

Intelligent Net Centric Command and Control Architecture Using Cognitive Approach

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Abstract - In this paper, the necessity of change in traditional command and control architecture is discussed and then the scientific and philosophical principles of distributed C2 are defined. One of the main characteristics of positive feedback learning cycle on which the cognitive architecture is based on, is taking account of sense making expansion methods from individual levels to social levels. It is concluded that intelligent net centric command is perfect for programming and simultaneous execution of set pieces.

Index terms - Cognitive approach, Complex adaptive system, Network Centric Warfare, Hierarchical structure

I. INTRODUCTION

The most effective consequence of Information age paradigms is deep changes in various fields including the war environment. Growing complexity and diversity of recent war missions, tasks and also methods have affected deeply Command and Control (C2) structure [1]. In fact, various missions in the war atmosphere require faster and more flexible plans where the traditional central and hierarchical C2

structure is not suitable. Threat-based development instead of strength-based development is among the traditional C2 properties which results in lack of flexibility and planning. In the trade C2, the innovation and creativity of people are restricted and therefore there is no guarantee for a smart response to the environment change. Also, there is neither agility nor fast movements and it is hard to plan complex operations in the right place and at the right time. These facts necessitate a new paradigm for the C2 and the main decision maker in the war. Practically, development in information processing tools has facilitated their paradigm shift [1], [2].

The Network Centric Warfare (NCW) is a good substitution for the traditional C2. NCW is a distributed warfare which is capable of overcoming the main obstacle the traditional C2 is faced for developing a robot information infrastructure, increasing qualified information, Upgrading shared awareness, cooperation and also self-synchronization are some of the principles of NCW. Having above-mentioned principles, various aspects of new warfare such as

power transferring to the edge, self-similarity, sense making, agility and effectiveness can be achieved more easily [3], [4].

Concurrent planning and execution is one of the most fundamental subjects in NCW in which there is always the opportunity to change, modify and/or heal the plans, therefore complex missions can be done. This requires development of sense making in different levels of involved teams and groups in any military operation.

This paper shows how the introduced cognitive architecture can be implemented by swarm operations as a specific type of NCW. By developing sense making and self-synchronization, it is shown how we can increase tempo of operations and responsiveness while at the same time we can decrease risks and costs of operation. These all will result in an increased combat effectiveness. In the swarm operation, there is a cyclic positive feedback operation where there are two steps in each cycle, attack and re-planning, for a new attack. Concurrent planning and execution is the major point of this type of swarm operation which should be based on an increased learning cycle [5].

Using positive feedback and learning mechanisms is mostly relied on philosophical views. In other words, this new type of architecture can not be understood using reductionism views. The holistic view is mostly relied on cognitive

approaches instead of behavioral ones. Also, this view does not consider experimentalism without considering the commander's intent. This new holistic architecture is based on extracting the four world paradigm and also the 3S \rightarrow 3P paradigm (System \rightarrow People, Structure \rightarrow Process, Strategy \rightarrow Purpose). On the other hand, the new type of architecture is based on Complex Adaptive System (CAS) as a scientific theory. The role of CAS is to specify and control the critical points affecting a great scope, otherwise the C2 changes to a chaos environment. Identifying and effective controlling of these points results in a self-synchronizing and convergent C2, [6], [7].

To develop a new cognitive C2 architecture, a semantic model is explored firstly. This model is based on incremental, evolutionary learning cycle in the four worlds cognitive (individual and social). Based on this semantic, a different reference model is introduced. In the next step, in a lower abstract level, the conceptual model used for decision making in the new architecture is introduced. Therefore we choose CECA (Critique, Explore, Compare and Adapt), due to the cognitive approach for designing this architecture.

According to this model, the major conceptual structure which is cooperative planning in C2 is introduced using Common templates.

Using the reference models, it is shown how the trust-based networks are developed and sense making, as the core part of NCW, and self-synchronization are achieved.

II. INFORMATION AGE AND WAR

MISSIONS

Information Age and the principles of war Information Age has affected various aspects of human life including the type of wealth production, power distribution, complexity increases, time compression and distance shortening. In this age, the war missions is also changing in different aspects including target diversity, planning and execution in which different organizations must cooperate for complex mission in a short time and in a large scope. On the other hand, the power distribution can yield more flexibility and agility in the war atmosphere. Also, changes in wealth production have affected deeply the targets and the way they are achieved in war missions. This includes paying attention to information knowledge and belief of people in organizations as the most important asset [8].

Though the missions of wars are becoming more complex in this age, the principles of wars have not changed so much since the time of introduction. In other words, the information age provides tools and methods to overcome complexity. However, using the advantages of information age, some new principles are introduced known as D4

(Diversely, Distributive, Divergence and Dynamism), suitable for swarm operation. The new architecture tries to comply and satisfy these new principles in addition to the traditional ones.

III. TRADITIONAL C2

The main feature of the traditional C2 is central and hierarchical structure as the best model for stability and convergence. This structure has various disadvantages including [1]:

- Emphasizing on technology (e.g. ICT) regardless of the commander's intent resulting in noisy and redundant information.
- Governing the platform centric view on C2 resulting in various and unrelated decision making centers. These, then, result in parallel redundant actions, uncontrolled resources consuming, and much worse, not sharing the experiences.
- Lack of architecturing the decision making element.
- Excluding and not considering the competencies of combatants in the arch, resulting in loss of the opportunities in the field.
- Excluding the beliefs and knowledge (Individual and Social) of the architecture.

In the modern architecture, C2 is based on a learning organization emphasizing on cognitive aspects. Then in the next levels, the operational tasks are developed. This is shown in (Figure-1).



Figure-1. Different levels of modern C2 architecture

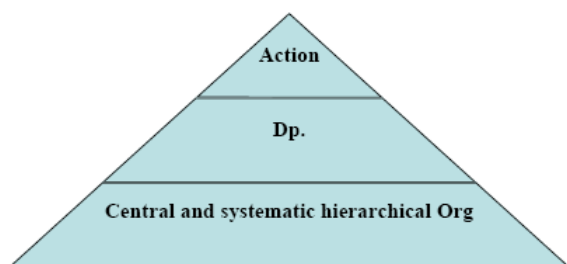


Figure-2. Different levels of traditional C2

Among the traditional C2 structures, we can have C4ISR architecture. This architecture is based on a systematic and structural approach (Figure- 2) and in complex environment, has faced many problems.

IV. NCW C2

NCW architecture is a different approach in comparison with the traditional C2. This new paradigm is based on three main features [9]:

1. Developing sense making as a necessary condition for planning and execution of different operations.
2. Developing collaborative planning based on the commander's intent.
3. Concurrent planning and execution.

The sense making process is one of the most fundamental features of Net Centric C2, emphasizing on cognitive aspects in the architecture. This process is the assuring mechanism for understanding the commander's intent. In other words, without this, no plan can be executed. This process may be considered equivalent to the trustworthiness in E-business.

The sense making process is included in most of the new architect's elements of different physical information and cognitive level. For example, the planning process is an integral part of sense making, and this is why this process can be run in a distributed and collaborative C2, while complying the commander's intent. Concurrent planning and execution in the new C2 makes sure that new emergent behaviours in the environment can be feedbacked immediately into the planning design. On the other hand, enemy's view from the battlefield become so foggy and it can not predict our course of action well. So after executing any plan, the planning and pre-assumptions for planning should be modified, the knowledge and awareness planners and combatants should share and confer their experiences. Then

based on achieving a good level of sense making among all participants in the maneuver, the concurrent planning and execution is allowed. Therefore, sense making assessment is one of the most important concepts in this model, which means different knowledge experiences and excitements are combined with the situational results in a new belief. Any action in the war environment results in new results and experiments and new experiments affect the perception of planners and combatants. This is positive feedback.

V. CONCLUSION

The main conclusion of this paper is expanding a cognitive architecture for distributed C2 which is supporting individual and social and scopes in addition to physical and informatics scopes. One the main points in this conclusion is the development of security as well as quality of services rendered by trust networks and reliability systems used in the current architecture. Making use of protocol and politics models, we represented the formalization of social groups keeping individual capabilities. We also complemented the sense making processes.

REFERENCES

[1]. D. S. Alberts and R. E. Hayes, "The future of command and control", Washington DC, USA, CCRP 2007.

- [2]. D. S. Alberts and R. E. Hayes, "Power to the edge: command control in the information age", Washington DC, USA, CCRP 2003.
- [3]. A. S. David and J. J. Garstka, F. P. Stein "Network Centric Warfare: developing and leverage information superiority", Washington DC, USA, CCRP 1999.
- [4]. A. H. Dekker, "A taxonomy of network centric warfare architectures", Systems Engineering/Test and Evaluation Conference, Brisbane, Australia, November 2005.
- [5]. D. J. Bryant, "Modernizing our cognitive model", Command and Control research and Technology Symposium, CCRTS 2004, San Diego, USA, 2004.
- [6]. A. Sloman, "What sort of architecture is required for a human-like agent", Foundations of rational Agency, 35-52, Kluwer Academics, Dordrecht, The Netherlands, 1999.
- [7]. A. Sloman, "The mind as a control system", Proceedings of the Royal Institute of Philosophy "Philosophy and the Cognitive Sciences", 69-110, Cambridge University Press, 1993.
- [8]. T. Czerwinski, "Coping with the bounds: speculations on nonlinearity in military affairs", National Defense University Press, Washington DC, USA, 1998.
- [9]. J. Moffat, "Complexity theory and network centric warfare", Information Age, Transformation Series, CCRP Publication Series, 2003.