A Web Service Model for Evaluating an e-Commerce Site: Mining On-Line Customers' Preferences

Hei-Chia Wang and Tian-Hsian Huang

Institute of Information Management, 1st, University Road, National Cheng Kung University, 701, Tainan, Taiwan

Summary

e-Commerce become a new way of doing business. Many businesses have built their own e-Commerce sites. Most of them cover lots of functions in one site. However, most company managers do not know how to evaluate the importance and the necessity of the functions on an e-Commerce site. In this paper, a web service model for evaluating e-Commerce function is presented to assist company managers to understand whether customers like their e-Commerce sites and which parts of the sites they like. Multiple regression and factor analysis is used in this service model, which is integrated with the multi-data sources to evaluate the functionality of e-Commerce components. Business organizations can use this service model to assess customers' preferences for an e-Commerce system. This evaluation service model can integrate multi-data sources to help chief information officers (CIO) to understand that which functions (or components) are really needed by the customers and can provide more supports for electronic customer relationship management (eCRM). After knowing the customers' preferences, system analyzers can then modify the electrical system development to fulfill customers' expectations. By using this evaluation service model, we aim to improve customers' satisfactions and to tighten the customer relationships. We illustrate the model with an example and draw managerial implications.

Keywords: e-Commerce function evaluation, evaluating model, eCRM.

1. Introduction

Customer Relationship Management (CRM) is a beneficial idea for an organization to maintain interactions with their customers in many ways. It has attracted much attention in the customer service department of most business organizations. There is no doubt that if a company wants to keep its advantage, it needs not only to attract new customers, but also to keep and maintain old valuable ones. In order to reach this goal, different technologies and services have been created and used for different types of customers. Use of electronic service on e-Commerce to extend the CRM of a company has been considered a common method [13].

Currently, use of an on-line system as an "interface" for customer interactions has become a trend. In order to attract customers to use the on-line system, advertisements, free on-line resources, and on-line services are three of the major methods for keeping old customers and getting new ones. Many studies found that getting new customers would cost much more than keeping old ones. Therefore, many companies start to devote more effort to keeping old customers on one brand forever. Related researches show that CRM has become an important issue [1, 2, 3, 7, 8,11, 15]. Some evaluation models for assessing customers' current values or potential values have been proposed [5,18,19]. In most of these models, customer-purchasing records are used to do the evaluation tasks. However, CRM needs to pay attention not only to the customer reactions, but also the companies' services. Good services will attract new customers and keep old ones. One of the popular services provided now is

on-line service, which are especially helpful to those customers who are busy at work. According to [13], eCRM could cover all the services in traditional CRM. It is expected that many companies will transfer their services on-line in the near future. This will make e-Commerce system include more services and grow into a complex system. Once it grows to a certain level, it is hard to know which part of this on-line system satisfies their customers most. In order to have an insight into which part customers like a site most, this paper proposes a service model for evaluating an on-line system. It will provide the system with the capability to analyze which functions or components that attract the customers most. Another reason for doing this is that most system analyzers design a system merely to analyze the value of the system and this usually will causes the site functionality unclear. Therefore, use of a good developing process with a good evaluation method will be a key to provide good on-line service.

To do this, a good developing process needs to be used for easier evaluation. We adopt the component-based developing method in this study. The component development method [6, 9, 14] has been regarded as a good way to build a system in the last decade and it changes the ways many project teams behaves. One of the main reasons is that components could be easily reused and their functionalities are clear. Once the component-based method has been implemented, any component can be inserted into or removed from a system easily. It means that a component can be added into a system when it is needed and can be taken away when it is no longer necessary for the system. Furthermore, this method is able to avoid wasting hardware resource and, at the same time, improve system performance. The evaluation service model proposed in this paper involves the component-based method for finding the effective factors of each component. The final reports generated by this model can provide some information to the CIO or system analyzers for deciding which function or component development they should concentrate on. The workflow of this model starts from running basic components for a period of time and collecting all available data for the basic components, which are the components included in most on-line system, such as company history, products list, and so on. After that, the decision makers need to decide several business policies that will affect the online system. By using this evaluation service model, the relations between the factors of business policies and the available variable can be found. Once the relations have been confirmed, new components can be added in one by one and run for a period of time for evaluation. The contents of referred resources adding in a period of time can be used to find the affection of each new component. The process of using this evaluation service model is shown in Figure 1.

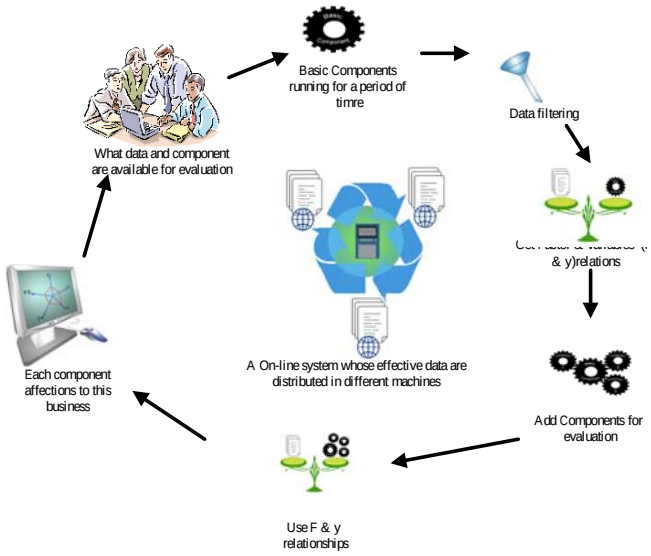

Figure 1. The workflow of the proposed evaluation model

This paper is organized as follows. In Section 2, the electronic customer relationship management and component-based implementation will be discussed. The scales used in the evaluation service model are outlined in Section 3. Section 4 describes the assessment procedure. Section 5 illustrates the procedure with application examples. Managerial implications are provided in Section 6. Finally, a summary and some conclusions are provided in Section 7.

2. Background

This section reviews the eCRM literature and component-based development methods for e-Commerce systems. The first part of this section focuses on eCRM. Next, the component-based development methods will be examined. After that, the possible e-Commerce system component value will be discussed and the conceptual model of this evaluation will be presented.

2.1 Electronic Customer Relationship Management

As seen in Figure 2, businesses orientations have undergone several changes in the last 150 years [2]. Each stage spanned across approximately half a century. Around 1850, business could be run if a company could produce something. In the early 1900, the growing competition drove a company to concentrate on motivating customers to purchase their products. From 1950, business administrators started to realize that they had to find out what people really need instead of trying to convince them to buy their products. However, this kind of market orientation has changed recently. Many leading firms are now ushering into a new orientation, called customer-centered orientation. This makes the customer relationship management an important issue in this stage.

CRM was paid much attention because customers have different preferences and purchasing habits. If all customers were alike, there would be little need for CRM [12]. Therefore, it can be seen that the most successful firms will be the ones practicing CRM. However, how to build a good CRM system is a big challenge to every company. CRM is a complex integration of company services and processes. In order to enhance the process speed to satisfy customers, information technologies are heavily used in dealing with this task. At the current age, the most popular method used to interact with customers directly is building a web site. Hence, the way to understand the customers' preferences is mining customers' preferences from their on-line behaviors. This new orientation has been proposed partly because the working style is changing. Many customers prefer to contact and interact with the organizations via the Internet. If this interaction style becomes popular, the current evaluation method cannot handle the fast changes. Therefore, the eCRM idea has been proposed in an e-Commerce system (Pan & Lee, 2003).

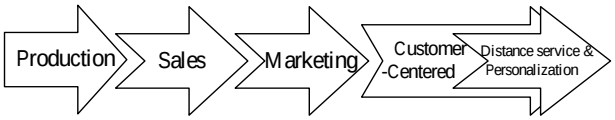

Figure 2. Business orientations of the last 150 years {modified from [2]}

2.2 The component-based development method

The component-based development method provides attractive benefits for building a web-based e-service system. The benefits are especially prominent when the components are used in a loosely coupled system [6]. It is possible that individual designers create components without communicating with each other in advance. This increases the possibility of component reusability.

Many researchers agree that organizations have the potential to benefit from software reuse [4, 9]. Component-based software development has the capability to achieve this. It was found that a component could:

(1) reduce the development cost and time to the market of an enterprise system,
(2) increase the reliability because each component undergoes several review,
(3) be easily replaced and improve the maintainability of a system, and
(4) enhance the quality of an enterprise system (Pour, 2000).

Moreover, many case studies have been published to prove that component reusing is a good way for system development [14, 17] especially when the e-service system is a loosely coupled system. Component-based

development is critical to the success of component reusing [6]. It is believed that component-based framework is suitable for e-service system development.

2.3 Component value to eCRM

Component management in an e-Commerce system involves administrative, performance, and value decision. The value decision includes evaluation of customer satisfactions. In the next section an evaluation service model for understanding is presented that which component provides the highest value to customers. This value can be used as an index of eCRM and it is also useful when this e-Commerce system needs to be rebuilt.

3. Service Model with Factor Analysis

An evaluation service model is constructed for assessing which component or function customers are interested in. In order to quantify the level of interest, the first step is to find observation variables and to collect data. The variable can be selected if it can reflect customers' preference. The data possibly come from log files, ERP database, or even the process records outside the business. If the random sample variables $y_{1,}y_{2,},...,y_p$, are used to represent observations from a homogeneous population with mean vector μ and covariance matrix Σ, efficiency scores $f_1, f_2, \ldots, f_m$ ($m < p$) are used to estimate the behavior of $y_{1,}y_{2,},...,y_p$, and are described as the following centered linear model:

$$\begin{aligned} f_1 &= \beta_{11}(y_1-\overline{y_1})+\beta_{12}(y_2-\overline{y_2})+\cdots+\beta_{1p}(y_p-\overline{y_p})+\varepsilon_1 \\ f_2 &= \beta_{21}(y_1-\overline{y_1})+\beta_{22}(y_2-\overline{y_2})+\cdots+\beta_{2p}(y_p-\overline{y_p})+\varepsilon_2 \\ &\vdots \\ f_m &= \beta_{m1}(y_1-\overline{y_1})+\beta_{m2}(y_2-\overline{y_2})+\cdots+\beta_{mp}(y_p-\overline{y_p})+\varepsilon_m \end{aligned} \quad (1)$$

In this linear model, $\overline{y}_i$ is the sample mean of y_i, $i = 1,2,\cdots,p$. β_{ij} are parameters and ε_i are error terms. This model satisfies three basic assumptions:

1. The error terms, ε_i, satisfy $E(\varepsilon_i)=0$, $Var(\varepsilon_i)=\psi_i$, and $Cov(\varepsilon_i,\varepsilon_j)=0$, for $i \neq j$,
2. The efficiency scores, f_j, satisfy $E(f_j)=0$, $Var(f_j)=1$, and $Cov(f_i,f_j)=0$, for $i \neq j$,
3. For all i and j, $Cov(\varepsilon_i,f_j)=0$.

With the theorem of factor analysis, the parameter matrix can be derived by the non-singular sample covariance matrix of y, S_{yy}, and the covariance matrix of y and f, S_{yf} ($\hat{B}=S_{yy}^{-1}S_{yf}$, $\hat{B}$ is the estimator matrix of β_{ij}). Hence the efficiency scores are estimated as

$$\hat{F} = YS_{yy}^{-1}S_{yf}, \quad (2)$$

where Y is the matrix form of y_i and $\hat{F}$ is the estimator of f_j. For computation purpose, by using the spectral decomposition method of linear algebra, equation (2) can be written as

$$\hat{F} = Y[(C_1D_1^{\frac{1}{2}})(C_1D_1^{\frac{1}{2}})']^{-1}(C_1D_1^{\frac{1}{2}}), \quad (3)$$

where

$$D_1^{\frac{1}{2}} = \begin{bmatrix} \sqrt{\theta_1} & 0 & \cdots & 0 \\ 0 & \sqrt{\theta_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sqrt{\theta_m} \end{bmatrix}$$

and C_1 is an orthogonal matrix which is deduced from the m largest eigenvalues (θ_i) and eigenvectors of S_{yy}. By using equation (3), the high-impact factors of each unobserved variable can be evaluated. This model can then be used to assess the effect of the software component on an on-line system.

4. Evaluation Procedure

This section discusses how to use the evaluation service model. An activity diagram, Figure 3, shows how the evaluation procedure is done. After that, the system architecture and how it interacts with its resoruces, shown in Figure 4, will be presented.

There is a precondition for using this evaluation service model. It requires that several basic components should be available and should have run for a period of time before

evaluating any function or component. After these basic components have run for a while, the observed variable data will be collected and the decision-maker will then define some unobserved variables of interest to the organization. After that, those high-impact observation variables data which might affect the unobserved variables will be grouped into suitable unobserved variable type. Those observed variables may come from different sources, such as system log, ERP system database, or even authorized collaboarted databases outside this company. After all these have been done, a component or a component set which needs to be evaluated will be added one by one into this system for a span of time. After a certain period, the decision-maker can check the effect of each component to the unobserved variables by using this decision model. This service model could then generate a report to show the effect of each component on the unobserved variables. The output format depends on the decision-maker's preference. It could be radar chart or any format the decision-maker likes.

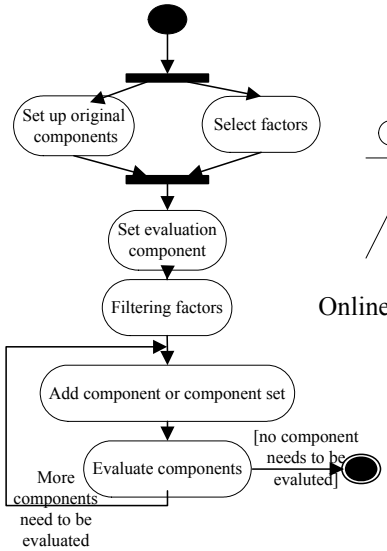

Figure 3. Evaluation procedure

5. Example Use

In this section, a medical on-line system is employed to test the service model. Parts of the data were collected from a healthcare center web site log.[1] First the dimension parameters, random unobserved variables $f_1, f_2, \ldots, f_5$ which decision makers consider related to eCRM, will be defined. Many studies have discussed the parameters for a medical on-line system, five unobserved variables referred from (Jutla et al., 2001; Kohli et al., 2001) have been concluded and are used in this paper. They are engage, order, fulfill, support, and eCare which maps to $f_1, f_2, \ldots, f_5$ of equation (1). After defining unobserved variables, all sample variables $y_{1,} y_{2,} ..., y_p$, available in the system log or database of the hospital will then be collected. Some of the collection items are referenced from the parameters of Baurer et al. (2002) suggestions and some are defined by this study. The parameters used in this case study are listed in Table 1.

Much data shown in this paper will be encrypted by a random generation program to protect identitiy and commerce secrets. This random data generator was written in Java. The data and program user interface are shown in Figure 5.

Figure 4. Evaluation service model and its data resources

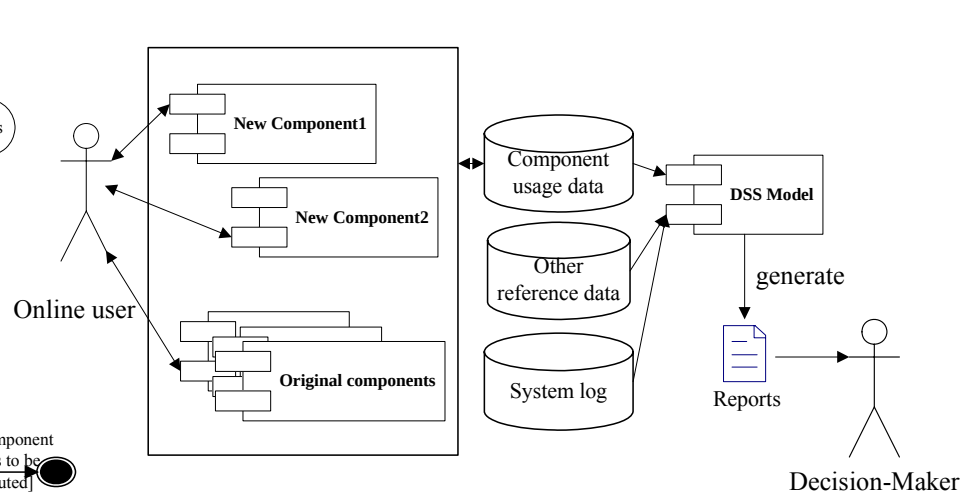

Table 1. The parameter items used in the case study {modified from (Baurer et al., 2002)}

[1] In order to ensure the data privacy, the data shown in this paper has been reorganized.

Engage (f_1)	Number of members (y_1) Amount of website browsing (y_2) Click rate of email advertising links (y_3)
Order (f_2)	Amount of treatment (y_4) Reply rate of email advertisements (y_5) Number of on-line registrations (y_6)
Fulfill (f_3)	Number of advanced registration people absent (y_7) Utilization rate of components (y_8) Run-time error rate of components (y_9)
Support (f_4)	Average execution time of components (y_{10}) Amount of medical e-news subscriptions (y_{11})
eCare (f_5)	Number of complaints (y_{12}) Number of telephone inquiries (y_{13}) Number of on-line FAQ browsers (y_{14}) Rate of patient check ups (y_{15}) Average number of website visits per member (y_{16}) Amount of messages on BBS (y_{17}) Reply rate of patient status reports (y_{18})

The data format in the output file (log.txt) is organized as "count number, number of observed variables, observed variable 1, observed variable 2, …., observed variable N". The file contents are used to indicate the log file number and log file name. For example, we can generate a file called "log.txt" with the contents "30, 5, patient, network, Homepage, Income, return" to mean that a customer has accessed this site 30 times and all data are saved in five log files called patient (y_1), network (y_2), Homepage (y_3), Income (y_4), and return (y_5). After this file has been generated, it can be included by the interface (Figure 5a & 5b). After generating random data and combining them with real data, this model will then provide an analysis result. One example of evaluating the on-line registration component in an on-line system is shown in Figure 6 which shows the effect of each dimension parameter on the on-line registration component in the radar map when this component was added to this system a few years ago.

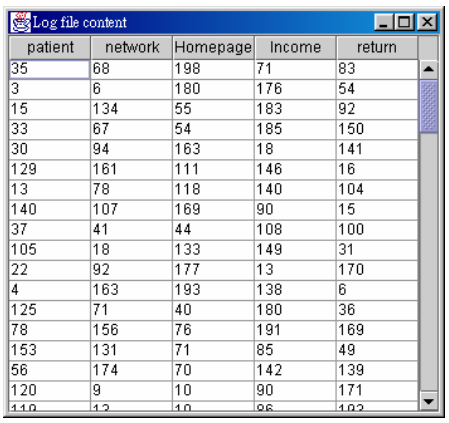

Figure 5a. Data generator for evaluation

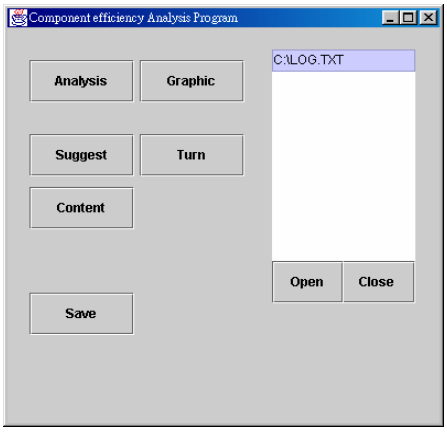

Figure 5b. Data generator for evaluation

The radar chart can then be generated as shown in Figure 7. It shows that on-line registration has the greatest effect on **engage** and **order** dimensions. According to this radar chart, a decision can be made by the decision support system, if it is available. This evaluation system will also provide a simple rule recorder, Figure 8, which was designed for decision-makers to give their suggestions when they check the model's reports. This information is significant reference to the future development of this web site if the CIO decides to update this on-line system, because the CIO could know the decision-makers' (such as dean of the organization) preferences and business orientation from these records before they

update the on-line system.

Online Registration Component	f_m ... f_1					
Observed variable / Date	Member Number y_1	Page viewed frequency y_2	Appointment number y_3	Component usage y_4	Retreatment frequency y_5	... y_l
3/2	321	3745	1834	43	42	...
3/3	23	5634	789	23	74	...
3/3	156	8632	498	52	17	...
. . .	. . .	. . .	. . .	. . .	. . .	...
3/30	593	2394	531	89	69	...

Figure 6. An example data of on-line registration component added into the proposed system

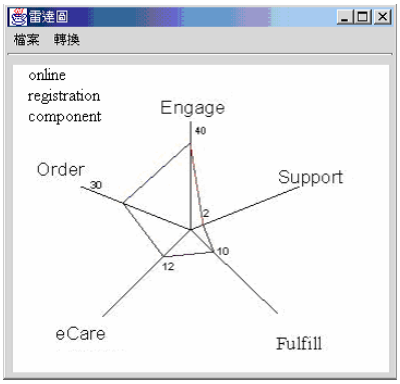

Figure 7.The result of component analysis

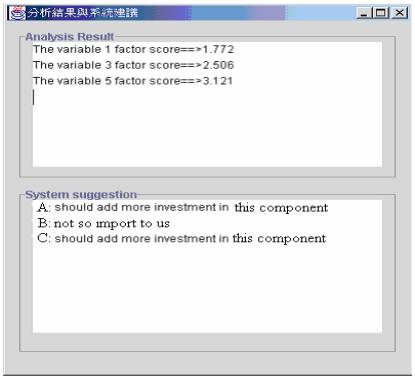

Figure 8. Result and decision-makers' records

6. Managerial Implications of this Service Model

Most companies aware that e-Commerce could be a new way of business and many of them have gone for it. Once the e-Commerce system is on-line, managers are urged to know what are improved by this system. Currently, most controllers and CIOs are frustrated with the lack of information they attain from the e-Commerce system. The way currently used to evalutate the e-Commerce system is to trace the pages that customers have accessed and it should not be the only way to understand the customer preference [18]. In order to give a deeper insight into the effects of an e-Commerce site, the propsoed serive porcess model uses enterprise resource planning (ERP) and customer data to support effective decision making. The main goal of this service model is to enable managers to use multi-data sources for strategic planning and managerial control of an e-Commerce system. One finding from this case study is that multi-data sources should be considered simulataneously. This service presented in this paper has the capability to integrate multi-data sources and provide more information then single data source. Furthermore, its reports can eliminate many manual tasks. For the example in the last secion, we only used two data sources, one from ERP system and the other from the e-Commerce log. Clearly the more data sources are applied, the more precise reports are generated.

7. Conclusion

One of the important works in dealing with the customer relationship management is to know what customers really need. In e-Commerce system, the customers' reactions (click ratios) and behaviors are important references to what kind of components they require. In addition, different business will have more observed variables for reference. Those observed variables would be used as reference of business operation. For example, some companies would prefer to have better income, and would focus more on those components affecting this variable. The service model presented in this paper can be used to evaluate the functions or components in an e-Commerce system and to provide the observed and unobserved value to a software component. The

evaluation result will be valuable information to decision-makers and CIO. This service model can be applied to most e-Commerce systems. However, the CIO needs to gather the unobserved variable and the observed variable into a proper set for the system. The final result of this model can be used as a decision support system input and a knowledge base to provide proper solutions.

Acknowledgement

The research was funded by NSC 91-2416-E- 006-025 project from National Science Council Taiwan.

References

[1] Bauer HB, Grether M, Leach M (2002) Building Customer Relations Over the Internet, *Industrial Marketing Management,* **31**(2), 155-163.

[2] Bose R (2002) Customer Relationship Management: Key Components for IT Success, *Industrial Management & Data Systems,* **102**(2), 89-97.

[3] Eriksson K and Vaghult AL (2000) Customer Retention, Purchasing Behavior and Relationship Substance in Professional Services, *Industrial Marketing Management*, **29**, 363-372.

[4] Griss ML (1993) Software Reuse: from library to factory, *IBM Systems Journal,* **32** (4), 548-566.

[5] Hesket JL, Sasser WE, and Schlesinger LA (1997) *The Service Profit Chain*, Free Press, New York.

[6] Hopkins J (2000) Component Primer, *Communications of the ACM*, **43**(10), 27-30.

[7] Jutla D, Craig J and Bodorik P (2001) Enabling and Measuring Electronic Customer Relationship Management Readiness, *System Sciences Proceedings of the 34th Annual Hawaii International Conference*, 2362 -2371.

[8] Karimi J, Somers T and Gupta YP (2001) Impact of Information Technology Management Practices on Customer Service, *Journal of Management Information System*, **17**(4), 125-158.

[9] Kim Y and Stohr EA (1998) Software Reuse: survey and research direction, *Journal of Management Information Systems*, **14**(4), 113-147.

[10] Kohli, R., Piontek, F.,Ellington, T.,Vanosdol, T.,Shepard, M. & Brazel, G. (2001) Managing Customer Relationship through E-business Decision Support Application: a case of hospital-physician collaboration, *Decision Support Systems*, **30**, 171-187.

[11] Ling R and Yen DC (2001) Customer Relationship Management: an analysis framework and implementation strategies, *Journal of Computer Information Systems,* **41**(3), 82-97.

[12] McKim B and Hughes A (2000) How To Measure CRM Success, *Target Marketing,* **Octber**, 138-149.

[13] Pan SL and Lee JN (2003) Using e-CRM for a Unified View of The Customer, *Communication of the ACM*, **46** (4), 95-99

[14] Pav H (1999) Architecture-Driven Component Reuse. *Information and Software Technology,* **41**(14), 963-968.

[15] Peppard J (2000) Customer Relationship Management (CRM) in Financial Services, *European Management Journal,* **18**(3), 317-327.

[16] Pour G (2000) Component Technologies: expanding the possibilities for component-based development of web-based enterprise applications, *Handbook of Internet Computing*, CRC Press, Boca Raton, 133-156.

[17] Sparling M (2000) Lessons Learned Through Six Years of Component-Based Development, *Communications of the ACM*, **43**(10), 47-53.

[18] Spiliopoulou M (2000) Web Usage Mining for Web Site Evaluation, *Communications of the ACM*, **43**(8), 127-134.

[19] Verhoef PC (2001) Predicting Custome Potential Value: an application in the insurance industry, *Decision Support Systems*, **32**(2), 189-199.