Thoughts On: Future Army Tactical Networks

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Mission:
To develop and integrate Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) Technologies that enable Information and Cyber Dominance and Decisive Lethality for the Networked Warfighter.

Vision:
To employ the imagination and innovation of this nation’s brightest professionals to provide America’s brave sons and daughters with the most effective solutions to ensure mission success and their safe return home.
Vision:
The DoD leader advancing innovative technologies to ensure networked Warfighter dominance.

Mission:
Research, develop and evaluate trusted communications and networking technologies to transition operationally relevant solutions to the Warfighter through employment of a dedicated and superior workforce, world class facilities and global partnerships.

Leveraging Technologies World Wide
Challenges
- **Operational Complexity (OC)** – while the network is extremely complex, it should not be operationally complex nor should it be complex to use. The Tactical Internet (TI) is too complex (using manual and static methods) to configure. The TI needs control algorithms to be able to adapt to demands placed upon it by mission (e.g., mobility), by data dissemination (e.g., applications) and by policy for all deployment scales.

- **Limited Throughput to Tactical User (LT)** – given our current deployment engineering rule, our LTI platoon radio networks provide limited per-user throughput. This throughput limit needs to be increased.

- **RF Interference (RFI)** – systems within the Tactical Internet need better integration for improved SWAP and simplification of operation within the Tactical Internet. Robust waveforms must be maintained and improved to meet future jamming challenges and future LPI/LPD requirements in the presence of Blue EW and Red EW.

- **Non-Convergence on Tactical Internet (NC)** – the Army’s prominent tactical applications require improved network services for full integration on our IP-based Tactical Internet.

- **Dis-contiguous Architecture (DA)** – the architecture has developed through multiple acquisitions.

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**SoS Challenges Characterized into These Broad Problem Areas**
• **Simplify Management and Operations**
  - Common data models
  - Common management protocols
  - Move towards improved automation, e.g., new control protocols
  - Promote Mobile Ad-Hoc Network (MANET) standards

• **Refocus on Robust Basic Capabilities**
  - Robust Voice, PLI and limited C2 to the soldier
  - Improved LPI/LPD operation in denied environments

• **Modularize the Architecture**
  - Common network protocol layers
  - Swap-able MAC/PHY ‘waveforms’

• **Improve Frequency Efficiency**
  - Better frequency reuse and coordination between RF systems
  - Frequency agile RF systems
Architectural Improvements
Future architecture be dominated by:
- A single, flat, scalable, non-hierarchical Black-side network structure
- A single, multilevel secure, network architecture
- Consistent solutions to common networking challenges

Current architecture is dominated by:
- HAIPE layered and dis-contiguous Black-side networks
- Hierarchical network structure for scalability
- Inconsistent solutions to common networking challenges, e.g.,
  - HAIPE
  - QOS (forwarding, precedence and preemption)
Recommended

- Standards based radio management model that simplifies radio configuration
- Common NetOps tool that integrates multiple radio management clients
- Common, standards based API’s to enable interface to radio management model and NetOps tool

Current

- Each Radio/waveform has its own Management Client and Architecture
- Each radio has 1000’s of parameters that have to be set
- Cannot manage across the HAIPE boundary
- Each radio has its own terminology, i.e. data model

Past attempts to fix have focused on the NetOps side only

To be successful the fix needs to be applied at both ends
The creation of a common operating environment allows for improved software reuse and collaborative software development.

The common operating environment makes for ease of porting across multiple hardware platforms and implementations.

The ‘Application Software’ in the figure covers Software Defined RF code which runs in the GPU and FPGA and RF-HW hardware.
Nodal Architecture Evolution: a Common MANET Stack

**Current Waveform Architecture**
- Reliance on stove-pipe architectures and monolithic waveforms

**Objective Waveform Architecture**
- Reliance on common network infrastructure and modular waveforms

Diagram:
- **Common Protocol Architecture**
  - Voice
  - PLI
  - C2
  - Data
  - SA
  - EW

**Internet Networking**
- Convergence layer for non-IP

**Resource Allocation**
- Narrowband Voice
- SRW
- Directional
- WNW
- LTE
- PHY/MAC
Network Abstraction Layer

Similar to commercial networks; a common network capability with plug-ins for RF (waveforms):

- The Common Network Protocol Stack (CNPS) runs in application software.
- The Network Abstraction Layer (NAL) hides the complexity of the lower level SDR functions from the upper layer protocol stack through a well defined open Layer 2 Service Interface.
- This level of abstraction allows for ease of portability of the CNPS onto new SDRs and allows the network to be somewhat agnostic to the underlying radio technologies.
- The NAL is to be based upon an improved Internet Protocol layer.

- Define a target architecture which identifies a Lower Tactical Internet (LTI) based upon an improved, open, standard-based Internet Protocol to meet Military Unique Requirements.
- Define a target architecture which naturally integrates the LTI into the GIG Enterprise Network at high echelons.
- Develop a well defined Service Interface between the NAL and the lower level SDR networking.
- Allows for the SDR to be tailored to the specific environmental requirements such as range, LPI/LPD, …

Disambiguate the upper level CNPS from the lower level SDR implementations - similar to a smart phones use of LTE, or Wifi, or Bluetooth, …
Few Standards Exist for MANETs

Standards defined

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Example Technology Advances
Improved Throughput via Protocol Efficiencies

Improved throughput via new and efficient networking control protocols for:
- PLI information broadcast
- Topology flooding for dynamic routing
- HAIPE discovery through multicast
- Combat Radio Network dynamic slot allocations and multicast operations
- Re-architecting the protocol stack

Re-architect Nodal Protocol Stack based upon:
- Requirements of the critical tactical applications
- M&S evaluation of protocol performance in range of representative scenarios

PLI Broadcast on the current LTI

11 (or 22 with ACKS) transmissions

Efficient PLI Broadcast using minimum Connected Dominating Sets (mCDS)

5 transmissions

Near-Term Reworking

e.g., Improved Networking Control Algorithms
Directional Networking offers several advantages for the Army, including:

- Higher data rates
- Higher Spectrum reuse (spatial)
- Reduced Mutual Interference
- Extended Reach
- Better LPI/LPD
- Targeted EW
• Initial Target Scenario is U.S. Army Brigade Tactical Internet (TI)
• Quasi-Hierarchical Topology
• Minimal Configuration Parameters
• Loop Prevention
• Support for Policy
• R&D Challenges:
  – Tracking subnet and nodal mobility
  – Lack of prefix aggregation
  – Limiting control overhead
  – Securing the system
Improved Network Services for Better Core Application Handling

End-to-end QOS and Precedence and Preemption Handling

Replace Layer 7 GWs and integrate separate SatCom transport

Transport Layer suitable for disruptive and lossy tactical networking environments

C2 applications running over separate radio networks

Lacking critical networking services, e.g., lateral routing, any-casting, for tactical application convergence

C2 applications down at the tactical edge
• Challenging network environment leads to link and network disruptions
• Need to develop a robust DTN-based transport service
• Requires solutions to addressing, routing, management, discovery and forwarding/QOS
• Not your fixed, high speed network environments found in commercial deployments
  – Brings with it a wealth of engineering and R&D challenges

• Mobile Ad-Hoc Networking is still in its infancy
  – Need more field and operational experiments and data analysis
  – Exciting times ahead as we gain more practical experience with larger field tests and deployments

• Moving towards more commonality for improved efficiency and simplified inter-operability
Questions?

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