FNT-09-02 Dynamic Tactical Communications Networks (DTCN) EC Technology Overview & BAA Topics

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Outline

- Major DTCN Features
  - BAA Topic Overlay
- Notional DTCN Architecture
  - Traffic Management Features
  - Edge Network and Tactical Core Factors
- Transport Layer for Dynamic C2
- BAA Topics
Major DTCN Features

Policy-Directed Traffic Management:
- Communication Requirements by Mission
  - Multiple applications
  - Criticality tiers
  - Vary by mission phase
- Aggregate along command hierarchy
  - Inter-mission deconfliction
  - Granularize at top-level
- Actionable, network-wide traffic management policy

Assured Information Exchange Aligned to Traffic Management Policy:
- Queuing/routing to maximize most critical IERs
  - Most critical IERs may even be flooded
- Reactive to Dynamic Network Conditions
  - Traffic, bandwidth, topology, etc.
- Multiple techniques:
  - Strict priority queuing
  - Adaptive Routing
  - Route control agent
  - Future Performers (BAA Topic)

General Infrastructure (i.e., maintain degraded capability):
- MANET Routing Enhancements
- Radio-Router Interface
- Autoconfiguration
- Dynamic Routing Across INEs
- Linux-Based Router Platform

Address Performance Metrics:
- Network Scalability (300 nodes)
- Config/Reconfig Time (2 min/30 sec)
- Join/Leave Time (5 sec)
- Security Enclave Mobility (20 sec)

Self-Organizing Networks (SON)
Assured Information Exchange (AIE)
Policy-Directed Traffic Management:

Tools to Manage and Monitor Coherent Application Prioritization
Develop, maintain and disseminate TM Policy which reflects and deconflicts Commander's Intent. Monitor system performance relative to this TM Policy.

Assured Information Exchange Aligned to Traffic Management Policy:

Dynamic Routing QoS Traffic Class Mechanisms
Service tiers with varying likelihood of message transfer success. Reactive to network state, TM Policy configuration, and offered traffic load. Packet duplication over independent paths is one example.

General Infrastructure (i.e., maintain degraded capability):

Heterogeneous Routing Architectures
To include heterogeneous radio technologies, multiple Tactical Cores, asymmetric, and simplex links. Consistent with system-wide prioritization objectives. Self-configuring and adaptive with minimal human intervention.

Self-Organizing Networks (SON)
Assured Information Exchange (AIE)
Assured Information Exchange (Above the Network Layer)

Serverless (Group) Communications
Either peer-to-peer or group communications that function without statically configured servers. Specific considerations include limited bandwidth, intermittent communications, ease of use.

Transport Protocols for Highly Asymmetric Networks
Asymmetry may be due to underlying network capability, or due to residual capacity for a given priority tier.
Purpose of This Notional Architecture

- Identifies discrete points where *DTCN capabilities* could be deployed so that:
  - Performers can express product value against a commonly understood architecture
  - Performers can appreciate INE implications
  - Integration discussion can proceed

- Can be varied to accommodate certain unknowns without significantly disrupting the relationship between DTCN components
  - Identify certain unknowns
  - Confirm the architectural independence to unknowns
  - Move on...
DTCN Notional Architecture

Selected Edge Networks may utilize DTCN MANET Capabilities, and may permit end-host mobility (USMC)

DTCN “Edge Capabilities”

DTCN “Core Capabilities”

Tactical RF Links / Subnets Throughout DTCN Core Network

DTCN Must Function Despite Loss of WAN and WAN-hosted Services.

Core Network, WAN (CT) (i.e., ADNS, DISN, etc.)

NOC, etc.
Tactical Core is inclusive of N6 Vision for Core Tactical Edge Networking within the AOR.
DTCN Notional Architecture

Selected Edge Networks may utilize DTCN MANET Capabilities, and may permit end-host mobility (USMC)

DTCN “Edge Capabilities”

DTCN “Core Capabilities”

Tactical RF Links / Subnets Throughout DTCN Core Network

DTCN Must Function Despite Loss of WAN and WAN-hosted Services.
**Architectural Features: AOR–Wide Traffic Management**

- Queuing/routing(*) to maximize highest priority IERs
  - Highest priority IERs may even be flooded
- Each mission IER is broken into tiers:
  - Traffic flow bounds
  - Abstract priority level
  - “Mission Impact” statement
- Aggregate per Commander’s Intent:
  - Cross-mission priority mapping (i.e., deconfliction)
  - Result: AOR–wide network flow prioritization
- Performance monitoring indicates “Mission Impact”
- Mission–phase dependent

(*) Includes load-balancing.
Note: 10 to 30 priority classes.
Architectural Features: AOR–Wide Traffic Management

Note: 10 to 30 priority classes.
# Architectural Features: AOR–Wide Traffic Management

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<tr>
<td>P₁</td>
<td>Highest</td>
<td>Only Most Stable Links</td>
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<td></td>
<td>61: P₁ Control Plane</td>
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<tr>
<td>P₂</td>
<td>High</td>
<td>Only Highly Stable Links</td>
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<td></td>
<td>59: P₂ Control Plane</td>
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<td>⋮</td>
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<tr>
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<td>Low</td>
<td>Most Links</td>
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<tr>
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<td>Lowest</td>
<td>All Links</td>
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<td></td>
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<td></td>
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<td>0: Pₙ Data Plane</td>
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Note: 10 to 30 priority classes.
A Challenging Environment

Architectural Features: Edge Network Edge Router (ENER)

- Tactical Core Reachability
- INE PT/CT Address Mapping
- Policy Enforcement Points
  - Traffic Policing and Remarking
Architectural Features: Tactical Core

- Tactical RF links interconnect routers
- Priority queuing by DSCP value
- Routing to maximize likelihood of high priority traffic flows’ delivery
- Independent of WAN
  - Operation
  - Design
- Likely operated at SECRET
  - Communication Requirements (TM Policy)
  - Mission phase
  - DSCP bypass
  - Type 1 link encryption likely required
FNT-09-02 Dynamic Tactical Communications Networks (DTCN) EC Transport Layer Efforts (with FNT-09-04 EC)

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FNT 09–02 Inter–EC Coordination (Transport Layer Efforts)

- C2 Transport Layer (priority–enhanced NORM)
  - Priority–Queued Application Messages
  - Multi-level Network QoS/Priority Marking

- C2 Video Transport
  - Adaptive to C2 Network Dynamics
  - Multi-layer fidelity encoding
  - Encoding aligned to network QoS/Priority Marking
## Notional C2 Priorities: Tracks

### Information Priorities

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<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
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<td>2</td>
<td>3</td>
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### Classification and Type Priorities

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<th>Sub</th>
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<th>UNK</th>
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<td>2**</td>
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<tr>
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<td>3</td>
<td>NA</td>
<td>3</td>
<td>NA</td>
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<tr>
<td>Suspect or Hostile</td>
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<td>1</td>
<td>1</td>
<td>NA</td>
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<tr>
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<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unknown or Pending (outside OPAREA)</td>
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<td>1</td>
<td>3</td>
<td>3</td>
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</tbody>
</table>

*Priority = 1 if track age > 30 minutes

**Priority = 1 if track age > 10 minutes

Source: Dynamic C2 EC “Information Priorities.”
Intended for experimental evaluation use only.
## Notional C2 Database with Transport Layer Control & Status

<table>
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<tr>
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<th>y</th>
<th>z</th>
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<th>rowid</th>
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<th>tx_priority</th>
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<td>10600</td>
<td>9500</td>
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<td>345</td>
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<td>10210</td>
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<td>100</td>
<td>11075</td>
<td>-</td>
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</table>

### Application Data

### DBMS Operational Data

### Transport Control

### Transport Status (*)

(*) Transport Status should be multi-valued to reflect Application Data versions.
Notional C2 App. With DTCN

Notional C2 Application

Enh. NORM Rate=$R_a$
DSCP=“A”

Enh. NORM Rate=$R_b$
DSCP=“B”

Enh. NORM Rate=$R_c$
DSCP=“C”

DTCN Traffic Management Policy Store

Policy May Affect Application Configuration

DTCN Policy Enforcement Point
(e.g., two rate, three color, color-aware policer)

Packet of size $B$?

 violated color marking?

Violate

Viole

Exceeding color marking?

Yes

Yes

Re-Mark

DSCP=$P_{10}$

Re-Mark

DSCP=$P_{5}$

Re-Mark

DSCP=$P_{3}$

No

No

No

$T_p>B$

$T_c>B$
Enhanced NORM for C2: Fits into DTCN Prioritization Tiers

Mission 1
- Chat A
- VoIP C
- SA B
- ISR Video H

Mission 2
- Chat D
- SA E
- e-mail F

Mission 3
- Chat G
- SA H
- ISR Video I

Mission 3
- ISR Video I

Fleet Command

Criticality of Function
- Most
- More
- Less
- Least

Note: 10 to 30 priority classes
Enhanced NORM for C2 App.

C2 Application

Priority Queue

DTCN Traffic Management Policy Store

Policy May Affect Application Configuration

Enh. NORM Rate=$R_A$, DSCP="A"
Enh. NORM Rate=$R_B$, DSCP="B"
Enh. NORM Rate=$R_C$, DSCP="C"

DTCN Policy Enforcement Point
(e.g., two rate, three color, color-aware policer)

Packet of size $B$

Violating color marking?

$T_p > B$

Yes

No

Re-Mark DSCP=$P_{10}$

Exceeding color marking?

$T_c > B$

Yes

No

Re-Mark DSCP=$P_{5}$

Conform

VioLate

$T_p > B$

No

Re-Mark DSCP=$P_{3}$

Cancel Messages

↑↓ Reprioritize Messages
Example C2 Priorities: H.264/Scalable Video Coding
H.264/SVC Video Example

- See video outside of PowerPoint
  “Vidyo vs. Legacy H.264 comparison video (HD).mp4”

- Note, packet loss is unbiased in video. In our LTE thread (and in DTCN), packet loss will be biased toward less-critical data tiers.
C2 Video with Enhanced NORM

- Cancel Messages
- Up/Down Reprioritize Messages
BAA Topics

Assured Information Exchange (Above the Network Layer)

- Serverless (Group) Communications
- Transport Protocols for Highly Asymmetric Networks

Policy-Directed Traffic Management:

- Tools to Manage and Monitor Coherent Application Prioritization

Heterogeneous Routing Architectures

Assured Information Exchange Aligned to Traffic Management Policy:

- Dynamic Routing QoS Traffic Class Mechanisms

General Infrastructure (*i.e.*, maintain degraded capability):

- Self-Organizing Networks (SON)
- Assured Information Exchange (AIE)
DTCN Goal: Maximize the delivery of mission critical IERs over an unpredictable and highly dynamic environment to meet Commander's Intent.

Traffic Management (TM) Policy represents:
- Accurate and actionable mission requirements
  - Multiple applications
  - Broken down by priority tiers
  - Mission impact statements per-tier
- Multiple concurrent missions
- Multiple mission phases (per mission)

TM Policy…
- Must be disseminated over the network
- Is the optimization objective for components & overall system

Performance monitoring is relative to TM Policy
- E.g. alerts cite “mission impact statements”
SON Topic 2: Heterogeneous Routing Architectures

- Enrich our *Tactical Core* capabilities with respect to:
  - Hierarchical networks
  - Network interconnection
  - Asymmetric link technologies, including:
    - Simplex datalinks
    - Split-IP SATCOM
    - EMCON

- While enriching capabilities, maintaining focus upon:
  - System-wide prioritization objectives
  - Minimal human intervention
AIE Topic 1: Dynamic Routing QoS Traffic Class Mechanisms

- “Routing Protocol Class” solutions to create service tiers
  - Varying likelihood of message transfer success
  - Different resource costs
  - Different network stability requirements

- Dynamic and reactive to:
  - Network state
  - TM Policy configuration
  - Mission phase
  - Offered traffic load

- Packet duplication over independent paths is one example.
Asymmetry may be due to underlying network capability, or due to residual capacity for a given priority tier.
AIE Topic 3: Serverless (Group) Communications

- Either peer-to-peer or group communications that function without statically configured servers. Specific considerations include limited bandwidth, intermittent communications, ease of use.