Development of a case based intelligent customer–supplier relationship management system

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Abstract

The integration of customer relationship management (CRM) and supplier relationship management (SRM) to facilitate supply chain management in the areas of supplier selection using a help desk approach has become a promising solution for manufacturers to identify appropriate suppliers and trading partners to form a supply network on which they depend for products, services, and distribution. In this paper, an intelligent customer–supplier relationship management system (ISRMS) using the case based reasoning (CBR) technique to select potential suppliers is discussed. By using ISRMS in Honeywell Consumer Product (Hong Kong) Limited, it is found that the outsource cycle time from the searching of potential suppliers to the allocation of order is greatly reduced.

Keywords: Customer and supplier relationship management; Supplier selection; Help desk function; Supply network; Case based reasoning

1. Introduction

The intensive global competition among manufacturers to co-ordinate with and respond quickly the industry value chain from suppliers to customers has made customer–supplier relationship management important in the new business era. In such circumstances, decision-making in each business plays a key role in cost reduction, and supplier selection is one of the important functions in the supplier relationship management (SRM) because doing business with appropriate suppliers is beneficial for the organization to provide a sufficient production volume with good quality. Very few manufacturers now own all the activities along the chain but integrate the supply network from various supplier networks and the ability to make fast and accurate decision often constitute a competitive advantage compared with the competitors or other networks. The rapid advance in information technology is now deployed not only to improve existing operational effectiveness of a business, but also to build the new capability to meet today’s business environment and complexity. Consequently, top management may feel hard to select the most appropriate suppliers globally.

Customer relationship management (CRM) has become very important in the competitive business environment since late 1990s and is now a multi-million-dollar industry. In increasingly competitive markets, customer satisfaction and relationship are the vital corporate objectives. As customers come to increasingly demand and expect higher quality service, the profit per unit on the product gradually decreases due to the increasing global competition especially after the explosion of e-procurement on the Internet. With the CRM solutions, which provide fast and efficient transactions to help companies to acquire, serve, and retain the ever-growing numbers of customers, enterprises can empower their customers to interact more directly with the company and deliver personalized products and services that build customer trust and loyalty.

In order to maintain the profit margin while increasing the quality level, it is essential for manufacturers to strengthen their own competitive edges by means of focusing their resources on the core competences. It is an increasing trend for manufacturers to build a close and collaborative relationship with their suppliers through outsourcing. These suppliers, through superior performance, can leverage the manufacturers to a higher level of competitiveness or success. By forming such link, a manufacturer becomes a customer-focused organization through collecting customer order and requirement and then subcontracting the order to appropriate suppliers to achieve total customer satisfaction. Hence, the selection of suppliers becomes a crucial factor for the manufacturer to become a successful out-sourced type company to get customer satisfaction in the business. SRM, a new category of supply
chain applications, contributes to the supplier selection and thus increases the competitive advantage of the manufacturer through three primary mechanisms: (1) support of improved business processes across the supply chain, (2) a next-generation architecture that can handle multi-enterprise processes, and (3) facilitation of rapid product cycles and new product introduction. Together, these mechanisms can drive competitive advantage through substantial reductions in the true cost of parts and materials, increased flexibility to respond to changes in customer demand, and faster cycle times which can enhance customer satisfaction and increase market share.

The integration of customer/supplier relationship management (CRM/SRM) to facilitate supply chain management in the areas of supplier selection using a help desk approach to validate the searching result done by the CBR technology during the retrieval stage of the cycle in a real time base becomes a promising solution for manufacturers to identify appropriate suppliers and trading partners to form a supply network on which they depend for products, components, services, and distribution. The result is the formation of an integrated supply network that allows the most appropriate suppliers of the manufacturers to deliver the competitively priced, high quality products and services to their final customers according to their demand effectively. In this paper, an intelligent customer–supplier relationship management system (ISRMS) using the case-based reasoning (CBR) technique to select potential suppliers from a supplier list, following the comparison with the best practice supplier list inside a built-in case based help desk module to verify the accuracy of the result, is discussed. By using ISRMS, manufacturers can shortlist appropriate suppliers according to the position the supplier is ranked, resulting in the identification of preferred suppliers with references to the suitability of the supplier attributes selected. As a result, the outsourcing cycle time from the searching of potential suppliers to the allocation of orders to the most appropriate supplier can be greatly reduced with high accuracy.

This paper is divided into eight sections. Section 2 is the introduction of CRM and SRM. Section 3 is the literature review in the areas of supplier/partner selection using various techniques. Section 4 is about CBR and its suitability in SRM. Section 5 is the development of ISRMS using a CBR system incorporating major tasks in customer-supplier relationship management to form a distinct intelligent supplier evaluation system with the aid of the help desk approach, which is important for the manufacturers to outsource its incompetence operations to reliable, correlative suppliers and business partners. Section 6 is an application case study using ISRMS as an ISRMS in the purchasing department of Honeywell Consumer Product (Hong Kong) Limited, to aid the conventional human reasoning process of suppliers selection. Section 7 is about the results and benefits of using ISRMS while a conclusion of the application of ISRMS in general is made in Section 8.

2. Customer and supplier relationship management

CRM is a process by which a company maximizes customer information in an effort to increase loyalty and retain customers’ business over their lifetimes. The primary goals of CRM are to (a) build long term and profitable relationships with chosen customers, (b) get closer to those customers at every point of contact, and (c) maximize the company’s share of the customer’s wallet (Shaw, 1999). In fact, CRM is an information industry term for methodologies, software, and usually Internet capabilities that help an enterprise manage customer relationships in an organized way. Simply stated, CRM is about finding, getting, and retaining customers. It is at the core of any customer-focused business strategy and includes the people, processes, and technology questions associated with marketing, sales, and service. In today’s hyper-competitive world, organizations looking to implement successful CRM strategies need to focus on a common view of the customer using integrated information systems and contact center implementations that allow the customer to communicate via any desired communication channel. CRM can assist the organization to improve telesales, account, and sales management by optimizing information shared by multiple employees, and streamlining existing processes. CRM allows the formation of individualized relationships with customers, with the aim of improving customer satisfaction and maximizing profits, identifying the most profitable customers and providing them the highest level of service. Moreover, under the Internet age, CRM accesses the new markets in everywhere throughout the world wide web (www) to access the world class capabilities and consequently increase the commoditization by shortening the product life cycle, and eroding margins. CRM enriches the competitiveness by increasing the customer choices while purchasing product, making use of technology to perform the information empowerment, developing new markets and new business models and also increasing the connectivity between all relative parties within a business.

In summary, CRM is focused on leveraging and exploiting the interaction with the customer to maximize customer satisfaction, ensure return business, and ultimately enhance customer profitability.

As the trend toward use of technology to drive competitive advantage has taken root, visionary manufacturers are starting to take advantage of a new competitive opportunity called SRM. Herrmann and Hodgson (2001) defined SRM as a process involved in managing preferred suppliers and finding new ones whilst reducing costs, making procurement predictable and repeatable, pooling buyer experience and extracting the benefits of supplier partnerships. It is focused on maximizing the value of a manufacturer’s supply base by providing an integrated and holistic set of management tools focused on the interaction of the manufacturer with its suppliers. In fact there is an interesting and satisfying symmetry between the role of...
CRM and the role of SRM in the manufacturing environment as shown in Fig. 1, which shows an enterprise operations architecture linking customers with the supply bases. As companies recognize the value of managing their supply base as a competitive weapon, SRM becomes the single most important technology investment they can make to ensure that supply chain transformation they are driving is successful.

By integrating CRM with SRM properly through the process of product design and development, and the application of supply chain management under the same platform of an ERP system, SRM solutions can provide significant competitive advantage by delivering value in three important areas. They are: (1) the dramatic cost savings, (2) the increasing flexibility and responsiveness to customer requirements, and (3) substantially faster cycle times. Together these benefits can lead to meaningful faster time to market share in the course of the product life cycle based on the customer demand with a maximum degree of customization.

3. Supplier/partner selection for lean supply

Today, the concept of customer-supplier partnerships is being adopted at an increasing rate by European and US. The just-in-time concept of the early 1980s introduced this philosophy of a supplier—customer inter-organizational relationship based on the Japanese supplier. Lamming (1993) suggested that the main features defining partnership often mentioned in the literature are exchange of ideas, information and benefits, joint problem solving, research and technology development based on long-term trust and faith, and neither the model for relationship management apparently being adopted in the west, nor the Japanese model, developed for a specific set of national circumstances over a period of 50 years, would be sufficient for effective collaboration.; he proposed a model for 'lean' supply as a means of developing and exploiting relationships between customers and suppliers. As a consequence lean supply approaches have become widely evident in research in purchasing and supply management. The concept of lean supply and subsequent theoretical developments in the areas of relationship management (Lamming, 1996) have led firms to conclude that they will more readily attain long-term cost reduction (via product or process re-engineering) by forming closer working relationships with key suppliers. Increasingly, discussion has focused on relationship management as a means of gaining competitive advantage across industries including automotive (Lamming, 1993), Japanese textile industries (Dore, 1983) and high technology industries (Sako, 1992). These closer, longer-term, more collaborative buyer-supplier relationships were termed as ‘partnerships’. The search for closer co-operation and integration is evident not only with customers; suppliers are increasingly being viewed as partners, becoming more deeply involved in co-operative problem solving, e.g. in new product development. There has been an observed shift away from multi-sourced adversarial trading with suppliers, towards single or dual sourcing, resulting in a reduction of supplier bases used by firms (Lamming, 1989). In practice, under the issue of supplier/partner selection, a lot of articles have addressed the importance of selecting supplier attributes for making decision on supplier selection (Briggs, 1994; Chao, Scheuing, & Ruch, 1993; Ghodsypour & O’Brien, 1998; Lamming, Johnsen, Zheng, & Harland, 2000; Petroni & Braglia, 2000; Weber, Current, & Benton, 1991; Wei, Zhang, & Li, 1997).

It can be seen that the supplier/partner selection process should not only consider price, but also a wide range of factors such as quality, organization and culture, with a view of decision-making by considering the whole supplier/partner capability in a long-term and strategic way. This long-term expectation developed between the manufacturer and supplier(s) can provide the opportunity for improving performance. To recognize the supplier in a long-term partnership, the measurement of supplier organization is needed. It should be analyzed quantitatively, such that far-seeing customer and supplier relationships can be evaluated. The literature and practice has seen the growth of customer and supplier relationships from a focus on operational purchasing relationships to strategic partners and boundary evaporation.

3.1. Various techniques in supplier/partner selection

Obviously the selection of supplier plays a key role in an organization because the cost of raw material constitutes the main cost of a final product. Selecting the right suppliers significantly reduces the purchasing cost and improves corporate competitiveness. There are various techniques for selecting suppliers/partners.

3.1.1. Mathematical techniques

In spite of the importance of supplier selection problems only a few articles have addressed the decision-making. Weber et al. (1991), who presented a review of 74 articles that discussed the supplier selection problem since 1966, stated that only 10 articles applied mathematical programming to vendor selection. Since their review, seven other articles have used these techniques. A comprehensive review of these articles, which have addressed the problem, can be found in Ghodsypour and O’Brien (2001), which include techniques like linear programming, mixed integer programming approach, goal programming techniques, multi-objective programming, and non-linear programming. Recently, Ghodsypour and O’Brien (1997a) developed a decision support system (DSS) for reducing the number of suppliers and managing the supplier’s partnership. They used integrated analytical hierarchy process (AHP) with mixed integer programming and considered suppliers’ capacity constraint and the buyers’ limitations on budget.
and quality, etc. in their DSS. In another issue, they proposed a model to deal with supplier selection, multiple sourcing, multiple criteria and discounted price Ghodsypour and O’Brien (1997b). The effects of limitations on budget, quality and suppliers’ capacity was considered. Ghodsypour and O’Brien (1998) developed an integrated AHP and linear programming model to help managers consider both qualitative and quantitative factors in the purchasing activity in a systematic approach. They proposed an algorithm for sensitivity analysis to consider different scenarios in this decision-making model. Lastly, in a recent paper, Ghodsypour and O’Brien (2001) developed a mixed integer non-linear programming model to solve the multiple sourcing problem, which takes into account the total cost of logistics, including net price, storage, transportation, and ordering costs. In the model, buyer limitations on budget, quality, service, etc. can also be considered.

3.1.2. Other techniques

Besides mathematical techniques, various techniques were used in developing DSSs for partner/supplier selection. Gupta and Nagi (1995) developed a flexible and interactive DSS to aid in optimal selection of manufacturing partners for a business initiative in an agile manufacturing environment. This DSS formally combined concrete quantitative information as well as user’s fuzzy qualitative information, providing quick and near optimal selection of partners. The approach starts with the construction of an AHP comparison matrix with default pairwise evaluation of attributes using fuzzy functions, at the same time, the user provides priorities for each attribute, then both pieces of information are combined and synthesized by Fuzzy-AHP to give relative priorities.

Herrmann, Minis, and Ramachandran (1995) identified three stages in the selection of partners: pre-qualifying partners, evaluating a product design with respect to the capabilities of potential partners, and selecting the optimal set of partners for the manufacture of a certain product. A new information model was presented describing the systems, process capabilities, and performance of a manufacturing firm, where the model was used as a part of a DSS for design evaluation and partner selection in agile manufacturing. Herrmann and Minis (1996) described a variant approach to evaluate, early in the product life cycle, a proposed design with respect to the capabilities of the potential partners. The result of this work was an integrated system for design evaluation and partner selection for flat electro-mechanical products. Using this system, a designer can define a feature-based product model, generate concise product descriptors, search for and sort similar products, generate alternative plant-specific process plans, evaluate those plans, and compare them to find the most suitable combination of processes and manufacturing partners. The main strength of this variant approach is the integration of the following issues related to variant design critiquing: hybrid feature-based product modeling, automated generation of Group Technology codes, concise but detailed product description, and the accurate and rapid retrieval of designs and process plans of similar products. However, additional research is needed for non-flat parts and non-mechanical parts.

Minis, Herrmann, Lam, and Lin (1999) developed a generative approach for concurrent manufacturing evaluation and partner selection. The approach evaluated the manufacturability of a proposed design with respect to the capabilities of candidate partners and allows the product development team to select a partner based on its ability to manufacture quickly and inexpensively. The generative approach developed consisted of three procedures: feasibility assessment, manufacturability assessment, and plan synthesis. Feasibility assessment generates feasible process and partner combinations. Manufacturability assessment evaluated these combinations. Plan synthesis combined this information and presents alternatives to the product development team. The approach was applied to a class of flat mechanical products and microwave modules. Future work must investigate performing concurrent manufacturability evaluation and partner selection for comparing preliminary designs. Thus, the product development team can receive useful feedback even earlier in the product development process.

It is noticed that although the earlier approaches can solve the supplier/partner selection problems, however, the complexity of the system is not suitable for enterprises to solve the issue efficiently without high capability in advanced computer programmers. Actually, most small and medium sized enterprises (SMEs) could not afford these complex mathematical and sophisticated intelligent
approaches. As a result, an applicable user-friendly knowledge-based software package, which can be used in providing the advanced supplier selection function with high compatibility, is needed.

4. Case based reasoning

Case based reasoning (CBR) is a subset of knowledge-based systems. However, CBR technology is different from other knowledge-based technologies such as rule-based systems typically provide only rule trace backs as an explanation of their activities, which even an experienced system operator has difficulty in interpreting. In contrast, a case based system is capable of explaining its activities in the context of the case from which it was reasoning, thereby giving the operator much more useful information to guide situation assessment. CBR is a plausible generic model of an intelligence and cognitive science-based method by the fact that it is a method for solving problems by making use of previous, similar situations and reusing information and knowledge about such situations (Kolodner, 1993). CBR combines a cognitive model describing how people use and reason from past experience with a technology for finding and presenting such experience. It is a problem-solving paradigm that is for many aspects different from other AI approaches. Traditional AI approaches rely on general knowledge of a problem domain, tend to solve problems on a first-principles, or ‘from scratch’ basis. CBR systems solve new problems by utilizing specific knowledge of past experience and basic competence is encoded within a corpus of previous problem solving episodes called case-base. Another important difference is that CBR is also an incremental learning approach since new experience is retained each time a problem has been solved, making it available for future problems. CBR provides a conceptual framework in which to store operator experience and to later provide that experience to other operators to facilitate the situation assessment and solution formulation processes. This is accomplished by providing a context in which the human operator can view the current state and recent activities of the system and easy access to previous experience.

4.1. Process of CBR

The process involved in CBR can be represented by a schematic cycle as shown in Fig. 2. Aamodt and Plaza (1994) have described CBR as a cyclical process comprising the four ‘Re’s.

1. Retrieve the most similar case(s).
2. Reuse the case(s) to attempt to solve the problem.
3. Revise the proposed solution if necessary.
4. Retain the solution as part of a new case.

The knowledge cases are structured and stored in a case-base, which the user queries when trying to solve a problem. The system retrieves a set of similar cases and then evaluates the similarity between each case in the database and the query. The most similar case(s) are presented to the user as possible scenarios to be reused for the problem at hand. The user has to decide if the solution retrieved is applicable to the problem, i.e. the system does not make the decision, it only supports the decision-making process. If it cannot be reused, the solution is revised (manually or automatically). When the user finds a solution, and its validity has been determined, it is retained with the problem as a new case in the database (the case is learned), for future reuse.

It can be seen here that a new problem is matched against cases in the case-base using heuristically cased indexed retrieval methods with one or more similar cases being retrieved. A solution suggested by the matching cases is then reused and tested for success. At this stage, if the best-retrieved case is a perfect match, then the system has achieved its goal and finishes. However, it is more usual that the retrieved case matches the problem case only to a certain degree. In this situation, the closest case may provide a sub-optimal solution or the closest retrieved case may be revised using some pre-defined adaptation formulae or rules. Adaptation in CBR systems means that such systems have a rudimentary learning capability, which can improve or become more discriminatory, as the number of case increases. Nevertheless, there are a number of limitations with CBR applications.

1. When using past experiences to solve problems, it is quite difficult to determine whether the solutions to past experiences have been successful over time.
2. Also, with the case expanding through the addition of new cases it is possible that a lot of cases within the case base may become redundant.
3. Case adaptation can be a very complex process in attempting to derive modification rules.

4.2. Applications of CBR

CBR applications can be broadly classified into two main problem types, namely, classification tasks and synthesis tasks (Watson, 1997). Classification tasks cover a wide range of application that all share certain features in common. A new case is matched against those in the case-base to determine what type, or class, of case it is. The solution from the best matching case is then reused.

Classification tasks come in a wide variety of forms such as planning, diagnosis, design, prediction, and process control. Synthesis tasks attempt to create a new solution by combining parts of previous solutions. Synthesis tasks are inherently complex because of the constraints between elements used during synthesis. CBR systems that perform synthesis tasks must make use of adaptation and are usually
hybrid systems combining with other techniques. The synthesis system is mainly used in design, planning, and configuration.

Planning is an area where experiences are commonly relied on. There are basically two measures to apply CBR in planning. First, it is simply to reuse the majority of the previous plan by reusing the same parameter setting, schedule, design and development stages, workflow, etc. Another is to adapt the old plan and modify the planning in order to fit the requirement of the particular planning criteria. TOTLEC was developed by Costas and Kashyap (1993) to solve complex manufacturing planning problems such as the detection of errors during the design phase, and warning and advising the user about non-manufacturing designs.

The diagnosis of disease has been one of the most popular problem domains for artificial intelligence since the early days of MYCIN, which is a classic rule-based expert system that diagnosed bacterial infections (Kolodner, 1993). Other CBR applications have been found in the diagnosis of building defects. Watson and Abdullah (1994) developed a diagnosis system, PAKAR, to identify possible causes for building defects and suggests remedial actions. It is able to combine textual information and CAD drawings to advise on possible causes of defects and their potential solutions.

Design is an area that is quite often used basing on past practices. Perera and Watson (1995) developed a case based design system, NIRMANI, to assist developers to construct light industrial warehouse units. The system contains a library of designs and their construction costs stored in a hierarchical case representation. It also contains two-dimensional and three-dimensional CAD drawings, specifications, photographs, and even video tours of completed buildings. From an initial client’s requirements, a design can be quickly retrieved and cost calculated. The use past cases augmented with multi-media helps the clients to refine their requirements and therefore improves the design. The application of CBR in the areas of process control and planning of work schedules can be found in Koegst, Schneider, Bergmann, and Vollrath (1999).

Besides the above applications in industry, in addition, there is a growing trend that enterprises have started to apply CBR technology in the customer service section. The history can be tracked back to Acorn and Walden (1992), who discussed the development of a CBR system, called support management automated reasoning technology (SMART) system, which was developed jointly by Compaq with Inference Corporation, to enhance the customer support service level in Inference Corporation, in order to increase customer loyalty. When receiving customer’s inquiry, SMART integrated with the existing call-routing and logging system to gather information. By doing so, engineers would be able to collect basic customer information such as name, address and then log the call. After recording brief description of the problem, and verbatim was typed into the summary field of the call log, SMART will use the description of the problem to perform an initial search in the case-base. A list of the matching cases that involved high similarities in parameter setting is presented. Moreover, additional information provided by customers to define the problem in detail is collected. Consequently, SMART would perform a new search in the case-base to retrieve a more accurate set of relevant cases. Once a sufficient level of certainly is reached, a solution will be suggested to the customers. By using this case based oriented help desk approach in solving customers request, companies can keep the customer loyalty to its product.

McIvor and Humphreys (2000) prompted that it is
effective in the decision making process of the make or buy methodology and practice with the use of AI techniques such as the CBR technique. It has become clear that CBR is useful in searching the knowledge, helping users in comparing various tasks and items, automatically notifying users with relevant new knowledge update, and so on (Dutta, Wierenga, & Dalebout, 1997; Pawar, Haque, Belecheanu, & Barson, 2000).

In summary, it can be seen that the application of CBR technique in the areas of SRM such as supplier evaluation/selection is a new approach, which can be used in integrating with CRM through the process of new product development and supply chain management. Since CBR is an advanced reasoning technique simulating human reasoning to retrieve a relative case, modify it and find a solution for the new coming problem, it can be used to supplement the conventional measures, which mainly rely on experts such as the purchasing manager or procurement engineer, to make decision on outsourcing matters.

5. An intelligent customer–supplier relationship management system

The ISRMS proposed in this paper is used for an organization to master its core competent by means of subcontracting operations that cannot be used in building up the knowledge inside the organization.

ISRMS uses one of the applications of CBR technology, which belongs to the classification task integrating CRM with SRM to provide the prediction and assessment of supplier capability. The architecture of the ISRMS is shown in Fig. 3. It is divided into front end and back end. In the front end, ISRMS is linked with the company’s local and overseas customers such as wholesalers and retailers to acquire their information related to the products. The back end of ISRMS consists of a case-base data warehouse containing cases stored in various departments within the company’s local and overseas offices as well as in other plants. Moreover, the CBR engine which uses the stored cases for problem solving is also installed at the back end. By doing so, CRM and SRM functions are linked up by the front and back end of ISRMS.

The intelligent (AI) computational tool, the CBR engine, embedded inside ISRMS is a new concept since there are no similar systems in the market using the CBR technique to manage and sort the potential supplier to form a customer–supplier integration strategies. The CBR engine, in which a case-base decision tree is constructed, arranges the past practices in a systematical way for the retrieval process. For the case-base module, each case includes the name of a case, a case description, a recommended solution and the further reference linkages such as the inter-link between the updated files or the front page on the Internet of the target supplier. In order to implement the concept of the customer–supplier relationship management, the database in the form of case-base is built on a web site for collecting the opinions from the customers.

The two CBR modules in ISRMS responsible for matching the customer demand with the respective supplier capability for a particular product are the supplier selection module and the help desk module.

5.1. Supplier selection module

A built-in supplier selection workflow is programmed in the case-base engine, as shown in Fig. 4, such that an authorized supplier list, consisting of three profiles: technical capability, quality assessment, and organization profile is stored. Data of each supplier are stored in a case structure, each consisting of a number of fields representing the criteria in each category. The cases in ISRMS show the relevant numerical performance values of the correspondent criteria of suppliers. During the supplier selection process, an external supplier list is converted to the format of a case and is then imported to the case-base of the authorized supplier list when either the case retrieval is exhaustive or potential suppliers are desired in sourcing (For details, see Choy & Lee, 2002a).

In order to perform the function of the integration of the customer/supplier relationship management, the CBR engine analyzes the product data collected from the web site such that the supplier performance according to the customer feedback is transformed to the requirements of the organization when selecting appropriate suppliers in the business.
5.2. Help desk module

A CBR help desk module, which is independent of the CBR supplier selection engine, is responsible for validating the accuracy level of the solutions from the supplier selection process. As shown in Fig. 5, while the selection of the potential suppliers is the duty of the CBR supplier selection module to analyze the criteria of potential suppliers, it is the merits of using the CBR help desk module to measure and benchmark the accuracy level of the selection. It is done by means of comparing the supplier’s attributes in the new supplier with that from the suppliers sorted from the past practices.

Similar to the supplier selection process, the help desk operation in the system is also driven by the CBR technology. The reasoning technique relied on the comparisons of the similarity ratios in the performance measurements of potential suppliers. The process in the help desk module can be separated into the following steps. First, the system developer makes use of the CBR software package to build a case-base, where each case contains number of records in the past practices. After arranging all cases in a systematic way on a decision tree, end users such as the senior management personnel starts to use the user interface to retrieve the past practices. The user needs to input the part number in the space provided, and hence answers the questions searched by the engine. The appropriate suppliers will be ranked automatically according to the answers given by the user. The mechanism of the help desk module is shown in Fig. 6.

As a result, the selected suppliers that are retrieved by the help desk module is the best past practice and thus the required solution, which was used as the best practice in the process of benchmarking potential suppliers proposed by Choy and Lee (2002b). The score acts as a reference when comparing with the potential supplier selected from the supplier selection process.

6. Case study—Honeywell Consumer Products (Hong Kong) Limited

With the intention of strengthening the SRM function in Honeywell Consumer Products (Hong Kong) Limited, ISRMS is applied. Honeywell is a multi-national based manufacturer of consumer products such as fan, heater,
humidifier, air-cleaner, etc. Its office is in Hong Kong and the main manufacturing plant in Shenzhen, Mainland China. Honeywell employs around 2800 workers and staff, 157 are located at the Shenzhen office and 33 at the Hong Kong office. Honeywell has around 50 core suppliers and over 2000 potential suppliers for sourcing. Its vision is to build up a knowledge-based learning organization, which can produce quality and innovative products with enhanced services to their customers on time within budget, through the collaborative product commerce via global networking with their strategic suppliers and customers for operational excellence. ISRMS can help to select appropriate suppliers to develop new products according to the customer demand received from the global network through its embedded CRM module.

When applying ISRMS for the identification of preferred suppliers, the database for the CRM is divided into six different attributes, namely the technical support, customer...
service, product price, product quality, product package, and customer satisfaction, to form a category of customer information database shown in Fig. 7. All the information of the past practices is stored in the case-base in the form of cases containing the weightings of these six attributes. They will be used for selecting suppliers/partners using the embedded CBR engine when new product development is required. In practice, after collecting the right information from customers through the web into these six categories, the data is summarized into key elements, which the company can transfer into a form of performance measurement criteria for selecting appropriate suppliers in the sourcing process. In the database for the SRM, as shown in Fig. 8, each supplier is assigned a special score in each criterion in the supplier selection system. The 11 criteria in the second layer in the supplier selection system act as the performance indicator for the suppliers (Choy & Lee, 2002c).

6.1. Interfacing the CRM and SRM module

Customers, who are normally referred to key wholesalers and retailers, send in the product requirement through the CRM module. Information collected in the customer information database is then correlated to the supplier selection criteria in the SRM module to aid the corresponding manager to make decision on selecting the appropriate suppliers. As shown in Fig. 9, for example, customer satisfaction is related to quality, shipment quality, delivery, and product price, while product package is linked with the shipment quality and product price. Indeed, the correlation, which is updated from time to time, mainly depends on the emphasis customers expressed in the information. Clear classification is necessary to ensure that the supplier selection process fulfills the requirements demanded from the key customers in order to retain good relationship.

When using ISRMS, the company will first set its supplier requirement in the form of a list of performance criteria with target scores; it forms a ‘new’ problem. The new problem is then entered into the supplier selection module’s CBR cycle for potential suppliers and sequentially goes through the help desk module, using question and answer approach to validate the resulting suppliers with those in the supplier list. The mechanism in parallel will result in a list of suggested suppliers generated by the system. By doing so, ISRMS provides an analytical result to help managers to make right decision rather than only relying on the original past practices or the human reasoning.

6.2. Implementations of ISRMS

Before implementing ISRMS in Honeywell, some preparation steps are done. They are:
1. to set up a ‘support’ link on the front page of the company web site, which is used in collecting the customer information,
2. to distribute all the information into suitable categories,
3. to group the supplier natures, supplier code, and supplier history records into a single database.

After finishing these preparations, Honeywell starts to install ISRMS into its existing supplier management system. ISRMS embeds a CBR software package called Case-Advisor to retrieve the supplier information into Honeywell’s server.

The core structure of the CBR engine is the Case-Advisor. Case-Advisor is traded by Sententia Software Company at Simon Frazier University, Canada. It is a CBR software package modeled on a standard technique where human uses in problem solving. This technique is to recall past experiences, or ‘cases’, that are similar to the current situation and adapt them to meet the needs of the new situation. The ‘reasoning’ depends on these cases, so it is called ‘CBR’. Case-Advisor is divided into three main components, namely, Case Authoring, Problem Resolution and Domain manager.

6.2.1. Case-advisor authoring module

It creates the case-authoring environment for the system developer. It is the case-base and decision tree-editing portion of Case-Advisor for maintaining and updating the case-base and decision trees. New cases, questions and decision trees can be added and existing ones can be edited. Case-Advisor Authoring is a simple tool. The interface is separated into two parts, the left side is the case list, and the right side is the question list. For the case list, the case author is presented with syntax-free environment for entering the details of a case’s name, description, solution, and the linkage to the file or supplier web page. A new case is created by feeding the case name; the full name of the supplier, the supplier description; the supplier code and the supplier nature, etc. and the supplier rank; the score in each performance measurement parameter into the case list. For the question list on the right side, questions linking the cases in the case-base are added. The system developer is responsible for setting the types of question and answer. The weighting for the importance of each supplier attribute is adjustable such that the answers to the questions are suitable for the cases. A decision tree is required to separate the cases in a systematic order. Most importantly, both the top management and the system developer are required to construct the hierarchy of the decision tree in order to fulfill the particular requirements of the company since the structure may be altered by the changing nature of the business. After completing the decision tree, the allocations of the cases are inspected periodically. It is because the supplier’s scores of the performance measurement parameters may change due to the change in their requirement from time to time.

6.2.2. Case-Advisor problem resolution module

For diagnosing problems and viewing case usage statistics, the Case-Advisor Problem Resolution Module is used. It is a real time case retrieval engine, where the search and retrieval of cases takes place. Here the Case-Advisor Problem Resolution works with the Netscape browser and uses the spreadsheet of Microsoft’s EXCEL or ACCESS to operate. In addition, it is linked with the suppliers’ web site through the inter-link mechanism in this module. By doing so, two things are done, which are (1) to view the company’s record in excel and access format, and (2) to find and compare between the past best practices according to the logic tree built in the Case-Advisor Authoring Module. This will result in the recommendation of the desirable solution.

6.2.3. Case-Advisor domain manager

Case-Advisor Domain Manager is an interface to case-bases that integrate with ODBC databases such as Oracle, Sybase, Microsoft SQL server, Microsoft EXCEL and ACCESS, etc. The Domain manager performs several functions like create, copy, and rename, etc. of the domain case-base list, which are used in the Case-Advisor.

By linking the CRM and SRM data base through Case-Advisor’s Domain Manager using the Authoring and Problem Resolution Modules, as shown in Fig. 10, the customer requirement can be linked with supplier’s capability in real time base.

6.3. Illustration example—air cleaner

ISRMS has been tested in Honeywell to validate the feasibility of this system in an actual industrial environment. Totally, five steps are involved in building the case-base and the application in the Authoring Module and the Problem Resolution Module of ISRMS, respectively. In the Case-Advisor Authoring Module, four steps are required.
6.3.1. Construction of the decision tree

The hierarchy of the decision tree in the core CBR structure is shown in Fig. 11. All potential suppliers inside an organization are arranged into particular groups according to their score points in each of the supplier attributes contained in the supplier selection criteria category. In the air cleaner project, the score points are divided into two classes, the first class contains marks from 1 to 5, regarding as the low performance; and the other class is from 6 to 10, regarding as high performance. The reasons to divide scores into two classes are in two folds. First, this helps the system to retrieve the suppliers in an efficient and accurate way. Second, this can minimize the complexity in the maintenance of ISRMS. The construction of the decision tree is crucial due to the fact that the accuracy in the retrieval stage is mainly dependent on the allocation of suppliers in the appropriate class.

6.3.2. Building the content of the case

The content in the Case Authoring module containing the Honeywell’s supplier list is shown in Fig. 12. It involves the case name, description, and solution. In addition, the case-base can be linked to a particular file in the format such as the word document (.doc), excel spreadsheet (.xls), or the front page of the suppliers’ web site. As the retrieval technique used by Case-Advisor belongs to the nearest neighbor one, it allowed the case name, contents inside the description or solution appearing in the form of the searching character.
6.3.3. Connecting the case with the related questions

It is necessary to build up the interrelationships between cases and questions so as to build the decision tree for the CBR cycle. As shown in Fig. 13, the case-base consisted of two sections: one is a pool of cases in the case list, and the other is a pool of questions in a question list. They are separately built and there is no interrelationship between the cases and question list. The way to link the case and the question list affects the accuracy of the retrieval steps as the CBR cycle relies on the logic built in the decision tree. In this CBR engine, they are simply linked by dragging and dropping the question to the particular case. In practice, one question can be interlinked with a number of cases, whereas a dialog box will be shown at the end of the connection. Moreover, a case can be linked with more than one question if it is necessary. By this connection, a case network is formed in the case-base within a short period of time.

6.3.4. Assigning a weight percentage to the supplier

After finishing the connection of all the related cases and questions, a dialog box appears on the screen showing the answer to the case with a weighting percentage representing
the fitness of the supplier to the requirement. As shown in Fig. 14, the weighting in each answer is adjustable by the constructor from low to high (with scale from 0 to 100%) when building the hierarchy. The purposes are to fit the requirement in different questions and to adjust the weightings when there is a change in performance of a particular supplier.

After completing the above four steps, the required case-base is built. In fact the building of this case-base for Honeywell is only required once in the beginning stage. Lastly, one step is required in the Problem Resolution Module to find the solution.

6.3.5. Finding solutions

When a user wants to search a supplier for supplying the air cleaner cover, the Problem Resolution Module is used. As shown in Fig. 15, the keywords of the problem description for searching potential suppliers for the air cleaner cover are entered in the case-base on the space provided in the left upper corner. After entering the
keywords, the CBR engine starts to retrieve appropriate suppliers by using the nearest neighbor technique. A question list is shown in the ‘questions’ area where the users select and answer those that are relevant to the task. The rank of the suppliers change until it reaches the final answer according to the questions provided. The detail information of the most appropriate supplier is shown on the right screen when double clicking the appropriate supplier.

The supplier thus found is then compared with those from the case-base using the help desk approach, which compares this supplier’s performance with those from the past best practice. The supplier thus recommended will be the most suitable one.

### 7. Results and benefits

After implementing ISRMS for the selection of potential suppliers in various projects, the performance result is compared with those using the experience-based approach. The performance measurement criteria are the Honeywell satisfactory rate, the degree of delay in delivery, quality below standard and the customer claims. As shown in Table 1, results indicate that the adoption of ISRMS has a significant contribution to Honeywell (Hong Kong) plant, which is shown by the increase in Honeywell satisfactory rate, although there is still room for further development. The chance in selecting the right suppliers/partners is increased resulting in the production of more reliable products produced. This can be shown by the significant decrease in the percentage of delay in delivery, quality below standard and the customer claims.

Moreover, by using ISRMS, other results and benefits are noticed. Using the parallel processing of the new product development process and supplier selection workflow mechanism of ISRMS, the preferred suppliers for a specific new product can be matched. Furthermore, it is unavoidable that the modification of the specification of a new product can trigger the change of objective(s) and rule(s) of retrieval and weightings of attributes in the supply management system simultaneously in the early phase. For example, the changing of the design when the material of a product is changed from metal to plastic would result in critical changes of all parameters of supplier sourcing development. ISRMS reacts by retrieving similar cases and at the same time suggests the updating of its case-base by means of supplier adoption if the retrieved case is unsatisfactory. In this way, ISRMS can enhance the function of supply management system in new product development by making it more agile. In addition, ISRMS can learn from experience and enrich its case-base throughout the searching process.

As Honeywell is a multi-national manufacturer, its suppliers and business partners number thousands. The usage of ISRM to handle highly structured supplier cases enables purchasing managers, engineers, and buyers to investigate different scenarios with finite supplier cases effectively. This is due to the system’s ability to combine with a ‘what–if’ analysis and the actionable knowledge obtained from the case-base in the case adviser. The speed of sourcing the capable, preferred or potential suppliers and decision-making in the related attributes is increased. Consequently, quicker reaction in supplier selection and management occurs, providing a shorter new product development cycle time to be achieved, and accordingly, cost reduction becomes possible. The other benefit is that the major part of ISRMS records the knowledge of workflow and can be fully implemented into the CRM module with little human involvement. This can solve the problem of losing supplier selection knowledge when any experienced key staff left the corporation. In fact, new staffs can allocate preferred suppliers easily by the help of the user-friendly help desk module in ISRMS. In summary, ISRMS records the corporate knowledge in the supplier case-base, its algorithm and workflow to support the CRM functions.

### 8. Conclusions

While CRM focused on leveraging and exploiting the interaction with the customer to maximize customer satisfaction, ensure return business, and ultimately enhance customer profitability, SRM involved the management of preferred suppliers and finding new ones whilst reducing costs, making procurement predictable and repeatable, pooling buyer experience and extracting the benefits of supplier partnerships. It becomes crucial for manufacturers to integrate the demand of customers to their preferred suppliers as well as sourcing new ones in a real time base during the new product development cycle in order to remain competitive in business.

The major function of ISRMS is to integrate the customer requirements on product quality, delivery time, and manufacturing cost by an advanced computational retrieval technology called CBR, to evaluate suppliers through a single software platform. With the implementation of ISRMS, an organization can shorten the workflow of selecting business suppliers after receiving a new order. In addition, the potential suppliers retrieved from the CBR engine is supported by a similarity ratio. The workflow of

<table>
<thead>
<tr>
<th>Supplier selection performance by human and by ISRMS</th>
<th>By human (%)</th>
<th>By ISRMS (%)</th>
<th>Honeywell expected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honeywell satisfactory rate</td>
<td>65</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Delay in delivery</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Quality below standard</td>
<td>30</td>
<td>25</td>
<td>15</td>
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<tr>
<td>Customer claims</td>
<td>25</td>
<td>18</td>
<td>15</td>
</tr>
</tbody>
</table>
the new system minimizes the human reasoning in the system in order to speed up and enhance the consistency of the mechanism of the system. The ISRMS platform helps the manufacturers to reduce the total production time and time to market. The computerization of the customer—supplier management process helps the enterprise to fully implement the CRM strategy in each department, to achieve a close relationship with suppliers/partners by the integration with the SRM strategy, and consequently increase the manufacturers’ own competitiveness, reputation and revenue in the market.

By using ISRMS, the main goal of CRM and SRM, which are to build long term and profitable relationships with chosen customers, and to maximize the value of a manufacturers’ supply base by increasing flexibility and responsiveness to customer requirements and substantially faster cycle times, can be achieved.

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