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Concept of Deployable Network Operations Center (DNOC)

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ABSTRACT

The movement and collaboration of information has never before been more important to the success of tactical missions. Advanced mobile and wireless networking technologies have the capability to put critical information at the fingertips of the operator, enabling tactical units to successfully carry out their missions. The increasing use of expeditionary and special operations forces in ad hoc, dynamic, and tactical environments poses a need for an adaptable, flexible, and responsive deployable network operations center (DNOC) to support their efforts. Whether co-located or virtual, the DNOC must support tactical units by supplying them with the right information, at the right time, and in the right format. This platform must also provide a rapid, reliable, and secure communications network so forces can collaborate in a manner which builds quality interaction and trust.

INTRODUCTION

The Naval Postgraduate School's (NPS) Tactical Network Topology (TNT) program is in the final process of implementing a DNOC to support tactical information transfer across a tactical networking testbed. In order to support and bring the DNOC concept to fruition, TNT has invested time and resources by making infrastructure improvements and equipment modifications to a double-wide trailer located at McMillan Airfield, Camp Roberts, CA. Within this DNOC, researchers can study and identify: 1) business processes wherein two or more users collaborate together and agree upon a course of action; 2) the negotiations between the suppliers of information and the users of information; 3) the utility of that information in helping tactical users coordinate their efforts; and 4) the roles, functions and tasks that support rich interactions among manned/unmanned sensors and decision makers.

Background

NPS's applied research, TNT, is a tactical networking testbed that is used to evaluate the effects of emerging technologies that may very well influence, shape, and transform the nature of future tactical operations. The eventual impact of TNT's research testbed redefines how specific innovations in mobile sensor and wireless networking technologies are discovered and demonstrated in terms of their potential to improve tactical mission capabilities. TNT is well-suited to study and support the ad hoc and expeditionary nature of tactical operations. This testbed provides a platform for network centric operations (NCO) field experiments and is also the subject of many of those experiments. TNT's primary research objectives are: 1) To pursue vigorous efforts aimed at the conceptualization and hypothesis testing of new wireless-sensor capabilities that allow us to better leverage the characteristics inherent in NCO; and 2) To focus attention on discovering interactions among sensors and decision makers that are necessary to generate synergistic effects. TNT strives to demonstrate shared perceptual awareness and trust by supporting communications, negotiations, and coordination amongst tactical operators within a wireless mesh network of mobile operators, platforms, and sensors.

TNT provides analytical background and hands-on experience with management systems and management infrastructures that integrate into the global information grid architecture. TNT targets support to manned and unmanned sensors, Network Centric Enterprise Services (NCES) as well as terrestrial, satellite, and mobile wireless network operation centers. Researchers and students look at fixed, vehicle-based, and man-portable network operations center solutions. Additionally, a significant effort is placed on research that supports the management challenges associated with the deployment of adaptive, self-forming/self-healing, mesh networks comprised of unmanned vehicles, sensors, and geographically dispersed operators. The TNT program is managed by a distinguished team of investigators – Dr. David Netzer (field experiment coordinator), Dr. Alex Bordetsky (network grids architect) and Mr. Eugene Bourakov (network systems engineer). The TNT investigators routinely conduct research in the following areas:

- Self healing and self organizing wireless networks
- Protocols and technologies for mesh networking
- Middleware services for collaboration in tactical environments
- Manned/Unmanned Sensor networks
- Security in ad hoc networks
- Policy based routing with QoS reliability and availability

Although the primary purpose of this research is to evaluate emerging networking technologies, the TNT campaign provides opportunities to conduct the three distinct types of experimentation: discovery, hypothesis testing, and demonstration. The primary deliverables from TNT includes: 1) A set of tools and methodologies encapsulated in a well-defined conceptual framework; 2) A set of studies that demonstrate the suitability of emerging sensor and network technologies for operational evaluation; and 3) A repository of networking scenarios, multi-criteria analysis measurements, and models. This effort substantially leverages existing network centric experiment campaign research funded by SOCOM, OSD and OFT.

Problem

The pressure for organizational change and transformation of current TNT management processes, as sufficiently surveyed by Kristina Jeoun in her thesis work concerning a facilitator's role in a tactical sensor-decision maker networks, calls for a new approach to network and sensor management (Jeoun 2004). As well as our hypothesis (based on observations during TNT 05-1 and 05-2) that the real advantages of distributed manned/unmanned teaming efforts, will only be realized through a better understanding of how deployable NOCs will support mobile tactical unit's work processes and procedures (Johnson and Thiry, 2004). It is also necessary that we include in our conjecture the role of social, cultural and cognitive domains associated with the physical and/or virtual working environments.

Inherent with combining new technologies with mature technologies, we are faced with complex problems of the character and volume of knowledge that the researcher and student must possess in relation to the number of dependent and independent variables. Given the variety of disparate sensors and wireless technologies involved with TNT experiments, neither the researcher nor the operator is capable of assimilating all the information visualization necessary to achieve shared awareness of every event scenario. To substantiate the impact of information visualization impact on mission effectiveness, the Defense Advanced Research Projects Agency (DARPA) conducted a number of experiments within its Command Post of the Future (CPOF) program. These experiments demonstrated that:

1. Better information visualization tools increase situational awareness.
2. Collaboration and shared information visualizations increase understanding.
3. Increased shared awareness and situational understanding increase the likelihood of mission accomplishment. (Kirzl 2001)

Motivation

There is no need for a lack of shared awareness and robustness when using the full potential of integrated and deployable Audio-Visual/Multi-Media (AVMM) NOC. Scenario information and experimentation goals may be quickly accessed, with drill-down detail, and may be obtained in a form most suitable for rapid assimilation. We do not purport that the fusion and display of tactical sensor and network management information replaces or supplants innovation. Rather that, integrating information to support rapid pre-attentive cognitive processing, carries collaborative innovation and creativity to a higher, more functional level. This integration uses and extensively applies the results of innovation, makes its application accessible, and converts it to productive and performance-capable action. The design, build and fielding of an integrated DNOC requires a baseline infrastructure; leveraging the flexibility and adaptability necessary to respond to future TNT program upgrades and end-user needs.

Our charter was to design, develop and implement a DNOC inside a double-wide trailer located at McMillan Airfield, aboard Camp Roberts Army National Guard base, in central California. Current TNT field experiments required significant power, processing, networking, and cabling in order to effect integration with the various components and participants in an ad hoc experimental environment. Anticipating these requirements would increase in the future, the DNOC maximized the use of increased power distribution, server, network upgrades, and furniture with integrated cable management. The hardware and furniture were purchased as individual, man-portable components, lending "deployability" to the NOC. The conceptualization of a deployable network operations center was based upon an extensive survey of both civilian and military mobile command and network operation centers, DARPA’s CPOF, and virtual learning environments (VLE). The design process required close communication with all project team members to ensure the design satisfied the end-user requirements and sponsor’s resource constraints. Additionally, we approached this project using incremental and co-evolutionary strategies in our development efforts.

Challenges

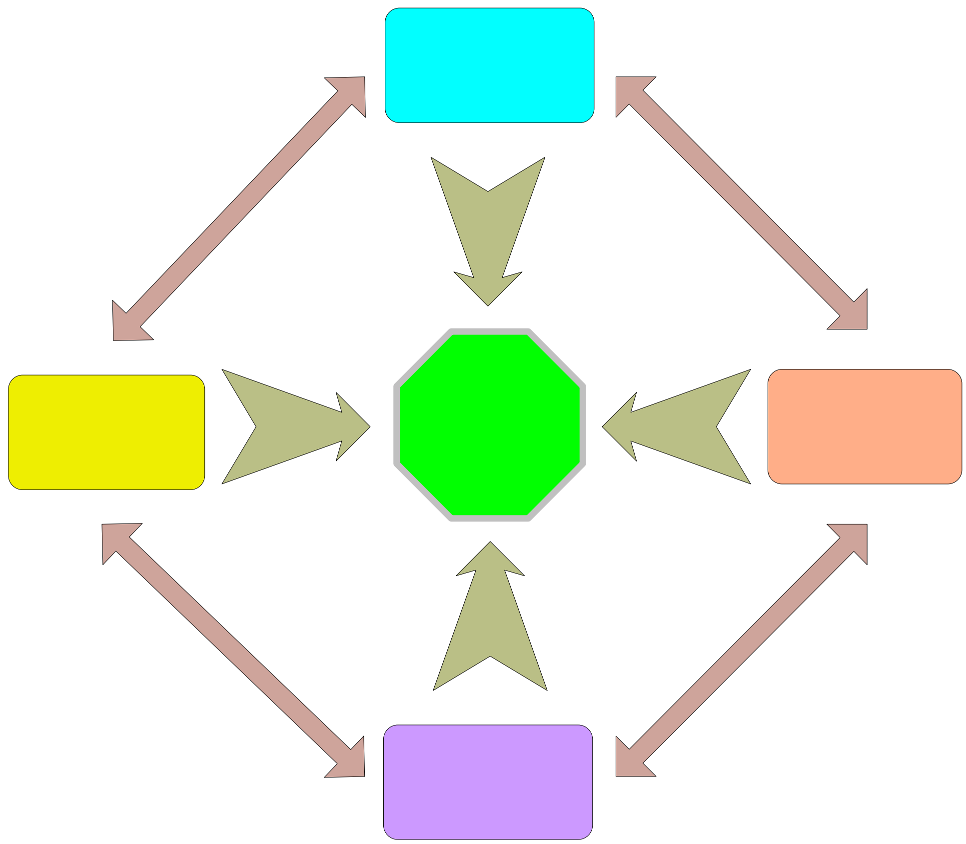
The challenges and opportunities associated with this project were to deploy a DNOC that had capability and the functionality to:

1) Fuse and place information in appropriate contexts, and present the information in ways to facilitate rapid and accurate inferences;
2) Increase efficient pre-attentive cognitive skills by integrating and managing information at the right level of abstraction to meet users’ needs;
3) Present users with accurate network fault, configuration and performance information when the sources may have substantial errors and/or suffering from gradual degradation;
4) Integrate information from large numbers of dynamically changing, inconsistent, heterogeneous sensors, collaborative SA agents, and network management agents
5) Provide rapid, accurate, automated site monitoring using imagery from UAVs, UUVs, mobile manned/unmanned tactical units, and balloons.

Methods

It was important to us to use design tools typically found in the operating forces, such as MS Visio and Project, and apply a collaborative approach to identifying innovative solutions. It was necessary to redesign the AVMM configuration of the current facility to improve efficiency and effectiveness of monitoring and managing TNT’s tactical sensor-decision making network operations.

The preparation and design decisions concerning the DNOC required a model that aided us in instantiating substantive requirements and the integration of TNT goals. We constructed a rough conceptual framework by which our decisions were prepared and formulated. The current TNT conceptual framework, as depicted in Figure 1, models four mesh-like confluence nodes that leverage value-added information between each node through transactional links.



The confluence nodes consist of: business processes & rules, organizational & informational structures, emergent & existing information technology, and knowledge & information management. As shown in the figure, the confluence nodes are connected by transactional links that represent conduits for communication, negotiation and coordination processes that enable interoperatability among the nodes.

This model is classified as a bottom-up, functional aggregation of components and attributes, structured to provide the supporting elements of interdependent discovery, hypothesis testing, and demonstration during TNT experimentation campaign. At a high level of abstraction, one can view the conceptual framework as an integrated network of transactional and transformational mechanisms that influence, shape and information. This conceptual framework became our DNOC's functional baseline. When this baseline is combined with advanced capabilities for intelligent network and sensor management, it will provide end-users with the flexibility to tune the infostructure and synchronize information transport and processing with tactical sensor-decision making operations.

Our point of departure for the DNOC project was to build a prototype that fosters and facilitates innovative concepts, improves collaborative dynamics, and inserts new and emerging technologies. This infrastructure needed to support the TNT experimentation campaign concerning discovery, hypothesis testing, and demonstration as outlined by Alberts' and Hayes' draft report "Campaigns of Experimentation - Pathways to Innovation and Transformation". The DNOC's purpose was not only to support tactical sensor and network decision making, but to make it possible to liberate TNT participants from manual administrative tasks and allow the intellectual activity of the experimenters to be applied to the process of developing sensor-network configuration, performance, and fault management mission capable packages. Complete liberation is the ultimate objective, and the level of liberation serves as a measure of DNOC success.

We recognized up front and early that the explosive growth of network and tactical information has clearly demonstrated the need to organize, filter, and present information in a more user-friendly way. New techniques and tools were needed to enable users to navigate, control, and understand network applications within the complex tactical sensor and network operations environment. We sought to procure technology that would enable TNT facilitators to readily access value-added information and present that information for immediate collaboration to those working in and outside of the DNOC.

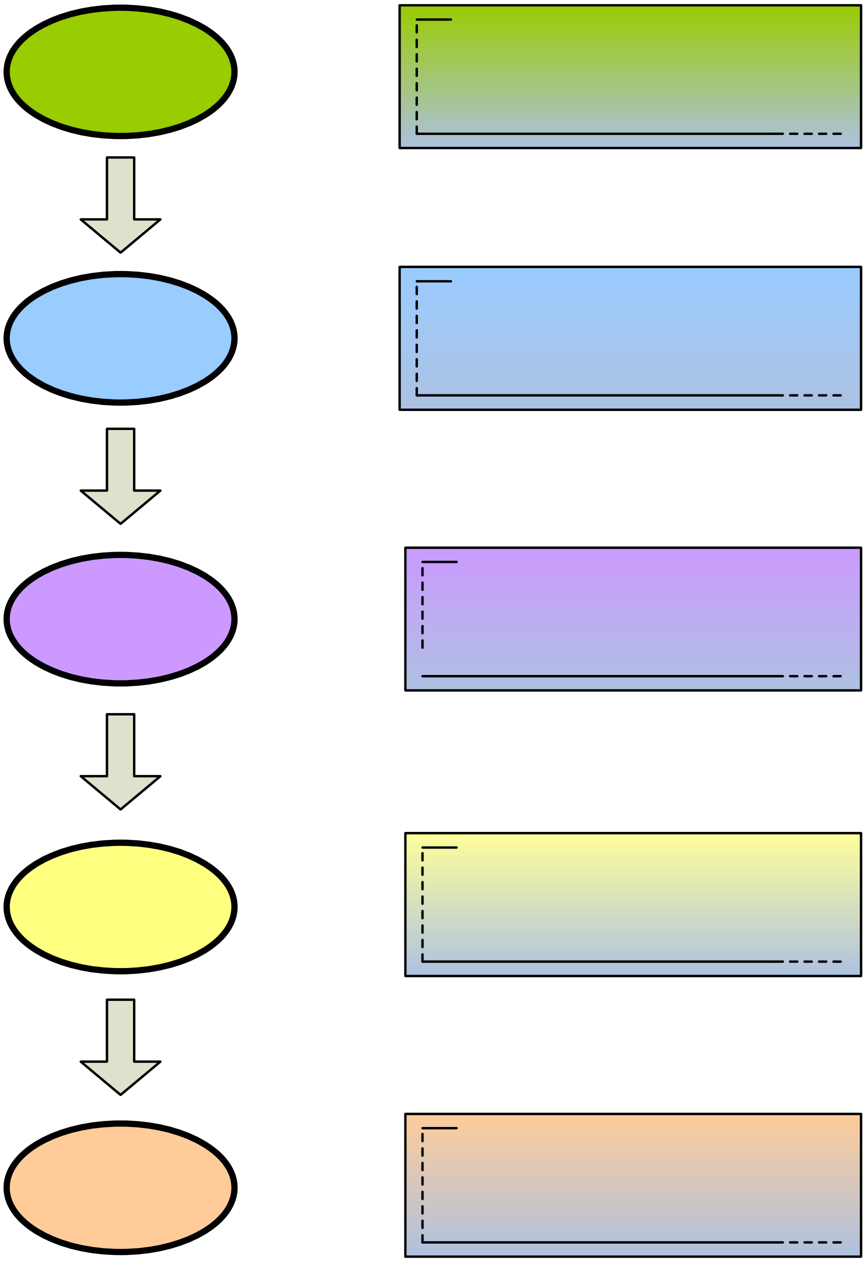
Since TNT field experiments vary in size and scope, no optimum display capability could be procured. To meet the varied demand a combination of large (50”) plasma screens and computer projectors with pull-down screens were installed. The same held true for workspace/work surface for experimenters and their associated equipment. Compromises were made in storage and space; which enabled portability, cable management and sufficient area to accommodate current and future needs. The result was a DNOC that satisfied the following design criteria:

- Deployable/Tactical Infrastructure
- Field-deployable Kits
- Flexible and Adaptable System with Interchangeable Parts
- Expeditious Setup and Tear-down
- Scalability To Meet Current and Future Experiments
- Enable Multi-disciplinary Collaboration
- Promote Real-time Decision Making

We approached the project by applying systems engineering, program management and acquisition principles in the concept, design and build construct as illustrated in figure 2.

Five design considerations were applied during the DNOC development process:

1) Operation and impact of current NOC during field experiments
2) Anticipated operation and impact of DNOC during field experiments
3) Availability of resources to meet budget and schedule constraints
4) Life Cycle Maintenance required to support and upgrade DNOC
5) Training required to ensure proper use of the DNOC



PROPOSA

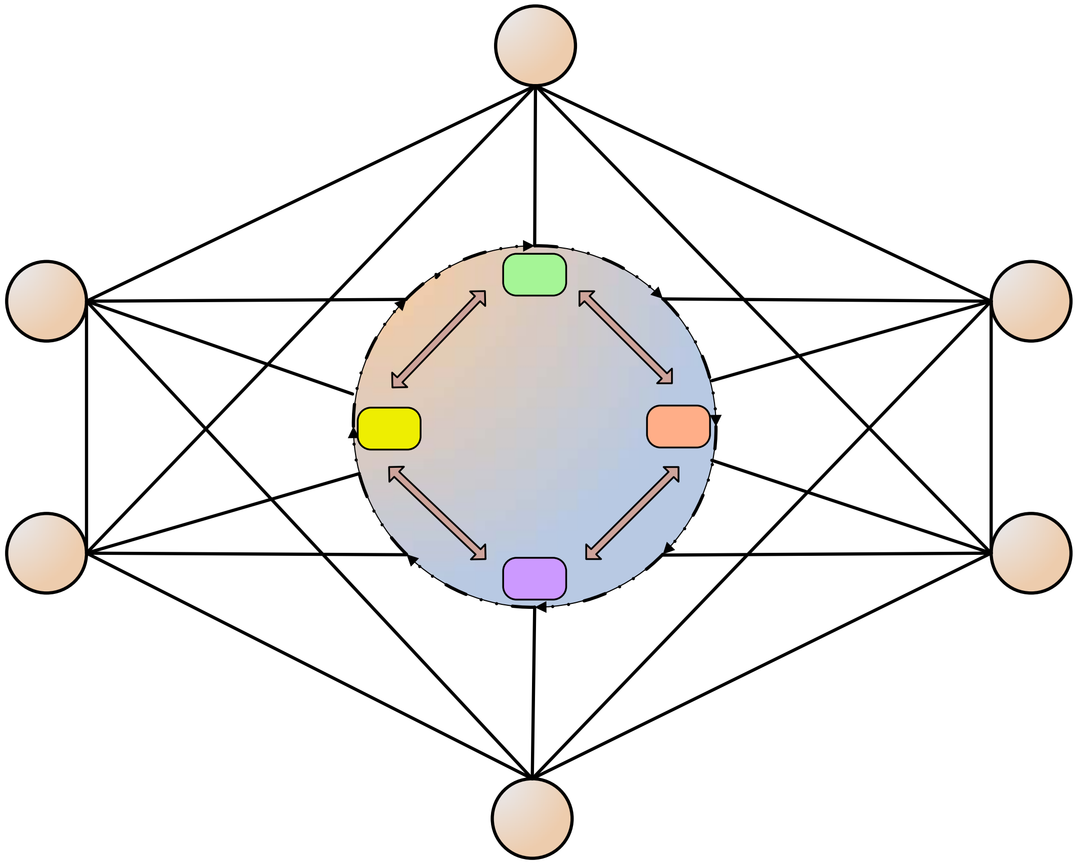
DESIGN

In previous field experiments, the information was displayed using computer projectors and pull-down screens. We sought to improve the information display quantity and quality by incorporating five plasma screens. Plasma screens are easier to set-up (no concern for focal length), provide a sharper image and experience minimal washout due to ambient lighting. Additionally, the dimensions of the DNOC were such that the maximum distance any participant would be from a display was no more than 20 feet, 50” screens provide sufficient size and resolution for all but the smallest text sizes. The DNOC team contracted the technical services of Media Systems Group Ltd., an audio-visual integration firm, to install the plasma and projector display equipment. The DNOC displays will allow operators to see more details with better clarity, facilitating rapid assimilation of visual information. The plasma displays can accept numerous input modes (RGB, DVI, etc.) and can be optionally configured to display these feeds in a multi-screen matrix format. This functionality improves the users’ ability to manage data sets and video streams from multiple sources.

Components obtained were integrated with current TNT equipment to provide maximum scalability to support configurations required for future employment and upgrades. The majority of components integrated were commercial off the shelf and open architecture items that require little or no modification. Contractors were leveraged to provide installation, on-site technical and life-cycle support; minimizing a large logistical footprint. While no requirement for ruggedized (MilSpec) equipment or transit cases was articulated, components were purchased that allowed for not only portability but durability as well.

Benefits

The DNOC’s design framework is a flexible and modular design that can expand and accommodate a wide variety of communication protocols. The DNOC design attempts to simplify the automation and integration of audio-video, network and communication technologies through intuitive user interfaces. As illustrated in figure 3, the DNOC serves as a deployable facility that can mesh with other fixed and mobile NOCs, manned/unmanned vehicle sensors, and decision makers. Examples include the NPS Global Information Grid Applications Lab (GIGA Lab) fixed NOC, a future sea-based NOC aboard commercial diving vessel Cypress Sea, ground-based mobile Light Reconnaissance Vehicle (LRV), and man-packable NOCs.



TNT's mesh network of Deployable NOCs will encourage research in a variety of disciplines. With diverse ad hoc technologies emerging, the TNT team seeks to aggregate and exploit key elements of these technologies, as well as study the qualities of the communication protocols. It is analogous to the concept of studying human behaviors that emerge during communication, negotiation, and coordination processes. TNT experimentation continues beyond the discovery and hypothesis testing phases of experimentation and facilitates the demonstration of refined operational concepts.

Conclusion

Future researchers and students can use the DNOCS to study new protocols in an effort to exploit emerging technologies. These infrastructures offer a research platform to study both local area and long-haul wireless capabilities with open-system standards. Additionally, these DNOCs will support a repository of wireless networking scenarios, performance capability packages, network and sensor modeling. Although there will be considerable opportunities to study the behavior of wireless mesh networks, there also now exist a testbed to research human teaming efforts involved in tactical sensor-decision maker networks.

The DNOC will provide a unique plug-and-play environment for TNT experiments involving ad hoc networking. It will facilitate discovery and exploration of different technologies and protocols. The DNOC's AVMM system will be easy to deploy, manage and operate. All of which translates into increased collaboration and productivity, greater flexibility, faster decisions, lower costs and improved interactions.

ENDNOTES

Kirzl, J. Code of Best Practice for Command Post of the Future. Vienna, VA: EBR Publishing, 2001.

Jeoun Kristina S. "The Tactical Network Operations Communication Coordinator In Mobile UAV Networks" Monterey, Naval Postgraduate School, 2004.

Johnson, Shawn E. and Thiry, Jeff A. "TNT Concept of Baseline Operating Processes - A Snapshot Observation & Overview" Monterey, Naval Postgraduate School, 2004.