Sensors & Transducers, Vol. 156, Issue 9, September 2013, pp. 181-186

Sensors & Transducers

Research on Key Technology of Cloud Design for Mechanical Equipment

[1, 2] Jun Chen, [1] Gang Guo, [2] Yonggang Zuo
[1] College of Mechanical Engineering, Chongqing University, Chongqing, 400030, China
[2] Department of Petroleum Supply Engineering, Logistic Engineering University, Chongqing, 401311, China
[1] Tel.: 13983455823, fax: 023-86731148
E-mail: chenjun657@163.com, zyg938@163.com

Received: 4 July 2013 /Accepted: 25 August 2013 /Published: 30 September 2013

Abstract: In order to carry out rapid response of design of products, aimed at problems existed in realm cooperation during the design process of mechanical equipment, this paper proposes design mode of mechanical equipment based on cloud environment, implementation method of cloudy domain analysis on design demand and mapping technology, serial expand strategy on discrete design resource and strategy integrated design task with resource in time, it can implement reasonable allocation and delivery in the resource demand domain DR, the state control domain T and feasible resource domain R. Correctness and feasibility of model and method is analyzed and verified with examples. *Copyright © 2013 IFSA.*

Keywords: Mechanical equipment, Cloud design, Mapping.

1. Introduction

The characteristic of mechanical equipment is usually including specialization, complex structure, high performance requirement, multidisciplinary integrated technology, complex manufacturing process, etc. Its organization form is mostly stage dynamic alliance. Converse option to high – quality resource is usually lost with multiple rigid constraints and incomplete information when Core research entities develop mechanical equipment. In recent years many scholars have conducted many research in the field of cloud design and manufacturing, Reference [1-4] analyze typical characteristics and key technology of cloud manufacturing, study the manufacturing resources optimization deployment in cloud manufacturing environment, etc. The present study mostly concentrated in manufacturing resources with explicit characteristic and ability assessment etc. Design of key business processes for manufacturing industry is an important support and cloud manufacturing precursor. Its knowledge attribute has decided to design concept, design principles design experience with the strong implicit feature, the corresponding research is insufficient. Aiming at the design of emergency equipment products, the design model and related key technical problems in design is solved using the cloud environment as the basis to achieve fast response.

2. Cloud Design Mode of Mechanical Equipment

Cloud design mode of mechanical equipment is different from traditional products design mode, because of the use of virtualization technology, what the user can use is no longer a single physical resources about the resource scheduling and sharing, design environment containing design knowledge, technique and ability is obtained mostly by VMware / XenfCitrix virtualization platform in some physical resource construction, its characteristics is highly complex, dynamic, uncertain, etc. In the collaborative design process, there are manufacturing mode of group organization regional cloud and private cloud product design characteristics, the mixed cloud characteristics of the industry chain department or enterprise collaborative innovation and public cloud and professional cloud feature model, government cloud mode of the administrative resources. Its characteristic is obvious cloudy domain interaction, mapping and integration etc. Therefore, this paper puts forward emergency equipment product design mode which contain analysis and mapping in the demand of cloud environment, serialization integrating discrete design resource and induced chain drive demand lead by design demand shown in Fig. 1.

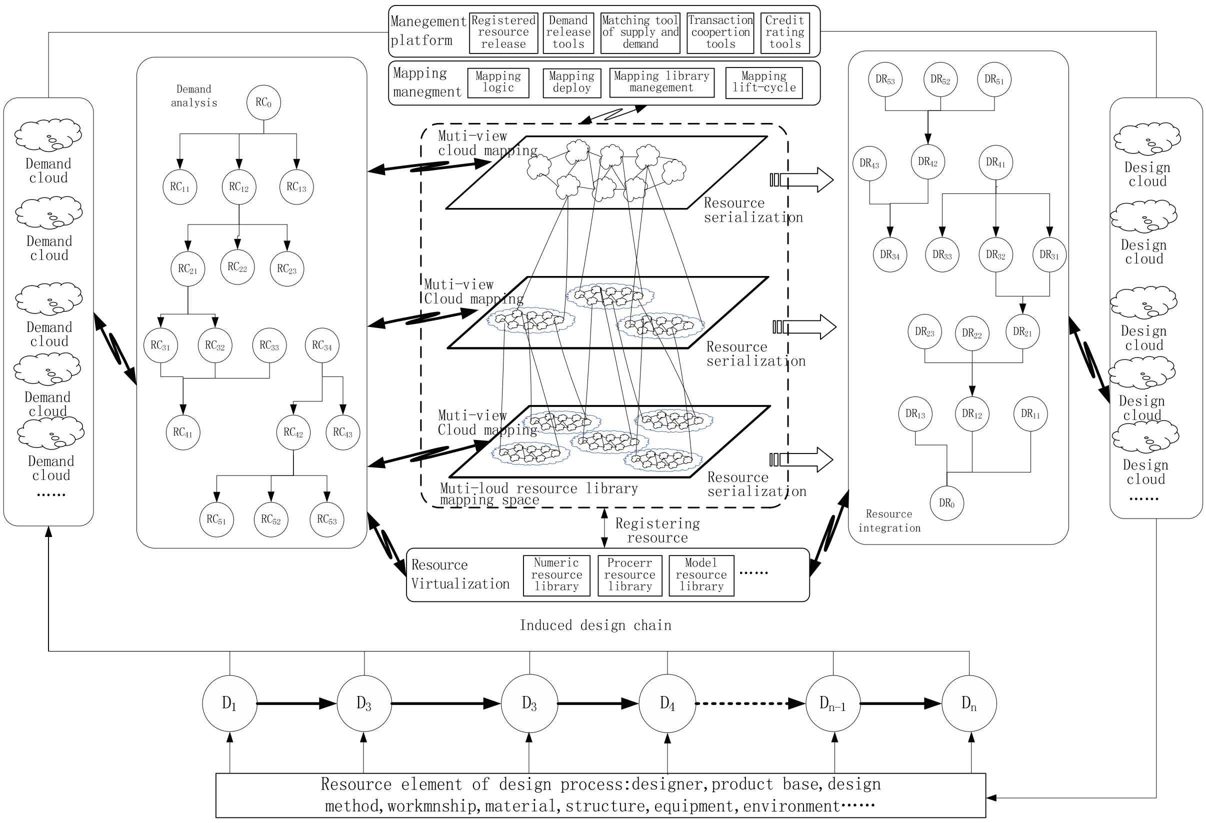

Fig. 1. Cloud design pattern of product for mechanical equipment.

The basic strategy of this model is driving design induction chain is the center of the core entity or the host factory, cloudy domain resource access based on the expression of different views and mapping of product design can spread out quickly own information and resource demand, When the cloud environment product is observed and analyzed in their point of view, the structure is more objective, more precisely, the circulation of information is more convenient, interactive resources is more symmetrical, decision-making errors and unstable factors is relatively reduced, design risk is greatly reduced. Design patterns by using serialization extended cloud resource and the collaborative design process is integrated, the configuration and design resources quickly was put forward with the premise using the least management and having minimal interaction with the service provider.

1) Cloudy domain data dependencies is established by analyzing the information of the design demand, loose information is placed in cloud data center domain, forming the demand cloud, so the high cohesion between different information sets and the low coupling and similar information is maintained, the tool is provided and the information is released or pushed through the platform management set;

2) Mapping strategy is scheduled to cloud domain with the biggest data dependence by mapping management, the new data is set into the high correlated data center to form the design cloud by discrete resource serialization;

3) Design resources which drives next design stage by design induced chain is integrated from the design cloud, subsequent design process is recursively affected, design interaction between clouds or in clouds is built, the cloud design mode for cloudy domain is achieved.

3. Cloudy Domain Analysis and Mapping Technology

It is necessary for design demand of cloud solution analyze mapping deployment demand, supporting generally public cloud, area cloud and various mixed cloud, on the other hand the case that leading party (demand side) effectively push or release information through the corresponding mapping logic and multi-domain mapping operation to solve the clouds is implemented.

1) Requirements analysis completes the combination and extension of resource requirements by the existing scenarios and domain knowledge and technical background, in the cloud resource pool deriving cloudy domain requirements set. Analytical model of requirement cloud is shown in Fig. 2.

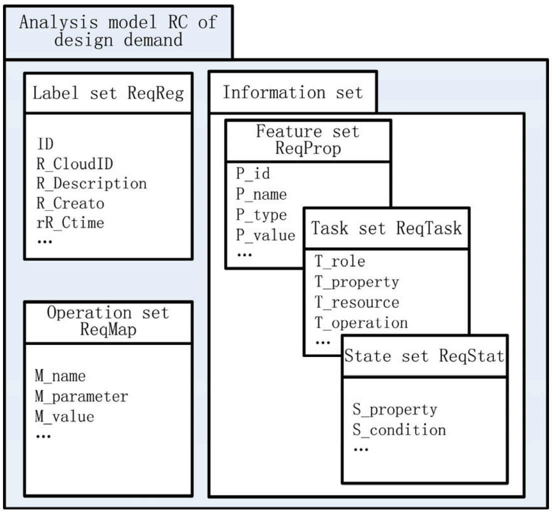

Fig. 2. Analysis model of demand.

Where ReqReg describes the identity property of demand, on behalf of the basic registration information need, ReqMap describes the mapping operation of demand, ReqProp is the demand feature set describing the characteristics property of requirements including functional requirements, structural demand, appearance requirements from customer expectation target and the engineering characteristic parameters, detection index, design technical requirements etc, analysis and processing of the statistical information can also be expressed, ReqTask describes the task set, demand produce many task execution sequence through the analysis and mapping, ReqStat describes the state set of demand, describing a collection of state information on demand, including demand process state, correlation constraints. The formal model of demand cloud is described for quintuple:

RC=(ReqReg,ReqMap, ReqProp, ReqTask, ReqStat)
ReqReg=(ID,R_CloudID, R_Description,R_Creator,R_CTime)
ReqMap=(M_name,M_parameter,M_value) (1)
ReqProp=(P_id,P_name,P_type,P_value)
ReqTask=(T_role,T_property,T_resource,T_operation)
ReqStat=(S_property, S_condition)

ID is the identification of RC, R_CloudID describes the identification of demand cloud which is the qualitative for demand cloud scope, divided into the public cloud, hybrid cloud, private cloud mapping identifier, R_Description describes the general demand, R_Creator is founder of demand, R_CTime describes the creation time of demand. M_name is operating name of mapping, M_parameter is operation parameters of mapping, M_value is return value of operations. P_id is characteristics identification of demand, P_name is feature name, P_type is type of feature, P_value is feature or attribute. T_role describes role set involved in task, T_property describes attribute set of the task, T_resource describes resources set executing the task. T_operation describes the methods set that operate task attributes or resource. S_property describes the state set in their current attribute, S_condition is constraint condition set when the state occurs migration.

2) Mapping logic provides a mapping operation on the demand set, completing multi-view structure on the RC model.

Mapping decomposition is operation that one demand is decomposed into several sub one which decomposes mapping with function RC_decompose (R_CloudID, {ID,P_id}), its mapping features is as follows:

The parameter R_CloudID is the cloud property identification decomposing demand, ID is demand identification, P_id is signature decomposing demand, after the demand is decomposed sub-demand inherit cloud properties of father-demand, the return value is the list signature of sub-demand {P_id1,P_id2,P_id3,…, P_idn}.

3) Aggregation mapping is the mapping operation that aggregates two or more demand into a new demand which is described with function RC_aggregate (R_CloudID, {ID1, ID2, ID3,..., IDn}), its mapping features is as follows:

The parameter R_CloudID is cloud properties, IDX is identification of aggregated demand, feature ReqProp of new demand of RC_aggregate produced by the polymerization inherits all the features in RC polymerization, and can combine these features into a new feature of its own, the return value of polymerization is the signature of RC_aggregate.

4) Derived mapping is the operation which expand characteristics of a set of RC ReqProp sion and map as a new demand which is described with function RC_derive (ID, {P_id1, P_id2,... P_idn}), its mapping features is as follows:

The new derived requirements RC_derive produce new features of its own through a combination, new generation, expansion, in addition to inherit all the characteristics of the original demand, parameter is the characteristic properties of ID and the expansion of RC {P_id1, P_id2,..., P_idn}, derived return value is ID of RC_derive.

5) Instance mapping is the operation that use the existing product case directly to solve RC which is described with RC_instance (ID), its mapping features is as follows:

Instance demand must map RC in the demand system for solution as RC instance,according to the objective demand information content, RC_instance can use the entity relationship model, object model, the XML document as a physical carrier. The parameter is ID of RC, the return value is ID of RC_instance.

4. Serialization Integration of Discrete Design Resources

Demand mapping solution not only have levels of granularity because the particle size of information itself is different, but also have complex, dynamic, decentralized and uncertain characteristics because the scene and the environment of cloud properties are different. Serialization integration of discrete design resources on amount of cloud "fragmentation" is basic ways to focus distributed resources and service.

1) Resource definition and description.

Design Resource Cloud，DRC is available information collection composed of discrete knowledge resources, intellectual resources, design tools, design, material, design field, service resources in various cloud domain, the design resources is divided into knowledge resources, technical resources, design ability, DRC (ResReg[], KnoRes[], TecRes[], SerRes[]), where ResReg[] is the cloud registration information of resources, because the resources are favorable for the clouds and provide product cloud collaborative design service, knowledge resources KnoRes[] contains design principles, design experience, design specifications, design process, and the model of existing products, test and inspection data, market and customer feedback information [9]; technical resources TecRes[] includes software resources, equipment resources, patent resources, technical service; design capacity SerRes[] includes the design qualification, credit grade, intellectual resources, design site, design efficiency etc.

2) Resource Serialization integration strategy.

Design of emergency equipment is generally divided into the design concept, principle, scheme, assembly equipment, key parts according to the task level, and each level design can be divided into the overall design, system design, assembly and parts design, the whole process of product design and the design hierarchy or design stage not only exist resource serialization, but also they are associated with the corresponding integrated real-time design tasks. Task level extends longitudinally, design domain serializes design resources through the mapping with feasible domain of cloud resource, expanding vertically, and design domain and design stage of task level expand horizontally which is mapped to feasible domain of cloud resource and serializes design resources with horizontal expansion, Resource Serialization mode is shown in Fig. 3.

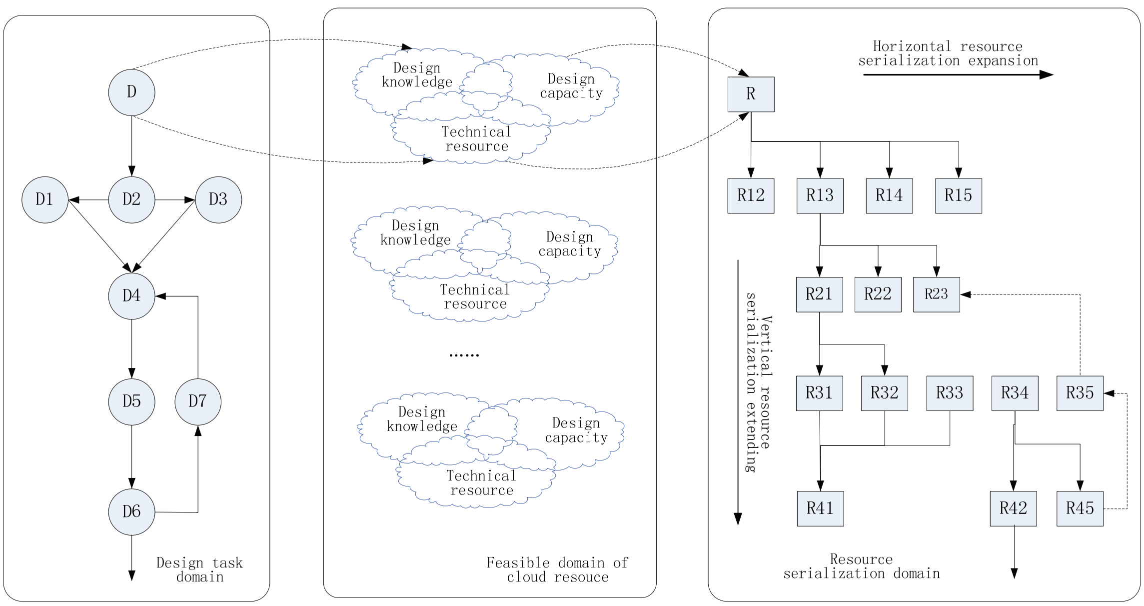

Fig. 3. Resource serialization model.

```
Resource Serialization model description:
Sort(DRC)   // Resource Serialization solution
{i=0 // Vertical expansion
Do
   {i=i+1;
    j=0;          // Horizontal expansion
    (a) ∀ rc ∈ RC, RC_decompose(rc)= R
    //Decomposition mapping
j=j+1;
    If R ≠ φ  then Rij= R goto (a)
        else j=j-1;goto (b)
    (b) ∀ rc ∈ RC, RC_aggregate(rc)= R
    // Aggregation mapping
        j=j+1;
    If R ≠ φ  then Rij= rc goto (b)
        else j=j-1;goto (c)
        (2)
    (c) ∀ rc ∈ RC, RC_derive (rc)= R
    // derived mapping
    j=j+1;
    If R ≠ φ  then Rij= rc goto (c)
        else j=j-1;goto (d)
     (d) ∀ rc ∈ RC, RC_instance (rc)= R
    // instance mapping
    j=j+1;
    If R ≠ φ  then Rij= rc goto (d)
   }
until  ∀ rc  ∈  RC,  ∃  Sort(DRC) = FALSE
   }
```

"i" is design level; "j" is design phase process of each level.

3) The feasible region of serialization resource forms resource serialization matrix R[] after resource serialization is completed shown in Fig. 4.

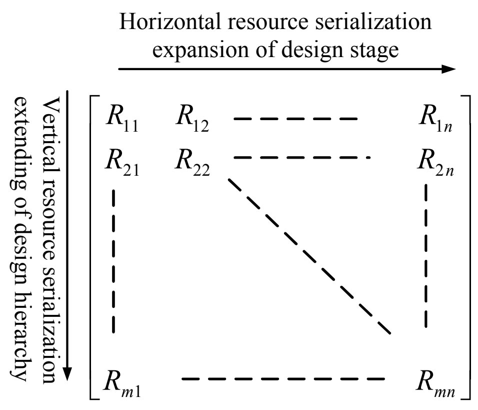

Fig. 4. Resource serializeation matrix.

The time-varying control of resource state is introduced after the sequence of tasks on cloud resource mapping completing resource serialization form feasible domain resource, resources is pushed and drawn reasonably between the requirement domain DR of design resource, state control domain T and feasible resource domain R, integration of the final serialization resources and design tasks is completed. Analysis expression of serialization resource integration:

$$DR[\ ] = T[\ ] \bullet R[\ ], \tag{3}$$

where DR[] is the demand domain of design resource, T[] is state change control domain, R[] is Sequence of cloud resource feasible domain of serialization resource matrix DR[] is collection of requirement of design task resource, which is issued by design resource requirements. T[] is time control vector sequences executing design task, defined formally as T[T1, T2,... , Tn], which is task sequence vector set mapped by task sequence of RC task set ReqTas and task state feature of ReqStat.

5. Example Analysis

The task list of one mechanical equipment design project is shown in Table 1 as an example, there are 8 design tasks coordinated, including 6 task required precursor collaborative tasks.

Table 1. Analysis with design project.

Design task sequence set			Feasible domain of design task	Expected time
Design task	Precursor task	Sub-task		
A		A1, A2	$R_A[\ ]$	4
B	A	B1, B2, B3,	$R_B[\ ]$	3
C	B	C1, C2	$R_C[\ ]$	8
D	B	D1, D2, D3	$R_D[\ ]$	9
E		E1	$R_E[\ ]$	2
F	C, D	F1, F2	$R_F[\ ]$	4
G	E	G1, G2, G3, G4	$R_G[\ ]$	8
H	F, G	H1, H2, H3	$R_H[\ ]$	6

Double time-scaled network diagram of the design task is drawn, shown in Fig. 5, which constitutes the task sequence, corresponding time-varying state control domain T[] without loss of generality, example assumes feasible region of the design resource is not empty, i.e. full resources, there are resources set DRC[]={$R_A[\ ]$,$R_B[\ ]$,$R_C[\ ]$,$R_D[\ ]$,$R_E[\ ]$,$R_F[\ ]$,$R_G[\ ]$,$R_H[\ ]$} to meet every mapping the minimum requirements, and there are no conflict for resource state, namely the state change control only consider the temporal association, a total length of 27 time units, corresponding resource requirement periods are ta= (0,4), tb = (4,7), tc = (7,15), td = (7,17), te = (0,2), tf = (17,21), tg = (2,10), th = (21,27), if the time relaxation problem is not considered, execution time of each activity is fixed, and time interval during handover of the activities is ignored, time zone is divided into T1 ∈ [0,2], T2 ∈ [2,4], T3 ∈ [4,7], T4 ∈ [7,12], T5 ∈ [12,15], T6 ∈ [15,17], T7 ∈ [17,21], T8 ∈ [21,27], take the previous task as sequence, T[]={T1 T2, T3, T4, T5, T6, T7, T8} is available.

Resource feasible domain spread serially shown in formula (2):

$$\begin{cases} Sort(R_A[\ ]) = \{R_{A1}, R_{A2}\} \\ Sort(R_B[\ ]) = \{R_{B1}, R_{B2}, R_{B3}\} \\ Sort(R_C[\ ]) = \{R_{C1}, R_{C2}\} \\ Sort(R_D[\ ]) = \{R_{D1}, R_{D2}, R_{D3}\} \\ Sort(R_E[\ ]) = \{R_{E1}\} \\ Sort(R_F[\ ]) = \{R_{F1}, R_{F2}\} \\ Sort(R_G[\ ]) = \{R_{G1}, R_{G2}, R_{G3}, R_{G4}\} \\ Sort(R_H[\ ]) = \{R_{H1}, R_{H2}\} \end{cases} \quad (4)$$

To obtain the Resource Serialization matrix R[].

$$R[] = \begin{bmatrix} R_{A1} & R_{A2} & 0 & 0 \\ R_{B1} & R_{B2} & R_{B3} & 0 \\ R_{C1} & R_{C2} & 0 & 0 \\ R_{D1} & R_{D2} & R_{D3} & 0 \\ R_{E1} & 0 & 0 & 0 \\ R_{F1} & R_{F2} & 0 & 0 \\ R_{G1} & R_{G2} & R_{G3} & R_{G4} \\ R_{H1} & R_{H2} & R_{H3} & 0 \end{bmatrix} \quad (5)$$

6. Conclusion

Mechanical equipment product design have typical multidisciplinary cooperative and temporary customization features with amount of resource demands and rigid time constraints, this paper research the design of cloudy domain requirements analysis and mapping method through cloud design theory model studying emergency equipment products, constructing formal concept model, the discrete design resource serialization and task integration strategy induce design process to promote cooperatively by controlling push and configuration of design resource in the process, which provides an effective means to realize the rapid response of product design. It is verified preliminarily by example.

References

[1]. Li Bohu, Lin Zhang, Typical characteristics, technologies and applications of cloud manufacturing, *Computer Integrated Manufacturing Systems,* 18, 7, 2012, pp. 1345-1355.

[2]. Jingsheng Li, Aimin Wang, Tang Cheng-Tong et al. Distributed coordination scheduling technology based on dynamic manufacturing ability service, *Computer Integrated Manufacturing Systems*, 18, 7, 2012, pp. 1562-1573 (in Chinese).

[3]. Nan Zhao, Zhanwen Niu, Wei Guo, Quantum harmony search method for design knowledge resource serialization combination in cloud manufacturing environment, *Computer Integrated Manufacturing Systems,* 18, 7, 2012, pp. 1435-1443 (in Chinese).

[4]. Qian Zhang, Deyu Qi, Service-oriented collaborative design platform for cloud manufacturing, *Journal of South China University of Technology: Natural Science,* 39, 12, 2011, pp. 75-81.