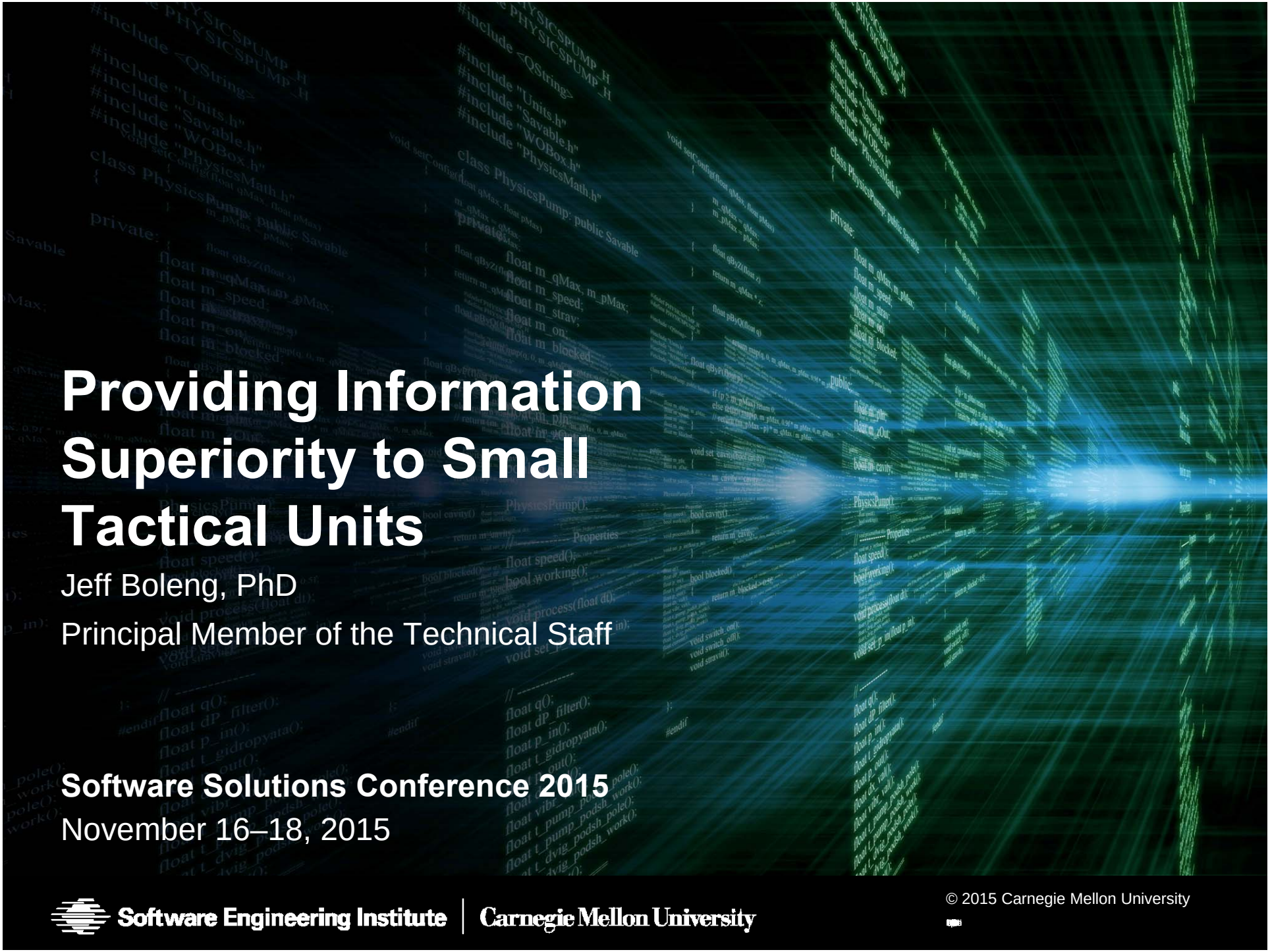

Providing Information Superiority to Small Tactical Units

Jeff Boleng, PhD

Principal Member of the Technical Staff

Software Solutions Conference 2015

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Overview

- Advanced Mobile Systems (AMS) Group Research Areas
- It's all about Context
- AMS context based computing
- Context use cases and experimentation
  - Benghazi case study (see demo in the hall)
  - Group activity recognition
  - Cooperative and opportunistic context sharing
  - Context in DIL environments

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Advanced Mobile Systems (AMS)

Investigates efficient and easily-deployable mobile solutions for teams operating in edge environments. Edge environments are characterized by dynamic context, limited computing resources, high stress, and poor connectivity.

AMS prototypes capabilities for stakeholders operating in mission-critical environments that

- improve situational awareness and data analysis
- reduce cognitive load and complexity by exploiting contextual information
- increase computing power, data access, and survivability while reducing power demands

AMS facilitates interactive mission assistance in edge environments by leveraging available sensors and information from other people and systems.

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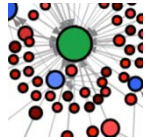
AMS Research Areas



Tactical Analytics *(TA)*	Application of data analytics to streaming and other data for near real-time analysis and rapid decision cycles in tactical settings
Tactical Computing and Communications *(TCC)*	Strategies for enhanced computing capabilities in environments characterized by limited computational resources and power, and frequently disconnected, intermittent, and low-bandwidth (DIL) communications

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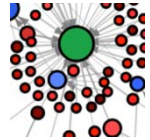
Tactical Computing and Communications (TCC)



Information Superiority to the Edge (ISE)	Mobile solutions that reduce cognitive load and conserve resources of individuals and groups by exploiting sensor, role/task, and event information, such that the right information, at the right time, is presented to the right soldier
Tactical Cloudlets	Cyber-foraging solutions that dynamically augment the computing resources of resource-limited mobile devices and address critical system qualities not considered by the commercial mobile ecosystem, such as survivability, resiliency, and trust
Delay Tolerant Networking (DTN)	Applying DTN to disconnected, interrupted, and low-bandwidth (DIL) tactical environments
Geo Intelligence	Obfuscation of queries to commercial geodatabases

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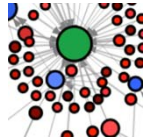
Tactical Analytics (TA)



Edge Analytics	End-to-end, near real-time data analysis of static and streaming data for resource-constrained edge environments. Current research is exploring algorithms that quantify credibility of social media
Transfer Learning	Exploration of a type of machine learning called transfer learning applied to the problem of helping junior analysts perform more like experienced analysts in recognizing recurrent patterns, relating new information to these patterns, and recognizing new variants of the pattern
Supervised LDA	Exploration of enhanced use of analyst-provided input to improve the ability of machine learning technology to structure open source data in order to improve the ability of analysts to explore, interact with, and understand the data
Fusion	Strategies to assist analysts in correlating and relating various forms of open source data and intel data from other sources

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It's all about Context

- "Understanding and using context"
  - Anind K. Dey, Personal and Ubiquitous Computing, 2001

    "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."
- Traditional usage is person, location, and time
  - Example: CoT -- What, Where, When
- Again from Dr. Dey

  "A system is context-aware if it uses context to provide relevant information and/or services to the user, ***where relevancy depends on the user's task****."*
- Context is the next battle in mobile
  - Google Now vs. Siri vs. Cortana vs. Amazon Echo vs. ???

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AMS Context Based Computing

- Expand context to include
  - *User, location, time* ***and***
  - *Mission, role, task*
- Leverage context across the group
- Enable adaptive behavior via rules engine
  - User context cues sensor tasking and information delivery
  - Sensor data cues context changes

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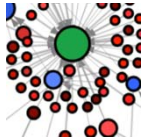
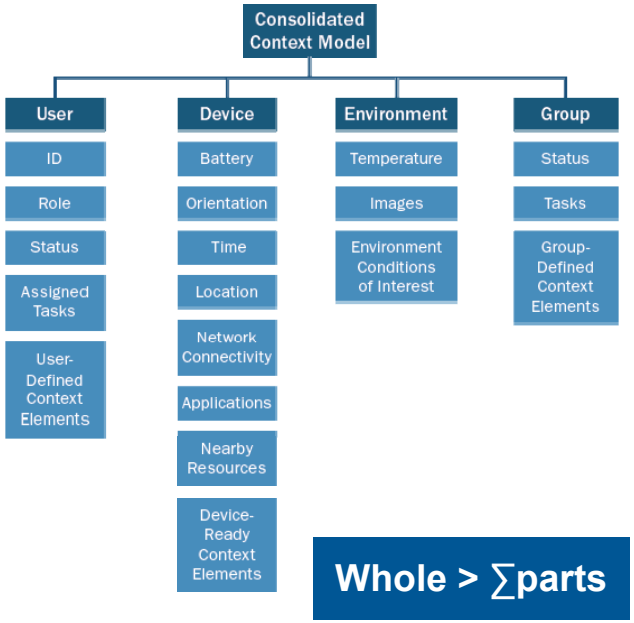
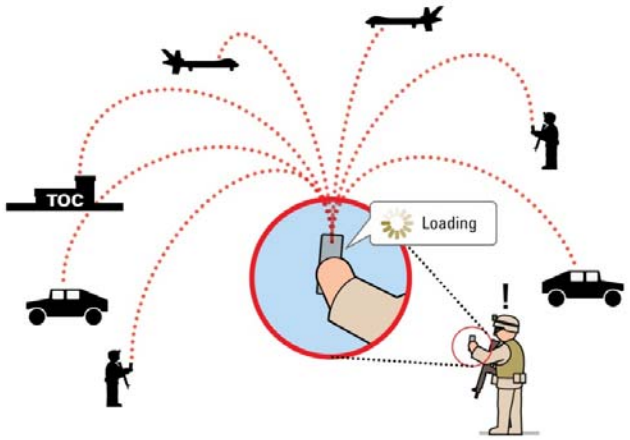
Information Superiority to the Edge





Whole > ∑parts



Group context aware reference architecture, middleware, data model, and prototype implementation to reduce cognitive load and conserve resources by using sensor, role/task, and event information to deliver the right information, at the right time, to the right soldier

Context Model: Expand the context model beyond time and location, resulting in broader and more complete understanding

Context Reasoning: Broader context model allows reasoning and reaction to the context of the individual, other individuals, the group, and the organization.

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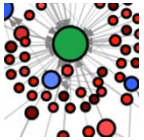
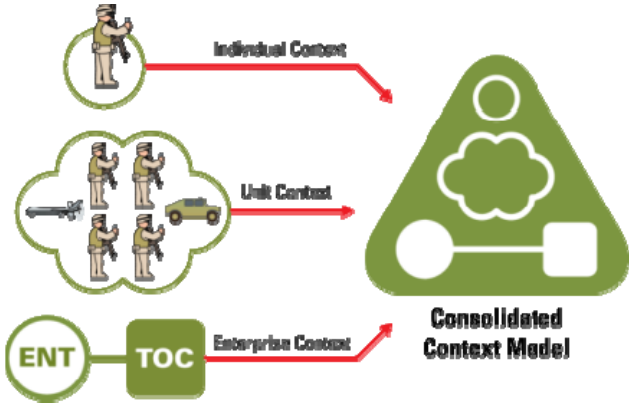
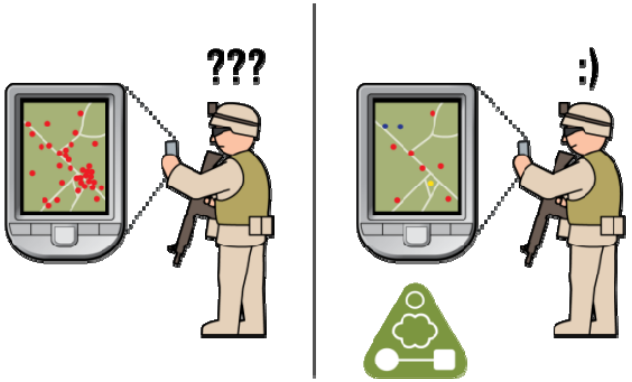
Information Superiority to the Edge





Resource Usage: Use of broader context allows smarter and more efficient resource allocation.

Cognitive Load: Richer context models can decrease the soldier's cognitive load required to capture, visualize and react to situational information.



Research Focus: Leveraging individual and group context to reliably deliver the right information, to the right soldier, at the right time

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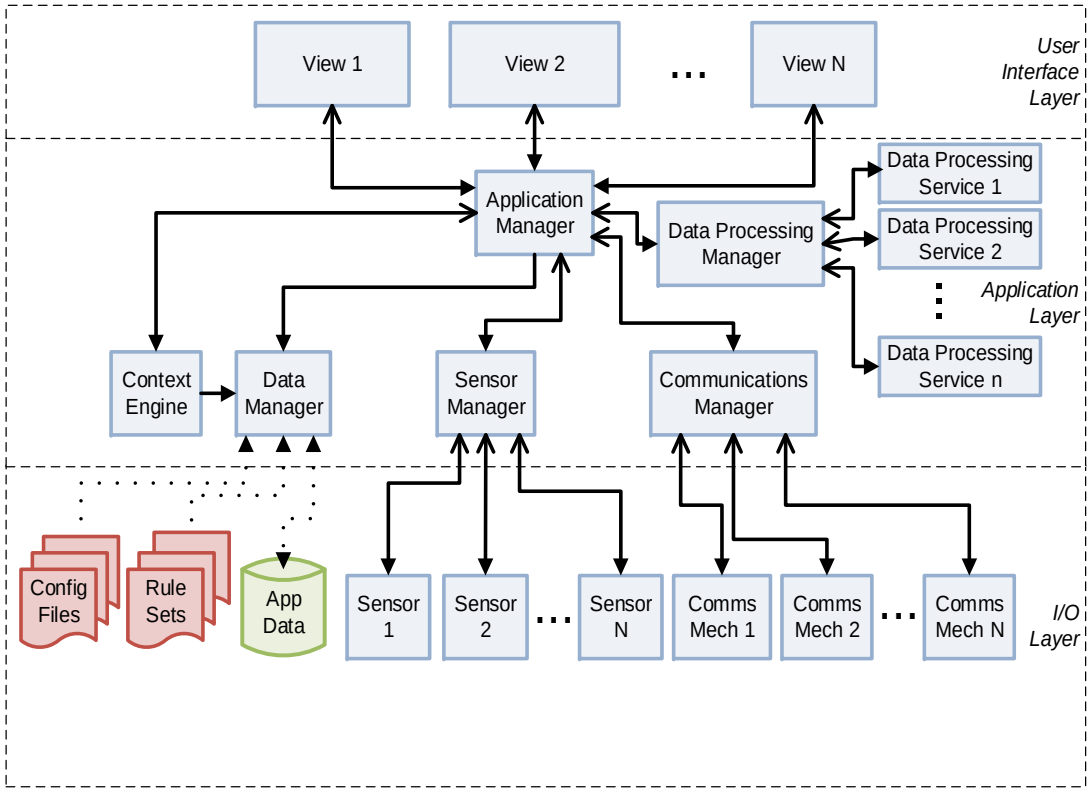
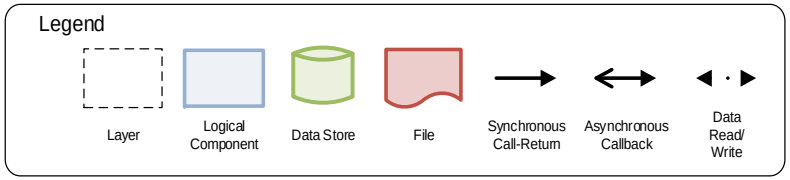
Reference Architecture for Mobile Applications at the Edge (ISE & DTN)





Key Qualities

- Modifiability
  - the ability to change between the views, rules, configurations, sensors, and radios without significant effort
- Extensibility
  - the ability to integrate new views, sensors, radios, profiles, and rules without impacting the rest of the architecture

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Context Use Cases and Experimentation

- Benghazi case study (see demo in the hall)
  - Combination of Edge Analytics (real time social media streaming analysis) and ISE for tactical situational awareness
- Group activity recognition
  - Collaboration with 911 AF Reserve Wing at PAS
- Cooperative and opportunistic context sharing
  - Combine CMU Group Context Framework (opportunistic context)
  - With ISE (cooperative context)
- Context in DIL environments
  - Metadata extensions to Delay Tolerant Networking (DTN) protocols

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Group context recognition

- Required a scenario with realistic feedback → paintball
- 20+ volunteers from 911th Air Reserve Wing
- Small squad tactics as scenarios
- 7 group activities, 10 individual activities, 3 IMU's and phone per person

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Group activity results

- Multiple Gigabytes of video data – challenging to annotate
- 5 types of classifier: SVM, decision tree, kNN, naïve bayes, neural network (# of hidden=10)
- Best combination of sensors: Phone (acc) + YEI arm sensor + YEI leg sensor
- 81% accuracy of individual activity recognition (SVM)
- Shooting, covering, running, etc.
- 71% accuracy on group activity recognition (kNN and Neural Net)
- Advance, covered advance, covering fire, etc.

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Cooperative and Opportunistic Context

- Experimentation at large music festival in PA
- Provided “assistance application” to festival volunteers
- Opportunistic Context → CMU Group Context Framework
  - http://ubicomplab.org/publications/the-group-context-framework-an-extensible-toolkit-for-opportunistic-grouping-and-collaboration/
- Cooperative Context – ISE
- Fuse and visualize data via MQTT message broker and web front end
- Scenarios
  - Location tracking
  - Bluetooth location
  - Noise localization
  - Lost person location
  - Cueing sensors from social media events (Edge Analytics)

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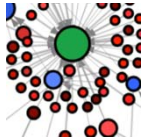
Context for Delay Tolerant Networking



Maintain shared group context Make best use of available bandwidth	Applications continue to function Predict state where possible	Re-establish shared group context as quickly and accurately as possible
Pre-cache data likely to be relevant later in the mission	Predict location of teams based on mission plan	Prioritize synchronization of critical messages • data staleness • data updates • redundancy elimination • conditional delivery
Delay transmission of noncritical data	Provide connectivity map to help the user reconnect	

Solutions that support warfighter networking in Disconnected, Interrupted, and Low-bandwidth (DIL) environments

Enhancements to existing networking protocols for managing these environments, significantly improving performance WRT to bandwidth usage and synchronization time

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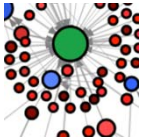
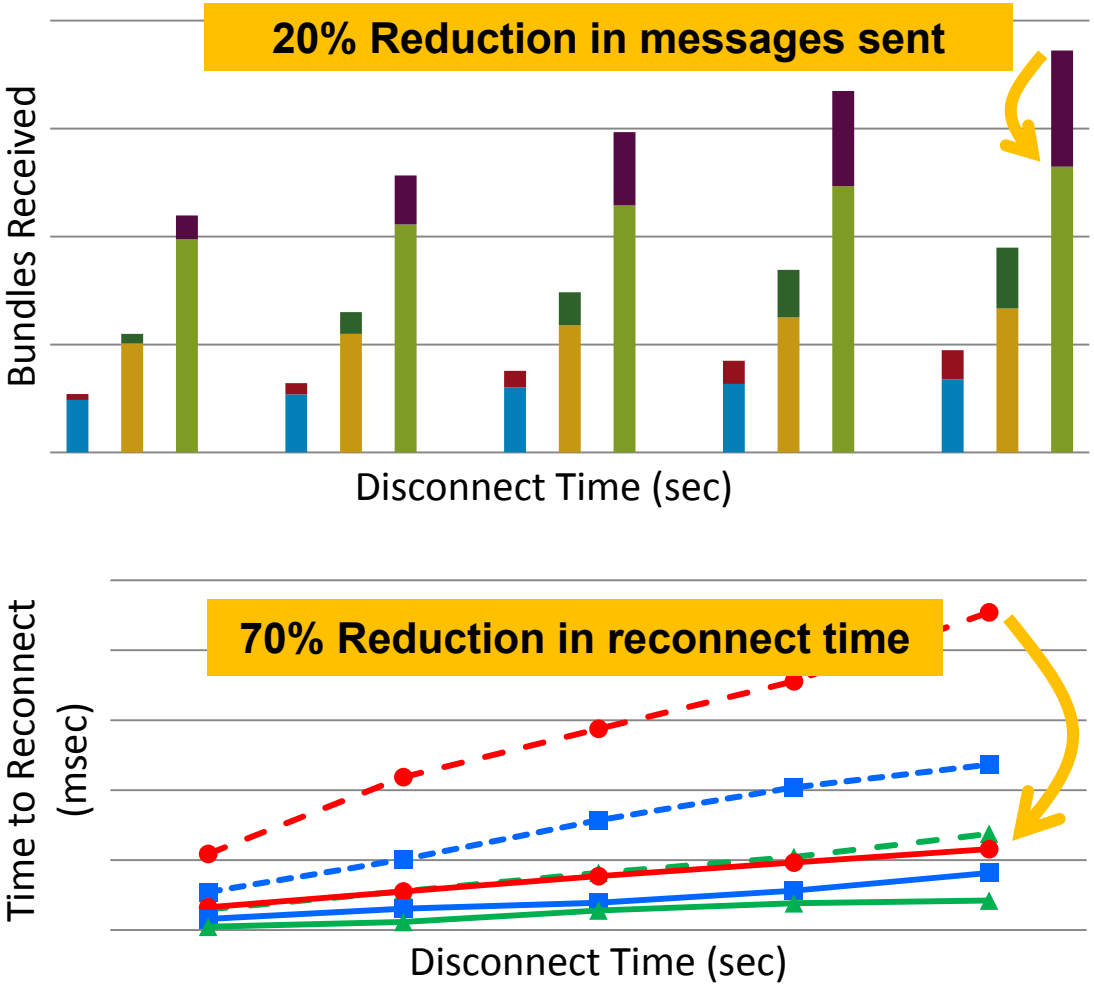
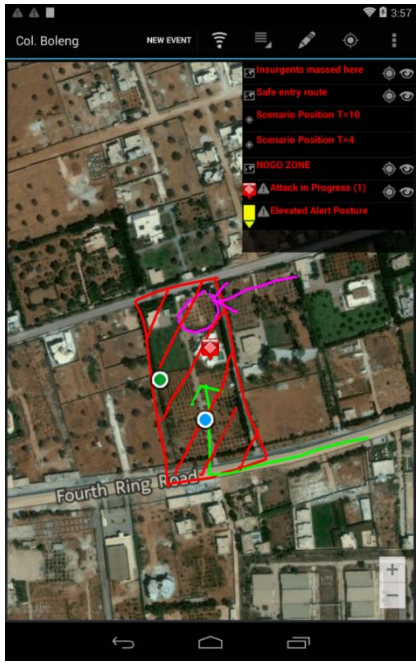
Delay Tolerant Networking







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Thank you for the time.

Questions and Comments?

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