Design and Study of Simulation Model for Organization of the VHF Station Network

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Abstract. A scientific and reasonable construction of the organizational simulation model of the VHF station is based on executing the simulation evaluation of the organization and effectiveness of the VHF station network. First, we analyzed in detail the requirements of the VHF station network organization simulation model construction from the perspective of organization. Secondly, the entity-oriented modeling method is adopted to design the model composition of the simulation entity, the relationship between the entity models, and the entity model behavior. Eventually, the UML modeling language is employed to create a connection between entity model behavior and information interaction. The simulation model constructed in this paper can provide core model resources for the design and implementation of the simulation system for VHF station network organization. Moreover, it can also provide reference for constructing organization simulation models of the other communication network.

1. Introduction

The VHF station network is an essential component of the mobile communication network system, which has powerful anti-interference and self-recovery capabilities. Hence, it has turned into a major way of communication to ensure the transmission of users' voice and data services in a complicated situation, and even the only mobile communication means in emergency units, for example, rescue and disaster relief. The simulation model of the organization of the VHF station network is the essential factor for evaluating the organization of the VHF station network. The current simulation model of the VHF station network employs either CMMS modeling method [1-4], or process-oriented modeling method [5-6], or entity-oriented modeling method [7-8]. The CMMS modeling method is comparatively mature, but it cannot be modified to suit user demands as the technology has been encapsulated. The process-oriented modeling method concentrates on the research of relevant details, and its model reusability is weak. For this reason, this research proposed an entity-oriented modeling method based on the perspective of organization from analyzing the requirements of model applications, thus composing a simulation model for the organization of the VHF station network.

2. Overall analysis for constructing the simulation model of VHF station network

2.1. Demand Analysis

Demand analysis is the foundation for software or system design. Meanwhile, the functions to be implemented by the software or system should be clear, but normally, the implementation method is not concerned. After analysis, the simulation model constructing demands is included in the following three perspectives.
2.1.1. Be able to reflect the construction process of the VHF Station network.
In general, the key to the communication network system to execute communication security is the construction of the network system, which is governed by several factors. Therefore, the organization simulation models of the VHF station network shall correctly indicate how the entities constructed with the network system engage in the construction activities of network systems, for instance, military power, geographic environment, weather conditions, and electromagnetic environment, and so on. Besides, it shall be paid attention to define the correlation between the builder, the safeguard object, and the communication network. Only on this foundation can three components of a communication network be developed: the main body of network construction, the main body of network security, and the network itself.

2.1.2. Be able to support the calculation of the communication guarantee efficiency of the VHF station network
The final object of communication network construction shall be reached through the end-to-end transmission of multiple communication services, such as voice of and data on the guarantee object from the perspective of the organization of communication networks. Accordingly, the simulation model is required to precisely define the performance of the communication service transmission: transmission delay, packet loss rate, and other indicators of communication services. Thus, it supplies assistance for estimating the communication support efficiency of the organization of the VHF station network.

2.1.3. Be able to support the optimization of the VHF station network organization
Normally, evaluation and optimization are complementary each other, and evaluation should supply reliable data for optimization. The dynamic evaluation of the organization of the VHF station network is required to optimize the organization and utilize the data output from the simulation model. Therefore, the transmission of data based on the communication service should be able to support the search of key links that affect the effectiveness of communication support through voice services, data services, etc. and provide accurate data support for the next step to organization and optimization.

2.2. Create Strategies
Several models are included in the process of organization modeling the entire scope of entities, behaviors, and interactions is complicated and harmful to reaching subsequent model development. Hence, an obvious strategy for simulation model construction is an essential basis for subsequent model construction. Then, it is mainly involved in the following three perspectives:

Subtract factors that are not relevant to the simulation derivation of the solution. The construction of the organization's simulation model is paid attention to the attribute behavior of the communication troops and equipment entities and the construction of the network system. The troops of the emergency unit can be adopted as a communication support user in the simulation deduction. Its role is to generate communication traffic through actions such as issuing orders and situation reports. Therefore, the attributes and behavior of the Emergency Unit Force can be simplified appropriately.

The influence of the environment is shown by taking data. Ordinarily, an entity model of the environment is required to be independently created during the operation of simulation system. By contrast, considering that this method needs to be based on the information exchange between the entity models, it will enhance the calculation of the simulation and produce more significant challenges in the simulation system's operating environment. This research will provide data directly to the related entity models as required by the system to decrease the complexity of modeling and advance the model's operating efficiency. Then, the entity models adjust their attributes to show the impact of environmental determinants.

A component modeling method is employed to formulate the model. The loading platform to which the VHF belongs is separate. It is involved in both communication vehicles and vehicle-mounted communication devices, as well as single communication equipment. Modeling every variety of
entities will increase workload and waste too many resources. Accordingly, this research used a component modeling method to compose a model template, defined the connection between parts, and arranged the content of the information interaction interface to assemble the numerous models required. Furthermore, it can not only diminish the complexity of modeling and improve the ease of application and flexibility of the model, but also heighten the model reusability.

3. Research on construction of simulation entity model

3.1. Composition and Design of the Entity Model

Typically, the entity model is basically an abstract description of entities included in related activities in the real space. Communication devices and support personnel are the main body in the organization from the viewpoint of the organization of communication networks. Each communication service is required to be transmitted via the communication network. According to the previous analysis, it is important to develop an entity model of the troops, an entity model of the devices, and an entity model of the network system in the simulation space. Moreover, in the emergency communication support plan, the task of building the communication node is to define the support unit and the communication vehicle. In order to create the link connection between the communication vehicle and the VHF stations, it is also required to make an aggregate entity model individually.

3.1.1. Troops entity model

The entity model of troops is the main part for performing emergency operations, which can be split into command entities and detachment entities based on various command levels. However, the classification can also be based on the task undertaken, which should be determined by the simulation demands. For this study, the goal of the simulation is to estimate the effectiveness of the VHF station's organization. It shall be categorized by mission variety into an entity model of Emergency troop and an entity model of Communication support troops and required to concentrate on the consideration of the composition of the entity model of the Communication support troops. Since the VHF station is mostly guaranteed by the communication support unit, it only needs to construct the entity model of the communication support department (unit). Besides, there is no requirement to identify the Entity Model of Emergency troop, as they are both targeted by communications support for the communications network.

3.1.2. Device entity model

From the perspective of communication network construction and formation, in the objective world, only if the devices at both ends of a communication link satisfy certain conditions (e.g. consistent frequency parameters, same antenna direction, energy loss meets requirements), can the network be formed. Accordingly, for this research, the entity model of devices shall be a VHF station in the objective world. It shall be noticed that some communication vehicles are also installed with VHF stations. The Entity Model of the Equipment for the communication vehicle equipment shall also be constructed separately to define the composition relationship between the VHF station of vehicle-mounted and the communication vehicle. Nevertheless, the VHF station of vehicle-mounted can be described in the form of configuration.

3.1.3. Network entity model

For the communication network, from the physical form, it can be classified into nodes and links. From a logical viewpoint, network protocols shall also be involved, and network protocols shall be the core and main body of the communication network. Hence, in order to precisely define the structure and composition of the network system in the simulation space, the network entity model can be split into the node entity model, link entity model, and network entity model. Among them, there must be a one-to-one mapping connection between the node entity model and the single equipment entity model.
3.1.4. Aggregate entity model

Aggregate entities are often used to describe various entities that come together to form an entity to achieve a particular purpose. Once the goal is carried out, the aggregation connection between these entities will no longer have existed. For this research, the aggregated entity model is demanded to be composed, primarily to describe the assurance relationship between the support unit and the communication nodes. Consequently, every communication node can be constructed as an aggregate, for example, an entity model for comprehensive node.

3.2. Design of behavior system of the entity model

Behavior is the foundation of interaction between entities. According to construction demands and construction strategies of the simulation model, the behavioral system of the entity model is designed by extracting the entity attributes that are intimately associated with the simulation purpose from the entity behavior in the real space. This research is aimed to extract entity behavior associated with the construction of the VHF station network, network condition, and communication service transmission from entities such as troops, devices, and networks. Since the goal of the simulation in this article is to measure the performance of the VHF station network and the transmission performance of carrying communication services, considering that the communication network is an abstract representation of the interconnection of communication devices. Accordingly, it only needs to investigate the behavior of the two types of entity models, troops and network.

For the troop entity model behavior, according to the simulation model construction needs and construction strategy, the behaviors that affect the distance between nodes, network capacity, node bandwidth, and communication service generation of the VHF station network shall be extracted principally. For example, troops maneuvering, communication guarantee of the troops, and Communication business generation of troops.

For network entity model behavior, such as network establishment, network topology, communication service transmission, and communication service control shall be extracted and reported, for instance, the establishment and maintenance of the VHF network link, communication service routing selection, communication service transmission and control, and other behaviors.

Table 1. Entity model behavior.

| Serial number | Name of Entity Model       | Behavior                                      |
|---------------|---------------------------|-----------------------------------------------|
| 1             | Troops entity model       | Maneuver                                      |
| 2             |                           | Communication Guarantee                        |
| 3             |                           | Communication service generation              |
| 4             | Network entity model      | Link establishment and Link maintenance       |
| 5             |                           | Routing selection of Communication Services   |
| 6             |                           | Transmission and Control of Communication Services |

3.3. Relationship design of the entity model

In the process of entity-oriented modeling, model relationship is normally meant static and dynamic relationships between entity models. Static relationships usually describe the inherent relationships between the components according to the composition of the entity. The dynamic relationship means the relationship between entity models via behavioral interaction. After analysis, the relationships between the entity models composed in this research include combination relationship, aggregation
relationship, command relationship, call relationship, and abstract relationship, and as presented in Figure 1.

![Diagram](image-url)

Figure 1. The connection among the organization of the VHF station by simulation entity models

The combination connection has essentially existed between the single equipment of the VHF station and the entity model of the communication vehicle. It is adopted to show the composition connection of the single station of the communication vehicle. The aggregation relationship is employed to describe the composition connection between the communication vehicle and the entity model of the integrated node and the information node of the emergency command post. Furthermore, the aggregation connection is applied to show the Equipment allocation relationship between the communication vehicle entity model and the communication support team entity model. And the abstract connection relationship between the nodes, links and networks in the VHF network is also displayed. The command relationship is used to represent the accusation and operation relationship between the subordinate force entity model, the force entity model and the equipment entity model. The calling relation is used to symbolize the entity model of the emergency troops, the entity model of equipment and environmental data. The abstract connection is used to describe the abstract representation relationship between the VHF equipment and the VHF station network's node.

4. Research on model construction of simulation behaviour

4.1. Design of behavioral activities

Behavior is normally formed of a range of actions. If creating a model of behavior, it is not necessary to analyze all of the constructed actions. Not only does it enhance the complexity of the simulation model construction but also decreases the operating efficiency of the simulation system. Accordingly, it is only required to extract actions intimately associated with the simulation purpose from the real behavioral composition based on the simulation demands. Moreover, it can be combined according to specific rules, which is the purpose of the behavioral activities composed in this section.

According to the analysis in Section 3.2, it is clear that the behavior model constructed in this research covers Maneuver of troops, Communication service generation, Link establishment and Link maintenance, Routing selection of Communication Services and Transmission and Control of Communication Services, etc. Considering that the behavior of the troop entity model has quite mature research outcomes which can be immediately utilized, it is properly to concentrate on the network behavior of the entity model. Then, this paper is used the transmission control of communication services as an example and uses UML to design behavioral activities, as presented in Figure 2. The
solid wireframe represents a series of actions that make up the behavior activity, and the dotted wireframe represents the event or interaction that triggers the action.

4.2. Design of interaction relationship of behavior
The interaction relationship of behavior is normally employed to define the procedure of the entity's execution of the behavior. The generated information interacts and triggers the associated entity, thus modifying the procedure of its state. It is a vital joint to accurate description the interaction behavior of the entity model in the simulation space, and it is also an essential procedure for composing the behavior model. From the viewpoint of system design, each behavior is triggered by behavioral interactions. That is, each behavior must be designed for behavioral interaction relationship. Likewise, this research used the transmission control behavior of communication services as an instance to compose the interaction connection of behavior, as revealed in Figure 3.
5. Summary
This paper compares the existing simulation model construction methods from the viewpoint of the VHF network organization using simulation. It starts from the requirements analysis of the VHF network organization using simulation model construction. It systematizes the design of the VHF network organization using entity model composition, entity model behavior, and entity model relationship in the simulation space. Based on the real interaction process of entities, we extracted the activities closely related to the construction and operation of VHF network and the transmission performance of communication services, and used UML to build a simulation behavior model by taking the communication service transmission control behavior into account. The simulation model design can provide model support for the design and implementation of the simulation model for the organization of VHF radio networks. It can also provide a reference basis for the other organization of the communication network system using a simulation model construction.

References
[1] DMSO, “Conceptual Models of the Mission Space (CMMS) Technical Framework”.1997.2.
[2] Guo Q, Bi Y. (2008) Research on Missile Combat Scenarios According to the Conceptual Model of Mission Space. Computer simulation, 25 (12): 88-91.
[3] Wang S, Kang F, Han H. (2015) Research and Application of an Improved CMMS Description Method. Journal of System Simulation, 27 (10): 2252-2257.
[4] Wu J, Lu M, Sun Z. (2011) Research on the Conceptual Model of Antisubmarine Combat Mission Space of Surface Warship Formation. Journal of System Simulation, 23 (1): 33-37.
[5] Wu J, Dong H. (2013) Modeling of Submarine Combat Behavior Process Based on Petri Net Theory. Submarine Academic Research, 31 (2): 47-50.

[6] Jiang L, Xu H. (2016) Modeling and Effectiveness Evaluation of Armed Helicopter Intercepting Anti-radiation UAV. Journal of Command and Control, 2 (3): 47-53.

[7] Zhou M, Zou Z. (2015) Design and Implementation of Simulation Communication Model for Entity-oriented Command Training. Fire and Command Control, 40 (8): 109-113.

[8] Zhang Y, Cao L, Pan M. (2014) Combat Simulation Entity Modeling According to the Integrated Modeling Method. Journal of Armored Force Engineering College, 28 (2): 57-62.