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The measurement of complexity of organization coordination network of major scientific and technological projects

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Abstract: Organization coordination network (OCN) of major scientific and technological project (MSTP) is a complex gigantic system. In this paper, in order to measure complexity of OCN of MSTP, we use entropy theory, based on complexity science theory. We discuss the application of entropy in organization management, and propose entropy model evaluating complexity of OCN of MSTPs, and compute the entropy of centralized network, adaptive network, distributed network. Three network models have different information order, structure order and total order. As for three network models, structure order and total order decrease, information order increases. Therefore, distributed network has the maximum information order.

Keywords: Major Scientific and Technological Projects, Organization Coordination Network, Complexity.

1. Introduction

Organization coordination network (OCN) of major scientific and technological project (MSTP) is a multi-agent system. The whole emergence is different, so it needs a universal quantity to describe the complexity of OCN evolution-entropy (He, 1993). To evaluate the complexity of OCN of MSTP, based on complexity science theory, we use entropy theory to construct information entropy and structure entropy of OCN. Based on this, we compute the entropy of centralized network、adaptive network and distributed network. Through quantitative analysis and comparison, we draw the corresponding research conclusion.

2. Entropy models design of OCN

(1) Information entropy

If there is relationship of direct information flow between elements in OCN of MSTP, we set this relationship links between elements, and define the connection number link length, said with Lij (i ,j represents the element number, $i, j = 1, 2, ..., N$). The direct length is 1, plus 1 when transit one time.

1) We set A1 as the summation of the microcosmic state that corresponds to information under macro-state of OCN of MSTP. Defined as:

$$A_1 = \sum_{i=1, i \neq j}^{N} \sum_{j=1}^{N} L_{ij} \tag{1}$$

2) Set P1 (ij) as the actual probability of information micro-state between elements i and j in OCN of MSTP, defining:

$$P_1(ij) = L_{ij} / A_1 \tag{2}$$

3) Define the information entropy H1(ij) between any two entity elements in OCN of MSTP:

$$H_1(ij) = -P_1(ij) \log_a P_1(ij) \tag{3}$$

4) The information entropy H1 of OCN of MSTP:

$$H_1 = \sum_{i=1, i \neq j}^{N} \sum_{j=1}^{N} H_1(ij) \tag{4}$$

5) The maximum of information entropy H1m of OCN of MSTP:

$$H_{1m} = \log_a A_1 \tag{5}$$

6) Information order degree R1of OCN of MSTP:

$$R_1 = 1 - H_1 / H_{1m}, R_1 \in [0,1] \tag{6}$$

(2) Structure entropy

We use the number of elements directly linked to each entity elements in OCN of MSTP to represent each elements' link range, indicated by K1 (i represents the elements code), reflecting the reality links between entity elements in OCN of MSTP.

1) Set A2 as the summation of the microcosmic state corresponded with structure under macro-state in OCN of MSTP. Defining:

$$A_2 = \sum_{i=1}^{N} K_i \tag{7}$$

2) Set P2 (i) as the probability of i-th structure micro-state corresponded with macro-state in OCN of MSTP, defining:

$$P_2(i) = K_i / A_2 \tag{8}$$

3) Define any element' structure entropy H2(i) in OCN of MSTP:

$$H_2(i) = -P_2(i)\log_a P_2(i) \tag{9}$$

4) Structure entropy H2 of OCN of MSTP:

$$H_2 = \sum_{i=1}^{N} H_2(i) \tag{10}$$

5) The maximum of structure entropy H2m of OCN of MSTP:

$$H_{2m} = \log_a A_2 \tag{11}$$

6) Structure order degree R2 of OCN of MSTP, related to A2:

$$R_2 = 1 - H_2 / H_{2m}, R_2 \in [0,1] \tag{12}$$

(3) Order degree R of OCN of MSTP:

$$R = R_1 + R_2 = (1 - H_1 / H_{1m}) + (1 - H_2 / H_{2m}) \tag{13}$$

3. The Entropy Computation of OCN

The paper assume that task decomposition structure model of MSTP which is shown in Fig. 1 on the left and the corresponding view of OCN is shown on the right. The three typical OCN model of MSTP, that is centralized network, adaptive network, distributed network, are based on the same view. Through the entropy computation of the three models, we can analyze comparatively the complexity of them and draw the conclusion. In the figure, "⑥" stands for the sixth physical element of OCN of MSTP. When we calculate the degree of order, we assume that the logarithm base 10, that is a=10, and set four decimal places.

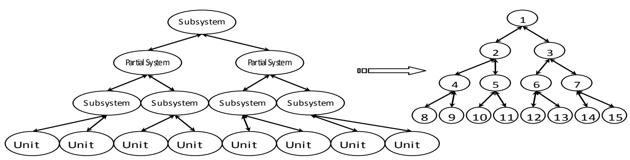

Fig.1. Task Decomposition Structure Model of MSTP and the Corresponding View of OCN.

3.1 The Entropy Computation of Centralized OCN of MSTP

Fig. 2 shows the centralized OCN model of MSTP which is evolved from the same task decomposition structural model.

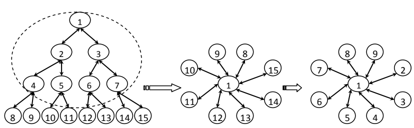

Fig.2. the Derived Process from OCN of MSTP to Centralized Network.

(1) We analyze the link length Lij between the elements in centralized network. Then according to Eq. 1, we calculate the summation of the microcosmic state: $A_1 = 128$

(2)According to the parameters Lij and A1, we use Eq. 2, 3, 4, 5 and 6 to calculate the related parameters of the information entropy in centralized network:

$$H_{1m} = 2.1072 \qquad H_1 = 1.872$$

And then, the information order in centralized network: $R_1 = 0.1116$

(3)We analyze the link range Ki of the various elements in centralized network. Then, we use Eq. 1 to compute the summation of the microcosmic state A2 which reflects the link range. $A_2 = 16$

(4)According to the parameters Ki and A2, we use Eq. 8, 9, 10, 11 and 12 to calculate the related parameters of the structure entropy in centralized network:

$$H_{2m} = 1.2041 \qquad H_2 = 0.7529$$

And then, the structure order in centralized network: $R_2 = 0.3747$

Thus, we can use Eq. 13 to calculate total order of the centralized OCN of MSTP:

$$R = R_1 + R_2 = 0.4863$$

3.2 The Entropy Computation of Adaptive OCN of MSTP

Fig. 3 shows the adaptive OCN model of MSTP which is evolved from the same task decomposition structural model.

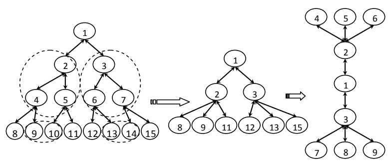

Fig.3. the Derived Process from OCN of MSTP to Adaptive Network.

(1)We analyze the link length Lij between the elements in adaptive network. Then according to Eq. 1, we calculate the summation of the microcosmic state: $A_1 = 176$

(2)According to the parameters L_{ij} and A_1, we use Eq. 2, 3, 4, 5 and 6 to calculate the related parameters of the information entropy in adaptive network:

$$H_{1m} = 2.2455 \qquad H_1 = 1.8127$$

(3)We analyze the link range Ki of the various elements in adaptive network. Then, we use Eq. 1 to compute the summation of the microcosmic state A2 which reflects the link range. $A_2 = 16$

(4)According to the parameters Ki and A2, we use Eq. 8, 9, 10, 11 and 12 to calculate the related parameters of the structure entropy in adaptive network:

$$H_{2m} = 1.2041 \qquad H_2 = 0.8655$$

And then, the structure order in adaptive network: $R_2 = 0.2813$

Thus, we can use Eq.13 to calculate total order of the adaptive OCN of MSTP:

$$R = R_1 + R_2 = 0.474$$

3.3 The Entropy Computation of Distributed OCN of MSTP

Fig. 4 shows the distributed OCN model of MSTP which is evolved from the same task decomposition structural model.

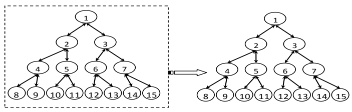

Fig.4. the Derived Process from OCN of MSTP to Distributed Network.

(1)We analyze the link length Lij between the elements in distributed network. Then according to Eq.1, we calculate the summation of the microcosmic state: $A_1 = 736$

(2)According to the parameters Lij and A1, we use Eq. 2, 3, 4, 5 and 6 to calculate the related parameters of the information entropy in distributed network: $H_{1m} = 2.8669$ $H_1 = 2.2722$

And then, the information order in distributed network: $R_1 = 0.2074$

(3)We analyze the link range Ki of the various elements in distributed network. Then, we use Eq. 1 to compute the summation of the microcosmic state A2 which reflects the link range. $A_2 = 28$

(4)According to the parameters Ki and A2, we use Eq. 8, 9, 10, 11 and 12 to calculate the related parameters of the structure entropy in distributed network:

$$H_{2m} = 1.4472 \qquad H_2 = 1.1189$$

And then, the structure order in distributed network: $R_2 = 0.2268$

Thus, we can use Eq. 13 to calculate total order of the distributed OCN of MSTP: $R = R_1 + R_2 = 0.4342$

4. Conclusion

The centralized, adaptive and distributed network models of organization coordination of MSTP have different information orders, structure orders and total orders. It is related to the information and structure summation of the microcosmic state. So, it does not only result from the link length and link range, but also the overall configuration and hierarchy.

In the centralized, adaptive and distributed network models of organization coordination of MSTP, with the information and structure summation of the microcosmic state increase, that is the complexity upgrades, the maximum information and structure entropy shows increasing trend. At the same time, the information order shows an increasing trend and the structure order and total order show a decreasing trend. It indicates that the centralized network has the minimum information order and the distributed network has the maximum information order.

According to the law of diminishing structure and total order of the three models, if we want to strengthen total order of the distributed network model, it is necessary to transform the distributed network into the centralized one.

According to the law of increasing information order of the three models, the distributed OCN model of MSTP has the maximum information order.

References

He, Z. M. (1993). *Complexity Study*. Science press, Beijing.

Yan, Z. L., & Qiu, W. H., & Chen, Z. Q. (1997). Evaluation of system order degree as viewed from entropy. *Systems Engineering-Theory & Practice*, 17(6), 45-48.

Zhou, L., & Liu, X. X. (2005). A target detection algorithm based on new definition of information entropy. *Information and Control*, 34(1), 119–122.

Hong, J. (2005). The research for entropy model for assessing the complexity of network organization. *Journal of Management Sciences in China*, 3.

Li, X. B. (1994). Entropy-information theory and an analysis of the effectiveness of systems engineering's methodology. *Systems Engineering-Theory & Practice*, 14(23), 37–42.