Understandable Capacity Level Assessment Method for Networking Information-Centric System-of-Systems Interoperability

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Abstract. According to the characteristics of the networking information-centric system-of-systems, starting from the understanding ability of the mutual understanding subjects and the information sharing degree of the mutual understanding objects, this paper analyzes the influencing factors of mutual understanding of networking information-centric system-of-systems, extracts four evaluation attributes of education, situation, decision-making and control, describes the selection process of four evaluation attributes, analyzes the factors that affect the mutual understanding level of the networking information-centric system-of-systems in each attribute field, constructs the mutual understanding maturity model of the networking information-centric system-of-systems, analyzes the basic characteristics of each grade, constructs the mutual understanding grade model of the networking information-centric system-of-systems, analyzes the symbolic characteristics of each attribute corresponding to each grade, and puts forward the mutual understanding evaluation method of the networking information-centric system-of-systems to achieve information advantages and decision-making advantages.

1. Introduction

According to the characteristics of networking information-centric system-of-systems, starting from the understanding ability of mutual understanding subjects and the information sharing degree of mutual understanding objects, this paper extracts four evaluation attributes of education, situation, decision-making and control, analyzes the factors that affect the mutual understanding level of networking information-centric system-of-systems in various attribute fields, and constructs the concept of networking information-centric system-of-systems, which has attracted extensive attention and research since it was put forward [1-4]. Document [1] proposes that the networking information-centric system-of-systems is an advanced form of system development. Document [2] proposes that the networking information-centric system-of-systems refers to a complex system formed around the construction of an integrated joint operation system, relying on the sharing of information infrastructure by the entire army and integrating various information equipment. Literature [3] thinks that the operation based on the networking information-centric system-of-systems is an integrated military confrontation with the core of seizing and establishing the information superiority, which is
carried out by the hostile parties around the information flow on the all-dimensional battlefields of land, sea, air, sky, electromagnetism, network, cognition, etc.

We believe that the networking information-centric system-of-systems takes the network as the center, integrates various types of operational resources such as detection equipment, command system, information weapons and so on into a whole, takes information as the leading factor, and carries out mutual integration and network-wide sharing so as to finally form the capability of the army's integrated joint operational system. [4-5].

In the process of joint operations, in order to form a tacit understanding between the combat units of the combat system, improve the effectiveness of the combat coordination, and generate decision-making advantages and operational advantages, the key premise is to make the combat units form a consistent understanding of the combat, and the common understanding is the fulcrum to realize self-synchronization. Therefore, how much support the networking information-centric system-of-systems can provide for the formation of mutual understanding among the combat units is a key point that needs to be investigated and evaluated.

With the development of weapon equipment and command information system [6-8], the information margin available for networking information-centric system-of-systems is gradually improving, which makes the quality of individual cognition and group sharing cognition also gradually improve, thus bringing about the improvement of mutual understanding level. Therefore, it is necessary to analyze the factors affecting the mutual understanding level of networking information-centric system-of-systems and grade the mutual understanding level, so as to evaluate the mutual understanding level.

As the research on understanding has risen to the level of cognition, there is relatively little research on the evaluation of mutual understanding ability of networking information-centric system-of-systems at present. Liu Junxian [6] et al. proposed that mutual understanding is a means to improve the self-adaptive ability of networking information-centric system-of-systems from the level of cognitive domain, and is an important influencing factor to obtain decision advantages. They gave the capability level and characteristic model of networking information-centric system-of-systems from the three general directions of command, control and cooperation, but did not give the evaluation model or method of mutual understanding of systems. Cao Jiang [9-10] et al. proposed to carry out research on the evaluation of mutual understanding level from the system level, extracted the three attributes of situation, decision-making and control as the three aspects to measure the level of mutual understanding of the system, and gave the maturity model of mutual understanding. However, these three attributes were all proposed from the normative perspective of mutual understanding objects, and did not consider the corresponding influencing factors from the understanding ability of mutual understanding subjects.

To sum up, this paper starts from the two aspects of the subject and object of mutual understanding, analyzes the factors that affect the level of mutual understanding of networking information-centric system-of-systems, extracts evaluation attributes.

2. Networking information-centric system-of-systems Mutual Understanding Maturity Model

2.1. Composition of Attributes
The factors that affect mutual understanding include two aspects: on the one hand, the understanding ability of mutual understanding subjects, and on the other hand, the information sharing degree of mutual understanding objects.

The factors that affect the mutual understanding subject's understanding ability include the subject's insight, personality, psychological quality, education and experience, etc. When evaluating the mutual understanding of the networking information-centric system-of-systems, this paper selects the subject's educational experience as the main assessment factor to assess the subject's understanding ability because the assessment work focuses on the subject's understanding based on the information system.
The mutual understanding of the networking information-centric system-of-systems is to enable each combat unit to form a consistent understanding of the combat information and combat activities involved in the whole observation-judgment-decision-action (OODA) combat cycle, thus improving the command and control capability in combat from the cognitive level. Learning from the level of understanding, we should first understand the basic situation of the battlefield, such as "what is there and what is it", then understand "why and what to do" and finally understand "how to do", which corresponds to the system combat process, i.e. the understanding of the situation, decision-making and control. Therefore, this paper selects situation, decision-making and control as the three evaluation attributes from the perspective of mutual understanding objects.

2.2. Maturity Model

The maturity model of mutual understanding of the networking information-centric system-of-systems is shown in Table 1, which divides the level of mutual understanding from low to high into isolation level, entry level, functional level, integration level, cooperation level and adaptation level, and describes the requirements of continuously improving consistent understanding.

| Level           | Sharing Understanding Features                                      |
|-----------------|---------------------------------------------------------------------|
| 5 - adaptation level | the common understanding of the dynamic change and real-time adjustment of action instructions can be realized |
| 4 - collaboration Level | the Understanding of Joint Operation Instructions can be shared |
| 3 - integration level | the understanding of operational instructions in the field can be shared |
| 2 - functional level | the understanding of decision-making elements (battle plans, plans, etc.) can be shared |
| 1 - Entry level | can realize common understanding of situation information based on unified text/graphic description specifications can be realized |
| 0 - isolation level | manually collects intelligence information, draws topographic maps, draws up operational plans in words, and gives operational instructions based on experience |

The six levels of mutual understanding have the following basic characteristics:

A) level 0: the isolation level is the manual operation level in the system, all combat units complete the links such as intelligence information collection, combat plan drafting, and combat command issuing manually.

B) Level 1: Entry level is to adopt the specification of words and graphics to achieve the basic understanding of situation sharing;

C) level 2: the functional level is to adopt standardized decision-making elements and can understand the control elements of combat operations based on standardized knowledge structure;

D) level 3: integration level is the control element that can understand the field operations based on the benchmark control knowledge and the knowledge structure of the field specification.

E) level 4: the cooperation level is to make the same control object in different fields have a consistent reference knowledge structure and can reach a consistent understanding of action control based on the standard knowledge structure in the joint operation system;

F) Level 5: The adaptation level is a control benchmark reconstructed according to requirements, which can synchronously adapt itself in the task collaboration body and achieve a higher level of understanding and cognition of action control through the adaptive benchmark knowledge structure.

3. Networking information-centric system-of-systems Mutual Understanding Hierarchy Model

The model of mutual understanding level of networking information-centric system-of-systems is shown in Table 2. The model defines the subjects of mutual understanding corresponding to different levels, and gives the education situation of the subjects corresponding to different levels, as well as the
symbolic characteristics of the situation, decision-making and control of the three objects of mutual understanding respectively, providing reference standards for the level evaluation of each attribute.

**Table 2.** The understandable capacity level model of networking information-centric system-of-systems

| Level | Name                | mutual understanding subject | subject education                                                                 | mutual understanding object                  |
|-------|---------------------|------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------|
| 5     | adaptation level    | level cross-service arms, cross-level personnel | Cross-domain business rotation training | Situation: Panoramic trends and trends, decision: Adaptive Operational Plan and Plan, control: Autonomous cooperative combat command |
| 4     | collaboration Level | Cross-service and arms, personnel at the same level | Cross-domain business system training | Situation: Cross-domain association status, decision: Joint Operation Plan and Plan, control: Joint operation instruction |
| 3     | integration level   | Cross-discipline and cross-level personnel in the services and arms | Comprehensive business rotation training | Situation: Domain status, decision: Operational Plan and Plan in Field, control: Domain control instruction |
| 2     | functional level    | The same kind of professional and cross-level personnel in the services and arms | Specific business system rotation training | Situation: Specific professional status in the field, decision: Operational plans for specific businesses in the field, control: Domain specific service control instructions |
| 1     | Entry level         | The same kind of professionals and personnel in the services and arms | Simple professional training | Situation: Status of specific disciplines and specific levels within the domain, decision: Operational plans for specific disciplines and specific levels in the field, control: End control command |
| 0     | isolation level     | The same kind of professionals and personnel in the services and arms | No professional training | Situation: Manual mapping of situation information, decision: Written battle plan, control: Control instructions within the scope of experience |

Next, for the three mutual understanding objects in Table 2, the meanings of the symbolic features corresponding to each level are analyzed respectively.

### 3.1. Situation Attributes

1. **isolation level**

   Each combat unit collects intelligence and draws topographic maps according to their respective duties. The situation information mastered by each combat unit only reflects the local situation. There is no specification to support situation sharing among combat units.

2. **Entry Level**

   To form a set of basic expression specifications for text/graphic documents of situation information, which will provide a basis for each combat unit to share the intelligence information collected and the conclusion on combat intention obtained from analysis to other combat units.

3. **functional level**

   For a certain combat application, such as target detection, target identification, target positioning, intelligence reconnaissance, etc., a set of specification for the expression of relevant situation information can be formulated, so that different sensors can share the relevant information acquired by themselves, and these information can be fused to obtain higher accuracy situation information.

4. **integration level**

   A set of situation information expression specifications can be formulated for a certain combat space, so that each information unit can share the situation information acquired by itself and
synthesize the information to form timely, integrated, accurate and reliable combat object information (including position, attributes, motion parameters, etc.) that can cover a certain combat space.

(5) cooperation level

According to a joint operation task, the specification of all situation information in the task area can be formulated, so that each operation unit can share tactical information from multiple networks and fuse the information to form a comprehensive situation that can maintain the joint operation task.

(6) adaptation level

According to different operational tasks, the flexible and universal situation information expression specification can be braked, and the situation information to be shared by each operational unit can be supported according to the adaptive selection of tasks.

3.2. Decision Attributes

(1) Isolation level: The decision-making results are given directly by the commanders through written expression. There is no process of discussion and interaction, sharing understanding, judgment and analysis of decision-making elements among commanders.

(2) Entry Level: Provide simple text and icon expression specifications for commanders to draw up battle plans and battle plans, so that commanders at all levels can more accurately understand the meaning expressed in the plans/plans when reading the battle plans or plans.

(3) functional level: It provides the basic framework and elements for the commander to draw up and revise the battle plan and battle plan, which is convenient for the commander to adopt normative elements to formulate the battle plan and plan under the framework.

(4) integration level: It has a decision-making system that can provide auxiliary decision-making for a certain military service. While assisting commanders to complete the process of making battle plans, it also generates normative decision-making products (e.g., battle plans) based on relevant knowledge structures.

(5) cooperation level: Decision-making system has high real-time performance, high compatibility between decision-making system and combat system, and strong interoperability between different decision-making systems of various services and arms.

(6) adaptation level: On the basis of cooperation level, the adaptive assistant decision-making system also includes battlefield, combat and military expert knowledge as well as intelligent systems with autonomous learning and self-improvement capabilities.

3.3. Control Attributes

(1) isolation level: According to experience, control instructions are issued without forming relevant norms and guidelines for the control process, and without unified training for the combatants, so that different personnel have the same knowledge system.

(2) Entry Level: Having a terminal control benchmark refers to a specific controlled object, such as an unmanned aerial vehicle. Having a terminal control benchmark refers on the one hand to having a set of detailed and clear specifications and standards on how to control a specific object, so that the controlled object can clearly understand the instructions and make accurate responses.

(3) functional level: With basic control benchmark, the "basic control benchmark" refers to the operational control process facing a combat mission and has corresponding control benchmark.

(4) integration level: On the basis of benchmark control knowledge, the knowledge structure based on domain specification can understand the control elements of domain operations. Field operations refer to various operations within a certain service and arm.

(5) cooperation level: It enables the same control object in different fields to have a consistent reference knowledge structure, and can reach a consistent understanding of action control based on the standard knowledge structure in the joint operation system.

(6) adaptation level: The control benchmark reconstructed according to requirements can be self-adaptive synchronously in the task collaboration body, and a higher-level understanding and cognition of action control can be achieved through the adaptive benchmark knowledge structure.
4. Networking information-centric system-of-systems Mutual Understanding Evaluation Method

In this paper, the qualitative evaluation method based on expert rule is mainly adopted, and the mutual understanding level of networking information-centric system-of-systems is evaluated based on the mutual understanding maturity model and hierarchical model of networking information-centric system-of-systems. The evaluation process includes the following steps:

1) Fill in the questionnaire. According to the mutual understanding evaluation index of the networking information-centric system-of-systems, the contents that need to be collected are extracted and made into several questionnaires on the mutual understanding level of the networking information-centric system-of-systems, which are filled in by experts.

2) Attribute grade judgment. According to the symbolic features in the mutual understanding hierarchy model of the networking information-centric system-of-systems, and in combination with the questionnaire survey results, the corresponding hierarchy of each attribute of the system is determined.

3) Determine the mutual understanding level of the networking information-centric system-of-systems. According to the evaluation criteria of the mutual understanding level of the networking information-centric system-of-systems, the mutual understanding level of the system is determined. Synthesizing the results of each attribute grade, the mutual understanding grade of networking information-centric system-of-systems is obtained.

5. Concluding

This paper analyzes the influencing factors of mutual understanding of networking information-centric system-of-systems, describes the selection process of four evaluation attributes of education, situation, decision-making and control, constructs the maturity model and grade attribute model of networking information-centric system-of-systems, analyzes the meaning of the symbolic features of the four attributes corresponding to six grades, and puts forward the evaluation method of mutual understanding grade of networking information-centric system-of-systems, which provides method support for the mutual understanding level of evaluation system and guidance for measuring the ability of the system to achieve decision advantages.

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