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The Optimization of Information Systems Outsourcing Strategies: A Constraint-Based Evolutionary Approach

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Abstract

Information systems (IS) outsourcing is an important issue of IS practices in organizations. To achieve better IS outsourcing performance, it is critical for organizations to develop appropriate outsourcing strategies. A prediction model is useful to forecast the possibility of a failure or to point out unforeseen problems. Based on a prediction model of IS outsourcing success, this study applied a constraint-based evolutionary approach for backward tracking the optimal values of organizational IS attributes that best approximate the target success level of IS outsourcing. One hundred forty-six real IS outsourcing cases, each with 22 features and 8 outcome features, are collected. The proposed system demonstrated that valuable suggestions can be made regarding the increase or decrease levels of adjustable IS attributes for organizations outsourcing their IS functions.

1. Introduction

Information systems (IS) outsourcing is an important option in managing the increasingly complex IS functions of organizations. Decisions for organizations to outsource part or all of IS functions are typically motivated by advantages in the competitive business environment. The main reasons for a corporation outsourcing IS functions include cost savings, accessing to new technologies and IS/IT expertise, focusing on its core business, improving IS service, and et al. [20]. However, without convincing possibilities of gaining such advantages, few organizations are willing to commit enormous resources and risk the loss of control over an important management function [23]. To make better IS outsourcing decisions and to achieve higher IS outsourcing performance, it is critical for organizations to develop appropriate IS outsourcing strategies.

Basically, appropriate IS outsourcing strategies can be formulated if effective models in predicting IS outsourcing success are employed. A prediction model can be used as a "What-If" mechanism to forecast the possibility of a failure outcome or to point out unforeseen problems. Our previous research developed a case-based system with a two-level weights design to predict IS outsourcing success [10, 11]. With the IS attributes of organizations as the case features, the proposed prediction model is able to forecast the potentially resulted benefits of IS outsourcing.

Based on the prediction model, this study further applies an evolutionary-based optimization technique to find out the decent values of adjustable IS attributes that best approximate the target success level of IS outsourcing. This is a parameter design problem that requires a backward tracking mechanism in search for the corresponding optimal values of adjustable input variables to match the target values of the outcome variables. That is, the optimal value of each adjustable input variable in the prediction model can be found to meet the expected outcome of IS outsourcing success within its valid value range if exists. The constrained-based genetic algorithms (CBGA) approach is employed for reducing the huge search space occurred in a parameter design problem.

The next session discusses the nature of IS outsourcing, strategy and success. This is followed by the methodology section that describes the CBR, a review of our previous study, that is, the case-based prediction model of IS outsourcing success, then the CBGA approach intended to resolve the parameter design problem in the domain of IS outsourcing. The final two sections discuss the experiment, the potential use of the results, and the possibilities for future research.

2. IS Outsourcing, Strategy, and Success

Today IS outsourcing has changed in many ways. For example, outsourced IS services are more likely to be telecommunication planning and applications [18], systems integration [8], and covering multiple systems and larger assets [7]. These changes make IS service providers increasingly involve in the business operations of the outsourcing corporations. The corporations therefore be more dependent on the capabilities of their IS service providers. Traditional "make or buy" thinking of IS outsourcing ignores the long-run and possible strategic implications [13]. IS outsourcing has become more strategic important than the view in the past.

As the scope and complexity of IS outsourcing expand, the reasons for corporations outsourcing their IS functions focus on business and technical considerations in addition to mere financial purposes. Financial benefits include cost saving and control, the economy of scale for IS resource and et al [9, 5]. Technical benefits include improving IS service, accessing to new technologies and technical talent [15]. Business benefits refer to the ability of a firm to focus on its kernel business and the enhancement of IT

capabilities [9, 21].

Grover et al. [9] assessed IS outsourcing success in terms of attainment of these benefits and defined success of outsourcing as the satisfaction with benefits from outsourcing gained by an organization as a result of deploying an outsourcing strategy. Their result showed that the relationship between the extent and success of outsourcing is likely to vary with different IS functions especially with system operations/ network management and maintenance. Lee [16] also examined the relationship between knowledge sharing and IS outsourcing success. His findings indicate that the service receiver's ability of absorbing the needed knowledge has a significant effect on IS outsourcing success.

In addition to the IS outsourcing extent and the knowledge sharing ability, a successful IS outsourcing practice also needs to address some important issues such as outsourcing evaluation [3], risk assessment [6], IS service provider selection [12], contract negotiation [14], and partnership cultivation [24]. However, most IS outsourcing researches focused on the decision model, the contract design and the relationship development required for effective outsourcing rather than IS resources management within an organization. This study employs a constraint-based evolutionary approach to determine the optimal values of organizational IS attributes. The result can be applied in guiding the IS resource allocation and investment so that the performance of the delivered IS resources can best approximate the target success level of IS outsourcing.

3. Methodology

3.1 Case-based Reasoning

CBR is a problem-solving method that is similar to the analogical decision making process. CBR can be considered as a reasoning process shown in Figure 1 [4].

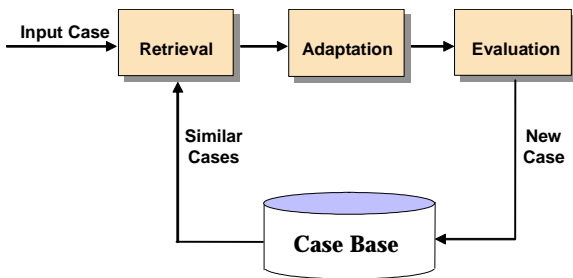


Figure 1. The CBR process

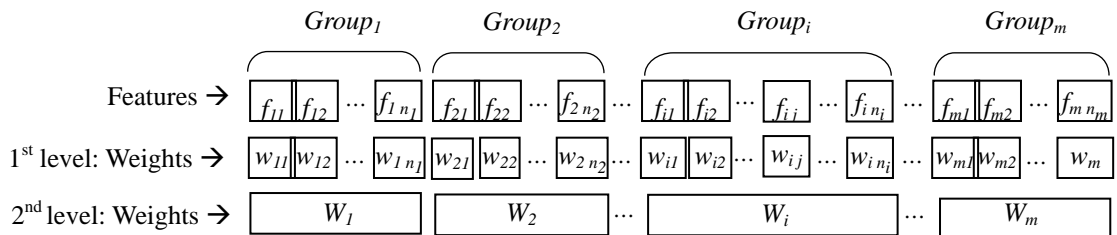


Figure 2. Two-level weight design

A description of the current problem as the input case is put into the CBR systems. The system retrieves the similar cases stored in a case base and then adapts similar cases to construct a solution for the current problem. The solution is later evaluated through feedback from the user or the environment. The new case can be incorporated into the case base for the use in future problem-solving.

A case is represented with features tied to a context. A case base consists of previous cases and their corresponding solutions. For each input case, features are used as indexes for retrieving similar cases. A weight is usually assigned to each case feature representing the importance of that feature to the match of the input case and retrieved cases. To design an appropriate case-retrieval mechanism in the retrieval stage, there are many evaluation functions for measuring the degree of similarity. An example of a similarity function containing the weights in the formula is shown in the following equation (1).

$$\sqrt{\sum_{i=1}^n W_i \times (f_i^I - f_i^R)^2} \quad (1)$$

where W_i is the weight of the i^{th} feature, f_i^I and f_i^R are the value of feature i in the input and retrieved case, respectively.

3.2 A Review of Previous Study

3.2.1 Two-level Weight Design

Hsu et al. [10, 11] have developed a case-based system with a two-level weight design to predict IS outsourcing success. To apply CBR to the IS outsourcing domain, IS outsourcing cases are collected from the questionnaire consists several IS attributes constructs within which question items are incorporated. These items are used to measure the constructs that are adapted from IS outsourcing literatures [2, 19, 17, 1, 9].

In the two-level weight design, as shown in Figure 2, there are several features sets ($Group_i$) according to the specific domain knowledge tied to the constructs. Each feature (f_{ij}) has a weight (w_{ij}) representing the importance of that feature to its corresponding group in the first level. In the second level, each feature set also has a weight (W_i) representing the aggregate importance of the group to the match of the input and retrieved cases.

where $i = 1$ to m , m is the total number of feature groups in a case. $Group_i$ is the i^{th} feature group. $j = 1$ to n_i , and n_i is the number of features in the i^{th} group. f_{ij} is the value of the j^{th} feature in the i^{th} Group. w_{ij} is the weight of the j^{th} feature in Group i , and capital W_i is the weight of the i^{th} Group.

In Figure 3, a similar notation is applied to the outcome features. Assume that there are q outcome features, where $i = 1$ to q , q is the total number of outcome features, and O_i is the i^{th} outcome feature value.

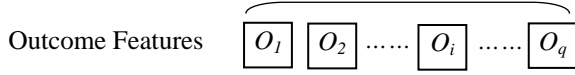


Figure 3 . Outcome feature

3.2.2 The Case-based Prediction Model

The overall system framework of the case-based prediction model is presented in Figure 4. The system consists of four major processes: *similarity process*, *weighting process*, *adapting process*, and *evaluation process*. The first two are corresponding to the retrieval phase in Figure 1.

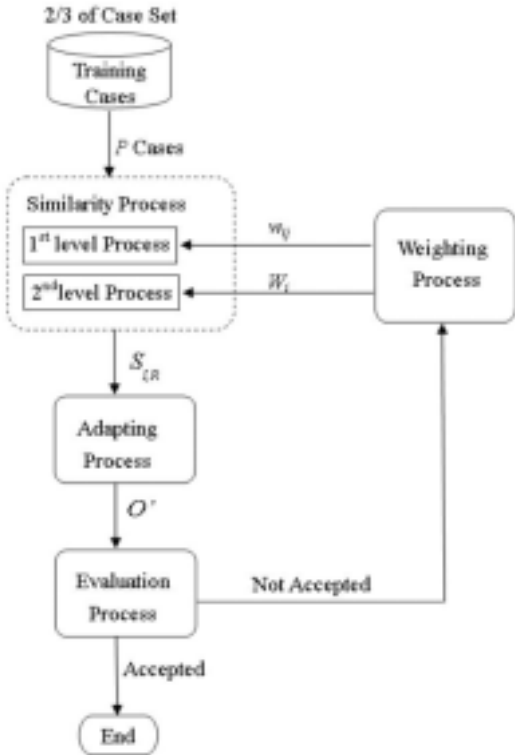


Fig 4. System architecture of prediction model

To effectively retrieve similar cases, the Similarity Process computes the similarity ($S_{I,R}$) between the input case and retrieved cases. The Weighting Process generates the weights to support the Similarity Process in which the GA is employed to determine w_{ij} and W_i . The $S_{I,R}$ is computed through two levels. In the first level, the similarity process computes similarities for each feature group (S_{Group_i}) based on equation (2). In the second level, the similarity process computes the aggregate similarity

($S_{I,R}$) between the input and retrieved cases based on equation (3).

$$S_{Group_i} = \sqrt{\sum_{j=1}^{n_i} w_{ij} \times \frac{1}{1 + |f_{ij}^I - f_{ij}^R|}} \quad (2)$$

$$S_{I,R} = \frac{\left[\sum_{i=1}^m W_i \times S_{Group_i} \right]}{\sum_{i=1}^m W_i} \quad (3)$$

where $i = 1$ to m , m is the total number of feature groups in a case. $j = 1$ to n_i , n_i is the number of features in the i^{th} group, w_{ij} is the weight of the j^{th} feature in Group i , f_{ij}^I and f_{ij}^R are the values of the j^{th} feature in Group i for the input and retrieved cases, respectively. S_{Group_i} is the degree of similarity for the i^{th} Group, W_i is the weight of the i^{th} Group, and $S_{I,R}$ is the aggregate similarity degree between the input and retrieved cases.

The Adapting Process aims to apply the outcome features of the most similar cases to generate a solution for the current problem, that is, the expected outcome features for a certain input case. This process adopts the cases with top 10% $S_{I,R}$ to generate a solution for the input case. If there are k cases with top 10% $S_{I,R}$, the expected outcome feature O_i' is computed based on equation (4). The composite outcome feature O' is computed by averaging the sum of all the expected outcome features O_i' , as shown in equation (5).

$$O_i' = \frac{\sum_{t=1}^k [S_{I,R}^t \times O_i^t]}{\left[\sum_{t=1}^k S_{I,R}^t \right]} \quad (4)$$

where $t=1$ to k , k is the number of cases with the top 10% $S_{I,R}$. $S_{I,R}^t$ is the t^{th} case with 10% $S_{I,R}$. O_i^t is the i^{th} outcome feature of the t^{th} case with the top 10% $S_{I,R}$. O_i' is the i^{th} expected outcome feature.

$$O' = \frac{\sum_{i=1}^q O_i'}{q} \quad (5)$$

where $i=1$ to q , q is the number of outcome features and O' is the composite outcome feature.

The Evaluation Process compares the expected outcome feature with the real one. As shown in equation (6), the Mean Absolute Error (MAE) is applied to evaluate the result.

Minimize

$$Y = \frac{\sum_{t=1}^p |O_i' - O_i|}{p} \quad (6)$$

where $t=1$ to p , p is the number of training cases. O_i' and O_i are the expected and real outcome feature of the t^{th} training case, respectively. Y is the Mean Absolute Error (MAE).

Chromosomes of the GA are designed for encoding the two-level weights. The fitness function is defined as the equation (6). The entire learning process stopped after 500 generations and generated the best approximate two-level

weights. Once these derived values were applied, this case-based prediction model demonstrated more accurate results than the equal weights approach and the regression method [10, 11].

3.3 A CBGA Approach

The overall CBGA system framework is presented in Figure 5. The CBGA approach integrates the constraint-based reasoning technique into the GA process. In general, the GA deals with constraints either by integrating a penalty into the fitness function (denoted as soft constraints) or by abandoning those invalid chromosomes after the whole population has been generated (denoted as hard constraints). The CBGA uses the constraint-based reasoning technique to perform the chromosomes filtering before each chromosome is constructed. For every gene in a chromosome, the CBGA checks the defined valid range to assure that chromosomes are made valid. That is, chromosomes are made to satisfy the requirements of constraints. Instead of checking chromosomes after they are constructed, the CBGA

excludes invalid chromosomes being made and therefore considerably reduces the search space compared with the general GA approach. The CBGA approach is especially suitable for solving a parameter design problem in which the search space could become very huge as the number of adjustable input variables increases.

Figure 6 illustrates the CBGA chromosome filtering process. A constraint-based reasoning technique called the local propagation is adopted. The local propagation uses the information local to the constraints to define the valid gene range (G_j domain). According to the restricted valid range denoted by the satisfactory universe S_{G_j} , the value of gene g_{ij} is replaced by a value randomly selected from S_{G_j} if the gene value is inconsistent with the constraints. By continuously executing the validation process on chromosome $C_i(g_{i1}, g_{i2}, \dots, g_{ij}, \dots, g_{im})$ in sequence ($j=j+1$), the new chromosome C'_i is thus able to satisfy the constraints. As a result the local propagation offers an efficient way to guide the GA toward searching for the optimal solution by reducing the search space already filtered because of the constraints.

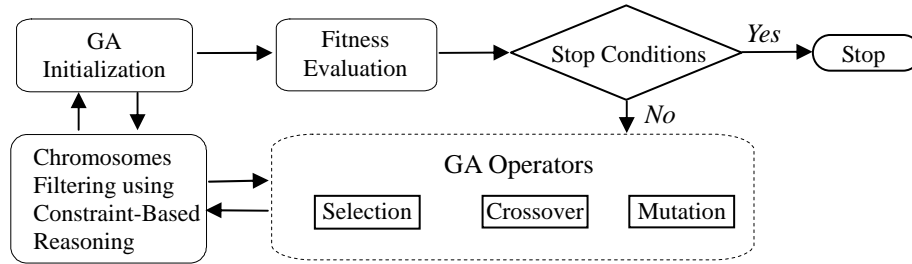


Figure 5. The CBGA system framework

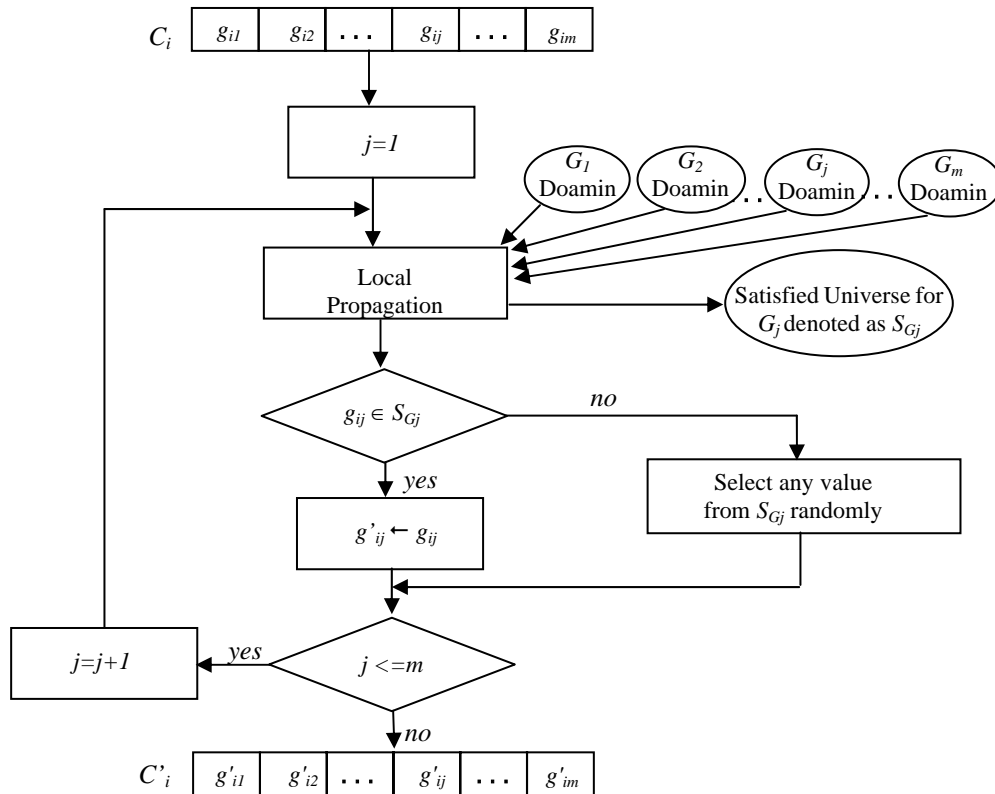


Figure 6. The chromosome filtering process

To apply CBGA to the IS outsourcing success domain, chromosomes are designed for encoding the values of the adjustable IS attributes. Their valid value ranges are considered as possible constraints. The fitness function is defined as the equation (7) in which the case-based prediction model ($CBR()$) is used to determine the predicted success level (O') for each chromosome (C') in the population. And O represents the target success level of IS outsourcing which has been set in advance. The function is to minimize the overall difference between the predicted outcome and the target one.

$$\text{Minimize} \\ \text{fitness} = |O - O'| ; \text{ where } O' = CBR(C') \quad (7)$$

4. The Experiments and Results

4.1 Case Description

Companies may outsource various services and products. To differentiate IS outsourcing from the diversity of outsourcing, the characteristics of the outsourcing target, IS attributes, are the basic components in describing the IS outsourcing situation. As shown in Table 1, four IS attributes are proposed as features for the IS outsourcing case, including IS asset specificity, IS measurement problem, IS strategic importance, and IS capability. The alphanumeric marks in the brackets used in Table 1 are the same as that used in Figures 2.

Table 1. Features for the IS Outsourcing Case

IS Asset Specificity($Group_1$)
Hardware & Other Equipments($f_{1,1}$)
Required IS Knowledge & Skills($f_{1,2}$)
Required Domain Knowledge & Skills($f_{1,3}$)
Operational Procedure($f_{1,4}$)
Trainings of IS Personnel($f_{1,5}$)
IS Requirements of Business($f_{1,6}$)
IS Measurement Problem($Group_2$)
Procedures of Most IS Activities($f_{2,1}$)
Change Frequency for Above Procedures($f_{2,2}$)
Output Quality Prediction($f_{2,3}$)
Proportion of Routine Tasks($f_{2,4}$)
Efficiency of IS Problem Solving($f_{2,5}$)
IS Strategic Importance($Group_3$)
The Way of Doing Business($f_{3,1}$)
Product or Service Differentiation($f_{3,2}$)
Timing of Market Entry($f_{3,3}$)
Imitation by Competitors($f_{3,4}$)
Contribution to Product or Service($f_{3,5}$)
Connection to Business Strategy($f_{3,6}$)
IS Capability($Group_4$)
Hiring of Best IS Personnel($f_{4,1}$)
Learning of Advanced IT($f_{4,2}$)
Periodical Education Training($f_{4,3}$)
Morale of IS Personnel($f_{4,4}$)
Problem Solving Capability of IS Personnel($f_{4,5}$)

IS asset specificity. This attribute refers to the degree to which an IS asset can be applied to alternative uses or users with loss of value. The specificity arises when firms have their IS assets for customized usage. The asset items are selectively adapted from Loh [17], Aubert et al. [2], and Ang and Cummings [1].

IS measurement problem. This attribute indicates the difficulty (or problems) of measuring the IS services and their output qualities. The minor is the IS measurement problem, the clearer the procedures of most IS activities. The measurement problem items are derived from Aubert et al. [2].

IS strategic importance. This attribute means the importance of using IS for a corporation to achieve its strategic goals. The strategic importance items are integrated from Loh [17] and Nam et al. [19].

IS capability. This attribute refers to the IS knowledge and skills capacity possessed by the IS personnel in a corporation. The IS capacity items are primarily adapted from Nam et al. [19].

The outcome features, IS outsourcing success, describes the eight IS outsourcing benefits including the degree of (a) focusing on kernel business, (b) the enhancement of IS capability, (c) accessing to the channels of IS professionals, (d) the economy of scale for human resource, (e) the economy of scale for IS resource, (f) the control of IS expenditure, (g) reducing the risk of outdated IS/IT, and (h) accessing to the channels of key IS/IT. These benefit items are primarily adapted from Grover et al. [9].

4.2. Case Collection

Based on the above case description, a cross-sectional questionnaire was developed for collecting IS outsourcing cases from a group of large-sized organizations in Taiwan. Formal interviews with five IS managers were conducted to provide valuable ideas and insights into developing the questionnaire. Ten other IS managers were pre-tested with the entire questionnaire to ensure the face validity. The sample population consisted of 1729 large organizations in Taiwan, including the top 1000 firms in the manufacturing industry, top 500 in the service industry, top 100 in the financial industry, and 129 government institutions. The final questionnaires were distributed to IS managers at 576 organizations by systematically sampling one third of this population. Each IS manager was asked to rate on a scale of 1-5 about his or her perception with the questionnaire items. One hundred forty-six IS outsourcing cases were collected, yielding an effective response rate of 25.57% (146/571).

4.3 CBGA Control Parameters

Chromosomes are designed for encoding the values of the adjustable IS attributes. The fitness function is defined as the equation (7). The key defined CBGA parameters consist of the population size, crossover rate, and mutation rate. A theory that can concisely guide the assignment of these values is rarely seen [22]. Initially, the

following values were adopted in this research. The population size was 100, crossover rate was 0.6, and mutation rate was 0.01. The entire process stops either that the solution converges or after 500 generations.

4.4 An Example and Potential Use of the Result

This research suggests that appropriate organizational IS attributes can be found to best approximate the target success level of IS outsourcing. The success level of IS outsourcing is rated on a scale of 1-5 regarding attainment of the eight IS outsourcing benefits. Assume an organization is not satisfied with benefits from outsourcing gained as a result of deploying an outsourcing strategy. In order to explore the appropriate organizational IS capability at the success level of four for instance, the CBGA system can generate suggestions about the optimal levels of the capability items of in Table 1, including the effort to recruit the best IS personnel ($f_{4,1}$) and to learn the advanced IT ($f_{4,2}$), the frequency to provide periodical education training ($f_{4,3}$), the endeavor to raise IS personnel moral ($f_{4,4}$) and to improve the problem solving capability of IS personnel ($f_{4,5}$). Chromosomes are designed for encoding the values of the five adjustable IS capability

items, which may use a number of -1 ~ 1 (that is the range of -100% ~ +100%) to represent the recommended change direction and percentage. The constraints can be set as their feasible ranges of adjustment (that is any ranges between -100% ~ +100%). The results make suggestions regarding the increase or decrease levels of these IS capability items for organizations to modify their IS resource allocation decisions and investment plans. This research provides the information with highly strategic values as IS outsourcing becomes a more strategic important practice to organizations.

5. Future Research

As shown in Figure 7, the entire system consists of the CBR prediction module and the proposed optimization module. Users can issue queries to inquire the possible outsourcing outcomes as well as to wait for the optimization module to prompt the suggestion leading to target outcomes. In the future, the proposed system is planned to be installed on the Web portal for public access after thorough system verification and testing.

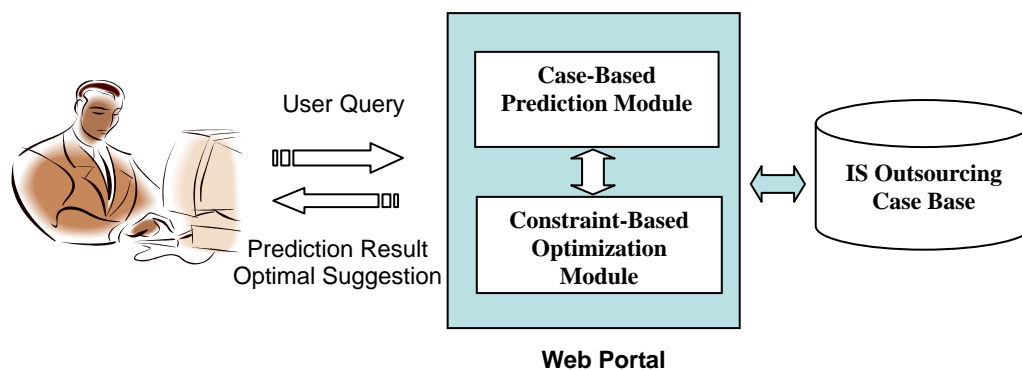


Figure 7. Entire Integrated Systems

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