NAVAL
POSTGRADUATE
SCHOOL

Knowledge Flow Mesh and its Dynamics: A Decision Support Environment

13th ICCRTS: C2 Architectures Track

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Motivation

- Personal Experience
  - *Desert Storm* and *The Long War*

- Advances in Modern Communications and Networking Ability
- Sensor Saturation &Maturation of Mobile Technology
- USSOCOM and NPS Partnership
- Arrival of Network Centric Warfare
  - Post Desert Storm of 1991
    - Air Plan Briefs to Airborne Downloads
  - FCS, UAVs, and UCAVs
    - *The Reaper*

DSS to DSE

In today's dynamic, information rich, and high operational tempo, the need for a robust, resilient, and adaptable decision support environment is greater than ever before.

Of particular emphasis here is the context of a "network-centric" approach or lens. Existing literature focuses on the development of the decision support system as a "system" under the control of one or more decision makers (Marakas 2003)).

Added to this is the need for a clearly defined problem statement which then, in turn, relates to a particular form of decision support system.

The form of DSS is based upon the problem structure, the type of outcome needed, and finally, the type of overhead or control required.

DSS Gap

Earlier attempts to bind the characteristics of robust decision support systems with the requisite ability to serve as a knowledge flow enablers to include the ability to adapt and mesh with existing networks and systems have come up short.

Articles and conference papers by such leading edge researchers as Bordetsky, Hayes-Roth and Vega, Clements, and Thompson have attempted to either bin the particular DSS as either hybrid (Vega, et al. 2007) or place the functionality onto an architectural structure (Bordetsky, Hayes-Roth 2007).

DSS Gap: GSS Update

Briggs, Nunamaker, Sprague
The University of Arizona
Center for the Management of Information

Group Support Systems: Defined as "a suite of software tools, each of which focuses team efforts in some unique way" (Briggs, Et al 2000), many have stated that the field of GSS research is dead.

However, ***the state of the art in GSS research does not presently support the needs of the tactical or crisis management team***. That said, this field deserves more in depth review and research and holds promise for the future of collaborative team work in a virtual environment.

Research Question

- Which DSS is best suited for today's rapidly adapting and evolving network centric tactical situations?

- In this paper we introduce the concept of *Knowledge Flow Mesh Dynamics* within a decision support environment, which we argue is the logical heir to a new type of decision support system as seen through the network centric lens.

Prior and Ongoing Research

- *"Leverage experiments that identify key gaps and deficiencies resulting from applications of advanced technology, unmanned systems, and net centric applications"*

- USSOCOM and NPS Partnership
  - Cooperative Field Experimentation
  - CENETIX Lab
  - MIO
  - UAS
  - Distributed Ops
  - Enhanced Battlefield Medical SA

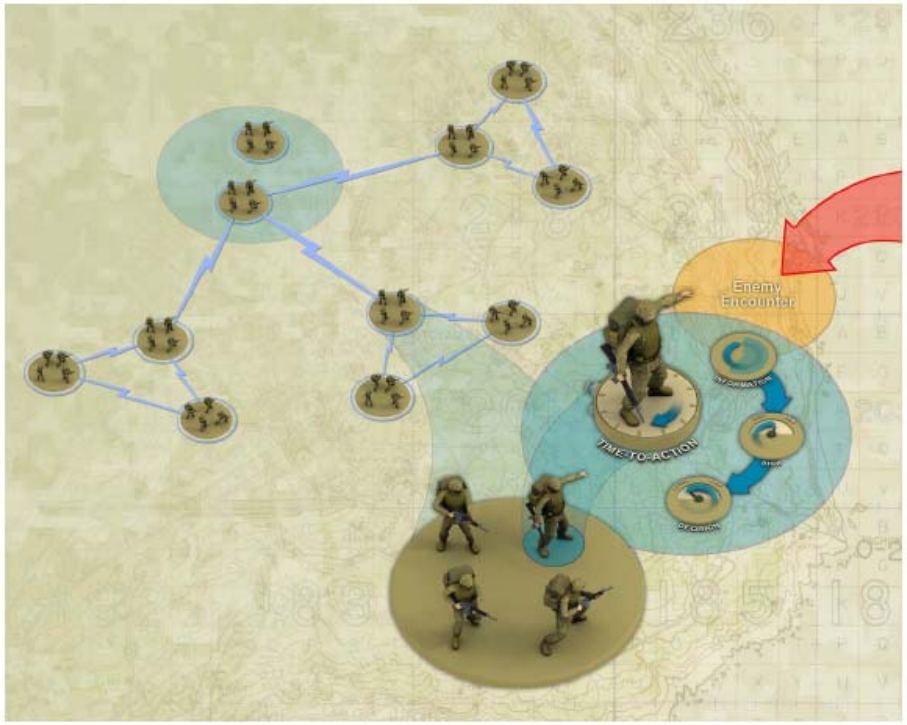
Decision Support Environment

- Identification of Knowledge Nodes
  - Knowledge Flows (Nissen, 2006)
  - Human or Machine
  - Dynamic (Right Expert-Right Time)
    - Bandwidth Optimization
    - Think IP Packets / Knowledge Packets & Nodes

We are trying to enable the dynamic transfer of knowledge across as yet to be determined network topologies and architectures at the right time and location.

Adaptive Knowledge Mesh Topology

- Information
  - Static
- Knowledge
  - Dynamic
  - Shelf Life
  - TTL
- Actor
  - Decision Maker
  - Shooter
  - New Information Created



The Proliferation of Decisionmakers

Building the Experiment

The primary goal of the experimentation phase is the successful discovery of the knowledge flows within the adapting network topology and to ultimately identify the best decision support model with which to support knowledge flows. We begin with three phases of experimentation:

1. Pre-experimentation (what we know, what we think, and what we are going to do).

2. Conduct the experiment (the empirical data and observations).

3. Post-experimentation (revised model, lessons learned, and data for future experimentation).

The bulk of our effort will be placed in the "pre-experimentation" phase in which we codify that information and knowledge we have, develop a series of assumptions and/or hypothesis, and design the experiment

Hypothesis Testing

Sample hypothesis for testing utilize the methodology contained in Alberts and Hayes *Code of Best Practice for Experimentation* (2005) include:

-If we reduce the amount of non-critical nodes (machine and human) between command node and actioner, then the reaction time will decrease.

-If we increase the amount of information access to the MIO boarding party, then knowledge will increase.

-If we reduce the amount of time needed to link critical knowledge experts, then the reaction time of the entire boarding party will increase.

Experimental Baseline

The proposed experiment baseline is to be the TNT MIO baseline stated earlier at the beginning of this paper:

The stated goals and objectives of TNT MIO 07-4 (Joint USSOCOM-NPS-LLNL Field Experiment Augmented by OSD/HD MDA Programs), to be conducted in the San Francisco Bay areas are as follows:

The objective of this experiment is to continue to evaluate the use of networks, advanced sensors, and collaborative technology for rapid Maritime Interdiction Operations (MIO); specifically, the ability for a Boarding Party to rapidly set up ship-to-ship communications that permit them to search for radiation and explosive sources while maintaining network connectivity with C2 organizations and collaborating with remotely located sensor experts.

The particular goal for TNT MIO 07-4 is to take the discovery, constraints analysis, and situational understanding process of network-centric MIO to a new level of fidelity (Bordetsky 2007).

Scenarios

We posit that three separate yet identical tactical scenarios be run, each with the goal of getting the best and most current knowledge flow to the primary actor.

In this case, the primary actor is the boarding party officer, yet we understand that due to the unpredictable nature of tactical situations, the ability of another member to gain a position of knowledge dominance needs to be looked at and monitored.

This is in a sense, the power of network centric operations and particularly relevant given today's networking and collaboration tools.

Data Collection

Using a Lickert scale model based on a rating of 1-10, each scenario would be run in an identical manner and the criteria listed above assessed.

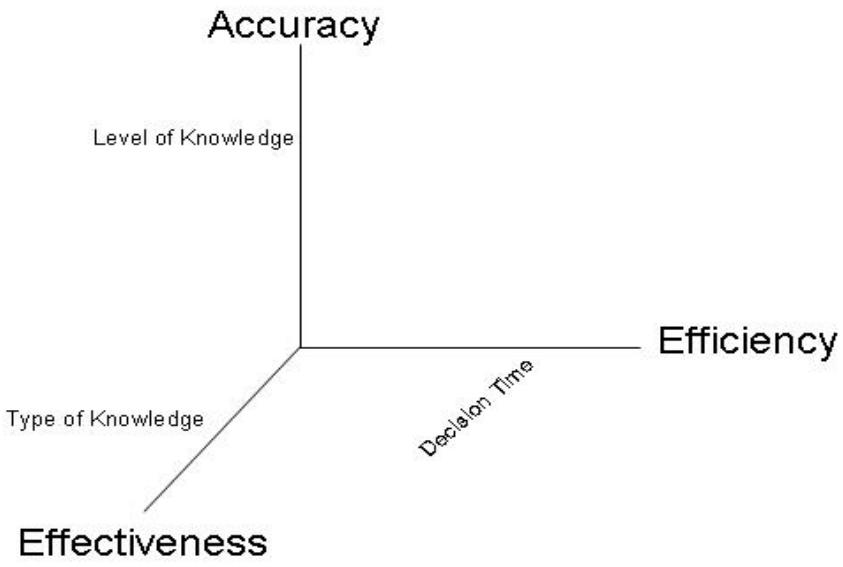
Certain relevance would be placed on knowledge and its use as we see this as the foundation of the new decision support system. The standard to be measured against would encompass accuracy, efficiency, and effectiveness.

This raw data can then be analyzed to give a statistical grounding in the development of our new model (Post-experimentation phase).

In effect, what we are looking for is a standard of fitness based on the scenario in which the goal is the identification of key attributes which support the need for a new network centric model.

The resultant data can then be mapped to a multidimensional visualization in order to tease out the requisite characteristics for each model as it applies to each scenario.

Multidimensional Visualization Matrix of Outputs



Limitations

- The Network is Impersonal
  - Information and Data are Easy
  - Transfer Bits and Error Checking
- Knowledge Transfer is Personal
  - Tacit vice Explicit
  - Hardest to Transfer (Nissen, 2006)

Implications for Future Research

One area that we believe to have special importance is the nature of the knowledge flow as it pertains to the boarding party and its relationship with the C2 nodes spread out across geographical boundaries.

The study of this ecology presents a perfect opportunity to identify the use of links to channel this flow across the various human and machine expert systems in addition to the primary “actioners”.

We intend to use the three scenarios as a chance to “map” these knowledge flows. This also has the advantage of identifying or ‘pointing” to those individuals who maintain tacit knowledge repositories in addition to those explicit knowledge clumps that are to be expected.

Further Research

Finally, there is a valid need to look into the work of Briggs and Nunamaker at the University of Arizona. Specifically, the field of **Group Support Systems** and it's relevance in the asynchronous virtual world of tactical operations and crisis management.

It is believed that once the technology matures to a point where it can support graphical intensive knowledge exchange in near to real time, that this may produce some interesting enables to support our work.

Questions and Comments