PAPER ID NUMBER: 090

19th ICCRTS

Essential structures of C2 subsystems and interaction logics to agility

Track: 2

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Essential structures of C2 subsystems and interaction logics to agility

Abstract

According to system engineering, the command and control (C2) system comprises of two basic subsystems including technical system (TS) and organizational system (OS). It is vital to identify the essential character of the structures of the two subsystems which can impact and contribute to C2 Agility. This paper discussed the essential structures of C2 system as well as the interaction logics to C2 agility. Typically, the TS is a net based structure with lots of TS nodes (TSNs) widely connected with information system. The OS is a tree like structure having strict relationship among OS nodes (OSNs), a structure that have been in use since ancient time and believed to be in use in future too. In C2 agility, there are two logics for the TS and OS to interact with each other. One is TOT logic that means C2 information flow from TS nodes to OS nodes, and then back to TS nodes. In this logic, OS nodes play a bridging role which limits the C2 agility. It is the OS nodes composed of personnel (commander and staff), organizational structures, work procedures limit the C2 agility. The other is OTO logic that means C2 information flow from OS nodes to TS nodes, and then back to OS nodes. In this logic, TS nodes play a bridging role which limits the C2 agility. This paper believes that to synchronize the logics, the intersection is common, standard, measureable, minable, visualized, diagrammatic (CSMMVD) signs and signals both for computers and officers. This paper argues that in future battlefield, enemy actions and friendly course of actions, operation plans, and orders should be made and displayed with CSMMVD signs and signals. Under standard procedures and tactics, facing with CSMMVD signs and signals, balance and efficiency in decision making is possible. Continuity and variety in decision taking is efficient in C2 system, and C2 agility is underway. Conclusion: Signs and signals are to be exploited for C2 system to function successfully in a variety of missions and circumstances.

1 Introduction

Command and Control (C2) is a continual process of evaluating and re-evaluating the situation and environment to support decision making as well as decision taking to achieve its objectives in military operations. Agility is the capability to cope with changes in the situation or environment. Extreme uncertainty in military mission space and the ongoing transformation which bring about the ability to leverage new information technologies of 21st century put emphasis on command and control (C2), interpreted in its broadest sense to include acquiring, managing, sharing and exploiting information, and supporting individual and collective decision-making. In particular, more mature C2 includes the ability to

recognize situational change, and to adopt the C2 approach required to meet that change—C2 Agility. Accordingly, The NATO NEC C2 Maturity Model (N2C2M2) addresses several key agility factors in analyzing C2 performance. The model is represented as a cube defined by three axes. "Patterns of interaction among entities" indicates the degree of self-synchronization between groups. "Allocation of decision rights to the collective" measures the extent to which organizations pass decision authority down to the lowest level possible. "Distribution of information among entities" reflects how freely information flows between groups and the accessibility of data. Together, the three axes determine the character of the approach and how the approach changes inside the cube in response to the needs of the mission at hand with circumstances determine the level of agility. (Alberts, Huber, and Moffat. 2010).

However, just as the 3rd finding of Network Centric Warfare Case Study, the information systems did not flatten the hierarchy—experience and knowledge were important as well as the frame of reference of the commander. The battlespace knowledge at the higher level commands, like division and corps, is not only the result of increased information system capabilities but also, and more importantly, the result of the experience of the commanders and staffs. This does not appear to follow the network-centric warfare (NCW) assumption that "rather than being hierarchical, NCW assumes a flattened command structure with a rapid decision cycle(ElihuZimet, Robert E. Armstrong, et al.2003)." On the whole, commanders (V Corps and the 3rd Infantry Division (Mechanized), (3 ID (M)), during the major offensive combat operations of Operation Iraqi Freedom (OIF) from March 2003 through April 2003), stated that they made better decisions more quickly because of the timeliness and accuracy of information they had readily available to them. The information systems did not make the decisions. There was still plenty of fog and the friction that results from the reaction of the enemy and from the physical environment. Commander-to-commander interactions were an important factor in reaching decisions quickly and were enabled by the connectivity and information systems that allowed them to communicate and work off a shared common operational picture (COP) and shared understanding(Cammons，Tisserand, et al. 2006). Accordingly, the focus of this paper is the last axes: "Distribution of information among entities" of the N2C2M2, and we take it as the main research objective for C2 agility.

In view of system engineering, the C2 system comprises two basic subsystems including technical system (TS) and organizational system (OS). The TS mainly refers to the new information systems such as the Force XXI Battle Command Brigade and Below(FBCB2) using the Blue Force Tracker (BFT) L-band transceiver that were fielded down to the maneuver company level, enabling a COP and unprecedented situational awareness as well as a limited beyond-line-of-sight communications capability. The TS also refers to the rapid progress of advanced commercial information and communications technologies which has placed unprecedented computing power, information storage, information processing, and connectivity into the hands of almost anyone who wants it. Such technologies include personal computers and peripherals, networking, geolocation, and mobile telephony (Vassiliou et al. 2012) that can be used in military operations.

The OS refers to the industrial-age hierarchical organizations as well as the information-age decentralized organizations, typically the command posts which have commanders and staff in. U.S. Army doctrine establishes that the corps and division generally employ three command posts: a tactical command post (TAC CP, also called the C-TAC at corps and D-TAC at division), a main command post (Main CP, also called the C-Main at corps, and D-Main at division), and a rear command post (Rear CP; also called the C-Rear at corps and D-Rear at division). These command posts are echeloned and are the principal facilities commanders use to control operations (Cammons, Tisserand III, et al.2006).

It is vital to identify the characteristics of the structures of the two subsystems which impact and contribute to C2 Agility. This paper discussed the essential structures of C2 system as well as the dynamic logics to C2 agility. The essential structures of C2 subsystems and interaction logics to C2 agility have been investigated. To accomplish the task, this paper is organized as follows: section 2 describes the essential structures of C2 subsystems. In section 3, two types of logics where C2 subsystems interact are explained simply. The conclusions are given in section 4.

2 Essential structures of C2 subsystems

The C2 system is integrated within the larger military system to support decision making. The C2 system consists of equipment and people (commanders and subordinates) organized in a structure to execute tasks (Brehmer 2010). In a view of system engineering, the C2 system comprises two basic subsystems including technical system (TS) that is constituted of equipments and organizational system (OS) that is constituted of people.

2.1 Net character of Technological System (TS)

The TS includes technical support systems consisting of assets (effectors), sensors, communications, decision support and situation displays. Sensors consist of all the elements deployed in the environment to collect data, consisting of radars, optical sensors, organic sensors of the effectors, and other information sources (including human intelligence) (Oosthuizen. 2013).The TS mainly refers to the new information systems such as the Force XXI Battle Command Brigade and Below(FBCB2) using the Blue Force Tracker (BFT) L-band transceiver that were fielded down to the maneuver company level, enabling a COP and unprecedented situational awareness as well as a limited beyond-line-of-sight communications capability (John B. Tisserand III, et al. 2006). The TS also refer to the rapid progress of advanced commercial information and communications technologies which has placed unprecedented computing power, information storage, information processing, and connectivity into the hands of almost anyone who wants it. Such technologies include personal computers and peripherals, networking, geolocation, and mobile telephony (Vassiliou et al. 2012) that can be used in military operations. The communication system is the transport medium for data between the sensors, command centre, and effectors(Oosthuizen. 2013)..

Typically, the TS is in net structure with lots of TS nodes (TSNs) widely connected followed with the information revolution. The rapid progress of communication technology, such as communicating satellite, and the rapid progress and broad applications of information and computer technology in military field make the TS net character improved continuously both in space and in information processing, information generalization, and information distribution ability. The structure of TS's net trait is shown as follows:

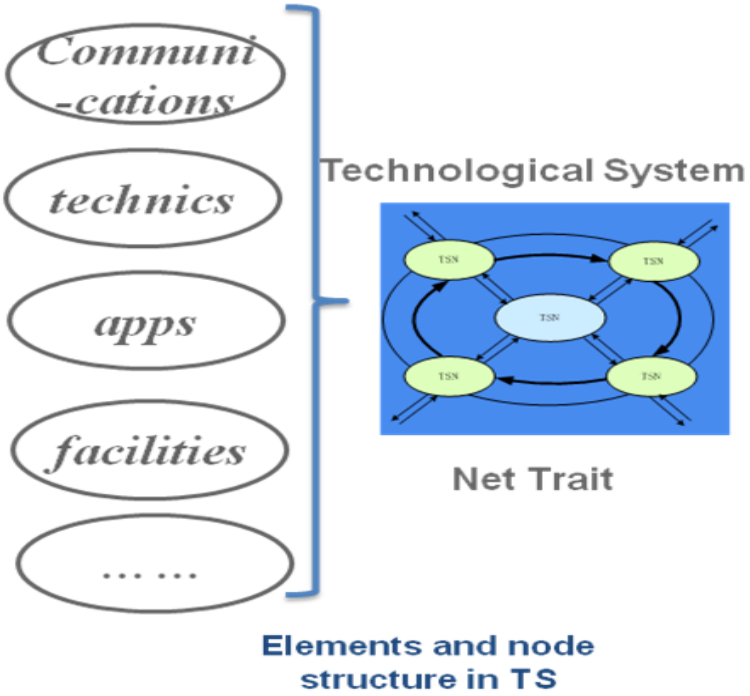

Figure1 Elements and node structure in TS

TS's net consists of large number of TS nodes (TSN) and edges between the TSNs. Each TSN can realize certain functions, and all the TSNs are connected with each other by the edges. Especially, the directions of the edges are double sided. The composing elements of TS include communications, techniques, apps, facilities, and so on. TS is the physical foundation and technical support of C2 system.

2.2 Tree character of Organizational System (OS)

The OS has been under tree-like echelon structure with strict relationship among OS nodes (OSNs) since the Stone Age war thousands years before and will continue on in the future. Although a marine regiment in Afghanistan which patrols a very large battlespace may follow a relatively decentralized mission command doctrine (Vassiliou et al. 2012), commanders along the echelon has strict relationship. "Commanders are the key to command and control. They execute the art of command with the science of control. They create a positive command climate to inculcate and foster trust and mutual understanding. Commanders visualize the battlespace, describe their visualization to subordinates, and direct actions to achieve results." (FM 6-0 Mission Command: C2 of Army Forces). The relationship between higher commanders and subordinates is tree like. From the view of military combat

operations command, the command “tree” will exist and will not be replaced as long as the echelon exists. Even in the future war, the “tree” character of command functions will not be eliminated. The structure of OS’s echelon trait is shown as follows:

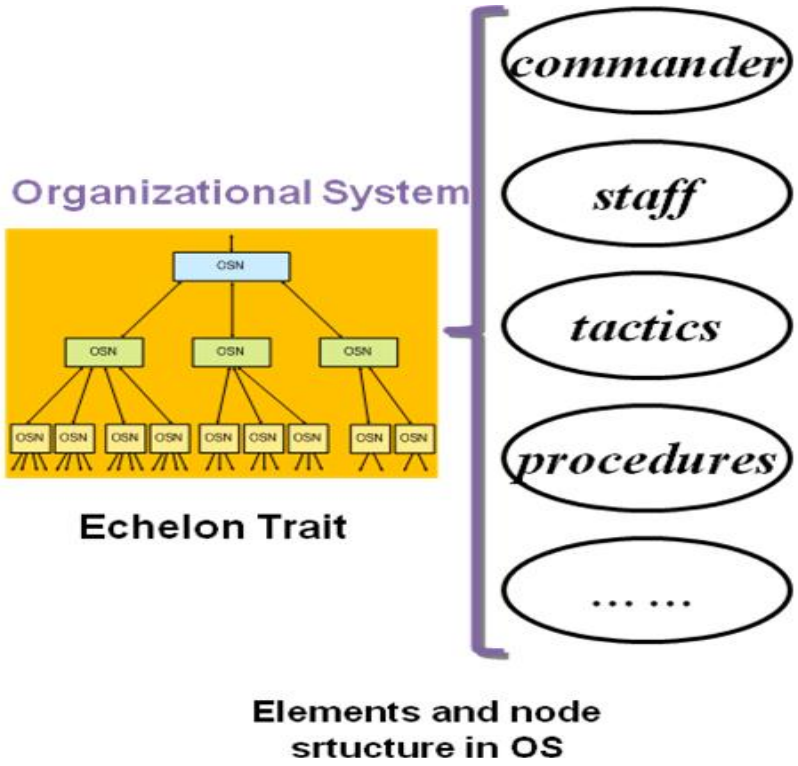

Figure2 Elements and node structure in OS

OS’s tree consists of a large number of OS nodes and edges between the OSNs. Each OSN fulfils certain command functions, and each OSN is connected with specified OS nodes with single higher headquarter. Especially, the directions of the edges are single, rigid and limited, the command and subordinate relationships are strict, which cannot be changed as one pleases. The composed elements of OS include commanders, staffs, tactics, procedures, and so on. OS nodes are the key driver and command center of C2 system.

3 Interaction logics of OS and TS to C2 agility

Agility is the capability to cope with changes in the situation or environment. It consists of responsiveness, versatility, flexibility, resilience, innovativeness and adaptability (Alberts 2011). For distributed force, the extended connectivity and bandwidth provided by the various military satellite, as well as commercial satellites communications systems break the bonds of line-of-sight tactical communications, enabling the flow of information (John B. Tisserand III, et al. 2006) at all levels of war across a dispersed network of connected TS nodes. In that circumstance, there are two logics for the TS and OS to interact with each other which affect the six capabilities of C2 agility. One is TOT logic that means C2 information flow from TS nodes to OS nodes, and then back to TS nodes. In this logic, OS nodes play a bridging

role which limits the C2 agility. It is the OS nodes composed of personnel(commander and staffs), organizational structures, work procedures which limit the C2 capabilities of responsiveness, versatility, flexibility, resilience, innovativeness and adaptability. The other is OTO logic that means C2 information flow from OS nodes to TS nodes, and then back to OS nodes. In this logic, TS nodes play a bridging role which limits the six capabilities of C2 agility. From this point of view, what is the intersection of the two logics?

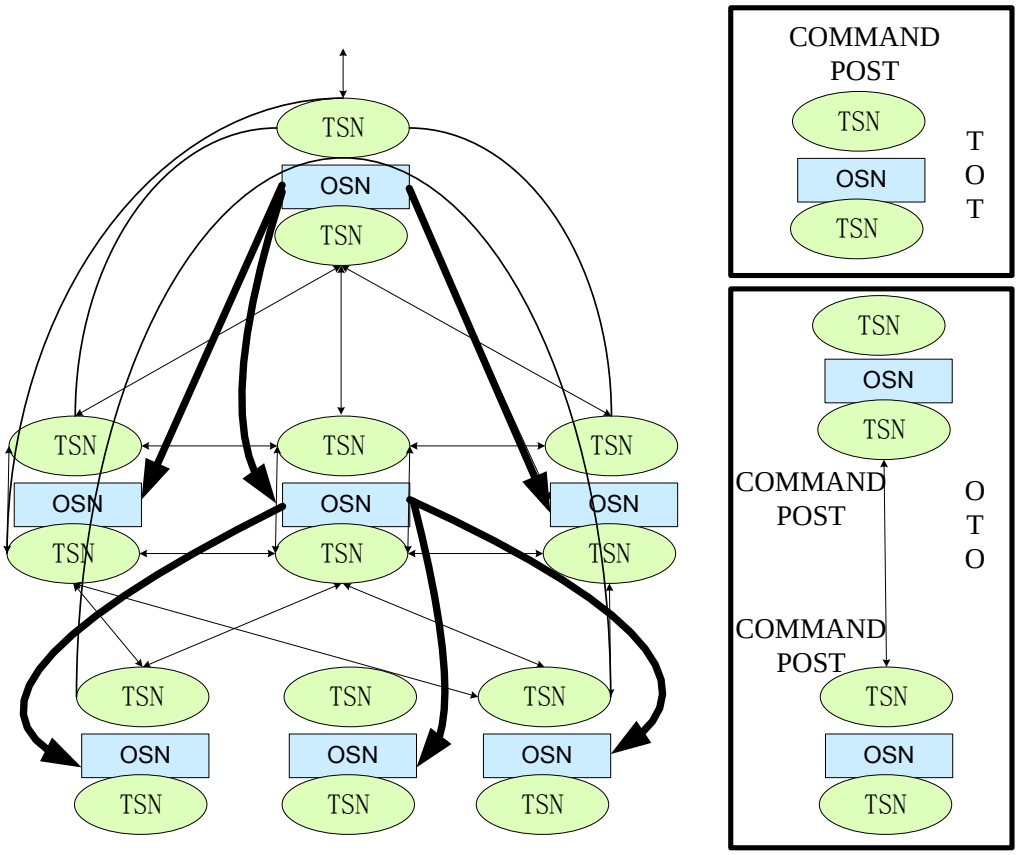

Figure3 TS and OS interaction logics (TOT and OTO)

This paper believes that to synchronize the logics, there is at least one intersection. It is what Sun Tzu had called "a question of instituting signs and signals." Technical system alone does not limit the flow of information. Extended connectivity and bandwidth provide enough capability for the information flow from one TS node to any TS nodes. Organizational system alone does not limit the flow of information if all levels of command post in one room where they can communicate with natural language face to face. The problem here is how to improve information sharing ability, and enable greater interactions and collaboration between all levels of command post (strategic, operational, and tactical), and all those forces (air, land, and marine) easily and effectively. We must establish a set of signs and signals supported with technologies that will eventually make their way into the military and their coalition partners in some form, and serve to increase both the coalition's information exchanges and each participant's internal flows and transactions, with the potential for

information overload derived from the fourth megatrend (data deluge) (Vassiliou et al. 2012). We believe that a kind of simplified signs and signals is needed to support for all levels of commanders and staffs to easily communicate with each other. We name that kind of signs and signals as common, standard, measureable, minable, visualized, diagrammatic (CSMMVD) that could display military plans and actions multimedia alike. C means this kind of signs and signals is commonly used in the community of commanders and staffs. S means this kind of signs and signals is firmly defined and strictly differentiated with standard rules. MM means this kind of signs and signals is data linked and is measureable and minable. VD means this kind of signs and signals can be displayed and demonstrated with graphic illustrations and diagrammatic format. CSMMVD signs and signals is dynamic and visualized both for computer display and for commanders and staff officers to make sense and to understand. That kind of signs and signals include common operational picture (COP), and more than COP, to provide commanders and staffs situational awareness and understanding.

The aim of CSMMVD signs and signals is to improve the efficiency of sense making of the circumstance in the battle space, and to reduce the influence of individual experience and expertise. CSMMVD signs and signals can help all leaders to provide near real-time information with objective conditions and cause since it is derived from the unit, community, or military organization and will allow all leaders to understand the tactical situation and act. With CSMMVD signs and signals, Enemy military actions and friendly course of actions and operation plans and orders should be transmitted, fused, displayed and observed at all echelons of command representing all levels of war like displaying multimedia. Under standard procedures and tactics, facing with CSMMVD signs and signals, balance and efficiency in decision making in C2 system is possible, and continuity and variety in decision taking is efficient, and C2 agility is underway. COP and CSMMVD signs and signals provide a common basis for interaction and collaboration among commanders, between commanders and staffs. This results in shortened decision cycles, greater unity of effort, more C2 responsiveness, versatility, flexibility, resilience, innovativeness and adaptability.

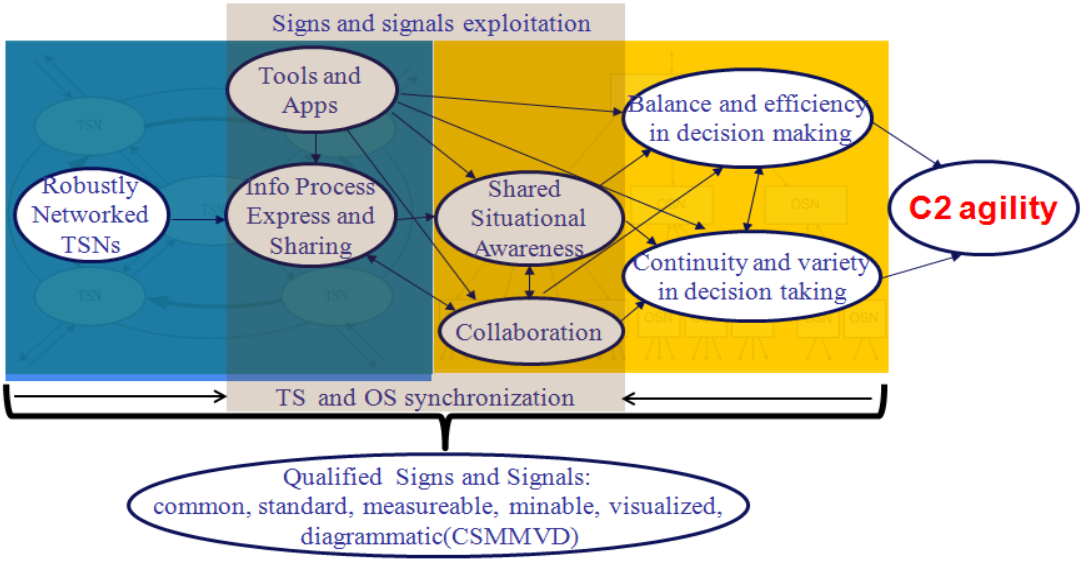

Figure4 Interaction of the TS and OS to C2 agility

4 Conclusions

C2 system has undergone great development. However, the efficiency improvement is mainly achieved by automatically transmitted, fused and displayed information in TS. In order to further improve C2 efficiency, the breakthrough should be explored in the interaction of the two subsystems of C2 system, but not in the basic functions of the TS itself. Signs and signals are to be exploited for C2 agility in a variety of missions and circumstances, as Sun Tzu said: "the control of a large force is the same principle as the control of a few men: it is merely a question of dividing up their numbers. Fighting with a large army under your command is no different from fighting with a small one: it is merely a question of instituting signs and signals."

We hope to discuss the concept of the dynamic mechanisms to interact the two subsystems of C2 system next year due to this year's time limit. The concept includes C2 signs and signals content, format and assessment indicator in a standard manner, realizing data connection between C2 signs and signals and TS database, as well as achieving standard procedure and C2 mode transformation, for optimizing and improving C2 effectiveness.

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