Conceptual Model Framework of Intelligent Distributed Ew Operations Based on OPM

Zheng Li *[a], Mingyue Feng *[a], Jianhao Liu *[a], Qingyun Wei *[a], Qiyong Liu *[a]

[a] *Air Force Early-warning Academy, Information Countermeasures Department, Wuhan, Hubei, CN;*
[*] *Corresponding author: 1348019340@qq.com*

Abstract
Modern warfare is increasingly intelligent and distributed, so a unified model framework is needed for future electronic warfare to ensure effective team communication and consistency among models. Therefore, an electronic warfare model framework based on OPM is proposed in this paper. The framework formally describes the elements of entity, environment, information and process involved in military action, and models intelligent distributed electronic warfare from four aspects: top-level conceptual model, operational entity model, operational action conception generation model and operational action process model, which provides a way of thinking for relevant personnel.

Keywords: *artificial intelligence; electronic warfare; model framework; opm*

1 INTRODUCTION

With the extensive application of artificial intelligence technology and high reliability sensors in the field of electronic warfare, the electronic warfare mode with intelligent and distributed characteristics is emerging. Its combat system is a dynamic, open and complex system composed of many decentralized combat units with autonomous characteristics and adaptive ability. The capability of combat system is a general term for the functional attributes of combat units and the characteristics presented in dynamic evolution. It has the characteristics of hierarchy, mutability, nonlinear, dynamic correlation and so on, and can emerge a higher level of combat capability along with the evolution of combat process. It is of great significance to study the principle and general process of intelligent distributed electronic warfare capability dynamic evolution and establish the corresponding capability evolution model to explore the winning mechanism of modern war and promote the generation and improvement of combat effectiveness [1].

2 OPM (OBJECT-PROCESS METHODOLOGY)

OPM (Object-Process Methodology) is a general system modeling method proposed by Dori in 2002 [2]. It is one of the six internationally recognized methodologies of Model Based Systems Engineering. OPM integrates object-oriented and process-oriented modeling paradigms in the same reference frame, establishes the system structure model and behavior model based on the unified view, organically combines the static structure and dynamic process of the system to form the whole model, and supports the modeling of the whole process of system engineering from system requirement analysis to system integration. At the same time, OPM supports model deduction to verify and verify system behavior.

2.1 *OPM modeling elements*

OPM modeling ontology is divided into Entity and Link, as shown in Figure 1. Entity is the basic module of OPM system modeling, and Object and Process are the main entities of OPM. Object describes the physics and information of the system. A process describes the transition between objects. Procedures can generate, consume, and change the state of objects. A State is a property of an object that is attached to the object as an entity. Links are divided into structural links and procedural links. Structural links describe static, time-independent relationships between entities in a system, while procedural links connect objects (processes and states) between entities and describe the behavior of the system. Unlike object-oriented methods, OPM procedures are not encapsulated in specific object classes. Independent process modeling allows multiple objects to be activated or changed in a single process [3].

B. Fox et al. (Eds.): IC-ICAIE 2022, AHCS 9, pp. 1596-1601, 2023.
https://doi.org/10.2991/978-94-6463-040-4_241

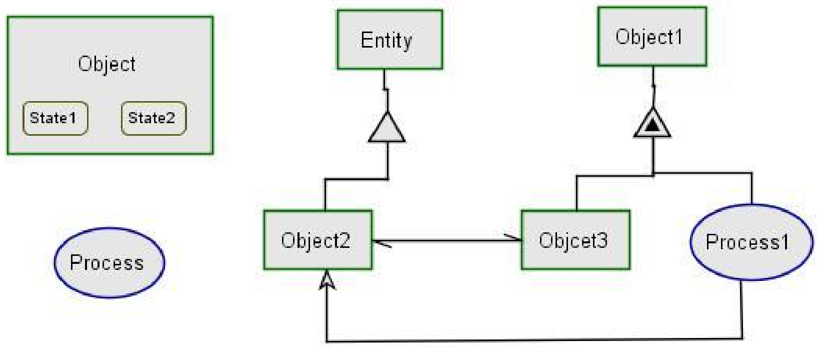

Figure 1. OPM models elements and hierarchical relationships

There are three ways to express system behavior in OPM, and they are represented by different procedural links. They are:

- Migrating links, transforming objects in the process, that is, generating, consuming or changing the state of objects in the process.
- Subject link, in which the object executes the procedure without being migrated by the procedure, such as the object starts or terminates a procedure.
- Event link, which triggers the event to invoke the corresponding process after the entity meets certain conditions. OPM supports internal events such as state entry, state migration, state timeout, process termination, and process timeout, as well as events triggered by the external environment.

2.2 *OPM model representation*

OPM provides two semantically equivalent expressions of graph and text, namely object-process Diagram (OPD) and Object-Process Language (OPL), as shown in Figure 2. Process object diagrams can represent process objects at different levels of granularity. Each OPM modeling element corresponds to an OPD symbol and explicit semantics in OPL. The syntax of OPD is used to define correct and consistent link relationships between entities. OPL is a model text description language, which corresponds to OPD elements one by one [4].

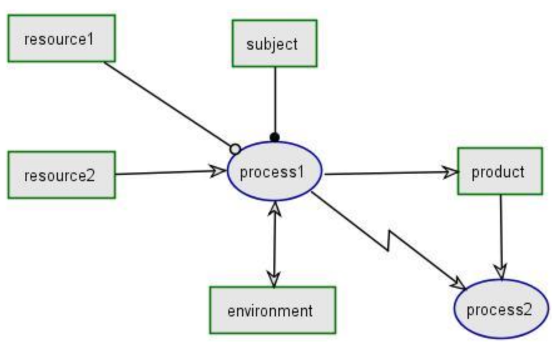

Figure 2. Model representation of OPD and OPL

2.3 *OPM deduction*

OPM models are executable and support model simulation inference. After initializing the model, modelers can deduce the execution semantics of the behavior model so that they can observe state changes of entities, dynamic interactions between entities, and real-time execution of processes. Based on the executable OPM model, the modeler can perform preliminary verification of the system behavior before developing the simulation model, avoiding the error of conceptual modeling to the simulation model.

2.4 *Advantages of OPM concept*

The advantages of using OPM for conceptual modeling are as follows:

- OPM models the system structure, function and behavior through unified type view, and adopts the "zoom in" function to achieve hierarchical modeling. Unified view modeling makes it easier to maintain consistency of model elements and improves the modeler's macro understanding of the system.
- The modeling elements of OPM are simple, and the modeling method is easy to learn and use,

which reduces the learning time of modelers and improves the efficiency of model development.

- OPM supports dynamic model deduction, through which the model can be preliminarily verified and verified.
- OPM supports automatic transformation with other modeling languages (such as UML, SysML), which is conducive to model reuse and communication.

3 MODELING INSTANCE

3.1 *Intelligent distributed electronic warfare concept*

The core idea of intelligent distributed ew is to disassemble and deploy the functions of expensive ew equipment system to a variety of heterogeneous small and low-cost manned/unmanned combat platforms in the whole domain instead of the current multi-purpose and high-value EW equipment platform to complete combat tasks independently. By establishing a distributed communication network among multiple platforms, autonomous cooperation and intelligent decision-making of combat tasks can be realized, and electronic warfare tasks can be accomplished together in the form of network and systematization. This combat style not only reduces the battle cost, but also improves the flexibility and adaptive ability of the whole ew system, so as to achieve the same or higher combat capability than the existing combat style.

In the concept of intelligent distributed electronic warfare, combat forces in land, sea, air, air, network and electricity are integrated into a unified framework. Its main characteristics are as follows [5].

- Scale. Distributed ew uses a large number of low-cost platforms to decompose the functions of high-performance platforms, which will greatly expand the scale of combat network and lay a foundation for the implementation of the concept of distributed ew. In the future battlefield, a small number of high-end human-machine nodes will bring quality advantages to the combat system, while a large number of UAV nodes will bring quantity advantages to the combat system, and achieve subversive combat capabilities through human-machine uav collaboration.
- Agility. Distributed networked characteristics of electronic warfare, make all levels of command and control system can timely grasp and combat unit is closely related to the local battlefield situation, real-time understanding of global information battlefield, on this basis, according to the real-time change of battlefield, in a timely manner to combat judgment, decision and action, thereby raising the speed of the accused, the information into decision making and action.
- Integrity. In distributed operations, the sensor modules, accusation modules and firepower modules distributed on each combat unit are networked separately to form the sensor network, accusation network and firepower network, thus connecting each combat unit into an organic whole and realizing the integration of combat forces. On the other hand, the dispersion of combat entities increases the difficulty of enemy detection and target selection. At the same time, combat capability decomposition, in the independent operation at the same time because only undertake part of the system of the system to improve the anti-destruction ability of their own system.
- Coordination. Under the condition of distributed combat, the coordination among all combat units is highly coordinated through the network, and all command and control units make comprehensive judgments and decisions based on the shared battlefield information, so that all combat units can be unified and coordinated, rationally divided, closely cooperate and efficiently carry out combat tasks.

3.2 *Intelligent distributed ew modeling based on OPM*

The OPM modeling tool used in this article is OPCAT 4.2, which supports the transformation from an OPM model to an object-oriented language. The conceptual model framework of intelligent distributed electronic warfare is divided into four parts: top-level conceptual model framework, combat entity model framework, intelligent combat action conception generation framework and combat action process model framework. The top-level conceptual model framework takes military action as the core and is used to describe various elements and relations involved in combat action as the most basic model framework. The last three parts are the development of the top-level conceptual model framework: the operational entity model framework describes the components and organizational structure of combat forces; The operational process model framework further refines the process of military action. Intelligent operational concept generation framework is a new operational concept generation method under the background of artificial intelligence.

3.2.1 Intelligent distributed ew top-level conceptual model

As shown in Figure 3, the framework elements are mainly composed of superior commanders and command institutions, local commanders and command institutions, physical entity units such as intelligent distributed ew formation, generation of intelligent combat action conception and intelligent distributed EW action process, etc.

The purpose of operations defines the objectives, time limits, guiding principles and other attributes of military operations. The expectation of the intelligent distributed ew action process is to achieve these intentions by changing the status of the combat objective from "not achieved" to "achieved". As the participants of the action, commanders and command institutions at the same level generate operational plans through intelligent combat conception in order to realize the determination and intention of superior commanders and command institutions. This process is influenced by battlefield environment, enemy situation and our situation. The operational plan is an approach similar to that used by ride-hailing software such as Uber, which creates multiple operational plans for commanders at their level to choose from. After the commander determines the combat action plan, he issues combat orders to the electronic warfare formation to implement intelligent distributed electronic warfare action.

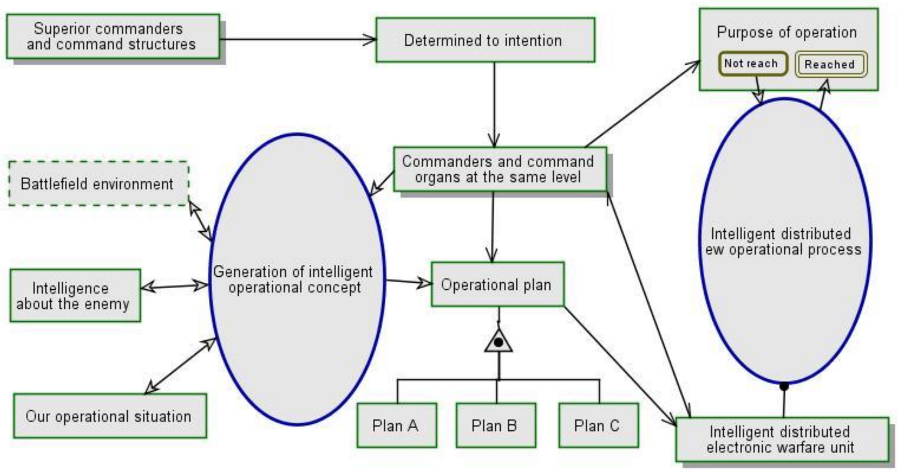

Figure 3. Overall model diagram

3.2.2 Operational entity conceptual model framework

As shown in Figure 4, the combat entity model framework is the expansion of the combat force object in the top-level conceptual model framework, and a general description of the force structure in combat operations. Combat platform is the main component of intelligent distributed ew force. Among them, the main features include geographical location, unit name, maneuvering height, speed, working state and so on. The combat platform is mainly composed of ground entity unit, air entity unit, space entity unit, surface entity unit and underwater entity unit. The functions of the combat platform include perception, communication, command, execution and so on.

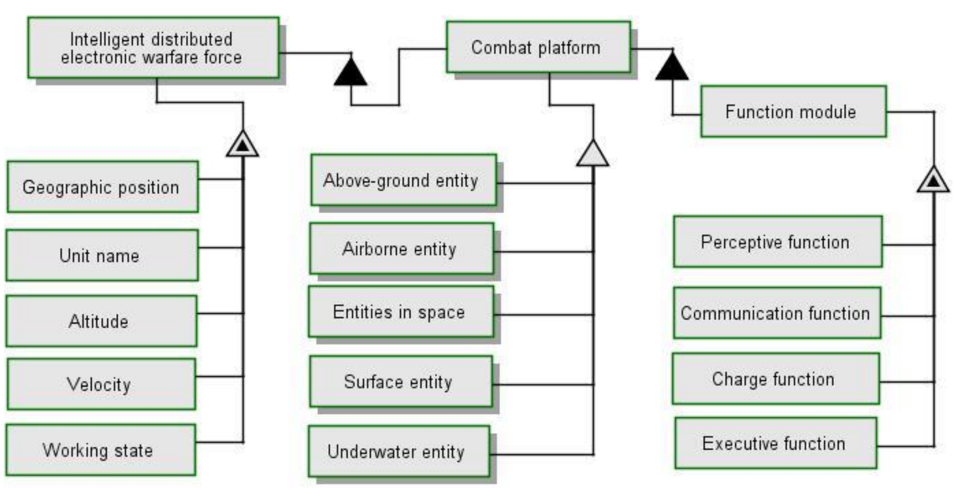

Figure 4. Operational entity map

3.2.3 A framework for generating the idea of intelligent combat operations

As shown in Figure 5, artificial intelligence technology can improve the efficiency of operation conception generation through its powerful computing ability and machine learning ability compared with traditional operation conception generation.

- Step1: the human commander first presents the overall battle plan to the intelligent system.
- Step 2: Intelligent systems provide the decision maker with a series of potential plays that fulfill the request, i.e., high-level templates that might be used to strike the target's kill chain category (kinetic or non-kinetic). The decision maker needs to select one or more of these plays. The playbook specifies the elements needed to form the kill chain and the quality of service (time, space, precision, energy, etc.) for each element.
- Step 3: the smart system sends bid requests across the battlespace to the smart distributed combat force for each service required by the selected playbook, which forms the service requirements for the kill chain. The smart system must determine if there are resources available to meet the requirements. And at what "cost", or constraint, to satisfy a particular request.
- Step 4: the intelligent system returns "offers", the set of task satisfaction and constraints, to the decision maker.
- Step 5: the decision maker determines these "offers" in the selected "play" and forms the optimal kill chain, that is, the option most likely to accomplish the task, according to the "value-function" of the least risk and least interference with other tasks.

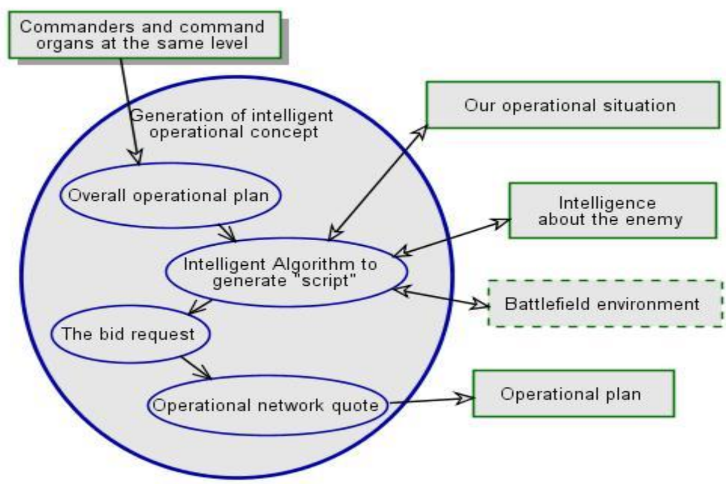

Figure 5. Intelligent operational concept generation diagram

3.2.4 Conceptual model framework for military operational process

The conceptual model framework of military operation process is used to describe the general process of military operations at the campaign and tactical levels. The specific details are shown in Figure 6. The process is subdivided into four sub-processes: perception, accusation, communication and execution. Each sub-process generates battlefield situation, battle plan, battlefield information, battle order and other objects respectively, and interacts with the functional module of intelligent distributed electronic warfare formation, ultimately changing the combat objective from unachieved to achieved.

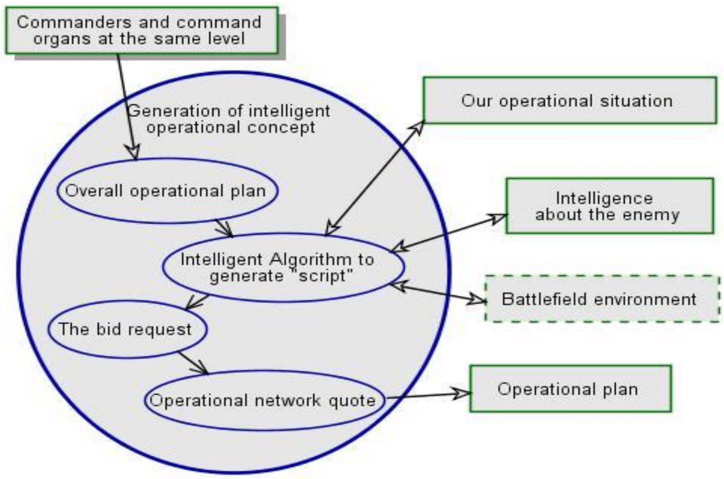

Figure 6. Diagram of intelligent military operation process model

4 CONCLUSION

As a new concept of electronic warfare under the background of network, intelligence and system integration, intelligent distributed electronic warfare is a continuation of the existing forms of warfare, and has a subversive and research value. In this paper, OPM4.2 software is used to establish the overall model framework, combat entity model, intelligent combat plan generation model and military action process model of intelligent distributed electronic warfare. In conclusion, the framework can clearly and accurately express the operational concept of distributed electronic warfare under the background of intelligent warfare, which is in line with the scale, agility, integrity and coordination characteristics of future electronic warfare, and can provide a new idea for the study of intelligent warfare.

REFERENCES

[1] XU Xiu-feng, SI Guang-ya, WANG Yan-zheng. Conceptual Model Framework of Military Operation Based on OPM [J]. Command Control & Simulation, 2020,42(06):1-8.

[2] LI Zi-mo, YAO Jian, Huang Qi-wang, YANG Feng. Military Conceptual Modeling Based on OPM [J]. Command Control & Simulation, 2015, 37(02): 1-5+12.

[3] Zheng zhan, Yang feng, Wang Tao, Wang Wen-guang. Weapon System Requirement Detemination for Concept Operations based on Object-Process Methodology [J]. Command Control & Simulation, 2017, 39(03):5-10.

[4] SHI Feng, GAO Xinghua. Application of OPM to Requirements Modeling in Equipments Demonstration [C]. Proceedings of the 34th Chinese Control Conference, 2015: 289-293.

[5] LIU Zhi-qi, CAO Jiang, YE Xiong-bing. Method of Converting OPM Model to DoDAF Operational View [J]. Fire Control & Command Control, 2021, 46(12):120-127.