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"The Evolution of C2"

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The Research On C2 System in networked environment

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The Research On C2 System in Networked Environment

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ABSTRACT

The development of operating concepts, C2 theory and information technologies bring significant challenge to C2 system. Legacy C2 systems can not satisfy the requirements of the new operating concepts, for example network centric warfare. And information technologies also changed the approach and realization technology to development, operation and management information system. In the future, there will be more than the difference between legacy system and the new concepts C2 system, include concepts, component and developed method.

The current trend is the network centric in the development of military information system. However there is not accurate description of network centric system. In fact, net centric C2 face several challenges: system scale becomes large, system is more complex. It is also not satisfy the requirement of C2, for example independency, security, reliability and diverse operating mode.

In this paper, we focus on the future of C2 system in three aspects. Firstly, we analyze net centric C2 system and its problems that we are working on. Secondly, we describe the future C2 system concept from systematology science. Last, we propose the model and characters of C2 networked-system.

Keywords: C2, network centric, networked-system, networked battle platform

1. INTRODUCTION

There are two key factors to promotes the development of C2 system: The first factor is the change of operating concepts and C2 theory. The new operating concepts always bring the new operating mode and C2 theory. For example command and control of net centric warfare (NCW) will be cross-organizational, cross-function and cross-Area. And it will be more accurate, more real-time, more agile and power to edge.

The second factor is the development of information technologies. Especially mobile communication technology and internet technology which brings endless possibility to

application patterns and system conformation of C2. Internet has been not only aggregated millions of computing devices, software, data resources and applications continually, but also provides a number of new application patterns such as SNS, SaaS etc. The Web 2.0, Web 3.0 and cloud computing technologies is the foundation to promote the development of C2.

So what is the future C2 system in the network environment? There is a prevailing view that future C2 system is network centric system. This means: a) C2 system is just parts of the large operational network without independence. b) The development, operation and management of system depends on networked and information infrastructure within it. However, such C2 system whether or not satisfied requirements for various operating missions? And how to ensure its security and reliability with lack in independent? These questions need to be answered in research of future C2 system. Network centric not reflects the characteristics and properties of future C2 system.

This paper will analyze the concepts and characteristics of Network centric C2, and discuss concepts, component and property of future C2 system from systematology science.

2. Future C2 wiil not be Net-Centric system

Operating forces becomes a coherent whole via heterogeneous network, provide a convenient way for optimizing resources and cooperating with each other. This is a trend to construct military systems. So future operating environment is networked.

From systematology view, the operation forces will be more wholeness and non-additive. The communication net linkage army forces, weapons, sensors and C2 node to connect and collaborate each other. It will generate new functionality and characteristics which are not in independent units.

This special large system includes all combat elements. It makes troops cooperated with others, troops interacted with weapon. So it greatly improved function, performance, operational efficiency of the large system compared to legacy system. This is a kind of large scale complex system. Systems' non-additive formula:

$$S \neq \sum_{i=1}^{n} \mathrm{A}i$$
$$Ai = \{ai, bi\ , ci, di \mid i \in N\}$$

Where a: operational force, b: weapon systems, c: sensors, d: C2 unit

While operating forces is networked. What is the C2 system? The future C2 system will be network centric systems is the prevailing view lately. Network centric C2 system will not only treat C2 as a component of the large scale complex system, but also regard this network

as the foundation and core to construct and organize C2 （Fig.1. The connotative meaning of network centric C2 system is stated as follows:

1. Design, development and integration of C2 system are based on information infrastructure of network. Information infrastructure provided fundamental environment to develop and integrate C2 system.

2. Operating and management of C2 system could not complete independently from network. C2 system would not cooperate and interact with other sensor and weapon completed independently, nor it would not operation and management self-implemented independently.

3. There was no boundary between C2 system and others system, for example sensors and weapon systems. Under the organization and management of information infrastructure C2 system will be re-constructed with other component in network.

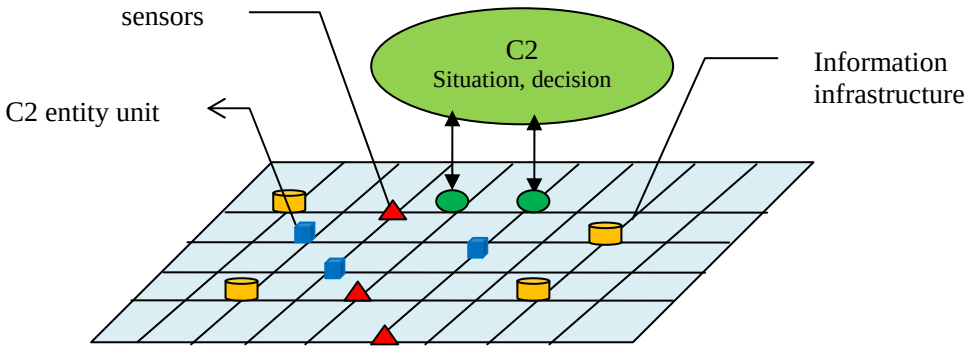

Figure 1. Network centric C2 system

Thus it can be seen that the network centric results in embedding C2 system in network completely. C2 system will be a part of the large scale system. This will share all kinds of resource in the network, reduce the scale of developing system, improve agility, flexibility of system, but it also brings following serious problems:

1. The restrictions on C2 method

The task of modern warfare is diversified. The army will act alone in some operation mission, for example counter-terrorism and special operations. The army not only do not need to be associated with other command organizations in a certain period of time, but also can not be contacted with other battle force because of the communication network and confidentiality of operation. Therefore, the construction and operation pattern of network-centric system is not appropriate. Network centric will place restrictions on command and control methods.

b. Reduce the system’s reliability and security because of lacking in independent

Learn from the systematology point of view, the elements of a network centric system itself does not form the organic whole. The whole of system is the result of dynamic evolution of C2 system after link network. Such a system does not have stand-alone and self-management

ability. Millions of elements linking the network result in its own complexity. The complexity brings the C2 poor reliability, vulnerable, difficult to guarantee the safety of C2. Local failure of network will directly affect functions failure. At the same time, some C2 systems itself required a closed-loop command and control capabilities, including reconnaissance, command and decision, fire control. These systems such as strategic nuclear submarine C2, missile defense C2 all hold a degree of independence and self-determination. Net centric is not a good choice for them.

c. It is very complex to manage system and creates even more uncertainty

The technical specifications, function, and performance of legacy system is clear. It could be easily tested and measured. Network-centric systems is a part of super large-scale complex system. These system's behavior will be more uncertainty and difficult to manage owing to the phenomenon of emergence. "Metcalfe's Law" itself has a double-sided nature, the law asserts that the power of the network is positive proportional to the square of the number of nodes in network, however, along with increase of number of nodes, its complexity is also a non-linear incremental. Especially when system will reconstruct the organization with other elements in networks according to task requirements. The reconstruction will bring some problem of system capacity scheduling, concurrency conflicts to system.

Therefore, net centric is not the most accurate characteristic of the future C2 system. We can not regard net centric as the only organization and application mode of C2 system. Future trends in C2 system will have capability for net connections, independence, self-determination and can cooperate with others.

3. What is the future C2 System?

C2 system is generally defined as an organism composed of commanders organization, weapons, sensors, army and the command and control instrument with the special architecture. From the systematology point of view, firstly C2 system is wholeness with specific function, secondly it subordinates to large system and is a part of the large system. Previously C2 systems buildup SoS (system of systems), we will compose C2 system in a large scale networked battle platform (Fig.2).

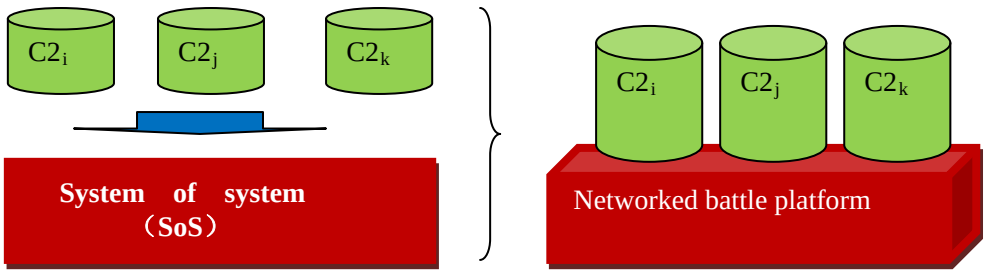

Figure 2.

Integration mode in SoS (system of system) and networked battle platform

The function of system is generally presented as $ET = \sum Ei + ER, i \in N$,

Where ET: The function of whole system; Ei: The function of sub-systems; ER: the function of deriving from relationships of elements. For SOS that is constituted of legacy C2. ER is definite and limited correspondingly, and it is not major contributor to ET. Though every function of C2 system is definite, ER is dynamically changed with time in the future networked operational platform. The increase of ER and its indefiniteness result in the uncertainty of large system's function and operational effectiveness.

In generally, the future C2 system exist in net environment , which cover the whole battlefield, We define this networked battle platform as "Networked battle platform is a large-scale complex system that together with tens of thousands of sensors, C2 nodes, weapons and army connected by heterogeneous wireless network and wired network". The networked battle platform is a carrier to systematically confront enemy in future warfare. It is a open system that the relationship of node is evolved constantly. The entire battlefield environment consists of independent combat elements and the networked battle platforms. (Fig. 3)

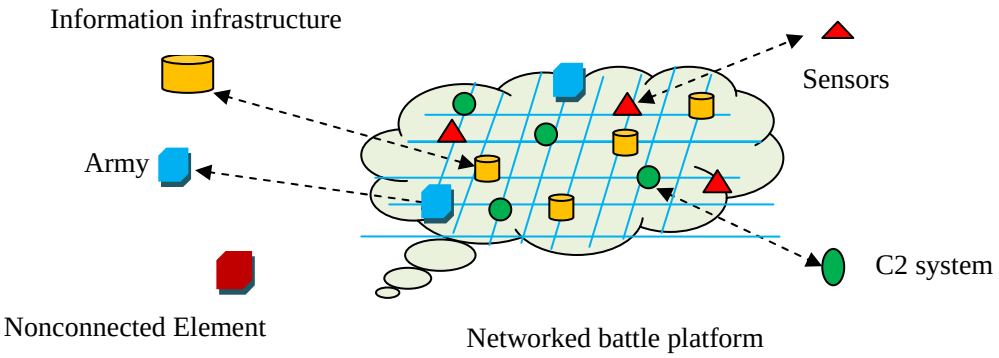

Figure 3. Combat environment

C2 system will be main two operating mode as other battle elements. One operating mode is independence mode which is disconnecting network and self-management and isolated operating. This operating mode can implement the designed capabilities. The other operating mode is connecting network, and as a part of networked battle platform. This operating mode can coordinate with other battle elements and the C2 system functions will be extended. According to the requirements of tasks C2 system will be reconstructed to new logical system. While operating in independence mode each part of the C2 system is linear correlation. While connecting to network, the relationship between C2 system and the elements of networked battle platforms is non-linear. The component of networked battle platforms is described as following:

Where $A = \{C2, Weapon, Sense, Army, DII, \}$, C2: command and control node,

DII: information infrastructure. The relationship of each other is a complex matrix (See

Figure 4). These elements coordinate to form logic systems, and generate new functions and application mode.

$$A \begin{pmatrix} \{C2_1, Weapon_1, Sense_1, Army_1, DII_1\} \\ \{C2_2, Weapon_2, Sense_2, Army_2, DII_2,\} \\ \{C2_i, Weapon_i, Sense_i, Army_i, DII_i,\} \\ \{C2_n, Weapon_n, Sense_n, Army_n, DII_n,\} \end{pmatrix}$$

Figure 4. Networked battle platform elements relation matrix

Learn from the systematology point of view, while C2 system operation independently, it is a physical system, after connecting network, C2 system general exited as a component of networked battle platform, that we are talking about is more like a logical system(Fig.5).

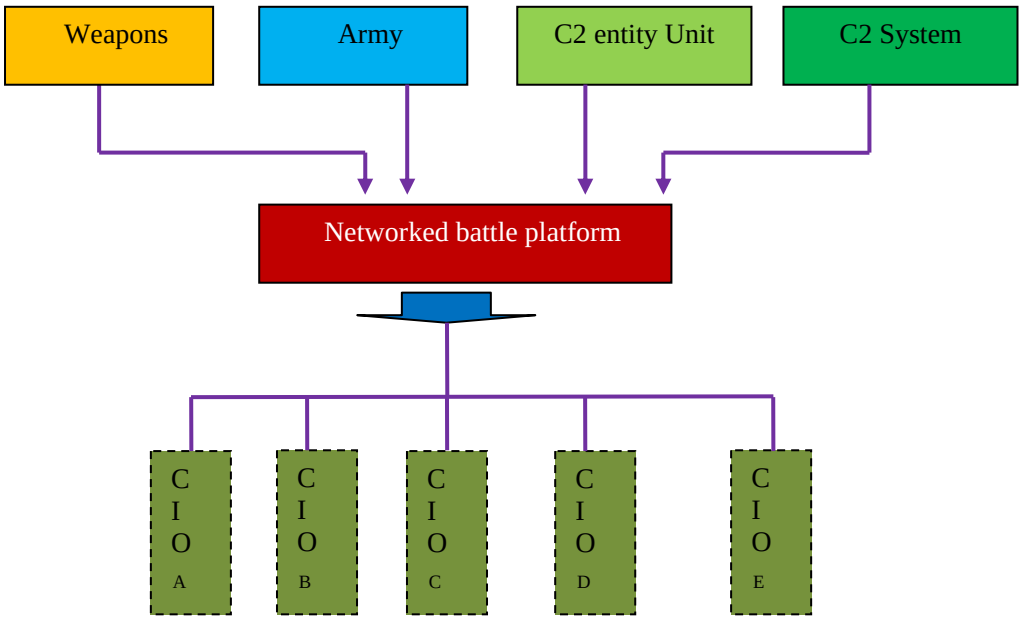

Figure 5. The evolution process of C2 system

So, this C2 system is a new conformation of system. We define this C2 networked-system as: “C2 networked-system is an information system which can be operated and managed independently, it can be published one or more C2 units to networked battle platform, as well as be connected and cooperated with other operational elements to construct Common of Interest(COI). ” Networked-system is an extension to legacy system, and it is quite different from legacy system which has developed for centralized closed environment. Its connotation is stated as follows:

1. The C2 networked-system is a physical system. It preserves the integrity and functionality. It is composed of physical elements .It can be operated and managed independently from network.

2. The C2 networked-system and its constitutions all have the ability to access the network, and becomes nodes in networked combat platforms. It also can form different mission systems (logical system) with connecting and cooperating with other operational elements. The mission system will generate new function and application mode, it also be able to impact on wholeness emergence.

3. The element of C2 networked-system provide information services and some capabilities to command and control. But it can not form a closed C2-cycle to complete the task independently. It must depend on the other elements in system or network command and control army.

4. The Component and Characteristics of C2 networked-System

C2 networked-system is composed of correlated C2 unit entity as compared with legacy system. C2 unit entity is the smallest element of C2 networked system with the characteristics of networked. C2 unit entity consists of five types (Fig.6): the functional entity of command and control, the passiveness entity of command and control, the commanders entity of command and control, and the cooperating entity of command and control. The functional entity of command and control consist of situation entity, decision entity and control entity etc. The passiveness entity of command and control consist of military forces, weapons, sensors etc. The commanders entity of command and control consist of various kinds of headquarters. The cooperating entity of command and control consist of net accessing entity, operation process entity, information sharing entity, services publishing entity etc.

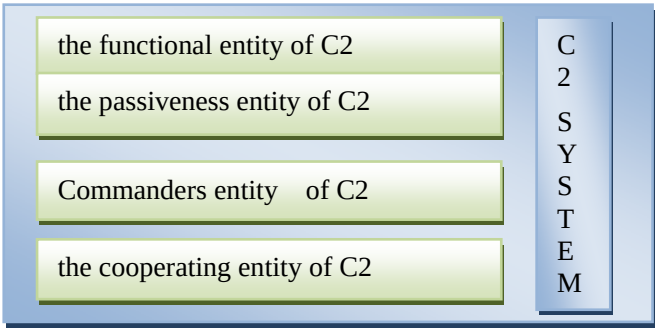

Figure 6. C2 system model

The C2 unit entity is autonomy. They have specific functions and behaviors, and can be operated independently. It has the capabilities to sense the changes of environment and to adapt to environment. The C2 unit entity model consists of three elements (Fig.7). It is stated as follows:

The C2 unit entity mainly model consists of three parts (Fig.7):

1. The functional components of C2, they preserve command and control function and behaviors;

2. The networked component, they to accomplish the description of units' properties and capacities, accessing network, publishing and providing C2 services, disseminating information, subscribing and receiving the sharing of information, calling external services, management and organization of cooperating object, etc.

3. The sensing and adaptive components, they have the capabilities for sensing changes of systems state, input/output information and network environment. They also can adaptive to environment according to changes.

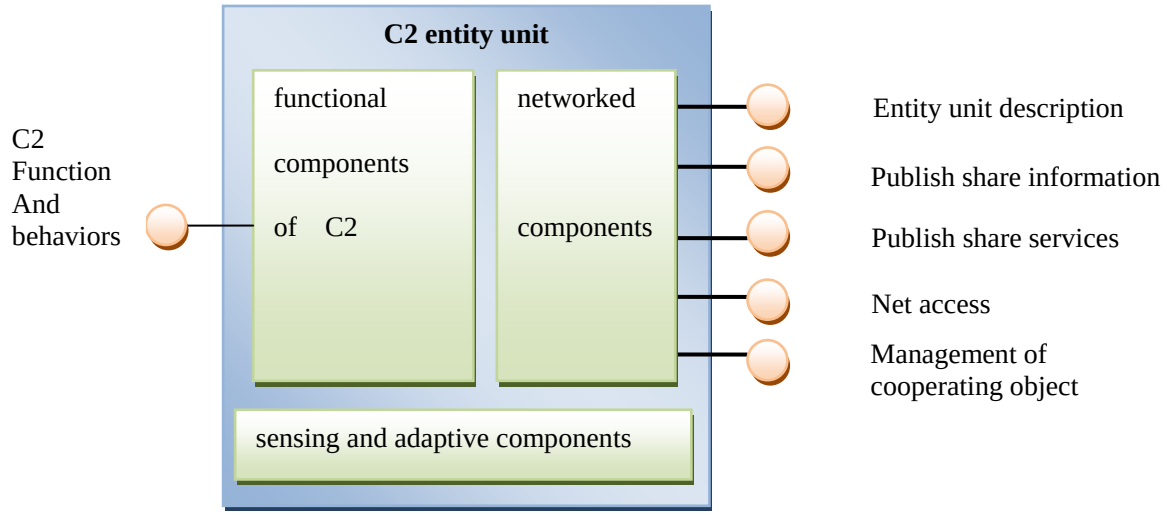

Figure 7. C2 entity unit model

C2 networked-system is an independent, self-determination system, with full autonomy. It can be able to response to the changes of the battlefield environment, self-determination and command and control army. Also, due to the existence of the cooperating entity of command and control and networked component of the C2 unit entity, the C2 networked-system is easy to access network. It is easy to cooperate with other elements in networked. It can enlarge command distance and increase function. It even can generate new function based on interaction with other elements (Fig.8).

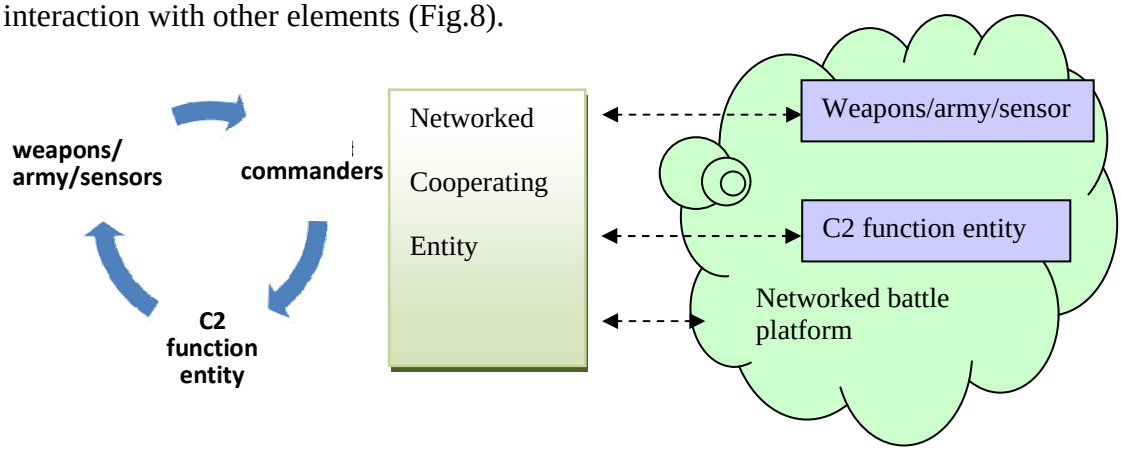

Figure 8. C2 cooperating with elements in networked battle platform

The future C2 system not only holds the features of legacy C2 system, but also used to provide cooperativity and agility (described above). The characteristics of C2 networked-system is stated as follows:

1. C2 networked-system is an autonomous system. It has the capability to access the networked battle platforms. But the relationships with other elements in networked battle platforms are collaborative, rather than being centralized control resource.

2. C2 networked-system is an open system. It can be reconstructed. Its constituent elements will be changed continuously and the relationship will evolve constantly.

3. C2 networked-system is the adaptive system. It can sense changes of environment and response to these changes. C2 networked-system can receive information from external environment, deal with change to adaptive to environment.

5. Results

In future C2 system is a networked system, but not a network-centric system. System operation and management independently are the embodiment of its characteristic of independence and autonomy. It is a physical system belong to certain organization and can be formed logical system used by another organization. The development trends of future C2 system indicates C2 system feature and characteristics will be closer to combat units of military organization. As combat units of military organization is has its own mission, composition and capabilities, and easy to form new organizations according to combat requirements.

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