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A Unified Multi-coarse Manufacturing Resource Model and Its Semantization Based on Extended OWL-S

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Abstract: In view of enterprise resources' composed business flow character, a Unified Multi-granularity Resource model (UMGR) is proposed which is described from four views of Multi-granularity Resource (MGR), i.e., base information, function, processes and the quality. To realize MGR's semantical service encapsulation, firstly, a Web service encapsulation model of UMGR is constructed based on extended OWL-S ontology web language for services, second, a process resource ontology and activity ontology are constructed. Based on the above model, an application framework for MGR is constructed. Finally, an application example of MGR is provided to verify the model and related ontology.

Key words: OWL-S, semantic web service encapsulation, multi-granularity manufacturing resource, ontology

INTRODUCTION

All kinds of granularity resources can provide users with resource selection of different granularity and can be arbitrarily selected or combined, as long as the results meeting the user's objectives, such as Quality of Service (QoS) target value. Extraction of fragment resources to construct the multi-granularity resource from the log to improve the quality of service is studied (Guo and Li, 2011). A service composition optimization methods based on multiple size requirements is studied (Ma *et al*., 2010). Manufacturing cloud service is organized to match the user's requirements according to its' granularity order (Jia *et al*., 2012).

Moreover, the traditional keyword-based query has larger repetition of Web service, difficult to accurately select the matching resources, while the semantic based service query is to overcome this shortcoming and can realize precise service query. OWL-S is used to describe semantic ontology for Web service (Wu *et al*., 2007) but it does not include quality of service description rules and the description of the service process is based on the operation process. An service model extended based on OWL-S is proposed which is with additional function and quality parameters (Fan *et al*., 2009). A manufacturing service is constructed based on semantic which supports the match and other related application of manufacturing service (Wu *et al*., 2012). A manufacturing service concept model with multiple views is proposed which is described by semantics (Wang and Liu, 2008). These researches provided references for semantic service modeling and service package of resource but did not involve a unified semantic service modeling on different granularity resources.

In this study, the primary practical contribution is to present a unified multi-granularity manufacturing resource model and its semantic service encapsulation.

A UNIFIED MULTI-GRANULARITY RESOURCE MODEL

Definition 1: A unified multi-granularity resource (UMGR) model: It is a joint description for the coarse grain and single particle flow of resources. For composite flow resource, resource includes a plurality of process resource and the flow formed by these processes resources is a continuous segment or the whole business process which can be regarded as a unified whole resources, whose input is the process's(or the whole process's) the first process resource input and output is the process's (or whole process's) the end of the process resource output and resource basic information is the basic information of the procedure segment. It includes four views: Resources View (RV), Function View (FV), Process View (PV) and Quality View (QV). RV includes resource's base information, such as name, enterprise and so on. FV describes resource's

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functions, i.e., input, output parameters, etc.. PV describes resource's flow logic. QV describes resource's business function exaction quality.

Therefore, it can be expressed as follows:

$$MGR = (B,F, P, Q)$$

where, B, F, P and Q is resource view, function view, flow view and quality view, respectively.

MGR's formation is necessary to meet one of the following conditions:

- It is a process resource of a business process of a manufacturing enterprise
- It is a process resource of fixed business processes of alliance which has relatively fixed business, closely process resource, often the advantage of process

For example, one MGR with a sequence structure business process fragment contains three resources, named R1, R2, R3 as shown in Fig. 1. R1, R2, R3 contains the process of atomic processes, respectively f1, f2, f3 and structure of the fragment is recorded as f1f2f3. They are combined into a multi-granularity resource which can be expressed as:

$$(R,\ F,\ f1f2f3,\ Q)$$

where, R expresses the newly generated MGR's name and other basic information, F the functions of the MGR's, f1f2f3 of the MGR's flow and Q of the MGR's QoS.

SEMANTIC FOR MULTI-GRANULARITY RESOURCE

Semantic encapsulation: OWL-S (Web Ontology Language for Services) is Web service Ontology described by OWL language. The OWL-S is divided into three parts: ServiceProfile, ServiceModel and ServiceGrounding. ServiceProfile describes what Web service is, ServiceModel specifies how to use it and ServiceGrounding specifies how to invoke it.

OWL-S is extended to cater to the MGR's service(WSMGR) encapsulation require_ ments in this study, called MGRWSO. Because OWL-S has the following agreement: a Web service can have multiple

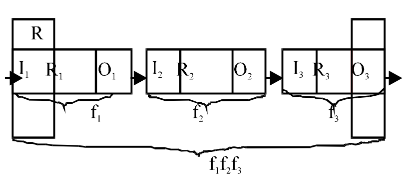

Fig. 1: An example of one MGR

ServiceProfile and ServiceGrounding, each resource service contained in MGR can be described through accordingly ServiceProfile and ServiceGrounding, respectively which would solve what is provided to the registration center or to the user. In the meanwhile, this study introduces the QoS as the ServiceProfile attribute which ensures that each resource QoS can be described in the respective ServiceProfile. While on MGR' overall information, such as basic information and total QoS, a ServiceProfile can be added to describe it and a ServiceGrounding have to be added accordingly to describe how to invoke the overall resource. MGR's flow can be described by ProcessModel which provides a combination process method. Abstract description of the whole process of MGR could be solved through SimpleProcess which can give abstract description for MGR'flow according to different requirements of fine-grained atomic or compound process, aimed at application in process planning and reasoning based on providing a simplified composite process view for user. An extended OWL-S model is presented in Fig. 2, in which contents in the dashed box are a virtual representation.

Ontology creation: Perez and Benjamins (1999) thought Ontology could be organized according to the classification. They summed up the Ontology consists of 5 basic modeling primitives: classes, relations, functions, axioms and instances. From the analysis of the semantics, instance represents the object of Ontology, class refers to a collection of objects and relation corresponds to the object tuple. The definition of the concept generally use frame structure, including concept names, the relationship with other concepts and the use of natural language for the description of the concept (Perez and Benjamins, 1999). This study uses the five tuple description Ontology, Ontology = (C,R, H,A,I), C,R,H,A,I represent the class, relation, attribute, axioms and instances, respectively.

Creation of process resource ontology: From the enterprise organization structure, all corporate sectors have their corresponding business processes and these departments' business processes can correspond to work together. In addition, there are hierarchical relations and the corresponding inclusion relations between businesses among enterprise organization departments. The construction of enterprise resource ontology is created in Fig. 3. The body is divided into 7 categories: enterprise resource class, planning process resources class, production process resource class, sales process resources class, personnel process resources class, financial process resources class and warehouse process

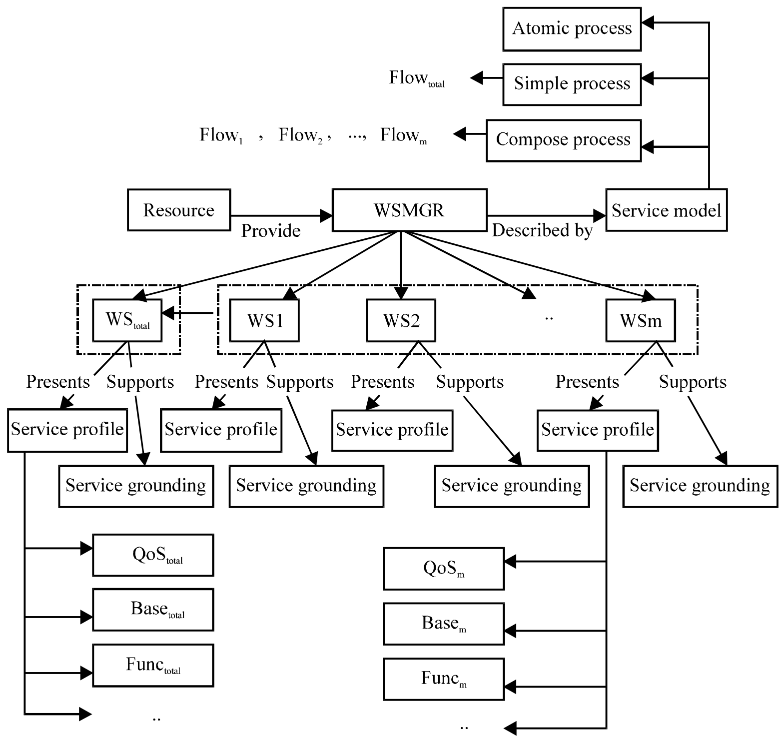

Fig. 2: An extended OWL-S for WSMGR(MGRWSO)

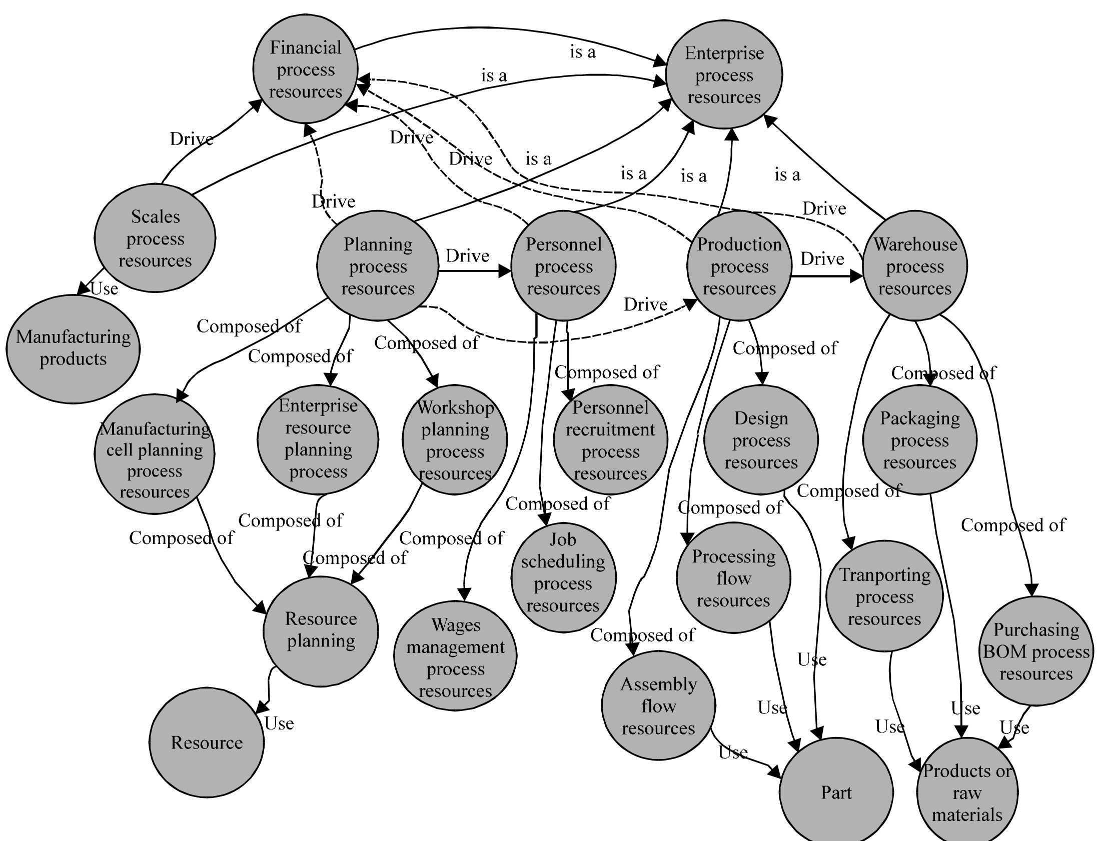

Fig. 3: Process resource ontology for MGR

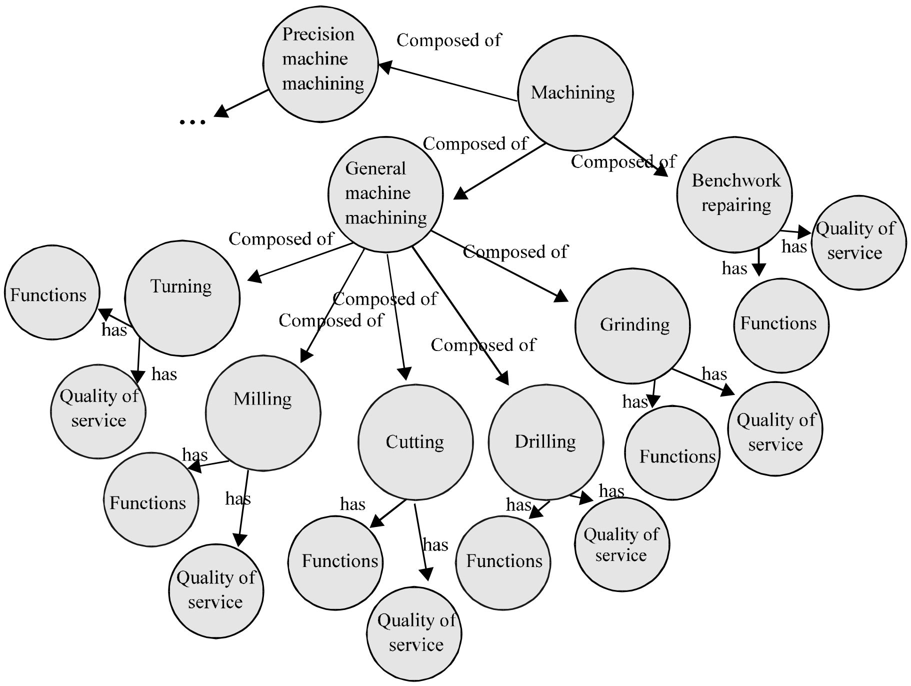

Fig. 4: A simple of activity ontology for one process of manufacturing workshop

resources class. The body frame contains the hierarchical relationships between types, dynamic relationships. Through the ontology framework, the relationship between the process resources at enterprises can be described which provides a semantic ontology support for the distinction of different process resources.

Based on the above ontology, the conceptual framework is further improved in this study, such as the refinement of all sorts of the subclass, attributes and so on, finally perfecting the body frame.

Creation of activity ontology: In addition, semantic service of MGR also needs to construct activity Ontology for domain activities. Figure 4 took the processing of a department as an example to describe construction of activity Ontology.

Through the above process resource ontology and activity ontology instances' Construction, on the basis of which semantic recognition of MGR on user's request can be done.

APPLICATION OF MGR

Application framework: A process tasks oriented application framework of MGR is constructed based on WSMGR which includes three levels as shown in Fig. 5:

- **Resource level:** It provides all manufacturing resources, including software resource, equipment resource and intelligence resource and so on. It provides material base for upper level service
- **Service level:** It is responsible for the lower resource service and service management and provides interaction with upper application level, including two databases of services registering database and ontology database and all other management function for services
- **Application level:** Oriented user, it provides demand customization and achievement based on process customization. In addition, it includes a series of related functions, such as flow customization, constraints editor of QoS and so on

Application methodology: Based on application framework discripted at Fig. 5, UMGR and its ontology's application process is as followed:

Step 1: Resources with different particle size are registered to the library by the form of MGRWS, of which semantic registration is realized by the WSDL/OWL-S converter

Step 2: User makes manufacturing task on-demand according to the business process template

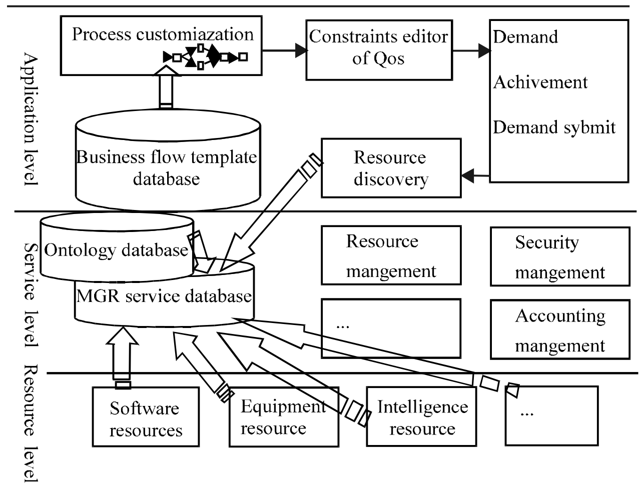

Fig. 5: An application framework for MGR

Step 3: User's requirements document is acquired and send based on XML

Step 4: Resource discovery is realized based on semantic matching which is three stages matching methods included MGRWS's function matching, process matching and QoS matching. Calculation formula of service matching is as followed:

$$Sim_{total} = W_q.\ Sim_{Qos}+W_p.\ Sim_{process}+W_m Sim_{parameter} \quad (1)$$

where, Sim_{total} is overall similarity value and Sim_{Qos}, $Sim_{process}$, $Sim_{parameter}$ is QoS similarity value, process similarity value, parameter similarity value whose calculation methods can referred the literature and W_q,W_p,W_m is weight value, respectively and $W_q+W_p+W_m = 1$.

SIMULATION AND VALIDATION

Simulation system and running environment: A prototype is partly developed based on application framework described at Fig. 5, including resource registration database, resource discovery function and so on. Running environment of the system is: Windows XP(sp3),i3-2350M CPU 2.3GHZ, 1.9GB memory.

Simulation design: Two simulation service resource databases are built for the comparison of simulation. One is MGR database and other is simple resources' registration database. Different scale resource discovery simulation experiment are done based on the two resource bases which are 20000, 40000, 60000, 80000 and 100000, respectively.

Simulation evaluation index is adopt by the simulation example.

Average query time means an average query time cost for one stochastic demand in the same service data which is descripted as followed:

$$avt_i = \sum_{i=1}^{n} t_i / n \quad (2)$$

where, t_i is executed time for the ith query.

RESULTS AND DISCUSSION

Table 1 presents the summary of performance of two sets of different scale data, i.e., average query time. One set of data is based on coarse grain resource of MGR, called Data(1), the other single particle resource of MGR, called Data(2). To simplify example, multiple particle size range of 3-5 activities is done.

It is found that Data(1) composed of coarse grain resource can be searched by shorter time than Data(2) composed of single particle resource from Table 1 which is basically proportional to the number of activities contained in coarse grain resources. This is because a multi-granularity resource only as a single resource is searched but many single particle resource need to be searched by different activities, respectively. Moreover, the resource scale increased, increased the search time which is no significant relationship on the proportion. This is because discovery algorithm adopt global search for the resource.

Table 1: Comparison of the average query time for two sets of data

Data (1)	vt (msec)	Data (2)	avt (msec)
20000	1.07	20000	3.33
40000	6.20	40000	18.47
60000	13.60	60000	40.07
80000	42.67	80000	122.13
100000	68.53	100000	208.40

For each data set, the average results of 15 times example is taken

CONCLUSION

In this study, the main work and innovation are as follows:

- Proposed a unified model of multi-granularity resource based on business process
- Proposed semantic encapsulation method for MGR based on extended OWL-S and constructed process resource Ontology, process activity Ontology
- Constructed multi-granularity resource application framework based on the proposed model, on which the model and related Ontology are validated through simulation example

MGR's service composition will become the future work.

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