Understanding Network Centric Warfare

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Abstract

Network centric warfare (NCW) is a new theory for war in the information age. NCW advocates that networking battlefield entities will produce shared information, shared knowledge and shared understanding which produce information superiority. In turn information superiority dramatically increases the power of combat. Since it is new, there do exist proponents and opponents. This paper reviews the theory of NCW, and some techniques and combat simulation systems which may help people gain more understanding of NCW.

Introduction

A fundamental truth of warfare was first codified by Sun Tzu, the Chinese strategist, in 500 B.C., when he stated in *The Art of War*, (Griffith 1963) "*… know the enemy and know yourself; in a hundred battles, you will never know peril. When you are ignorant of your enemy but know yourself, your chances of winning or losing are equal. If ignorant of both your enemy and yourself, you are certain in every battle to be in peril. …*"

This is one of the early statements about the significance of information in battle. In different ages, information transmission is different in the war. In ancient war, information is transferred by war flame, homing pigeon or solider running from one place to another. In the World War II, information is mainly transferred by telephone, telegraph and wireless radio. What we are living today is the information age, where the internet and other technologies have emerged for information transmission.

The changes of underlying economies, information technology, business processes and organizations are affecting the very character of war and are leading to the fundamental shift from platform-centric warfare to network centric warfare (NCW), also known as network centric operation (NCO) (Cebrowski and Garstka 1998). This fashion concept was first realized in the 1983 U.S. invasion of Grenada, impressed in the 1990 Persian Gulf War and widely accepted in the 2003 lightning-fast invasion of Iraq and the war on Afghanistan (Wilson 2000). Networked information technologies supplied the forces with unprecedented battlefield advantages during these wars. The technologies allowed military commanders in the theatre and in the United States to watch the battle for Iraq unfold in near real-time. Troops in the field likewise had a more comprehensive view of the battlefield than ever before (Garstka 2003 and Blash 2003). The USA is trying to transform its primer platform centric force to a network centric force which may create and leverage information advantage to dramatically increase its combat power. However not everyone is convinced (Kaufman 2002, Caterinicchia and French 2003, Borgu 2003).

It is not possible to verify and better understand NCW in real engagements. Fortunately red teaming, agent-based distillation, complex system theory and other modern information technologies may help us understand NCW.

In this paper, we will introduce the concept of NCW and the previous technologies. The rest of this paper is organized as follows. The theory of NCW is first introduced. Then some technologies and existing systems will be discussed.

Network Centric Warfare (NCW)

Generally NCW is trying to combine various types of information technologies to produce information superiority and then dramatically increase combat power through self-synchronization and other network-centric operations (Alberts *et al.* 1999, Alberts and Garstka 2001 and Wilson 2004). A robust, secure and broadband network plays a crucial role in future war,

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which connects all kinds of sensors in the air, on land and under the sea, distributes the logistics to ensure timely supply of military forces and coordinates military attacks, including conventional, electronic and information attacks.

In 1999, Alberts *et al.* proposed a complete definition of NCW (Alberts *et al.* 1999).

"*We define NCW as an information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. … In essence, NCW translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace*."

The key of NCW is not only connecting geographical dispersed forces, retrieving information from sensors, human intelligent agents and other information sources, but also analysing different information, generating useful knowledge and then distributing it to the right person in the right format. It adds values to control and command (C2) processes, increases the speed of response and speed of command, and increases combat power. The objectives of NCW are (Alberts *et al.* 1999, Alberts and Garstka 2001 and Wilson 2004):

- Self-synchronizing warfighers' behaviours or doing what needs to be done without traditional orders based on high shared situation awareness;
- Improving the ability to comprehend higher commander's intent;
- Improved understanding of the operational position at all levels of command;
- Increasing ability to integrate the collective knowledge of all coalition forces to reduce the "fog of the war".

Warfare takes place in and among three domains: the physical, information and cognitive domain. NCW adds values to all three domains (Alberts *et al.* 1999, and Alberts and Garstka 2001).

The physical domain is the ground, air and sea environments where strikes, protection and manoeuvres take place. Traditionally combat power is measured in this domain. Survivability and lethality are two benchmarks of effectiveness of combat operations. In NCW, all elements in this domain are connected robustly. With such secure and seamless connectivity, NCW dramatically increase survivability and lethality.

The information domain is where the information flows and the C2 process and communication between war-fighters occurs. In this domain the information is created, manipulated and shared. A networked force may improve its capability of sharing, accessing and protecting its information so that it creates and maintains the information advantage over its enemy. With the higher capability of information coordination, the networked force may improve its information position via analysis process.

The cognitive domain is the domain of knowledge. It houses all knowledge of all elements in a force: leadership, moral, situation awareness, experience, intention, believe, religion, doctrine, tactics, techniques and etc. A network centric force has the capability to share situation awareness, develop a shared knowledge of commander's intention and self-synchronize its operations.

With the new attributes and capabilities in these three domains, in NCW, the information sharing has largely been increased so that the degree of shared situation awareness is significantly enhanced; highly shared situation awareness improves collaboration and self-synchronization of military operations, which increase sustainability and speed of command. All these in turn are thought to dramatically increase mission effectiveness and combat power (Alberts *et al.* 1999, Alberts and Garstka 2001 and Wilson 2004).

Red Teaming

Red teams and red teaming processes have long been used as tools by both government and commercial enterprises to study a problem, a system, a plan, the way of thinking or a concept by anticipating adversary behaviours. Their purpose is to reduce an enterprise's risks and increase its opportunities. Although it may be applied

into various domains, the common role is that the "BLUE" side attempts to find the risk through the eyes of an adversary or competitor, the "RED" side. Mateski proposed the following broad definition of red teaming (Mateski 2004).

"*Red teaming involves any activity - implicit or explicit - in which one actor ("BLUE") attempts to understand, challenge, or test a friendly system, plan, or perspective through the eyes of an adversary or competitor ("RED")*"

In the military context, red teaming serves all four purposes. It is a connotation for playing the devil; trying to penetrate the mind of the enemy or competitor and simulate their behaviours; understanding risks in the eyes of the opponent and mitigating vulnerabilities before it is too late. Red teams, in this context, are specially selected groups designed to anticipate and simulate the decision-making and behaviours of potential adversaries. Red teaming has already been recognized as an especially important tool by defence organizations (DOD 2003). Red teaming can deepen and widen understanding of options and behaviours of adaptive adversaries which help us to find risk and vulnerabilities in our strategies, postures, plans, programs, and concepts, wake the people which indulged in old theory and doctrine that often lead to success, and train war fighter to be veteran.

Normally there are two types of red teaming: human-based red teaming and software-based red teaming. However, human-based red teaming is extremely expensive and does not enable analysts to explore all aspects of the problems. Computer simulations of multi-agent systems are used for software-based red teaming. These simulations explore abstract higher level scenarios of different vulnerabilities in a plan or operation. Once the weaknesses in the system are identified and a risk analysis is conducted, human-based red teaming can be used in a more focused way to increase the fidelity of the analysis.

Next section will discuss current models of software-based red teaming for NCW.

Warfare as a Complex Adaptive System (CAS)

Traditionally, defence analysts adopt what is known as Lanchester Equations to model and theorize about combat attrition (Ilachinski 1997, Ilachinski 2000, and Ilachinski 2004). But equation based models are unable to deal with the dynamics of nonlinear interaction. Recent research (Ilachinski 1997, Ilachinski 2000, Lauren 2000, Scherrer 2003 and Ilachinski 2004) shows that warfare is characterized by non-linear behaviours and can be modelled as Complex Adaptive System (CAS).

With the view of warfare as a CAS, agent based distillation (ABD) or agent-based simulation has frequently been adopted to understand and gain insight into military operations. Multi-agent systems (MAS) is the natural platform for studying CAS. By modelling an individual constituent of a CAS as an agent, people are able to simulate a real world system by an artificial world populated by interacting processes.

A number of MAS designed specifically for warfare has been developed in the literature.

ISAAC (Ilachinski 1997 and Ilachinski 2000) is a skeletal agent-based model of land combat. The goal of ISAAC is to become a fully developed complex system for analysing nonlinear dynamics in land combat by identifying, exploring, and possibly exploiting emergent collective patterns of behaviour on the battlefield. The basic element of ISAAC is ISAAC agents (ISAACA), each of which presents an entity on the battlefield. ISAAC allows for two sides (typically friends and enemies), which may be composed of several groups. Groups are initially located in a user-defined location on a grid. One flag or objective may also be positioned for both sides.

EINSTein (Ilachinski 1997, Ilachinski 2000 and Ilachinski 2004)) is another agent based complex adaptive system for exploring self-organized emergent behaviour in land combat from the US Marine Corps Combat Development Command. It is developed as an extension of ISAAC by offering several new functionalities and features. In addition, EINSTein provides a comprehensive user interface for the system. This makes the user much easier to set up a scenario and view what is happening during a simulation

run, and consequently lets the user gains a better understanding of embedded dynamics of a combat scenario.

MANA (Lauren 2000) is similar to ISAAC and EINSTein which is developed by New Zealand's Defence Technology Agency using same underlying agent paradigm and design. Like EINSTein, MANA has a very user friendly user interface which allows user to set up and run simulation quite easily. Many of the parameters are exactly the same although there are some important additions. MANA offers three critical functionalities: way-points, an internal situational awareness (SA) map and event-driven personality changes.

CROCADILE (Barlow and Easton 2002) is a multi-agent-based combat distillation which tries to improve the limitation on generality and fidelity in previous systems. CROCADILE implements a 3D environment where the agents interact and incorporates a projectile-physics model where factors such as target size, speed, and distance away and the terrain itself are taken into account. Hierarchies of command and communication can be established between groups of agents. Higher fidelity combat resolution was achieved by incorporating blast effects, round penetration, rates of fire, and line-of-sight.

WISDOM (Yang *et al.* 2004) is a new multi-agent simulation combat system which facilitates the analysis and understanding of NCW. The acronym stands for "A Warfare Intelligent System for Dynamic Optimization of Missions". Version 1 of WISDOM is similar to the previous systems. The design of Version II (release in December 04, http://www.itee.adfa.edu.au/~alar/wisdom/) is centred on the theory of NCW. The key contribution is that WISDOM realized and applied the core tenet of NCW – information superiority increases the power of combat dramatically – into the system. WISDOM emphasizes the effect of information sharing, information access, knowledge sharing, situation awareness sharing and speed of commander. WISDOM does not only uses the spirit of CAS in explaining its dynamics, but also centre its design on fundamental concepts in CAS. Lastly, WISDOM abstract concepts on a reasonable level in order to increase the efficiency of the systems. It is implemented based on the concept of "keep it simple, informative, efficient but realistic".

Beside agent technologies and complex adaptive systems theory, there also exist other techniques which are useful in to understand in this context such as cellular automata (CA), genetic algorithm (GA), evolutionary games, coevolution and artificial life. Although existing systems developed on traditional platform-based warfare do not fully support NCW, people may still gain more understanding of NCW by playing with them.

Conclusion

In this paper, we presented a comprehensive overview of the NCW concept. We also presented a review of different multi-agent models in the literature that are good candidates for experimenting with the NCW concept.

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References

[1] D. S. Alberts, J. J. Garstka, and F. P. Stein, *Network centric warfare: Developing and leveraging information superiority* (2nd ed.), CCRP Publication Series, 1999

[2] D. S. Alberts and J. J. Garstka. *Network Centric Warfare: Department of Defense Report to Congress.* 2001.

[3] M. Barlow and A. Easton, "CROCADILE - An Open, Extensible Agent-Based Distillation Engine," *Information & Security*, vol. 8, no. 1, pp. 17-51, 2002.

[4] E. C. Blash, "Network-Centric Warfare Requires a Closer Look: Concept May Be too Ahead of Its Time." *Signal* 57, pp.: 56-57, May 2003.

[5] A. Borgu, "The Challenges and Limitations of 'Network Centric Warfare'," Presented at the "Network Centric Warfare: Improving ADF Capabilities Through

Network Enabled Operations" conference, 17 September 2003. Posted on the Australian Strategic Policy Institute website.

[6] D. Caterinicchia and M. French, “Network-centric warfare: Not there yet,” June 2003 http://www.fcw.com/fcw/articles/2003/0609/cov-netcentric-06-09-03.asp.

[7] V. A. K. Cebrowski, and John J. Garstka. “Network Centric Warfare: Its Origin and Future,” *Proceedings of the Naval Institute* 124:1 (January, 1998), 232-35.

[8] DOD, “Defense science board task force on the role and status of dod red teaming activities," Technical Report. Unclassified Report 20301-3140, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics Washington, D.C., 2003.

[9] D.B. Fogel, *Blondie24: Playing at the Edge of AI*, Morgan Kaufmann Publishers, Inc., San Francisco, CA, 2002.

[10] J. J. Garstka, "Network-Centric Warfare Offers Warfighting Advantage: Datalinks Are the New Weapon of the Information Age." *Signal* 57 pp.: 58-60, May 2003.

[11] S. B. Griffith, *Sun Tzu – The Art of War*, Oxford University Press, 1963

[12] A. Ilachinski, “Irreducible Semi-Autonomous Adaptive Combat (ISAAC): An Artificial Life Approach to Land Combat," Research Memorandum CRM 97-61, Center for Naval Analyses, Alexandria, 1997.

[13] A. Ilachinski, “Irreducible Semi-Autonomous Adaptive combat (ISAAC): An Artificial Life Approach to Land Combat," *Military Operations Research*, vol. 5, no. 3, pp. 29 - 46, 2000.

[14] A. Ilachinski, *Artificial War: Multiagent-Based Simulation of Combat*, World Scientific Publishing Company, Singapore 2004.

[15] M. K. Lauren, “Modelling Combat Using Fractals and the Statistics of Scaling Systems," *Military Operations research*, vol. 5, no.3 , pp. 47 - 58, 2000.

[16] M. Mateski, “Toward a Red Teaming Taxonomy, 2.0,” *Red Team Jouunal*, September 2004.

[17] J. H. Scherrer, “Risks and Vulnerabilities of Network-Centric Forces: Insights from the Science of Complexity”, Newport, R.I., Naval War College, February, 2003

[18] J.R. Wilson, “Network-centric warfare 21st century,” *Military & Aerospace Electronics*, January 2000.

[19] C. Wilson, *Network Centric Warfare: Background and Oversight Issues for Congress*, CRS Report for Congress, June 2, 2004

[20] A. Yang, H. A. Abbass and R. Sarker. Landscape Dynamics in Multi-agent Simulation Combat Systems. *Proceedings of 17th Joint Australian Conference on Artificial Intelligence, LNAI 3339,* Cairns, Australia, 6-10 December, 2004. Springer-Verlag.