Research on Operational Architecture Modeling and Validation Method Based on DoDAF

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Abstract: Military information system has the tendency of larger scale, more complicated component, on the contrary of shorter and shorter developing cycle. Aiming at these, this paper puts forward an operational architecture modeling method based on DoDAF, and gives the detailed steps of operational architecture design , as well as how to accomplish related architecture products. Then, combined with detail example, a remote target indicator system is established and validated by dynamic simulate experiment. The experiment results show that this method can describe system architecture effectively as well as practicably.

Introduction

It is very important to strengthen the top-level design for Military information systems, which have the characteristics of huge scale, complicated structure, and the variable mode of operations. Finishing architecture design before system is developed can not only enhance the development efficiency, but also reduce the design risk and prove the system's availability. Finally, the interconnection, interworking and interoperability of military information systems will be enhanced. Nowadays, architecture design is being paied more attention for scientific research organizations and commerce teams, and some achievements are gained[1,2]. However, most of them are still confined within theoretical research or the development of architecture supporting tools[3,4]. While few military information systems frame according with our national conditions is found, not even mention to the architecture modeling based on detailed operation demonstrations [5]. So on the basis of doing deep studies on the architecture frame of USA defense department, we presents a remote target indication operational architecture based on DoDAF, emphasize particulary on system operational architecture modeling and the generation of architecture products, and finally test its feasibility and practicability by specific example.

Operational Architecture Design

As the most formalize and extensive applied architecture frame at present, DoDAF V1.5 defines a series of standard view[6], such as all view, operational view, system view and technology view, which describes the architecture of military information system from different angles[7,8]. Different views are composed by different architecture products, and these architecture products are taken shap in the course of operational architecture modeling, system architecture modeling, and technology architecture modeling respectively[9]. For the reason that DoDAF just gives the architecture result formats of military information system and some guideline principles, however it doesn't provide how to design the architecture products or a clear process[10]. Therefore it is important to make it clear of the implication about the architecture products, and their logical relation, as well as the design method and steps for structuring architecture model.

(1) Operational Architecture Products

Operational architecture is a model which describes the relationship between operational mission, operational action and operational element, whose main function is to make sure the information requirement for operational roles, and describes the operational function and logical demand[11]. The design of this view will confirm the relationship between operational mission, node, activity and element， and the information exchange around the operational nodes for special operational action.

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There are 9 products in the operational view of DoDAF V1.5, including High-Level Operational Concept Graphic(OV-1), Operational Node Connectivity Description(OV-2), Operational Information Exchange Matrix(OV-3), Operational Relationships Chart(OV-4), Operational Activity Model(OV-5), Operational Rule Modeling(OV-6a), Operational Status Change Description(OV-6b), Operational event Sequence Description(OV-6c) and Logical Data Model(OV-7).

(2) Steps of Operational Architecture Design

There are internal connection and interdependence relationship between the operational architecture products. Consequently, operational architecture design can be executed by some steps, as illustrated in Fig.1.

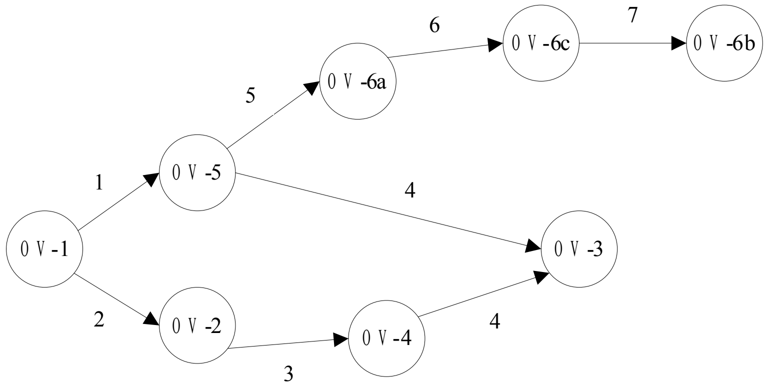

Fig.1 steps of operational architecture design

Step 1: determine High-Level Operational Concept Graphic, which is OV-1 and describes high-level operational concept by graphic or literal. The contents include operational mission, connective ability of geographical distribution for different facilities, various of synoptic pattern description, and so on. So that it's convenient for the senior policymaker to communicate[12].

Step 2: confirm operational nodes, operational activities and organizational command relationships, include OV-2, OV-5, OV-4. While OV-2 describes the relationships between operational node, connected relation and information exchange requirements, and OV-5 illustrates operational activities, information inputs and outputs conditions, and OV-4 represents the relationships among organizations, roles, resources and depicts them in a hierarchy.

Step 3: define information exchange around the operational nodes and their flow direction relationships OV-3, which is a summary of information exchanged between nodes with attributes, such as security, timeliness, and usually marked as a matrix.

Step 4: make sure operational events and rules, include OV-6a and OV-6c. OV-6a specifies operational or business rules as constraints, yet OV-6c provides a time ordered examination of information exchanges between participating operational nodes against a given scenario.

Step 5: specify internal status transform for each node and exact data characteristic for operational nodes if necessary, they are OV-6b and OV-7. Nevertheless, OV-6b refers to a signal node, which describes how an operational node or activity responds to various events by changing it's state. On the contrast, OV-7 describes the main data structures of operational architecture used and the interrelation between them.

Operational architecture modeling and validation for remote target indicator system

The typical operational scene of remote target indicator system can be described as: at first, detection platform sends out target information to command platform when it detects the target information of hostile warships, and then channel organization command is dispatched to both detection platform and weapon platform by command platform, according to which, the detection platform organizes communication plan and transmits target indicator orders to weapon platform. At the same time, the dispatched remote target indicator information is send to weapon platform by command platform. Finally, weapon platform attack the target in accordance with the finally target indicator information dispatched by detection platform and command platform.

(1) Operational Architecture Modeling

According to the operational scene described above, the operational concept graphic OV-1 should be developed at first to confirm the summary of operational scenes, so as to make certain of operational mission, participants, operational elements. Take the remote target indicator system for example, the main participants are confirmed detection platform, command platform, weapon platform, missiles and hostile warships etc, as Fig.2 describes.

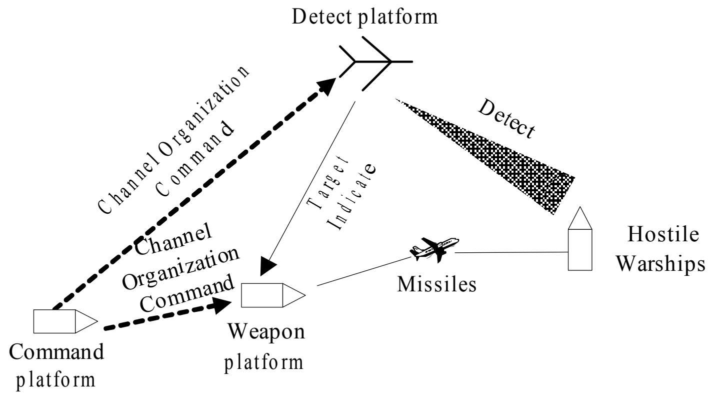

Fig.2 high-level operational concept graphic OV-1

Then determine the main operational activities and their inputs and outputs relationships in this operational scene, which form the operational activity model OV-5. The operational activities in this scene are divided into three parts: detection, command and attack, as illustrated in Fig.3. After that, In order to accomplish the operational node connectivity description OV-2, we can find out the main operational nodes and their connected relationships, as well as information exchange requirements.

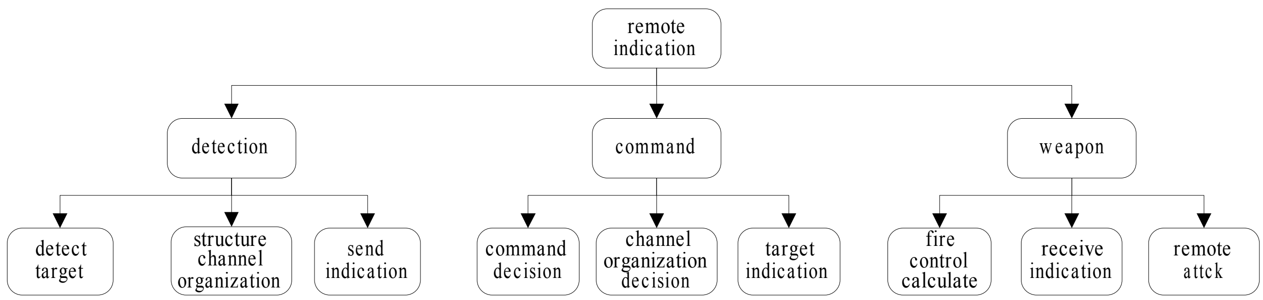

Fig.3 operational node connectivity description OV-2

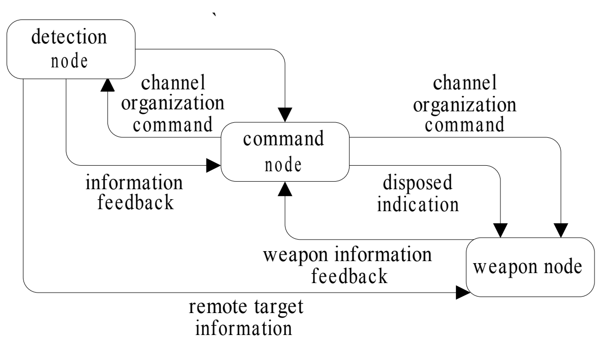

Fig.4 operational activity model OV-5

Fig.4 defines the primary operational nodes including detection nodes, command nodes and weapon nodes in this scene. In addition, the operational relationships chart OV-4 shows various operational organization and command relationships among operational roles. The major operational roles in this scenario are depicted in Fig.5, including early warning airplane, detection radar, command center, channel organization, GPS satellite and guided missile, etc.

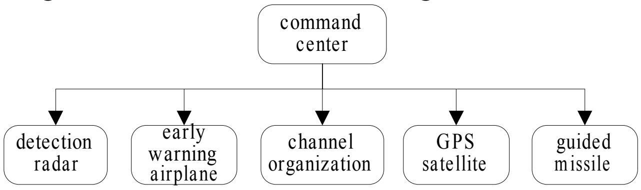

Fig.5 operational relationships chart OV-4

Besides, the operational information exchange matrix OV-3 can be fixed after all those modeling are formed, which displays the information exchange between operational nodes and their related property. The requirement correlation between producer and consumer in the course of information exchange are showed in table 1.

Table 1 operational information exchange matrix OV-3

[num]	[information exchange]	[start node]	[node activity]	[end node]	[node activity]	[timeliness]	[classi-fication]
[1]	[target information]	[detection node]	[detection target]	[command node]	[command decision]	[real-time]	[confidential]
[2]	[channel organization command]	[command node]	[channel organization decision]	[detection node]	[structure channel organization]	[real-time]	[confidential]
[3]	[feed information]	[detection node]	[structure channel organization]	[command node]	[target indication]	[real-time]	[confidential]
[4]	[channel organization command]	[command node]	[channel organization decision]	[weapon node]	[receive indication]	[real-time]	[confidential]
[5]	[feed information]	[weapon node]	[receive indication]	[command node]	[target indication]	[real-time]	[confidential]
[6]	[disposed indication]	[command node]	[target indication]	[weapon node]	[receive indication]	[real-time]	[confidential]
[7]	[indication information]	[detection node]	[send indication]	[weapon node]	[receive indication]	[real-time]	[confidential]

Finally, the operational event sequence description OV-6c can be determinated after OV-2 and OV-3 are confirmed, which depicts a time ordered logical of information exchanges under the special operational circumstances for each node, and focus on the information exchanges and the order of them. The operational event sequence description in this scenario is represented in Fig.6.

(2) Operational architecture model validation

The judgment of model design's feasibility will be done after a serial process, including continuous description for operational states, leading them into the architecture model validation tools, and comparing the actual running state with the expectant running state of operational flow.

In the experiment we used the prevailing architecture model validation tool Rhapsody as validation platform, and imported the designed operational state models OV-6b and OV-6c to this tool, and also defined the correlated message driver. By running the OV-6c model, we got the sequential chart as Fig.7 showed, which demonstrated the generated action for every node when system was running, and the information change order between different nodes of remote target indicator system. The experiment result showed the real running order was according with predicted operational event sequence description OV-6c, and meanwhile conformed to system requirements as well as design requirements.

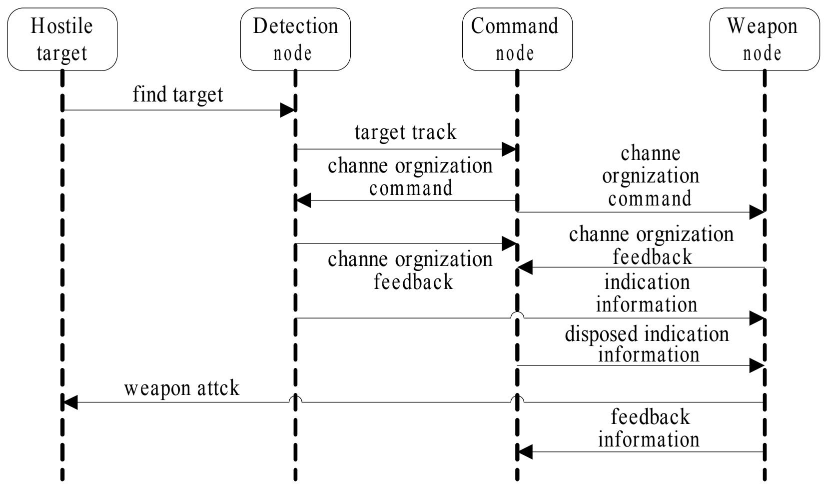

Fig.6 operational event sequence description OV-6c

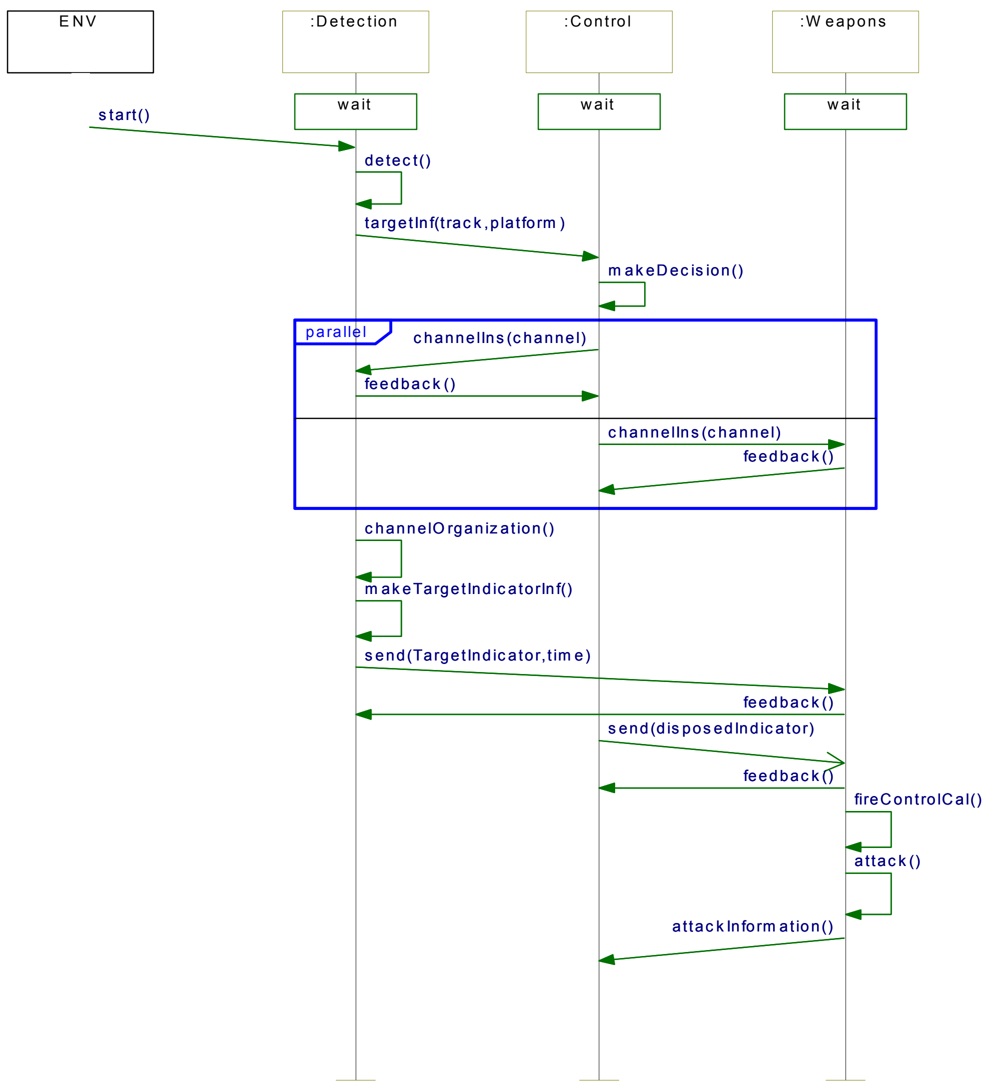

Fig.7 running result of model validation

Conclusion

In this paper, we have proposed an operational architecture modeling method based on the USA defense department architecture frame DoDAF. Different to most researches of the military information system architecture frame limited to theory, we proposed the detailed design steps of operational architecture, and how to accomplish related architecture produces. Besides, we also verified the rationality of our model by dynamic simulation experiment. The experiment results showed that this model can describe system architecture effectively as well as practicably.

Furthermore, the model can be also applied to the early development of other large comprehensive electronic information system, which can not only enhance the understanding of uniformity between developers and designers, but also is an important measure of controlling development cycle as well as deducing design risk.

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