other. Even though these Chinese online retailers try to become a source of quality products for buyers, many illegitimate businesses have been set up at these marketplaces to sell shoddy products or defraud consumers (Yu, 2006). Unlike online shopping malls or storefronts where transactions are guaranteed solely by a seller who simultaneously acts as a market-maker, in the e-marketplace the buyer's transaction is guaranteed by both a market-maker and a seller (Kim & Ahn, 2006). Since the quality of the product and customer service are still largely determined by the direct seller, buying from a popular e-marketplace but from an unknown seller still creates a lot of uncertainty among Chinese online shoppers. Therefore, the findings from this study indicated that the availability of the information on the direct seller's reputation could significantly reduce consumers' perceived risk in online transaction. Second, because e-commerce in China is still in the infancy stage, even the most reputable e-retailer in this country, Taobao, has not won consumer confidence. According to Lu et al.'s study (2009), Chinese customers' evaluations of Taobao are not positive in a number of variables, such as content quality and customer support. The logical conclusion is that a popular Internet retailer for Chinese consumers means a shopping destination with high traffic but not necessarily a trusted seller. Based on these findings, we think Internet retailers in China should not only explore the reasons for low customer trust in order to raise customer confidence in the retailers' websites but also ensure the high quality of the third-party seller in order to attract more buyers to the seller's marketplace.

The results of this research show that the availability of information on the online seller's reputation on an online retailer's website has a negative impact on Chinese consumers' perceived risks of online shopping (M = 12.34 vs. 13.42), F (1, 273) = 31.19, p < 0.0001. The e-commerce industry in China is still at the infancy stage compared with

more developed markets. Fraud is endemic in China's online markets. Therefore, online customer reviews are critically important for Chinese customers when they transact with an unknown seller in such an immature and unsafe online shopping environment (Ye et al., 2009). Because online customer reviews on the seller play a central role in helping Chinese online shoppers overcome perception of risk and insecurity in online transactions, Internet retailers' websites should support the provision of recommendations and customer reviews about sellers' reputations and former customers' online experiences for prospective customers' reference.

The study results also suggest that the perceived risks associated with online shopping critically affect Chinese consumers' decision whether to engage in this form of shopping. This is consistent with previous research suggesting that consumers' risk perception is a primary obstacle to online commerce's future growth (Jarvenpaa & Todd, 1997). The results from this study and previous studies suggest that Chinese Internet shoppers' major concerns include product quality and security of payment and personal information (Yu, 2006). Internet retailers should take steps to address these concerns to help increase Chinese consumers' confidence in making purchases on the Internet.

The findings of this research are limited in several ways. First, the number of levels of each risk reliever is limited to two in this study (manufacturer brand reputation was manipulated at two levels: new and unknown vs. established and well-known). Future studies could explore the use of more levels. For example, manufacturer brand reputation could be manipulated at four levels in future studies: "new local manufacturer brand," "new international manufacturer brand," "established local manufacturer brand," and "established international manufacturer brand." Second, this study examined only the effect of the availability of information on the online seller's reputation on consumers' perception of risk in online shopping. We suggest future research should also investigate the influence of a seller's reputation (good or bad) on consumer perceived risk. Last, we recognize that using only polo shirts in this research design may have limited the findings from the present study to this particular product category, and the convenience sample used in this study also reduces the ability to generalize findings to a broader population. Therefore, a future research opportunity could cross-validate our results by including diverse product categories and expanding into other regions in China.

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A Graph Theoretic Approach to Sustainable Steganography

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ABSTRACT: *An algorithm based on graph-theoretic approach is introduced in this paper. A bipartite graph is created from message and cover object. Message M is broken into units of x (= 2, 4, or 8) bits long. For each x, a matching with m number of such x bits from cover file is determined using the bipartite graph. Wherever a matching for a node in left side is found with a node in right side then this part of the message is treated as either naturally or cross embedded in that port of the cover. Nodes in left side correspond to bits in message and those in right side correspond to group of bits in cover. The matching relationship is then embedded in the extra bytes of cover, fully utilizing the available redundancy or alternatively the sequence of indices is compressed and sent through separate channel. The algorithm achieves almost 100% matching for message elements in cover elements. The embedding algorithm has been put through mathematical and statistical test to ensure that it not only retains visual similarity in stego with cover file but also leaves other statistics of cover undistorted after embedding. Therefore it achieves sustainability. In this paper, we have taken BMP file to implement the algorithm.*

KEYWORDS: *Extra Bytes, Graph Theoretic Approach, Steganography, Information Hiding, Sustainable Embedding, Natural Embedding, Partial Embedding, Cross Embedding, Explicit Embedding.*

1. Introduction

Steganography, also called "covered writing" is defined as the art and science of communicating in a way that hides the very existence of the communication. Steganography and Cryptography are excellent means to achieve privacy and secrecy of information to be shared between communicating partners. A mechanism to combine them provides multiple layers of security. Statistical and visual undetectability of a stego object when compared with cover object is an important consideration for any steganographic schemes. By undetectability, we understand the inability of an attacker to distinguish between stego and cover objects with success rate better than random guessing, given the knowledge of embedding algorithm and the source of cover media.

There are a number of steganographic approaches in use for hiding information in digital images. The spatial domain, frequency domain and spread spectrum technique are mostly used for information hiding (Anonymous, 1995; Sellars, 2006). The simple

and most obvious is substitution method that replaces Least Significant Bit (LSB) or randomly selected bit, image downgrading, cover region and parity bits etc (Katzenbeisser & Petitcolas, 2000). Another approach is statistical steganography that utilizes a 1-bit steganographic scheme (Katzenbeisser & Petitcolas, 2000). These approaches alter some bits that are part of color pallet of the image. Thus statistical analysis between the known cover and stego object may reveal the presence of information in the image. Another work based on information theoretic approach by Cox et al. (2005) embeds information using correlation coefficient between two distributions drawn from message and cover. The number of bits to be altered depends on the value of the correlation.

Steganographic research is primarily driven by the desire to have complete secrecy of information in an open-systems environment. This is not available with cryptographic systems. Steganography (Cole, 2003; Cox et al., 2007; Johnson, 1995; Johnson & Jajodia, 1998a) and cryptography (Stallings, 1999) are used for the purpose to protecting the information from a third party. In a cryptographic system, a hacker may be able to detect, intercept, modify and/or destroy messages without being able to violate certain security premises guaranteed by a cryptosystem (Lenstra, Wang & Weger, 2005; Merkle, 1990; SANS Institute, 2001; Schneier, 1996), whereas in a steganographic system a message is embedded inside other harmless messages in a way that it does not allow third party to even know the presence of the message (Johnson, Duric & Jajodia, 2001; Krinn, 2000). Information hiding is used in digital watermarking (Cox et al., 2007) wherein cover needs to be retained after retrieval of message unlike in steganography. Also in administrative control some administrative decision needs delayed disclosure of information. Until that time privacy of information is to be ensured. This is applicable to both data at store as well as data on move in the era of Internet where most of data is shared using telecommunication transmission i.e. computer network.

If a message is embedded without replacing or exchanging any color bits of cover data, an almost perfect steganography is achieved! In this paper, a steganographic algorithm using graph theoretic approach is introduced that exactly achieves that. The following four factors influence a steganographic security.

- Type of cover media
- Method of selection of places within the cover that might be modified
- The embedding operations
- The number of embedding changes

The idea behind a steganographic process is to find an embedding algorithm that finds a suitable cover, determines redundancy in it and finally preserves statistics of the cover. Statistics such as color frequency, average absolute difference (AD), mean squared

error (MSE), L^p-norm, Laplacian mean squared error (LMSE), peak signal to noise ratio (PSNR) and histogram similarity (HS) of the original cover image should be preserved in the stego to confuse the hacker. The graph theoretic approach to steganography is presented by Hetzl and Mutzel (2005) that basically preserves color frequency of the cover by exchanging a basic elements of cover from one block to another to infer message as a functional output of the exchanged block. The approach does not preserve the other statistics outlined above. A novel approach is presented in this paper that preserves the above statistics besides the color frequencies.

There are two ways of using graph theoretic concept in steganography.

- Find relationship (if required) between smallest data unit of message and a group of such smallest unit of cover object and represent the relationship using a graph. If required, hide the relationships in the zero bytes of cover.
- Use a graph as cover object and find redundancy in its feature like node or segment or its attributes and embed payload in it (Krinn, 2000).

A digital cover image can be treated as collection of data units. Each data unit is nothing but string of some x bits. Thus a cover is an array of such data units. Similarly a secret message to be embedded in the cover may be treated as an array of data units each of the same x bits length. Utilising this concept and the first approach listed above, an algorithm is presented in this paper to hide information in an image in sustainable way. We generate a bipartite graph from cover image and message.

The paper is organized is seven sections. Section 2 contains terminology and a theoretical description of the graph theoretic approach for finding relationships. The algorithm to represent the relationship in graph and to store, wherever required, in cover is described in Section 3. In Section 4, we have explained how to get basic information about cover image and use it to store any information if required. Extraction process is mentioned in Section 5. Steganographic security of our approach is described in Section 6. The paper is concluded in Section 7.

2. Theoretical approach

We treat message (M) as an array of elements, each element containing sequence of x bits, where x is taken from set {2, 4, 8} to avoid padding of bits. The value 4 is found very optimal and in many cases (> 99%) we have achieved 100% natural and cross embedding. Before proceeding further it is important to briefly introduce terms frequently used in this paper.

2.1 Terminology

2.1.1 Bipartite graph

A graph G = (V, E) is called a bipartite graph if vertex set V can be partitioned into two non empty disjoint subsets V_1 and V_2 in such a way that every edge in set E joins a vertex in V_1 to a vertex in V_2. No node in $V_1(V_2)$ is adjacent to any node in $V_1(V_2)$. However some nodes in V_1 are adjacent to some nodes in V_2.

2.1.2 Embedding factor

Let size of message array be L. An embedding factor is defined as ratio

$$k = \frac{\text{size of cover array}}{\text{size of message array}}$$

It implies that potentially k data units are available in cover for one data unit of secret message.

2.1.3 Cross embedding

Let embedding factor k be 4 and data unit size x be 2. A r^{th} data unit of message is said to be cross embedded in the s^{th} k data units of cover, if $r \neq s$ and additional modulo 2^x of s^{th} k data units of cover is equal to r^{th} data unit of message.

2.1.4 Explicit embedding

When none of the embeddings like cross, natural or partial is achievable, then r^{th} data unit of message is to be explicitly written in the extra bytes of the cover. This situation is defined as explicit embedding.

2.1.5 Extra byte

While storing an image in a file format a certain format constraint is maintained. In 24 bit BMP a pixel needs 3 bytes for RGB. Every line starts from a quad boundary, thus a few bytes (0 to 3) are padded to ensure that number of bytes in a line remains multiple of 4. These padded bytes are called extra bytes or zero bytes.

2.1.6 Natural embedding

Let embedding factor k be 4 and data unit size x be 2. A r^{th} data unit "01" of message is said to be naturally present in the r^{th} k data units of cover "10 00 01 10" because additional modulo 4 of 10, 00, 01 and 10 is equal to 01.

2.1.7 Partial embedding

When r^{th} data unit of message is neither naturally embedded nor cross embedded but it is present as one of the k in the r^{th} k data units of cover then it is called partially embedded in the cover.

2.1.8 Sustainable steganography

By sustainable steganography we mean preserving statistics of cover in stego by avoiding possible distortion in the cover due to embedding of the message in it.

2.2 Methodology

Let $m_1, m_2, m_3, \ldots m_L$ be L sequences, each of x bits, of message M. Let us use M to denote size of message, thus

$M = L*x$ bits.

We use 24bit BMP file as cover object (C) to implement the algorithm. The 24bit BMP image has 2^{24} colors and the palette field does not contain any entry (Gonzalez & Woods, 1992). Each 3-byte triplet in the bitmap array represents relative intensities of blue, green, and red color of a pixel. The actual pixel data begins at the offset of 54 bytes from the start. The 54 bytes header info is left unchanged. If size of cover image is W * H, where W is width and H is height in pixels then there are

$3*(W * H)$ bytes

for colors, some zero bytes besides 54 bytes used for header in the cover. Zero bytes are added at the end of every line (3*W) bytes to ensure that next line begins at the 32bits-boundary (Gonzalez & Woods, 1992).

We also consider 3(W * H) bytes of cover image C as array of elements, each element containing x bits. The value of x is same as in M. Let $c_1, c_2, c_3, \ldots c_N$ be N sequences, each of x bits, of cover C. If we take C as size of bitmap array in 24bit BMP cover then

$C = 3* (W * H) = N*x.$

This implies that each m_j has k

$$k = \frac{N}{L}$$

c_j's available in C. For implementation purpose, $c_1, c_2, c_3, \ldots c_N$ can be organized as $(c_{1,1}, c_{1,2}, c_{1,3}, \ldots c_{1,k})$, $(c_{2,1}, c_{2,2}, c_{2,3}, \ldots c_{2,k})$, $\ldots(c_{L,1}, c_{L,2}, c_{L,3}, \ldots c_{L,k})$ such that

$N = k*L$

Since k bits of cover are used for one bit of message, k is called embedding factor of the algorithm. We find relationships between each m_j and $(c_{j,1}, c_{j,2}, c_{j,3}, \ldots c_{j,k})$ as follows.

(a) If ($c_{j,1} + c_{j,2} + c_{j,3} + \ldots + c_{j,k}$) modulo $2^x = m_j$, then m_j is considered as naturally embedded in C.

(b) For the leftover m_i's, if it is found that it is naturally embedded in a ($c_{j,1}$, $c_{j,2}$, $c_{j,3}$, … $c_{j,k}$) for $i \neq j$ then index j of cover is used to represent m_i. This relationship is actually found using bipartite graph adjacency where m_i is adjacent to c_j. In this case m_i is considered as cross embedded in C.

(c) For the left over m_j's, if it is equal to any of $c_{j,1}$, $c_{j,2}$, $c_{j,3}$, … $c_{j,k}$, say $c_{j,x}$ then triplet (C, j, x) is stored in zero byte area of cover. In this case, m_j is said to be partially embedded in C.

(d) If still any m_j is left then it is treated as isolated node of graph and is stored in zero byte as triplet (M, j, m_j), where M stand for message, j is index in array of message elements and m_j is the corresponding x bits. We refer the situation of embedding as explicit embedding.

The concept introduced for message hiding is shown in the schematic diagram in Figure 1 and the symbols used are described in Table 1.

The steganographic method finds *natural embedding* of the message in the selected cover. Natural embedding can be described as an embedding process in such a way that message bits can be thought of already present in the cover. For example, if j^{th} four groups ($c_{j,1}$, $c_{j,2}$, $c_{j,3}$, $c_{j,4}$), each of 4 bits, in the cover be

0110 0101 1001 1100

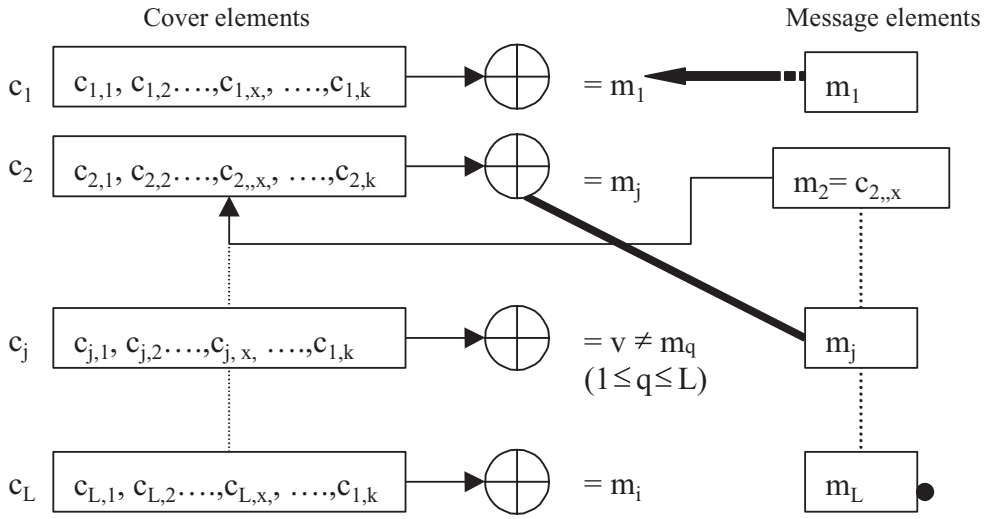


Figure 1 Schematic Diagram for Embedding

Table 1 Legends

Sr. No.	Symbol	Meaning
1.	$\oplus$	Addition Modulo 2^x
2.	⟵	Natural Embedding
3.	—	Bipartite graph edge for cross matching
4.	←	Partial embeddings
5.	•	Implies that the corresponding message element is an isolated node and has to be embedded as (M, L, m_L).

then

$$(0110 + 0101 + 1001 + 1010) \text{ modulo } 2^4 = 1110,$$

implies that bit string

$$m_j = 1110$$

of message is naturally embedded where m_j is j^{th} 4 bits in M. If all m_j's are not naturally embedded in the cover and say some

$$m_i = 0010 \ (i \neq r)$$

is equal to addition modulo 2^4 of some

$$(c_{r,1}, c_{r,2}, c_{r,3}, c_{r,4}) = (1000 , 0100, 0011, 0011)$$

then index r of cover is used to represent m_i. Similarly, if

$$m_r = 1001$$

then it is partially embedded in

$$(c_{r,1}, c_{r,2}, c_{r,3}, c_{r,4}) = (0110\ 0101\ 1001\ 1100)$$

at 3rd location in c_r and a triplet (C, r, 3) is stored in zero bytes of cover to embed this part of message. Here C stands for cover, r for r^{th} element of message array and 3 for 3rd element in r^{th} block in C. Finally, if a m_j, say 0000, is still not found to be embedded in or related to any block of elements in C, then this part is stored as (M, j, m_j). This too is stored in extra bytes.

Notice that no information part is directly stored but only the association and that too without disturbing any color bits of the cover. While reconstructing the message this information is used to reconstruct the message part from the cover itself. In the following section, we describe the algorithm to implement the concept by taking an example. We have used 24 bit BMP (Gonzalez & Woods, 1992; Kirkby, n.d.) image file as cover in this paper for the purpose.

3. Implementation

Given message is scanned byte by byte from left to right and its size is optimized for embedding by removing all white spaced, punctuation marks and formatting characters. Format is not so important as it can be restored (reformatted) at the receiving end. Each byte of the resultant text is unpacked into 8/x units. Each unit contains x bits. To illustrate the concept we have taken x = 4. Thus a given message of M bytes is stored in an array of size

$$L = 2M$$

We use two mask bits 00001111 and 11110000 to unpack one byte into two nibbles: most significant and least significant four bits. Let the text be "This is steganography." After removing spaces and punctuation the resultant text is "Thisissteganography." 19 characters of this text are divided into 38 nibbles and stored in an array TEXT [38] as shown below.

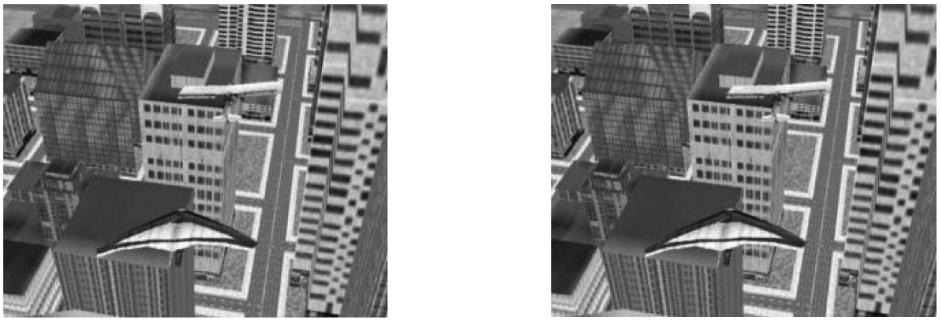
TEXT[38] = {5, 4, 6, 8, 6, 9, 7, 3, 6, 9, 7, 3, 7, 3, 7, 4, 6, 5, 6, 7, 6, 1,
6, E, 6, F, 6, 7, 7, 2, 6, 1, 7, 0, 6, 8, 7, 9}

After transforming text into array of x bits data, it is turn to find graph relationships between image and data units. The basic information about a 24-bit BMP file is retrieved using structure that is defined in Table 3 and 4 of Section 4. For example see the image in Figure 2(a). The image is 24 bits BMP having height = 135 pixels and width = 167 pixels. The number of bytes required in every line is

$$167*3 = 501$$

Next line starts at quad word boundary, so each line in the colour palette portion shall contain

$$[4 - (501 \% 4)] = 3$$



(a) (b)

Figure 2 (a) Original Image and (b) Image after Embedding the Message.

extra (or zero bytes).

The image has in total 135*3 = 405 extra bytes. The total bytes for colour pixels

= 167 * 135 * 3
= 67635 bytes = 135270 nibbles.

Therefore for every nibbles of text, we have

$$\frac{135270}{38} = 3559$$

nibbles in the image to hide. The addition modulo 2^4 of these 38 units of 3559 nibbles is stored in IMAGE [38] array and the values are as below.

IMAGE[38] = {0, 6, A, 3, 9, C, 5, 0, B, 2, 8, F, 5, E, 6, 8, 7, 4, 0, 7,
5, 0, 8, 9, 1, D, 0, 0, 8, 7, B, 7, B, 9, 0, C, B, 0}

Now we find relationships between TEXT [38] and IMAGE [38] for the correspondence as per algorithm outlined in Section 2. Table 2 is partitioned in three parts (a), (b) and (c) to accommodate 38 indexes.

Table 2 Matching Index Table

(a)

Text Index	1	2	3	4	5	6	7	8	9	10	11	12	13
Nibble Value	5	4	6	8	6	9	7	3	6	9	7	3	7
Image Index	7	18	2	11	2	5	17	4	2	5	17	4	17

(b)

Text Index	14	15	16	17	18	19	20	21	22	23	24	25	26
Nibble Value	3	7	4	6	5	6	7	6	1	6	E	6	F
Image Index	4	17	18	2	7	2	20	2	25	2	4	2	12

(c)

Text Index	27	28	29	30	31	32	33	34	35	36	37	38
Nibble Value	6	7	7	2	6	1	7	0	6	8	7	9
Image Index	2	17	17	10	2	25	17	1	2	11	17	5

First row of the Table 2 contains indexes of TEXT [ ] and the next row contains corresponding nibble value from TEXT. The third row contains the index from IMAGE for the corresponding nibble value. Notice the index 20 -- the natural embedding. The remaining 37 values are embedded through cross matching. The value to be embedded is

the indexes in third row i.e. (7, 18, 2, 11, 2, 5, 17, 4, 2, 5, 17, 4, 17, 4, 17, 18, 2, 7, 2, 20, 2, 25, 2, 4, 2, 12, 2, 17, 17, 10, 2, 25, 17, 1, 2, 11, 17, 5). The cover selection and embedding is described in the following section. The key of the steganography is

(<Message length in bytes>, x) = (19, 4).

We have experimented on over 200 images, and it is found that a data unit of text is either naturally embedded or cross embedded in an image if x = 2 or 4. The reason is the span of values that we have to find matching for. In case of x = 2, the possible values of data unit is {0, 1, 2, 3} and in case of x = 4, it is 16 hexadecimal symbol. Thus the steps 3 and 4 of partial and explicit embedding are rarely required. Even if it is required in few cases (< 1%) it is embedded in the extra bytes. The following section describes the method of retrieving information about a 24bit BMP and availability of extra bytes in it to accommodate partial and explicit embedding, if required.

4. Embedding process

BMP file format is designed to easily work with the Windows API using the same structures that Windows applications use to manipulate in-memory bitmaps. There are some variants of BMP file formats. With a little work, a single set of structures can be produced to describe all bitmap files. Table 3 illustrates the BMPFILEHEADER structure and Table 4 the BMPINFOHEADER. The structure defined in the "Box 1" is based on the BMPFILEHEADER. And the structure defined in the "Box 2" is based on the BMPINFOHEADER. Other information stored is pallet and image data. Pallet is an array of RGBQUAD structures, each of which is a color. The number of colors in the palette was specified in the biClrUsed field of the BMPINFOHEADER structure. The color Table is used only in 1-bit, 4-bit and 8-bit BMP files. Image data is a 1 dimensional array of unsigned characters, where each value is an index into the palette. In 16-bit, 24-bit and 32-bit BMP files each value in the image date section is a pixel stored in (b, g, r) format and therefore pallet is absent.

The oldest forms of the bitmap file format use 16- instead of 32-bit integers for the width and height fields of the BMPINFOHEADER structure. Fortunately, it is easy to tell when such a file is being read, since the *size* field is always 12 for those structures and greater than 12 for the newer structures. Additionally, files based on the "new" format will add an extra byte to the end of every RGBQUAD structure, in order to align it on a 4-byte boundary.

In order to ensure that the cover file is a BMP, header information from cover file is read using the following code. We then check ***bitcount*** field in bmpi structure to ensure that the BMP image file is of 24 bit. Information read in the bmpi structure is used to get

Table 3 BMPFILEHEADER Structure

Field	Bytes	Description
BfType	2	Bitmap identifier. Must be 'BM.'
BfSize	4	Can be set to 0 for uncompressed bitmaps, which is the kind we have.
BfReserved	2	Set to 0.
BfReserved	2	Set to 0.
BfOffbits	4	Specifies the location (in bytes) in the file of the image data. For our 24-bit bitmaps, this will be size of (BMPFILEHEADER) + size of (BMPINFOHEADER).

```
typedef struct
{
        char type[2];
        long size;
        char reserved[4];
        long offbits;
}bmpfileheader;
```

Box 1

Table 4 BMPINFOHEADER Structure

Field	Bytes	Description
BiSize	4	This is the size of the BMPINFOHEADER structure. **Size of (BMPINFOHEADER)**.
BiWidth	4	The width of the bitmap, in pixels.
BiHeight	4	The height of the bitmap, in pixels.
BiPlanes	2	Set to 1.
BiBitCount	2	The bit depth of the bitmap. For 8-bit bitmaps, this is 8.
BiCompression	4	Our bitmaps are uncompressed, so this field is set to 0.
BiSizeImage	4	The size of the padded image, in bytes.
BiXPelsPerMeter	4	Horizontal resolution, pixels per meter, of device displaying bitmap. Not significant for us, thus set to 0.
BiYPelsPerMeter	4	Vertical resolution, in pixels per meter, of device displaying bitmap. Not significant for us, thus set to 0.
BiClrUsed	4	Indicates how many colors are in the palette.
BiClrImportant	4	Indicates how many colors are needed to display the bitmap. We set it to 0 as all colors are used.

```
typedef struct
{
        long size;
        long width;
        long int height;
        int planes;
        int bitcount;
        long compression;
        long sizeimage;
        long xpm;
        long ypm;
        long colused;
        long colimp;
}bmpinfoheader;
```

Box 2

the image size so that embedding factor can be calculated. This also provides information about the number of extra (zero) bytes availability in the image.

```
bmph = (bmpfileheader *) farcalloc (1,sizeof (bmpfileheader));
fread (bmph, sizeof (bmpfileheader), 1, fbmp);
bmpi = (bmpinfoheader *) farcalloc (1,sizeof (bmpinfoheader));
fread (bmpi, sizeof (bmpinfoheader), 1, fbmp);
Image_width = bmpi- > width;
Image_height = bmpi- > height;
extra_bytes_perline = 4 – ((Image_width*3) % 4); //% is C
language operator for mod
Total_ extra_bytes_in_image = Image_hieght * extra_bytes_perline;
```

After computing the association (bipartite adjacency) between image data and text data we hide the relationship in the image. First, relationship related to the partial and explicit embedding, if there is any, is embedded in the extra byte. Number of extra bytes required is computed ≅ 5 bytes for partial embeddings of the form (C, j, x): 1 byte for C, 2 bytes for j and 2 bytes for x. Similarly all explicit embeddings of the form (M, j, m_j) is written in 4 bytes: 1 byte for M, 2 bytes for j and 1 byte for m_j. If number of partial and explicit embeddings is > 1% of the total data units of text, then we discard the selected cover and go for new one. We have not found even a single case of such embeddings till now. Natural and cross matching suffices the need.

Process of embedding starts from bottom. Compute number of lines required to hold the required number of bytes. If T be the total bytes required for partial and explicit embeddings, then Number of lines in image required for this is given by

$$\text{Number\_of\_lines\_required} = \left\lceil \frac{T}{\text{extra\_bytes\_perline}} \right\rceil$$

Randomly select first location where partial and explicit embeddings are to be written in ascending order of j. Skip to randomly selected line from bottom and then skip to (Image_ width * 3) bytes from left in a line and overwrite extra bytes with value to be embedded. Then every time skip (Image_width * 3) bytes from left in a line until all T bytes are written. Now to embed the relationships of natural and cross embeddings, we may explore one of the following two choices.

(i) Send the key through one channel and store the list of indexes obtained in previous section in the extra bytes of image and send it through another channel.

(ii) Send the image through one channel as it is and send combination of keys and list of indexes compressed in a mutually known ways through another channel.

The 38 indices are then written in the extra bytes using option (i). The stego is shown in Figure 2(b). Alternatively, the 38 indices are packed into 10 long integers of 4 bytes (1st in LSB and 4th in MSB). For the last two bytes (39th and 40th) we use NULL bytes to complete the process. Finally 10 long integers, thus computed together with key (19, 4) is sent through another channel using option (ii).

In this paper, we have restricted our discussion to 24 bit BMP files only. The same concept can be extended to other BMP file format. A message of reasonable size of say 500 characters, can very well be embedded in an image of size ≅ 800x800 24bit BMP having 3 extra bytes per lines. If x = 4, then there are 1,000 indices, each requiring 2 bytes. Thus a total of 2,000 extra bytes will be needed to embed using option (i) or alternatively 500 long integers in a file can be send with key (500, 4) to retrieve the message at the recipient end.

5. Extraction process

While retrieving information from the stego, we use the given key (L, x). We compute the length m

$= L*x \text{ bits} = \frac{m}{8}$ bytes or characters.

Then we retrieve information about the image (stego) from its header using the structures defined in the previous section. The embedding factor k is determined from the size of message m and number of pixels in stego. Once basic information: length of message (m), embedding factor (k), size of stego in terms of number of pixels and number of extra bytes are computed, the addition modulo 2^x of the every k data units of stego is calculated. Let the computed values in sequence are:

$v_1, v_2, v_3, \ldots v_L$

Now suppose the retrieved (or received) sequences of indices be

$d_1, d_2, d_3, \ldots d_L$

where $1 \leq d_i \leq L$. Each d_i is an index number in the image (stego). Now values

$v_1, v_2, v_3, \ldots v_L$

are rearranged using indices

$d_1, d_2, d_3, \ldots d_L$

as

$vd_1, vd_2, vd_3, \ldots vd_L$

Now depending upon the value of x, 8/x values are grouped together from left to right to form string of characters without punctuation marks and white spaces. Thus retrieval is easy when key (L, x) is known.

6. Steganalysis

Most of the steganalysis techniques of images (Johnson & Jajodia, 1998b; Noto, 2001) are basically based on the detection of statistical difference introduced in the cover due to embeddings. Anonymous (2001) provides detailed study as to how to improve privacy using steganography. This graph-theoretic approach to steganography is based on the idea of sustainable embedding that neither exchanges nor overwrites any color bits. Mathematically, it is established in the following theorem that almost 100% matching for numeric value of nibbles of text is found in the in array of values from image. No statistics related to color of the image are changed at all. Additionally, since there are absolutely no visual differences between cover and stego, therefore there is no way that anybody can guess presence of stego in any communication channel. Even statistical error values like average absolute difference, mean squared error, L^p-norm, Laplacian mean squared error, peak signal to noise ratio and histogram similarity have been found in the imperceptible (excellent) embedding range because there is no difference in cover and stego.

Theorem: Probability P(C) that a data unit of message is either naturally or cross matched in cover C is $\cong 1$, when data unit size is 2 or 4.

Proof: Let x be the size of smallest data unit in message then x is one from {2, 4, 8}. If it is 2, then four possible decimal values of bit string x are from the set {0, 1, 2, 3}. In case, x = 4, this count is 16 and in case of x = 8, it is 256. Obviously, the number of decimal values for bit string of length x is 2^x. Let Z be random variable indicating that a decimal value z out of 2^x is equal to a randomly selected value from array IMAGE [L]. Then Z = 0, 1. If z is not equal to the randomly selected elements from IMAGE [L] then Z = 0 otherwise it is 1. Now the probability that z is equal to randomly selected one of the L items in IMAGE is given by

$$P(Z=1)=\frac{1}{2^x}$$

and probability that it is not there is given by

$$P(Z=0)=1-\frac{1}{2^x}=\frac{2^x-1}{2^x}$$

Thus probability that a value z from TEXT is neither naturally matched with corresponding element in IMAGE nor cross matched with any element in IMAGE is 1 – P(C) and it is given by

$$1-P(C)=\left(\frac{2^x-1}{2^x}\right)^L$$

Therefore,

$$P(C)=1-\left(\frac{2^x-1}{2^x}\right)^L$$

For an array TEXT of reasonable size L = 100, P(C) ≅ 0.99999 if x = 2. Similarly P(C) ≅ 0.99842 if x = 4, however P(C) ≅ 0.3239 if x = 8 which goes up to ≅ 0.980 for L = 1,000.

Let y_T be the number of different possible decimal equivalent z in TEXT corresponding to chosen value x and y_C be the corresponding number in IMAGE then following special cases arise. Note that in the example taken in the paper $y_T = 12$ and $y_C = 16$.

Case 1: When $y_C = 2^x$, then irrespective of the value of y_T P(C) = 1. Note that y_T can be 2^x at the maximum.

Case 2: When $y_T < 2^x$ and $y_C < 2^x$ but all different z in TEXT are also in IMAGE. Here again P(C) = 1.

Case 3: When $y_C < 2^x$. In this case possibly, ∃ z in TEXT such that z is not in IMAGE. The third step of the algorithm is used to find of partial embedding.

The probability of getting third case is < 0.001. Even in this rare situation the algorithm uses partial embedding techniques. No explicit bit from message is written anywhere in the cover and no color bit of cover is either overwritten or exchanged.

A graph is constructed from the cover data and the secret message. A vertex in left of the bipartite graph corresponds to a smallest data unit of text and that in right corresponds to group (embedding factor) of data units from image (excluding extra byte). The L data units in left can match to a node in right in L! ways. The value of L depends on message

size and value of x. The same image may carry many messages just by changing the key (L, x). The situation when extra bytes need to be used has no effect on the statistics of the image color as these bytes do not participates in color patterns and are used just to maintain storage format of the file. In the absence of any knowledge about key and indices, any brute force approach is of order

$$(2^x)^L$$

for every guess of message size m. For a reasonable L = 100 and x = 4, it becomes of order 2^{400} even in the case of known stego.

Therefore, it is statistically infeasible for steganalyst to detect presence of a message in cover. The strength of this steganographic scheme lies in the concept of "hiding without disturbing any color bits." In case when image is destroyed by converting from one format to another, the relationship is lost. Thus an active hacker who wants to destroy the stego may destroy it but cannot retrieve message from it (Anderson & Petitcolas, 1998; Bender et al., 1996; Weiss, 1993). In order to overcome even this menace of destroying the stego, the communicating sites may maintain a list of cover images and instead of transmitting stego, only key and compressed indices may be exchanged using option (ii) of key exchange.

7. Conclusion

We have introduced a graph theoretic approach to steganography that retains all bits that participate in the color palette of image. The method is based on exploring maximum natural and cross embedding and then finding relationship that conveys the presence of message in cover without either replacing or exchanging any bits of cover. This way the algorithm achieves sustainability. Sustainable steganography can be described as a method of hiding such that no color bits are altered. Today various digital data formats are used in steganography. Most popular among them are bmp, doc, gif, jpeg, mp3, txt and wav because of the relative ease by which redundant or noisy data can be removed from them and replaced with a hidden message. 24bit BMP image taken as cover in this paper is just for illustration. Since every cover file is simply stream of bits, the same algorithm can be applied to any image/audio format with a little modification in finding zero bytes and header information. The technique used in this paper for natural embedding can be further improved by using variable embedding factor k for adjusting its value whenever maximum natural embedding is achieved.

Steganographic research is primarily driven by the lack of strength in the cryptographic systems on its own and the desire to have complete secrecy in an open-systems environment. Redundancy is not always useless. A lot of research is required to evolve techniques to naturally embed message in digital cover media. It can be used

for the benefit of the society as well as for better administrative management by keeping any secret information secret and beyond the reach of spoiler by maintaining its utmost privacy. The rich resources of spatial data available under national spatial database project by many governments around the world may also be used for the purpose of steganography using graph-theoretic approach to steganography. "A successful steganography is one that neither disturbs nor replaces any useful bits of cover. A successful steganalysis is one that retrieves message from stego without any clue about it (Johnson et al., 2001)."

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Inspiration comes from many sources. In fact it is always there. One has to look around to know the presence of something worth noticing. The paper is result of the present potential threat that the wide spread information exchange through network is facing from amateur hackers. The open world today wishes to exchange information using a public network infrastructure but in secured manner. Thankfully, the situation provides an opportunity to think about. We are also grateful to all those who have been constantly encouraging us to go for such scientific research work besides the regular work which we are doing in our respective departments. We are very grateful to the anonymous reviewers who helped in enriching the contents of the paper in improving the presentation.

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Assessing the Effectiveness of E-learning via User Profile Analysis: An AHP-based Dynamic Programming Approach

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ABSTRACT: *Electronic learning (E-learning) has been widely adopted as a promising tool by many organizations to offer learning-on-demand opportunities to individual employees (learners) in order to reduce training time and cost. While the success of information system (IS) models has much been investigated by researchers, little work has been conducted to assess the success and/or effectiveness of E-learning systems. The development of information technologies has contributed to the growth of on-line training as an important educational method. The on-line training environment enables learners to undertake customized training at any time and any place. Moreover, information technology allows both the trainers and learners to be decoupled in terms of time, place, and space. Here, we propose an assessment procedure by applying a dynamic programming approach to model the problem of shortest path in the user profile and using AHP (Analytical Hierarchy Process) to turn the qualitative parameters into quantitative values. A dynamic program is used to find the optimal path for the user in the E-learning environment. The validity and effectiveness of the proposed model are illustrated by two examples.*

KEYWORDS: *Electronic learning (E-learning), Adaptive Learning System, Virtual Learning Environment (VLE), Dynamic Programming, Analytical Hierarchy Process (AHP).*

1. Introduction

Modern societies have dramatically changed due to technological changes such as the development of information technology systems. Service industries have become knowledge oriented, production economies have become knowledge economies and production workers have become knowledge workers. Learners need to be flexible and adaptive if they are to function well in today's complex and global societies.

As part of the larger drive to change the curriculum, assessment needs to be reformed as well. Biggs' (1996) idea of constructive alignment amongst instruction, learning and assessment implies that these three elements should be based on the same underlying principles. The new assessment methods are not without problems either and some feel that the evidence against traditional tests is not as strong as has been claimed (Hambleton

& Murphy, 1992), and that the claim that newer forms of assessment are better suitable to address learners' requirements still needs empirical confirmation (Stokking et al., 2004). Studies have shown that no greater impulse for learning exists than assessment (Frederiksen, 1984) and that a strong relationship exists between learning and assessment, implying that what is assessed strongly influences what is learned (e.g., Alderson & Wall, 1993).

Though it is clear that assessment needs re-thinking, but it is not clear what requirements should be used for these new assessments. This is an important question to address, as the quality of assessment is increasingly being regarded as a very important element of the quality of education as a whole. Assessments in education may require new and other quality criteria to evaluate them. These criteria need to be more compatible with the principles and ideas of education (Fazlollahtabar & Sharma, 2008).

Internet has significantly impacted the establishment of Internet-based education, or E-learning. Internet technology evolution has affected all industrial and commercial activities and accelerated E-learning industry growth. It has also fostered the collaboration of education and Internet technology by increasing the volume and speed of information transfer and simplifying knowledge management and exchange tasks. E-learning could become an alternative way to deliver on-the-job training for many companies, saving money, employee transportation time, and other expenditures. An E-learning platform is an emerging tool for corporate training. Employees can acquire competences and problem solving abilities via Internet learning for benefits among business enterprises, employees, and societies while at work (Fazlollahtabar & Yousefpoor, 2009).

Self-regulation requires adequate monitoring strategies and meta-cognitive skills. The created E-learning environments should encourage the application of learners' meta-cognitive skills by prompting learners to plan, attend to relevant content, and monitor and evaluate their learnings (Fazlollahtabar & Mahdavi, 2009).

Although E-learning has been developing for several years, evaluating E-learning effectiveness is critical as to whether companies will adopt E-learning systems. A considerable number of studies have been conducted emphasizing the factors to be considered for effectiveness evaluation. Several evaluation models are considered with specific aspects. The criteria used for E-learning effectiveness evaluation are numerous and influence one another (Mahdavi, Fazlollahtabar & Yousefpoor, 2008).

User modeling is a fundamental mechanism to achieve individualized interaction between computer systems and humans (Paiva, 1995). It is usually concerned with modeling several user related issues such as goals, plans, preferences, attitudes, knowledge or beliefs. The most difficult task in this context is the process of interpreting the information gathered during interaction in order to generate hypotheses about users

and students behavior (Paiva, 1995), and involves managing a good deal of uncertainty. Interactive computer systems deal in general with more meager and haphazardly collected users' data than it usually happens when humans are engaged in a face-to-face interaction (Jameson, 1996). Thus, the gap between the nature of the available evidence and the conclusions that are to be drawn is often much greater (Jameson, 1996). Numerical techniques have been employed in several cases in order to manage uncertainty (Conati, Gertner & Vanlehn, 2002; Herzog, 1994), and neural networks have been used in order to add learning and generalization abilities in user models and draw conclusions from existing user profiles (Chen, Norcio & Wang, 2000; Harp, Samad & Villano, 1995; Stathacopoulou, Magoulas & Grigoriadou, 1999; Yasdi, 2000). Here, we present a dynamic programming approach to identify the shortest path in virtual learning environments, and apply an AHP to change the qualitative parameters to quantitative values.

Virtual Learning Environments (VLEs) are computer-based environments that are relatively open systems, enabling interactions and encounters with other people and providing access to a wide range of resources (Wooldridge, 1999). VLEs can supplement face-to-face teaching methods, or totally replace the teaching methods in the case of distance learning. VLEs offer a number of advantages over traditional teaching environments in terms of convenience and flexibility (Carrillo, 2004). There are no geographical boundary limitations for using VLEs. They are capable of reaching potential learners in remote areas around the world at a very low cost. For these reasons, VLE is becoming one of the fastest growing areas in educational technology research and development. Many traditional colleges and universities, individually or in various forms of partnerships, are embracing information technologies to create new learning models that enhance the effectiveness and reach of their programs (Alavi & Leidner, 2001).

Researchers and developers are making rapid improvements in the design and implementation of VLEs, resulting in continuous progress toward successful VLEs. However, on-line learning is not always effective and sometimes fails to meet learning objectives because of the following limitations:

1. Unstructured learning materials. On-line learning materials are usually unstructured across different media, without any close associations with the E-learning processes (Zhang & Nunamaker, 2003). Learning material is distributed without consideration for learners' capacities and prior learnings, and therefore lacks contextual and adaptive supports (Hiltz & Turoff, 2002).
2. Insufficient flexibility. In many current VLEs, the material contents and choices have been predefined, regardless of the learning process and learners' differences. On-line learners have little flexibility to adapt the learning content and process to meet their individual needs (Alavi & Leidner, 2001; Hiltz & Turoff, 2002).

3. Insufficient interactivity. Studying on-line, by its nature, requires on-line learners to be more actively engaged and interact with their VLEs (Hiltz & Turoff, 2002). However, some current VLEs are not very interactive. There is less opportunity for receiving instant responses and feedbacks from the instructor or VLEs when on-line learners need support.

Nowadays, there is a growing trend of web-based technology applied for distance education. Particularly, web-based educational systems have many advantages because they can adapt the courses to specific needs. Different types of computer based educational systems are proposed as follows:

Type 1: Stand-alone learning system, in which direct linking is established with the virtual educational system without the presence of teacher or any collaboration.

Type 2: Remote teaching system, in which everyone is conducted with the aid of individual connections between a teacher and multiple students providing a method of teaching more students during a lecture.

Type 3: Group learning session, where multiple connections between participants are arranged, and thus a level of support for co-operative work is offered.

The advantages of the stated systems for the students are to experience and to access education and training courses that otherwise wouldn't have been taken, and besides to participate in a distributed learning environment which they feel to be stronger than the traditional, and also to have the opportunity to discuss their own professional situations with other learners and with their colleagues. From the teacher viewpoint, it is important to experience teaching in a virtual university in order to gain a specialized understanding and to offer the possibility of learning to those learners who would not find it possible to participate in a traditional face to face learning experience. An architecture for a virtual learning environment is presented in Figure 1.

2. Adaptive learning systems

Here, we assume a decentralized paradigm of instruction where educational resources and services are made available beyond the boundaries of any single institution or discipline. Information technology can play the pivotal role of making resources more malleable and reusable, linking instructors and learners frequently and intensely, while adjusting to their requirements in novel ways, and compensating for limitations imposed by time and geography. Ultimately, information technology tools resulting from this program must foster a demand-oriented market for instruction (Mahdavi et al., 2008). If this occurs, the market for educational technologies can be expected to expand far beyond

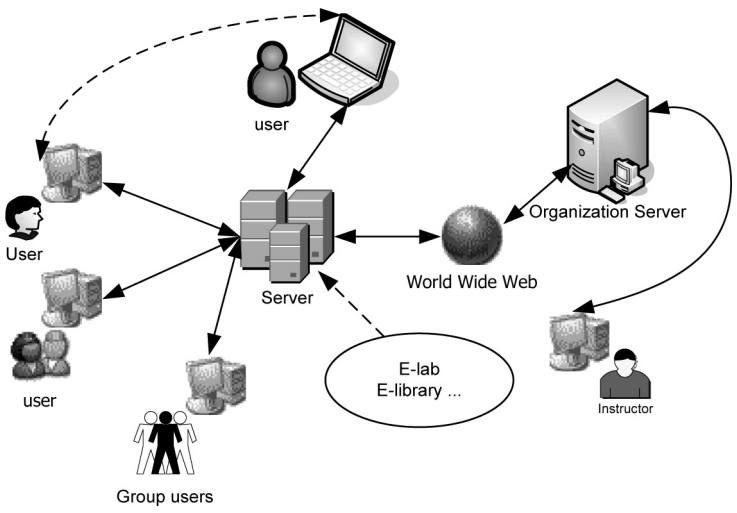

Figure 1 A Virtual Learning Environment

the current bounds. Learners in particular and the economy as a whole will benefit greatly. The term *adaptive learning system* best depicts the role that technology can play in correcting problems that have stymied educational technology markets in the past (Specht, 1998). This program is designed to facilitate the development of technology that will adapt knowledge to the needs of learners. Experience proves that the best way to avoid a mismatch between supply and demand is to deploy technology in response to clearly articulated needs. Unlike any other tool applied to instruction in the past, many of the latest information technologies can comprise the platform of a future *learning economy* where learning experiences are pulled by demand rather than driven by any supply. Thus, if deployed within an open-market paradigm, information technologies can have positive impacts on the accessibility, affordability, and quality challenges that now confront education and training. The term *adaptive* also relates to the flexibility and scalability of the envisioned learning system. In the future, content and courseware must be reusable, interoperable and easily organized at many different levels of complexity throughout the on-line instructional environment. Tools for developing instructional content and courseware will need to operate across different platforms and communicate with other tools used to build and manage learning systems (Mahdavi et al., 2008). The systems themselves must accommodate numerous and varied learner requirements, needs and objectives. The needs of instructors and instructing organizations must also be addressed. Achieving this level of adaptability will require advances in a wide range of technologies that support diverse training and educational tasks. They include but are not limited to authoring systems, multi-sensory interfaces, search technology, and network middleware. Continued progress will also be required in software reusability and interoperability, specially for high-bandwidth applications. Some of the advantages of the adaptive learning systems are presented in Table 1.

Table 1 Advantages of Adaptive Learning System

- To make high-quality instructional content more affordable.
- To adapt instruction to the end-user requirements of both learners and educators.
- To make high-quality instructional content more available.
- To increase the capacity and usability of instructional content production technology.
- To improve upon the precision and context-sensitivity of search and retrieval technology.
- To improve upon quality of service levels in distributed instructional systems.

Key technical challenges that now confront net-centric, web-based learning systems fall into four categories: content, delivery, search, and quality of service (using technologies such as tele-presence, virtual reality, and multi-sensory interfaces). These comprise the scope of the adaptive learning systems and are represented in Figure 2, illustrating the envisioned system. The four research thrusts constitute only a portion of the research challenges now at hand in on-line learning technologies:

- **Content.** Research will concentrate on efficient production of instructional components, interoperability and reusability of components, as well as the wrapping, retrofitting, and transformation of legacy data to fit training purposes.
- **Modes of Delivery.** Research will focus on technical solutions for synchronous and asynchronous collaboration, as well as providing full access to and mobility of data in a complex system of distributed repositories. Innovation may address

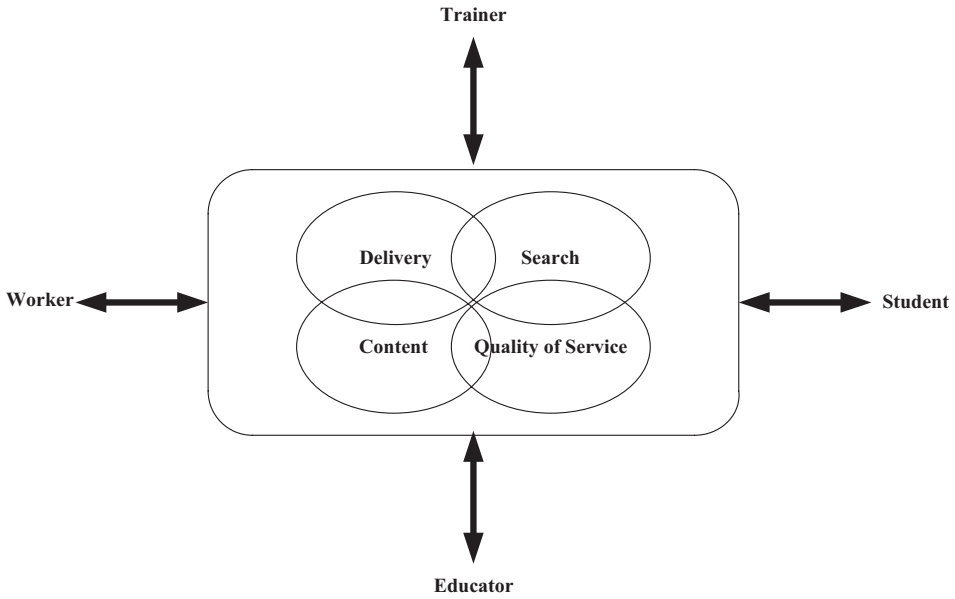

Figure 2 Basic Components of Adaptive Learning Systems

needs arising from new architectures and linking structures for repositories and may focus on one or more layers of metadata, i.e., new technologies in data labeling, authentication, and filtering.

- **Search and Retrieval.** Research will concentrate on the infrastructure to support educators, students, and workers with complex information acquisitions and management requirements. Search and retrieval systems should be highly interactive and must extend the current limits of artificial intelligence and expert systems in order to produce knowledge outputs that are precisely tailored to end-user needs and constraints.
- **Quality of Service.** Research will focus on middleware applications to ensure low latency and robustness for high-performance applications (synchronous and asynchronous interactions or simulated environments) in the midst of scale-up and extension. In addition, certain transactions specific to education and training will be researched, some of which may pose the need for special components or large-scale modules (i.e., translation, evaluation, accreditation, collaboration around learning tasks, and education transaction processing) and others of which present systems integration challenges.

Currently, E-learning is based on complex virtual collaborative environments where the learners can interact with other learners and with the tutors or the teacher. It is possible to provide different synchronous and asynchronous services for the learners. The synchronous services include virtual classrooms and individual sessions with the teachers or tutors. The asynchronous services include the classic didactic materials as well as web-based seminars or simulations always on-line. These functions can be usually accessed by the means of software platforms called Learning Management Systems (LMSs). Among the other functions, the LMS manages learners, keeping track of their progress and performance across all types of training activities. It also manages tasks and allocates learning resources such as registration, classroom and instructor availability, monitors instructional material fulfillment, and provides the on-line delivery of learning resources (Tajdin et al., 2008).

The adoption of Course Management Systems (CMSs) for web-based instruction continues to increase in today's higher education. A CMS is a software program or integrated platform containing a series of web-based tools to support a number of activities and course management procedures (Severson, 2004). Examples of CMSs are Blackboard, e-WebCT, e-College, Moodle, Desire2Learn, Angel, etc. A supportive argument for the adoption of E-learning environments using CMSs is the flexibility of such environments when reaching out to potential learners in remote areas where brick and mortar institutions are non-existent. It is also believed that E-learning environments can have potential added learning benefits and can improve students' and educators' self-regulation skills, and in

particular their meta-cognitive skills (Akkerman et al., 2007). In spite of this potential to improve learning by means of using a CMS for the delivery of E-learning, the features and functionalities built into these systems are often underutilized. As a consequence, the created learning environments in CMSs do not adequately scaffold learners to improve their self-regulation skills. In order to support the improvement of both the learners' subject matter knowledge and learning strategy application, the E-learning environments within CMSs should be designed to address learners' diversity in terms of learning styles, prior knowledge, cultures, and self-regulation skills. Self-regulative learners are learners who can demonstrate 'personal initiative, perseverance and adaptive skill in pursuing learning' (Zimmerman, 2002).

The goal of adaptive presentation is to adapt the content of a hypermedia page to the user's goals, knowledge, and other information stored in the user model. In a system with adaptive presentation, the pages are not static but adaptively generated or assembled from different pieces for each user. For example, with several adaptive presentation techniques, expert users may receive more detailed and deep information, while novices receive additional explanations.

The goal of curriculum sequencing (also referred to as instructional planning technology) is to provide the student with the most suitable, individually planned sequence of knowledge units to learn and sequence of learning tasks (examples, questions, problems, etc.) to work with. In other words, it helps the student to find an "optimal path" through the learning material (Kay, 1995).

The goal of an adaptive navigation support is to support the student in hyperspace orientation and navigation by changing the appearance of visible links. In particular, the system can adaptively sort, annotate, or partly hide the links of the current page to simplify the choice of the next link. Adaptive navigation support can be considered as an extension of curriculum sequencing technology into a hypermedia context. It shares the same goal -- to help students to find an "optimal path" through the learning material. At the same time, an adaptive navigation support has fewer directives than traditional sequencing: It guides students implicitly and leaves them with the choice of the next knowledge item to be learned and next problem to be solved.

Intelligent analysis of student solutions deals with students' final answers to educational problems (which can range from a simple question to a complex programming problem), no matter how these answers are obtained. Unlike non-intelligent checkers, which can only detect whether an answer is correct, intelligent analysers can tell exactly what is wrong or incomplete and which missing or incorrect piece of knowledge may be responsible for the mistake. Intelligent analysers can provide the student with extensive feedbacks for a mistake.

The goal of the interactive problem solving support is to provide the student with intelligent help on each step of problem solving -- from giving a hint to proceeding with the next step for the student. The systems implementing this technology can monitor the actions of the student, understand them, and use the understanding to provide help.

3. The proposed model

Here, we propose an adaptive learning system based on an individual student's profile. The aim is to choose the best path associated with student's interests and qualitative attributes such as capability, attitude, knowledge level, motivation, and learning style. Of course, other criteria could also be added based on the decision maker's choice. In this system, a user is encountered with some service providers that support VLE. Each service provider submits courses that are being taught by some instructors. The layers are identified in a network as Figure 3. Initially, a user should choose a service provider which suffices his preferences. Thus, the user systematically weighs the service providers by measuring each service provider using the stated criterion. This way, the qualitative knowledge of the user is turned into numerical values and recorded in the learning management system. The same process is repeated for selecting courses and instructors. Finally, the user finds his optimal path applying the aforementioned assessment procedure. At the final stage, his path is recorded in the data base and then a next user is allowed to enter the system and choose his learning items. For each user the system refreshes itself and records the results in the data base of the LMS.

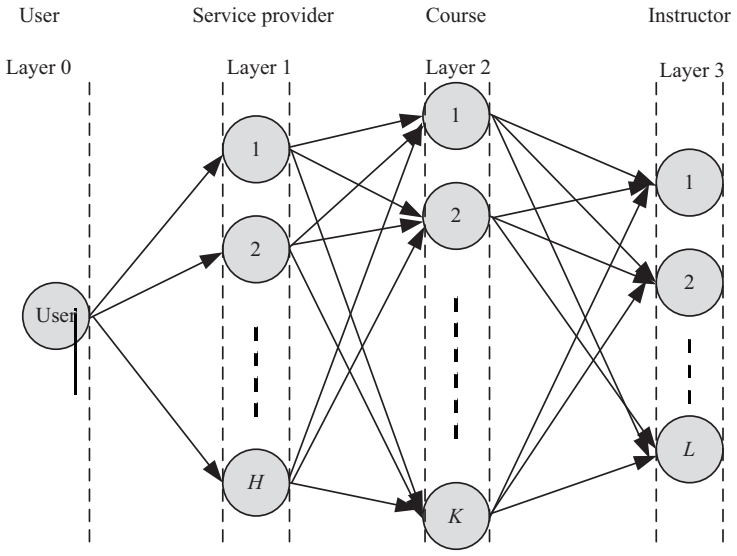

Figure 3 The Proposed Network

The selection of the user is based on the qualitative criterion on each arc. To apply dynamic programming, we need quantitative values for the arcs. To achieve this, we have to transform the qualitative criteria to numerical values based on the user preferences. A suggested arc preferences associated with their numerical values are given in Table 2.

Table 2 Arc Preferences with Their Numerical Values

Preferences	Numerical Value
Extremely Preferred	9
Very Strongly Preferred	7
Strongly Preferred	5
Moderately Preferred	3
Equally Preferred	1
Preferences among the Above Preferences	2, 4, 6, 8

3.1 A dynamic programming approach for optimal path

Dynamic programming (DP) was introduced by Bellman (1957). Toth (1980) presented the early DP-based approaches and reported numerical experiments with a limited success. More recently, Pisinger proposed a DP algorithm, which constructing a core problem of a minimal size, to minimize the sorting and reduction efforts. Hybrid methods, combining dynamic programming and implicit enumeration, were developed. The first approach was developed by Plateau and Elkihel (1985). A recent approach, the so-called combo algorithm, is able to solve very large instances of up to 10,000 variables within less than one second, with basically no difference in the required solution times for “easy” and “hard” instances (Martello, Pisinger & Toth, 2000). Marsten and Morin (1978) proposed the first hybrid method, which combines heuristic algorithms, dynamic programming and branch-and-bound approaches. More sophisticated methods can be found in Ibaraki (1987).

Dynamic programming is a technique to tackle multistage decision processes. A given problem is subdivided into smaller subproblems, which are sequentially solved until the initial problem is solved by the aggregation of the subproblem solutions. In each stage, a set of states is defined. The states would describe all possible conditions of the process in the current decision stage, which corresponds to every feasible partial solution. The set of all possible states is known as the state space. The states of a stage u can be transformed to states of a stage $u + 1$ by using a transition. A transition indicates the decisions adopted in a stage, and a sequence of transitions taken to reach a state starting from another state is known as a policy. Dynamic programming approaches can be seen as transformations

of the original problem to one associated with the exploration of a multistage graph G (S, T), where the vertices in S correspond to the state space and the arcs in T to the set of transitions, leading to an optimal policy.

The basis of dynamic programming can be traced to the optimality principle of Bellman (2003). The optimality principle states that an optimal policy should be constituted by optimal policies from every state of the decision chain to the final state. Here, we make use of a dynamic programming approach to our proposed network to identify the optimal path for the user. This model helps the users to determine their curriculum profiles in an adaptive learning system. The advantages of such a model are simplicity, the ability to determine the exact optimal value, and implementability on more detailed networks. The dynamic model would be defined as:

Indices:

i	*Number of layers*	$i = 0,1,2,3$
j'	*Start node number corresponding to layer*	*j'=1,2, … , H (in layer 1); 1,2, … , K (in layer 2); j'=0 (for the start node)*
j	*End node number corresponding to layer*	*j=1,2, …, H (in layer 1); 1,2, … , K(in layer 2) ; 1,2, … L (in layer 3)*
H	*Number of service providers*	
K	*Number of courses*	
L	*Number of instructors*	

Notations:

$S_i(j')$	*The maximum value of moving from node j' in layer i to an end node in layer 3*
$F_{j'j}$	*Numerical value of an arc from node j' to node j*

Objective function: *Optimal path*

$$S_i(j') = \underset{j \text{ in layer } i+1}{Max} \{S_{i+1}(j) + F_{j'j}\}, \qquad i = 0,1,2, \ \forall j' \text{ in layer } i,$$

$$S_3(j) = 0, \ j = 1,...,L,$$

$$S^* = S_0(0).$$

Note that S^* identifies the optimal path. An approach is needed to turn qualitative criteria into numerical values. We propose the approach of Analytical Hierarchy Process (AHP) as illustrated in the next section.

3.2 Determining weights by AHP

The analytical hierarchy process (AHP) was proposed by Saaty (1980). AHP was originally applied to uncertain decision problems with multiple criteria, and has been widely used in solving problems of ranking, selection, evaluation, optimization, and prediction decisions. Harker and Vargas (1987) stated that "AHP is a comprehensive framework designed to cope with the intuitive, rational, and the irrational when we make multi-objective, multi-criteria, and multi-factor decisions with and without certainty for any number of alternatives."

The AHP is expressed by a unidirectional hierarchical relationship amongst decision levels. The top element of the hierarchy is the overall goal for the decision model. The hierarchy decomposes to a more specific criterion on a level and each criterion may be related to some subcriteria (Meade & Presley, 2002). The AHP separates complex decision problems into elements within a simplified hierarchical system (Shee, Tzeng & Tang, 2003).

Our enquiry in the AHP has the purpose to construct a hierarchical evaluation system based on the independent factors as capabilities, attitudes, knowledge level, motivation and learning style. The AHP could gain factor weights and criteria, and then obtain the final effectiveness of each arc. The AHP usually consists of three stages of problem solving: decomposition, comparative judgments, and synthesis of priority. The decomposition stage aims at the construction of a hierarchical network to represent a decision problem, with the top level representing the overall objectives and the lower levels representing the criteria, subcriteria, and alternatives. With comparative judgments, users are requested to set up a comparison matrix at each hierarchy by comparing pairs of criteria or subcriteria. A scale of values ranging from 1 (Equally Preferred) to 9 (Extremely Preferred) as given in Table 2, is used to express the users preferences. Finally, in the synthesis of priority stage, each comparison matrix is then solved by an eigenvector method for determining the importance of the criteria and alternative performance.

One major advantage of AHP is its applicablility to the problems of group decision-making. In a group decision setting, each participant is required to set up the preference of each alternative by the AHP and the collective views of the participants are used to obtain an average weighting of each alternative.

Here, for the stated criteria, the following hierarchy is proposed. The aim is to obtain the numerical value for each arc to be used in the objective function of shortest

path. The hierarchy is presented in Figure 4 (where $N = H$ or K or L, respectively for the corresponding layer).

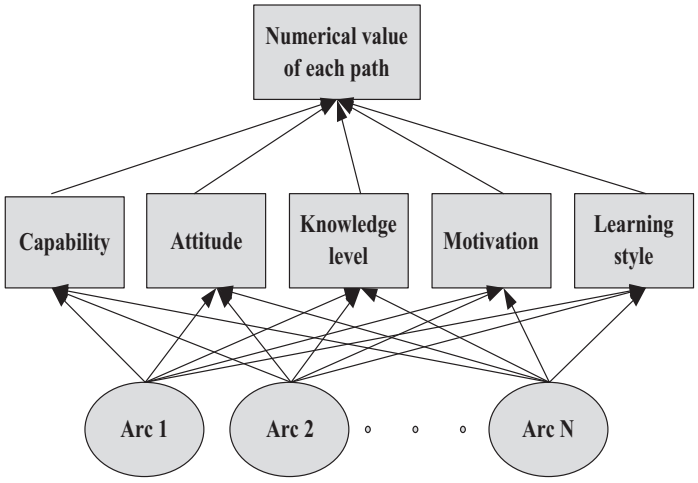

Figure 4 The Hierarchy of the Proposed Model

For each layer (1, 2, or 3) in Figure 3, a corresponding pairwise comparison table is used to calculate the numerical value ratio of arcs determined by capabilities, attitudes, knowledge levels, motivations and learning styles of a user based on their preference numbers (A_{bc}) as stated in Table 2 (N is H or K or L depending on the layer).

Table 3 The Preference Assessment

Capability	Arc 1	Arc 2	.	Arc H,K,L
Arc 1	1	A_{12}	.	A_{1N}
Arc 2	$1/A_{12}$	1	.	A_{2N}
.	.	.	.	.
.	.	.	.	.
Arc N	$A_{N1} = 1/A_{1N}$	$A_{N2} = 1/A_{2N}$	.	1

The same table is used for each one of the other criteria (capability, attitude, knowledge level, motivation and learning style). After calculating the above tables, a table that indicates the weights (W_{bc}) of the arc for the considered criteria is formed as Table 4.

Table 4 The Weight of the Arcs

	Capability	Attitude	Knowledge level	Motivation	Learning style
Arc 1	W_{11}	W_{12}	W_{13}	W_{14}	W_{15}
Arc 2	W_{21}	W_{22}	W_{23}	W_{24}	W_{25}
.	.	.	.	.	.
.	.	.	.	.	.
Arc N	W_{N1}	W_{N2}	W_{N3}	W_{N4}	W_{N5}

Next, the criteria pair-wise comparison matrix is configured in Table 5.

Table 5 The Criteria Pairwise Comparison

	Capability	Attitude	Knowledge level	Motivation	Learning style
Capability	1	A_{12}	A_{13}	A_{14}	A_{15}
Attitude	$1/A_{12}$	1	A_{23}	A_{24}	A_{25}
Knowledge level	$1/A_{13}$	$1/A_{23}$	1	A_{34}	A_{35}
Motivation	$1/A_{14}$	$1/A_{24}$	$1/A_{34}$	1	A_{45}
Learning style	$1/A_{15}$	$1/A_{25}$	$1/A_{35}$	$1/A_{45}$	1

At this point, the weight of each criterion is at hand using the above matrix. Therefore, the weight for each arc considering the criteria is determined as follows (*N* is *H* or *K* or *L* depending on the layer):

$$\text{Total weight for arc 1} = W_{11}\times W_C + W_{12}\times W_A + W_{13}\times W_K + W_{14}\times W_M + W_{15}\times W_L$$

$$\text{Total weight for arc 2} = W_{21}\times W_C + W_{22}\times W_A + W_{23}\times W_K + W_{24}\times W_M + W_{25}\times W_L$$

.

.

.

$$\text{Total weight for arc N} = W_{N1}\times W_C + W_{N2}\times W_A + W_{N3}\times W_K + W_{N4}\times W_M + W_{N5}\times W_L,$$

where W_C = capability's weight, W_A = attitude's weight, W_K = knowledge level's weight, W_M = motivation's weight, W_L = learning style's weight, that are obtained by Table 5. This way, the weights of the arcs are calculated. These weights are used as the numerical values for the proposed network arcs. As a result, the optimal path for the user will be determined after solving the proposed dynamic programming problem. In Section 4 below, we provide examples for illustration of the proposed model.

4. Numerical examples

To illustrate the effectiveness of the proposed model, two comprehensive examples are described. In the following examples, the number of service providers, courses, and instructors are determined for layers. We apply the LINGO software package for the necessary computations. The encoding of LINGO is illustrated next.

4.1 LINGO encoding

The following is the LINGO encoding for our proposed model in a virtual learning environment.

```
MODEL:
SETS:
  Nodes /1..j/: P;
  Arc (Nodes, Nodes)/
1,2  1,3  ...  1,j
2,5    ...     2,j
j-1,j`/: P_j;
ENDSETS
DATA:
P_j =
a     ....  b
z;
ENDDATA
P (@SIZE( Nodes)) = 0;
 @FOR (Nodes (j)| j #LT# @SIZE (Nodes):
  P( j) = @Max( Arcs( j, j'): D( j, j') + P(j)) );
END
```

In the above encoding, P is the numerical value of the optimal path. Two comprehensive examples have been considered for the testing.

4.2 Example 1

Here, the number of service providers is 3, the number of offered courses is 3, and the number of instructors for the courses is 2. Initially, based on the user preferences the numerical value for each arc is determined by the AHP. The arcs and their related numerical values are shown in Table 3. Note that the value of each arc i, j (from node i to node j) is set after determination of the weights in the AHP using the stated attributes. Then, the data are input to the LINGO encoding and the numerical value for each node is obtained. The results are shown in Tables 6 and 7.

Table 6 Arcs and Their Related Values

Arc	Value	Arc	Value	Arc	Value
0,1	1	0,2	5	0,3	2
1,4	13	1,5	12	1,6	11
2,4	6	2,5	10	2,6	4
3,4	12	3,5	14	3,6	10
	4,7	3	4,8	9	
	5,7	6	5,8	5	
	6,7	8	6,7	10	
		7,9	5		
		8,9	2		

Table 7 Variables and Their Related Values

Variable	Value
P (0)	*27*
P (1)	*24*
P (2)	*21*
P (3)	*25*
P (4)	*11*
P (5)	*11*
P (6)	*13*
P (7)	*5*
P (8)	*2*
P (9)	*0*

Consequently the optimal path for a user based on his preferences is identified. As shown in Figure 5, the optimal path is 0-3-6-7-9, i.e., the set comprised of the third service provider, the third course, and the first instructor is determined to be optimal.

4.3 Example 2

Here, the number of service providers is 5, the number of offered courses is 5, and the number of instructors for the courses is 5. Initially, based on the user preferences the numerical value for each arc is determined by the AHP. The arcs and their related numerical values are shown in Table 8. Then, the data are input to the LINGO encoding and the numerical value for each node is obtained. The results are shown in Table 9.

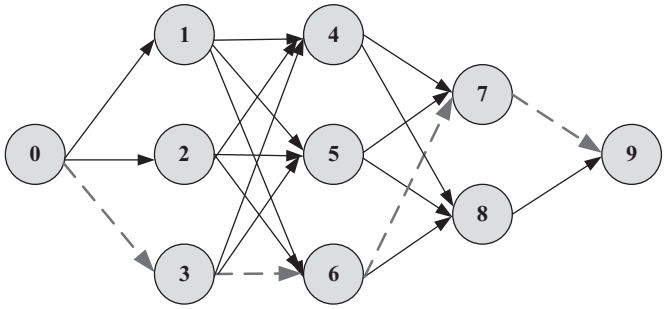

Figure 5 Optimal Path for Example 1

Table 8 Arcs and Their Related Values

Arc	Value	Arc	Value	Arc	Value	Arc	Value	Arc	Value
0,1	2	0,2	2.3	0,3	2.7	0,4	3.2	0,5	3.5
1,6	2.7	1,7	2.5	1,8	3.1	1,9	4.1	1,10	4.2
2,6	1.7	2,7	2.5	2,8	2.6	2,9	3.7	2,10	3.9
3,6	5.6	3,7	8.9	3,8	8.3	3,9	7.6	3,10	9.5
4,6	3.7	4,7	5.2	4,8	6.1	4,9	6.3	4,10	5.4
5,6	7.1	5,7	5.6	5,8	4.3	5,9	2.5	5,10	7.3
6,11	4.5	6,12	5.6	6,13	9.1	6,14	3.7	6,15	2.9
7,11	2.3	7,12	5.6	7,13	7.3	7,14	3.4	7,15	5.9
8,11	4.5	8,12	2.6	8,13	7.6	8,14	8.2	8,15	3.4
9,11	8.6	9,12	7.5	9,13	6.4	9,14	5.3	9,15	4.6
10,11	7.5	10,12	6.9	10,13	8.5	10,14	4.8	10,15	3.5
				11,16	7				
				12,16	8				
				13,16	4.2				
				14,16	5				
				15,16	2.5				

Consequently, the optimal path for a user based on his preferences is identified. As shown in Figure 6, the optimal path is 0-3-9-12-16, i.e., the set comprised of the third service provider, the fourth course, and the second instructor is determined to be optimal.

5. Conclusions

We presented a model to find the optimal learning path for a user in an adaptive learning system. Considering the network as a model, a dynamic programming approach

Table 9 Variables and Their Related Values

Variable	Value
P (0)	*27.1*
P (1)	*19.7*
P (2)	*19.3*
P (3)	*24.4*
P (4)	*21.9*
P (5)	*22.2*
P (6)	*13.6*
P (7)	*13.6*
P (8)	*13.2*
P (9)	*15.6*
P (10)	*14.9*
P (11)	*7*
P (12)	*8*
P (13)	*4.2*
P (14)	*5*
P (15)	*2.5*
P (16)	*0*

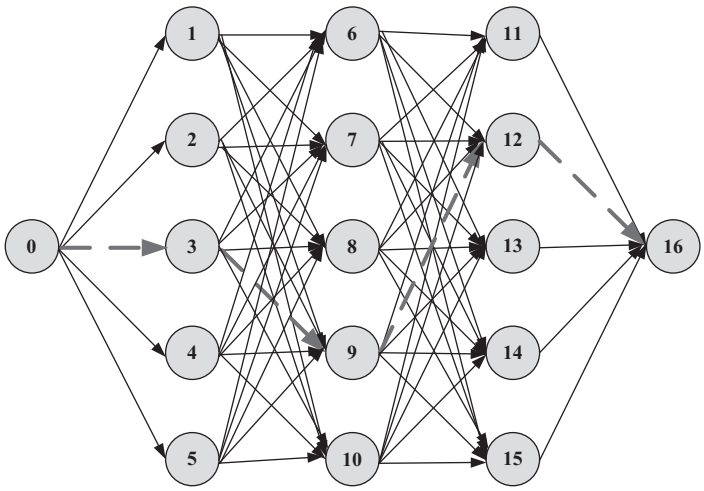

Figure 6 Optimal Path for Example 2

is applied. To allow for assessing quality in the educational system, an environment providing several qualitative criteria for the user is designed. The system is capable to help the user in identification of the optimal path. Using the AHP, the qualitative criteria of a user for selecting the arcs are turned into numerical values. User can select from amongst the provided facilities in accordance with his preferences. Thus, a user is able to reach both a better quality and an optimal learning path simultaneously. The cleared path is mainly concerned with the personal profile of a user and therefore the user is the decision maker. The validity and effectiveness of the proposed model are illustrated by working out two comprehensive examples using a LINGO encoding for the computations.

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Why Do People Make Online Group Purchases? Risk Avoidance, Sociability, Conformity, and Perceived Playfulness

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ABSTRACT: *Group buying websites have drawn considerable attention in the business world. By improving buyers' bargaining power, these sites help consumers obtain more of the surplus created by network externality. This paper studied what makes online group buying (OGB) attractive to customers and how to strategically identify what customers need to effectively OGB. A modified Unified Theory of Acceptance and Use of Technology (UTAUT) and online group buying data from Taiwan were employed. Tests for content validity, reliability, convergent validity, discriminant validity, and model fitness show that our model, survey, and data are all valid. The author identified five reasons why people want to engage in online group buying: perceived risk avoidance, sociability, performance expectancy, effort expectancy, and social influence. The relationship between behavioral intention and use behavior, although in the positive direction, was not significant. Two moderators, gender and conformity, were tested. Females reported that they were influenced more than males in their intention to use OGB services by perceived risk avoidance, sociability, and perceived playfulness. The impact of the intention to use OGB on actual usage was stronger among those who evidenced conformity than those who did not. This study is the first instance of academic empirical research on OGB. The relationship between network externality and OGB is revealed. The moderating effect of conformity shows the importance to identify bridging persons in buying groups. The importance of role of gender is revealed.*

KEYWORDS: *Group Purchase, Sociability, Unified Theory of Acceptance and Use of Technology (UTAUT), Group Buying, Risk Avoidance, Social Network Services.*

1. Introduction

Group purchase organizations (GPOs) came into being before the advent of the Internet or Web 2.0. For example, hospitals in the US form GPOs to aggregate their buying power and negotiate with vendors for discounts. Friends can have an important effect on group purchases by creating such benefits as enhanced shopping enjoyment and information acquisition (Mangleburg, Doney & Bristol, 2004). Other benefits of GPOs for customers include increased bargaining power, feelings of empowerment and security, the opportunity to experience social interactions, and enhanced feasibility of the group purchasing process (Ramus & Nielsen, 2005).

The appearance of Internet social network services has caused group buying to take on new forms. For example, Groupon assembles local companies and offers one "Groupon" (group coupon) per day to customers in each of its local markets. If a certain number of people sign up, the deal becomes available to all. The discount can be as high as 50%. Customers do not need to know one another or belong to the same organizations; they are simply Internet users who happen to see the same discount information. Thus, collective intelligence becomes collective bargaining power. The company, which began operations in Chicago in November 2008 (Anonymous, 2011a), has recently been valued at US$11.4 billion if underwriters sell the maximum number of shares at the top of a proposed US$16-to-US$18 price range in the IPO set on November 04, 2011 (Raice & Smith, 2011).

Today, online users can engage in crowdsourcing and create new business models. Examples of these crowdsourcing models are wikis, social bookmarking, co-creation of content, collaborative map services, open innovation, and presumption, a portmanteau derived from professional consumption. Group buying goes a step further: It not only sources the crowd, it empowers the crowd.

Groupon is not the first website to offer group buying. In March 2004, a Taiwanese telnet-type BBS called Professional Technology Temple (PTT) launched its group buying department, which currently completes more than 100 group buying transactions a day. Considering that the Taiwanese population is only 24 million, this volume is huge. In 2005, China's group buying website Tuangou became popular. According to some reports, the company drove unprecedented bargains by combining the reach of the Internet with the power of the masses, and it has spread through China like "wildfire" (Anonymous, 2006). These Chinese predecessors differ from the American Groupon in the sense that they originated through online chat-rooms or indigenous BBS users rather than from firms or specific Internet platforms. People create the buying groups, become the group leaders, and target specific products. Anyone who reads the initiation notice can join a group. They do not even have to live at the same location or make purchases at the same time. In fact, the members may never meet one another. What brings them together is the grassroots power they can collectively wield to bargain with big firms.

Online group buying also benefits small and medium size sellers who cannot afford to expend large sums of money on the Internet. SMBs do not need to spend their marketing resources upfront. If they cooperate with online group buying sites and find enough interested customers, they can generate sufficient transactions to stay in business.

The aforementioned importance of online group buying motivated us to study what makes it attractive to customers. Our research is based on a modification of the Unified Theory of Acceptance and Use of Technology (UTAUT). The application of this model is

described in Section 2. Section 3 reports the methods of data collection and analysis, and conclusions are stated in Section 4.

2. Literature review and model formation

2.1 Group buying

The first problem one faces in studying group buying is the paucity of the literature. As Wei, Straub and Poddar (2011) stated, "In spite of this rapid growth, IGP (Internet Group Purchase) is nearly completely unstudied in scholarly circles, there being no academic research on how to manage IGP." For this exploratory qualitative study, Wei used collective cognition theory (Montealegre, 2002) to identify the cognitive processes that underlie group buying.

In addition to Wei, Tsvetovat and colleagues have shown how customer coalitions can become groups capable of procuring goods at a volume discount, thereby creating economies of scale among like-minded customers (Tsvetovat et al., 2000). Yamamoto and Sycara cited the benefits of buyer coalitions in e-markets, which also allow buyers to take advantage of volume discounts (Yamamoto & Sycara, 2001). These authors proposed a method that increases the number of buyers who can obtain a given item better than traditional group buying schemes can.

Kauffman and Wang (2001) explored the effects of using auctions as a group buying strategy. They specifically discussed bidding participation externalities (the number of new orders generated from an increase in the quantity of the original order) and the perceived price-drop effect (the increase in the willingness to bid when the bidder predicts that the price will suddenly drop, as opposed to when it actually drops) (Kauffman & Wang, 2001). There are two possible explanations of this effect: (1) the buying group may create more buyers, and (2) when buyers notice the price drops at previous group-buying sessions, they expect the price to drop in the next session as well; this leads them to join in the group buying.

In 2010, soon after the group buying business model appeared, Kauffman et al. conducted experiments that focused on three issues: risk, trust, and fairness (Kauffman, Lai & Ho, 2010; Kauffman, Lai & Lin, 2010). These issues are major concerns at the initial development stage of new business models, especially when the businesses are Internet-based (Light, 2001). When such business models become more advanced, they invent specific mechanisms to address these issues. For example, PayPal's escrow service for online auctions has reduced trust and risk problems to the point that online auction sites such as eBay can prosper. When eBay came online in 1996, there were only 250,000

auctions there (Anonymous, 2011b), but in 2010 eBay's sales reached US$9,156.3 million (Anonymous, 2011c). This enormous growth demonstrates that auctioneers do not see fairness as a problem that should cause them to avoid making transactions.

Whether the group-buying business model is yet sufficiently advanced is an open question. In any case, the rapid growth in recent years of Groupon and other group buying services may require that future research begin with strategies for the promotion of group buying. In particular, businesses want to know what makes people use online group buying so they can develop strategies to attract more users. In the next subsection, we explain how we developed the modified UTAUT model. Then we draw on the literature review to identify the key determinants of how much group buying services are used.

2.2 Research model and hypotheses

The UTAUT has been widely used in online behavioral research (Venkatesh et al., 2003). We use UTAUT for the following reasons. First, the group-buying web services we study are human-computer interfaces; HCI is the topic of TAM, which is the foundation of UTAUT (Davis, Bagozzi & Warshaw, 1989). Second, the original UTAUT covers a wide variety of platforms including corporate systems and websites. Third, many studies have demonstrated the validity of UTAUT with excellent goodness of fit (R^2) (AbuShanab, Pearson & Setterstrom, 2010; Al-Gahtani, Hubona & Wang, 2007; Chan et al., 2010; Chen, Wu & Yang, 2008; Chiu & Wang, 2008; Im, Hong & Kang, 2011; Lu, Yu & Liu, 2009; Yeow & Loo, 2009; Yuen et al., 2010). Finally, UTAUT has been applied to the study of what drives the acceptance of technologies, which corresponds to the research question: Why do people engage in online group buying?

However, there are differences between UTAUT and our model:

2.2.1 Sociability

When UTAUT was developed, most Internet sites were uni-directional: The site owners provided the content, stipulated the rules, and initiated the transactions. Today the Internet is composed of social networks. In addition to empowering buyers, the group buying sites in our study also provide for social interaction. Members are allowed to exchange ideas before, during, and after the transaction. Before the transaction they can share search results and recommend sellers, and during the transaction they can discuss what price to offer, how the product is to be delivered, and so on. After the transaction, they can post their reviews of the seller, the product, and the group leader. This social interaction gives buyers a better chance to complete the group formation. In other words, the buyers need to interact to increase their bargaining power and share information. They share a common goal, which is why it is necessary for them to unite.

Preece highlighted the importance of "understand[ing] how technology can support social interaction and design for sociability" for online communities (Preece, 2001). She previously identified three key factors that contribute to good sociability (Preece, 2000):

- **Purpose:** a community's shared focus on an interest, need, information, service, or support that provides a reason for individual members to belong to the community.
- **People:** members of the community who interact with one another and who have individual, social, and organization needs.
- **Policies:** the language and protocols that guide people's interactions and contribute to the development of folklore and rituals that bring a sense of history and accepted social norms. More formal policies may also be needed, such as registration policies, and codes of behavior for moderators. Informal and formal policies provide community governance.

While analyzing PTT, one of the largest group buying sites in Taiwan, we found these three components to be represented as follows: The purpose of the site was clearly stated at the portal, followed by the policies that users must adhere to. The website is popular and interaction takes place continually. These components created sociability for PTT, and it became our research goal to investigate whether this sociability had an effect on the use of group buying sites.

2.2.2 Conformity

Asch discovered in an experiment that one third of a team's members tended to follow the majority regardless of whether the majority decision was correct (Asch, 1951). Allen labeled such effects as "conformity" (Allen, 1965). Although online communities may not impose "public compliance," "private acceptance" is likely to occur because of "informational social influence" and "normative social influence" (Burnkrant & Cousineau, 1975; Deutsch & Gerard, 1955). Informational social influence refers to the conformity among team members that results from their belief that others' interpretations of an ambiguous situation are more accurate than their own, thereby helping them choose an appropriate course of action. Normative social influence refers to "the influence of other people that leads us to conform in order to be liked and accepted by them" (Aronson, Wilson & Akert, 2009). In the group buying situation, if a buyer follows others' interpretation or decision, and the buyer wants to belong to a certain buying group in order to enjoy steep discounts the next time, we can say that the buyer is trying to narrow the distance between the self and the group; in other words, the buyer is "conforming" to the group.

We added conformity to our model as a moderator between intention and behavior. To justify this decision, we turned to Lascu and Zinkhan's model linking conformity and consumer behavior (Lascu & Zinkhan, 1999). These authors specified three levels of conformity: compliance, identification, and internalization. Compliance is not applicable to our study because it refers to situations in which group members are monitored. Identification, on the other hand, is applicable, because it means that members follow the lead of the buying group to identify with the group so they can participate in group buying the next time. Internalization is also applicable; it means changing one's behavior after changing one's mind because of informational social influence.

2.2.3 Perceived playfulness

The positive relationship between perceived playfulness and use of the Worldwide Web was identified by Atkinson and Kydd (1997). Following Blehar (Blehar, Lieberman & Ainsworth, 1977), they defined playfulness as "an internal personality trait [defined] as physical, social, and cognitive spontaneity; manifest joy; and a sense of humor." Moon and Kim identified playfulness as a factor influencing the acceptance of technology on the Worldwide Web (Moon & Kim, 2001). Based on Csikszentimihalyi's flow theory (Csikszentmihalyi, 2000), Moon and Kim defined three dimensions of perceived playfulness: the extent to which the individual (1) perceives that his or her attention is focused on interacting with the WWW; (2) demonstrates curiosity during the interaction; and (3) finds the interaction intrinsically enjoyable or interesting. Enjoyment has also been identified as a factor influencing users' adoption of a social network on the Internet (Hassanein & Head, 2005/2006; Lu & Wang, 2008; Klimmt, Schmid & Orthmann, 2009).

2.2.4 Perceived risk avoidance

Bauer introduced the concept of "perceived risk," which refers to the fact that consumers characteristically develop decision strategies and ways of reducing risk that enable them to act with relative confidence and ease in situations where their information is inadequate and the consequences of their actions may be drastic (Woodside & Delozier, 1976). Bauer defined two components of the level of perceived risk: (1) the amount at stake in the purchase decision, and (2) one's feeling of subjective uncertainty that one will win some or all of the amount at stake.

Virtual stores are perceived to involve greater risk than bricks-and-mortar establishments. When e-commerce was just getting started, this perceived risk prevented online stores from making money (Bhatnagar, Misra & Rao, 2000). One cause of this perceived risk may be consumers' concern about the security of transmitting credit card information over the Internet. Consumers may also be apprehensive about buying something without touching or feeling it, as well as not being able to return it if it fails to meet their approval.

It has been demonstrated that a consumer's peer groups, reference groups, and significant others can offer social support and legitimize one's purchasing decisions (Woodside, 1972). In a similar vein, online group buying may reduce the purchasing risks. First, it increases buyers' bargaining power, enabling them to avoid being "ripped off" by the seller. Second, buyers in a group buying situation have the chance to share information about the product with other group members having the same goals and stakes. They also can ask whether the group leader has a conflict of interest with the seller. Third, the privacy of the group members can be protected; although sellers can identify the group leader, they cannot identify the other members.

By adding these factors, we modified the UTAUT model as illustrated in Figure 1. The new variables are shown in bold font.

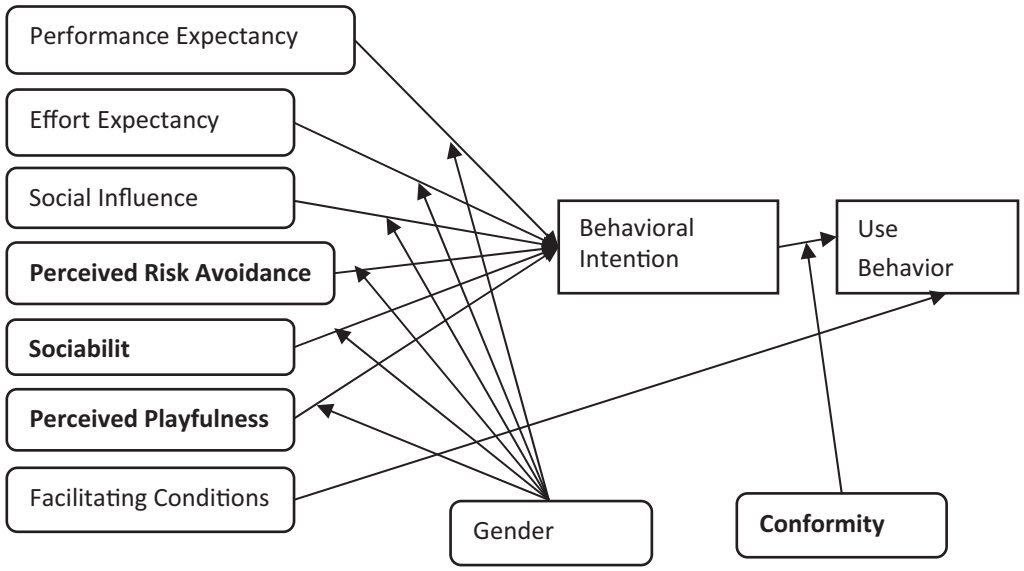

Figure 1 Group Buying Acceptance and Use Model

The model has several other noteworthy features besides the new factors. First, the original UTAUT did not emphasize social and emotional factors; perceived risk avoidance, sociability, perceived playfulness, and conformity all have emotional elements. Second, the original UTAUT includes voluntariness as a moderator. These variables are not applicable to our research, as all our survey respondents were using group buying sites voluntarily.

Based on the model, we proposed the following hypotheses (see Table 1). In the questionnaire, "group buying" means online group buying.

Table 1 Research Hypotheses

H1	Users' performance expectancy with regard to group buying leads to their intention to engage in group buying.
H2	Users' low expectancy of effort in group buying leads to their intention to engage in group buying.
H3	Social influence leads to users' intention to engage in group buying.
H4	Users' perceived risk avoidance with regard to group buying leads to their intention to engage in group buying.
H5	Sociability on the group-buying site leads to users' intention to engage in group buying.
H6	Users' perceived playfulness with regard to group buying leads to their intention to engage in group buying.
H7	Facilitating features of the group buying site lead to users' intention to engage in group buying.
H8	Users' intention to engage in group buying leads to their use of group buying.
H1a	The influence of performance expectancy on intention to use group buying is moderated by gender, such that the effect is stronger for women.
H2a	The influence of effort expectancy on the intention to use group buying is moderated by gender, such that the effect is stronger for women.
H3a	Social influence on the intention to use group buying is moderated by gender, such that the effect is stronger for women.
H4a	The influence of perceived risk avoidance on the intention to use group buying is moderated by gender, such that the effect is stronger for women.
H5a	The influence of sociability on the intention to use group buying is moderated by gender, such that the effect is stronger for women.
H6a	The influence of perceived playfulness on the intention to use group buying is moderated by gender, such that the effect is stronger for women.
H8a	The influence of behavioral intention on the use of group buying is moderated by conformity, such that the effect is stronger for users showing the greatest conformity.

2.3 The survey

The design of the questionnaire and the preliminary selection of items was guided by the literature review. The items are shown in Table 2. The new variables described in Section 2.2, as well as the measures of performance expectancy, effort expectancy, and social influence, were adapted from several sources (Davis et al., 1989; Moore & Benbasat, 1991; Thompson, Higgins & Howell, 1991; Venkatesh et al., 2003). The measures of facilitating conditions and behavioral intention were adapted from these sources as well as from Ajzen (1991) and Ajzen and Fishbein (1975).

Table 2 Measures

Label	Measure
Performance Expectancy	
PE01	I think online group buying can improve buying performance.
PE02	I think online group buying can make buying more efficient.
PE03	I think online group buying makes buying easier.
PE04	I think online group buying makes for a higher quality buying experience.
PE05	Overall, I think online group buying helps my buying activity.
Effort Expectancy	
EE01	Online group buying is easy to learn.
EE01	It is easy to engage in buying activities using online group buying.
EE03	It takes time to do online group buying.
EE04	Online group buying is complicated and hard to understand.
Social Influence	
SI01	My family members and good friends have influenced my use of online group buying.
SI02	Online group buying is common in my society.
SI03	People think those who use online group buying are cool.
SI04	Those who use online group buying easily get the attention of other people.
Perceived Risk Avoidance	
RA01	Online group buying may reduce risks.
RA02	I may avoid some losses when I do online group buying.
RA03	Online group buying is safe.
Sociability	
SO01	I can socialize with other people during online group buying.
SO02	I feel a sense of amiability when I do online group buying.
SO03	I like the feeling of interacting with other people when doing online group buying.
Perceived Playfulness	
PP01	I feel immersed when I do online group buying.
PP02	I do not feel that other things interfere with me when I do online group buying.
PP03	When I do online group buying, I tend to ignore other things.
PP04	I feel online group buying is interesting.
PP05	I feel online group buying is inspiring.
Conformity	
CO01	I follow the group leader’s ideas for online group buying.
CO02	It bothers me if I cannot keep up with the other members of an online purchase group.

Table 2 Measures (continued)

Label	Measure
CO03	I am concerned about how other people react to what I say and do in an online purchase group.
CO04	I change my thinking to avoid other people's negative comments in an online purchase group.
CO05	I insist on my ideas when they are different from the group leader's.
Facilitating Conditions	
FC01	An online group buying site can help me with buying even if I have no prior experience with it.
FC02	I feel puzzled because online group buying sites have different interfaces.
FC03	I like the interfaces of online group buying sites.
Behavioral Intention	
BI01	Online group buying is a good idea.
BI02	I like to buy things using online group buying.
BI03	I recommend that other people use online group buying.
UB	The popularity of online group buying increases every year.

3. Data collection and analysis

3.1 Pre-test

The questionnaire has three parts. The first part is a general survey on group buying that we used to screen inappropriate respondents from the test sample. Those who did not have online group buying experience were excluded. The second part of the questionnaire is shown in Table 2. The third part consists of demographic items, the data from which were used for F-tests to check the effects of demographic differences.

The first step in the pre-test was to invite ten scholars with domain knowledge and extensive experience with online group buying to examine the above preliminary version of the questionnaire. Two MIS professors checked the internal validity of the questions, and three Ph.D. candidates helped them evaluate the questionnaire further. Five professionals were invited to check for ecological validity; i.e., whether the questions are really important for online group buying. All ten judges agreed that the questionnaire "can measure what it is supposed to measure" and that "all dimensions are essential to the evaluation of SNS and SNS games." Thus, face validity and content validity were achieved.

We then put the questionnaire on Google Docs for the pre-test. Through personal connections with sites such as MSN, Skype, BBS, personal blogs, and Facebook, we

recruited 82 respondents, 14 of whom submitted invalid questionnaires. The reasons for disqualifying the questionnaires were: (1) the same answer was given to each item; (2) at least one question and its reverse-worded counterpart had contradictory answers, and (3) more than one questionnaire was submitted (as inferred from the same IP address). The sampling period was March 15 through March 20, 2010.

Cronbach's α was used to assess the reliability of the scales composing the questionnaire. Because reliability for all the scales met this criterion (see Table 3, $\alpha > 0.7$), all the items were retained in the final questionnaire (Guilford, 1965).

Table 3 Reliabilities of the Preliminary Scales

Scale	Cronbach's α	# of Items
Performance Expectancy	0.819	4
Effort Expectancy	0.847	4
Social Influence	0.827	3
Perceived Risk Avoidance	0.879	3
Sociability	0.879	3
Perceived Playfulness	0.850	4
Conformity	0.873	4
Facilitating Conditions	0.878	3
Behavioral Intention	0.826	3

3.2 Main test

The survey was then posted on Google Docs where it remained for 12 days, from April 23 through May 3, 2010. The link was provided on several popular Taiwanese online group buying websites, and sites affiliated with university BBSs. All respondents had an equal chance to win the provided lottery rewards. The total number of questionnaires received was 402, but 85 were discarded due to invalid responses, leaving a final sample size of 317. The reasons for disqualifying these questionnaires were the same as in the pre-test.

3.3 Demographic variables

Table 4 gives the demographic data.

We then conducted a series of one-way ANOVAs to test for possible significant relations between the demographic and psychological variables. As shown in Table 5, the only demographic factor that affected the results was gender, a moderator variable in our model.

Table 4 Demographic Variables

Variable	Category	#	%	Accumulated %
Gender	Female	221	69.7	70.7
	Male	96	30.3	100.0
Age	< 18	2	0.6	0.6
	18 - 23	198	62.5	63.1
	24 - 30	103	32.5	95.6
	31 - 35	9	2.8	98.4
	36 - 40	1	0.3	98.7
	41 - 45	2	0.6	99.4
	46 - 50	2	0.6	100.0
Online time each day	< 1 hr	5	1.6	1.6
	1hr - 3hr	55	17.4	18.9
	3hr - 5hr	106	33.4	52.4
	5hr - 7hr	83	26.2	78.5
	7hr - 9hr	37	11.7	90.2
	9hr - 11hr	13	4.1	94.3
	> 11hr	18	5.7	100.0
Average monthly income (in NT$, US$1 = NT$30)	< 1,000	24	7.6	7.6
	1,000 - 5,000	69	21.8	29.3
	5,000 - 10,000	125	39.4	68.6
	10,000 - 20,000	30	9.5	78.2
	20,000 - 30,000	29	9.1	87.4
	30,000 - 40,000	21	6.6	94
	> 40,000	19	6.0	100.0
Membership status	Leader	24	7.6	7.6
	Follower	293	92.4	100.0
Type of buyer	Professional	6	1.9	1.9
	Regular	311	98.1	100.0
Experience (time elapsed since first buy)	< 0.5 year	80	25.2	25.2
	0.5 - 1 year	79	24.9	50.2
	1 - 1.5 years	50	15.8	65.9
	1.5 - 2 years	32	10.1	76
	> 2 years	76	24	100.0

Table 4 Demographic Variables (continued)

Variable	Category	#	%	Accumulated %
Frequency of buying each year	1	13	4.1	4.1
	2 - 4	121	38.2	42.3
	5 - 9	96	30.3	72.6
	10 - 13	28	8.8	81.4
	14 - 17	6	1.9	83.3
	18 - 20	3	0.9	84.2
	> 20	50	15.8	100.0

Table 5 Scores on the Psychological Dimensions as a Function of Demographic Variables

	Gender		Age		Experience	
	F	**p**	***F***	**p**	***F***	**p**
Performance Expectancy	1.318	0.112	0.719	0.885	1.022	0.439
Effort Expectancy	1.634	0.015**	1.005	0.466	1.169	0.240
Social Influence	0.996	0.480	1.095	0.332	1.164	0.246
Perceived Risk Avoidance	1.835	0.034*	1.046	0.402	0.706	0.898
Sociability	1.783	0.038*	0.912	0.612	0.838	0.734
Perceived Playfulness	1.535	0.030*	1.603	0.146	1.088	0.342
Facilitating Conditions	1.018	0.445	1.112	0.309	0.966	0.529
Behavioral Intention	0.927	0.593	1.298	0.125	1.116	0.304

* $p < 0.05$. ** $p < 0.025$. *** $p < 0.01$.

3.4 Reliability and validity tests

All the measures continued to show good reliability in the main test (see Table 6).

To test the validity of the dimensions, we began by applying the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to determine if the scales were suitable for factor analysis (Kaiser, 1974). A KMO value greater than 0.8 means that the items have low partial correlations with the total scale of which they are a part; the obtained value was 0.83. We also applied Bartlett's sphericity test, which yielded $p < 0.05$. Thus, the scales are factorable by both criteria.

The factor analysis yielded 9 factors corresponding to the 9 psychological dimensions in Table 7. This means that the constructs are valid.

Table 6 Scale Reliabilities for the Main Test

Dimension	Cronbach's α	# of Questions
Performance Expectancy	0.793	4
Effort Expectancy	0.872	4
Social Influence	0.718	3
Perceived Risk Avoidance	0.800	3
Sociability	0.797	3
Perceived Playfulness	0.714	4
Conformity	0.706	4
Facilitating Conditions	0.700	3
Behavioral Intention	0.897	3

We next conducted tests for convergent and discriminant validity. Convergent validity is achieved when the following three conditions are met: (1) all the standardized factor loadings exceed 0.5, (2) the composite reliability (CR) is greater than 0.7, and (3) the average variance extracted (AVE) exceeds 0.5 (Fornell & Larcker, 1981). Table 8 shows that convergent validity was achieved based on these criteria.

Discriminant validity is achieved when the square root of the AVE of a construct is greater than the correlation between that construct and another construct (Fornell & Larcker, 1981). Table 9 shows that discriminant validity was achieved by this criterion.

3.5 Model fit

We next sought to determine whether our model is the best of the available choices. The three kinds of model fit (absolute fit, incremental fit, and parsimonious fit) for the data are presented in Table 10. As shown in Table 10, the results meet the minimally acceptable levels by all three model fitting criteria.

3.6 Hypothesis testing

Finally, we used maximum likelihood estimation to test the hypotheses listed in Section 2.2. Table 11 shows the structural equation model for the path analysis and the results of the hypothesis tests.

3.7 Moderating effects

To test the moderating effects of conformity, we used the following multiple regression formula:

$$UB = \alpha_0 + \alpha_1 BI + \alpha_2 BIxCO$$

The notation is the same as in Table 2. The results are presented in Table 12.

Table 7 Factor Loadings for the Psychological Scales

	Factor								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
EE01	**0.871**	0.209	0.095	0.055	0.103	0.032	0.018	-0.025	0.104
EE02	**0.841**	0.206	0.068	0.091	0.066	-0.012	0.160	0.083	0.162
EE03	**0.718**	0.162	0.035	0.259	0.027	-0.045	0.202	0.146	0.086
EE04	**0.727**	0.178	-0.052	0.059	-0.012	-0.066	-0.022	-0.029	0.335
BI01	0.289	**0.757**	0.051	0.175	0.099	-0.046	0.094	0.144	0.181
BI02	0.289	**0.777**	0.120	0.205	0.100	0.033	0.041	0.143	0.051
BI03	0.204	**0.771**	0.089	0.188	0.151	0.059	0.124	0.129	0.113
SO01	0.114	0.076	**0.737**	0.047	0.019	0.053	0.159	0.238	0.027
SO02	0.033	0.020	**0.874**	0.097	0.042	-0.014	0.080	0.091	0.094
SO03	-0.020	0.050	**0.818**	-0.050	0.017	-0.019	0.035	0.081	0.099
PE01	0.221	0.406	-0.098	**0.527**	0.198	-0.074	0.176	0.040	0.012
PE02	0.063	0.097	0.146	**0.824**	0.057	-0.055	0.008	0.048	0.113
PE03	0.130	0.206	-0.012	**0.780**	0.153	0.074	0.164	0.064	0.043
PE04	0.201	0.446	-0.010	**0.528**	0.117	0.039	0.126	0.025	0.147
CO01	0.023	-0.175	0.108	0.267	**0.522**	0.012	0.122	0.149	-0.194
CO02	0.020	0.318	-0.041	0.095	**0.707**	0.135	-0.035	0.079	0.055
CO03	0.067	0.299	-0.002	0.085	**0.764**	-0.001	0.001	0.174	0.073
CO04	0.089	-0.021	0.054	0.031	**0.784**	0.020	0.088	-0.052	-0.074
RA01	0.008	0.006	0.008	0.108	0.049	**0.827**	0.051	-0.059	0.053
RA02	-0.025	-0.066	0.003	-0.030	0.024	**0.843**	-0.022	0.025	0.075
RA03	-0.047	0.059	-0.005	-0.089	0.050	**0.844**	0.054	0.044	0.125
PP01	0.138	0.242	0.333	0.134	0.129	0.018	**0.598**	0.238	0.180
PP02	0.135	0.132	0.116	0.051	-0.048	0.084	**0.743**	-0.148	-0.055
PP03	0.117	0.307	0.043	-0.056	0.190	0.124	**0.681**	0.123	0.235
PP04	-0.002	-0.160	0.021	0.235	0.025	0.028	**0.669**	0.105	0.099
SI01	0.044	-0.032	0.176	0.070	0.061	0.001	-0.053	**0.829**	-0.115
SI02	0.117	0.266	0.021	0.025	0.190	0.038	-0.126	**0.706**	0.150
SI03	-0.028	0.202	0.293	0.058	0.029	0.145	0.095	**0.677**	-0.010
FC01	0.197	0.035	0.178	0.127	0.035	0.034	0.108	-0.108	**0.763**
FC02	0.271	0.105	0.044	-0.007	-0.077	0.093	0.056	-0.008	**0.762**
FC03	0.140	0.302	0.085	0.205	0.095	0.062	-0.201	0.230	**0.570**

Table 8 Measures of Convergent Validity

Dimension	Factor Loading	CR	AVE
Performance Expectancy	0.527 - 0.824	0.786	0.58
Effort Expectancy	0.718 - 0.871	0.877	0.64
Social Influence	0.677 - 0.829	0.714	0.56
Perceived Risk Avoidance	0.827 - 0.844	0.784	0.55
Sociability	0.737 - 0.874	0.770	0.53
Perceived Playfulness	0.598 - 0.743	0.668	0.54
Facilitating Conditions	0.570 - 0.763	0.735	0.58
Behavioral Intention	0.757 - 0.777	0.898	0.75
Use Behavior	0.808 - 0.817	0.608	0.54

Table 9 Correlation Matrix of the Scales

Dimension	PE	EE	SI	RA	SO	PP	FC	BI	UB
Performance Expectancy	**(0.76)**								
Effort Expectancy	0.49	**(0.80)**							
Social Influence	0.32	0.29	**(0.74)**						
Perceived Risk Avoidance	-0.02	-0.07	-0.10	**(0.74)**					
Sociability	0.31	0.33	0.56	-0.06	**(0.73)**				
Perceived Playfulness	0.51	0.43	0.46	-0.01	0.45	**(0.73)**			
Facilitating Conditions	0.45	0.58	0.30	-0.18	0.44	0.55	**(0.76)**		
Behavioral Intention	0.66	0.57	0.50	-0.03	0.56	0.49	0.53	**(0.86)**	
Use Behavior	0.19	0.11	0.24	-0.05	0.15	0.13	0.28	0.22	**(0.73)**

Note: Numbers on the diagonal are the square roots of AVE.

The α_2 coefficient shows that conformity had the predicted moderating effect. This means that the positive effect of the intention to use group buying on actual use was greater if the users conformed to their group.

We then tested the moderating effects of gender on all the dimensions except facilitating conditions, which has no support in the literature. The regression formula was:

$$BI = \beta_0 + \beta_{i1}X_i + \beta_{i2}G,$$

where X_i is the score for dimension we and G is a dummy variable for gender (male = 0, female = 1). β_{i2} is the coefficient representing the moderating effect of gender on dimension i.

Table 10 Measures of Model Fit

Statistic	Value	Threshold	Result
Absolute fit			
$\chi 2/df$	2.03	< 3	Good
GFI	0.87	> 0.8	Good
AGFI	0.83	> 0.8	Good
RMSEA	0.057	< 0.1	Good
Incremental fit			
IFI	0.96	> 0.9	Good
CFI	0.96	> 0.9	Good
Parsimonious fit			
PGFI	0.69	> 0.5	Good
PNFI	0.79	> 0.5	Good

Table 11 Results of Hypothesis Tests

	Path	Coefficient	t	p	Supported
H1	Performance Expectancy → Behavioral Intention	0.42	6.41***	< 0.001	Yes
H2	Effort Expectancy → Behavioral Intention	0.24	4.19***	< 0.001	Yes
H3	Social Influence → Behavioral Intention	0.14	2.05**	0.025	Yes
H4	Perceived Risk Avoidance → Behavioral Intention	0.12	2.50***	0.009	Yes
H5	Sociability → Behavioral Intention	0.29	4.19***	< 0.001	Yes
H6	Perceived Playfulness → Behavioral Intention	0.02	0.22	0.492	No
H7	Facilitating Conditions → Use Behavior	0.18	1.70	0.429	No
H8	Behavioral Intention → Use Behavior	0.13	1.42	0.078	No

* $p < 0.05$. ** $p < 0.025$. *** $p < 0.01$.

Table 12 Moderating Effect of Conformity

	Coefficient	t	p
α_0	0.374	1.620	0.053
α_1	0.316	1.517	0.035
α_2	0.229	1.794	0.037*

* $p < 0.05$. ** $p < 0.025$. *** $p < 0.01$.

As can be seen in Table 13, gender had significant effect on perceived risk avoidance, sociability, and perceived playfulness. This means that when females (1) perceived that group buying can help avoid risk, (2) were sociable, and (3) perceived group buying to be playful, they tended to use group buying more than males did.

Table 13 Results of Testing the Moderating Effects of Gender

Dimension	β_{i0}	Coefficient	t	p
Performance Expectancy	β_{10}	-0.3221	-1.8353	0.034*
Effort Expectancy	β_{20}	-0.2378	-1.9032	0.029*
Social Influence	β_{30}	-0.9623	-1.8238	0.035*
Perceived Risk Avoidance	β_{40}	-0.2353	-1.0328	0.151
Sociability	β_{50}	-0.8623	-0.9822	0.164
Perceived Playfulness	β_{60}	-0.0932	-0.2018	0.420
Dimension	β_{i1}	**Coefficient**	**t**	**p**
Performance Expectancy	β_{11}	0.9662	5.9587	< 0.001***
Effort Expectancy	β_{21}	0.9352	4.8136	< 0.001***
Social Influence	β_{31}	0.9111	2.0138	0.023**
Perceived Risk Avoidance	β_{41}	0.9047	2.4338	0.007***
Sociability	β_{51}	0.9133	4.0234	< 0.001***
Perceived Playfulness	β_{61}	0.9148	0.2013	0.420
Dimension	β_{i2}	**Coefficient**	**t**	**p**
Performance Expectancy	β_{12}	0.0234	1.1430	0.1271
Effort Expectancy	β_{22}	0.2383	1.0931	0.1377
Social Influence	β_{32}	0.0983	1.0902	0.1383
Perceived Risk Avoidance	β_{42}	0.0931	1.8381	0.0336*
Sociability	β_{52}	0.1026	1.7779	0.0383*
Perceived Playfulness	β_{62}	0.0517	1.7909	0.0372*

* $p < 0.05$. ** $p < 0.025$. *** $p < 0.01$.

4. Discussions and conclusions

It takes only 3 years for group buying businesses to grow from the situation where "the number of accumulated orders sometimes is small" (Kauffman et al., 2010) to billion-dollar enterprises. As the industry evolves, new challenges await. Whereas the problem two years ago was too few auction startups, the problem today is how to strategically identify what customers need to effectively use group buying. The results show that

perceived risk avoidance and sociability, in addition to the factors previously identified by UTAUT (performance expectancy, effort expectancy, and social influence), have a significant impact on the use of online group auctions. However, in contrast to the results of most studies employing UTAUT, the relationship between behavioral intention and use behavior, although in the positive direction, was not significant in the present study.

The present study also revealed the role of gender as a moderator. Females reported that they were influenced more than males in their intention to use online group buying (OGB) services by perceived risk avoidance, sociability, and perceived playfulness. Conformity was the other moderator: The impact of the intention to use OGB on actual usage was stronger for those who evidenced conformity than those who did not.

Our literature search indicated that our study is the first instance of academic empirical research on OGB. Although being first is not always a positive contribution, we believe in this case it is. We noted in Section 1 that studying OGB is important because Internet companies, regardless of whether they are sellers or social network services, take advantage of the Internet to grow. Will OGB sites and consumers start to take advantage of the same Internet features? How will network externality, which has created many large Internet firms, affect the growth of OGB services? Will the result be to create another set of giant companies by exploiting the power of collective buyers, as happened when large sellers and social networks were created by exploiting ubiquity and user bases?

But will the effect of these Internet features on the fast growth of big Internet companies be the same for OGB? The answer is not clear, because there are many differences between OGB and the models exemplified by eBay and Facebook. First, there is always the question of how the increase in utility created by network externality is distributed between suppliers and consumers. In the past, users of companies such as eBay enjoyed the convenience, and they arguably did not care much about the lack of significant monetary benefits. To the contrary, buyers on OGB sites enjoy discounts and do want to get higher utility created by the network externality.

The second possible difference between OGB websites and other websites with respect to network externality is that the effect of the network is weaker in the OGB case (Sundararajan, 2007). As long as the buying group is big enough or powerful enough to get its members a steep discount, there is no need for a larger network. Thus, unlike big companies that take advantage of the network externality of the entire Internet, is it possible for OGBs to have multiple archipelagos, each serving a single city or an industry? Or is the network effect so small that there is no need for large OGB sites?

Third, many network effects are word of mouth. As Galeotti noted, an increase in word-of-mouth communication enables a greater spread of information, thereby increasing

sales and profits. However, in the case of OGB, negative adoption externality carries more weight: An increase in the number of neighbors makes it harder to satisfy the requirement that everybody buy the product (Galeotti & Goyal, 2009). This creates a dilemma: Increasing the number of buyers can reduce prices, but it can also increase the difficulty of forming buying groups.

Fourth, the findings from the present study show that conformity is an important moderator of the effect of behavioral intention on use behavior. Although there was a positive relationship between the two, it is not significant. When conformity was added, however, the combined effect of conformity and behavioral intention on usage becomes significantly positive. This result implies that it is necessary that the group have a strong leader whom the other buyers can follow. As Galeotti noted, "The interaction may involve word of mouth communication about product quality and prices. In this case, the presence of a single informed neighbor leads to product awareness and possibly purchase." (Galeotti & Goyal, 2009) This concept is similar to that of a "gatekeeper," or bridging person (Fleming & Marx, 2006). Consistent with Fleming, we define a gatekeeper as a person who maintains personal connections with different types of people, someone who knows the products and services and can provide unbiased advice. Thus, the gatekeeper is someone who buyers can follow in deciding whether to participate in a group purchase. Companies such as Groupon have already established relationships with local vendors (Anonymous, 2011a; Weiss, 2010). However, OGB sites probably also need to identify gatekeepers to lead the group buying. This may limit their opportunity to take advantage of the network externality enjoyed by other types of Internet companies.

Fifth, the network externality of social network services (SNS) such as Facebook may have to be local; users may want to acquire offline friends online, and they may not need to connect with the whole Internet. Nonetheless, they can still take advantage of ubiquity: Everything a user posts on her own page can be viewed by anyone in the world, which matters if users want their posts to have social impact. In the case of OGB, we have not observed that social influence matters much. What OGB participants cared about is there being enough buyers to get discounts or share information. The implications of this lack of ubiquity are two-fold. First, OGB companies can learn lessons from sites such as Craig's List (http://www.craigslist.com/), which features not only mass collaboration, but also localization. Second, Internet ubiquity may not be significant for OGB businesses, and global companies can face local competition.

If any of the above questions are worth asking, studies similar to ours are necessary. It may not be obvious that being the first mover of the OGB market has advantages with respect to factors such as ubiquity and network externality. First movers will not always be as successful as Facebook, which took advantage of the 6-degree separation phenomenon

and then just waited to reap the benefits of network externality. To keep their customers, OGB companies must also have good strategies. The present results demonstrate that a productive strategy that any OGB company can benefit from is to convince customers that group purchases can help them avoid risk, allow them to socialize, and show them how to select and follow good group leaders.

However, this list of suggestions is far from exhaustive. For example, we did not include "affinity" as a dimension. According to our informal interviews, many Taiwanese and Chinese like group purchasing because it offers them affinity. Females, especially, love this sense of belongingness.

Another limitation of this study is the unit of analysis. We analyzed only buyers, but it may be valuable to analyze vendors as well. OGB has some of the characteristics of a two-sided market (Eisenmann, Parker & Van Alstyne, 2006; Parker & Van Alstyne, 2005) in that OBG sites such as Groupon function as platforms; the site is a meeting ground for buyers and sellers. Buyers form their own network, but so do sellers. The utility of being a network member is determined by the size of the other network. The key to success for a two-sided market is to form one side and allow the other side to grow symbiotically. In the case of OGB, it is unclear which side should start first. In Taiwan, sites that emerged from the formation of buyer networks have not generated significant business. On the other hand, in the US, Groupon started with sellers and now enjoys strong capitalization. Research similar to ours, but applied to sellers, should provide a different perspective on online group buying.

All this raises other questions. What results would we get if we studied buyers in the US rather than Taiwan? Are there any factors other than starting with buyers that explain why Taiwan's OBG companies did not become giants? If they start by forming seller networks, would they become another Groupon? These questions are complicated. First, the Chinese prefer to act collectively (see Benvenisti, 2008; Earley, 1989). It follows that it is natural for Taiwanese companies to start with buyers, because in Chinese culture buyers form groups with common goals. Second, the fact that starting by organizing vendors was successful for sites such as Groupon does not mean, at least in theory, that it was necessarily a mistake for Taiwanese sites to start by organizing buyers. Internet social network services create personal profiles and classify customers according to common personal characteristics. This is sometimes called "hypertargeting" (Shih, 2009). The classifications can be in any combination and in any number of parameters. Every group of individuals with the same set of characteristics is potentially a buying group for a specific product. Then, online social network sites such as Facebook can take advantage of hypertargeting to sell products to idiosyncratic buying groups.

To conclude, the above report and discussion of this pioneering empirical study not only provide managerial insights but also raises many questions for future studies. We hope it will stimulate a comprehensive body of research on online group buying.

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