

Content-Based Mobile Edge Networking (CBMEN) DARPA-BAA 11-51

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Proposers' Day Presentation

13 May, 2011



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0830 – 0845 ... Opening Remarks and Introduction

0845 – 0915 ... Program Overview

0915 – 0930 ... Procurement Overview

0930 – 0945 ... Performance Evaluation

0945 – 1000 ... Contracts Administration

1000 – 1030 ... Break – Submit Program Questions

1030 – 1100 ... Operational Scenarios

1100 – 1200 ... Q&A



Opening Remarks and Introduction



Introduction

- 13 May 2011
- BAA 11-51 ... Content-Based Mobile Edge Networking (CBMEN)
- BAA web site:
 - <https://www.fbo.gov> (search for BAA-11-51 or CBMEN)
 - BAA and all amendments
 - Proposers' Day Slides
 - Proposers' Day Attendee List (optional inclusion)
 - Questions and Answers – updated regularly
- The Plan:
 - Present Program, Procurement Strategy, Performance Evaluation, and Contracts
 - Attendees can submit formal questions during break
 - DARPA will organize question and develop answers as scenarios are discussed

This Proposers' Day is intended to provide insight into the planned program and procurement. In the event of a conflict between Proposers' Day and the BAA, the BAA is the official source of information.



Schedule

- BAA Schedule
 - Solicitation Issued: April 26, 2011
 - BAA Questions Due: May 18, 2011
 - 20-Minute Feedback Meetings with PM: 19, 24, and 26 May 2011
 - Proposal Due Date: June 10, 2011
 - BAA Closing Date: October 24, 2011

Administrative, technical or contractual questions should be sent via e-mail to

DARPA-BAA-11-51@darpa.mil



Program Overview



CBMEN - Motivation

- Modern warfare is prosecuted/fought at the edge
- Success or failure often hinges on up-to-date local knowledge
 - e.g., Is the neighborhood elder trustworthy? On our side?
 - e.g., Are there usually young men in the marketplace?
- But, the information experience at the edge is typically
 - Non-interactive and stale – when there is information at all



The fight is at the edge – the information should be there, too!



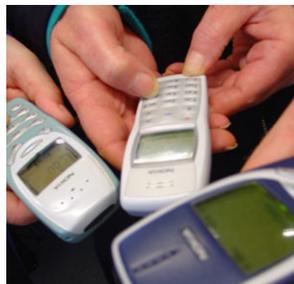
CBMEN - Problem

Civilian Capability

Where's a close sushi restaurant?

What movies are playing?

What's Tom up to?



Mobile access to arbitrary content at the edge



Leverage Tech Base

Military Need

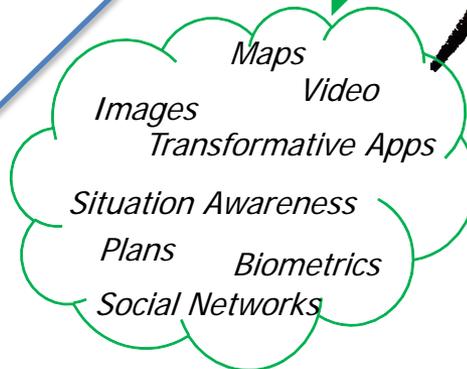
Mobile access to needed operational content at the edge



Where have IED attacks been lately?

How do I get to FOB Alpha?

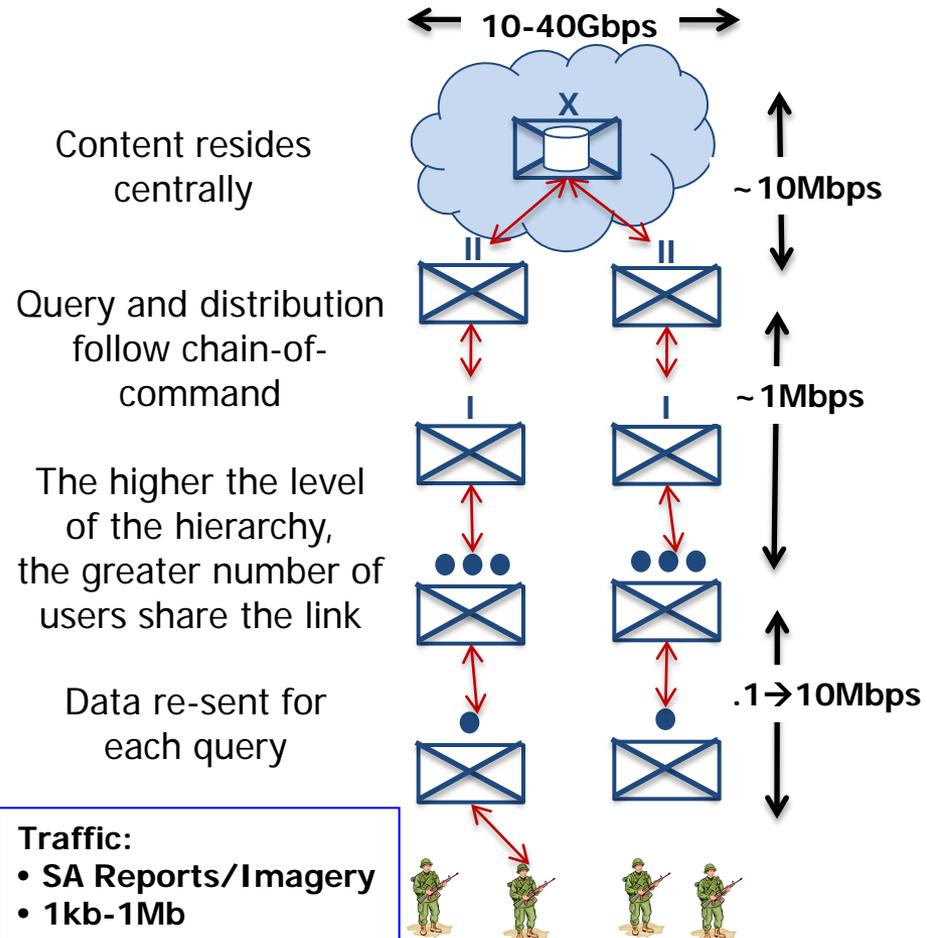
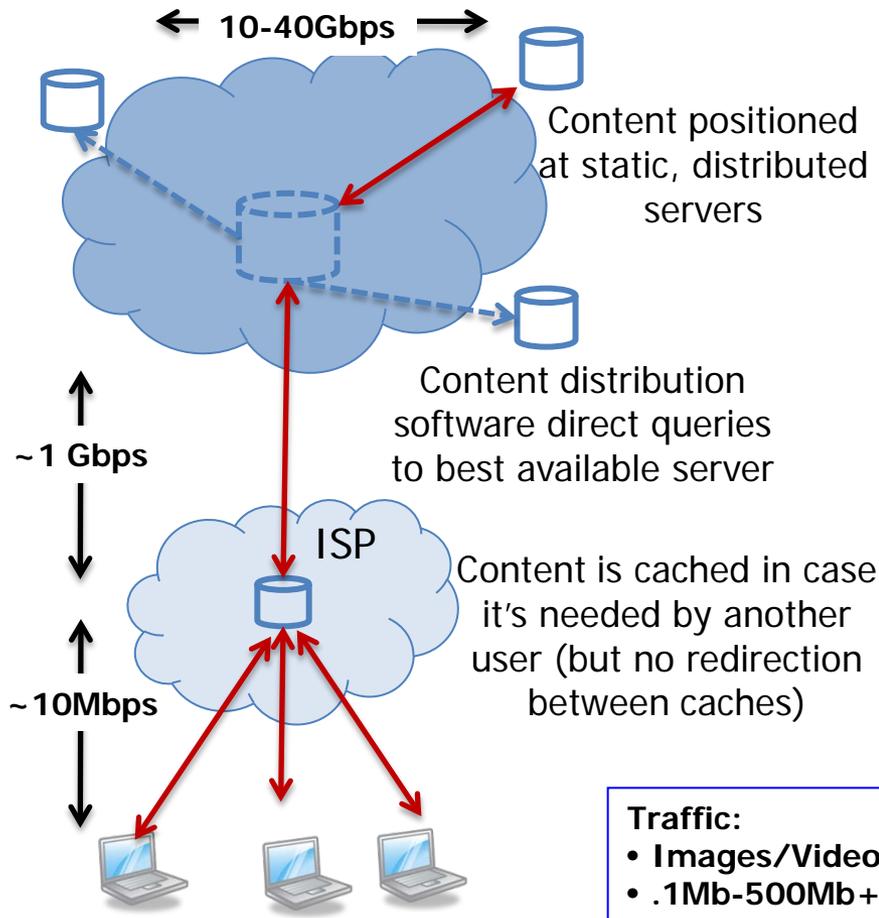
Who does the HVT associate with?



Give warfighters at the edge efficient access to relevant content!



Content Distribution: Commercial and Military SOTA



The architecture and constraints of content distribution are different in the commercial and military domains.



Content Distribution and Military Communications

Modern military communications is turning to mobile ad hoc networks (MANETs) at the edge

- Horizontal links provide connectivity
- All edge nodes are routers

Military content needs are highly correlated

- Most content is shared locally

Processing and memory are cheap and plentiful

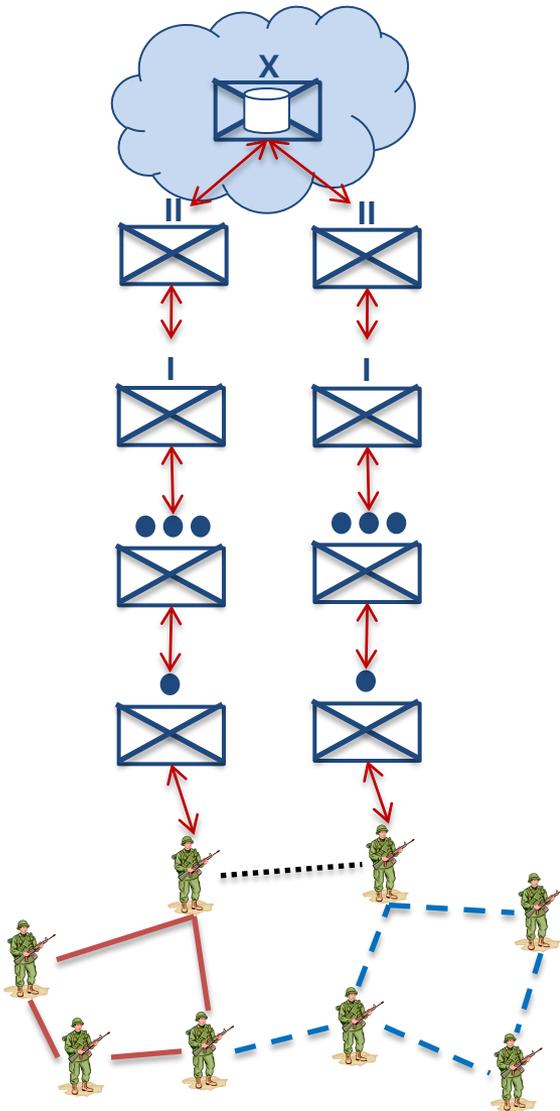
- Today's hand-held has the power of yesterday's server

The opportunity exists to:

- Take advantage of MANET technology to efficiently distribute content using available links
- Take advantage of cheap processing and memory to distribute content from the edge
- Take advantage of content correlation to anticipate content needs and proactively deliver content

But, the MANET environment is challenging

- Node mobility
- Dynamic, intermittent links





CBMEN - Objective

- CBMEN seeks to develop network services for content distribution in mobile ad hoc networks to improve the content experience for warfighters
 - Minimize reach-back and latency
 - Transparently locate, distribute, and share battlefield content
- Developing content distribution for military environments has unique challenges and opportunities

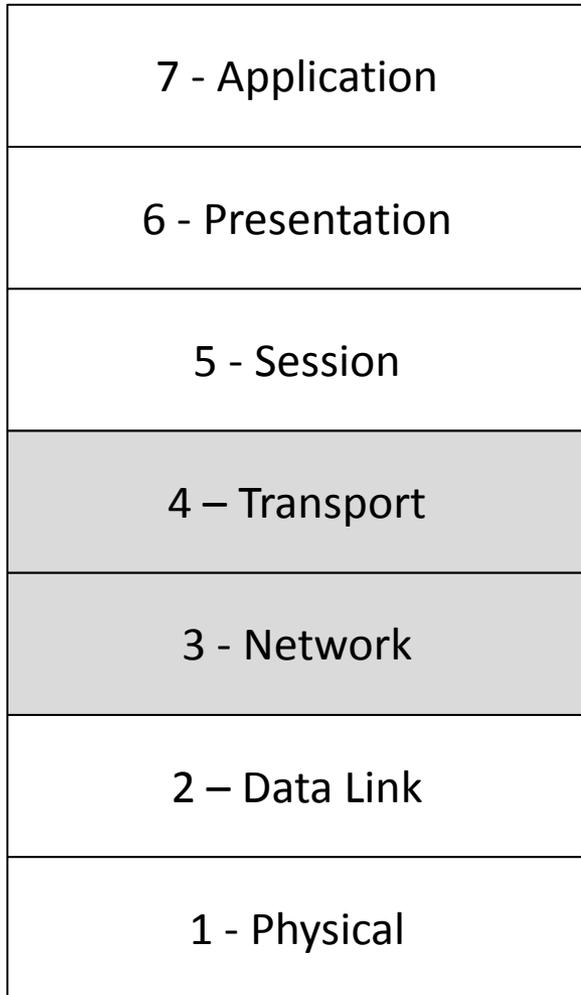
Challenges / Constraints	Advantages / Opportunities
Wireless network dynamics	All resource owned by single entity:
Dynamic, time-sensitive content	• The network
Limited infrastructure	• The content
Limited power	• The resources (i.e., the edge)
Limited reachback bandwidth	Content is correlated

Develop content distribution as network services that are:

- **Application independent;**
- **Network agnostic.**



CBMEN – Possible Approaches



Content distribution services can be built for either the transport or network layers

Content distribution at Layer 4

- Use underlying network APIs
- Use underlying network routing protocols

Layers 3 and below are hidden from content distribution services

Content distribution at Layers 3 & 4

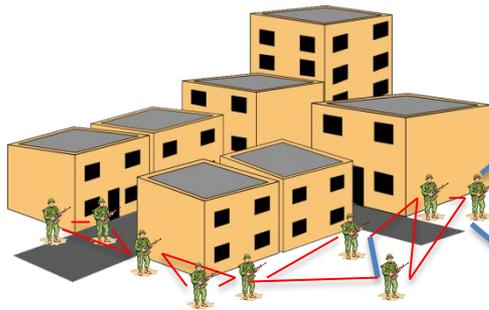
- Customize network APIs
- Customize routing protocols

Layer 3 optimized for content routing



CBMEN – the End Product

- Generalized network services for content distribution
 - Application independent
 - Radio and lower layer network independent
- Demonstration and Evaluation in a dismounted small-unit environment

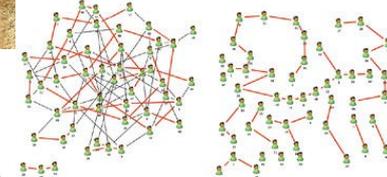
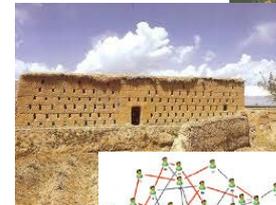


Small unit MANET

Operationally relevant scenario



Military-grade equipment



Content-rich, operationally relevant applications



What CBMEN is NOT about ...

- RF Engineering
 - CBMEN is not a program to develop an advanced waveform
 - CBMEN is not about developing LPI/LPD/AJ technology
 - CBMEN is not about efficient transport encoding
- Soldier-Borne Equipment
 - CBMEN is not about developing communications hardware
 - CBMEN is not about developing handheld computers
 - CBMEN is not about developing human-machine interface technology
- Soldier Applications
 - CBMEN is not about developing warfighter applications
 - CBMEN is not about developing “intelligent” assistants for the warfighter
- And ...
 - CBMEN is not about developing new connections to sensor assets or databases, augmented cognition, advanced displays, ...



Procurement Overview



Program Structure

- Phase 1 (15 months)
 - Develop and demonstrate basic content distribution services
 - Focus is the dismounted small unit communicating via MANET
 - 20-30 nodes
 - Timely, efficient distribution
 - Content correlation
 - Broadcast medium
 - Cope with MANET dynamics
 - Mobile nodes that join and leave
 - Intermittent links
 - Final evaluation and demonstration
 - Operationally relevant scenario
 - Satisfactory progress required for passage into Phase 2
- Phase 2 (15 months)
 - Scale Phase 1 developments:
 - Retain focus on dismounted communicating via MANET
 - Increasing distribution challenges
 - Larger content
 - Mixed content requiring filtering and prioritization
 - Increased network size and dynamics
 - 75-100 nodes
 - Increased number of mobile nodes
 - Group joins and leaves
 - Final evaluation and demonstration
 - Operationally relevant scenario

Phase 1: Content distribution for a small mobile ad hoc network
Phase 2: Scale to larger networks and increased dynamics



Technical Areas

- Technical Area 1 (TA 1): Technology Development
 - Develop core algorithms and software for content distribution
 - Objective is to integrate developments into one or more of the mobile systems (TA2)
 - Multiple awards possible
- Technical Area 2 (TA 2): Mobile System Integration
 - Develop and maintain a demonstration (radio+network+computer) system
 - Provide development kits and integration support for the technology developers
 - Plan and execute end-of-phase evaluation and demonstration events
 - Up to 2 awards possible
- Evaluation will be performed by a Government team
 - Perform analysis and simulation to define metric goals
 - Work with performers to instrument software
 - Collect and analyze experimental data

Effective collaboration among Technology Developers, Mobile System Integrators, and the Evaluation Team is essential to CBMEN success.



Integrator responsibilities

- Develop, integrate, and maintain the CBMEN mobile system
 - Radio + MANET + computer (hand-held devices and displays) + applications
- Support the TD hardware and software infrastructure needs
 - Software development kits
 - Representative hardware – as appropriate for development
- Define (with the TDs) and maintain the CBMEN software architecture
- Support TDs in integration and maintenance of the CBMEN software
- Support the performance evaluation team
- Execute of end-of-phase performance demonstrations
 - Define operationally relevant scenario
 - Instrument system and collect data

The Mobile System Integrators are facilitators of technology development and system evaluation/demonstration.



Roles of and Relationships between Task Areas (1)

- TA1: Technology Developers (TDs) :
 - Develop basic CBMEN networking services and supporting technology
 - Perform self-assessments to track progress and quantify capabilities
 - Work with one or more MSIs to
 - Define and maintain CBMEN software architecture
 - Integrate the CBMEN mobile system
 - Demonstrate integrated CBMEN capabilities
 - Support CBMEN performance evaluation
 - TDs are free to select the MSI(s) to work with
 - Which MSI has the most compatible approach?
 - Which MSI provides the most support?
 - Which MSI is the easiest to work with?
 - Which MSI has the best baseline system (radio+network+computer+apps)?

The goal of each Technology Developer is to integrate and demonstrate advanced capabilities on a mobile system.



Roles of and Relationships between Task Areas (2)

- TA2: Mobile System Integrators (MSIs) :
 - Develop, integrate, and maintain the CBMEN mobile system
 - Define and execute end-of-phase capability demonstrations
 - Work with one or more TDs to
 - Define and maintain CBMEN software architecture
 - Integrate the CBMEN mobile system
 - Demonstrate integrated CBMEN capabilities
 - Support CBMEN performance evaluation
 - MSIs must attract the TDs to work with them
 - TDs will be the source of advanced capabilities for demonstration
 - TDs will depend on MSIs for development and integration support
 - MSIs must determine balance between engineering discipline and freedom to innovate

The goal of each Mobile System Integrator is to integrate and demonstrate advanced capabilities on a mobile system.



Competition is good!

- MSIs compete to:
 - Integrate the “best” system
 - Execute the “best” demonstration
- MSI’s “best” interest is to facilitate technology development and integration
 - MSIs depend on TDs for content-based software
 - Without TD software, the MSI system has nothing to demonstrate
 - MSIs should encourage creativity
 - MSIs should support development and simplify integration
- TDs compete to:
 - Develop the “best” approaches to content distribution
 - Integrate into the “best” system
 - Enable the “best” demonstration
- TD’s “best” interest is to collaborate with one or more MSIs
 - MSIs will demonstrate and evaluate TD products
 - Without integration with an MSI, a TD has no demonstration platform

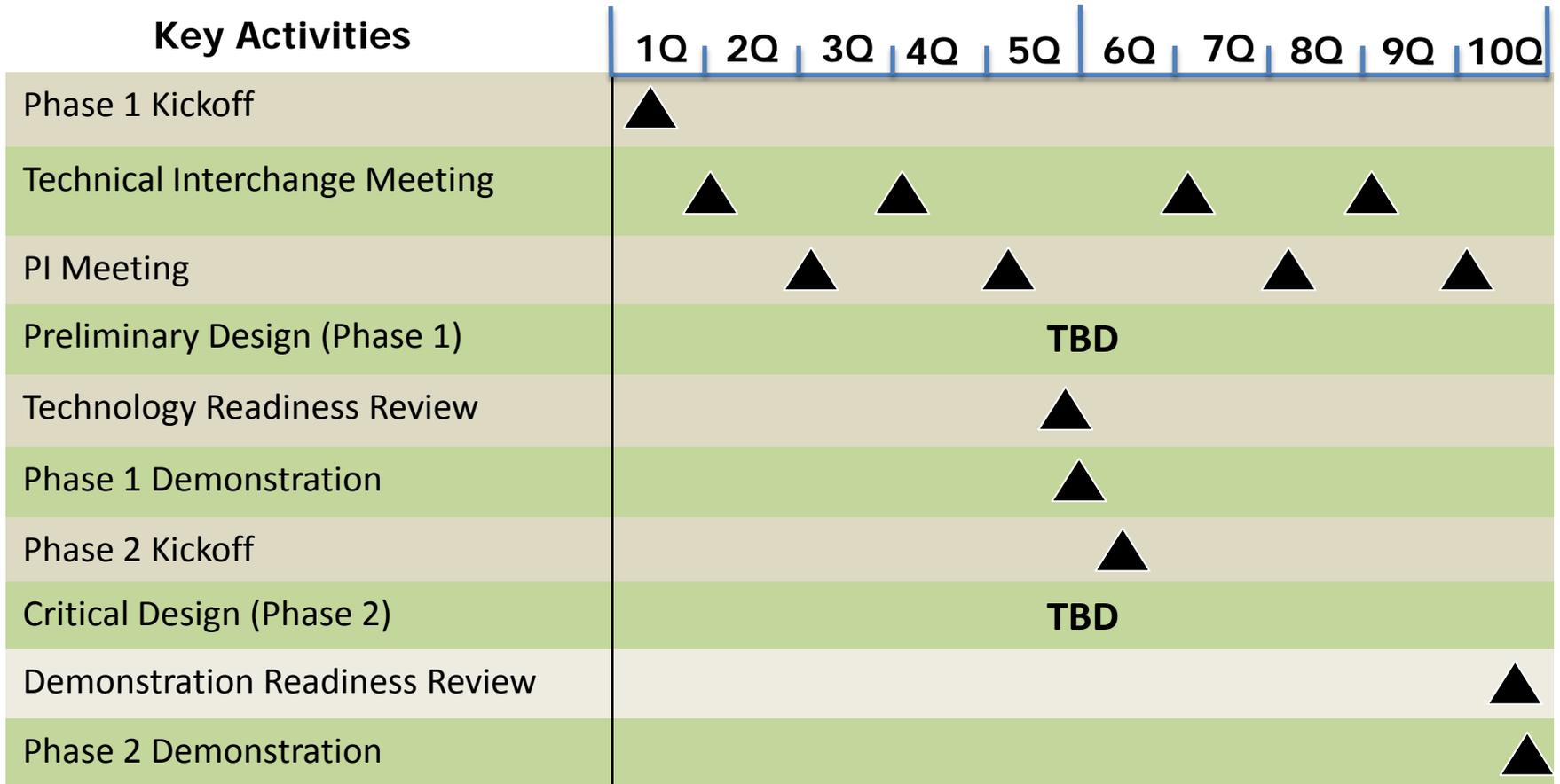


Phase 1 to Phase 2 Transition

- Transition from Phase 1 to Phase 2 is not guaranteed
 - Acceptable progress required
 - Self-assessments against own plan required
 - Transition requirements for TDs
 - To what extent are own goals accomplished (as laid out in proposal)?
 - To what extent have products been integrated with MSIs?
 - To what extent have TD products enhanced the CBMEN system?
 - Transition requirements for MSIs
 - To what extent are own goals accomplished (as laid out in proposal)?
 - What quality of support was provided to the TDs?
 - To what extent were TD products integrated?
 - What level of performance is supported by the CBMEN system?
- Phase 1 to Phase 2 is NOT (necessarily) a downselect
 - All Phase 1 participants may progress into Phase 2
 - Need to show potential to achieve Phase 2 goals



CBMEN Milestone and Schedule





Program Metrics

- Demonstrate that CBMEN improves the content experience for warfighters at the tactical edge.

Area	Metrics
Naming content	Coverage
	Expressiveness
	Auto-generation capability
Content distribution	Latency
	Transport efficiency
Content management	Accuracy
	Stale/Overhead ratio
Securing content	Time overhead
	Space overhead
System	Content /Energy ratio
	Content/Latency ratio
	Delivery/Overhead ratio

Performers are encouraged to define other metrics to demonstrate that their technology improves operational effectiveness.



Evaluation Criteria

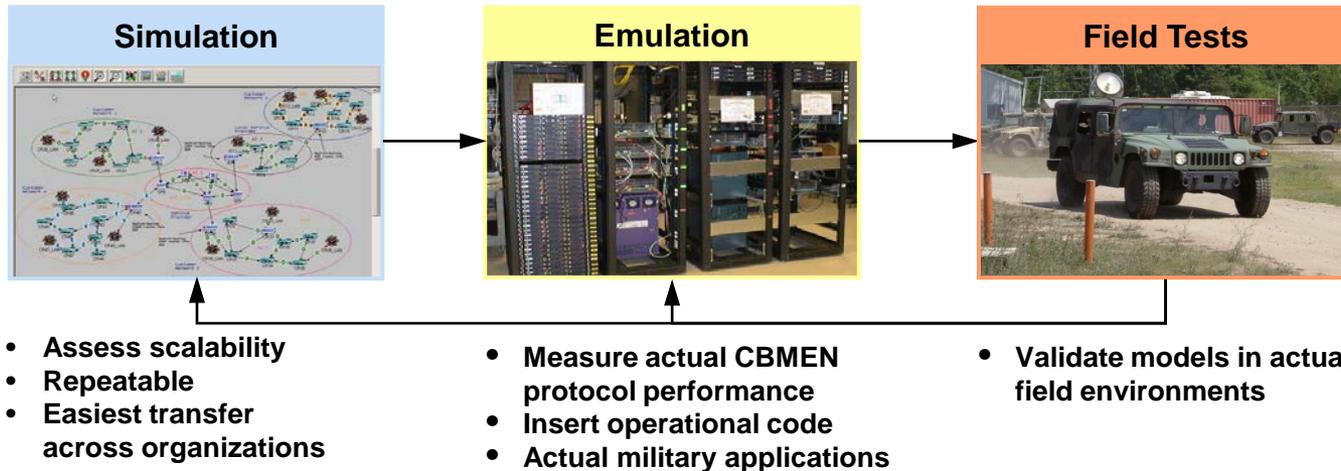
- In the order of importance:
 - **Overall Scientific and Technical Merit**
 - **Potential Contribution and Relevance to the DARPA Mission**
 - **Plans and Capability to Accomplish Technology Transition**
 - **Proposer's Capabilities and Related Experience**
 - **Cost and Schedule Realism**



Performance Evaluation



Approaches to Wireless Network Evaluation



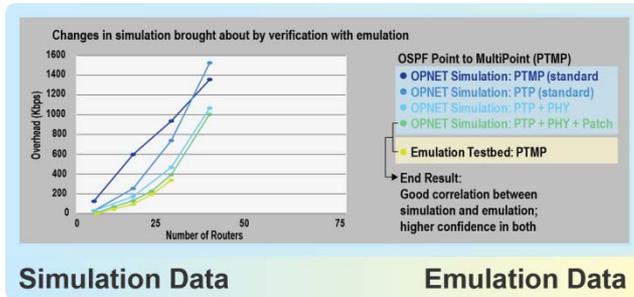
	Simulation	Emulation	Field Tests
Operational Equipment Use (interoperability)	Low	Moderate to High	High
Scalability	High	Moderate to High	Low
Effort to Complete New Test	Low	Moderate	High
Repeatability	High	Moderate to High	Low

All three approaches will be used in the CBMEN program

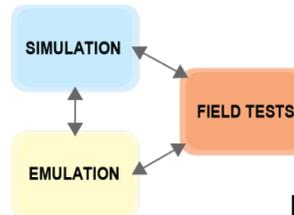
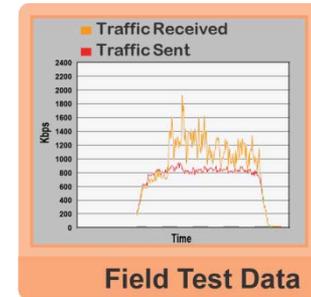
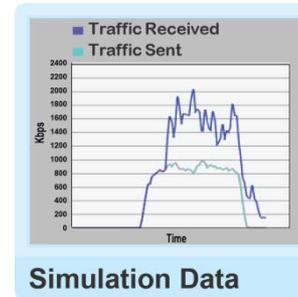


Wireless Network Evaluation Approaches Complement and Calibrate Each Other

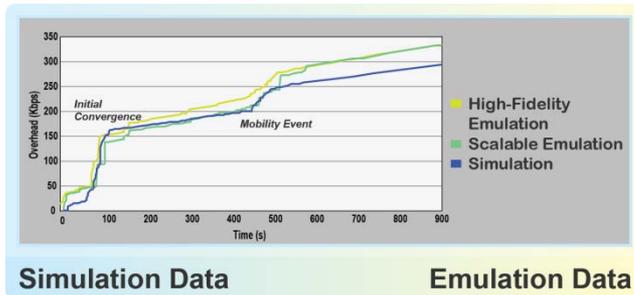
OSPF Traffic Load



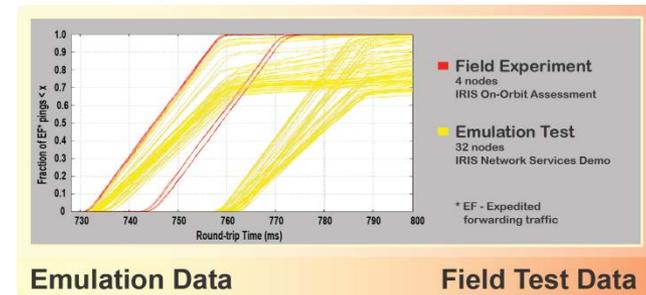
Traffic Delivered



Network Overhead

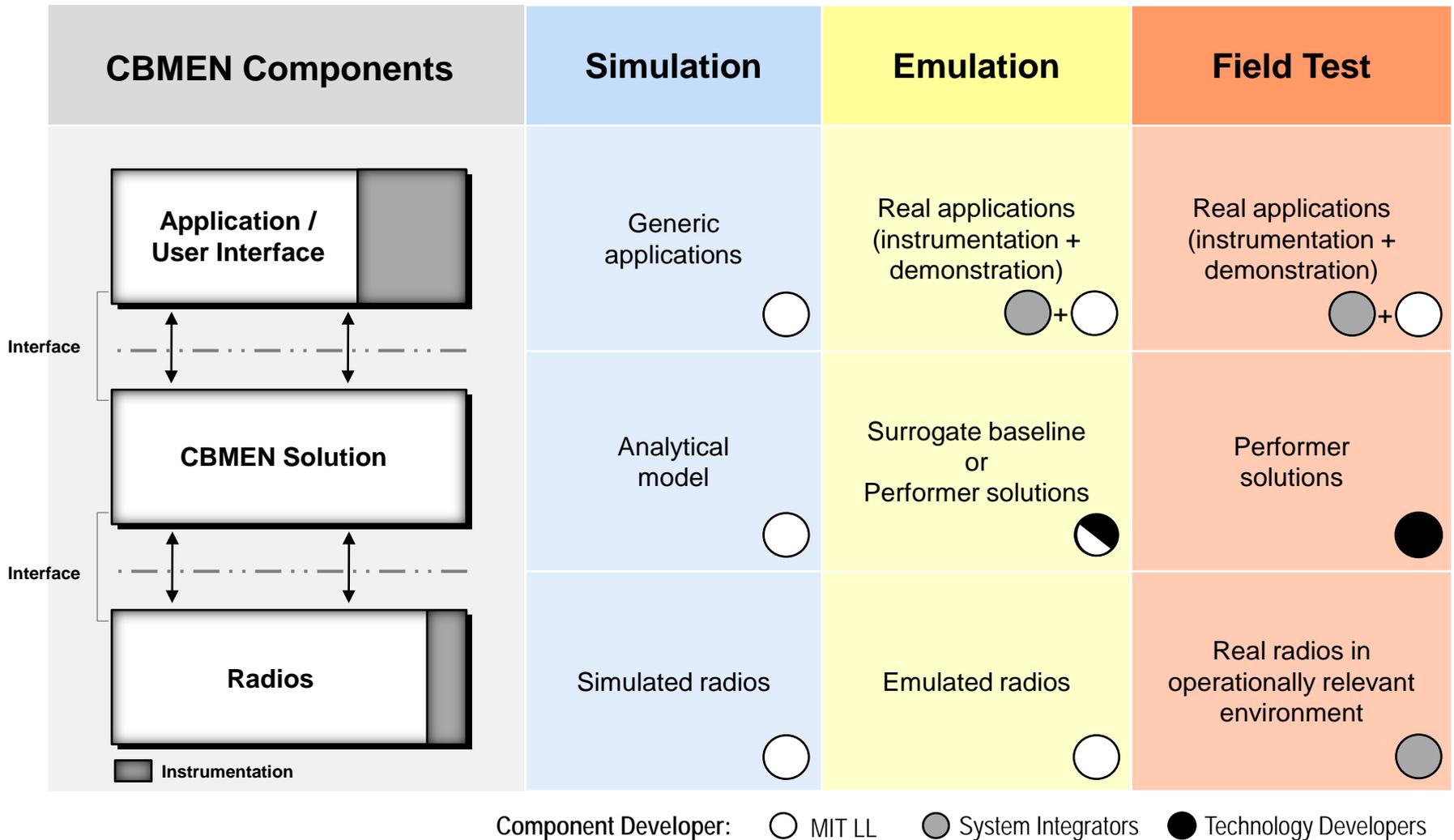


Latency



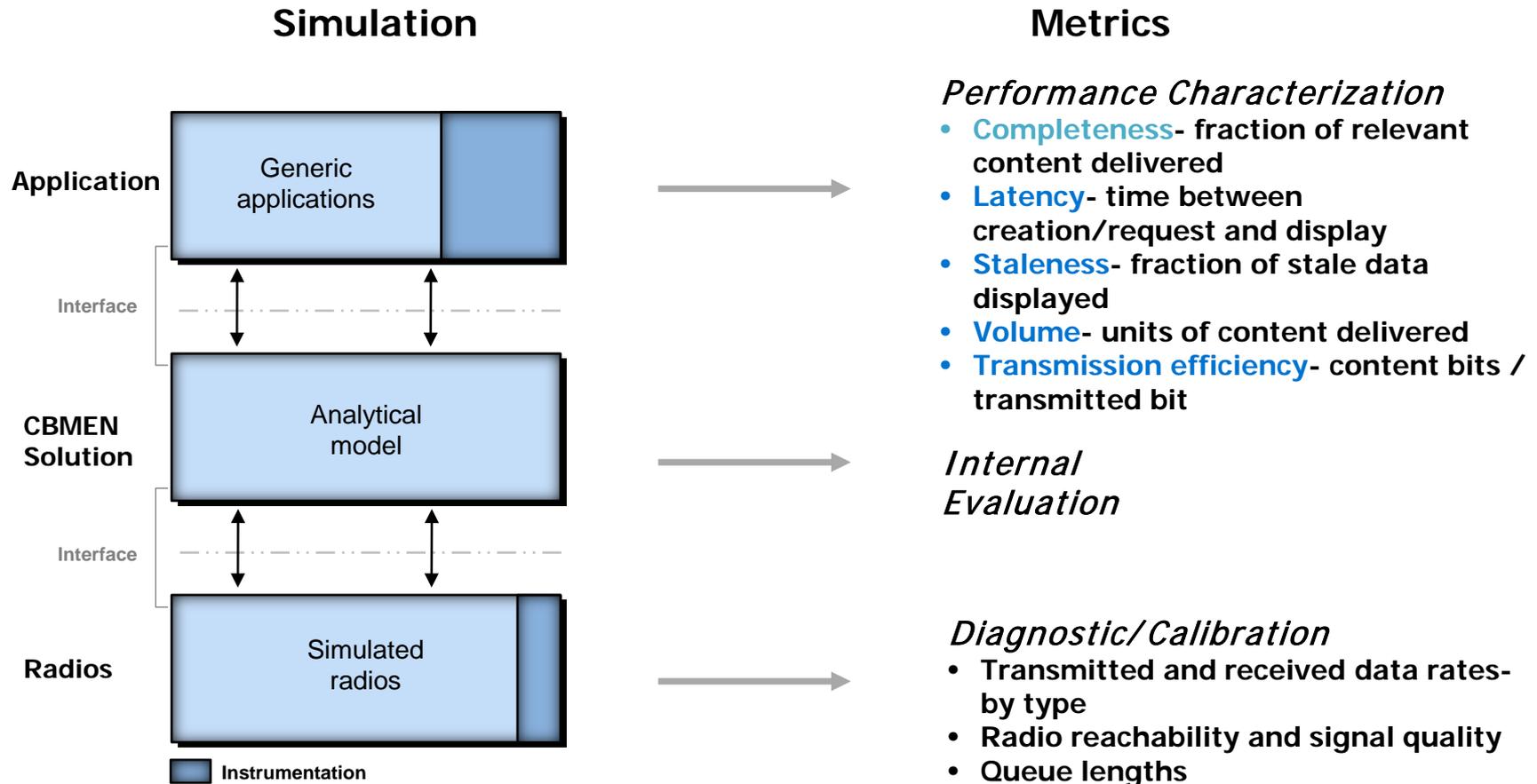


Wireless Network Evaluation in the Context of CBMEN





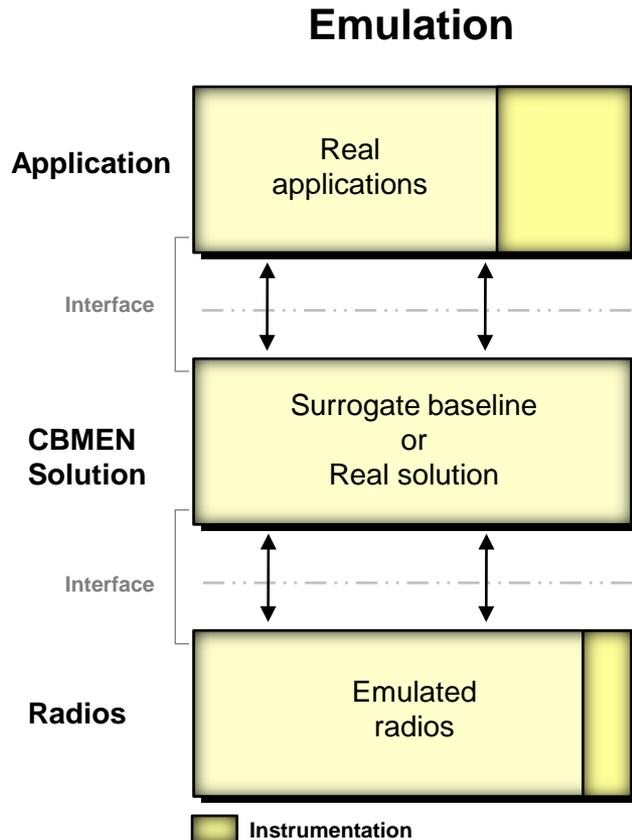
Simulation Used to Establish Metrics and Instrumentation



Simulation results provide an upper bound on potential improvement



Emulation Used for Early Evaluation of Solutions

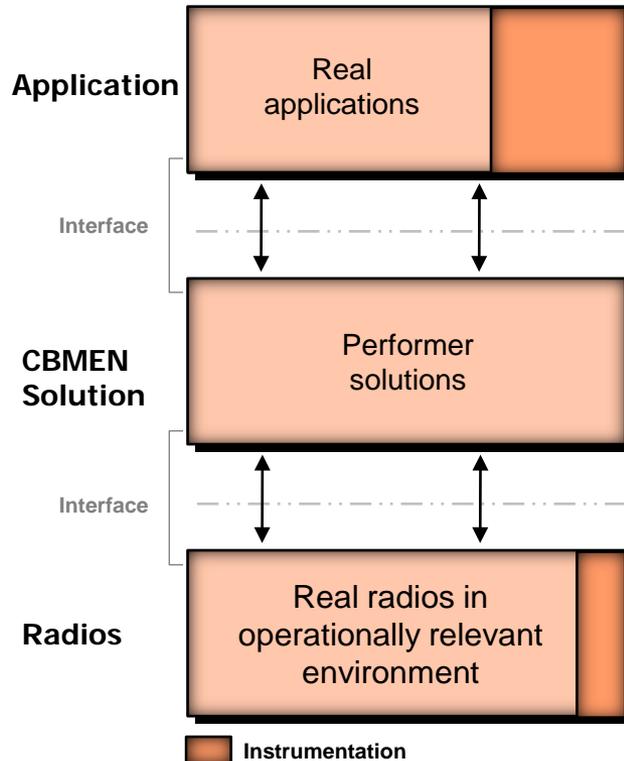


- **Applications are instrumented to record user-level metrics. Machine-time automated test program creates repeatable stimulus.**
- **Technology developers, system integrators, and MITLL work closely to define interface to, and features of, the instrumented applications.**
- **Emulation environment based on equipment developed for numerous programs including the ASD(R&E) Networks Program.**
- **Allows for repeatedly unreliable network experimentation and development testing.**



Field Testing Uses the Same Instrumentation as Emulation

Field Test

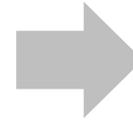
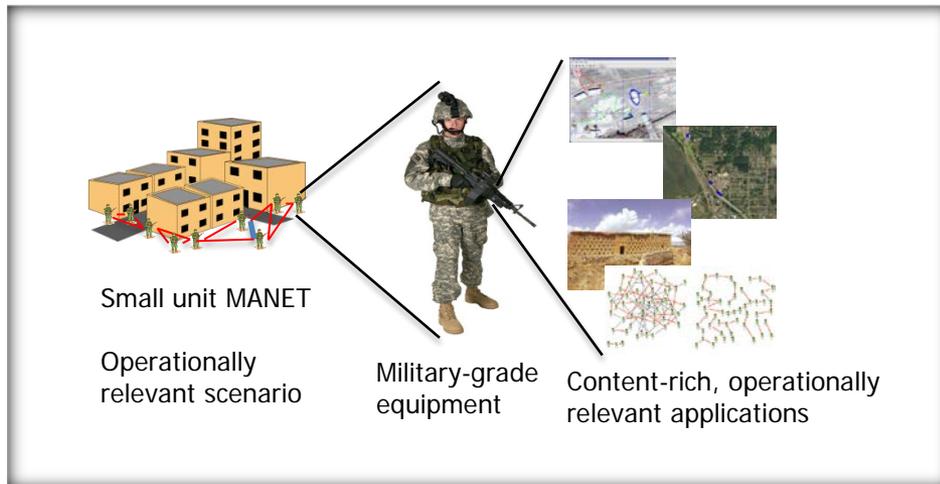


- **Application layer consists of the same instrumented applications and includes visual human-interactive demonstration elements.**

- **Radio layer measures the same metrics as the emulation environment**



Evaluation Scenarios



wnl.ll.mit.edu

- The Government will develop and provide a representative scenario for small unit operations.
- The scenario will be available to all performers via the **Wireless Networking Library**, which consolidates and provides on-line access-controlled data to support tactical networking research.



Contracts Administration



Break – Submit Program Questions



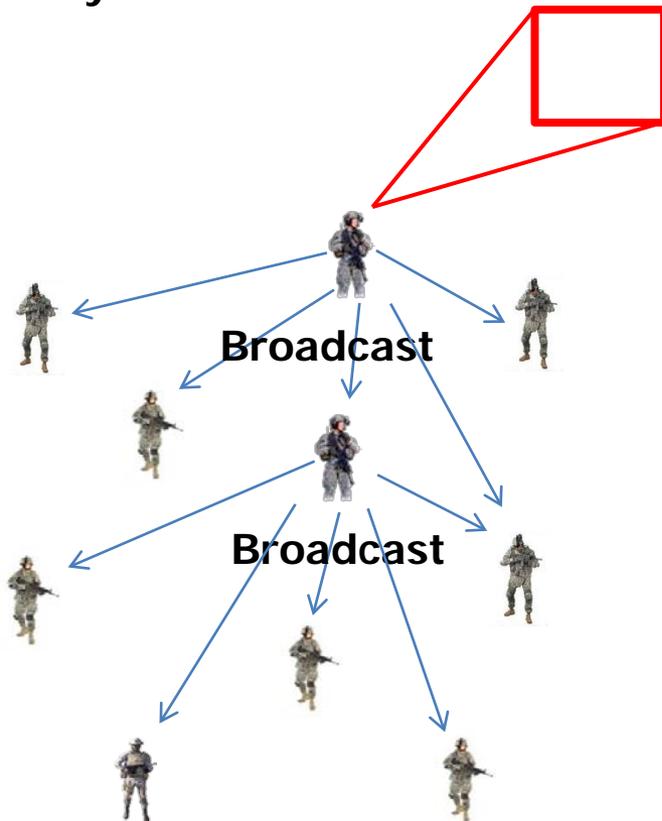
Operational Scenarios



CONOPS Scenario 1 – Sharing Content at the Edge

A soldier in a squad takes a picture of a suspect and other squad members get it automatically.

Edge-to-Edge Delivery



Scenario Highlights

An Army Squad on a patrol mission to support stability operations in an Afghan town identifies a potential insurgent among the local populace.

A CBMEN content “interest” related to local insurgents has been previously established by each member of the squad prior to the mission.

A Squad member takes picture of a suspect and inputs features and attributes (time, location, suspect features) for this content.

CBMEN automatically matches this new content to the “interest” previously established.

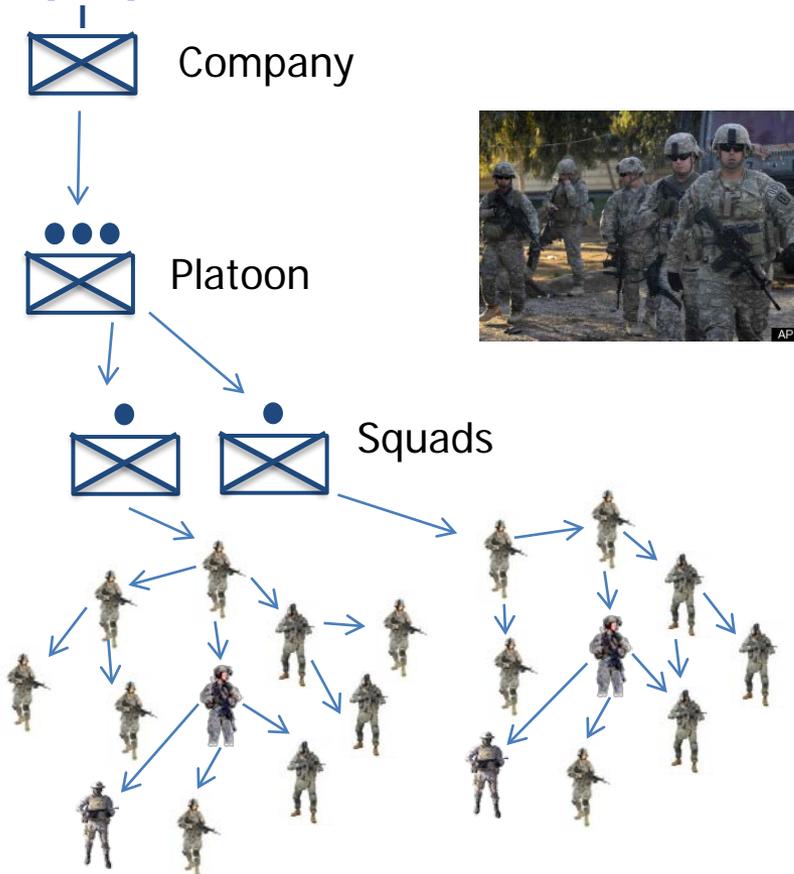
CBMEN automatically distributes the content to all the members in the squad by efficient broadcast -- direct edge-to-edge delivery.

The Squad continues the mission with the latest content dealing with insurgents in the area of interest.



CONOPS Scenario 2 – Pro-active Push of Content

Pro-active content push in preparation for a mission



Scenario Highlights

A Platoon is given a mission to find and destroy an IED factory in a small Afghan town.

In preparation for the mission, “interests” are established for content related to IED factories in the area for all warfighters in the platoon before the mission begins.

Because of these “interests,” CBMEN proactively pushes relevant content to the warfighters in the unit. The distribution takes advantage of broadcast capabilities and opportunistic caching.

All warfighters in the platoon now have the data load of the relevant information necessary to prosecute the mission. Individuals may or may not access the CBMEN data, though it will be available.

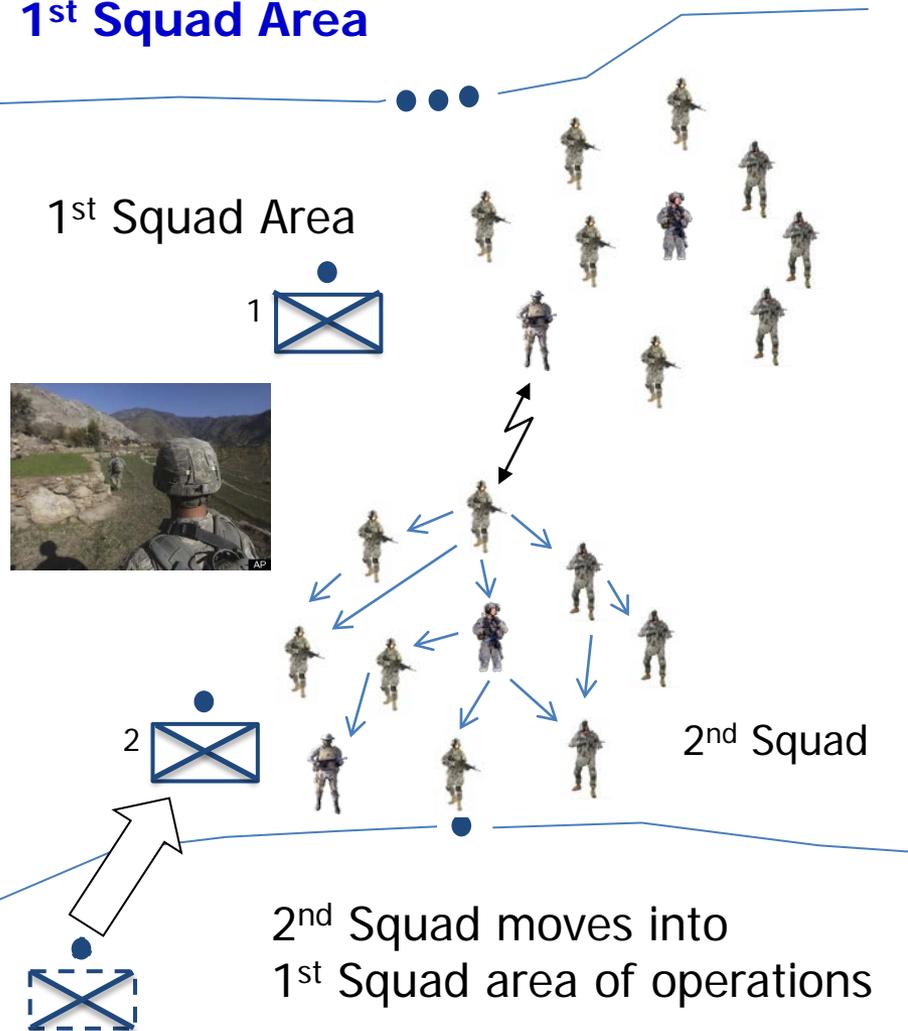
The platoon successfully executes the mission, identifies and captures a key insurgent bomb maker, and discovers and destroys an insurgent IED factory.

CBMEN directly contributes to mission success based on automated content distribution and the improved availability of relevant information for all members of the unit.



CONOPS Scenario 3 – Reactive Pull of Content

2nd Squad automatically receives content updates when entering 1st Squad Area



Scenario Highlights

1st Squad becomes engaged in a fire fight with a small local insurgent team.

Another Squad, 2nd Squad, is given a mission to move to and support 1st Squad to defeat the enemy. 2nd Squad moves to this new area, and now has the same mission to identify and engage insurgents.

2nd Squad "interests" are modified to include content related to insurgency in the 1st Squad area.

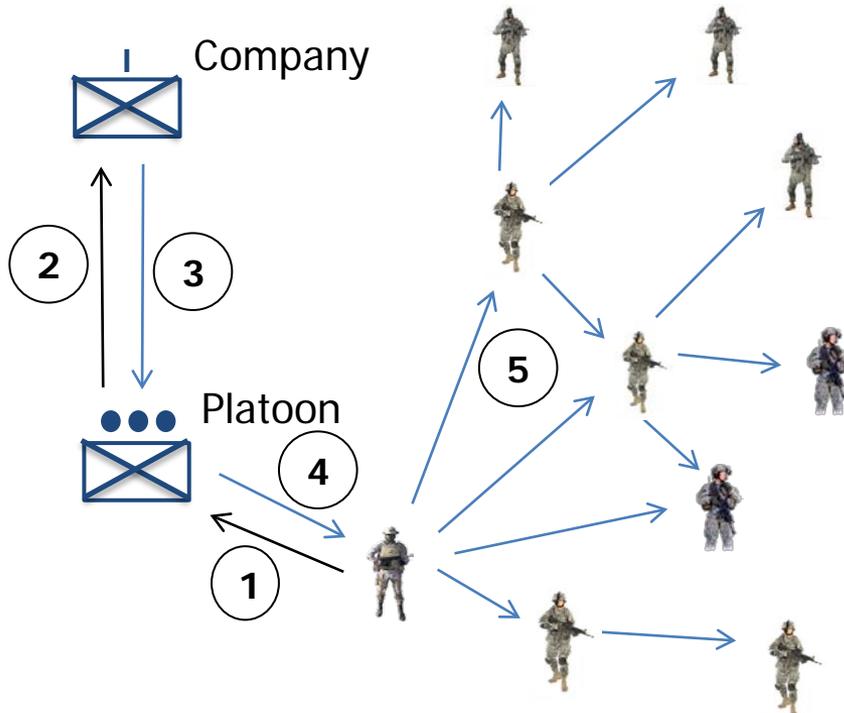
CBMEN pulls the relevant content matching this modified "interest" from nearby devices. CBMEN updates all devices to efficiently propagate the needed data.

Everyone involved in the mission has the latest content. The two squads successfully engage and defeat the insurgent team.



CONOPS Scenario 4 – Dynamic Query Generation and Proactive Content Sharing

Pro-active push using predicted correlation of content.



Scenario Highlights

A Squad is executing a mission to patrol an Afghan village with possible insurgent activity.

While on patrol, a squad member observes an unusual container in the area.

The squad member expresses a new “interest” (#1) for content relevant to the container and recent IED encounters in the area.

The query is propagated through the system (#2) and matched with content on recent IED devices emplaced by insurgents. Relevant content is returned to the squad member (#3 and #4).

CBMEN proactively pushes this new content to other squad members (#5), who all have similar interests. Additionally, other warfighters whose interests are typically correlated also receive the content.

The squad correctly identifies the container as an IED and then searches the local area for potential insurgents. Two insurgents are captured with bomb making materials and the mission is successful due to improved content sharing.



Conclusion



Responses to Questions