Combining Information Sharing and Seeking in Networked Coalitions

Tim Grant
Koningin Wilhelminastraat 13, 3405XP Benschop, Netherlands
tim.grant.iscram@gmail.com

ABSTRACT

Coalitions are the rule in crisis management and military operations. Although the partners do not form part of an organizational hierarchy, they need to share information to find their place in the coalition, to prepare plans collaboratively, to synchronize their actions, to evaluate their achievements, and to negotiate changes in their relationships. Interviews of experienced military officers have shown that information sharing in coalitions is more complex than one-way information transmission. It has the characteristics of an information market in which security regulations give information a scarcity value, with both sources and recipients initiating action.

The emerging literature on information markets includes few process models. The purpose of this paper is to propose a theoretical, four-stage process model for information sharing between coalition partners in the context of Network Enabled Capabilities. The model combines information sharing and seeking, integrates intelligence collection, and supports a range of market mechanisms.

Keywords

Coalition, information market, process model, information push and smart pull, network enabled capabilities.

INTRODUCTION

Coalitions are the rule in modern crisis management and military operations. They comprise multiple organizations from diverse disciplines and nationalities that wish to retain their own sovereignty. Their long-term goals may not be aligned, and their organizational cultures may even be antagonistic. The partners do not form part of a single organizational hierarchy, but constitute a temporary coalition for the duration of the operation. Nevertheless, they need to share information to find their place in the coalition, to prepare plans collaboratively, to synchronize their actions, to evaluate what they have achieved, and to negotiate changes in their relationships with other coalition partners.

On the basis of interviews with 47 experienced military officers in a NATO setting, Grant and van der Heuvel (2010) have shown that information sharing in military coalitions is more complex than a simple, one-way, linear process. Security regulations give information a scarcity value, although trust may allow the regulations to be waived in certain circumstances. They conclude that information sharing in military coalitions often has the characteristics of an information market (McGee & Prusak, 1993), and that a better model of information sharing is needed to suit the network structure of coalitions.

The purpose of this paper is to propose a theoretical, four-stage process model for information sharing between coalition partners in the context of Network Enabled Capabilities (NEC). The research reported here is work in progress towards the development of an agent-based simulation of multicultural coalitions. If successful, the simulation could serve as a decision support tool for coalition designers and the partners' commanders.

This paper consists of five sections. Following this introductory section, the second section outlines the literature on information markets. The third section describes the NEC context. The fourth section proposes the information-sharing process model. The fifth section draws conclusions and identifies further research.

INFORMATION MARKETS

For the purposes of this paper we make no distinction between data, information, and knowledge, using

Reviewing Statement: This short paper has been fully double-blind peer reviewed for clarity, relevance and significance..

"information" as our portmanteau term. A piece of *information* is a set of explicit data objects that is acquired or generated, identified, stored, retrieved, and/or exchanged by coalition partners. *Information sharing* is the process of making information available to other individuals, teams, or organizations in the coalition. Information may be shared through one or more communication *channels* that combine transmission and routing functionalities. Channels may be face-to-face or technically mediated using wired or wireless media (e.g. telephone, radio, digital telecommunications, email, instant messaging / chat, written or printed documents, etc.). In NEC, channels also have a repository function.

An *information market* is a mechanism for distributing information resources (Stewart, 1996). This assumes that a *source* has information available for distribution, that someone (an intended *recipient*) wants it, and that the market's purpose is to connect the two. There are two views on how such a mechanism can function: in one, legal constructs make the information a *scarce resource*, and, in the other, information is treated as a *public good* and should be shared freely. Since there is no consensus among researchers on the relative merits of the two views, our proposed process model supports either view or both in combination.

Stewart (1996) observes that information is very different from physical goods. Because information can be readily copied, a piece of information can be in more than one place at a time. When information is viewed as a scarce resource, selling it does not diminish the supply, buyers generally purchase it once only, and, once sold, it cannot be recalled. Information can be easily combined to create new information. These differences imply that information markets are different from markets that trade physical goods and services.

McGee and Prusak (1993) note that people barter information, trading it for information of greater value, or use it as an instrument of power. Grant and van den Heuvel (2010) showed that these characteristics were to be found in the transcripts of interviews with experienced military officers in NATO settings. Security regulations restrict the sharing of information across organizational boundaries. The currently-prevailing security principle of "need to know" means that the source determines how the information should be protected and with whom the information may be shared. This gives information a scarcity value.

A barter economy has a number of limitations (O'Sullivan & Sheffrin, 2003). When it is information that is being bartered, the market is hampered. The need for both parties to have some information that the other wants is the biggest limitation. This is compounded when the information is time-sensitive, because not only is the information perishable, but time-sensitivity also reduces the chance that two parties simultaneously have information that the other wants. While power offers a way of measuring the value of information in coalitions, this value is strongly dependent on the situation and on who is doing the measuring.

Simard (2006) has proposed a sequential, nine-stage, cyclic process model for information markets, but there are several problems with it. While the model is cyclic, the stages occur in a fixed sequence. Moreover, it is source-centric, while under NEC both source and recipient take the initiative. An alternative is to combine information sharing and seeking (He & Wei, 2009).

NETWORK ENABLED CAPABILITIES

In the military operational sciences, the concept of networked operations has attracted considerable research, development, and experimentation. Networking enables military units to coordinate their individual actions to achieve greater operational effectiveness. The coordination mechanism is Command & Control (C2), defined as "*the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission*" (US DoD Joint Publication 1-02). A C2 system is "*an arrangement of personnel, equipment, communications, facilities, and procedures*", and the functions of C2 include "*planning, directing, coordinating, and controlling forces and operations*" (ibid.) Traditionally, C2 has been organized as a hierarchy with the commander at the top and the military units under his/her command at lower echelons. Situation reports flow up the hierarchy, and the commander's orders flow downwards.

By the mid 1990s, the commercial benefits of the Internet for linking businesses and customers had become apparent. In the military world, these lessons inspired the initial application of networking concepts to C2 under the name of Network-Centric Warfare (NCW), defined as "*the combat power that can be generated from the effective linking of the warfighting enterprise*" (Alberts et al, 1999, p.88). Technology was the driver.

Ten years later, it is now recognized that C2 systems are socio-technical in nature (Van Ettinger, 2008). Within NATO, NCW is now known as Network Enabled Capabilities (NEC). NATO (2009) distinguishes three networks. The *social network* is the extended group of people with similar interests or concerns who interact for mutual assistance. The *knowledge network* is the collection of knowledge in these people's minds, and is where situation awareness is maintained and decisions are made. The *technical network* is the infrastructure that allows the acquisition, generation, storage, distribution, manipulation, and utilization of information.

To transform the traditional way of working into NEC, it is not sufficient just to introduce technology. The infrastructure must support information flowing across (as well as up and down) the hierarchy and, in coalitions, between hierarchies. The organization must also become decentralized, with the people and units at the bottom of the hierarchy being empowered to collaborate and to synchronize their actions directly with one another. Most importantly, the security culture must change from "need-to-know" to "need-to-share", obliging anyone who owns or generates information to place it on the network where recipients can discover and retrieve it. This is known "information push and smart pull". "Push" and "pull" are asynchronous, requiring the network to act as an information repository. When "pull" precedes "push", the network must be able to record information needs. In terms of the literature, the network splits information sharing from information seeking.

PROCESS MODEL

Approach

We adopt mathematical network theory (Newman, 2003) as the basis for developing our process model. The theory has demonstrated its analytical tractability in representing biological, social, organizational, and telecommunications networks. In network theory, a network is a collection of nodes linked by arcs. We model a coalition as a network by representing the partners, their organizational units, and individuals as nodes. We term these *actors* because they appear in all three networks. Nodes that appear in just one or two networks are known as *objects*. Arcs represent the connections between nodes. In the social network, the connections are the informal acquaintance relations between actors (i.e. who knows whom) and their formal authority relations (e.g. superior-subordinate). In the knowledge network, the connections are the cognitive relations between actors and pieces of information (i.e. who knows what). Pieces of information must be represented as objects. The technical network is a distribution network over which messages flow. Messages encapsulate either pieces of information or information needs. The connections in the technical network are the physical links that transmit the flow of messages from one actor to another. Network repositories, hubs, and routers are objects.

Given that our goal is to develop an agent-based simulation, we can borrow concepts from the multi-agent systems (MAS) literature. Nodes can be implemented as agents, with message-passing as the underlying information transport mechanism. We identify two models: an intra-agent process model to represent decision-making within an agent, and an inter-agent process model to represent interactions between agents.

Decision-making models can be found in the scientific literature on psychology, cybernetics, organisation theory, and economics. Leading architectures in MAS include BDI (Rao & Georgeff, 1995) and several cognitive architectures (Langley, Laird & Rogers, 2009). In military C2, empirical process models predominate (Mayk & Rubin, 1988), most being variants of Boyd's (1996) Observe-Orient-Decide-Act (OODA) model. We have selected rationally reconstructed OODA (Grant & Kooter, 2005) as our intra-agent process model.

By contrast, there are few candidate inter-agent process models, none of which meet the NEC requirements. Hence, our research focuses on the inter-agent process model. Our approach is to look at the communication process from the viewpoints of the source, recipient, and channel. First, we consider information contribution process from the source's viewpoint. Then we consider information seeking from the recipient's viewpoint. Finally, we observe from symmetry that intelligence collection can be integrated into the process model. The process model (Figure 1) is depicted using a simplified form of SADT[1] (Marca & McGowan, 1988) in which rectangles represent processes, and information flow as directed arrows. A process' input information enters from the left, and output information goes out to the right.

Source's viewpoint: information push

Actors create pieces of information as a result of observing a situation or event in their environment or by deriving information from other pieces of information. In so doing, they become the information source. In military applications, the information is classified on creation. If the source complies with the need-to-know principle, then it also determines the set of actors to which the information should be sent. This is not necessary for need-to-share. Finally, the source encapsulates the information in a message, and transfers the message to the channel using the underlying message-passing protocol. Encapsulation may involve translation, encoding (e.g. for error-correction), and/or encryption of the information.

[1] Also known as IDEF0; see http://www.idef.com/IDEF0.htm (accessed 8 March 2011).

Upon receipt, the channel extracts the information from the message and checks whether this information is already present in its repository. If so, then the channel notes the name of the source and the time at which the message was sent. If not, then the channel adds the information to its repository. Depending on the underlying protocol, the channel may or may not send an acknowledgement back to the source to indicate that the message has been successfully received. Figure 1(a) shows this information contribution stage.

The channel's repository also records the information needs of recipients. The channel checks the received information against these needs. If it matches, then the channel encapsulates the information in a message, and transfers it to the recipient(s). Figure 1(c) shows this information transfer stage.

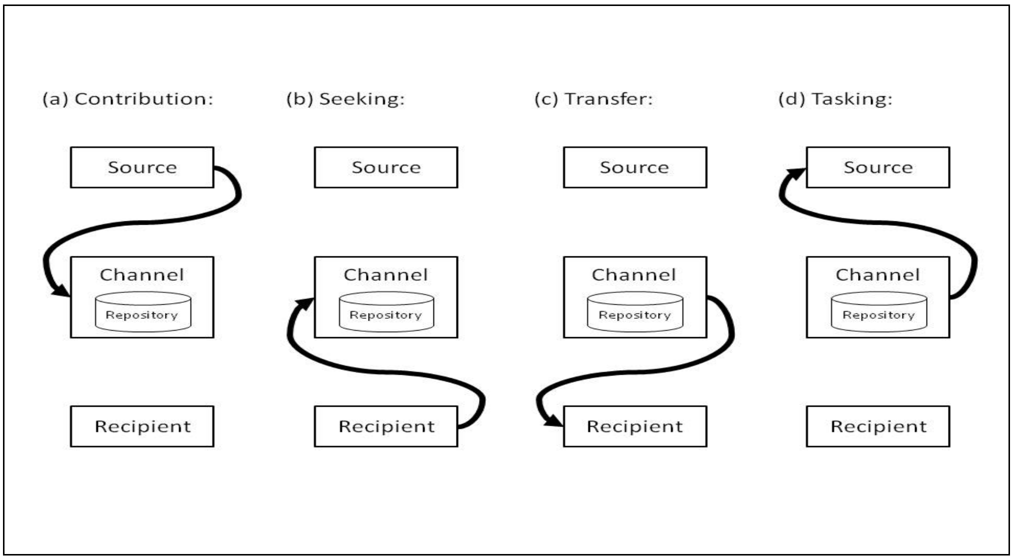

Figure 1. Four-stage inter-agent process model, in SADT notation (Marca & McGowen, 1988).

Recipient's viewpoint: smart pull

When an actor recognizes that it lacks a piece of information, then it has an information need. It encapsulates a request for the information in a message, and transfers this message to the channel. Figure 1(b) shows this information seeking stage. Upon receipt, the channel extracts the request from the message and checks whether the information requested is available in its repository. If it is, then the channel encapsulates the information in a reply message, and transfers the message to the requesting actor. Figure 1(c) shows this information transfer stage. Otherwise, the channel adds the information need, the name of the requesting actor, and the time at which the request was sent to its repository. The channel may or may not send an acknowledgement back to the requester to indicate that the request has been received, but that no information is available.

Integrating intelligence collection and dissemination

Together, the information contribution, seeking, and transfer stages support information sharing in a NEC context (i.e. "information push and smart pull"), under both need-to-know and need-to-share. We introduced a repository within the channel to allow "push" and "pull" to be asynchronous. By storing needs as well as information in the repository, we enable "pull" to precede "push".

However, Figure 1(a), (b), and (c) show that, while the interaction between channel and recipient is symmetric, the interaction between source and channel is not because messages can be transferred from the source to the channel, but not back. We introduce the missing message in Figure 1(d). The information needs stored in the channel's repository are used to task sources with collecting the information needed. When a source has acquired or created this information, it can contribute the information (Figure 1(a)), and the channel can then disseminate the information by transferring it to the actors needing it (Figure 1(b)).

CONCLUSIONS AND FURTHER RESEARCH

Information sharing is essential in coalitions, but is more complex than a simple, one-way, linear process. Case study of military coalitions shows that it has the characteristics of a barter-based information market, with security regulations giving information a scarcity value. This paper proposes a theoretical process model for information sharing between coalition partners in the context of Network Enabled Capabilities (NEC).

The four-stage inter-agent process model we propose can support the existing and future NEC information sharing protocols, and integrates it with the intelligence cycle, as follows:

- Need-to-know (existing; information push): contribution + transfer.
- Need-to-share (NEC; information push and smart pull): contribution + seeking + transfer.
- Intelligence tasking, collection, and dissemination: seeking + tasking + contribution + transfer.

For the ISCRAM and NEC communities, the primary contribution of this paper is the proposal of a four-stage process model for information sharing between coalition partners. A significant contribution for the C2 community is the synergistic integration of the intelligence cycle into information sharing. The key limitation is that the process model has not yet been implemented and tested. Several research issues remain open, such as:

- Would it be advantageous to make channels actors, rather than objects?
- How scalable, robust, and secure is the proposed process model?
- How do actors get to know each other or become superiors and/or subordinates?
- How do recipients assimilate the shared information into their pre-existing store of information?

Beyond addressing these issues, further research will be aimed at implementing and testing the proposed model and integrating it with the already-selected intra-agent process model.

REFERENCES

1. Alberts, D.S., Garstka, J.J., & Stein, F.P. (1999) Network Centric Warfare: Developing and leveraging information superiority. US DoD Command and Control Research Program, Washington DC.
2. Boyd, J.R. (1996) The essence of winning and losing. Unpublished lecture notes.
3. Grant, T.J. & Kooter, B.M. (2005). Comparing OODA and other models as operational view C2 architecture. *Proceedings of the 10th International Command and Control Research Technology Symposium*, McLean, VA.
4. Grant, T.J. & van den Heuvel, G.G.A. (2010) Modelling the Information Sharing Process in Military Coalitions: A work in progress. *Proceedings of the 7th International ISCRAM Conference*, Seattle, WA.
5. He, W. & Wei, K.K. (2009) What drives continued knowledge sharing? An investigation of knowledge-contribution and -seeking beliefs. *Decision Support Systems*, 46, 4, 826-838.
6. Langley, P., Laird, J.E., & Rogers, S. (2009) Cognitive architectures: Research issues and challenges. *Cognitive Systems Research*, 10, 2, 141-160.
7. Marca, D. & McGowen, C.L. (1988) SADT: Structured Analysis and Design Technique. McGraw-Hill, New York.
8. Mayk, I. & Rubin, I. (1988) Paradigms for Understanding C3, Anyone? In Johnson, S.E. & Levis, A.H. eds. 1988. *Science of Command and Control: Coping with uncertainty*. AFCEA Press, Washington DC, 48-61.
9. McGee, J. & Prusak, L. (1993) Managing Information Strategically. John Wiley & Sons, New York.
10. Newman, M.E.J. (2003) The structure and function of complex networks. *SIAM Review*, 45, 2, 167-256.
11. North Atlantic Treaty Organization. (2009) Whitepaper on NATO NEC Maturity Levels. Working draft version 2, dated 22 April 2009.
12. O’Sullivan, A. & Sheffrin, S.M. (2003) Economics: Principles in action. Pearson Prentice Hall.
13. Rao, A.S. & Georgeff, M.P. (1995) BDI agents: From theory to practice. *Proceedings of the 1st International Conference on Multiagent Systems (ICMAS95).*
14. Simard, A. (2006) Knowledge markets: More than Providers and Users. *IPSI BgD Internet Research Society Transactions*, 2-2, 4-9.
15. Stewart, T.A. (1996) Intellectual Capital - The New Wealth of Organizations. McGraw-Hill.
16. Van Ettinger, F. (2008). NATO network enabled capabilities: Can it work? *Carre*, 11, 22-26.