Evaluation of Resource Scheduling Ability of Joint Action System of System in Military and Local Government

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Abstract. Based on the normal process of system evaluation, this paper defined the resource scheduling ability of the Joint Action System of System in Military and Local Government from some aspects such as staff, equipments and materials. In this paper, the quality of task completion was taken as the utility function of resource scheduling for building the evaluation method of resource scheduling ability of Joint Action System of System in Military and Local Government. Moreover, the feasibility of the evaluation method was verified by actual cases, so this paper solved the operational problem of resource scheduling capability evaluation of this system.

1. Introduction

The connotation of joint action in military and local government is: the joint actions of military and local units around the same mission. Therefore, it can be extended from this connotation: any form of joint military-civilian action is a joint action in military-local action, regardless of the nature of the mission, joint scale, time span, and joint depth, it can be regarded as "joint action in military and local government."

The assessment of joint action system of system in military and local government is an extremely complex project. First of all, the joint action system of system in military and local government evaluation is an evaluation practice with the joint action system of system in military and local government as the research object, which has natural complexity. The system is composed of other complex systems \(^1\). Although it is composed of multiple component systems, it is indivisible. The function of the system of system is not equal to the sum of its parts. It emphasizes the interaction between component systems and the local autonomous behavior of component systems. And each component system has local regional influence. Second, joint action system of system in military and local government is composed of two major system of systems, the military and local governments, with completely different missions, operating methods, and evaluation criteria. The evaluation index system is extremely complex and the objective function is difficult to determine. In addition, the structure of joint action system of system in military and local government is not unique. It is often task-oriented and has temporary characteristics. It is difficult to implement assessments in a fixed and unified way. At present, extensive domestic research has been conducted on the evaluation of joint action system of system in military and local government. Judging from the research results, the current "resource scheduling capability" evaluation problem of joint action system of system in military and local government still needs to be resolved urgently. For joint action system of system in military and local government, it involves the military-local two major subsystems, as well as a large number of different business systems. The effective use of resources such as personnel, equipment, and materials is to solve the core problem of the "resource scheduling" of joint action system of
system in military and local government. The resource scheduling capability of joint action system of system in military and local government, in essence, is to schedule resources from multiple channels of joint action system of system in military and local government for a certain task.

This paper uses task completion quality as the utility function of resource scheduling evaluation [2-7]. Based on the normal process of system evaluation, this paper defined the resource scheduling ability of the Joint Action System of System in Military and Local Government from some aspects such as staff, equipments and materials. In this paper, the quality of task completion was taken as the utility function of resource scheduling for building the evaluation method of resource scheduling ability of Joint Action System of System in Military and Local Government. Moreover, the feasibility of the evaluation method was verified by actual cases, so this paper solved the operational problem of resource scheduling capability evaluation of this system.

2. The definition of resource scheduling in joint action system of system in military and local government

The essence of the resource scheduling capability assessment of joint action system of system in military and local government is to evaluate the strengths and weaknesses of the joint action system of system in military and local government -task allocation relationship. The task completion quality is used as the resource scheduling assessment. The related concepts are defined as follows:

Definition 1 Resource-task allocation vector, which represents the quantity allocation relationship between resources and tasks. The resource allocation vector of task $T_i$ can be expressed as:

$$y = [y_1, y_2, \ldots, y_m]^T$$

$$\forall y_{ij} \in Z, y_{ij} \geq 0$$

(1)

Among them, $y_{ij}$ represents the number of resource channels allocated to the task $T_i$ by the military-ground linkage system, and $Z$ represents an integer set.

Definition 2 Resource satisfaction degree refers to the ratio of the amount of resources of the first type that all channels allocated to the task $T_i$ can provide to the amount of resources of this type required by the task, and the maximum degree of resource satisfaction is 1. The satisfaction degree of task $T_i$ for the $l$ resource is expressed as:

$$Z_{il} = \min \left( \frac{\sum_{j \in R_{il}} y_{lj}}{R_{il}}, 1 \right)$$

(2)

Definition 3 The quality of task completion is a measure of the degree of matching between the resource capacity of the channel assigned to the task and the task resource demand. This article is based on the concept of resource satisfaction. The quality of task completion can be defined by four mathematical methods:

$$QT_i = \min_{t \in R_{il}} Z_{it}$$

(3)

$$QT_i = \frac{1}{|R_{il}|} \sum_{t \in R_{il}} Z_{it}$$

(4)

$$QT_i = \left( \prod_{t \in R_{il}} Z_{it} \right)^{1/|R_{il}|}$$

(5)

$$QT_i = \left( \prod_{t \in R_{il}} Z_{it} \right)^{1/|R_{il}|}$$

(6)

Among them, $R_{il}$ represents the set of resource types required by task $T_i$; $|R_{il}|$ represents the number of resource types required by task $T_i$.

Formula (3) adopts the minimum value definition method. Its advantage is that it is simple to calculate and can ensure that all necessary resource types are available before the task can be processed. Otherwise, the task completion quality is 0; its disadvantage is that the task is assigned more resources may not improve the task completion quality, resulting in larger measurement errors.

Formula (4) adopts the arithmetic mean definition method. Its advantage is that it can reflect the impact of resource quantity on task completion quality in time, and its sensitivity is high; the
disadvantage is that it cannot guarantee the completeness of all resource categories required by the task, that is, some this kind of resource satisfaction is 0, and the task completion quality is high.

Formula (5) uses the square root definition method. Its advantage is that it can ensure the completeness of the resource categories required by the task; its disadvantage is that the sensitivity is not high, that is, when additional resources are allocated to more tasks, the quality of task completion is not improved. Obviously, it is not conducive to comparative analysis.

In order to ensure the premise that all required resource categories are complete for task processing, and can sensitively reflect the impact of resources on the quality of task completion, this paper adopts the geometric mean definition method of formula (6).

3. Resource scheduling capability evaluation model of joint action system of system in military and local government

Because the goal of resource scheduling is to ensure the highest degree of satisfaction of all tasks, that is, the highest quality of task completion[8]. For the overall joint action in military and local government operation, the overall resource scheduling goal is the weighted sum of the completion quality of all tasks:

$$\max QM = \sum_{i=1}^{n} \omega_i \cdot \left( \prod_{T \in R_{T_i}} Z_{it} \right)^{1/|R_{T_i}|}$$  \hspace{1cm} (7)

The above formula satisfies the following two constraints:

3.1. Time constraints

The completion of task \(T_i\) must be the completion of its immediate task \(T_j\), namely:

$$\begin{align*}
    s_j - s_i & \geq D(T_i) \\
    G_T(i,j) & = 1 \quad i, j = 1,2,\cdots,n
\end{align*}$$ \hspace{1cm} (8)

The waiting time between \(T_i\) and \(T_j\) is ignored in the formula; \(D(T_i)\) is the processing time of \(T_i\); \(s_i\) and \(s_j\) are the service start times of tasks \(T_i\) and \(T_j\), respectively; \(G_T(i,j)\) is the task sequence that must be followed for task processing. If the task \(T_i\) must be completed before \(T_j\), then \(G_T(i,j) = 1\), otherwise it is 0.

3.2. Resource constraints

The condition for task \(T_i\) to be successfully processed is that the ability to be assigned to handle this task is that the emergency resources of all services \(S\) are not less than the requirement \(R_i\) of task \(T_i\), namely:

$$\sum_{k=1}^{n} R_{S-T}(k,i)S_{kl} \geq r_{it} \quad (i = 1,2,\cdots,n; \quad l = 1,2,\cdots,L)$$ \hspace{1cm} (9)

4. Resource scheduling capability level of joint action system of system in military and local government

The resource scheduling capability level is used to measure the state of the system's resource scheduling capability. The division of the resource scheduling capability level reflects a static attribute and cannot reflect the dynamic development process of the system. In the previous article, the publicity 7 is used to quantify the resource scheduling capability of the system. The resource scheduling capability calculated by this method is generally limited to the range of \([0, 1]\), but because there are countless numbers in the interval \([0, 1]\), it represents countless states, cannot directly and prominently indicate the development state of the system, and lacks qualitative information. Therefore, it is necessary to establish a resource scheduling capability level to measure. The resource scheduling capability level is to divide the range of the resource scheduling capability into a number of continuous intervals according to thresholds. Each interval represents a resource scheduling capability state, forming a continuous resource scheduling capability level ladder. The concept of resource scheduling capability level is essentially to assign all resource scheduling capabilities in a certain interval to a resource scheduling capability, that is, to assign all resource scheduling states in this
section to a resource scheduling state, which promotes the development of theory in the direction of practice. According to the level of resource scheduling capability and the opinions of industry experts, the resource scheduling capability of the general-local linkage system is divided into five levels: "super high level, high level, general level, low level, and ultra low level". Within the range of [0, 1] of resource scheduling capability, the upper bound threshold of 0.9175 is calculated according to the resource scheduling capability function, and it is divided into several continuous intervals, each interval represents a resource scheduling capability level, and each interval represents a resource scheduling capability status forms a continuous resource scheduling capability level ladder (see the table1 below).

5. Application examples
Assuming that in a certain place, joint action system of system in military and local government is dealing with emergencies, the resource scheduling capabilities of joint action system of system in military and local government mainly includes 9 tasks such as team concentration, medical scheduling, material deployment, target verification, medical rescue, challenge implementation, expert consultation, information release, and loss assessment.

According to the analytic hierarchy process, the weight of each index is set as $\lambda = (0.08, 0.1, 0.1, 0.08, 0.05, 0.2, 0.1, 0.15, 0.1)$. Among them, the team concentration includes two resource channels, namely the army team concentration and the local team concentration; the medical scheduling includes three resource channels, namely the army medical dispatch, the local department medical dispatch and the local superior department medical dispatch; Material deployment includes 4 resource channels, namely military material deployment, local-level material deployment, local superior material deployment, and social donation material deployment; Target verification includes 5 resource channels, which are civil aviation verification, civil defense verification, public security verification, electronic countermeasure force verification, and reconnaissance intelligence force verification; Medical rescue includes two resource channels, namely local medical rescue and military medical rescue; The challenge implementation includes three resource channels, which are resource channels for the navy, land and air forces; 1 resource channel for expert consultation; 4 resource channels for information release, namely the military internal information release channel, the military external resource release channel, the local internal resource release channel and the local external resource release channel; There are two resource channels for loss assessment, namely military loss assessment and local loss assessment.

The relationship between the resource amount of each task and the required resources is shown in the following table2. According to the resource satisfaction degree defined by formula 2 above, the resource satisfaction degree of various task can be calculated, as shown in the following table2.

### Table 1. Resource scheduling capability classification table.

| MaxQM range | Resource scheduling capability level | Meaning          |
|-------------|-------------------------------------|------------------|
| 0<0.1616    | 1                                   | Ultra low level  |
| 0.1617~0.4142| 2                                   | Low level        |
| 0.4143~0.6667| 3                                   | General level    |
| 0.6668~0.9174| 4                                   | High level       |
| 0.9175~1    | 5                                   | Super high level |

### Table 2. Resource satisfaction of various tasks.

| Task weight | team concentration | medical scheduling | material deployment | target verification | medical rescue | challenge implementation | expert consultation | information release | loss assessment |
|-------------|--------------------|--------------------|---------------------|---------------------|-----------------|--------------------------|--------------------|-------------------|-----------------|
| 0.08        | 0.1                | 0.1                | 0.12                | 0.05                | 0.2             | 0.1                      | 0.15               | 0.1               |                 |
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According to the geometric mean definition method, the quality of joint action system of system in military and local government in handling emergencies is as follows:

$$\max QM = \frac{\sum_{i=1}^{n} \omega_i \cdot (\prod_{l \in R_T} Z_{il})^{1/|R_T|}}{=0.96}$$

That is, the resource scheduling capability of joint action system of system in military and local government to deal with emergencies is 0.96. According to the classification table of the resource scheduling capability of joint action system of system in military and local government, it can be seen that the resource scheduling capability of joint action system of system in military and local government to deal with emergencies is at level 5. It is an ultra-high level and has extremely strong resource scheduling capabilities.

6. Summary

This article uses task completion quality as the utility function of resource scheduling. Based on the typical process of system of system evaluation, this article defines the resource scheduling evaluation completion quality of joint action system of system in military and local government from the aspect of resource scheduling of personnel, equipment, and materials between the military and local. A resource scheduling capability evaluation method of joint action system of system in military and local government was constructed, and verified through simulation examples, the evaluation method can better complete the resource scheduling capability evaluation of joint action system of system in military and local government.

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