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A New C2 Model Based on Confrontation Analysis*

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Abstract: Many models have been developed to represent the decision making process in C2 context of wars. However, one of the most critical elements of the C2 decision making has not been explained in these models. That is the high-strength confrontation in human cognition, which is also one of the most fundamental elements of wars. This characteristic helps to distinguish the decision making activities in C2 domains from the other ones in scientific, business and other domains. Firstly, we develop a new model from cognitive perspective. Secondly, we compare the new model with the classic ones. Secondly we explain the high-strength confrontation described by the model in detail to highlight its central role in C2 decision making activities and even the whole war context. Then based the model we analyze the high cognitive confrontation in different ages. Finally, this new model can help to comprehend C2 organizations' goal and thus develop measures of effectiveness of C2 organizations in the Information Age.

1 Introduction

Modeling the C2 decision-making process has always been an ongoing undertaking by different people including military commanders, consultants and Engineers. Many models have been presented to help people understand the military decision-making process, including the famous Observe-Orient-Decide-Act (OODA) Loop which has been used since 1950s[1]. Each of the models has made a valid contribution from some perspective. However, we haven't been able to understand them comprehensively. Moreover, it is surprising that none of these models can tell us the difference between the C2 decision-making activities and the general decision-making activities in other domains such as the financial field. In fact, the models that were built for the military decision-making activities can be used to explain the decision-making activities in business domain without making modification. But undoubtedly these two types of activities are not the same thing. In order to better comprehend the military decision-making, a more comprehensive and adequate C2 decision-making model is needed which can distinguish the military decision-making activities from the general ones. In this paper, we present a new C2 decision-making model that will explain that the high-strength confrontation is the key characteristic of the military decision-making activities.

This paper is organized as follows. The new C2 decision-making model is presented in section 2. In section 3, we will explain this model in detail and further analyze the impact of confrontation on the efficiency of decision-making activity. And then the newly-presented model will be compared with the current C2 model. In section 4, the applications of this C2 decision-making model at different ages will be discussed, and its difference from and connection with the decision-making models in the business field will be accounted for. In the end, the significance of this C2 decision-making model will be summed up, and the future research orientation.

2 A new C2 decision-making activity model

Most of the C2 activities models suppose that operations are the goals and results of the relevant C2 activities such as the OODA model. On the contrary, in our opinion, all the operations are just the methods with which the cognitive subjects realize the cognitive superiority and force the enemies to accept their will in the end. The complex, high-strength and high-timely C2 activities in military domain can be understood in the cognitive aspect as follows:

- For what: The goals of C2 activities are to force the enemies to accept the will of the performers.
- Do what: Attacking and Defending. On the one hand, by observing, judging and predicting the enemies' cognitive states and results, the cognitive subjects plan how to act in order to

make the enemies makes decisions as they wish. On the other hand, the cognitive subjects predict the possible attacking from the enemies on their cognitive processes and plan how to defense accordingly.

- The processes in the two domains: In cognitive domain, the cognitive subjects obtain, store, operate and transmit the cognitive objects in different levels and constitute many cognitive links of which the key nodes are the cognitive subjects in the different levels. Accordingly, in the physical domain the military take the relevant actions in two aspects. One is the cognitive function aspect in which the military take actions to destroy the functions of the enemies' cognitive links and protect their own ones. The other is the semantic aspect in which the military take actions to change the content of the enemies' cognitive links and meanwhile make the content of their own links suitable, complete and reliable.

2.1 constitution of the new model

As is shown in Figure 1, the C2 activity model involves the cognitive and physical domains.

The cognitive domain consists of 4 levels: they are the data level, information level, knowledge level and strategy level from the bottom to the top, which are respectively the groupings of the following types of cognitive objects:

1. Data: the results of observing and measuring physical objects;
2. Information: the data which have been classified, indexed and organized;
3. Knowledge: the information that has been understood and explained;
4. Strategy: the knowledge that can be effectively used to provide guidance in practice.

The above four types of cognitive objects are defined and classified from the cognitive perspective, but they do not exist for no reason. No matter it is data, information, knowledge or strategy, they are all related to physical entities. The functions of these entities include the storage, transfer, distribution and treatment of all kinds of cognitive objects. There are not any cognitive objects which can exist independent of physical entities. Furthermore, the change of physical entities, such as damage and alteration, will also result in the change of related cognitive objects.

The physical domain is constituted of all the related entities in the space of battlefield, including the battlefield environment and the staff, equipment, weaponry platform, and communications facilities of the enemy and our army. Through analysis, it can be found that the relationship between the objects in the cognitive domain and those in the physical domain is not that of one-for-one projection, but that of multiple projection. That's because one set of data may have been obtained from more than one sensor, and also may be stored in more than one physical entities. For the same reason, a physical object can store more than one set of data and knowledge at the same time. A commander is a typical example.

In Figure 1, the Function (F) domain indicates the projection between the cognitive domain and physical domain. The F domain re-classifies and organizes the entities in the physical domain P according to the cognitive levels. The entities in F domain and the cognitive objects in C domain correspond with each other, but the relationship between the entities in F domain and those in P domain is that of multiple correspondence.

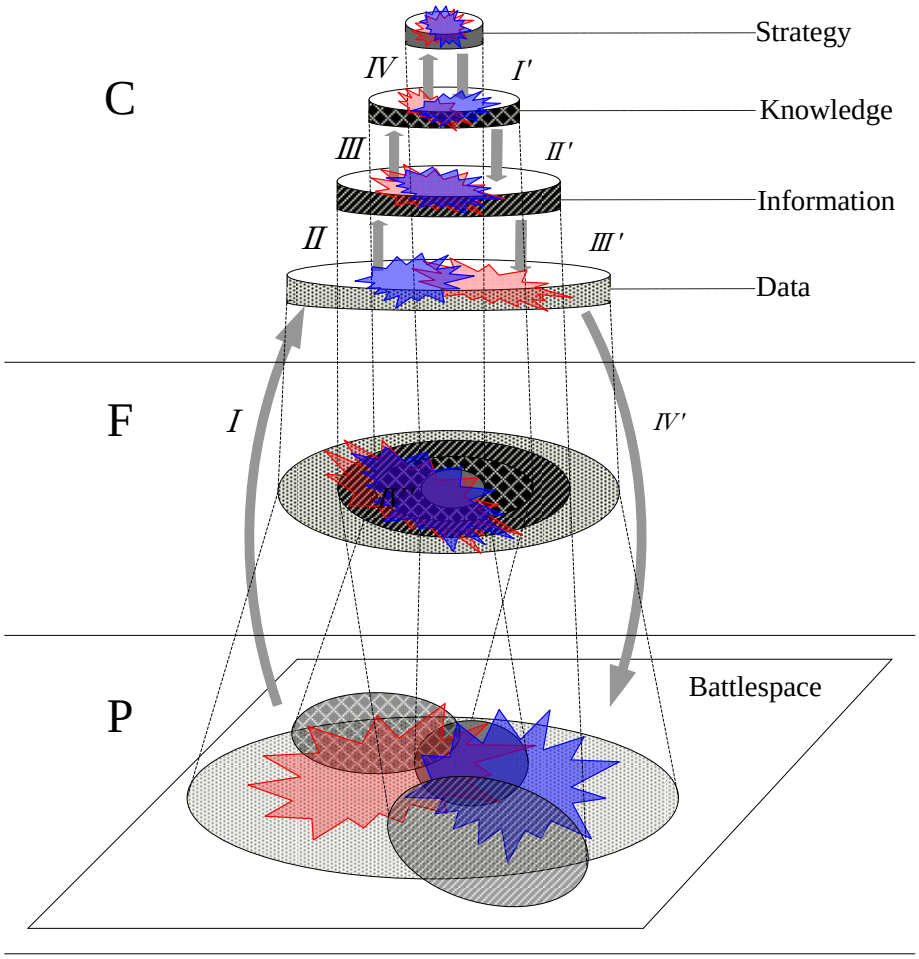

Figure 1 A C2 decision-making activities model with confrontation

2.2 One decision-making cycle

One decision-making cycle consists of 8 sub-processes which are divided into 2 phases. Sub-process $Ⅰ, Ⅱ, Ⅲ, Ⅳ$ belong to the first phase and sub-process $Ⅰ', Ⅱ', Ⅲ', Ⅳ'$ belong to the second phase.

- $Ⅰ$ (Observe). Being observed, measured and formatted, the physical entities are described in data such as the enemy staff, equipment, environment, etc. The possible description includes: time, space, measurement equipment, measurement number and that of the belief, etc.
- $Ⅱ$ (Manage). The data obtained in phase I are transformed, modified, selected, classified, indexed and stored as meaningful texts in order to be understood and applied more conveniently. In the end the data will be stored according to some possible classifying standards such as space, time order, original, meaning, usefulness and other possible factors. Then the data can be called information.
- $Ⅲ$ (Understand). By cognitive individuals' comparing, searching, examining and other possible treatments, the static and dynamic relationships among the above information can be found. The higher level information models are built to explain the information and their relationships.

- IV (Decide). It is high-level cognitive activities. The commanders make the strategies for the specific mission based on the above knowledge with the aids of the consultants and some possible computer systems[2].
- I' (Apply). The action plans and schemes are produced according to the decision in strategy level.
- II' (Explain). The plans and schemes are transformed into operational commands and other type information flow.
- III' (Operate)，The command and other type information are formatted as different type of data according to their usefulness that will be transmitted to the entities such as soldiers, platforms, equipments, etc.
- IV' (Act). The entities in the physical domain take actions after the data have arrived.

Such above decision-making 8 processes are continuous and happen at the same time.

3 Confrontation

3.1 Description

As is shown in Figure 1, the confrontations between the Red Army and the Blue Army are described in red and blue waves that exist in each domain and all the levels. The confrontations in the physical domain are the mappings of the confrontations in cognitive domain. Both of the two armies try their best to achieve cognitive superiority and control.

A simple example is used to explain the effect that the confrontations have on the cognition superiorities. In the battle with the Blue Army, the Red Army has found the place of the commander by using satellite technology to trace his mobile phone signals. Then the Red Army fires a missile and hits the command office. The commander is dead.

This could be explained by the model as follows. The entities of the Blue Army in the P domain have been destroyed by the Red Army. When this event is projected into the F and C domains it is clear that the relevant entities in the F domain are destroyed and the cognitive resources in C domain are also significantly reduced. Moreover, the key cognitive entities and the important processes are ruined. This model can answer the following question directly and clearly –“why does a small strike with only a few persons lost cause such a great impact to the Blue Army?” If the Blue Army has no candidate commanding officer to appoint at once, it will be defeated. This simple example verifies that including fire attacking and information disguising, the confrontations in the battle space are all the means to realize cognitive superiority and master the cognitive control in the end. This conclusion can also be strengthened by citing the sentence of Sun Tzu “The best warfare is the one that can defeat the enemy without any operation”[3].

3.2 Analysis

Figure 2 is used to analyze the effect that the confrontation have on the cognitive capabilities and the final decision by describing the cognitive process in the first phase of a decision-making cycle.

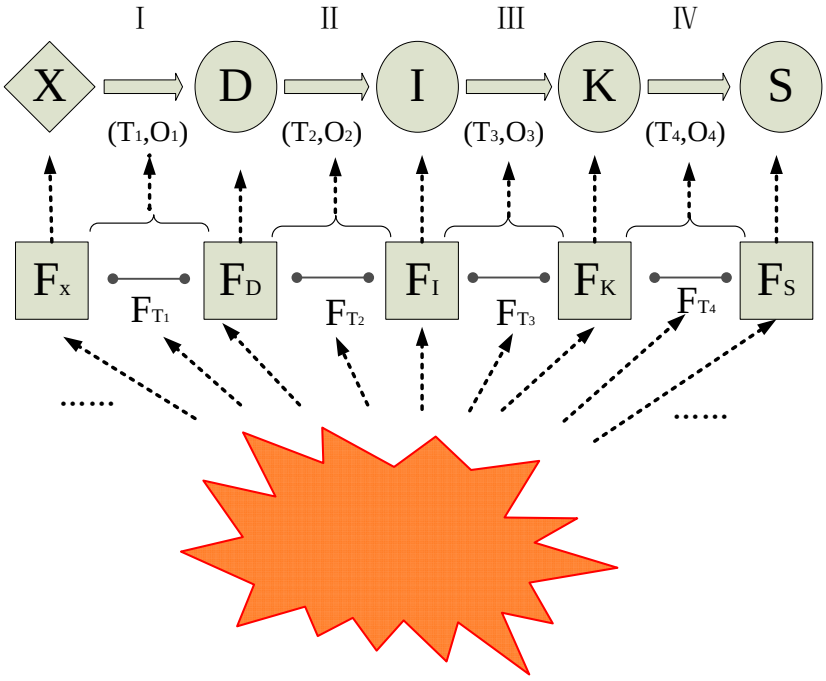

Figure 2 Cognitive process of the confrontation C2 decision model

As shown in figure 2, phase *I, II, III, IV* correspond with the equivalent phases in figure 1. X is the cognitive ontology of the cognitive objects. D, I, K, S are used to represent the cognitive resources and results respectively of data, information, knowledge and strategy levels. F_D, F_I, F_K, F_S are the relevant entities in physical domain. $T_i (i = 1,2,3,4)$ are the processing operations that don't change the meaning of the cognitive resources or results such as transmitting. $O_i (i = 1,2,3,4)$ are the processing operations of which the goal is to produce new or higher-level cognitive resources. $F_{Ti} (i = 1,2,3,4)$ is the relevant entities that undertake the operations $T_i (i = 1,2,3,4)$.

So, the following can be obtained:

$$D = (T_1, O_1)(X), I = (T_2, O_2)(D), K = (T_3, O_3)(I), S = (T_{4,} O_4)(K) = Y \quad (1)$$

For the confrontation exists, $X \to X'$, and :

$$D' = (T_1', O_1')(X'), I' = (T_2', O_2')(D'), K' = (T_3', O_3')(I'), S' = (T_{4,}' O_4')(K') = Y' \quad (2)$$

From figure 2 and the above formulas we conclude that the confrontation in P domain affects the cognitive activities in different levels of the processes and may cause the output Y' to change greatly. For the Red Army, the goal of the C2 organization is try to make its own cognitive result $Y_R' \to Y_R$ and make the enemies' cognitive result $Y_B' \to Y_{RE}$. Here, Y_{RE} is the result that the Red Army wish the Blue Army to produce.

3.3 Comparing to the OODA-Loop model, CECA model

As a simple model, the OODA-Loop model provides commanders and consultants a description about C2 decision-making activities from an activities perspective[4]. It doesn't consider the internal cognitive activities in human brains. Comparing to it, the sub-process I, II, III, IV and

I', II', III', IV' of the confrontation model can be understood as the OODA process in cognitive domain.

On the other hand, from the cognitive perspective the CECA model describes the whole decision-making process including the modifications of different level cognitive requirements according to the battle status[5]. However, the limitation of the CECA model is that the cognitive process is still an enclosed one. The events can't affect the cognitive activities directly except the lowest level sub-process information gathering. It is obviously not the case.

What distinguishes this confrontation C2 model from other models is that it points out that the main difference between the C2 decision and the general one is its high-strength confrontation by relating the confrontation in physical domain with the cognition activities in cognitive domain. We believe that the high-strength confrontation is one of the causes of war's complexity that is called as "the fog of war" by Clausewitz[6].

4 C2 activities analysis in different ages

It is listed in table 1 that the C2 activities in physical and cognitive domains in four different ages – Primitive, Agricultural, Industrial and Informational ages. Because the technologies applied in those ages are very different, the weapons, the tools, the cognitive subjects and even the operation styles are different in the four ages. However, cognitive confrontation is always the key characteristic of the C2 activities. The general cognitive links "$D-I-K-S-K'-I'-D'$" are divided into four levels according to the four types of cognitive objects shown in figure 1. And moreover, the cognitive subjects in each level are divided into three classes according to their cognitive functions – storing(S), operating (O) and transmitting (T). By the analysis of the cognitive confrontation happened in those types of cognitive subjects in the four ages, we can easily find the rules among the C2 activities in the physical and cognitive domains.

Table1. The Operations styles in the different ages based on cognitive confrontation analysis

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">→→→D→→→
←←←D'←←←</td><td colspan="3">→→→I →→→
←←←I'←←←</td><td colspan="3">→→→K →→→
←←←K'←←←</td><td colspan="3">→→→→→→
←←←←←← S</td></tr>
<tr><td>S</td><td>O</td><td>T</td><td>S</td><td>O</td><td>T</td><td>S</td><td>O</td><td>T</td><td>S</td><td>O</td><td>T</td></tr>
<tr><td rowspan="3">Primitive Age</td><td>Cognitive subjects</td><td colspan="3">S: human brains;
O: sense organs & human brains;
T: voice, fire, flags, and other simple audiovisual tools</td><td colspan="9">S: human brains;
O: human brains;
T: fire, voice, flags, etc, simple audiovisual tools;</td></tr>
<tr><td>Cognitive function confrontation</td><td colspan="12">Equipment with woods, stones and cooper weapons, to kill human bodies face to face</td></tr>
<tr><td>Cognitive semantic confrontation</td><td colspan="3">disguise and deception</td><td colspan="9">Confrontation about manual intelligence acquiring and spy strategies</td></tr>
</table>

Agricultural Age	**Cognitive subjects**	S: documents & brains; O: sense organs & human brains; T: documents & simple audiovisual tools	S: documents & human brains； O: human brains; T: documents & simple audiovisual tools, such as fire, voice, flags, etc,
	Cognitive function confrontation	Equipment with cold weapons and hot weapons, to kill human bodies in a larger scale	
	Cognitive semantic confrontation	disguise and deception	Confrontation about manual intelligence acquiring and spy strategies
Industrial Age	**Cognitive subjects**	S: documents & brains; O: sense organs & human brains; T: wired/wireless communication tools & documents	S: documents & brains; O: human brains; T: electronic communication tools & documents
	Cognitive function confrontation	Equipment with hot weapons and machinery weapons, to kill human bodies in a very large scale	
	Cognitive semantic confrontation	disguise and deception	Both the manual intelligence and the technology intelligence are important. The latter focuses on the encryption and decipher of the wired/wireless communications.
Informational Age	**Cognitive subjects**	computers´ chips High-technology sensors Satellites, communication net.etc	Computers, chips Computer systems Satellites, communication net.etc Computers, documents, human brains Computers aid human brains Satellites, communication net.etc Computers, documents, human brains Computers aid human brains Satellites, communication net.etc
	Cognitive function confrontation	The physical destroy that focuses on the computers, high-technology sensors	Equipment with high information technology weapons, to destroy and control the key C2 activities tools and subjects by attacking precisely and effected based operations not killing the bodies in large scale

	Cognitive semantic confrontation	Except for disguise and deception, many new forms of operation are presented and applied such as Information Operations, Electronic Operations, Effects Based Operations, Media War, Psychological War, etc.

(1) In primitive age with the low technology level, the battle information was acquired mainly by human sense organs. All the cognitive operations in the four different levels were done by the human brains. The information and the commands were transmitted by the simple audiovisual tools such as fire, flags, human voice, etc. So, to destroy the functions of the enemy's cognitive links, the most effective way is to kill the human bodies of the enemies. On the other hand, to change the semantic contents of the cognitive links of the enemy, the effective methods include disguise and deception.

(2) Because of the papers invention, in Agricultural age, the documents were widely used in the storing and transmitting functions in different cognitive levels. On the one hand, much more battle information, knowledge, decision results were written in the corresponding documents than in primitive age. On the other hand, these documents were sent by the soldiers to do the transmitting work with the help of the simple audiovisual tools. Because the human brains were still the main subjects to do the cognitive operation in the four levels, killing the enemy's human bodies were still the most effective way to realize the cognitive superiority. In addition, the cognitive semantic confrontation about the documents appeared as the encryption and decipher of the documents. However, it was far from the main role.

(3) In Industrial age, one of the most advance was the widely use of the communication technology and the relevant tools such as the telegraph, telephone and wireless electronic communication. However, the confrontations which focus on the new communication methods didn't become one of the main operation styles. Because of the technology limits, it was very difficult to advance into the enemy battle space deeply and destroy the relevant communication devices avoiding the enemy soldiers. In fact, unless the enemy soldiers who undertook the defending tasks were killed, such activities could success. On the other hand, as same as in the agricultural age, human brains were still the main subjects to do the cognitive operation in the four levels. So, the most effective and direct way to realize the cognitive superiority was still killing the enemy soldiers. In addition, the confrontation forms about the new communication methods are the encryption and decipher in the cognitive semantic aspect, not the function.

(4) In Informational age, the outstanding characteristic is the widely use of computer and communication technology in the whole process of the cognitive links. As shown in table 1, the three kinds of subjects in the four levels all include many kinds of electronic devices. Especially, many operation cognitive functions which were done by human brains are now undertaken by different computer devices with artificial intelligence. Thus, the goals of the battle operations that were killing the human bodies in the past have changed into affecting, destroying and controlling the key cognitive nodes and links with the precision strike on the key equipments and units and some direct confrontations in information domain. The conclusion can be supported by the relevant new concepts such as Information Operations, Electronic Operations, C2 Warfare Operations, Effects Based Operations, etc. The representative example is Bekaa valley air battle.

From the above battle operations analysis in different ages, we can see that, although the operation weapons, equipments, methods, and styles may vary according to the different technology level, the internal and fundamental characteristic of the operations is unchanged. The nature of the operations are to affect, destroy the enemies cognitive links and in the meantime protect own cognitive links from the enemies destroy operations. The goal of the war is to realize the cognitive superiority and in the end force the enemy to accept own will. With the C2 cognitive confrontation model, the internal relationships among the technology level, the equipments, the weapons and the operation styles can be understood and explained well.

In addition, suppose that if all the confrontations were deleted in figures 1 and 2, then the model could also be used to describe the general decision making in business domain. Although there are

also confrontations in the business domain, the confrontations do not have direct effects on the decision. First of all, the goal of one company is to make profit as much as possible, not to master cognitive superiorities. Making profit is not equal to destroying opponents. Moreover, the companies can't take excessively fierce measures to attack their opponents because of the constraints of the society such as morals, laws, etc. General speaking, the confrontation factor has little direct effect on the decision efficiency and the process. Comparing to the cognitive capabilities of the decision maker and other relevant decision conditions, the confrontation factor could be neglected.

5 Conclusion

In this paper, we present a new confrontation C2 decision making model to describe the decision in military domain. By building the relationship between the entities in physical domain and the cognitive objects in cognitive domain, the model could be used to analyze the effect the confrontations have on the cognitive objects, the cognitive activities and the products. Based on it, we can research on: (1) the assessment of C2 organization decision making efficiency; (2) the assessment the operation efficiency. That is also our ongoing work.

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