iPrice: a collaborative pricing system for e-service bundle delivery

Wei-Lun Chang*

Department of Business Administration,
Tamkang University,
151, Ying-chuan Rd., Tamsui,
Taipei County, Taiwan
E-mail: wlchang@mis.nccu.edu.tw
*Corresponding author

Soe-Tsyr Yuan

Department of Management Information Systems,
National Chengchi University,
64, Sec. 2, Zhi-nan Rd., Wenshan,
Taipei, Taiwan
E-mail: yuans@mis.nccu.edu.tw

Abstract: Information goods pricing is an essential and emerging topic in the era of information economy. Several researchers have devoted considerable attention to developing and testing methods of information goods pricing. Nevertheless, in addition, there are still certain shortcomings and challenges to be overcome. This study encompasses several unexplored concepts that have attracted research attention in other disciplines lately, such as collaborative prototyping, prospect theory, ERG theory, and maintenance from design, economic, psychological, and software engineering, respectively. Compared to other methods, our pricing model not only provides the feasibility but the applicability for information goods.

Keywords: information goods pricing; collaborative prototyping; ERG theory; prospect theory; electronic business; e-service; bundle delivery.

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Biographical notes: Wei-Lun Chang is currently an Assistant Professor at the Department of Business Administration, Tamkang University. He received his PhD Degree in MIS from the National Chengchi University in 2007. He majored in Computer Science for his BA and in Information Management for his MS. His areas of research include intelligent systems, data/text mining, mobile computing, and information goods pricing.

Soe-Tsyr Yuan is a Professor in the MIS Department, National Chengchi University. Her research interests include mobile/ubiquitous commerce, multi-agent systems, agent-based e-commerce technologies, data mining in business intelligence management, and agent-based service oriented computing.

1 Introduction

Due to the unique cost structure and product characteristics (Economics of IT, http://oz.stern.nyu.edu/io/pricing.html) of information goods, the possibility to follow traditional pricing strategies becomes unfeasible and the differential pricing strategy is recognised to be crucial. Varian (1995) identified two key pricing issues (price discrimination and bundling).

The nature of price discrimination, in general, aims at optimising the prices instead of lowering the prices, possibly from different perspectives. For instance, from the perspective of producers (i.e., maximised profits), a producer charges different users at different prices according to their different Willingness-To-Pay (WTP).

Conversely, bundling is another pricing issue identified by Varian (1995) as an approach to reduce the heterogeneity of consumers' WTP. A producer can gain more profit because of a higher average WTP achieved by bundling. Accordingly, the number of bundles, the bundle strategies and the factors of bundling are the main areas of concern in bundling. Besides the issues of price discrimination and bundling, another major issue is to furnish a synthesised method to manifest existing different perspectives of pricing in order to develop a comprehensive treatment of pricing in complex settings.

Several researchers have devoted considerable attention to developing and testing methods of information goods pricing. Nevertheless, in addition, there are still certain shortcomings and challenges to be overcome:

- lack of consumer involvement in the pricing process
- only the producer's perspective is considered (either cost-based or profit-based oriented)
- the prices are determined without interacting with consumers, based on maximum satisfaction.

Thus, dynamic pricing has become an essential issue recently and, of late, has been widely accepted to overcome this dilemma.

Dynamic pricing is a new version of the age-old practice of price discrimination that current technologies have made not only widely possible but also commercially feasible. Dynamic pricing is the dynamic adjustment of prices to consumers depending upon the value that these customers attribute to a product or service. Many industries, in the past, have attempted to segment their consumer markets in the hope of charging different prices. A variety of mathematical models have been used in computing dynamic prices. Naragari et al. (2005) provide a list of five categories of models, which are inventory-based models, data-driven models, game theory models, machine learning models, and simulation models (e.g., any combination of above models).

Conversely, the environment constantly changes with demands being uncertain and fluctuating all the way in a typical digital goods market. Hence, the machine learning-based models can put all available data into perspective and change the pricing strategy to adapt best to the environment. In this study, we seek to extend current pricing methods by addressing the gap in taking both parties (consumers and producers) into account, which could help to resolve the dilemma smoothly.

Accordingly, this study proposes a novel method for information goods pricing and investigates the intended contributions:

- provides a collaborative process that could generate several prototypes via trial and error in the pricing process
- deliberates the belief of consumer and producer by maximising utility and profit
- offers an appropriate service bundle by interacting with the consumer and discovering the actual needs.

The remainder of this paper is organised as follows. Section 1 elucidates the concepts relevant to information economy and discusses the issues associated with pricing methods. Section 2 presents a unifying framework for existing pricing methods. Section 3 presents the iPrice system framework. Sections 4–6 elaborate three principle modules of the system and the evaluation is furnished in Section 7. Section 8 comprises the summary and conclusion of the paper.

2 Literature

2.1 Background

2.1.1 Collaborative prototyping

Prototyping, which is the process of developing prototypes, is an integral part of iterative user-centred design; it enables designers to try out the ideas with users and to gather feedback (Nelson, 1961). The main purpose of prototyping is to involve the users in testing design ideas and get their feedback in the early stages of development; thus, reducing the time and cost (Abernathy and Rosenbloom, 1968).

Collaborative prototyping is a novel approach that is based on the notion of prototyping. Collaborative environments for product development have become the new design paradigm for engineering organisations. Collaboration permits greater information sharing, concurrent engineering, virtual prototyping and testing, and total quality management (Terwiesch and Loch, 2004). Additionally, the anticipated benefits of a prototype in reducing risk must be weighted against the time and money required to build and evaluate the prototype.

Collaborative prototyping identifies user requirements and furnishes feedback on the working design against the requirements. Moreover, it provides certain advantages:

- reduces development time, costs and risks
- requires user involvement to receive user feedback
- facilitates system implementation based on users' anticipation and satisfaction
- exposes developers to enhance the product in the future

2.1.2 ERG theory

ERG theory is a model of human motivation, which appeared in 1969 and was proposed by Clayton Alderfer, extended and simplified Maslow's Hierarchy in a shorter set. It approaches the question of "what motivates a person to act?" and assumes that all human activities are motivated by needs. ERG theory consolidated Maslow's five need categories into three; meanwhile, the letters ERG stands for three levels of needs:

Existence, Relatedness, and Growth (Alderfer, 1972). Further, the details for each category are described as follows:

- *existence needs*: include all the various forms of material and physiological desires (e.g., food, water, air, clothing, safety, physical love and affection)
- *relatedness needs*: involve relationships with significant other people (e.g., to be recognised and feel secure as part of a group or a family)
- *growth needs*: impel a person to make creative or productive efforts on his own behalf and on the environment (e.g., to progress towards one's ideal self).

Moreover, three relationships among different categories are identified in ERG theory, which are satisfaction-progression (moves up to higher-level needs based on satisfied ones), frustration-regression (moves back from current unsatisfied needs to lower-level needs), and satisfaction-strengthening (strengthen current level of satisfied needs iteratively). As for the implications for management, the ERG theory assists the managers in recognising that an employee has multiple needs to satisfy simultaneously. Furthermore, if growth opportunities are not furnished to employees, they may regress to relatedness needs.

2.1.3 Prospect Theory (PT)

Prospect Theory (PT) was developed by Kahneman and Tversky (1979) and is concerned with the behaviour of decision makers under risk. The definition of prospect theory is "decision making under risk can be viewed as a choice between prospects or gambles". Unlike Expected Utility Theory (EUT), which concerns itself with how decisions under uncertainty should be made (a prescriptive approach), prospect theory concerns itself with how decisions are actually made (a descriptive approach) (Markowitz, 1952; Galanter and Pliner, 1974).

Prospect theory has been successfully used to explain a range of puzzles in economics, especially for behavioural finance. Nevertheless, there are several phenomena which violate these tenets of expected utility theory such as certainty effect, reflection effect, and isolation effect. For example, if there is a problem for a person to make the decision that:

A 2400 with certainty

B 2500 with probability 0.33, 2400 with probability 0.66, and 0 with probability 0.

The result reveals that 82% of people chose (A) from the experiment. However, the rational decision maker is supposed to choose (B) with maximum utility (i.e., $2500 \times 0.33 + 2400 \times 0.66 = 2433$) from the viewpoint of expected utility theory. This demonstrates the certainty effect, which stands for people tend to weight and choose outcomes with certainty.

Furthermore, the reflection effect is the second critique for expected utility theory. The reflection effect implies that risk aversion in the positive domain is accompanied by the risk of seeking in the negative domain from the empirical data. Ultimately, the isolation effect means people often disregard components that the alternatives share and focus on the components that distinguish them.

Conversely, the decision maker is assumed to evaluate the prospects and choose the highest value among them according to the definition of V in terms of two scales: π and υ. The first scale, π, associates each probability p with a decision weight $\pi(p)$, which reflects the impact of p on the over-all value of the prospect.

The second scale, υ, assigns to each outcome x a number $\upsilon(x)$, which reflects the subjective value of the outcome. The outcomes are defined relative to a reference point which serves the zero point of the value scale. Thus, υ measures the value of deviations from the reference point as gains and losses.

The prospect theory is derived from behavioural finance of economics (Stigler, 1961). Prospect theory is a descriptive theory of making risky choices. In prospect theory, the mapping of real probabilities onto subjective decision weights is described by a special function called the 'π' function. Further, the mapping of real value onto subjective value is described by a special curve called the 'S' curve, which is defined in terms of losses and gains from a status quo.

2.1.4 Mental account

Mental accounting is the extension of prospect theory which divides utility into acquisition utility and transaction utility (Thaler, 1985). Acquisition utility is a measure of the value of a good obtained relative to its price, similar to the economic concept of consumer surplus. Transaction utility measures the perceived value of the deal.

For the analysis that follows, three price concepts are used. Let p be defined as the actual price charged for some good z. Next, $\overline{p}$ is defined as the value equivalent of z for some individual. Finally, let p^* be called the reference point for z. Thus, the acquisition utility is the net utility that accrues from the trade of p to obtain z which is designated as $\upsilon(\overline{p}, -p)$. Conversely, the measure of transaction utility depends on the price that the individual pays compared to some reference price (p^*). Formally, it is defined as the reference outcome, which means the value of paying p when the expected or reference price is p^* and is designated as $\upsilon(-p: -p^*)$.

Hence, the total utility from a purchase is the sum of acquisition utility and transaction utility. The value of buying good z at price p with reference price p^* is defined as $w(z, p, p^*)$ where $w(z, p, p^*) = v(\overline{p}, -p) + v(-p : -p^*)$. Additionally, the most important factor in determining p is fairness, which depends in large part on cost to the seller.

The concept of mental accounting applies prospect theory to move towards consumer behaviour. The mental account includes other features of prospect theory such as concavity of gains and loss aversion. Meanwhile, the total utility will be estimated more accurately from acquisition utility and transaction utility which furnish the notion of reference price. Thus, prospect theory can be linked with a great many other psychological and cognitive theories.

2.1.5 Software maintenance

Software maintenance has become a significant issue nowadays and previous researches have focused upon the prevention and elimination of errors in newly developed software. The goal of software maintenance is to produce software which is close to error-free.

Conceptually, variations in error rates are expected to be a function of either the software system or factors in the maintenance environment.

A maintenance process takes the previous version of the system as the main input; however, it is affected by other factors such as the skill of maintainers. The existing system can be examined with a measurement of reliability that can identify the system's static characteristics causing higher error rates. Meanwhile, most of these characteristics can be described as software size and complexity.

The maintenance model is proposed and used to identify managerially controllable factors which affect software reliability. The results reveal that high error rates may result from:

- frequent modification undertaken
- programmers with fewer experiences
- high reliability requirements.

Thus, the managers can make quantified judgements to reduce error rates via implementing a number of procedures, including enforcing release control, assigning more experienced maintenance programmers and establishing and enforcing complexity metric standards.

2.2 A unifying framework for pricing methods

In this section, we aim to provide a unifying framework of the pricing methods manifesting existing different perspectives of pricing and overview the main models of pricing. There exist some pricing taxonomy models classifying the pricing methods:

- Sundararajan (2004) categorised the pricing methods of information goods into usage-based pricing, fixed-fee (unlimited usage) pricing, and both fixed-fee and usage-based pricing
- Stiller et al. (2000) proposed a pricing classification model encompassing three dimensions (technical, research, and economical/social)
- Jain and Kannan (2002) identified four pricing strategies for online servers, which were connect-time-based, search-based, subscription-fee, and others.

Nevertheless, each of the aforementioned pricing classification models takes on a particular perspective in examining the pricing methods. A given perspective might be further segmented into a few sub-perspectives. However, a unifying framework of classification models of current pricing methods still awaits further development (Wang, 2004). Accordingly, we devise such a unifying framework which has two-fold benefits:

- providing a conceptually intuitive but comprehensive classification model
- suggesting possible areas of new pricing methods.

Various differences and commonalities in pricing paradigms for information goods were examined in the unifying framework. As for shared characteristics, the goal of each method was not necessarily to maximise profits, but rather to optimise pricing from different perspectives. Differences in terms of functional structural elements were extracted via categories in the unifying framework.

The strengths and weaknesses of methods were further analysed. The categories of tactic, perception and decision were used to investigate psychological factors. However, these methods merely regarded the psychology of consumers, based on qualitative considerations. Conversely, the categories of society, individual, versioning, and bundling are grounded in mathematical models developed using different viewpoints, such as those of consumers, producers and government. Each method is skewed toward a specific perspective. For instance, the perception category only regards the consumer perspective.

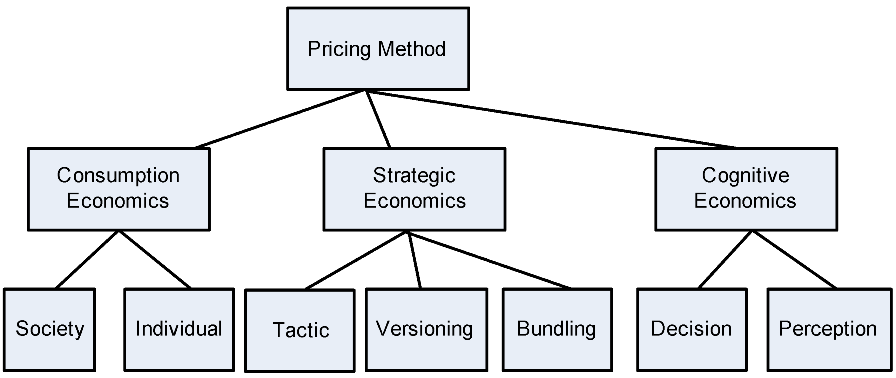
Rather, this study synthesises and analyses studies in terms of objectives, structural elements, and beneficiaries (e.g., consumers, suppliers, or government). The beneficiaries are stakeholders upon whom the current pricing research focuses. The taxonomy model is a comprehensive classification approach (as shown in Figure 1) that considers numerous perspectives when designing pricing approaches. Nevertheless, each perspective considers only some pricing issues for certain confined problems. Real-world problems frequently require consideration of numerous perspectives.

Novel pricing methods combined with synthesised perspectives can be devised to tackle real pricing issues. For example, the macro (versioning) and micro (bundling) perspectives can be considered simultaneously, thereby benefiting both producers and consumers. Hence, a Synthesis category, which combines pricing issues addressed in the other categories, was created to optimise pricing.

Compared with existing pricing taxonomy models, the proposed taxonomy model clearly assigns pricing methods to categories; this process will help in the creation of future pricing methods). In the proposed model, structural elements are unfolded for each pricing method category; these elements are used to identify the external behaviour required to achieve their respective purposes. Additionally, these elements can also be attached for method enhancement according to the affiliation of a new method.

The taxonomy model also recognises the strengths, weakness, opportunities, and threats of specific pricing methods. For example, when a new pricing method is located in several categories, the approach may not be too skewed or biased (strength) but, rather, too complex (weakness). The comparison of existing methods with the proposed method identified the differences and advantages/disadvantages (opportunities). Overall, the taxonomy model can compete with existing pricing methods (threats).

Figure 1 A unifying framework for information goods pricing



3 iPrice: conceptual framework

3.1 Research method

iPrice aims to provide a framework for an intelligent pricing method which encompasses the concept of value co-production. We synthesise certain approaches by studying reality and stressing utility of artifacts based on Jarvinen's taxonomy of research method (Jarvinen, 2000). This study builds an artefact, called iPrice, as a novel pricing system and evaluates it with proposed metrics. An artifact, in general, embodies two perspectives which are analytic and synthetic and can be characterised in terms of functions, goals, adaptability. Thus, this study applied the concept of design science to build and evaluate the artifact in terms of combining various theories and implementation.

3.1.1 System framework

The shortcomings of the extant pricing methods are addressed in Section 2; commonly, the focus is merely on specific category up to the present. Few researches offer a synthesised approach to information goods pricing. Additionally, a critical challenge occurs in omitting the interactive pricing process under risk to elicit the needs accurately. This synthesised approach, called the iPrice system, comprises a collaborative prototyping module, an optimal-price estimation module, and a version revisionary module as the major components of the system (as shown in Figure 2).

The Collaborative Prototyping module (CP module) is the core module; additionally, it discovers the most appropriate bundle by interacting with the individual. Next, the Optimal-Price Estimation module (OPE module) evaluates the price based on the related parameters offered by the collaborative prototyping module and considers the design fee, testing effort, and cost. Eventually, the version revisionary module (VR module) adjusts the version with the lowest profit periodically.

3.1.2 Pricing process

An interactive pricing process behind the system can be unfolded such as the notions of collaborative prototyping, prospect theory, need hierarchy, and software maintenance. The four sub-processes are divided as follows in Figure 3:

1. *Select one among versions*. The consumer chooses a version which contains various services. Meanwhile, these versions are generated and packaged via numerous service providers. Thus, the consumer perceives a version with bundled services that would satisfy current needs. If the version satisfies the needs without further rectification, the system estimates the price immediately; otherwise, the system enters into a collaborative prototyping process.
2. *Collaborative Prototyping* (*CP*). The system interacts with the consumer and generates prototypes continuously until it meets the needs. In this part, the system rectifies the initial version based on the customer's profile, pricing history, and service information as a new bundle. Conversely, if the system does not meet the needs, the loop of collaborative prototyping will continue.

3 *Needs prediction and price estimation*. The system applies the concepts of prospect theory and needs hierarchy as the analysis and prediction for furnish bundles. When the system completes the interaction, it will choose the optimal utility among the prototypes from that the consumer perceived. The system then estimates price which pursues testing efforts for prototypes, design fee for customisation, and services' costs into account, simultaneously.

4 *Appraise the profits and revise versions*. The system appraises the profits for each version periodically. Meanwhile, the version with the lowest profit would be replaced or revised by a new one, automatically, based on the knowledge-base.

Figure 2 System framework

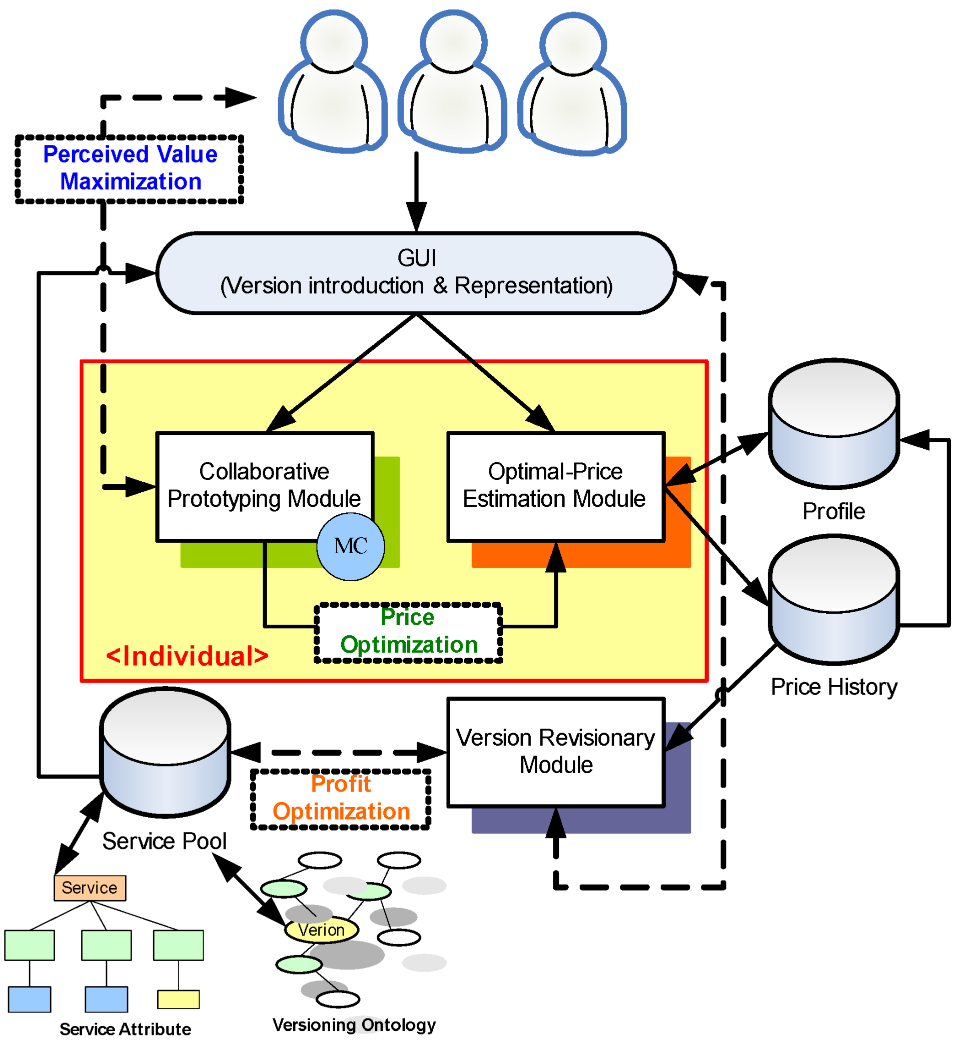
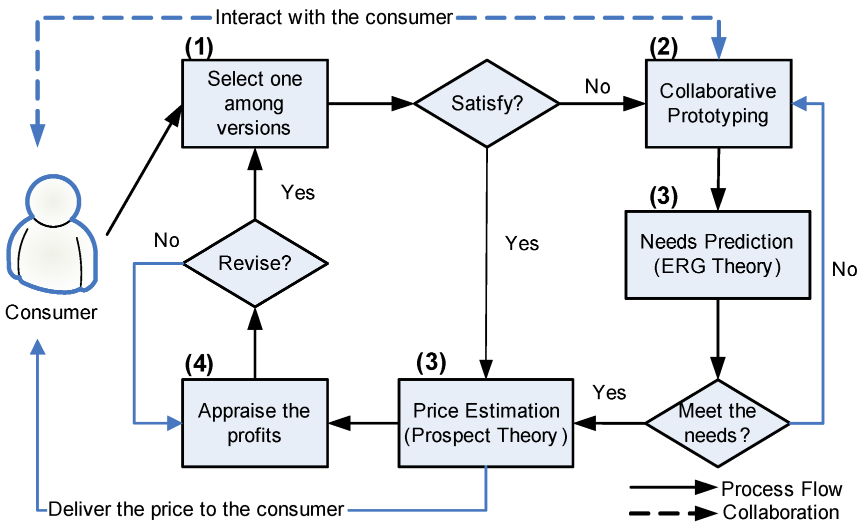


Figure 3 Pricing process of the system



3.2 Collaborative Prototyping module (CP module)

The CP module is the foundation among other modules; meanwhile, the aim is to co-design the bundle with the user that evolved from a selected version. There are two possible inputs for the collaborative prototyping module. A selected version from GUI is one of the inputs for this module while the user's feedback is another input that will enhance the quality of collaborative process. Conversely, an ultimate bundle and the utility are two outputs of the module. The bundle satisfies user's needs and enfolds the combinations of services.

The core concept of CP module is the mixture of collaborative prototyping and ERG theory to furnish customised bundles via interaction. The needs could be separated into three categories which are introduced in ERG theory. We assume that the user's needs shift among three categories time by time. The three different needs are identified as existence, relatedness, and growth needs. Moreover, a Markov chain is employed to predict the behavioural patterns of needs (with the assumption of a user's need shifting along variant time).

A Markov chain is a discrete-time stochastic process with the Markov property (only the current state is necessary for predicting a subsequent state or states and states prior to the current state are not needed if the current state is known). The Markov chain has certain advantages:

- finite states
- time interval
- probability-based
- dynamic.

We assume that our system is described at continuous times and states (each of which has known a finite number of possible outcomes). At these times the system may have changed from the state it was in the moment before to another, or remained in the same state. The changes of state are called transitions. The system is in the initial state (N^0) and the transition matrix (P). The possible states of need hierarchy at any time period can be determined according to the initial state and transition probabilities.

The state in a given period depends on the iteration of the state of preceding period (N^{t-1}) and the transition probabilities: $N^t = N^{(t-1)}P$. The initial probabilities of P are derived from the user's profile and will be rectified in accordance with the user's behaviour. The composition of the need hierarchy can be expressed in a row vector (e.g., $N^t = (E, R, G)$ where N represents a need hierarchy and t represents time).

Suppose we have a sequence with t frames and the states are represented by $\{N^1, N^2, N^3, \ldots, N^t\}$, where N represents the state at time t. The furnished bundles are denoted as $\{B^1, B^2, B^3, \ldots, B^T\}$. Each furnished bundle is conditionally dependent on only the previous state (i.e., $P(N^{t+1} = B^{t+1} \mid N^1 = B^1, \ N^2 = B^2, N^3 = B^3, \ldots, N^t = B^t) = P(N^{t+1} = B^{t+1} \mid N^t = B^t)$). Accordingly, the formula for the Markov chain to forecast the next state is $N^t = N^{(t-1)}P$.

In summary, collaborative prototyping identifies user requirements and furnishes feedback on the working design against the requirements. Moreover, it provides certain of advantages:

- reduces development time, costs and risks
- requires user involvement to receive user feedback
- facilitates system implementation based on user's anticipation and satisfaction
- exposes developers to enhance the product in the future.

3.3 *Optimal-Price Estimation module* (*OPE module*)

The OPE module is the most significant component in the estimation of the optimal price for charge. The inputs of the OPE module are the information of each bundle and the profile of the user. Meanwhile, the output is the optimal price that mixes and takes various inputs into account. The notion of the OPE module comprises the design of prospect theory and mental account which will be detailed in the following sub-sections.

The major components are identified in the OPE module as optimal price estimation, which are design fee, number of bundles, and testing efforts. The design fee stands for the costs for customised prototypes (i.e., bundles) and is estimated by the maximum utility among them. The number of bundles is related to testing efforts which consider whether the collaborative process is worthy and needs to be charged for the user.

The cost of a bundle stands for the costs for a sequence of services enfolded in a bundle. Accordingly, a formula emerges according to four identified components which is $P \geq D(U) + T(N) + C$, *where D is the design fee function*, *U is the maximum utility*, *N is the number of bundles*, *T is the function of testing efforts for collaborative process*, *and C is the function denotes the service costs for a bundle*.

Furthermore, it is essential for the OPE module to explore the maximum utility among bundles. The operational process for probing maximum utility is separated into two folds and formulated as $U = \upsilon(p) + \pi(p)$, which are prospect theory (the utility is equal to the value function by weight function) and mental account (the value function is the sum of acquisition utility and transaction utility).

As in the basis of the prospect theory, the value function and weight function are dissimilar according to different users. Supposedly, the value function and weight function initiate from normal distribution and adjust by the profile and behaviours of each individual, respectively. The value function is divided into acquisition utility (the value of good received that compared to the outlay) and transaction utility (the perceived merits of the deal).

Acquisition utility is the net utility (i.e., $\upsilon(\overline{p},-p)$ that accrues from the trade of p (i.e., the cost of a bundle and we assume that it is equal to the price needed to pay at least) to obtain z (where is valued at $\overline{p}$) which will be coded as the integrated outcome $\upsilon(\overline{p},-p)$. Additionally, the transaction utility depends on the costs that are compared to reference price p^*. Formally, it is defined as the reference outcome $\upsilon(-p:-p^*)$; in other words, it stands for the utility when the costs and reference price are p and p^*, respectively.

Furthermore, three functions in the formula are identified as design fee function (D), testing effort function (T), and cost function (C). Firstly, the design fee function is a convex and incremental function (map utility value to design fee). Secondly, the testing effort function is a concave and incremental function (map the number of bundles to testing effort). Ultimately, the cost function is a concave and incremental function (map number of services in the bundle to cost).

In short, the estimation for optimal price will be calculated from the sum of the design fee, the testing effort, and the cost. The design fee is based on the maximum utility from the concepts of prospect theory and mental account. Hence, the outlay for charge will become reasonable and be in accord with the maximum utility and profit for consumers and providers, respectively.

3.4 Version Revisionary module (VR module)

The VR module is based on the theory of software maintenance. The concept of the VR module is derived from software maintenance and the aim is to revise the version which may be unselected for a long time or yield lower profits than others. The inputs of the VR module are price history and the versions from the GUI module. The price history records the price for each bundle, which is related to the original version; thus, the system can estimate the profits for each version. Additionally, the output of VR module is the revised version that may replace the original one with lower profits.

The error rate (λ) is modelled as a stochastic variable whose mean varies from application system to application system, specifically as a multiplicative function of several explanatory variables pertaining to those systems. (A multiplicative form is used due to the impact of each variable being higher for higher levels of other explanatory variables rather than independent of other variables as in a linear model.)

In particular, the error rate is modelled as a random draw from a lognormal distribution with mean Lambda, the formula represents as $\lambda = f(\textit{static}, \textit{dynamic}, \textit{environmental})$, *where* $f(\cdot)$ *is a multiplicative function*. The lognormal distribution and the exponential distribution are widely used in the software reliability literature, both being consistent with the intuition that error rates should be distributed with an early peak and a single long tail.

The parameter value of error rate varies from application to application, based on the values of the structural variables which determine it. The following fixed effects regression model was estimated: ln $ERRORS = \beta_0 + \beta_1 \times S + \beta_2 \times C + \beta_3 \times OF + \beta_4 \times V + \beta_5 \times Sa + \beta_6 \times P + \varepsilon$, where β_0~β_6 is the weight coefficient for each indicator and ε is the residual parameter (as shown in Table 1). The independent variable (ERRORS) is defined as the unselected decision among all versions (i.e., unselect or select).

Table 1 The indicators of error rate

$\lambda = f(static, dynamic, environmental) = \ln ERRORS = \beta_0 + \beta_1 \times S + \beta_2 \times C + \beta_3 \times OF + \beta_4 \times V + \beta_5 \times Sa + \beta_6 \times P + \varepsilon$	
Static indicators	
Size (*S*)	The number of bundles
Complexity (*C*)	The number of different services in the version
Dynamic indicators	
Operational frequency (*OF*)	The number of bundles paid last month
Volatility (*VF*)	The version is subject to the number of frequent changes up to present
Environmental indicators	
Satisfaction (*Sa*)	The subjective score that is assigned by the user
Profit (*P*)	The average profit for each version

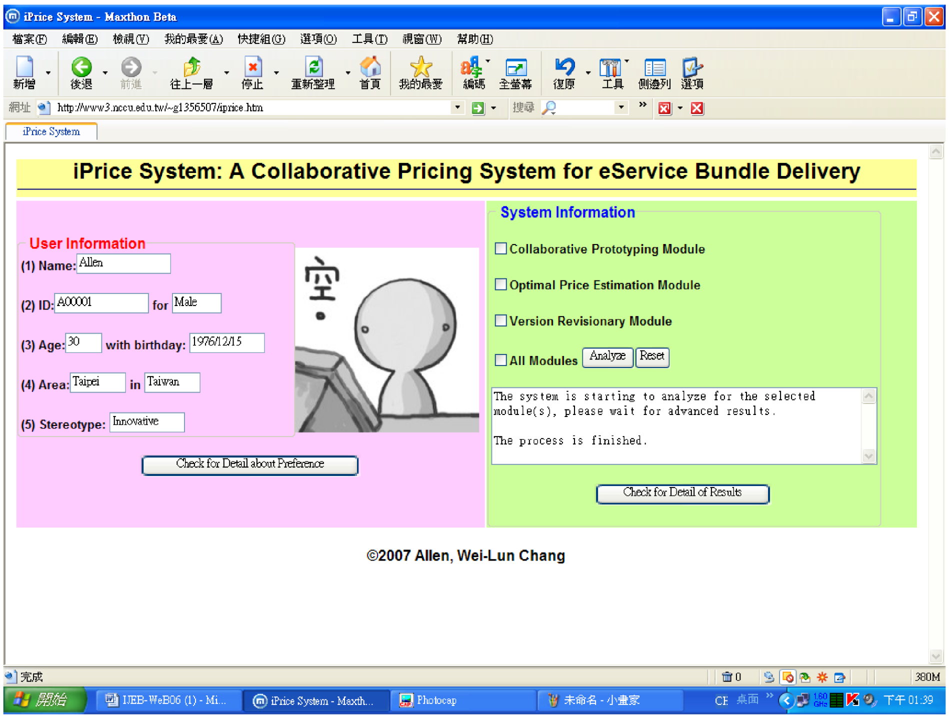
The system gathers the information for each version periodically and initiates the estimation of weight coefficients at a specific time. The independent variable ERRORS provides the clue to predict the discrimination among versions via the significance of weight coefficients. If the error rate is greater than an error threshold, the system terminates the computation. Meanwhile, the system rectifies the version(s) based on versioning ontology and service attribute taxonomy. Subsequently, the new version(s) will be assigned to replace the old one until all versions are verified.

In summary, the VR module is triggered by the system at a specific time period. The system sets a threshold to determine whether to trigger the revisionary process. If the process is in progress, the system reassembles the services inside the version and replaces the old one simultaneously. Thus, the un-profit version will be rectified and eliminated in order to provide better versions for choose.

4 A system prototype

A web-based system prototype, iPrice, has been designed to help users collaborate with service providers. The system (shown in Figure 4) includes the previously mentioned modules, e.g., CP module, OPE module, and VR module. This work used JAVA to design web pages based on the web 2.0 concept. The main web page furnishes two types of information. One is current user information, including name, gender, living area, etc. Another is system information that guides the service provider to analyse by choosing different modules.

Figure 4 iPrice system



The collaborative prototyping module provides two approaches to compare, which are ERG with a Markov chain and Maslow with Markov chain. Three stereotypes of users are also identified in the system–regular, extroverted and innovative. This module demonstrates the results based on different approaches (e.g., the changed probabilities are on the left and the transition matrix is on the right side, as shown in Figure 5).

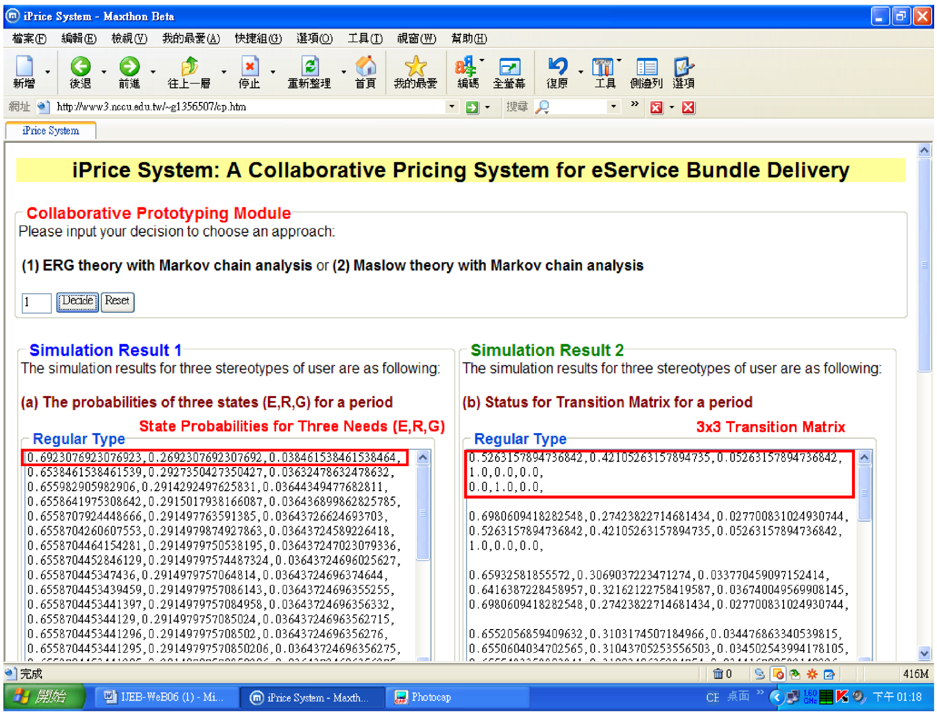
In the left side of Figure 5, each row represents the probabilities of three needs at a time slot. The system simulates 30 rounds used as the behavioural patterns for the three types of users. Conversely, on the right side of Figure 5, each square within nine probabilities represents a transition matrix at a given time slot. The system generates 30 different transition matrices for the three types of users.

The results also show that the needs converge to around 5–7 steps regardless of stereotypes. Additionally, this module predicts the possible needs of user behavioural patterns for the three types of users, Figure 6. The results would be to 0, 1 and 2 from the meanings of *E*, *R* and *G*, respectively, which help the system to decide on the appropriate e-service bundle to deliver and then interact with the user in the collaborating process.

The optimal price estimation module analyses two methods to estimate utility – EUT and prospect theory. The results (as shown in the lower side of Figure 7) for different probabilities (from 0.5 to 0.9) address certain information, such as average service cost, number of service in the bundle, the utilities and predicted prices for both methods.

Additionally, this module compares the utility between the approaches based on EUT or the prospect theory and shows that the prospect theory approach estimates the utility and price more realistically than the EUT approach. The prices between the two theories have big differences, based on high probability (e.g., $P = 0.7$, 0.8, 0.9), for decision, but are insignificant when the probabilities are low (e.g., P = 0.5 or 0.6), as shown in Figure 7.

Figure 5 Collaborative prototyping module (probabilities)



The VR module revises the less profitable version automatically and periodically. This module simulates three stereotypes of users and utilises the multivariate linear regression to analyse the significance of dependent variables. The coefficients of variables, the *F*-test, the *t*-test, and the *R*-square values are also represented in Figure 8. The results reveal that number of service and satisfaction are important variables to select decision.

Furthermore, this module gathers the detailed information about three initial versions and checks the lowest profit version. Next, the system triggers a knowledge-base to generate a new price based on the rules in the lower side of Figure 9. The new price is either greater both than previous and average prices of all versions or between them. Conversely, each recommendation represents the new price and profit, and average cost of the new version. The new price will be considered as the basic price to analyse for next time period.

Figure 6 Collaborative prototyping module (prediction)

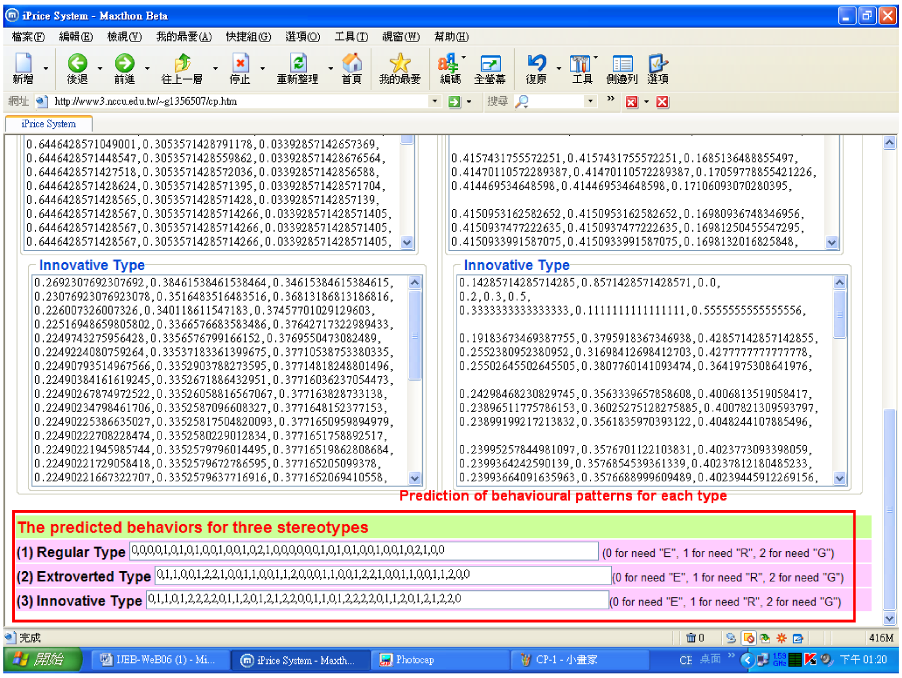
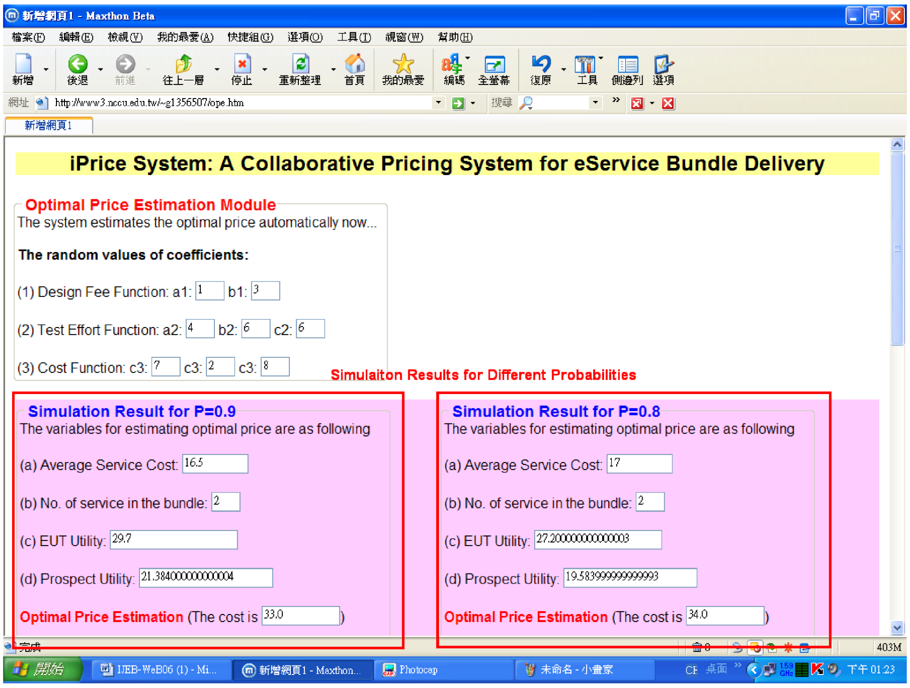
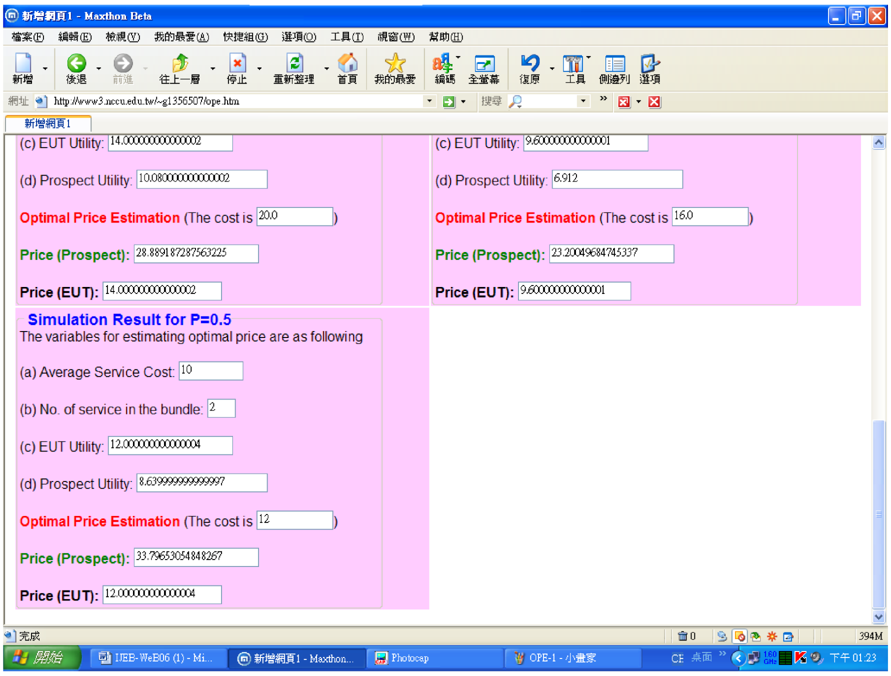


Figure 7 Optimal price estimation module



(a)

Figure 7 Optimal price estimation module (continued)



(b)

Figure 8 Version revisionary module (linear regression)

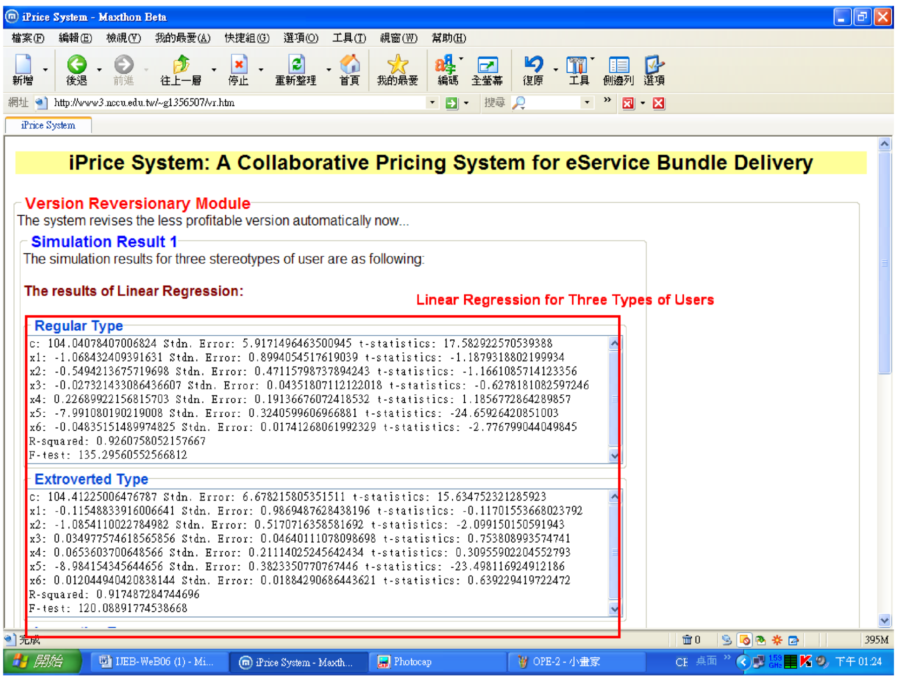
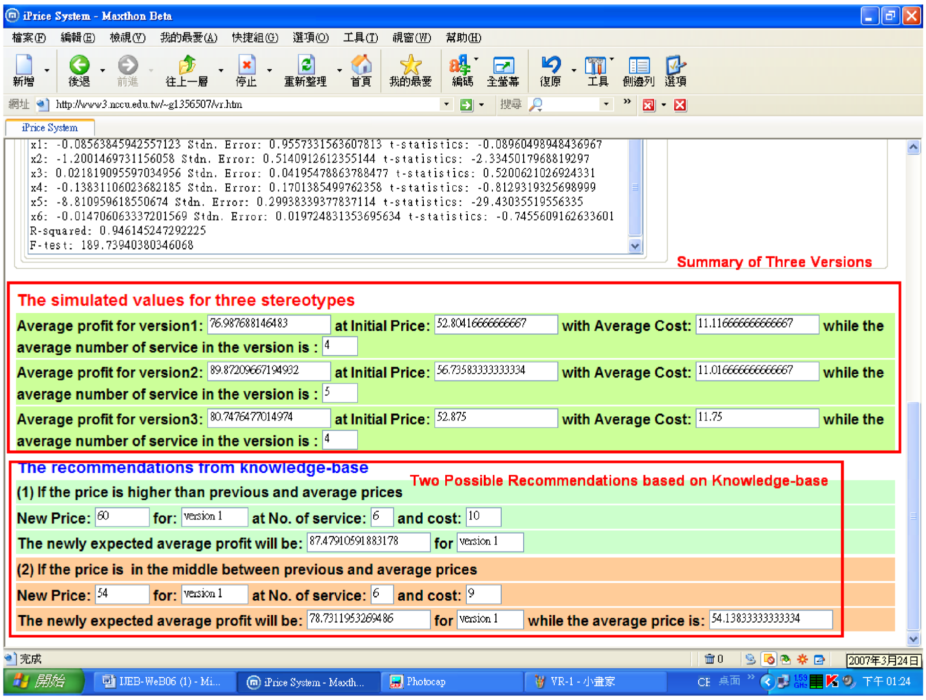


Figure 9 Version revisionary module (recommendations)



5 A case scenario

In this section, a case scenario will be demonstrated in the following story with a day for David, an elderly person who lives independently. We assume that there is an embedded-portal system at home and connects to the iPrice system. David is 64 years old and has been living in Taipei for ten years. His living habits are regular and simple; for example, waking up around 4 o'clock and taking a walk in the park in the morning. He cooks lunch for himself, takes a nap, and chats with friends in the afternoon. Finally, he eats lunch at around 4 o'clock and watches TV until 9 o'clock.

One day after taking a nap, it rains when David is going to exercise and thus disarranges the schedule. Hence, the embedded-portal system attempts to discover an alternative service which is innovative and may fulfil healthy requirements at that moment. This service is collectively decided upon by David's son, daughter, and family doctor simultaneously with their delegated agents. The system finally provides the video teaching Chinese shadow boxing at home and David can exercise regardless of the rain outside (innovative life-style).

Moreover, iPrice furnishes a collaborative prototyping process to shape the services to customisation in the aforementioned situation. For example, David not only needs to enjoy home movie service with his daughter but is also willing to play chess or learn cooking additionally. The iPrice system collaboratively generates with David the bundled services for him to try, and charges the bundled services based on the optimal utility.

The final price considers the collaborative process, charges for prototypes and testing efforts, and satisfies both parties with reasonable profits and price.

iPrice connects with the embedded-portal system (featuring ambient service accessibility, unbound information reach ability, innovative life style creation, and seamless social connection) in terms of the generation and pricing of the bundled services. iPrice provides the bundled services based on real-time customer's needs, delivers acceptable bundled services, charges for trial prototypes and testing efforts, and estimates the optimal price for not only the customers but also for the service providers.

6 Conclusion

Information goods pricing is an emerging and critical topic in the era of information economy. An appropriate method which takes the consumer and the provider into account simultaneously is essential nowadays. We put forward a novel pricing method for information goods which synthesises the notions of collaborative prototyping, ERG theory, prospect theory, and software maintenance.

The contributions of the new pricing method for the system are explained which:

- furnishes prototypes for the user during the collaborative process
- predicts the need for next time period proactively and accurately
- generates certain prototypes for trial
- estimates the optimal price based on maximum utility
- revises the versions with lower profits automatically.

Moreover, there are several implications for service providers which:

- generate prototypes in order to grasp user's feedback simultaneously
- grab the user's needs immediately so as to response quickly
- estimate the optimal price based on user's maximum utility
- rectify the versions with mobility except the automation by the system.

In short, the new pricing method for information goods fills the gap between previous literatures which only take the consumer or the provider into account.

Different from existing works, the proposed pricing method is novel in integrating distinctively important concepts yielding more benefits to consumers, and profits to more providers, based on an optimal price. The optimal price is assumed to be at equilibrium and generates maximum consumer and provider surpluses without any deadweight losses. Compared to non-collaborative prices, our pricing model not only provides the feasibility but the applicability for information goods. Thus, the synthesis method also guides and provides a roadmap for information goods pricing for future research.

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References

Abernathy, W. and Rosenbloom, R. (1968) 'Parallel and sequential R&D strategies: application if a simple model', *IEEE Transactions on Engineering Management*, Vol. 15, No. 1, pp.2–10.

Alderfer, C.P. (1972) *Existence, Relatedness, and Growth*, Free Press, New York.

Galanter, E. and Pliner, P. (1974) 'Cross-modality matching of money against other continua', *Sensation and Measurement*, Holland Reidel, pp.65–76.

Jain, S. and Kannan, P.K. (2002) 'Pricing of information products on online servers: issues, models, and analysis', *Management Science*, Vol. 48, No. 9, September, pp.1123–1142.

Jarvinen, P.H. (2000) 'Research questions guiding selection of an appropriate research method', *Proceedings of European Conference on Information Systems*, 3–5 July, Vienna University of Economics and Business Administration, Vienna, pp.124–131.

Kahneman, D. and Tversky, A. (1979) 'Prospect theory: an analysis of decision under risk', *Econometrica*, Vol. 47, pp.263–291.

Markowitz, H. (1952) 'The utility of wealth', *Journal of Political Economy*, Vol. 60, No. 2, April, pp.151–158.

Naragari, Y., Raju, C.V.L., Ravikumar, K. and Shah, S. (2005) *Dynamic Pricing Models for Electronic Business*, White Paper of Indian Institute of Science, April–June, Vol. 30, Parts 2–3, pp.231–256.

Nelson, R.R. (1961) 'Uncertainty, learning, and economics of parallel search and development efforts', *Review of Economics and Statistics*, Vol. 43, pp.351–364.

Stigler, G.J. (1961) 'The economics of information', *Journal of Political Economy*, Vol. 69, No. 3, June, pp.213–225.

Stiller, B., Reichl, P. and Leinen, S. (2000) 'Pricing and cost recovery for internet services: practical review, classification, and application of relevant models', *Economic Research and Electronic Networking*, Vol. 2, No. 1, January, pp.149–171.

Sundararajan, A. (2004) 'Nonlinear pricing of information goods', *Management Science*, Vol. 50, No. 12, pp.1660–1673.

Terwiesch, C. and Loch, C.H. (2004) 'Collaborative prototyping and the pricing of custom-designed products', *Management Science*, Vol. 50, No. 2, February, pp.145–158.

Thaler, R. (1985) 'Mental accounting and consumer choice', *Marketing Science*, Summer, Vol. 4, No. 3, pp.199–214.

Varian, H. (1995) 'Pricing information goods', *Proceedings of the Symposium on Scholarship in the New Information Environment*, Harvard Law School, Boston.

Wang, K.L. (2004) 'Pricing strategies for information products: a review', *IEEE International Conference on e-Commerce Technology for Dynamic E-Business* (CEC04EAST), Beijing, China, 13–15 September, pp.345–348.