ATHABASCA UNIVERSITY

A STUDY ON REPUTATION SYSTEMS IN INTERNET MARKET

BY

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A thesis submitted in partial fulfillment

Of the requirements for the degree of

MASTER OF SCIENCE in INFORMATION SYSTEMS

Athabasca, Alberta

April, 2009

DEDICATION

To the memory of my father, Prof. Yunshu Mu, who built the first prototype of Chinese color television with his colleagues in the early 1970's.

ABSTRACT

Trust and reputation is considered a significant part of the Internet marketing. They are tightly coupled and platform-independent components that allows communications being carried out during processes between participants. Internet transactions or interactions involve anonymity of participants, which are more risky on account of uncertainty about the quality of service or identity of service providers. Reputation system is a mechanism to determine who is trustworthy and induce Internet marketing's participants to maintain a good reputation while performing Internet activities. We consider that the evaluation of service provider's reputation or participant's honesty and responsibility constrained in some way by three factors, they are service quality, transaction time, and dollar value involved in the transaction(s), we called them as triple constraint. Although, there has been considerable theoretical research and practical implementation work done in trust or reputation on Internet marketing, very little research done to pinpoint the relationship between trust and reputation with this triple constraint, especially when trust decay and time decay factors involved in the reputation evaluation process. We propose and investigate a novel dynamic trust and reputation framework based on the three factors mentioned above to reflect the more realistic reputation of the service providers in the Internet market. The proposed system model has been verified through a series of simulations. To the best of our knowledge, this is the first study to integrate decay factors into reputation evaluation process. The simulation experiments results have indicated that reputation systems can signal current level of reputation of being evaluated service providers and can be benefit only if the providers have performed certain number of Internet transactions or services.

ACKNOWLEDGMENTS

I would first like to express my gratefulness to my thesis supervisor, Dr. Maiga Chang, whose amazing patience, great resource for research ideas, infinite help in all aspects. There was a couple of times where I had reached the 'crossroads' and each time Dr. Chang was patient of listening to me and steered my efforts towards the right path. His willingness to offer me so much of his time, knowledge, perceptiveness and intellect is the major reason this thesis was completed. I can never thank him enough.

I would also like to acknowledge my thesis committee member, Dr. Yuren Yen for giving me valuable suggestions, comments, and for evaluating this thesis.

My parents have been a great source of inspiration and support through my life. They always kept their hardworking with positive attitude in the face of life's adversities. This was their most important gift and my late father's legacy to me, which certainly gave me the strength to complete this thesis.

Finally, and perhaps most importantly, I would like to thank my family especially my wife and my son for their understanding, continued support and constructive suggestions during the writing of this thesis.

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CHAPTER I

INTRODUCTION

The Internet is profoundly affecting almost all businesses and commerce paradigms (Menascé & Almeida, 2000). It not only provides the opportunity for companies switching from "brick-and-mortar" traditional behaviour to "brick-and-clicks" businesses style, but also opens up new opportunities to provide quality products and improved customers services in the most efficient way as traditional businesses provide. In addition, Internet marketing also offers several benefits such as timing, immediacy, less expensive, targeting and scalability. Some studies (OECD, 2008; Statistics Canada, 2008a) have showed that people worldwide are making greater and more diverse use of the Internet meanwhile Internet sales continue to grow up. According to Statistics Canada report (2008b), that more Canadian used the Internet to purchase goods and services in 2007, which totally worth $12.8 billion of orders, up 61% from 2005. Internet has become a supplement to traditional retail shopping more than a substitute. In fact, Internet marketing has become an essential part of today's electronic business since its core value is its ability to promote productivity and efficiency.

1.1 Motivation

Internet marketing is growing and evolving with the focus shift among main application areas very quickly whenever it could be applied. In general, Internet marketing is associated with several business models (Stair & Reynolds, 2003). The main models include business-to-consumer (B2C), business-to-business (B2B) and consumer-to-consumer (C2C). B2C is a form of e-commerce in which consumers deal directly with

an organization and avoid any intermediaries. C2C involves consumers selling directly to other consumers, whereas B2B involves organizations only.

For doing successful business on the Internet, effective marketing strategies and necessary evaluation procedures must be established and one of them is the implementing feedback mechanism or reputation system. Reputation system is considered a significant part of the Internet business. Since Internet transactions involve anonymity of participants, which are more risky on account of uncertainty about the service of quality or identity of service providers, people would like to deal with honest merchants and reputation system is how to determine who is trustworthy. We consider that that the evaluation of service provider's reputation or participant's honesty and responsibility constrained in some way by three factors, they are service quality, transaction time, and dollar value involved in the transaction(s), we called them as triple constraint. Although, there has been considerable theoretical research and practical implementation work done for a long time in trust or reputation on Internet marketing, very little research done to pinpoint the relationship between trust and reputation with this triple constraint, especially when trust decay and time decay involved in the evaluation process of the reputation, what the realistic reputation value is. The effectiveness of reputation systems should induce Internet market's participants to maintain a good reputation while performing Internet activities. Since Internet marketing is prosperous growing up, fraud on the Internet is also developing into a major threat for consumers, business and governments (Gavish and Tucci, 2008). We consider that Internet market and frauds as well as being developed or used reputation systems are close combined together, it is

necessary and worthy to treat them as a whole while doing study to gain a significant understanding from the reputation system.

1.2 Research Goals

This research will study and analysis current existing reputation systems and propose a novel dynamic trust and reputation system framework which can be applied into and promote Internet market activities. Therefore, the goals of this thesis are established as follows:

- Analysing the commercial attributes of the Internet markets

  This goal will outline the commercial attributes of the Internet marketing in order to gain better understanding and cope with the reputation system.

- Analysing the current available reputation systems

  This goal will analyse the current available reputation systems in use and identify their advantages and disadvantages.

- Developing a new suitable framework of reputation system which can be applied in general Internet marketing

- Evaluating the performance of the proposed model through a series of simulations

1.3 Contributions

In this thesis, we extend the usage of reputation system, i.e., provide a generalist survey for the current available reputation systems and based on that, develop a novel and suitable algorithm of reputation system, which reflects three factors in the evaluation of the reputation. These three factors are service quality, transaction time, and dollar

value involved in the transaction(s); we called them as triple constraint. Reputation systems can play an important and active role during Internet marketing processes. We consider that reputation systems can signal current level of reputation of being evaluated service providers and can be benefit only if the providers have performed certain number of Internet transactions or services.

1.4 Thesis Organization

This thesis consists of five different chapters. Chapter I introduces the audience to the research subject, motivation, goals and possible contribution. Chapter II will present the research background and literature reviews where we describe the current issues of trust and reputation in Internet market. In Chapter III, the algorithm of proposed reputation system is explained thoroughly followed by Chapter IV, which presents some of the simulations and their results. Finally, the conclusions made, the recommendations and the future research work will be covered in Chapter V.

CHAPTER II

RELATED LITERATURE REVIEW

Trust and reputation are considered pure abstract concepts. They can become more meaningful only after applying to certain physical participants or entities. Trust and reputation are tightly coupled and platform-independent components that allows communications being carried out during processes between participants. They have led to a new breed of systems, which are quickly becoming an indispensable component of every successful online trading community: online feedback mechanisms (Dellarocas, 2003), also known as reputation systems (Resnick, Zeckhauser, Friedman, & Kuwabara, 2000). Reputation system provides a virtual platform which combining these two components together to address individual participant' past behaviour and to predict future behaviour. Actually, reputation systems have been studied for a long time and applied into many domains and fields and have been considered playing an essential role for establishing and developing robust, but complete Internet marketing. The design of the suitable reputation system must be done with great care to reflect the characteristics of Internet marketing. This chapter will study the trust, reputation, reputation systems and commercial attributes of Internet marketing literature to gain the better understanding of the reputation systems currently in use and their development as well as advantages and disadvantages.

2.1 Trust and Reputation

The Internet marketing have created numerous opportunities to interact with strangers; these processes are also obviously raising a number of challenges such as lack of quality

of services or even fraud during transactions, which may form asymmetric information flowing and lead up to the lemon problem (Akerlof, 1970) and finally only the lowest quality goods are traded and thus opportunities to achieve better profits from trading high quality goods are forgone (Yamagishi & Matsuda, 2002).

With the prosperous development of Internet marketing, we have responsibility to provide fair and positive environment for Internet users staying in this market with confidence. Trust and reputation are important concepts which constituting the foundation of reputation systems and enabling participants to reliably assess the quality of services and the reliability of other participants based on the same standard in Internet market.

2.1.1 Trust

The concept of trust is generally considered having broad-based meaning and varies between disciplines. Therefore, researchers in psychology, sociology, history, political science, economics and information technology area have done lots of research work to create suitable definitions for this abstract and crucial concept.

Lewicki and Bunker (1996) based on previous researchers' work (Boon & Holmes, 1991; Shapiro, Sheppard, & Cheraskin, 1992) consider trust development to be an iterative process and a dynamic phenomenon that takes on a different character in the early, developing and mature stages of a relationship with each participant involved. They proposed three types of trust which are Calculus-Based Trust, Knowledge-Based Trust and Identification-Based Trust. They also suggested that these three trusts are linked in a sequential iteration in which the achievement of trust at one level enables the development of trust at the next level in a professional relationship.

In information technology field, Marsh (1994) is among the first to introduce a computational model for trust in the distributed artificial intelligence. His model is complex, but draws on many relevant real world phenomenons based on social and psychological factors. He defines trust in three categories which are basic trust, general trust and situational trust. Although his work is widely cited, but the model is theoretical and often considered too difficult to practically implement (Mui, Mohtashemi, & Halberstadt, 2002; Golbeck & Hendler, 2004). Jøsang (2007) defines trust as a directional relationship between two parties that can be called trustor and Trustee. And he considers that a trust relationship has a scope, meaning that it applies to a specific purpose or domain of action. Wang and Vassileva (2003) define trust as a peer's belief in another peer's capabilities, honesty and reliability based on its own direct experiences. Dillon, Chang, and Hussain (2004) also consider that trust has a dynamic aspect in the virtual world.

Upon to now, there is no standard definition of trust; while considering our research interest, we define trust in Internet market as follows.

Definition 1 (Trust): Trust is a giving confidence to another object (thing, person or organization, etc.) based on direct or indirect relationship. Trust is associated with risk and having scope and dynamic attributes.

2.1.2 Reputation

The concept of reputation is generally considered having meaning of trustworthiness. As trust, reputation has been studied in various research fields, such as in psychology (Bromley, 1993; Karlins & Abelson, 1970), philosophy (Hume, 2000), sociology

(Buskens, 1998), economics (Celentani, Fudenberg, Levine, & Psendorfer, 1966; Milgrom & Roberts, 1982) and Information technology (Jøsang, Ismail, & Boyd, 2007; Resnick, Zeckhauser, Friedman, & Kuwabara, 2000; Sabater & Sierra, 2001). Sabater and Sierra define reputation as the opinion or view about something. This opinion can be updated direct interactions or indirect experiences from other members while Resnick et al point out that reputation to be the community opinion of a subject's standing. Jøsang, Ismail and Boyd define reputation as generally said or believed about a person's or thing's character or standing.

Apparently, the concept of reputation can be applied into many disciplines; however, its definition has not been widely agreed. Since our research interest will be focusing on Internet market, we define reputation as follows.

Definition 2 (Reputation): Reputation is an earned confidence or trust from other object or group of objects (thing, person or organization, etc.) based on direct or indirect relationship. Reputation is associated with risk and having scope and dynamic attributes.

2.2 Reputation Systems

Trust and reputation are tightly coupled components when considering building constructive and cooperative business environment for Internet markets. Reputation is one important affecting factor where trust is based on. Windley, Tew, and Daley (2007) have detail-argued the attributes of reputation and its relation with trust. People want to deal with honest behaviour and reputation mechanism is how to determine who is trustworthy. Due to the fact that transactions or communications in Internet markets require a great

deal of trust and reputation among anonymous participating partners, so the discussion of application of reputation systems in Internet markets is obvious becoming crucial issue.

The Internet offers vast opportunities and huge platform for Internet users to interact with totally unknown strangers. Therefore, building reputation system is particularly important for individual or company who wishes to reach the maximum benefits of potential Internet markets (Dellarocas, 2001).

Reputation system collects, distributes, and aggregates feedback about participants' past behaviour (Resnick, Zeckhauser, Friedman, & Kuwabara, 2000). Generally, in order to operate reputation system effectively and to provide incentives for honest and trustworthy behaviour, several properties must be taken into account (Fasli, 2007, Resnick, Zeckhauser, Friedman, & Kuwabara, 2000), they are:

- Entities are long-lived, so that there are chances of future interaction;
- Feedback about current interactions is recorded and distributed, such information must be visible in the future;
- The costs for submitting and distributing feedback should be reasonable low;
- Feedback information must be aggregated and presented in a suitable way to guide trust decisions;
- Showing clear guidelines on how the rating system operates and how potential conflicts can be resolved;
- The reputation system provider itself must be reputable and trustworthy.

Reputation system has become the most significant foundation of the Internet business transactions or communications. It can be used to maintain trust in Internet communities,

where we anonymously interact with people that we might have never met, not even heard of, and that we might never meet again (Andrews, 2006).

2.3 Reputation Systems in Practice

Reputation systems have been the hottest research topic and studied for more than a decade and its various theories have been implemented into many domains and fields especially in auction area. Reputation system has been considered playing an essential role for establishing and developing robust, but complete Internet markets.

The most significant feature of Internet market is that it has implemented the reputation system or feedback system. The Internet market's giant, eBay firstly introduced reputation system into the Internet market and enables its online auction system. This revolutionary pioneering spirit has been greatly absorbed by many other companies since then and significantly promotes the healthy development of Internet market. Several literature or books have tried to establish methods or framework to make comparisons possible between these reputation systems current in use in the Internet market. Based on previous researches (Chang, Dillon & Hussain, 2006; Dellarocas, 2004; Guha, 2001), Table 2.1 summarize several noteworthy examples of Internet market reputation systems in use today.

2.4 Internet Commercial Behaviour

Internet commercial behaviour is a way for someone to show a disposition to buy or sell services and goods through the Internet. These services and goods are advertised on the Internet where they are available to anyone anywhere in the world. It provides Internet

Table 2.1: Examples of Internet Market Reputation Systems

Business Name	Function	Summary of Reputation System	Format of Solicited Feedback	Format of Published Feedback
eBay[1]	Marketplace for buyers and sellers to come together and trade almost anything	Buyers and sellers rate one another following transactions; PowerSeller: 98% total positive feedback in terms of consistent sales volume and customer satisfaction;	Positive, negative or neutral rating plus short comment; Rated party may post a response	Sums of positive, negative and neutral ratings received in the last 1, 6, and 12 months; Members can be authorized colored star based on earned feedback score from yellow star (at least 10) all the way to a red shooting star (above 100,000)
Elance[2]	Online services marketplace for outsourcing projects to professional service providers to get work done	Business employer and service provider rate one another following transactions	Numerical rating from one to five plus comment based on the satisfaction received by business employer; Service provider may post a response	Rating calculated based on same criteria with different weighed factor; Average of ratings received during past six months and lifetime
Epinions[3]	Online opinions forum, helps people make informed buying decisions	Users write reviews about a variety of different products/services; Other members can also rate the usefulness of reviews	Users rate multiple aspects of reviewed items typically on a scale of one to five; Readers rate reviews based on a scale of four ratings, from very useful to useless, etc.	Averages of item ratings; % of readers who found a review “useful”
BizRate[4]	Comparison shopping service which enable shoppers to quickly and easily find information about product worldwide	Users write reviews and rate products; Offering "Customer Certified" identification logo based on some criteria	Four BizRate Smiley Scale about a store's capabilities; Five star rating about a product; 16 quality ratings applied to evaluate the produce and service	Store Ratings and Reviews updated on a weekly basis and based on last 90 days data;

1 eBay. http://www.ebay.com
2 Elance. http://www.elance.com
3 Epinions. http://www.epinions.com
4 BizRate. http://www.bizrate.com

shoppers alternative choice besides traditional store shopping. The advantages of Internet shopping as perceived by shoppers can be characterized as convenience, more selections, easy price comparisons, abundant information access, etc. In general, Internet shopping follows four steps to complete a purchase, which are:

- Search
- Choose
- Make an order
- Give Feedback (optional)

The major benefit of Internet shopping is the ability to obtain abundant information related to the products which shoppers interested in through various search engines in use today. Shoppers then know who the main service providers are, and the information related to their products or services. After these efficient searches, shoppers enter into the next step - choose, i.e., to determine which service provider(s) best fit their needs. Shoppers need do some kind of analysis and make comparisons based on the following evaluation criteria (Beck, 2009; Brandt, 1996):

- Accuracy – how reliable and error free is the information;
- Authority – how reputable is the service provider(s);
- Objectivity – does the information show a minimum of bias and to what extent is the information trying to sway the opinion of the Internet shoppers;
- Currency – Is the content of the web page related to products up-to-dated;

Once the shoppers filter all these information gathered and found the product or service is what they wanted, based on their personal experience, knowledge and judgment, they can make an order. When the service provider received the order, the financial transaction take place and the product is shipped to the shopper. After got product and based on the service received, the shopper may have option to give feedback or make comment to the service provider before closing this transaction. Internet shopping is a complicate process, the detailed study about Internet consumer shopping behavior has gone beyond this research.

CHAPTER III

DYNAMIC TRUST AND REPUTATION SYSTEM

As described previously, trust and reputation are crucial to a service participant or a service provider's success. Service providers closely work with service participants and the other people involved in certain reputation system to meet individual goals and vice versa.

Every service provider or participant's reputation is often considered consisting of a series of discrete points or values and constrained in different ways by several factors, such as quality of service, transaction time, and dollar value involved in evaluating process of provider or participant's honesty and responsibility. We call these three factors as the triple constraint. To create a successful reputation system and give a reasonable result, quality, time and dollar value must be reflected in the reputation system. Here, we give their operational definitions which will be frequently used in our dynamic trust and reputation framework described below.

Definition 3 (Quality of service): The satisfaction level of unique product or service received by service participant from committed service providers. Normally, it involved two dimensional evaluation criteria, i.e., product itself and service provided after receiving that product.

Definition 4 (Transaction time): It denotes the time period during which a transaction take place. Since our model especially focuses on decay, the date after service participant receives product or service will play an important role, because it would affect reputation of the service provider in the future.

Definition 5 (Dollar value or **Transaction value):** The amount of money spent for the product or to complete the service.

In this thesis, we propose and investigate a new dynamic trust and reputation framework based on the three factors mentioned above for improving rating service to reflect the more realistic reputation of the service providers in the Internet market. Actually time factor will play an important role on the obtaining the reputation of service providers at different length of time windows. We will explain it thoroughly as below.

3.1 Trust Value and its Rating

The level of trust relationship between service provider(s) and participants after each transaction or interaction can be represented numerically or linguistically by different scale systems. Sometimes these representations can be mutually exchangeable. It is reported that eBay provides three scales such as positive, neutral, and negative (i.e. 1, 0, -1) to allow buyer and seller to rate each other. The advantage of eBay's mechanism is that it is simple and easy to be understood by average users. However, due to its primitive, this led to a vague image of the service provider's reputation (Jøsang et al., 2007). Amazon and Elance use five scale rating system to evaluate the seller's trustworthiness through buyer while ignore seller's feedback on ratings. The latter approach is a step further to detail ratings scale than eBay's method. Apparently, a reputation system with five scale levels is better than a system with three levels. However, it doesn't mean the more scale levels the better. For example, some people may propose seven or even more scale levels, they can only become effective unless too trivial. In our proposed model, we also use five scale rating system, the difference is that our defined rating levels are distributed over the

most positive aspects as listed in Table 3.1. Since we want to quantify representing the trustworthiness of the service provider, it is unavoidable that we mathematically calculate the trust values. The value of trustworthiness is computed based on past experiences given by the service participants for a specific service provider and it can be converted into five scale star system. Therefore, we also give the corresponding reputation levels versus the values of trustworthiness. These calculated numerical values called trust values that ranges from [1...5] can be interchanged to linguistic representations such as "Excellent", "Very Good", "Good", "Fair" and "Poor". The reason that we leave only one scale to represent the reputation level "Poor" is that, in Internet market, people would like to deal with honest merchants or in other words, no one would like to conduct business with service provider(s) only having 50% possibility or even lower success rate. Therefore, there is no point to define extra scale ratings such as "Very poor" or "Extremely poor". Since most transactions involved in the Internet market are participants with anonymity, there are certainly possibilities that uncertainty and risk accompanying online trading course. We encourage people to deal with only the service providers with higher reputations to reduce these potential risks to the minimum level.

Table 3.1: Schematic Diagram of Trust Value and Its Star Rating

Trust Value (%)	**Stars Rating**	**Reputation**
5 (95 ~ 100)	★ ★ ★ ★ ★	Excellent
4 (85 ~ 94.9)	★ ★ ★ ★	Very Good
3 (70 ~ 84.9)	★ ★ ★	Good
2 (50 ~ 69.9)	★ ★	Fair
1 (0.1 ~ 49.9)	★	Poor
0	No Rating	New Service Provider or Participant

3.2 Trust Shifts

The reputation of the service provider is considered consisting of a series of discrete numeric values given by the service participants in the reputation model. These values can change from time to time. They are accumulated together at a given length of time to generate an average value which is used to determine the trustworthiness of the service provider. For each individual transaction, the given value of trustworthiness of service provider may not in a stable stage which means it might go up or down after this transaction. We call this as trust shifts or trust transient phenomenon as depicted in Figure 3.1. In business environment, once the service provider accumulate enough "trust" from service participants and keep momentum on good customers service, their reputation will maintain certain level or even go to upper level. However, this process can go in the opposite direction if service provider loses confidence from service participants, their reputation level will go down.

Initially, we assume that each service provider's reputation will stay at ground stage (trust value = 0) before any transaction happens because they are new service providers. We consider the lowest trustworthiness stage (trust value = 1) as the first stage or "Poor" stage of the service provider. The higher the trust value is, the better the reputation will be, and thus the more reliable the service is. To keep good reputation, the service provider needs to put great efforts on their business.

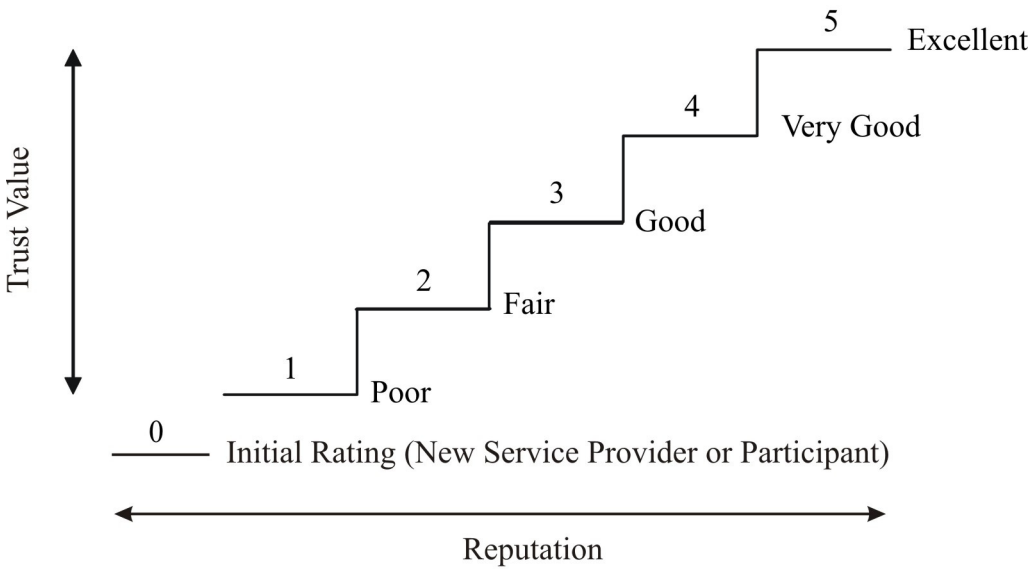

Figure 3.1: Trust Shifts vs Reputation Levels

3.3 The Transaction Time and Decay

In order to quantify the trustworthiness of the service provider and give it an adequate value, in addition to the quality of service or product received which will be used to evaluate the trustworthiness of the service provider, there is also another important factor which may affect the evaluation of reputation of service provider – decay. For example, trust decay may occur when trust value become outdated due to the lack of fresh transactions or interactions. This may led to the question about the realistic trustworthiness about the reputation of service provider.

Time based decay function is a concept which can be used to model trust decay phenomena and leading in designing realistic trust environments. Burt (2000) defines decay in trust relationship "a power function of time in which the probability of decay decreases with tie age". Actually, trust decay is the tendency for trust to weaken or disappear over certain period of time. For instance, if customer John trusts restaurant A at level B based on personal experience ten years ago, the trust level today is very likely to be lower or to be faded from his mind unless he has provoked one or more return visits to his venerable one since then. In this research, we introduced time stamp into the decay function to enhance trust aggregation and reputation representation.

In this thesis, we consider a real business situation and assume that, if a service participant gives a feedback to the service provider after a transaction, this feedback could decay starting the following month. In reality, the decay process may take either exponential or linear format. In our research, we use simple linear depreciating function which decays the trust value by passed months relative to current month. The decay rate based on time R_{time} can be represented as following:

R_{time} = desired percentage of decayed rating changed/ (number of months involved – 1)

For instance, we consider that the desired decay rate after one year decay is one star (20 percentage of rating change based on five star rating scale levels), and there are 11 months (current month does not have any contribution to the decay process) for one year run, the decay rate would be calculated as: R_{time} = 0.2/11 or 1/55.

Since our model assigns more weight to the recent transactions (month). Let's consider 12 time windows (one year) or time slots, i.e., first month (current month); second month … until twelfth month. The decay rate month by month for 12 months is decreased by 1/55 listed as follows:

$$R_{decay} = \{1, \frac{54}{55}, \frac{53}{55}, \frac{52}{55}, \frac{51}{55}, \frac{50}{55}, \frac{49}{55}, \frac{48}{55}, \frac{47}{55}, \frac{46}{55}, \frac{45}{55}, \frac{44}{55}\} \quad (3.1)$$

Once we have decided to consider decay factor in obtaining the trustworthiness of reputation, furthermore, we also consider the time weighting factor and assign different weight to different time slot's feedbacks. Where, time slot is a period of time that corresponds to an academic cycle, and during which various feedbacks can be collected. We assign equal weight to all transactions' feedbacks at the same time slot. Different time slot may have different period of time. The more recent time slot, the more weigh for feedbacks.

3.4 The Transaction Value and Decay

In the previous section, we have discussed transaction time issue which involved in the decay process for our proposed dynamic trust and reputation system framework. We also consider another factor which may play a role in the evaluation of the reputation of the service provider – transaction values or dollar values whether for each individual transaction or totality of transactions. Since each transaction involved certain amount of money, it should be reflected in the model. We consider that dollar value factor could increase or decrease the decay rate. Also we assume that current month does not have any contribution to the decay process as we discussed in Section 3.3. Based on above

assumption, we make a correction, i.e., the decay rate with consideration of the transaction value R_{dollar} for the system can be represented as following:

$$R_{dollar} = R_{time} / \text{amount of transaction value}$$

This means that the more dollar value involved in the transaction, the slower the rate decreases.

3.5 Calculation of Reputation

The central point of the Dynamic Trust and Reputation System is establishing a platform between service provider and service participants to evaluate the satisfaction level after each interaction or transaction and give a reference to the potential users of the service.

The proposed reputation system, which allows the value of trustworthiness, be changed with time and amount of transaction value. To model this aspect, we multiply the trust rating by a time decay function and a dollar value decay function. This certainly reflects the dynamic attribute of the being developed system. Currently, the mechanism of eBay is simply to sum the number of positive feedback and negative feedback separately and then calculating the percentage of the positive over a combined total feedback to show the seller's reputation (Resnick & Zeckhauser, 2002). While Epinions and Amazon use average concept to compute the reputation of all ratings relevant to service provider. The latter approach is vivid and easy to be understood by the average users. Our model

adopts this method and considers the group ratings at given time window or time slot. This means we only consider the average rating of the service provider at given time slot.

In Sections 3.3 and 3.4, we have mentioned two factors that need to be considered in the calculation of reputation or trustworthiness for the service providers. Let's consider a business situation described as following: after a transaction has been completed at time t between service participant X and service provider P, X gives P a trust rating or feedback f for service context c based on received quality of service. The mean trust rating or reputation TR of all transactions during time slot t for the service provider P after considering time decay is given by Equation 3.2:

$$TR\ (P, tc)_{time} = \frac{1}{n}\left(\sum_{i=1}^{n} f(i, c, t)\right) * R_{decay} \qquad (3.2)$$

Here, tc is the current time (month); f (i, c, t) is the trust rating given by the unique participant X at time t for the i^{th} transaction of the service provider, n denotes the total number of transaction at given time slot t when transaction happened. R_{decay} is a time decay value which can be chosen from equation 3.1 based on the considered time slot.

Through the similar deductive process**,** we could get the mean trust rating or reputation for the service provider P after considering only transaction value decay at given time slot, which is given by Equation 3.3:

$$TR\ (P, tc)_{dollar} = \frac{1}{n}\left(\sum_{i=1}^{n} f(i, c, t)\right) * (1 - R_{dollar}) \qquad (3.3)$$

So the overall mean trust rating or reputation of service provider P can be represented by Equation 3.4 in the form of weighted aggregation of an averaged series of individual trust ratings over all for the past interested given time windows (for example, 12 months):

$$TR(P, tc)_{overall} = (\sum_{j=1}^{m} * TR(P, tc)_{time} * TR(P, tc)_{dollar}) / (\text{given number of months}) \quad (3.4)$$

Here, m represents the maximum months considered in the calculation.

3.6 The Model Hypotheses

Before entering the database design process, we are now developing business rules that will be used to ensure that we understand how the programming logic should be implemented to give the proposed system users a fully functional system that will capture, store and retrieve the data in a meaningful and correct way and also give users an unbiased estimation.

- The service provider(s) must have regular business; the more the transactions or interactions, the more accurate the model.
- If the service provider stay at the higher stage (higher reputation) than other providers, then this provider may get more business.
- Only registered participants can provide feedback related to their transactions or interactions with service provider(s); the feedback is not accepted unless the transaction has been completed.
- If one unique participant has had several transactions or interactions and leaves more than one feedback for service provider during same time slot, the system will count only the recent two significant different ones if any, otherwise, only one feedback will be counted.

- If service provider has stable and excellent reputation (all 5 star ratings) during the whole considered time windows, then no decay deduction will be involved in the reputation evaluation of the service provider.

CHAPTER IV

RESULTS AND EVALUATION

In order to evaluate the performance of the proposed reputation system, we conducted a series of simulation studies based on different parameter settings which explained in Sections 3.3 and 3.4. The results have been examined and analyzed along with its origination.

The proposed system is a fully integrated and graphical user interface system that will support the interactions required by the service participants or service providers. The system has a fully integrated and centralized database to allow all data to be cross-referenced by the system itself. We use relational database model to describe our database design. A relational database is a collection of relations or tables which are composed of records. The rows of a table in a relational database are known as tuples and each column of a table is called an attribute. Normalization is a vital component of relational model of databases. Redundant storage of data will be eliminated and data need to be updated in only one place; the system ensures that the changes will be properly reflected through the system. The database stores all the information of the service providers, services provided, service participants and their transaction history.

Next, we are going to discuss the database design following the simulation experiments, results and discussion.

4.1 Database Design

Figure 4.1 shows the entity relationship diagram or ERD with optionality and cardinality for the proposed reputation system. An ERD is a model that identifies the

entities that exist in a system and the relationships between those entities. Each entity represents a database table, and the relationship lines represent the keys in one table that point to specific records in related tables. In our proposed system, there are five entities (tables), they are SERVICE PROVIDER, SERVICE PARTICIPANT, TRUST, SERVICE and RATING.

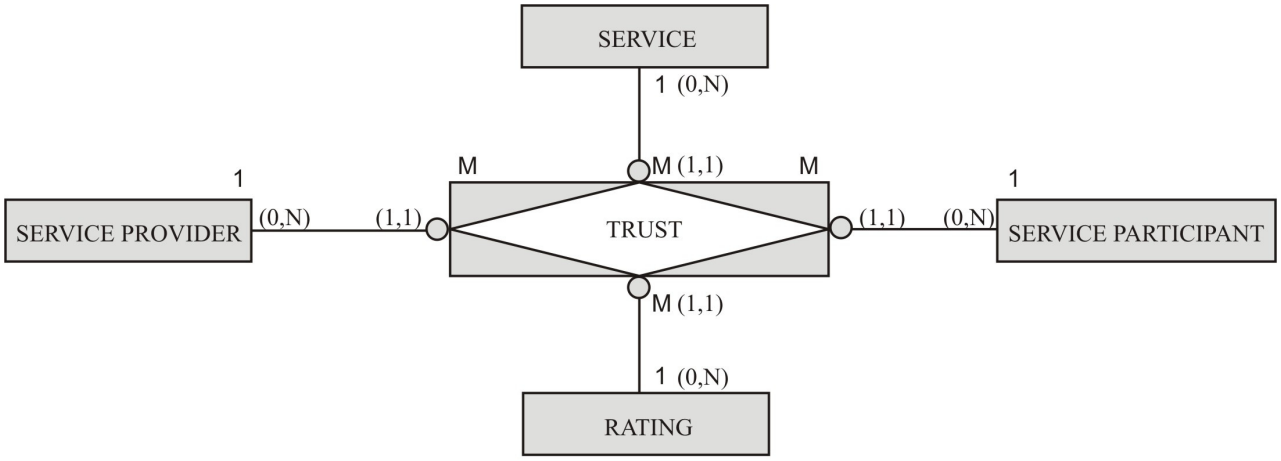

Figure 4.1: The ERD for the proposed reputation system

Figures 4.2 and 4.3 show the database tables and the relational schema for the proposed reputation system, respectively.

Table name: PROVIDER

PROV_NUM	PROV_NAME

Table name: PARTICIPANT

PART_NUM	PART_NAME

Table name: SERVICE

SERV_CODE	SERV_NAME

Table name: RATING

RAT_CODE	RAT_NAME

Table name: TRUST

PROV_NUM	PART_NUM	SERV_CODE	RAT_CODE	TRANS_DATE	SERV_CHARGE	PROV_COMMENT	PART_COMMENT

Figure 4.2: Database tables for the proposed reputation system

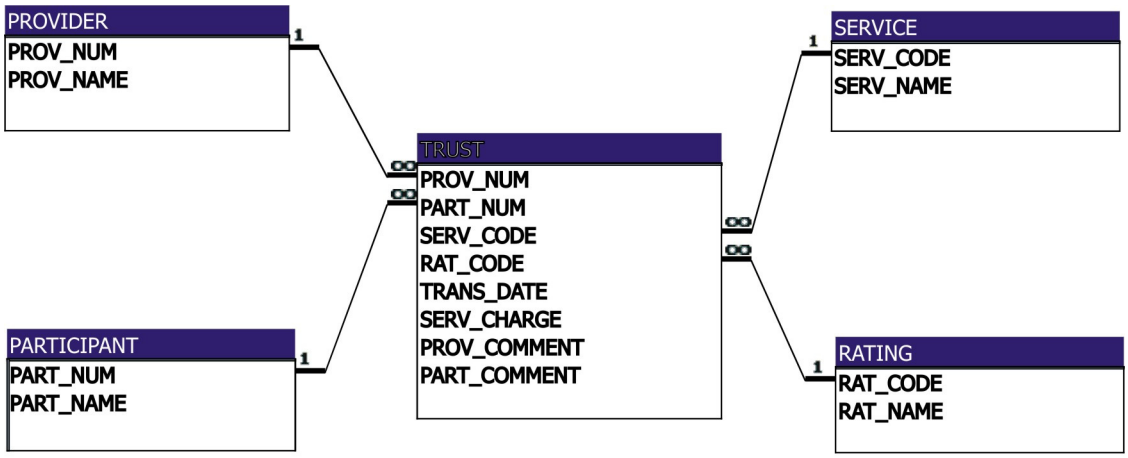

Figure 4.3: Relational schema for the proposed reputation system

Through reviewing Figures 4.1, 4.2 and 4.3 – the ERD, the database tables, and the relationship schema, we understand how the ERD is translated into the database.

- The SERVICE PROVIDER entity is the 1 side of the "SERVICE PROVIDER earns TRUST" relationship. Note that each SERVICE PROVIDER occurs only once in the SERVICE PROVICER table.
- The TRUST entity is the M side of the "SERVICE PROVIDER earns TRUST" relationship. Note that the TRUST table contains several of the PROV_NUM values more than once.
- The SERVICE PARTICIPANT entity is also the 1 side of the "SERVICE PARTICIPANT gives TRUST" relationship. Note that each SERVICE PARTICIPANT occurs only once in the SERVICE PARTICIPANT table.
- The TRUST entity is the M side of the "SERVICE PARTICIPANT gives TRUST" relationship. Note that the TRUST table contains several of the PART_NUM values more than once.

- The SERVICE entity is the 1 side of the "SERVICE occurs in TRUST" relationship. Note that each SERVICE occurs only once in the SERVICE table.
- The TRUST entity is the M side of the "SERVICE occurs in TRUST" relationship. Note that the TRUST table contains several of the SERV_CODE values more than once.
- The RATING entity is the 1 side of the "RATING occurs in TRUST" relationship. Note that each RATING occurs only once in the RATING table.
- The TRUST entity is the M side of the "RATING occurs in TRUST" relationship. Note that the TRUST table contains several of the RAT_CODE values more than once.
- Some SERVICE PROVIDER and SERVICE PARTICIPANT may not occur in the TRUST table. Also, some SERVICE and TATING may not occur in the TRUST table, neither. It appears that TRUST is optional to those four tables: SERVICE PROVIDER, SERVICE PARTICIPANT, SERVICE and RATING. Reflecting the fact that some SERVICE PROVIDER and SERVICE PARTICIPANT have not established business yet and some services and ratings have not (yet) been used by any service participant.

4.2 Experiments

This section provides numerical examples illustrating how the performance of our proposed dynamic trust and reputation framework is used to evaluate the service provider's reputation by different parameters. These affecting parameters considered include mean rating without any decay, time decay, dollar value (involved in the

transactions) decay, and composite decay. Subsections 4.2.2 to 4.2.13 discuss the simulation experiments in detail. Although the data used in this simulation is random, artificial made, they do have solid and broad foundation to support real world business environment.

4.2.1 Setting up the simulation situation

Consider a simple service provider situation where it provides a series of online services to buyers (service participants) which they need some kind of services. We randomly assigned these services into categories listed in Table 4.1.

Table 4.1: The Category of Services

Category of Services	**Primary Service**
1	Appliances
2	Electronics
3	Toys
4	Gaming
5	Clothing & Shoes
6	Health & Beauty
7	Jewellery & Watches
8	Home & Garden
9	Bed & Bath
10	Exercise & Fitness

Furthermore, suppose that,

- The service provider can generate any number of transactions per month.
- Services participants will choose services at a random basis
- Since there are 10 service categories available, these number of transactions per month are randomly assigned to these services; therefore, some services may get

more transactions, some may get less or even none. This process is in line with the nature of the business.

- The simulated experiments were all started from January, ended at December. This means that we treat time window January to June as the first half year, while from July to December as second half year. The current month is December which does not have any contribution to the decay process as mentioned in section 3.3.

4.2.2 Experiment 1 - higher trust rating without decay

In this experiment, we consider the following situation:

- Service provider get higher trust rating (4 or 5) after each transaction for last 12 months
- No decay is implemented

4.2.3 Experiment 2 - higher trust rating with time decay

In this experiment, based on Experiment 1, we consider the following situation:

- Service provider get higher trust rating (4 or 5) after each transaction for last 12 months
- Only time decay is implemented

4.2.4 Experiment 3 - higher trust rating with both time and transaction value decay

In this experiment, based on Experiment 1, we consider the following situation:

- Service provider get higher trust rating (4 or 5) after each transaction for last 12 months

- Both time decay and transaction value decay are implemented

In Experiments 1 ~ 3 (Sections 4.2.2 to 4.2.5), we assume that service provider has very good business performance and get high rating (4 or 5) for all transaction. The comparison of service provider's reputation (before and after decay) for Experiments 1~3 is illustrated in Figure 4.4. The red curve represents the mean rating or reputation of service provider without any decay for the last 12 months, which implies that we are considering all the transactions happened in each month equally contributed to building provider's reputation. The value of each month's mean rating fluctuates along the baseline (4.5 is the statistical saturated value) which reflects that the provider's trustworthiness is pretty high. The green curve represents the reputation after applying the time decay factor, which coincide with the theory we discussed in Section 3.3, i.e., assign more weight to the more recent transactions depending how long the transactions take place from present time. The blue curve represents the reputation after applying transaction value decay for the past 12 months; this decay is small comparing to time decay which makes sense for the realistic business situation. While black curve represents the composite decay that combining time decay and transaction value decay for the service provider. Since we assume that service provider is in very good business and earns higher rating after each transaction, reputation (value) reinforces the provider's reliable trustworthiness even after considering two decay factors and still yields a higher reputation value. Table 4.2 lists service provider's present month, the recent six months and 12 months mean reputation values.

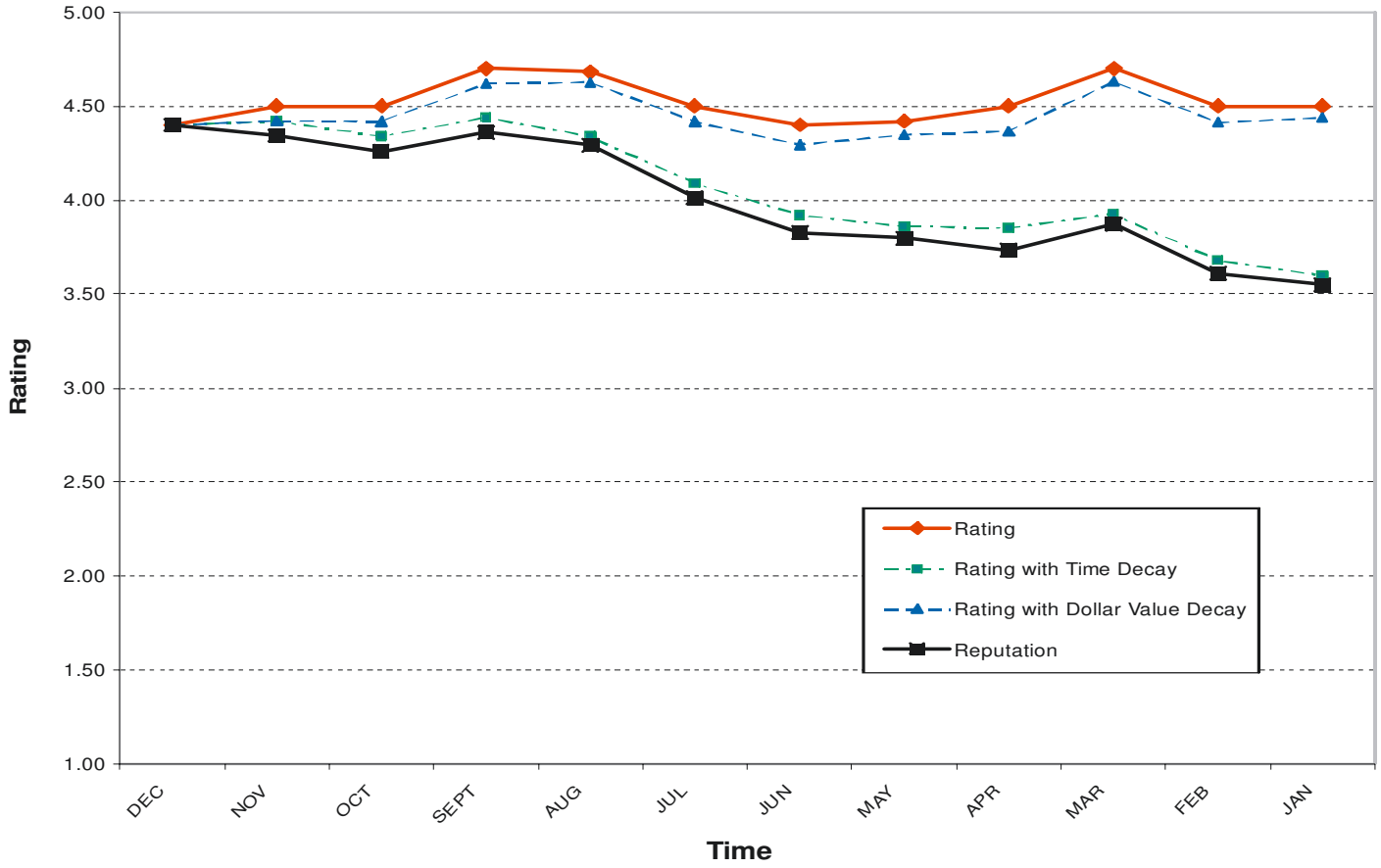

Figure 4.4: Comparison of reputation of service provider (before and after decay) for Experiments 1 ~ 3

Table 4.2: The mean reputation value of the service provider

(Experiments 1 ~ 3)

Month(s) (recent)	**Rating (without decay)**	**Rating (composite)**	**Overall Change (%)**
1	4.40	4.40	0.00
6	4.54	4.27	5.95
12	4.52	4.00	11.50

4.2.5 Experiment 4 - lower trust rating without decay

In this experiment, we consider the following situation:

- Service provider get lower trust rating (1, 2, 3 or 4) after each transaction for last 12 months
- No decay is implemented

4.2.6 Experiment 5 - lower trust rating with time decay

In this experiment, based on Experiment 4, we consider the following situation:

- Service provider get lower trust rating (1, 2, 3 or 4) after each transaction for last 12 months
- Only time decay is implemented

4.2.7 Experiment 6 - lower trust rating with both time and transaction value decay

In this experiment, based on Experiment 4, we consider the following situation:

- Service provider get lower trust rating (1, 2 or 3) after each transaction for last 12 months

- Both time decay and transaction value decay are implemented

In Experiments 4 ~ 6 (Sections 4.2.5 to 4.2.7), we tried to simulate the opposite case, which assumes that service provider does not have stable business performance and get lower ratings for most transactions but get higher ratings such as 4 on rare occasions. After running the experiments we can see in Figure 4.5, the mean rating or reputation of service provider without any decay is in pretty low level for the last 12 months, which fluctuates along the baseline (2.5 is the statistical saturated value). This means that the service provider maintains the reputation levels between "Good" and "Fair". The green and blue curves represent the reputation after applying the time decay factor and transaction value decay factor, respectively. Once considering the time decay and transaction value decay factors, the reputation of service provider is obvious even in lower level. Table 4.3 lists service provider's present month, the recent six months and 12 months mean reputation values.

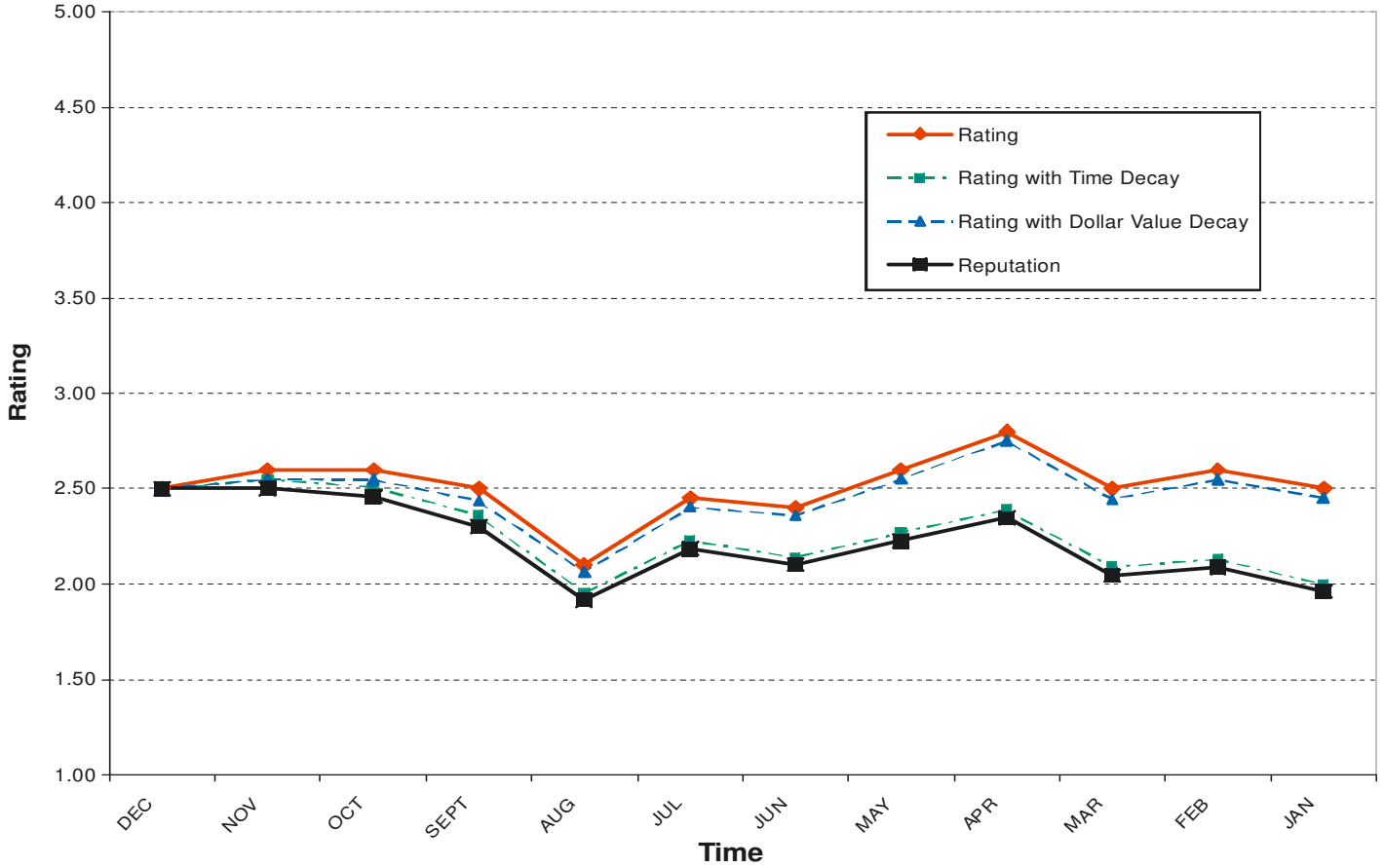

Figure 4.5: Comparison of reputation of service provider (before and after decay) for Experiments 4 ~ 6

Table 4.3: The mean reputation value of the service provider

(Experiments 4 ~ 6)

Month(s) (recent)	**Rating (without decay)**	**Rating (composite)**	**Overall Change (%)**
1	2.48	2.48	0.00
6	2.46	2.31	6.10
12	2.53	2.23	11.86

4.2.8 Experiment 7 - lower trust rating for the first half year and higher trust rating for the second half year without decay

In this experiment, we consider the following situation:

- Service provider get lower trust rating (1, 2, 3 or 4) after each transaction for the first half of the calendar year but get higher trust rating (4 or 5) after each transaction for the second half of the calendar year
- No decay is implemented

4.2.9 Experiment 8 - lower trust rating for the first half year and higher trust rating for the second half year with time decay

In this experiment, based on Experiment 7, we consider the following situation:

- Service provider get lower trust rating (1, 2, 3 or 4) after each transaction for the first half of the calendar year but get higher trust rating (4 or 5) after each transaction for the second half of the calendar year
- Only time decay is implemented

4.2.10 Experiment 9 - lower trust rating for the first half year and higher trust rating for the second half year with both time and transaction value decay

In this experiment, based on Experiment 7, we consider the following situation:

- Service provider get lower trust rating (1, 2, 3, 4) after each transaction for the first half of the calendar year but get higher trust rating (4, 5) after each transaction for the second half of the calendar year
- Both time decay and transaction value decay are implemented

Experiments 7 ~ 9 (Sections 4.2.8 to 4.2.10), demonstrate another business situation, which assumes that service provider get unstable trust rating (1, 2, 3 or 4) for each transaction for the first half of the business calendar year but having business improved and get higher trust rating (4 or 5) for the rest transactions of the second half of the calendar year. In Figure 4.6, it can be seen that the reputation of the service provider is kept in lower level in first half of the year; however, due to the fundamental changes of business management, its reputation value has drastic increased. If we only consider the recent 6 months' performance, the provider apparently has higher trustworthiness value; however, once we have decided to consider year round performance, the provider's reputation has to downgrade to the next level which is "Good" due to the first half business performance. If the service provider keeps getting good feedbacks after, its reputation will be at a better value as suggested by this model. This is the example of reputation change from bad to good. This model encourages service providers to provide consistent good services, to improve their services; punishes those to provide poor services or to downgrade their services as shown in Experiments 10 ~ 12. Table 4.4 lists

service provider's present month, the recent six months and 12 months mean reputation values.

Table 4.4: The mean reputation value of the service provider

(Experiments 7 ~ 9)

Month(s) (recent)	**Rating (without decay)**	**Rating (composite)**	**Overall Change (%)**
1	4.61	4.61	0.00
6	4.54	4.28	5.72
12	3.40	3.07	9.71

4.2.11 Experiment 10 - higher trust rating for the first half year and lower trust rating for the second half year without decay

In this experiment, we consider the following situation:

- Service provider get higher trust rating (4,5) after each transaction for the first half of the calendar year but get lower trust rating (1, 2, 3) after each transaction for the second half of the calendar year
- No decay is implemented

4.2.12 Experiment 11 - higher trust rating for the first half year and lower trust rating for the second half year with time decay

In this experiment, based on Experiment 10, we consider the following situation:

- Service provider get higher trust rating (4,5) after each transaction for the first half of the calendar year but get lower trust rating (1, 2, 3) after each transaction for the second half of the calendar year
- Only time decay is implemented

4.2.13 Experiment 12 - higher trust rating for the first half year and lower trust rating for the second half year with both time and transaction value decay

In this experiment, based on Experiment 10, we consider the following situation:

- Service provider get higher trust rating (4,5) after each transaction for the first half of the calendar year but get lower trust rating (1, 2, 3) after each transaction for the second half of the calendar year
- Both time decay and transaction value decay are implemented

Experiments 10 ~ 12 (Sections 4.2.11 to 4.2.13), demonstrate opposite business situation of Experiments 7 ~ 9, which assumes that service provider gets average higher trust rating (4 or 5) for each transaction during the first half of the business calendar year; however, the provider gets into business dilemma since then and has lower trust ratings for the rest transactions of the second half of the calendar year. As the result, its reputation for the recent months is lower even though the provider has a higher trustworthiness value in the first half year, because when reputation value being calculated by this model, the trust value from earlier time contributes less due to time decay as showed in Table 4.5. The overall change of the mean reputation value after considering time decay and transaction value decay for the recent six months (second half year) is 6.20%; comparing with the

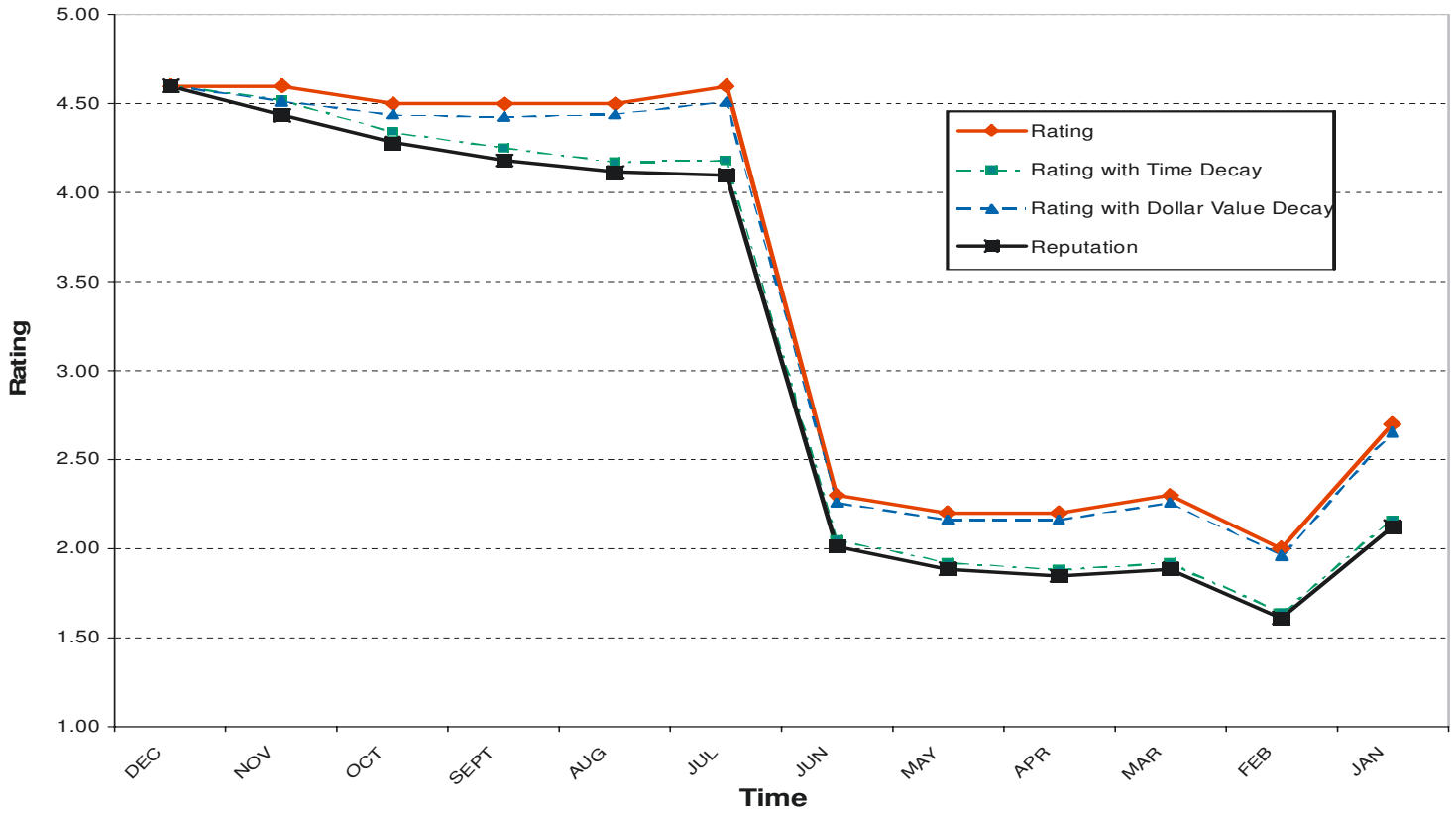

Figure 4.6: Comparison of reputation of service provider (before and after decay) for Experiments 7 ~ 9

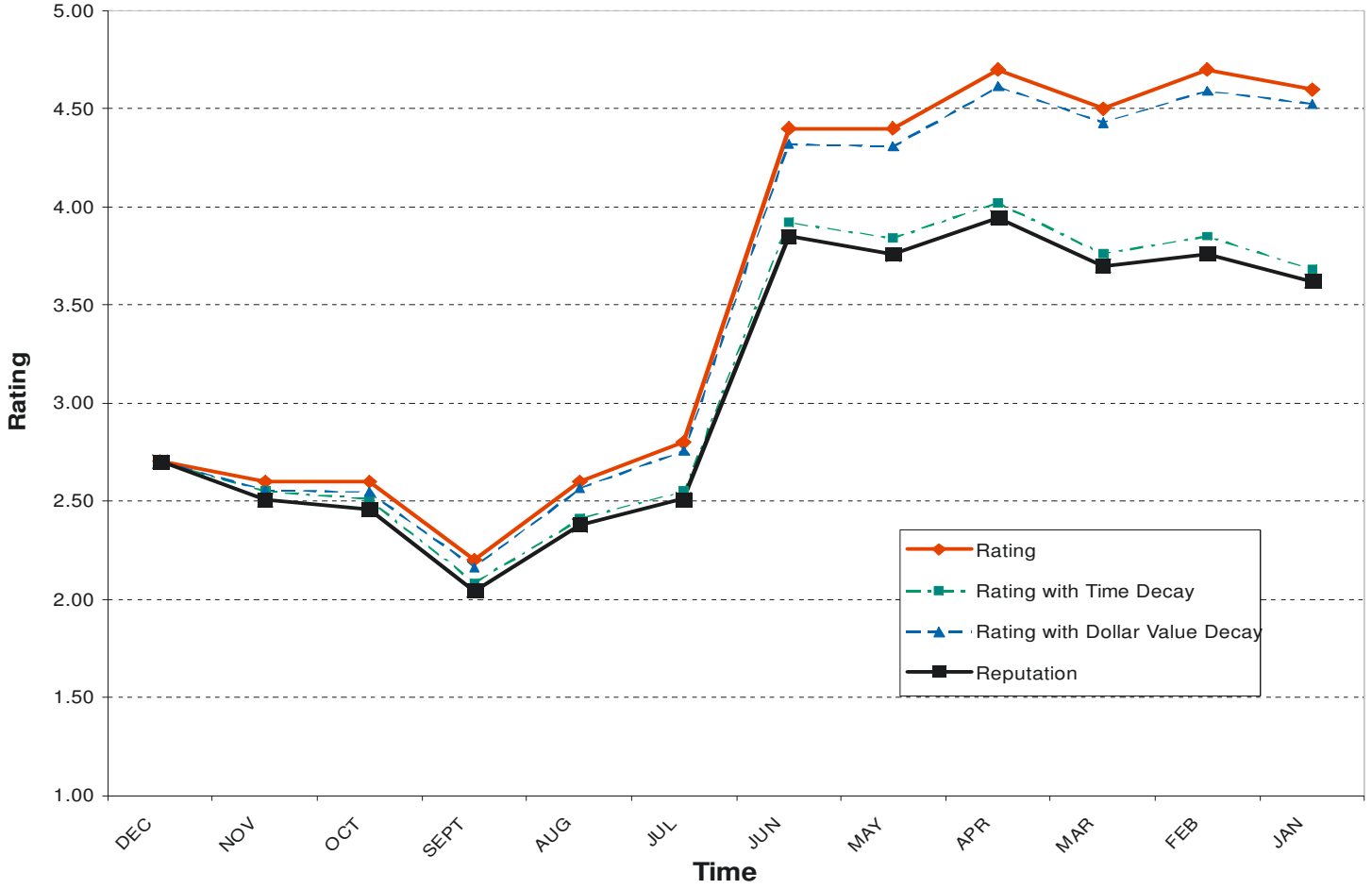

Figure 4.7: Comparison of reputation of service provider (before and after decay) for Experiments 10 ~ 12

year round overall change 13.20%; this result is in compliance with our proposed dynamic trust and reputation framework; i.e., the longer the time involved, the more contribution to the overall change of the service provider's performance. The trend of the reputation is illustrated in Figure 4.7.

Table 4.5: The mean reputation value of the service provider

(Experiments 10 ~ 12)

Month(s) (recent)	**Rating (without decay)**	**Rating (composite)**	**Overall Change (%)**
1	2.65	2.65	0.00
6	2.58	2.42	6.20
12	3.56	3.09	13.20

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

In this thesis, a novel application of dynamic trust and reputation system framework is presented for Internet marketing. It details the design, implementation and evaluation on the usage of this system based on the trust and reputation concepts. The algorithm takes into account three factors or called the triple constraints, i.e., quality of service, transaction time, and transaction value which are involved in evaluating process of provider or participant's honesty and responsibility; therefore, the system can give more reliable and reasonable trustworthiness value of the service providers or participants. The core idea of the framework's algorithm is to express quantitatively representing the trustworthiness of the service providers or service participants.

5.1 Conclusions

The system framework has been examined based on different decay factors to evaluate performance of service providers through a series of simulations.

Our algorithm has given precisely depreciating functions which describes how past trustworthiness values evaporate or decay. In the thesis, all possible business cases have been studied. The evidence from model and simulations analysis has suggested that service providers should maintain consistent good services, or improve their services if they are not proper as soon as possible to keep their reputation in higher levels; otherwise, they would be "punished" and obviously downgrade their trustworthiness values and eventually, may lose their business. The results also show that the proposed framework reaches an acceptable level of representing the reputation of service providers or

participants. In the two special cases (sections 4.2.8 to 4.2.10 and sections 4.2.11 to 4.2.13), the former represents the business scenario from unstable to reach a high level along the calendar year; while the latter demonstrate the opposite situation, i.e., business is in a dilemma after first half year's success. As a result, the overall changes (year round) for two cases were 9.71% and 13.20%, respectively. The number clearly shows the objective of the model in this essay to each internet service provider, that is, if they want to keep good reputation for their business, they have to keep good services all the time or improve their service as soon as possible after unsatisfactory services. Even their business was good in the past, for some reasons their services start to get worse, they will be punished by a big drop in their overall reputation value as shown in the latter case. This is very significant because it has proved that time decay factor can actually play an important role during the evaluation process of service providers since we assign more weight to the more recent transactions depending how long the transactions take place from present time. While transaction value decay has less effect comparing to time decay which makes sense for the realistic business situation. As we stated in our hypothesis, if service provider keeps higher reputation, then this provider will get more business or more transaction value in total; as a result of our algorithm, is unlikely to dilute the provider's trustworthiness even after considering two decay factors and still yields a higher reputation value.

5.2 Suggestions for Further Research

There is still some work needs to be done to make this feasible system in practical in Internet market environments. Those are:

- Evaluate the performance of the proposed system framework with realistic data, for example, directly come from related Internet commercial markets, to compare with other traditional evaluation methods.
- A further refine work related to decay algorithms may be modified. Since we adopt the linear depreciating function in this thesis, exponential depreciating function may also be used if applicable.
- Since we randomly assigned 10 category services into monthly business transactions, the research work may go a step further, i.e., do detailed simulations about unique product or service and their contribution to the reputation.

The proposed dynamic trust and reputation system framework will be helpful and an alternative approach to overcome some limitations of reputation systems or feedback mechanisms currently in use and give more realistic trustworthiness value to reflect the reputation of the service providers.

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APPENDIX A

Simulations Data for Experiments 1 ~ 3 - higher trust rating

Transaction Date	No of Transaction	Mean Rating	Transaction Value (in thousands)
December	31	4.39	1.157
November	30	4.53	1.049
October	31	4.45	0.983
September	30	4.67	1.035
August	31	4.68	1.637
July	31	4.52	0.989
June	30	4.40	0.769
May	31	4.42	1.109
April	30	4.50	0.612
March	31	4.71	1.266
February	29	4.52	0.955
January	31	4.48	1.321

APPENDIX B

Simulations Data for Experiments 4 ~ 6 - lower trust rating

Transaction Date	No of Transaction	Mean Rating	Transaction Value (in thousands)
December	31	2.48	1.178
November	30	2.63	0.983
October	31	2.58	0.905
September	30	2.50	0.721
August	31	2.13	1.045
July	31	2.45	0.967
June	30	2.43	1.021
May	31	2.61	0.963
April	30	2.83	1.035
March	31	2.55	0.837
February	29	2.59	0.942
January	31	2.55	0.950

APPENDIX C

Simulations Data for Experiments 7 ~ 9 - lower trust rating for the first half year and higher trust rating for the second half year

Transaction Date	No of Transaction	Mean Rating	Transaction Value (in thousands)
December	31	4.61	0.843
November	30	4.57	0.957
October	31	4.45	1.304
September	30	4.47	1.100
August	31	4.48	1.347
July	31	4.58	0.943
June	30	2.33	0.976
May	31	2.16	1.002
April	30	2.17	1.019
March	31	2.26	0.963
February	29	1.97	0.949
January	31	2.65	1.071

APPENDIX D

Simulations Data for Experiments 10 ~ 12 - higher trust rating for the first half year and lower trust rating for the second half year

Transaction Date	No of Transaction	Mean Rating	Transaction Value (in thousands)
December	31	2.65	1.059
November	30	2.60	1.060
October	31	2.58	0.875
September	30	2.23	1.047
August	31	2.55	1.331
July	31	2.84	1.144
June	30	4.43	0.999
May	31	4.39	0.853
April	30	4.67	0.993
March	31	4.52	1.129
February	29	4.66	0.802
January	31	4.58	1.104

APPENDIX E

Symbols

f (i, c, t)	service provider's trust rating	22
t	transaction time	22
tc	current time	22
P	service provider	22
R_{decay}	mean decay rate month by month	20
R_{dollar}	decay rate based on time & transaction values	21
R_{time}	decay rate based on time	19
$TR(P, tc)_{time}$	mean trust rating based on time	22
$TR(P, tc)_{dollar}$	mean trust rating based on time & transaction values	22
$TR(P,tc)_{overall}$	overall mean trust rating	22
X	service participant	22