Chapter 10
Complex Adaptive Information Networks for Defence:
Networks for Self-Synchronization

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ABSTRACT

This chapter focuses on understanding the nature of the information networks that can create Self-Synchronization of the force. The analysis takes place at a number of levels, which for simplicity, are called Levels 1, 2, and 3. At Level 1 ("linked"), the author considers the basic node and linkage topology. At Level 2 ("synched"), he considers the local interaction between intelligent nodes, sharing the information and awareness required for Self-Synchronization in the cognitive domain. At Level 3 ("cliqued"), the author considers how such local networking feeds through into emergent clustering effects in the physical domain. Structured experimental games coupled with information entropy-based measures of merit illustrate these ideas, as do models of fundamental information networking dynamics and their resultant emergent behaviour. It turns out that the tools, models, and concepts of Complexity Theory give deep insight into the topic of Self-Synchronization.

INTRODUCTION

Modern military operations now cover a broad spectrum of missions that are beyond conventional warfare and span the range from peace-keeping and counter-terrorism to large-scale disaster response. Major coalition interventions resemble *complex endeavours* (Alberts & Hayes, 2007). They include military and non-military participants with multiple 'chains of command' and different objective functions, a lack of understanding of cause-effect relationships and unpredictability of effects. In such an uncertain environment, Network Enabled (or Network Centric) approaches are necessary in order to allow the necessary force adaptability and agility to emerge.

Synchronization of the Force

A key aspect of the Network Centric value-chain consists of a force's ability to Self-Synchronize, that is, *the ability of a well-informed force to or-*

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ganize and synchronize complex warfare activities from the bottom up (Cebrowski & Garstka, 1998). This definition comprises two aspects;

- Synchronization, as an output characteristic of the C2 processes that arrange and continually adapt the relationships of actions (including moving and tasking forces) in time and space in order to achieve the established objective(s). […] Synchronization takes place in the physical domain (Alberts, Garstka et. al., 2001).
- Self, as being a result generated by the system itself without the need for guidance from outside (Atkinson & Moffat, 2005).

Synchronization has been a fundamental concept in warfare throughout history, of course, but achieving it is becoming more challenging due to increased complexity, growing heterogeneity, and a faster pace of events (Alberts, Garstka et. al., 2001). Thus, we consider the dynamic aspect of Self-Synchronization a key one in the context of modern operations. We also consider that its application is beyond the physical domain of the battlespace and covers the cognitive and social domains of awareness, shared awareness, decision making and task sharing. The experience of a number of case studies (NATO, 2006; NATO, 2010) indicates that it can only be sustained where there is high trust and the group involved is 'hardened' – i.e. it has most likely trained together and each member understands the group as well as the task. Typical examples might be special force units or teams of medical experts.

Aim of this Chapter

This Chapter focuses on understanding the nature of the information networks which can create and sustain Self-Synchronization of the force.

Our analysis takes place at a number of levels which for simplicity we call Levels 1, 2 and 3. At Level 1 we consider the basic node and link 'topology' of the information network. At Level 2 we consider the local interaction between 'intelligent' nodes, sharing the awareness required for decision making in the cognitive and social domains. At Level 3 we consider how these feed through into emergent effects in the physical domain.

Chapter Structure

As a result, the Chapter structure follows the classification of networks at these three levels. At Levels 1 and 2 we begin by discussing the standard networks (Random, Small World and Scale Free) and then go into more detail on the node and link structure (the 'infostructure') of information networks which are required to underpin the possible range of approaches to military Command and Control (C2).

Approaches to Command and Control

Consistent with the five levels of operational capability defined by the NATO Network Enabled Capability Feasibility Study (NC3A, 2005) a range of approaches to C2 have been developed by a diverse group of experts drawn from across the NATO nations and endorsed by NATO. These approaches extend from Conflicted C2 through De-conflicted C2 to Coordinated C2, Collaborative C2 and Edge C2 (NATO, 2010). To illustrate what they mean we can characterise them by three first order variables:

- The degree to which decision rights are allocated by entities to the collective.
- The patterns of information networking and interaction among entities.
- The degree to which information is distributed across these information networks.

The regions in the resultant three dimensional 'C2 approach space' within which these classes of C2 approach are located are shown in Figure