KNOWLEDGE ENVIRONMENTS TO SUPPORT HORIZONTAL FUSION

M. Barnes and B. D. Broome
US Army Research Laboratory
Aberdeen Proving Ground, MD 21005

B. Chandrasekaran
Ohio State University
Columbus, OH 43210

ABSTRACT

While a great deal of technology is in place to support the tenets of DoD's Horizontal Fusion program, considerable research must be accomplished to achieve the program's goals of a network customized to its users, providing both shared situation awareness and data availability that is limited only by policy. This paper outlines some of the issues that must be addressed to make that vision a reality and some of the current Army Research Laboratory initiatives in place to address them.

1. INTRODUCTION

Network-Centric Warfare (NCW) is the embodiment of DoD's Information Age transformation. Its tenets are:

- "A robustly networked force improves information sharing.
- Information sharing enhances the quality of information and shared situational awareness.
- Shared situational awareness enables collaboration and self-synchronization, and enhances sustainability and speed of command.
- These, in turn, dramatically increase mission effectiveness." (OSD2, 2001)

Horizontal Fusion, a component of NCW, refers to the means and methods that enable the smart pull and integration of data by users throughout the networked environment, and as such is a core requirement for insuring the responsiveness, sustainability and versatility of the Objective Force. While a great deal of technology is in place to support the tenets of this far-looking program, considerable research must be accomplished to achieve the program's goals of a network customized to its users, providing both shared situation awareness and data availability that is limited only by policy. This emphasis on horizontal fusion reflects an increased awareness of the knowledge-oriented nature of the defense mission and operations. Both the Army Science Board (ASB, 2001) and the Army's Assistant Secretary for Acquisition, Logistics, and Technology (Andrews et al., 2002) have identified "knowledge technology" as a key enabler for the Objective Force Warrior. The Army Research Laboratory, both through its internal research initiatives and test beds and through its Collaborative Technology Alliance, has responded to this new focus.

We use the term "knowledge" to refer to any information that users need to perform their jobs. Thus, data in databases, newspaper articles in natural language, maps and pictures, movies that describe how to perform some activity are all knowledge in this context. Knowledge includes descriptions giving factual information about some domain of discourse (declarative knowledge) as well as descriptions or demonstrations of how to do something (procedural knowledge). The knowledge will be used in the service of prediction (the inferring of intent and possible enemy actions) and for planning and execution. Our vision of knowledge support is a user-centered Knowledge Environment (KE). A KE is an integrated whole, and not simply a set of independent knowledge tools. A KE is a set of knowledge assets that covers the spectrum of knowledge requirements for a specific venue and that has a common interface logic and visualization conventions for all assets. In contrast, knowledge tools are designed for specific problems and may be stove piped into any number of applications. KE is a particular way to realize the vision of knowledge sharing. A KE is tuned to the knowledge needs of a user, which are identified from an analysis of his or her task. The same analysis can also be the basis for identifying the most effective forms of information presentation and interaction. A research program on KEs must bring together ideas from knowledge management, knowledge-based systems, ontologies, heterogeneous databases, and graphical and other interfaces to serve the knowledge needs of an identified class of users.

2. RESEARCH ISSUES

An underlying principle of the KE is that identifying a user (actually a class of users) makes it possible to deliver knowledge in a more effective way than is conceived in the current vision of general purpose Assistant Secretary for Acquisition, Logistics, and Technology knowledge-sharing. By analyzing the structure of the user task, not only can many knowledge needs be identified in advance, but knowledge sources can be identified as well, thus increasing the likelihood of the user accessing the requisite knowledge (Chandrasekaran, 2002).The knowledge environments that we propose are

conceived not just as servers of specifically requested information, but as systems that make use of an understanding of the user task to take the initiative in seeking the needed knowledge and integrate the elements into useful higher level information. An environment that tries to put together a coherent situation description, alerts the analyst when certain events of interest can be hypothesized from available observations, and helps suggest courses of action and evaluate them against the current situation and goals can be a powerful intelligence amplifier for Army personnel engaged in a dynamic real-time situation. Thus, ongoing research to support the development of military KEs includes:

- Fusion. User overload is a direct result of our inability to combine information in a manner that allows the user to see the "big picture." Current relational databases support storing and retrieving battlefield facts; however, considerable research is required before we can automatically combine those facts to determine what the enemy is doing and what the appropriate response is. Both user-directed and automated data mining tools will be essential to the evolution of a KE. (Powell and Broome, 2002)
- Situation Assessment. The goal of analysis is to produce a consistent description of the situation in a language that is appropriate for taking action. Typically, this means an account of the location of friendly and hostile elements along with their intentions and plans.
- Course of Action (COA) Generation, Simulation and Embedded Training. In addition to analysis, the KE should suggest possible problem solutions. The purpose is not to have the computer software find the best option but to create a synergistic environment in which operators gain insight into alternatives more quickly. Embedded training is one mechanism for insuring the usefulness of new tools within their intended environment.
- Visualization. Advanced visualization techniques can be used to give the analyst insights into the complexity of unfolding military situations. Work in diagrammatic representations is relevant; however, the visualizations must be understood easily as part of the analyst knowledge milieu.
- Integration of heterogeneous sources. A good deal of the information needed will have to come from distributed heterogeneous sources (structured, semi-structured, and unstructured), and it would often be necessary to combine data from several different databases to produce the knowledge needed. This raises the problem of translating between the different semantics of the databases. Ontologies combined with syntax standards provide an initial approach to capturing the meanings of terms in databases and other less structured sources.
- Frameworks. Developing knowledge systems requires software development frameworks that provide a smooth bridge between domain-specific knowledge representation by Subject Matter Experts (SME's) and final implemented systems. Any KE should be easily modifiable so that knowledge sources can be added, changed, or deleted by relatively inexperienced users.

The issues of extending horizontal fusion to the tactical environment can be quite daunting, given the constraints under which real-time responses must be provided. Communications are severely restricted by limited bandwidth. Information security threats are particularly aggressive. Data is not only incomplete and sometimes inaccurate, but quite volatile as well. And, of course, decision makers are working under extremely adverse conditions, while their decisions can have a life-or-death impact. To extend the KE to the tactical Army, ARL has chosen a test bed approach. This facilitates exploration of new techniques to extend current automated functionality and to insure interoperability among systems. During the current year ARL initiated a Command and Control in Complex and Urban Terrain Project that focuses on a suite of tools to identify and fuse critical decision making information for the dismounted and mounted Objective Force Unit of Action. Similarly, the Fusion Based Knowledge for the Objective Force Project, a joint CECOM/ARL initiative, addresses the Level-2/3 Fusion issues for the Objective Force Unit of Employment. With each, the issue is to develop tools that assist in fusing information from diverse sources. In this paper we describe methods for extending the KE concept to include the Unit of Action and the Unit of Employment and the impact of this research on the issues

REFERENCES

Andrews, A M, Beatrice, P, Brandler, P and Cooper, R (2002) A Vision for the Objective Force Warrior. *Army AL&T*

ASB (2001) Knowledge Management and Information Assurance Final Brief. http://www.saalt.army.mil/sard-asb/ASBDownloads/KMExecutiveBrief-Final.pdf.

Chandrasekaran, B (2002) Presentation: Putting User at the Center: Lessons for Knowledge Management from Knowledge-Based Systems Research. In *Track H of the Army Knowledge Symposium*.

OSD2 (2001) Network Centric Warfare. http://www.c3i.osd.mil/NCW.

Powell, G and Broome, B D (2002) Fusion-Based Knowledge for the Objective Force. In *National Symposium on Sensor and Data Fusion*.