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INTEGRATED OPTIMIZATION AND DEPLOYMENT MECHANISM OF INFORMATION RESOURCES IN COMPLEX MANUFACTURING COLLABORATIVE LOGISTICS NETWORK

[1]XIAOFENG XU, [2]JINLOU ZHAO, [1]YIRUI DENG

[1]College of Economics and Management, China University of Petroleum, Qingdao 266555, Shandong, China

[2] Shipbuilding Industry Management Research Institution, Harbin Engineering University, Harbin 150001, Heilongjiang, China

ABSTRACT

To achieve effective information resources integration of complex manufacturing collaborative logistics network, it firstly must understand the integration content and the specific steps of integration. Based on this, the paper describes the related problems of optimization deployment about information resources integration, and uses the Mutil-Agent technology means to achieve information resource optimization deployment, finally, realizes the ultimate goal of providing high-quality service levels.

Keywords: *Information Resource Integration, Deployment Mechanism, Collaborative Logistics Network*

1. INTRODUCTION

Information resources integration in collaborative logistics network makes use of superior resources in network, achieves the purpose of sharing network resources by technical means. It mainly virtual integrates the resources which have competitive advantages and geospatial discrete distribution in network, strengthens cohesive relations, improves resource response speed and reduces resource redundant waste [1]. For complex manufacturing collaborative logistics network, the huge resource information will make the users at loose ends, and increase the disorder degree of network system. Therefore, it must be effective integrated resource information according to user needs [2,3], it can be said that only the heterogeneous formation of information resource integration which accords with the demand can satisfied the higher level of resource sharing.

As the key link of resource optimization system, the most different between information resource integration and acquisition is that: resources obtain matching is the process of resource properties, resource property is the smallest searching unit, and information resource integration is a combinatorial optimization process among different resources which takes individual resource as the smallest unit.

2. MAIN CONTENT OF INFORMATION RESOURCE INTEGRATION

The network nodes in complex manufacturing collaborative logistics network usually provide the specialized service, which only partly meet the resource demand coming from logistics working package of complex manufacturing. Therefore, it needs multiple specialty resources if the network wants to fulfill the logistics task [4]. If the nodes in network lack information communication and coordination mechanism, it will affect the respond speed and performance schedule of logistics task, and reduce variances in complex manufacturing production plans. Information resource integration is to quickly respond the users demand [5], it can be achieved the fast respond and reconstruction of distribution resources through dynamic integration of superior resources. The main content description of information resources integration is composed of the basic form, the relational model and the main framework three parts.

2.1 Basic Form

Considering references on information resources integration [6,7], the traditional integration ways mainly have local horizontal integration and off-site longitudinal integration in two forms. Combined with the complex manufacturing features, it can be

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found that: there is a special hybrid integrated form in addition to the above forms.

(1) The local horizontal form

The integration form in complex manufacturing collaborative logistics network is focused on the core manufacturing enterprise, actually, it is the logistics resources management of core enterprise which includes its own and the region where it is. Its management way is to establish the standard database of local logistics resources, typed access the static fixed and dynamic changed properties of information resource by adopting unified resource description language, and in accordance with the actual situation of dynamic update, delete, query, and add resources library information. When the resource demand of logistics tasks in complex manufacturing is produced, the network will first searches the local repository, and achieve local information resources integration by information matching. When the local repository is unable to meet demand, carries through the off-site vertical information resources integration, until reaches a reasonable resources combination which can respond the logistics tasks package of complex manufacturing. Local horizontal information resources integration is faster, more agile compared to other integrated form of response, thus it is the first considered approach on carrying out the information resources integration. The process of local horizontal information resources integration is shown in Figure 1:

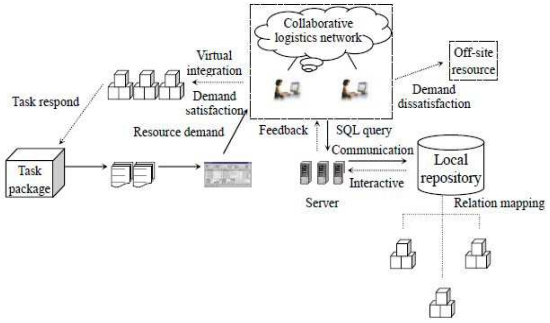

Figure 1: Process of Local Horizontal Resource Integration

(2) The off-site vertical form

When local resources are completely unable to meet the needs of the demand resources, the network needs to conduct a search of off-site resources, and ensure the implementation of rapid response to tasks. Off-site vertical integration is for resource nodes which have the spatial distribution, it faces not a large number of dispersed resources in network, but rather the matching resources in the phase of resources obtaining, and realize virtual integration of resources with the Internet / Intranet network technology. The integration form is based on the logistics resource demand of each links, carries different types of resource through vertically optimal combination. In this process it relates to resource optimization database and resource package database, combines with expert knowledge database, it can be done optimal decision-making. The process of off-site vertical information resources integration is shown in Figure 2:

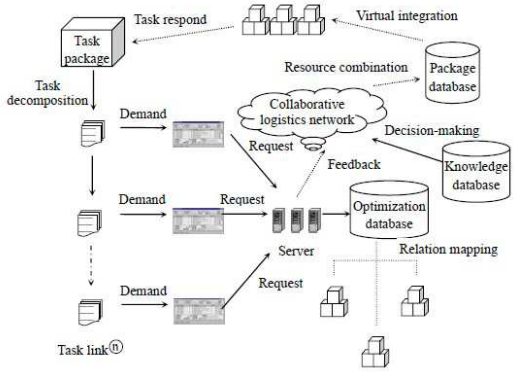

Figure 2: Process of Intercity Vertical Resource Integration

(3) The vertical and horizontal hybrid form

The above-described integration forms are the extreme form of information resources integration (fully local and fully off-site). During the process of complex manufacturing logistics tasks implement, there is often appeared the hybrid integration status including local resources and off-site resources. The local resources can meet the resource demand partly, on this basis, off-site resources can be integrated through complex manufacturing collaborative logistics network, and eventually the vertical and horizontal hybrid form is selected to respond logistics tasks. This information resource integration is an organizational form of spatial distribution, standard packages, loosely coupled and temporary mechanism, the main technologies used include distributed object technology and network Web technologies, which can be well adapted to the heterogeneity of network organization and the diversity of resource types.

2.2 Relational Model

Analysis of information resources integration relational model should include the analysis of resource relationship features and communication mechanisms in additional to resources static and dynamic properties [8]. The analysis shows that the information integration and the integration content consist are entirely different things, therefore, the relational model can be regarded as a 4 element

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architecture array which is made up of basic properties, functional characteristics, correlative relationship and communication mechanisms. The data structure of relational model can be described as:

$$Res_{int-model} = \{Res_{int-pro}, Res_{int-fun}, Res_{int-rel}, Res_{int-com}\} \quad (1)$$

Where $Res_{int-pro}$ represents the resource basic property domain, $Res_{int-fun}$ represents the resource functional characteristic domain, $Res_{int-rel}$ represents the resource correlative relationship domain, $Res_{int-com}$ represents the resource communication mechanism domain. The advantage of this structure is that: it can storage different types and structures resource information.

(1) $Res_{int-pro}$ - resource basic property domain

This domain covers the solid-state and changing property information, and it contains two sub-domains $Res_{int-pro}.Static$ and $Res_{int-pro}.dynamic$, each sub-domain contains two structures, the form of structure is that:

$$Res_{int-pro}.Static = \{Static_{gen}(1\times 4), Static_{fuc}(1\times 4)\} \quad (2)$$

$$Res_{int-pro}.dynamic = \{dynamic_{sta}(1\times 4), dynamic_{sev}(1\times 3)\} \quad (3)$$

Therefore, the resource basic property domain can be expressed as 4 element architecture array including two sub-domains.

(2) $Res_{int-fun}$ - resource functional characteristic domain

This domain is different from the functional information of resource property domain, it is more side for the integrated resources description of operational capability, cost, time constrains and service quality, it indicates the level of service and the achieved effect of operation which resources provide. Thus, the resource functional characteristic domain can be expressed as 3 element architecture array, the form of structure is that:

$$Res_{int-fun} = \{Res_{int-fun}.Unit, Res_{int-fun}.Task, Res_{int-fun}.Result\} \quad (4)$$

$Res_{int-fun}.Unit$ is the main logistics resource, according to the object-oriented technology and methods, it represents the maximum load information and service form which resource can provide under the resource type. $Res_{int-fun}.Task$ is the object of resource task, it represents the logistics task which resource can undertake, the description of resource characteristics and content. $Res_{int-fun}.Result$ is a resource service effect, it represents cost, time requirements and the provided service quality which resource requires when bear logistics task.

(3) $Res_{int-rel}$ - resource correlative relationship domain

Through the analysis of information resources integration form, it can know that the hybrid integrated form is the main form in complex manufacturing collaborative logistics network, this integration form is the external expressive form of virtual group which is formed by wide distribution network and multi-source resources. Due to the complex situation of multiple levels, regional and membership organization, it makes the resources relationship perplexing. Therefore, if the network would realize the integrated optimization of information resources, it need to describe the complicated relationship between resources.

Resources relationship domain of information resources integration is the set which describes the interactive relationship between resources, these relationships include resource collaboration, mutex relations, coupling relationship, subordinating relation, spatial relationship and time connection relation and so on. It is shown as:

$$\begin{aligned} Res_{int-rel} = \{&Res_{int-rel}.Cooperation, Res_{int-rel}.Exclusive, \\ &Res_{int-rel}.Coupling, Res_{int-rel}.Attacting, \\ &Res_{int-rel}.Space, Res_{int-rel}.Connect\} \end{aligned} \quad (5)$$

Resources relations are the complex relations of one-to-many or many-to-many. At the same time, because complex manufacturing collaborative logistics network is an open complex system, it leads to resource relations with non uniqueness, dynamic and multilateral characters, which make information resources integration must be based on the actual situation and resources status.

(4) $Res_{int-com}$ - resource communication mechanism domain

This domain is mainly to ensure communication unblocked of the collaborative logistics network information resources integration from technical view, and realizes resources sharing and scheduling under the distributed environment. It includes information driving $Res_{int-com}.Driven$ and business package $Res_{int-com}.Packaging$ two groups. It is shown as:

$$Res_{int-com} = \{Res_{int-com}.Driven, Res_{int-com}.Packaging\} \quad (6)$$

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$Res_{int-com}$.*Driven* is based on communication protocol, publishes the standardize information of resource providers. $Res_{int-com}$.*Packaging* can package the information processing function, the request processing interface and receiving a trigger interface in accordance with the standard, and achieves the scheduling of resources integration.

2.3 Main Framework

The continuity of complex manufacturing requires that the logistics tasks of collaborative logistics network can achieve rapid response [9], this requires network resources logically achieve the optimal combination scheme of information resources integration in the shortest possible time, namely resource rapid reconfiguration. It can be said the reconstruction process of resource rapid response must be accompanied with information resources integration activities. Meanwhile, the asymmetry, fuzzy, dynamic and uncertainty of resources information all can make stringent requirements rapid integration and reconstruction response. Therefore, building the main frame of information resources integration to better support resources reconstruction activities becomes the necessary antecedent conditions. The framework of information resource integration are composed by five levels from top to bottom, which include the task execution layer, the decision support layer, the coordination layer, the data mapping layer and the physical resource layer. The framework is shown as:

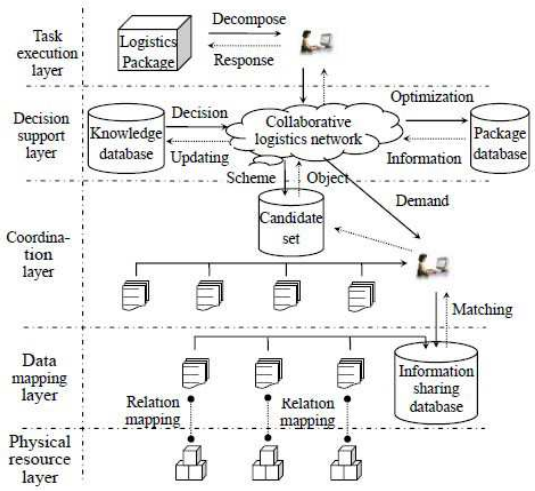

Figure 3: Main Structure of Resource Integration

3. CONCRETE STEPS OF INFORMATION RESOURCE INTEGRATION

The object of information resources integration in complex manufacturing collaborative logistics network isn't the large number of heterogeneous distribution resources, but it make the alternative resources by optimization matching as the object in resource acquisition phase, and achieves resources dynamic integration through a series of registration, package, sharing operation activities. Information resources integration is the ties between resources provider and resources demand, its purpose is to provide resources demand the matching scheme of resource combination, and achieves the rapid reconfiguration response.

3.1 Resource Register And Package Coupling

External resources want to join and provide service for complex manufacturing collaborative logistics network, they must first register indicating resources in the network exists, and then the resource encapsulation and sharing, eventually to become a node of the network. The network will use unified modeling description of resources before registration, and realizes the standardized representation of resource property information, eliminates the communication barriers between heterogeneous resources. Resource register includes the resource information model description and the resource use overview (interface definition, functional characteristics, time constraints, service mode and sharing strategy etc.)

Standard packaging on heterogeneous resources will carry out according to a certain standard after resource register, and achieves resources "modular", The packaged resource is no longer subject to its internal structure, the offer will be stable and reliable "plug-and-play" resource service. Generally, complex manufacturing collaborative logistics network will provide the corresponding resource packaging template because of the difference of resource type, and achieve the different resource package with the help of template package parameters. At the same time, along with the external environment dynamic development and internal network relationship adjustment, the network can also be self-built package templates through authorized, stores it into network package template library, and achieves the heterogeneous resources standardization. The process of resources packaging is shown as:

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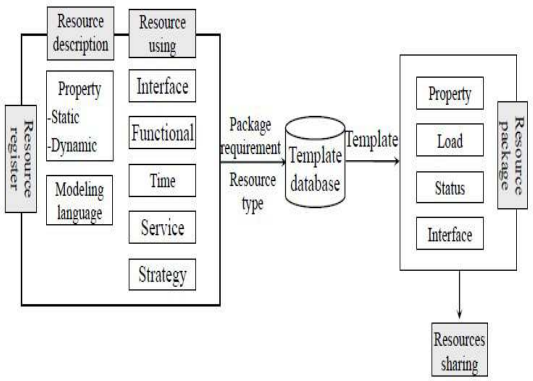

Figure 4: Process Of Resource Packing

3.2 Resource Collaboration and Sharing Design

Resource collaboration is on resource use and service characteristics, in the traditional logistics system, each node of logistics resources has exclusive and inward service characteristics, the other nodes can't enjoy the services provided by the node. Complex manufacturing collaborative logistics network is different other network, resources have sharing and extraversion after registration and packaged. The package service is oriented all members of the entire network [10]. Resource sharing is the synergistic expansion, specifically, clear nodes can provide shared resources (they can also be used by other nodes), Separation with the inward-oriented resources, the network can provide shared services together with the appropriate use of constraints package. Resource sharing is an important part of information resources integration, a variety of different types of heterogeneous distributed resources have shared after packaged throughout the network, and it has laid a solid foundation for the effective of resources integration, provides efficient service level a powerful supported.

In the process of information resources integration, resources registration and package are on the purpose of providing a more effective logistics services, and meet and respond to the logistics tasks faster. If only for a registration package, while the resources in the network is idle, it only indicates that the value of the use of resources, and can't reflect the value of its application. Therefore, only through the synergy and sharing design between resources, links the distribution network and the diversion of resources across organization, provides a modular integrated combination of services, in order to compensate for the independent resources, the resource imbalance between supply and demand, the inefficient communication, the insufficient, and realize its true value.

3.3 Resource Allocation And Scheduling Management

The combination scheme of information resources integration was finalized, the network will be triggered and coordinated the resources, which is about resource scheduling and allocation management. Resource scheduling is the physical mapping process between information resources integration logic relations, based on the relationship between integrated resource information, it will form a logical relational mapping to the physical resources of network space and determine resource allocation strategy, and ultimately achieves the task orderly execution. Resource allocation is a supplement and extension of resource scheduling, and the relationship is between the input and the output. Resource scheduling is the input process to obtain the actual use rights, resource allocation is the output process to delegate the use rights based on resource scheduling, it is also a reasonable and effective allocation resources process for logistics task of various execution environments.

Resources scheduling and allocation is a dynamic decision-making problem with multi-objective constraints, it is based on the resource demand on resource sharing platform through information exchange and resource node, selects the best resource nodes and logistics task execution link to match the deployment of resources, complex manufacturing collaborative logistics network has the following characteristics:

(1) The deployment object is the heterogeneous distributed physical resources across organizations

The resource scheme of information resources integration decision-making only has a logical sense, if it would make the resources to effectively perform logistics tasks, it must be realized the resources deployment of physical significance. Although the resource information in database is a unified, standardized structure, but the geographic distribution, organizational affiliation, resource type, and the internal structure of the actual different resources are vastly different. Resources allocation can be said that: it can deploy the heterogeneous resources according to the data mapping relations between resource information in database and physical resources in unified sharing platform.

(2) The deployment process doesn't involve the internal relations of resource nodes

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Resource nodes are independent autonomous node in the network, external individual resources join the network after registration and package, and become a node member. The information and relationship within the resource nodes can provided the identify standardized service after packaged. Resource node in network is the smallest unit of resources allocation, and thus, resources allocation is only for the service of resource nodes, doesn't involve internal situation of nodes.

(3) The deployment of main body requires a dynamic adaptive and scalability

Complex manufacturing collaborative logistics network is a dynamic and open system, it can continuous exchange energy with the outside world, and this is mainly reflected in the resource individuals join and exit the network, dynamics of resources structure and relationship in network require that the deployment of resources subject must have a dynamic adaptive capacity, in order to respond the dynamic changes of network resources. With the continuous development and growth, the size of resource is increasing, which requires the deployment of resources subject have expansion capabilities.

4. OPTIMIZATION DEPLOYMENT OF INFORMATION RESOURCE

Researches on resource scheduling problem are mostly concentrated in the manufacturing and delivery of transport [11]. The research on logistics resources scheduling is focused on the transport node and the path of the individual or combinatorial optimization. Scheduling problem has been shown to be the NP-hard problem, it doesn't using the traditional mathematical analysis method to search the optimization solution, and must use the nonlinear methods of artificial intelligence to have the approximate solution. Resource optimization deployment is a multi-technology coupled and integrated optimization problem, which includes automation technology, systems engineering theory and artificial intelligence methods multidisciplinary field.

4.1 Deployment Problem Description

The resource deployment problem is usually defined as: deploying a set of resources to perform a set of tasks. Resources optimization scheduling are the optimized operating activities under the deployment target (such as time, shortest minimum cost), which involves the deployment of resources, logistics various aspects of the task execution order and time. The resources optimization deployment problem is specifically described as follows:

(1) Scheme description of information resources integration

This link is a guide to action, has a clear allocation in resource optimization deployment. Described by the model $Res_{int-model}$ of integrated information resources, decision-makers can understand the combination scheme of information resources integration, extract the contents of the two domains involving $Res_{int-pro}$ and $Res_{int-fun}$, clear resource type, quantity, etc., and finally prepare to create a mapping relation set $Res_{sch-set}$ for the deployment of resources and physical resources.

(2) Tasks description of resources deployment

The network presets the content of $Res_{int-rel}$ and $Res_{int-com}$ in the information resource integration model, combines the mapping relation set between logistics task set $Log.Task = \{T_1, T_2, \cdots, T_m\}$ and resources deployment $Res_{sch-set} = \{R_1, R_2, \cdots, R_m\}$, and establishes of resource deployment task links-resource deployment scheme set $T.R$. The form of $T.R$ is shown as:

$$T.R = \begin{Bmatrix} T_1 R_{f\times i} \\ T_2 R_{g\times j} \\ \vdots \\ T_m R_{h\times k} \end{Bmatrix} \quad (7)$$

$T_m R_{h\times k}$ represents the T_m -logistics task, the h logistics chain and k redeployment scheme. $R_{h\times k}$ is shown as:

$$R_{h\times k} = \begin{Bmatrix} R_{11} & R_{12} & \cdots & R_{1k} \\ R_{21} & R_{22} & \cdots & R_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ R_{h1} & R_{h2} & \cdots & R_{hk} \end{Bmatrix} \quad (8)$$

(3) Methods description of resources deployment

The scheme performance of information resources deployment needs use to the technical deployment method set $Res_{sch-meth}$, which includes the heuristic intelligent resource scheduling [12], the Petri net resource scheduling, grid resource scheduling, resource scheduling based on Agent.

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4.2 Optimal Deployment Mechanism of Mutil-Agent

Because resources in complex manufacturing collaborative logistics network have heterogeneous distribution, independent and autonomous, and dynamically changing characteristics, and they increase the difficulty of resources deployment. Mobile Agent technology has the characteristics of decentralized modular autonomy, network communication and collaboration, dynamic and open structure, and has strong fault tolerance uncertain information and knowledge. It can promptly eliminate barriers to resource differences, and solves the problems existing in the network resource scheduling process, provides users with efficient resource response service, thus, it becomes dependent resource scheduling technology means. The independent Agent is only faced a thing-oriented or a link, its capacity has limitations. In view of the complex deployment problems in network, Mutil-Agent is required to communicate with each other, and jointly solves the resources deployment problems.

The basic idea of Mutil-Agent in resource scheduling is that: the distribution of resources in the network is packaged into the resource Agent, therefore, the object of the resources deployment can be seen as a resource Agent set. When the logistics tasks packages is received from the complex manufacturing, its resource requirements and constraints are packaged into task Agent, and results management Agent, protects coordination between tasks the Agent and resources Agent, monitors the tasks implementation. In order to ensure continuity of complex manufacturing, task Agent can't be changed, therefore, the class Agent doesn't provide any operator interface. On this basis, the formation of multi-layer optimization deployment mechanism model is shown as:

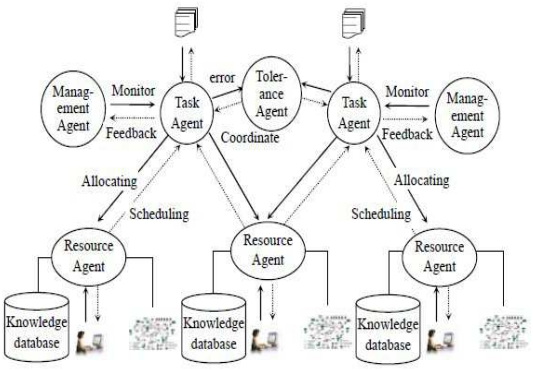

Figure 5: Multi-layer Optimization Deployment Mechanism Model Based on Multi-Agent

5. CONCLUSION

Information resources integration makes optimal resources as target object in the resource acquisition phase, it mainly faces complex manufacturing collaborative logistics network, and provides the service including resources register and package, coordinate and sharing, scheduling and allocating. Information resources integration is different from the signal resource obtained, it provides a combination of multi-resource services. Based on the summary of information resources integration in complex manufacturing collaborative logistics network, the paper analyses the specific steps of information resources integration, and combines Mutil-Agent technology, provides the multi-layer optimization deployment mechanism model of information resources integration.

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