CHEMICAL ENGINEERING TRANSACTIONS
VOL. 46, 2015
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Peiyu Ren, Yancang Li, Huiping Song

ISBN 978-88-95608-37-2; **ISSN** 2283-9216
DOI: 10.3303/CET1546176

Dynamic Recognition Research of Parts Information of MC - VE Based on the Optimal Binary Tree and Fuzzy Reasoning

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Part information is the research object with the background of cloud manufacturing. And parts information are acquired and recognized. The characteristic and demand of part information are analysed of a mixed cloud virtual enterprises (MC-VE) based on the Internet and Internet of thing. Part information content and information process are summarized of the MC -VE. The sources and the characteristics of the part information are analysed. The retrieval method of parts information is two-dimension code, which can be concluded basic needed information and the context of the information associated with it of MC-VE. Identifying and obtaining of parts geometry information is combined by using the theory of the optimal binary tree method. The information matching of surface, side, between side and surface adopts the method of fuzzy reasoning in the geometry information of parts. The research works on matching and combination are respectively done between the typical side, typical side and typical surface. It is concluded that common matching rules and combination conclusion of the combination of geometry information. And it implements dynamic combination and recognition of the parts geometry information under the environment of MC-VE. It provides reference for acquiring the parts geometry information of MC-VE in heterogeneous and long-distance.

1. Introduction

Mixed Cloud Virtual manufacturing enterprises (MC-VE: Mixed Cloud - Virtual Enterprise) has the link of cloud manufacturing, which makes the manufacturing ability and manufacturing resources as the foundation. All elements in the whole life cycle of products, including content, information, people, equipment manufacturing and so on, are done the intelligent collaboration and functions which include real-time manufacturing, real time analysis, judgement, decision, and control and interconnected, tracking. It has characters of digital, instrumentation, integrated, co-ordinated, virtualization, and network. This advantage is greatly significant and is more than the management mode in the past enterprise. As Ben Buckholtz et al (2015) showed that MC-VE is generally temporary combined by public and private clouds enterprises with large difference and strong complementarity of different structure and resources, geographical differences. Part information sort is various in the process of cooperation, and the number are usually huge and sources are different heterogeneous. Expression of some information is different. The information demand is higher, need time is shorter. So research of dynamic recognition is very important about part information oriented to MC-VE, and it has practical significance.

2. Part information analysis for MC - VE

2.1 Requirement analysis of part information for MC - VE

The part information based on MC- VE is put on resources pool of public cloud manufacturing. The parts information in the cloud pool generally are divided into the application of products, components, parts, process and auxiliary level according to enterprises applications on the public and private cloud, as is shown in the paper of Xu Liu, Yingguang Li , Lihui Wang (2014). And each level is a large collection. Auxiliary level service is mainly involved in procurement, transportation, materials, etc. Information is analysed in the process of cooperation. Part number and variety of enterprise or business cooperation are more than the past ones. The requirement characteristics of parts information can be concluded: first, inconsistent of the sources and expression of the part information; Second, large amount and many kinds of parts information; Third, information security to be guaranteed; Fourth, full of the digital information; Fifth, more important of information

Please cite this article as: Li G.R., Ge Y.F., Wang Y.X., 2015, Dynamic recognition research of parts information of mc - ve based on the optimal binary tree and fuzzy reasoning, Chemical Engineering Transactions, 46, 1051-1056 DOI:10.3303/CET1546176

management; Sixth, guaranteed to acquisition speed of information, and change fast and response fast; Seventh, guaranteed to the correctness of acquisition on parts information; Eighth, long cycle, wide, more application; Ninth, strong controlling and matching. Tenth, more influence factors.

2.2 Part information in cloud pool of MC - VE

All kinds of resources and capabilities are included in the whole manufacturing process of MC - VE cloud pool. Resources include equipment and processes, material resources, software resources, human resources, knowledge resources, logistics resources, etc, as is shown in the paper of Yingfeng Zhang et al (2014). Capabilities specially include production ability, cooperation ability and service ability, innovation ability, etc. They are as shown in Figure.1. All contents of part information can be generalized and all the information is involved of product life cycle, which also includes other content associated with this part. It also covers different expression forms of information in the Internet of things and Internet. Parts information can be formally divided into inherent information and peripheral information. Peripheral information of parts refers to the information associated with itself, but does not directly change the parts attribute, and they especially include equipment and processes information, human information, logistics information, part of the material information and related service application information. Inherent information of parts is unique to parts information on itself, such as part geometry, materials information, design information, special performance, precision characteristic information, technical information, etc. The act of part information for MC - VE mainly include sensing and integration, application, management. Its contents involve the information identification and real-time acquisition, integration, storage, processing, analysis, tracking etc. These are in the process of process analysis, cost analysis, quality control, dynamic optimization and testing process, as shown in Figure. 1.

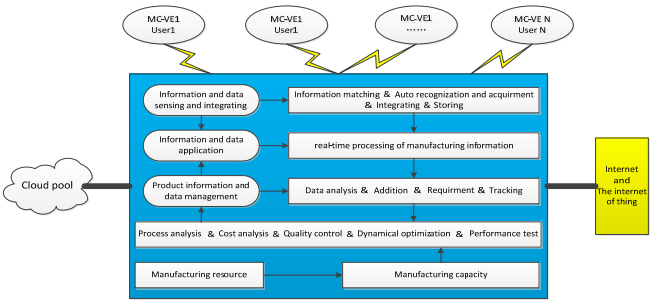

Figure 1: The contents of information processing of MC-VE

2.3 Part information source oriented to MC-VE

The sources of part information oriented to MC-VE are more. They involve information of cooperation enterprises, also some information about the Internet and Internet of thing. The content of information mainly includes part information of public clouds, which also have part information of different private cloud enterprise. And they involve information from the Internet of things and Internet interactions, which include part information of each department in the public clouds enterprise and also some of different department of private enterprise, and include parts of information of the interactive in the process of cooperation. Because information source is wide, department is more, information compatibility is not very good. And the security and privacy of information interaction need to be made sure, as in the paper of Namin Jeong et al (2014). Matching and combination of part information are involved at the same time in the process of application.

3. Dynamic recognition of part information based on MC-VE

3.1 Recognized partial information of the part and the automatic ID device

It is very important for the massive part information in the cloud pool, which is how to find accurate information in the shortest time, and how to quickly get the part information through the network, and how to accurately and completely identify the part feature information. These problems are facing and must be solved for MC - VE, and that is foundation of MC - VE. Basic information of parts can be identified by automatic ID devices and two-dimensional barcode of parts, which can accurately and quickly get some information. The two-dimensional Barcode is electronic code with the graphics symbol information using a particular geometric Figure with distribution of black and white in the plane according to certain rules. Information can be automatically recognized by image input device or photoelectric scanning equipment in order to realize the automatic processing of information. All parts can be uniquely identified by setting the two-dimension code of parts, with the advantages of large capacity, wide coding, correcting error automatically, decoding high reliability, high safety, wide applicability and strong adaptability, low cost, durability, which ensure its high

reliability and high safety. The relevant information of parts can be gotten through automatic ID device to scan and detect parts. Identity need to be authenticated and verified before getting the information, and part information also need to be described clearly.

3.2 Combination and recognition of some parts information

Some parts in the cloud pool of MC - VE can be determined by two-dimension code. The information can be tested and validated by the application of modern automatic ID device. And some information, especially the inherent parts geometry information, design information and accuracy of information, technical information, is difficult to directly obtain. So parts information often need to be identified, matched and combined etc. based on the Internet of things and Internet, as Yi-Cong Gao et al (2013)shown in his paper. Related technical would be used to determining. Information in different states, different levels, and different forms are matched and combined by the combined identification technology based on the requirements of public and private cloud enterprise. The needed part information is gotten. Parts geometry information can be gotten through certain combination algorithm based on STEP neutral file. Design information can help identify the geometry information under the condition of the public. Parts geometry information is acquired through the network transmission of XML file based on the Internet and Internet of things, and then the XML file can be converted to STEP files of international standard. Part information of the STEP files is recognized and matched.

3.3 Dynamic combination of geometry information of parts based on the theory of the optimal binary tree

3.3.1 Tree theory

Huffman tree is also called the optimal binary tree or optimal search tree, as Chen Guiying et al (2014) expressed in his paper, which is a kind of the binary tree with weight and shortest path length. In many applications, tree nodes are often assigned to real number of a certain meaning, which is called the weight of the node. Weighted path length (WPL) is called to be the multiplication between the path length from the root node to the nodes and the weight. The sum of the weighted path length of all the leaf nodes in the tree is called the weighted path length of the tree, which is usually written as:

$$WPL = \sum_{i=1}^{n} w_i l_i$$

Where L_i is path length of the node i, W_i is weight of corresponding nodes.

The optimal binary tree (Huffman tree) is binary tree of minimum WPL. The leaves of the greater weight are closer to the root in the optimal binary tree.

3.3.2 Characteristic analysis of part information combination oriented to MC-VE

Parts geometry information oriented to MC-VE is described by the international standard STEP and XML format file. The information sequences can be learned from the closed-shell to Advanced_face to Face_bound to Edge_loop to Oriented_edge to Edge_curve to Vertex_point to Axis2_placement_3d to Cartesian_point order. Related parts is descripted from shell, surface structure, ring, line and point in the nested data, which also can be descripted in the order from the leaves of a tree to the little tree to the trunk and then to the roots by nested data. Various point, such as namely Cartesian_point and Vertex_point, will be combined into line. The line will be judged to be combined with surface according to vector direction. The specific process of judgment is as shown in Figure. 2. Matched element is determined, and then required elements are obtained. Other matching elements are found according to the side matching or face matching in the relevant database. Then information are matched and combined according to fuzzy theory and theory of optimal binary tree. The graphic information is obtained according to the file. Then information is verified. If the information is not suitable or correct, the elements are matched again until the correct information is gotten.

3.3.3 Part information combination of MC - VE based on dynamic and optimal binary tree

It can be listed according to the definition of the optimal binary tree. Specific algorithm is as follows: (1) n binary tree can be gotten in T1, T2,... Tn, and forest can be respectively gotten of F = {T1, T2,... Tn} , which have n nodes with weights W1, W2... Wn. Each binary tree Ti only have a root node weights for Wi; (2) the left and right subtrees are constructed a new binary tree by selecting two root node weights of the smallest tree in F. And the weights of new binary tree root node are the sum of weight of subtree root node, the weights of leaf node = Wi; (3) these two binary tree is removed from the F, adding new binary tree to F at the same time; (4) the step of (2), (3) is repeated until the F contains only a binary tree, and the binary tree is a Huffman tree.

Some elements in the STEP file, such as Advanced_face, Face_bound, Edge_loop, Oriented_edg, Edge_curve, Vertex_point, are as each node T1, T2,... Tn of the optimal binary tree. The sequence of elements in the files is node weight W1, W2... Wn. According to theory of binary tree, the smallest weight of the tree is as the left and right subtrees which are combined. Characteristics and information are judged using fuzzy reasoning after the combination of information. The weight of root node of a new binary tree is just the

sum of weights of a combination of two child nodes. Part information are combined by binary tree, finally getting the Huffman tree and namely the last part information. Some examples are as shown in Figure. 3, and a weight W1 of T1 and a weight W2 of T2 are combined. Then a weight W5 of T5 can be gotten, and W5 = W1 + W2, and so on. Finally Tn can be drawn.

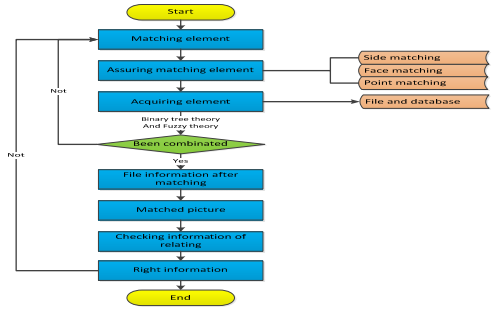

Figure 2: The flow chart of information recognition of MC-VE

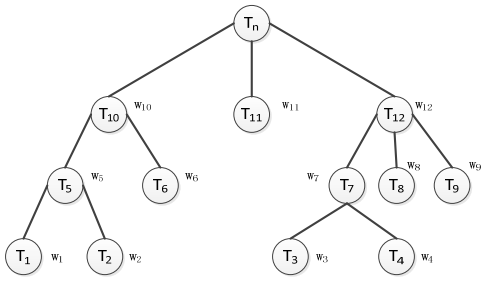

Figure 3: Optimal Binary Tree

4. Dynamic identification of parts geometry information based on the fuzzy theory and the optimal binary tree

4.1 Fuzzy theory

According to the fuzzy reasoning method, which is shown in the book of Wu Wangming (1994), as shown in type (1), specific reasoning method is as follows:

Premise 1: $\text{if } x \text{ is } A \text{ and } y \text{ is } B \text{ then } z \text{ is } C$

Premise 2: $x \text{ is } A' \text{ and } y \text{ is } B'$

Conclusion: $z \text{ is } C'$

The theory is combined with part information elements, namely Advanced_face, Face_bound, Edge_loop, Oriented_edg, Edge_curve, Vertex_point. And x, y express object name of combination element with the property and geometric constraint. A is the specific values of various elements with the determined geometry data and constraints. B may be the value of the elements with geometric constraint and attribute, and it can also be the specific combination results according to the rules determine. z is the object name of the characteristics after the combination, which have certain properties and constraints. A', B' is the desires and specific part with geometric constraints and properties, and may be the basic elements of a combination or without combination. C' is the desires conclusion. The properties of each element mainly include bound, cartisian_point, direction, vector, radius, α and other specific parameters.

4.2 Information combination of different type of sides and the typical surface

The values of A, B and the corresponding values of C are analyzed in the process of combination of basic elements of parts. And value of fuzzy sets and combination result is as shown in Tab. 1 for different types sides. According to the fuzzy reasoning and the actual combined conditions, three kinds of combinations results can be judged, as shown in Tab. 2.

Table 1: fuzzy sets values of different typical sides

A	B	C
Line	line,	Line or angle
	Oriented_edg,	Line or angle
	curve,	curve
	bound	curve or boundary
Oriented_edg	Curve,	curve
	bound	boundary
curve	curve,	curve
	bound	curve or boundary

Because μ_B is B of membership function, the specific value of μ_B can be gotten through the average comparison method, relative comparative method and merit confirmation, which could be obtained Wu

Wangming (1994). R_a, R_m, R_c, R_s, R_g are parameters for fuzzy implication rule of the Zadeh, Zadeh, Mamdani, Mizumoto, Mizumoto, which are used for combination under different types reasoning.

Table 2: three conditions of reasoning

A'	B'	R_a	R_m	R_c	R_s	R_g	C'
A	B	$\frac{1+\mu_B}{2}$	$0.5 \vee \mu_B$	μ_B	μ_B	μ_B	$(A' \cap B') \circ R_i(A,B;C)$ and i is a,m,c,s,g
A	$notB$	1	1	$0.5 \wedge \mu_B$	1	1	
$notA$	$notB$	1	1	$0.5 \wedge \mu_B$	1	1	

4.3 Information combination of the typical surface and different types of edge

The combination oriented to part information matches of MC-VE includes side and the typical surface in addition to side and side, the typical surface and the typical surface. Value range of fuzzy set and the combination results is such as shown in Tab. 3for the combination the typical surface with different type side. A and B can also be the combination of being matched or characteristics in addition to the basic matching elements. Combination and matching is more complex between irregular surface and irregular surface, and involves more contents, which shape is irregular.

Table 3: Fuzzy sets values of typical surface and different types of edge

A	B	C
Plane	Line,	Plane class
	Oriented_edg,	Plane class
	Curve,bound	Entity boundary
Cylindrical_surface	Line,	Cylinder class
	Oriented_edg,	Cylinder or cone class
	Curve, bound	Combination class
Conical_surface	Line,	Cone class
	Oriented_edg,	Frustum of a cone or cone
	Curve, bound	Sweeping and combination
Spherical_surface	Line,	Sphere or half-sphere
	Oriented_edg,	Sphere or combination
	Curve, bound	Irregular sphere
Toroidal_surface	Line,	torus
	Oriented_edg,	thread or tooth profile or torus
	Curve, bound	groove or combination

4.4 Matching of coordinates, parameters, direction

The relationship of specific parameters is involved in acquisition and recognition of geometry information of parts. And related elements have coordinates, various parameters, DIRECTION. The expression of each element are different, such as the representation of point in the STEP file is CARTESIAN_POINT (' ', (12), 3., 40.9999999999999)). The representation of the conical surface is CONICAL_SURFACE (' ', #759, 45.), and the representation of a cylinder is CYLINDRICAL_SURFACE (' ', # 754, 10), and the representation of plane is PLANE (' ', # 764), and the representation of the direction is DIRECTION (' ', (0., 0. 1.)), and so on. Some final information can be gotten through the layers of integrated information, and they can be expressed as follows. The information of torus face can be expressed to be TOROIDAL_SURFACE1 (AXIS2_P_3D (C_P,0,9 (0), DIR (0, 0, 1), DIR (0, 1)), R = 10, R = 1). The information of conical face could be expressed to be CONICAL_SURFACE2 (AXIS2_P_3D (C_P (0, 1), DIR (0, 1), DIR,0,7.193e-017) (1), R = 10, alpha = 45). The information of cylinder face could be expressed to be CYLINDER_SURFAC (AXIS2_P_3D (C_P (0, 0), DIR (0, 1), DIR (0, 1)), R = 10). The information of plane could be expressed to be PLANE (AXIS2_P_3D (C_P (0, 0), DIR (0, 0, 1), DIR (0, 1))). If it is matching and operations of CARTESIAN_POINT, calculation of addition and subtraction could be directly done with the x, y, z coordinate of one CARTESIAN_POINT and x, y, and z coordinates of another CARTESIAN_POINT. DIR (0, 0, -1) means the negative direction of Z axis, and DIR (-1,0,0) means the negative direction of X axis. And the combination and matching of the cone surface and cylinder surface and plane are judged according to the direction at first, which are judged to whether their direction is in the same direction or how many does the Angle of direction is. And the relationship of location is judged according to the anchor point and the radius of its position.

4.5 Instance

Part information are combined and recognized through the optimal binary tree theory and fuzzy reasoning. Following a simple example, two elements information is as follows which was obtained from the relevant STEP file, # 12 = TOR_FACE (C_P,0,9 (0), DIR (0, 0, 1), DIR (0, 1), 10, 1) and # 3 = CYL_F (C_P (0, 0), DIR (0, 1), DIR (0, 1), 10). First of all, the value for minimum 15 is determined according to the order of file. Then information in detail can be judged by fuzzy reasoning, and the one is a torus, the other is a cylinder. Ring surface properties is C_P (0,0,9) of the basis, and is vertical to the negative phase of x axis and z axis, and the radius of the ring is 10 and 1 respectively. Cylindrical information is (0,0,0) of the basis, and is vertical to the positive phase of x axis and z axis, and cylinder radius is 10. Two intersecting torus and cylinder surface are gotten according to the fuzzy inference by its properties.

5. Conclusions

It is concluded that the way is gotten of parts information based on Internet of things and the Internet, which is based on analysis of requirements and characteristics of data interaction of MC-VE. Basic information can be gained through real-time scanning and tracking and recognition of two-dimension code, which is relatively easy. The geometry information of parts can be gained by certain matching method. Combination of data elements is first judged by optimal binary tree, and then the result of combination is inferred according to fuzzy reasoning. In this way part information of STEP and XML file can be identified. It can be met for combination and recognition of typical side and surface and get the result of combination. It provides a way for part information interaction based on Internet of things and Internet.

Acknowledgments

This project is supported by research fund project of Nanjing institute of technology (No. CKJB201201) and the support project of science and technology of Jiangsu Province, China (No. BE2011712) and the planning project of humanities and social science research fund of the ministry of education（No. 12YJAZH151）and the college fund project of Jiangsu Province , China (No. 10KJB460003) and the youth project of humanities and social science research fund of theministry of education, China (No. 12YJCZH209)..

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