A decision support system to facilitate resources allocation: an OLAP-based neural network approach

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Keywords

Decision support systems, Resource allocation, Neural nets, Artificial intelligence

Abstract

The emergence of advanced information technologies strengthens the capability to the entrepreneur to manage and manipulate data. However, the quality of information, the capability of providing the right information to the right person, and the utilization of information are still in doubt. Therefore, increasing numbers of firms have realized and started to develop as well as improve their existing information systems to fit the ever-changing business needs of the organization to support decision-making for the volatile business environment. Indeed, previous research studies have found that logistics management is the great frontier of cost reduction. Therefore, in this paper, an infrastructure of a decision support system is proposed to capture and maintain the business and resources allocation information with the adoption of the neural network for its artificial intelligent characteristic that mimic the operation of human brain to generate solutions systematically. The proposed system is adopted by a shipping company to assist allocation of containers.

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Introduction

Enterprise nowadays is facing global competition; being able to have competitive edge with continual improvement, operate in low cost, and response to customer demands becomes the key of survival. It is especially difficult for companies whose operating costs are relying on high investment in assets; the only way to reduce cost of operation is to reduce complexity of workflow and to utilize the resources within the company.

Tremendous amount of data that are related to business operations and decisions are flooding into business. There is no doubt that data is one of the organization's most valuable resources. However, not many organizations are able to fully utilize their available data to assist decision-making and daily operations, which directly affect the competitiveness in the market. Therefore, it is crucial to be able to generate the right information and deliver the information to the right person at the right time. Indeed, the major activity of business operation lies on the systematic processing of knowledge to create value for customers. The key to build a successful enterprise depends heavily on the agility of the company to face the ever-changing business environment. Evidence to date suggested that extensive delays in the delivery schedule, quality problems, cost overruns, and increasing clams and litigation have caused serious harm to the companies. In order to simplify workflow and utilize the resources in the organization by closing monitor the available resources, the company reengineers the workflow processes and reallocates the available resources. In this paper, a framework of a resources management system is proposed to control resources consumption within organization, which would also affect the workflow processes in a positive way.

Related studies

Number of research studies have been performed to propose an information System framework to manage supply chain network and logistics. However, most of them are focused on information exchange between companies and vendors, and companies and customers, not many of them have proposed any strategically developed system or even addressed the needs in managing the physical segment – transportation management, of supply chain and logistics management.

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Wan and Levary (1995) had proposed a linear programming transportation model to allow the shippers to evaluate all possible means of obtaining the lowest price for a given shipping route in a short period of time. The model described in the study incorporates linear programming into price negotiation process for contracting shipping companies. However, it was lack of flexibility to allow management to make decisions for tackling unpredicted problems and generate strategic offers to meet the market needs. In other words, the proposed model did not allow the management to manipulate with the data to satisfy his/her desires. On the other hand, Mason *et al.* (2003) have simulated an integration of warehouse management systems what contain information on supplier/customer warehouse inventory levels and key customer order patterns. In the study, it found that the integrated paradigm improved customer service through improved efficiencies, reduced costs, reduced lead-time variability. Moreover, Shen and Khoong (1995) have proposed a decision support system that is embedded with optimization model to solve the problems concerning the distribution of empty containers for a shipping company. The optimization model deployed in the decision support system was able to solve the problems for land transportation systems, however, it required further development to carry out processes for land and sea systems. Furthermore, the proposed system did not include techniques such as artificial intelligence and forecasting.

Stopford (2002) analyzed and addressed the opportunities and threats to the commercial organization of shipping by the e-commerce revolution, and the impacts of the different information technologies on the shipping industry from a management prospective. The author suggested five benefits of Web communications:

(1) compatibility – Web browser provides a common platform for system development;
(2) convenience – demand driven access to information that allows user to obtain information as he/she needs;
(3) simplicity – the learning curve is short and it is easy for user to post, view, change, and obtain information;
(4) integration – systems developed independently can be integrated to a standardized platform (Web browser) easily; and
(5) affordability – Web systems are more economical to be developed than other communication systems (Stopford, 2002).

However, the author was not able to suggest the use of artificial intelligence and other advanced technologies with the advantageous use of Web systems that are beneficial to shipping industry.

The recent trend of global manufacturing is to implement system infrastructure that allows analysis being performed on vastly distributed data according to the elements of business strategies. In the era of information-based management, the key of success is to recognize the company's competitive advantages and weaknesses with the support of information technologies for decision-making (Porter and Millar, 1988). Therefore, we propose to use online analytical processing (OLAP) as a tool for knowledge discovery with the support of neural network to generate an informed solution.

Proposed framework of resources management system

The proposed resources management system consists of three main modules: user interface, databases, and OLAP-based neural network module. The user interface is a Web-based application that enables user to access the system and submit information to the system anywhere at anytime. The databases, on the other hand, maintain and acquire the data that are generated in the transactions processes and other workflow processes. It also ensures, all the valuable data are accessible for the management to make decisions. Lastly, the OLAP-based neural network module is considered the brain of the resources management system (Figure 1).

The brain of the decision support system for resources allocations is the OLAP-based neural network module that is capable to analyze tremendous information that is pouring into the company through different medium. The main purpose of adopting OLAP is to analyze the aggregate data with multidimensional view. It collects distributed data while performing as a single information source. OLAP tool assists the decision-maker to create appropriate knowledge and analysis models by browsing the appropriate data groups, and defining the model relations between them (Datta and Thomas, 1999). In early 1990s, technological advances in data modeling, databases, and application developments made it feasible for decision-makers to analyze data with a common data source. According to the definition of OLAP Council, OLAP is a "category of software technology that enables analysts, managers and executives to gain insight into data through fast, consistent, interactive access to a wide variety of possible views of information that has been transformed from raw data to reflect the real dimensionality of the enterprise as understood

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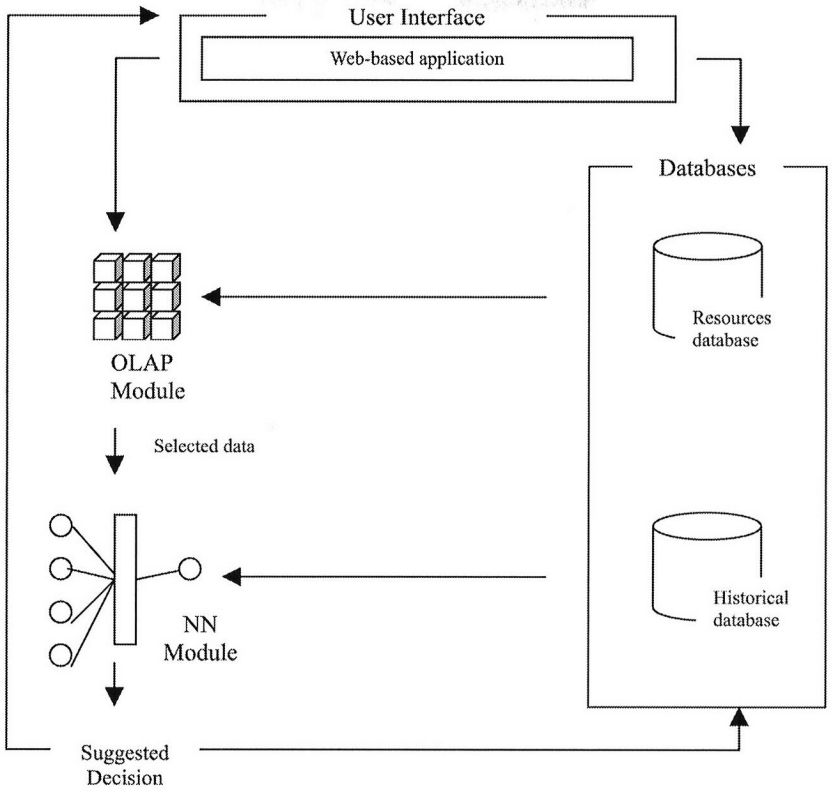
Figure 1 Resources management system infrastructure



by the user (Inmon, 1992)". In other words, OLAP converts data into useful information by transforming raw data to meaningful and organized information with its analysis features so that it reflects the real dimensionality of the enterprise that is understandable by user. Most importantly, OLAP has the ability to provide managers with information they need to make effective decisions about an organization's strategic directions. Devlin summarized the direction of information-based management as: single information source, distributed information availability, information in a business context, automated information delivery, and information quality and ownership (Delvin, 1997).

However, OLAP has its own drawbacks. Whilst OLAP is able to provide numerical and statistical analysis of data in an efficient and timely manner, it lacks the intelligent element to provide predictive advice. For example, it is unable to project possible outcomes based on the historical records and it cannot provide recommendations with previously recorded cases. In this respect, it is necessary to find an approach to cope with its pitfalls in order to form a complete system. Neural network is chosen to be the complement of OLAP since one of the objectives of the system is that it should generate suggestions that are as good as or even better than the decision made by the expert, provided that the same set of input data are given. The learning process of human is through a repetitive learning cycles which is similar to the learning process of neural network. Therefore, the neural network is selected to be part of the hybrid system to take advantage of its capability to operate with incomplete data to generalize, abstract, and reveal insight (Wasserman, 1989; Sharda, 1994; Kasabov, 1999). Neural network is statistically oriented tool that excels at using data to classify cases into categories (Davenport and Prusak, 2000). Neural networks "learn" patterns from data directly by examining the data repeatedly, searching for relationships, automatically building models, correcting over and over again the model's own mistake (Datta and Thomas, 1999). In other words, like other simulation models, neural network substitutes the real system in predicting and controlling system responses for the purpose of dynamic control (Haykin, 1994). These characteristics of neural network assist decision-making for resources allocation, since resources are often limited and the resources must be used in the operations of the corporation that are beneficial to the overall performance of the company.

The resources data and information are enshrined in the OLAP system to take the advantages of its provision of multi-dimensional

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views on the scattered data and generation of aggregated data. The resources database provides the necessary data input for OLAP system. The resources database includes the assets information, usage constraints, and the policy of the company regarding the use of the resources. The in-depth data that are generated by the drill function of OLAP system would be submitted to the neural network system for analysis and a proposed solution will be generated based on categorizing a multi-dimensional input vector. The suggested solutions are provided to the user through the Web-based user interface.

Case study

Background

Victory Shipping Co. Ltd is a medium size shipping company that provides shipping and handling services from Europe to Pacific Rim. Owing to the intense competition in the market, Victory Shipping Co. has to stay low cost in operation by reducing cost in managing containers, which are the biggest assets as well as costs of the company. In order to reduce the burden of investment, Victory Shipping Co. has been actively engaged in the use of free one-way lease offer by the container manufacturers in China. The container manufacturers in China are willing to offer free one-way lease to shipping companies to take advantage of the free charge of delivery of container to the buyers in Europe. The container manufacturers instead of chartering vessel to reposition the new containers to European buyers, they would offer the shipping company 60 days free-of-charge usage, and the shipping company must deliver the containers to the designated depots in Europe within the free-of-charge period. However, if the shipping company cannot deliver the containers on time, a high rental fee will be charged to the shipping company.

After the containers have arrived their destination, besides the free one-way lease containers, Victory Shipping Co. would have to make decision about the containers, such as re-use its self-owned containers, refurbish its containers, or phase out the leased containers to the container leasing companies. Victory regional offices are responsible to prepare instructions regarding the usage of the containers and the agent at the depot would know what to do with the units after the arrival of the containers.

Existing practice

Container Control Department in the head office of Victory Shipping Co. controls all the contracts with leasing companies and container manufacturers. The manager of the Container Control Department decides the procedures for controlling the container fleet, phasing out the units, or delivering the one-way leased unit to the container owner. The manager would inform the operators and the regional managers through the e-mailing system regarding the instructions. Operators would extract a complete on-board list in MS Excel format of the particular vessel, and type in the disposal instructions for each unit manually. After the instructions are added to the MS Excel file, the file would be sent to the agents of the destinations through e-mail.

After analyzing the workflow operations of Victory Shipping Co., number of problems are found. Firstly, problems of the existing practice are that most of the disposal instruction files are distributed through e-mail, which is quite difficult to keep track of the status as the files may be updated without acknowledging all the associated personnel. Secondly, there is lack of a systematic way to keep track of the records of each container, which creates problems to the manager to obtain the information for decision-making regarding refurbishment and disposal of container. Thirdly, since the disposal instructions are input manually, there are possible human errors, which would create financial loss to the company if the containers were not delivered on time to the container buyer. Fourthly, it commonly requires at least 30 minutes time to prepare one disposal instruction even for the experienced operator. Moreover, the right personnel are necessary to be recruited as the operator, since the operator would need to have the knowledge on the leasing contracts. For example, if the destination does not allow re-using the one-way leased container, the operator must give proper advise to the manager when he/she sees there is violation to the leasing contracts. Furthermore, the change of the inter-ports activities are usually not recorded to the on-board list, which has often created problems in controlling the one-way unit and the possibility that Victory Shipping Co. failed the one-way leasing commitment and ends up paying high cost for late delivery of the container to the container buyer. Lastly, the activities are not recorded properly and the containers could not be fully utilized by planning the routes.

The management of Victory Shipping Co. realized the need to strengthen the control of the container, especially the one-way leasing containers, which often incur high costs to the company due to delay of delivery to the destination accordingly. Also, there are needs in expanding the services and one-way leasing activities for different vessels. The management of Victory Shipping Co. has decided to develop a resources allocation and

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management system to assist decision-making and generates reliable disposal instructions for the regional managers and agents (Figure 2).

Adoption of proposed resources management system

An online decision support system was developed to facilitate the control of containers for Victory Shipping Co. Managers can obtain the information needed through the Internet by submitting the inquiries and instructions to the system. Since the system is connected to the corporate database, managers can find the information regarding the leasing contracts, container type, container status, destination, customers, vendors, etc. through the system. On the other hand, the system allows the agents extracting the on-board disposal instruction from the resources management system and distributes the disposal instruction through the system to the regional managers and agents. The regional managers and agents are also responsible to submit information of the containers which leave and arrive the port to ensure the inter-ports activities are recorded and updated (Figure 3).

A resource management system includes an OLAP module is built with Web-based application, which ensures the system is accessible through the Internet. The data enshrine in the system repository are transmitted to OLAP, which captures all the necessary information for manipulation to take advantage of its provision of multi-dimensional views on the scattered data and generation of aggregated data. For Victory Shipping Co., the information regarding the usage of the containers, leasing contracts information, container on-board lists, customer information, vessels, etc. are captured in the multidimensional data structure that allows the managers to drill for information. The neural network, which is linked to the OLAP system, would generate suggested routes that fully utilize the containers to avoid paying any extra rental costs for the one-way leasing containers and extra delivery costs to the repair shop for the containers that need refurbishment. The suggested routes are provided to the managers who would make the final decision of the disposal instructions for the containers. The disposal instructions are then made available on the Internet and distributed to the associated

Figure 2 Existing practice of Victory Shipping Co.

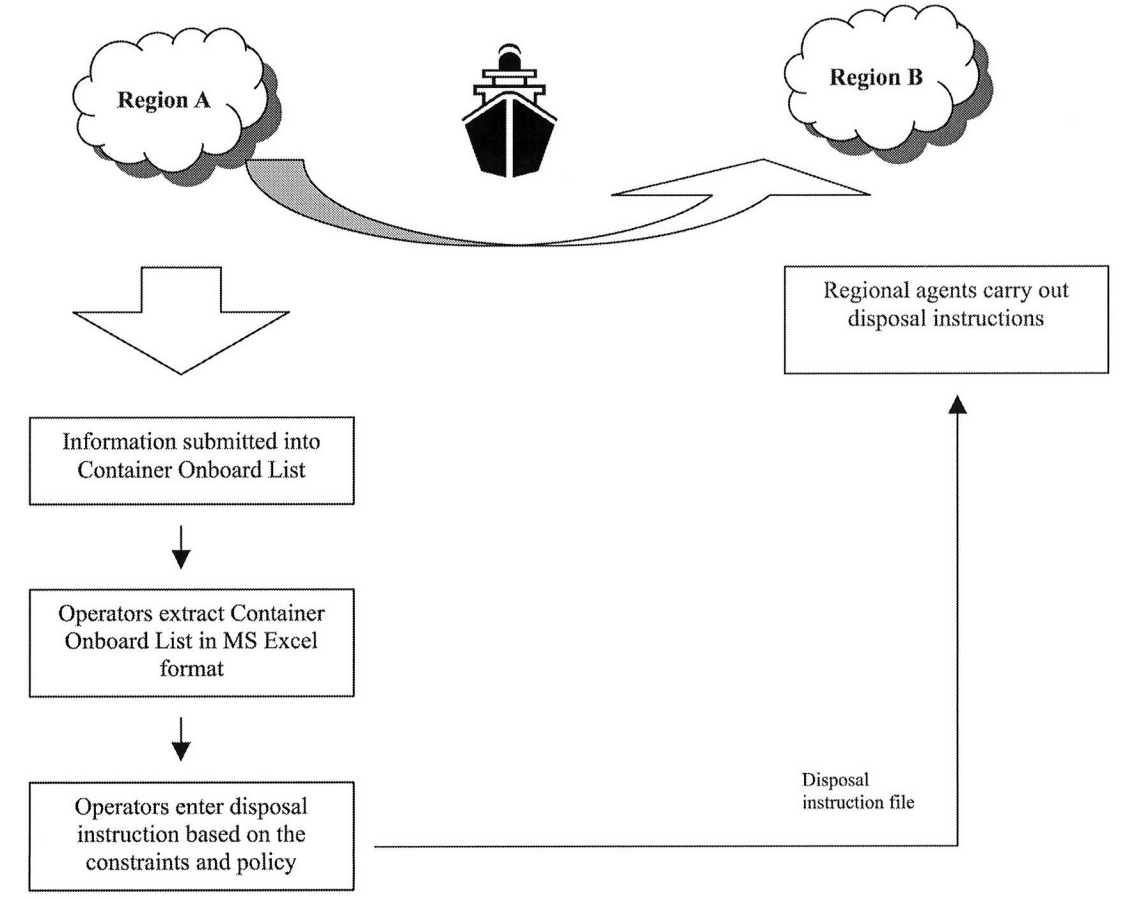

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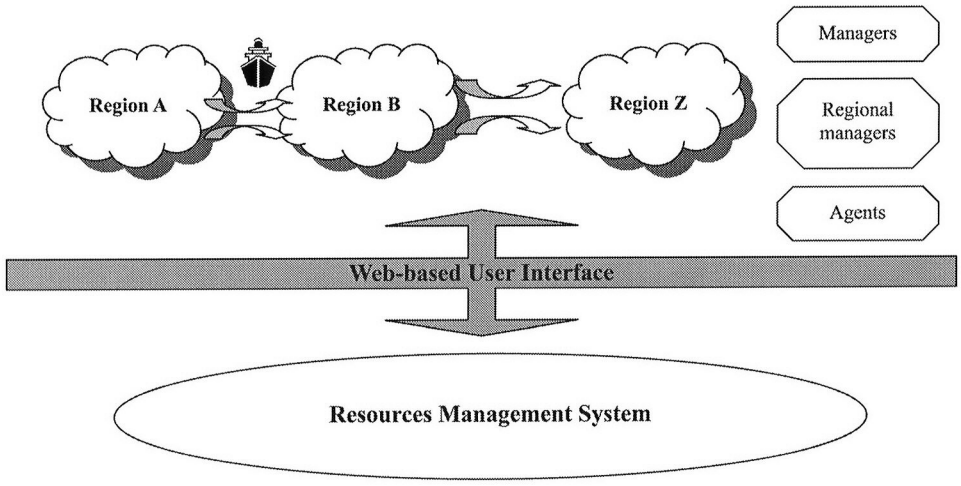
Figure 3 Flows of information with the new system in Victory Shipping Co.



personnel who can then plan ahead for the regional activities (Figure 4).

Victory Shipping Co. has deployed the proposed resources management system in numbers of vessels and locations before full implementation of the system in the company. The company has selected the Asia vessel, which includes the ports in Singapore, Hong Kong, Shanghai, etc., and the Europe vessel, which includes the ports in Hamburg, Southampton, Rotterdam, etc. The resources management system has installed in the corporate Intranet for testing.

Managers in the headquarters, which is located in Hong Kong, plan the routes for a shipment after it has left from the port in Shanghai, and compared the routes of the containers suggested by the resources management system. The managers found that the suggestion generated by the system has approximately 90 percent of the routes and ports that are similar to the one the manager planned, and all of the routes that are suggested by the system are able to deliver the containers to the container buyer on time. However, the managers are still concerned regarding the utilization of the containers according to the system suggested routes. Since the suggested routes are bounded strictly by the contract dates, the system lacks the capability to compare the benefits and costs of the usage of a container. However, the intelligence of the system can be improved by training the neural network with an additional set of data of the costs and benefits of using a contract-expired container.

Furthermore, managers found that the OLAP system enables them to obtain the in-depth information regarding the usage of the company-owned containers and the leasing containers. Indeed, the managers find out by the OLAP system that some of the containers are empty or not fully occupied but are placed on-board, instead of waiting for the next shipment (Table I). Also, the managers found that the empty containers are not due for the one-way leasing contract nor require any refurbishment yet for the next destination. In other words, the empty containers should be reused and wait for the next shipment in order to fully utilize the containers before the end of the contract or repair period. There are surely wastes of the limited resources. Furthermore, the OLAP system allows the company to monitor regional performance by generating an on-land disposal instruction report to see if the instructions have been completed on time.

Evaluation of the proposed resources management system

By adopting the resources management system, Victory Shipping Co. is able to benefit in number of ways. Firstly, Victory Shipping Co. can reduce the labor costs for administration operations, which was meant to provide the information to support decision-making, as the managers are able to access the information through resources management system that also generates suggestions for the managers to utilize the limited resources and exploit opportunities. As mentioned above, the managers in the Victory Shipping Co. are able to monitor the regional performance closely with the assistance of OLAP system, managers can expand or even shrink the services depending on the needs of the region. Furthermore, resources management system helps in minimizing the delay of instructions distribution within the company. The information regarding the shipment, containers, etc., all the information

Figure 4 New practice of Victory Shipping Co. after adoption of resources management system

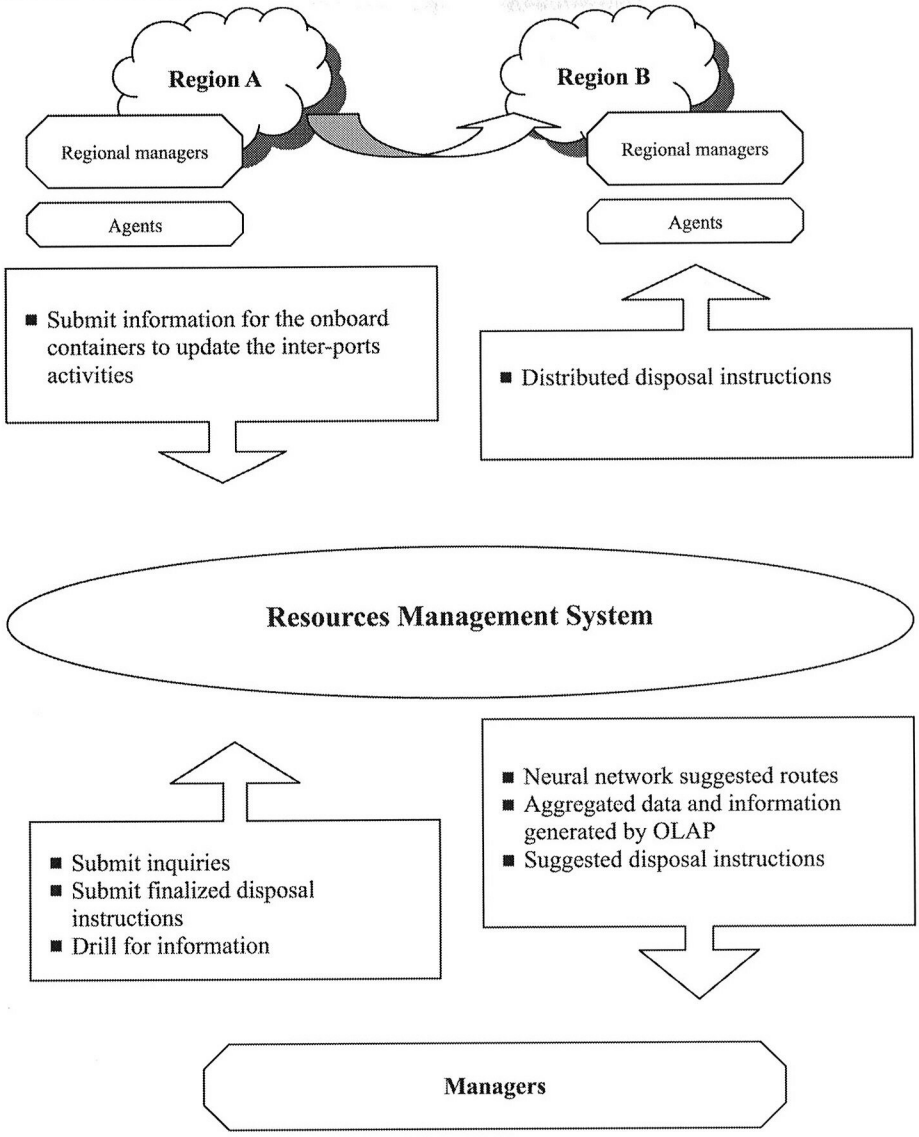


Table I OLAP output table

CTR_no	CTR_type	Owner	Status	Date	Destination	Disposal remark
AMZU8370509	45G1	O	Empty on-board	22 February 2002	YANTIAN	CSV03
AMZU8386547	45G1	O	Empty on-board	22 February 2002	YANTIAN	CSV02
BOXU2215581	22G1	S	Empty on-board	22 February 2002	YANTIAN	
CAXU2043601	22G1	M	Empty on-board	17 February 2002	NINGBO	
CAXU2185360	22G1	M	Empty on-board	22 February 2002	YANTIAN	
CAXU2192035	22G1	M	Empty on-board	22 February 2002	YANTIAN	
CAXU2340976	22G1	O	Empty on-board	17 February 2002	NINGBO	
CAXU2562000	22G1	M	Empty on-board	17 February 2002	NINGBO	
CAXU2575754	22G1		Empty on-board	17 February 2002	NINGBO	
CAXU2994874	22G1	M	Empty on-board	22 February 2002	YANTIAN	
CAXU4106139	42G1	M	Empty on-board	22 February 2002	YANTIAN	
CAXU4363918	42G1	M	Empty on-board	22 February 2002	SHANGHAI	
CLHU2145807	22G1	M	Empty on-board	17 February 2002	NINGBO	

Notes: CSV03 YANTIAN: reuse unit to Los Angeles; CSV02 YANTIAN: reuse unit to Genoa, Venice

that are necessary for decision-making and carrying out instructions, are available through a Web-based Resources Management System that is accessible anywhere at anytime. Also, the agents are able to obtain the most updated disposal instructions through the system. Different time zone and the occurrences of national holidays will no longer be a barrier of communication in the company anymore. Moreover, the disposal instructions are not input and filtered manually anymore, the accuracy of data improves significantly.

However, intensive training is needed to equip the managers with the knowledge of using the resources management system. Especially for the OLAP application, which has an interface that allows the user to drill down for information by combining the data in multi-dimensional manner. The user may find it difficult to visualize their needs and express their needs by manipulating the data with an OLAP application. Moreover, one of the main benefits of the resources management system is that it is accessible through the Internet. In other words, the Internet connections are critical to the capability of the system. However, the Internet infrastructure of some developing countries is not so sophisticated, which creates problems for the regional managers and agents to access the information.

Conclusion

Economic organizations always devote their full efforts to obtain the best available information in order to make informative decisions. The proposed infrastructure of decision support system allows the user to obtain the information that are necessary for decision-making while enables to exploit opportunities with the existing information. Further development of a decision support system that links with the supplier and customer by enabling them to logon to the company portal to access the information they need for business operations.

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