Research on Discovery and Evaluation of Network Manufacturing Resources

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Abstract

For the disadvantages of discovery mechanism of current networked manufacturing resources based on Semantic Web Service, a joint discovery mechanism based on UDDI (Universal Description, Discovery and Integration) and WSIL (Web Services Inspection Language) was put forward. Basic process features are matched in UDDI and corresponding eigen values are matched in local WSIL. An evaluation model combined fuzzy theory with analytic hierarchy process and the law of comparative judgment was presented. Discovery architecture of networked manufacturing resources was built. Basic principles and characteristics of the integrated architecture were analyzed. Key technologies for realizing the integrated architecture were studied. The joint discovery mechanism prototype platform for manufacturing resource was developed by borrowing ideas from this model. The system improves the efficiency of finding manufacturing resources and enhances scientificalness and reliability of evaluation.

Introduction

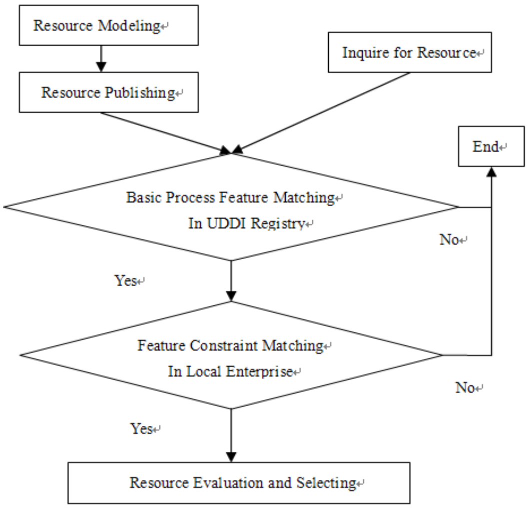
Under normal circumstances, enterprise production tasks are compatible with its production capacity. Along with economic globalization, if a core enterprise can't complete the tasks in time, it will look for external resources to complete its tasks. It is very important whether manufacturing resource capability matches with processing [1].

In recent years many researchers have been working on discovery. A Multi-Agent Autonomous Learning systems was put forward to find resources on its own initiative [2]; XML technology is used for integration of heterogeneous data storage systems to build a repository. The system provided standard interfaces to the developer to quickly find the relevant resource information in a single or multiple UDDI [3]; The STEP standard was used to solve the problem of sharing and exchanging data. The system based on the STEP standard achieved integration and interoperability application to find manufacturing resources[4] .

So far in 2008 discovery researches on manufacturing resources through the WWW have made some achievements. For example a distributed discovery mechanism based on P2P was proposed in literature [5]; a centralized discovery mechanism based on UDDI was proposed in literature [6]; The flaws of the distributed discovery mechanism based on P2P lie in difficulties of network search and management. UDDI is a centralized discovery mechanism. It is easy to manage UDDI. But with the rapid growth of network manufacturing resources, UDDI will have heavier load. WSIL is very similar with the specification of UDDI. According to the respective characteristics of UDDI and WSIL, the paper first proposed a joint discovery mechanism with the organic combination of UDDI and WSIL. In determining the index weight factors, there are usually the analytic hierarchy process (AHP) and the improved methods. But the method is difficult to meet the consistency requirements when there are many factors. And psychology experiments show that, when the number of the factor exceeds nine elements, the judgment is not accurate, so AHP method can't be applied directly [7]. For the above reasons, an evaluation model combined fuzzy theory with analytic hierarchy process and law of comparative judgment was presented.

Framework of Manufacturing Resource Discovery

This article focuses on equipment resources. Resource provider publishes basic process features of equipments in the UDDI registry. The basic process features usually include plane feature, hole feature, shaft feature, tank feature, cured surface feature et al. The basic process feature = (feature value 1, feature value 2, feature value 3, et al.). Feature values can include machining accuracy, scope of size and other process parameters. Feature values organized by WSIL are released in a local enterprise. (refer with: Fig. 1) At present a normal system retrievals according to keyword, not according to the semantic. Search results do not include synonymous, nearly-defined words. The system will automatically match the basic process feature according to the semantic similarity of ontology. If the value of semantic similarity of concept A and B is greater than threshold value set by the administrator, the system thinks the basic feature of concept A and B is same. If values of semantic similarity of all basic process features exceed the threshold value, the system will link to WSIL to conduct feature constraint matching. If all matching are met, that means machine tool capacity meets the manufacturing process constraints of a part and the system will return information to the service requester. (refer with: Fig. 2)



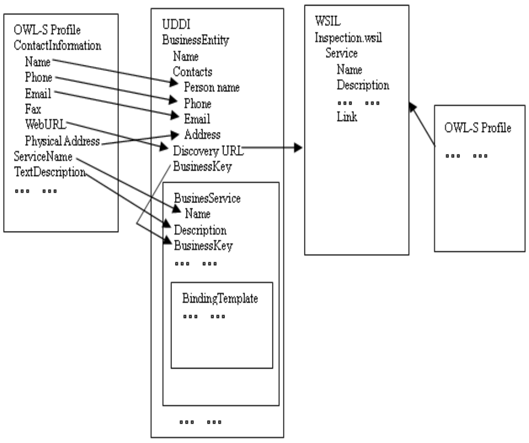


Fig.1 Discovery flowchart Fig. 2 A semantic expansion joint discovery mechanism

The Key Technologies

Domain Ontology

Ontology is conceptual explicit instructions in application areas [8].Ontology is an important component of the knowledge management system. Constructed ontology is seen as an important means of improving the knowledge engineering process, enhancing knowledge sharing and reusing, promoting interoperability among heterogeneous systems [9]. Through the introduction of Ontology semantic information and matching algorithm, it will greatly enhance the retrieval efficiency of the system.

Similarity Algorithm

There are many ontology similarity algorithms and this paper introduces ontology similarity algorithm [10].

$$Sim(o_1,o_2)=\frac{L}{L+a(O_1,O_2)\frac{L_1}{r(O)}+(1-a(O_1O_2))\frac{L_2}{r(O)}}. \quad (1)$$

$$a(O_1,O_2)=\begin{cases}\frac{L+L_1}{2L+L_1+L_2} & L_1\le L_2\\ \frac{L+L_1}{2L+L_1+L_2} & L_1>L_2\end{cases}. \quad (2)$$

$$r(O)=\frac{\sum_{t=0}^{M-1} nhyp^{t^{0.20}}}{descendant\ s_0}. \quad (3)$$

Where α(O1,O2) is asymmetric adjustment parameters of the similarity, ρ(O) is the concept density[11] ; "nhyp" is the number of the next-bit word of average each node; "h" is the level high of public nodes concept O; "M" is the significance quantity of the concept O in the hierarchy tree , "$descendants_0$ "is statistical quantity.

Combination weight

With reference to the comparison method to determine the weight.

We suppose that the expert chooses an index, such as x_{jm}, which he thinks it is the least important in the index set $\{x_j\}$. Then we relabel the m indexes $x_1,x_2,\mathbf{L},x_m$ as $x_{j1},x_{j2},\mathbf{L},x_{jm}$, where x_{jk} is some index. It is obvious that there is a one-to one correspondence between the two index sets $\{x_j\}$ and $\{x_{jk}\}$.

The interval estimation case. When the expert assigns a_k a number, he is not certain that the chosen assignment is the right one because of the shortage of the information in some cases. He can assign a_k the value range, i.e., an interval, instead.

We suppose that $D=[d_1,d_2]=\{x|d_1\le x\le d_2\}$ is a closed interval. $e(D)=d_2-d_1$ and $n(D)=\frac{d_1+d_2}{2}$ are the width and the midpoint of the interval respectively. For the risk of the decision-making, the experts' risk attitudes are different. We can divide the experts into three types——risk averse, risk neutral and risk appetite. And $j_e(D)=n(D)+ee(D)$ is the interval mapping function with the expert's risk attitude, where $e : |e| \le \frac{1}{2}$ is the risk factor. We take $-\frac{1}{2} \le e < 0$ for the risk averse expert, $e = 0$ for the risk neutral expert and $0 < e \le \frac{1}{2}$ for the risk appetite expert. And e is a known number for a given expert.

Based on the related information, the expert assigns a proper interval D_k to the ratio r_{km} of the importance level of evaluation index x_{jk} to that of evaluation index x_{jm} with respect to some criterion, that is to say, he estimates the value range of the ratio r_{km}:

$$r_{km} = a_k \in D_k = [d_{1k}, d_{2k}], k = 1,2,\cdots,m-1,$$

where $d_{1k} \le d_{2k} (k = 1,2,\cdots,m-1)$ and $d_{2m} = d_{1m} = 1$.

For a given sequence $\{D_k\}$ of intervals, if the assignments of $\{D_k\}$ are precise, then

$$w_k = \varphi_e(D_k) \Big/ \sum_{i=1}^{m} \varphi_e(D_i).$$

With reference to AHP method to determine the weight.

The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making and is used around the world in a wide variety of decision situations.

By the paired comparison approach in factor group, we can compose the pairwise comparison matrix $A = (a_{ij})_{n \times n}$ by means of the fundamental 1~9 scaling method. And the pairwise comparison matrix $A = (a_{ij})_{n \times n}$ is a positive reciprocal judgement matrix. Suppose that the eigenvector corresponding the biggest eigenvalue $\lambda_{\max}$ of the reciprocal judgement matrix A is W. By the vector normalization of the eigenvector W, we can get a certain level factors' relative importance to that of the sort weights above them in the hierarchy and the procedure is called hierarchical single ranking. The consistency check of judgement matrix includes the following steps:

- computing the coincidence index; finding the corresponding Mean Random Consistency Index.

Fuzzy theory

The fuzzy second level comprehensive evaluation set is $B_i = w_{bi} \circ R_{bi}$, where the operator $\circ$ is a fuzzy composition operator.

One fuzzy subclass can be worked out by applying the synthetic operation of fuzzy transform, which is the comprehensive evaluation result: $A = w_a \circ [B_1 \quad B_2 \quad \cdots \quad B_i]^T$.

Prototype System Developments

Main Module of System. (1) The user registration landing module. (2) Data storage modules. (3) Manufacturing Resource Discovery module.

Development Environment and Tools. (1) XML document creation and editing tools (2) Ontology editing tools (3) Visual Studio.NET is the most powerful development tools of .NET platform (4) Prototype system is designed by Microsoft SQL Server 2000.

Retrieval Interface. (Refer with: Fig. 3 and Fig.4)

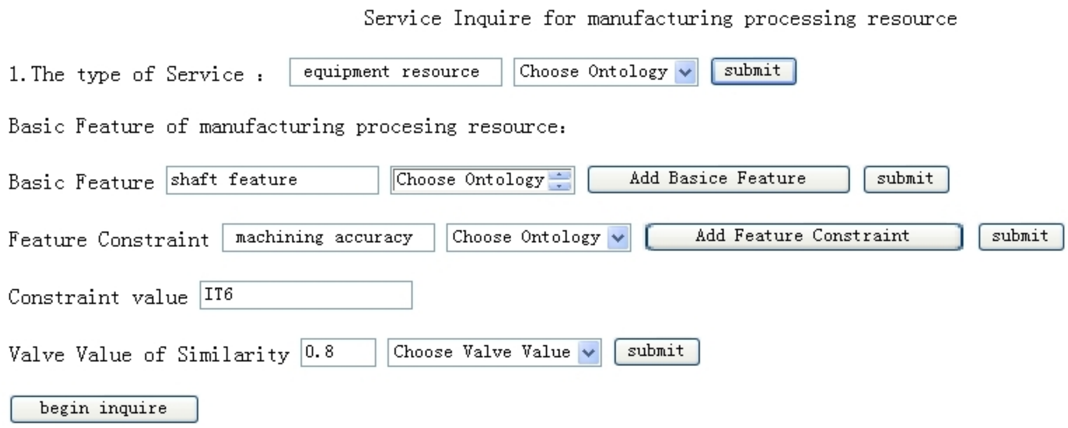


Fig.3 Retrieval Interface

The result of the matching

encode	name	number	location	MAX length	Machining accuracy	current status	particular description
CAK1626	CAK SIEMENS 802D	3	shanghai	200	IT6	free	http://211.65.91.191/CAK1626.html
CAK3665	CCYD	2	beijing	750	IT7	working	http://211.65.91.21/CAK3665.html

Fig.4 Retrieval Interface

Conclusions

(1) A joint discovery mechanism is introduced first in the uncertain network environments. (2) An evaluation model combined fuzzy theory with analytic hierarchy process and law of comparative judgment was presented. The method solves to decide the weight factors when there are many evaluation indexes, enhancing scientificalness and reliability of evaluation. (3) Various functions of the system are verified through running of the prototype system.

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