

Multilevel Coordinate Optimization of Cloud Manufacturing

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Abstract. In order to solve the allocation and logistics service resources in cloud manufacturing environment coordination and optimization, based on the analysis of operation mode of cloud manufacturing and resources allocation process, fully consider the group of cloud manufacturing platforms, the author made a model concerning coordination and optimization of multi-layer cloud which includes public and private cloud. The experiment shows that the model is effective.

1. Introduction

In the era of intelligent economy, the development of an enterprise is no longer entirely dependent on its own human resources, equipment resources, site resources and other conditions, but mainly depends on its effective integration of the resources. Cloud manufacturing is a centralized and manageable mode that can virtualize manufacturing resources and capabilities, which can optimize the allocation of resources to provide customer standard manufacturing services dynamically and transparently. This manufacturing mode means that the resources and capabilities in platforms will be used frequently and efficiently. The manufacturing model needs a corresponding allocation and logistics model. Cloud Manufacturing optimization has become the most complex field in the operation because it contains many links, such as procurement, production and sales, and the characteristics of each link are different.

Large manufacturing enterprises such as CASIC(China Aerospace Industry Group Corporation), whose logistics and manufactures demand scattered in various departments and enterprises. But a considerable number of subordinate enterprises still remain the "big and complete", "small and complete" mode, where resources are not used effective. The core problem of cloud manufacturing is resource coordination.

We create a new cloud platform contains private and public cloud which have three level of raw material procurement, production, wholesalers and sale.

2. Research status

Er Shi Qi and other Manufacturing experts [1] reviewed the cloud manufacturing mode. Resources allocation from raw materials to sales is the guarantee of intelligent manufacturing, also is an important issue in cloud manufacturing. Many scholars have been try to optimize this problem [2-11].

These models are applied in different areas such as agricultural machinery industry, large-scale equipment manufacturing industry [12,13] contained upstream raw materials to downstream manufactory problems. The model contains 4 different parties (raw materials, transportation and wholesalers process, manufacturing process and so on), some model considered manufacturing products demand pattern and function, manufacturing constraints, and the optimization targets.



There are also some scholars, such as Mao Dejun [14] did not considered the multi-level platform but created a model with limited resources and several constrains. Ren [15] divided tasks into different degrees by its importance. Coordination refers to the process and ability to achieve a goal with multiple or more than two different resources [16].

In practical application of the complex products for aerospace, CASIC and the BUAA (Beijing University of Aeronautics and Astronautics) built the cloud manufacturing service platform together. However this platform had problems in high cost of resources distribution, multi-level optimization. Those problems are typical under the cloud manufacturing.

Besides, our platform is different from what we reviewed. It is divided into an internal manufacturing oriented private cloud, and an external oriented public cloud group. Enterprises under private have priority like less restriction in the flow in and out. We considered three levels which is different from what we had reviewed.

3. Model For aerospace manufacturing

3.1. Model basic assumption

Considering the users of the platform, the cloud manufacturing platform is usually composed of three levels, including raw material supplier, manufacturer, and wholesaler. The raw material is delivered to the manufacturer, and then delivered the product to the wholesaler after the manufacturer's production. The raw material supplies are defined as set A , the product manufacturers is defined as set B , and the wholesalers is defined as set C . The three set of A , B , and C are positive connections between hierarchies, flow from set A to set B , and B to C . the raw material suppliers of $A_1 \sim A_m$, product manufactures of $B_1 \sim B_p$, wholesalers of $C_1 \sim C_u$ belong to the private cloud. The raw material suppliers $A_{m+1} \sim A_n$, manufactures $B_{p+1} \sim B_q$, and wholesalers $C_{u+1} \sim C_v$ belong to the public cloud. Figure 1 shows the structure.

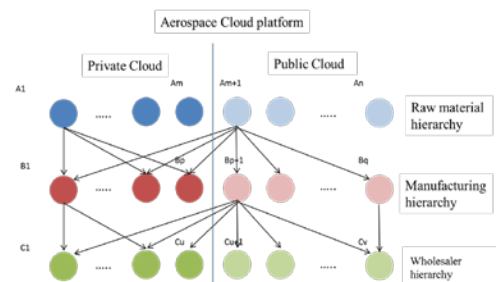


Figure 1. Aerospace Cloud Platform Structure

The cost function between the set A and B is T , and the unit cost from A_i to B_j is T_{1ij} , and the cost between B and C is T_{2jk} . T_{ij} is given cost matrices, in the form of Table 1, and T_{2jk} Structure is similar with T_{1ij} and thus omitted.

We assumed the inventory of manufacturers are b . we also assume that the handling parameter of manufacturing is e . the handling parameter means the scale from raw material into finished goods. Considering the priority of the private cloud, we defined a priority factor d , used as a supplement to the private cloud, let the cost in private cloud reduced to $T_{...} \cdot d$.

We define the manufacturing cost as set M , the single manufacturing cost of each manufacturer is m_j .

3.2. Model construction

$$\min \text{cost } t = \sum_i \sum_j x_{ij} * t_{1ij} + \sum_j x_{ij} * m_j + \sum_j \sum_k y_{jk} * t_{2ij} \quad (1)$$

s.t.

$$\sum_{j=1} x_{ij} \leq A_i \quad i \in A \quad (2)$$

$$e \sum_{i=1} x_{ij} + bj = \sum_k y_{jk} \quad j \in B \quad (3)$$

$$\sum_{j=1} y_{jk} = C_k \quad k \in C \quad (4)$$

The formula (1) is the optimization goal of the model: to minimize the sum of transportation cost and manufacture cost.

The formula (2) shows how many materials can be sent from each supplier.

The formula (3) constraints how many materials need to be sent to each manufacture and its products can be sent to each wholesaler.

The formula (4) means each wholesaler's requirement must be satisfied.

4. Numerical simulation

4.1. Case situation

The actual demand of 30 closely related (A level) 10 suppliers, (B level) 10 producers and 10 C group needs to be listed below.

4.2. Experimental data

Table 1. The unit cost matrix between the t_{1ij} : material layer and the main body of the manufacturing layer

$B_j \backslash A_i$	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
B_1	64	38	56	29	65	20	1	35	45	22
B_2	57	18	54	52	37	37	47	30	64	51
B_3	57	57	49	12	6	6	27	5	46	15
B_4	46	68	7	28	19	43	66	67	40	62
B_5	19	50	12	66	35	19	65	26	47	9
B_6	55	56	69	26	35	31	15	53	22	9
B_7	38	49	29	37	5	29	61	35	0	3
B_8	17	10	57	5	5	49	30	58	38	35
B_9	63	44	9	47	38	29	34	11	7	45
B_{10}	55	59	25	41	33	20	52	64	41	0

Table 2. T2jk, the unit cost matrix of the manufacturing and demand layer

$C_k \backslash B_j$	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
C_1	0	5	32	62	60	41	3	63	28	12
C_2	7	69	47	30	35	47	18	53	41	45
C_3	65	37	2	27	7	9	22	36	4	47
C_4	54	68	45	40	64	66	38	69	9	56
C_5	60	60	56	32	34	36	49	27	13	33
C_6	64	38	2	20	27	37	44	58	54	9
C_7	4	64	40	60	18	61	58	54	27	12
C_8	14	5	26	53	16	60	17	65	56	46
C_9	69	42	44	54	7	12	27	44	48	18
C_{10}	19	61	44	32	43	46	42	23	4	16

Table 3. The raw data of supplier's raw material wholesalers, manufacturer's capability, manufacturer's value in product. (Demand business and unit price of manufactured goods are confidential).

Supplier	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
Numbers	30	34	54	34	42	31	39	34	34	30
Producer	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
Capability	32	38	49	58	49	52	36	45	48	54
On-Hand	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}
OHQ	14	23	42	24	34	24	24	34	23	35
Demand	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
DQ	26	26	8	26	30	10	1	7	12	24
Product	m_1	m_2	m_3	m_4	m_5	m_6	m_7	m_8	m_9	m_{10}
Price	6.00	8.40	1.52	9.71	2.99	8.80	2.29	3.98	1.79	3.36

Notes:

OHQ is On-hand quantity

DQ is demand quantity

We deem e and d as matrix with value 1 for easy test.

4.3. Case results

Using the model of part two, the data are written into the model in turn, and the tables IV, V are calculated as X_{ij} and Y_{jk} , respectively.

Under the premise that the target is the cost of processing and the lowest circulation cost of the goods, the final total cost is 15722 after the iteration of the solver. At the same time, the results of the coordinated optimal allocation between the A layer and the B layer at the lowest cost and the coordinated optimal allocation between the B layer and the C layer are obtained.

Table 4. Coordination and optimal allocation of raw material layer to manufacturing layer

X_{ij}	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
B_1	0	6	0	8	0	10	12	1	1	2
B_2	0	3	0	1	0	1	0	1	0	0
B_3	0	0	0	5	10	4	0	4	0	2
B_4	2	0	1	3	1	1	0	0	1	0
B_5	5	1	0	0	0	3	0	2	1	3
B_6	1	0	0	4	0	2	0	0	5	3
B_7	3	1	0	3	2	2	0	1	6	3
B_8	5	4	0	5	2	0	0	0	3	1
B_9	1	1	5	2	0	2	0	3	6	0
B_{10}	1	0	0	2	0	3	0	0	3	4

Table 5. Coordination and optimal allocation of raw material layer to manufacturing layer

Y_{jk}	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
C_1	23	31	6	0	0	6	26	0	5	20
C_2	3	0	3	12	1	5	2	3	4	3
C_3	0	1	7	7	8	8	2	6	7	2
C_4	0	0	3	6	3	3	1	3	6	2
C_5	0	0	2	6	5	6	0	7	6	4
C_6	0	1	7	7	6	6	0	4	3	6
C_7	3	0	4	4	7	4	0	5	5	5
C_8	2	4	5	5	7	4	2	4	2	3
C_9	0	1	3	5	8	8	2	6	3	5
C_{10}	2	0	3	6	5	5	0	7	7	5

5. Conclusion and prospect

Based on the actual situation of science and engineering group, this paper constructs a multi-level coordination optimization model of logistics resources under cloud platform. In order to meet the requirements of all levels, the model is solved with the aim of overall cost optimization. This paper considered the public cloud and private cloud in the aerospace science and technology group, and assumed that there is no resource exchange among the subjects at the same level. As a matter of fact, the same level of agents not only has different levels but also has the coordination of logistics resources among the subjects. Therefore, the next research area can mainly consider the coordination and optimization of logistics resources in the same level of resources flow.

6. References

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