



Network-Aware Wireless Peer-to-Peer Collaborative Environments

Alex Bordetsky
Sue Hutchins
Bill Kemple
Eugene Bourakov

Naval Postgraduate School

Acknowledgements

- ☀ Sponsors: JFCOM, DHS, ONR, USSOCOM/JSOCOM
- ☀ Dr. Mike Letsky, ONR
- ☀ Paul Keel, MIT
- ☀ Dr. Dave Netzer, NPS
- ☀ CWII Chris Manuel, US Army SOF, NPS
- ☀ NPS GIGA Lab Student Team

Research Goals

- ✿ *Explore the solutions for an emerging concept of network aware tactical sensor-decision maker P2P collaborative environments. GIG/FORCEnet correspondence:
 - adaptive multipath collaborative environments,
 - GIG tactical extension*
- ✿ *Explore the models for network awareness enabling P2P grid nodes to self-organize their collaborative behavior and maintain quality of data sharing.*
- ✿ *Explore the multiagent solutions enabling node networking role and status sharing*
- ✿ *Explore the human-centric solutions for network awareness facilitation: network of operation centers*

Approach

- ✱ Three limited objective experiments conducted at the Naval Postgraduate School (NPS), Monterey, CA, Camp Smith, Hawaii, and Camp Roberts, CA
- ✱ The first experiment was focused on providing initial data to evaluate the potential impact of using collaborative P2P technology in an urban warfare environment.
- ✱ The second experiment was conducted to evaluate the effects of sharing network awareness and common operational picture on the tactical level humanitarian operations.
- ✱ The third experiment, STAN-6, was conducted at Camp Roberts, CA, to evaluate tactical sensor-decision maker collaboration and self-organizing capability in the environment of unmanned (UAV, UGV, and AUV) networks
- ✱ We used DARPA CoABS agent services approach to evaluate the awareness sharing effects in P2P collaborative environment. ⁴



JFCOM Experiment on Peer-to-Peer Surveillance and Reconnaissance Collaborative Command and Control Environments

P2P Tactical Grid Nodes: Small Unit Members with PDAs

- ✦ Sharing Situational Awareness with Small Expeditionary Unit Members
- ✦ Enabling Adaptive Wireless Networking for Support of P2P Collaboration on rescue phase of S&R



P2P Collaboration via Groove: Maintaining Location Awareness Feedback to Small Unit Members

The screenshot displays a Groove workspace window titled "P2P LOE 13Mar02 - Links - Groove". The interface includes a menu bar (File, Edit, View, Options, Help) and a toolbar with navigation and utility icons. The main content area shows a web browser window with the URL "http://localhost/loe/loemaps.asp". The browser displays a map application titled "Peer-to-Peer Limited Objective Experiment".

The map application interface includes:

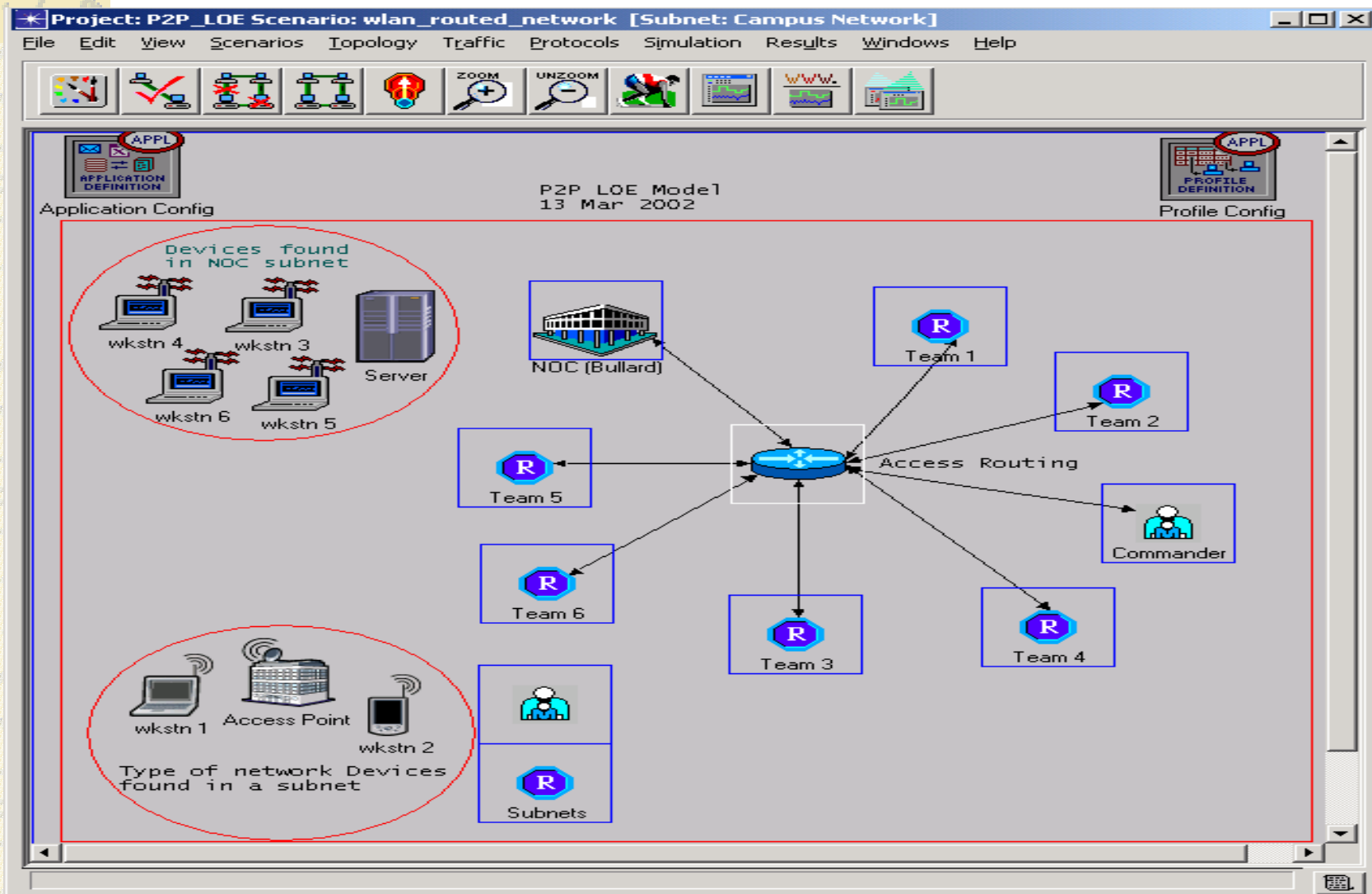
- Identity:** Local_CP
- Target type:** Radio buttons for "Terrorist" (selected), "Bomb", and a dropdown menu set to "type to be defined".
- Location Data:** "Your last known Longitude: -121.530760°, Latitude: 36.357560°" with a red "GPS is down" warning.
- Map:** A floor plan showing a "HAL" area and a "ROOT" area, with a green highlighted region.
- Navigation:** A "Back" button.

On the left side of the Groove workspace, there is a sidebar with the following sections:

- Invite:** An "Invite" button.
- Active:** A list of active users, including "TMS".
- Online:** A list of online users, including "Bordetsky, Alex".
- Not Online:** A list of users who are not online, including "Adam Michels (...)", "Crowson, Jeff", "Heather Penta", "Kemple, Bill", "Kline, Jeff", "Pilnick, Steve", "Rulof, Rob F.", "Sawyer, Lee", "TeamSpare", "Thate, Tim", "TM1", "TM2", "TM3", and "TM4".
- Conversation:** A chat window showing messages from "tm6", "TM1", "TM6", and "Uhrig, Bill".
- Navigation:** A "Navigate Together" checkbox.

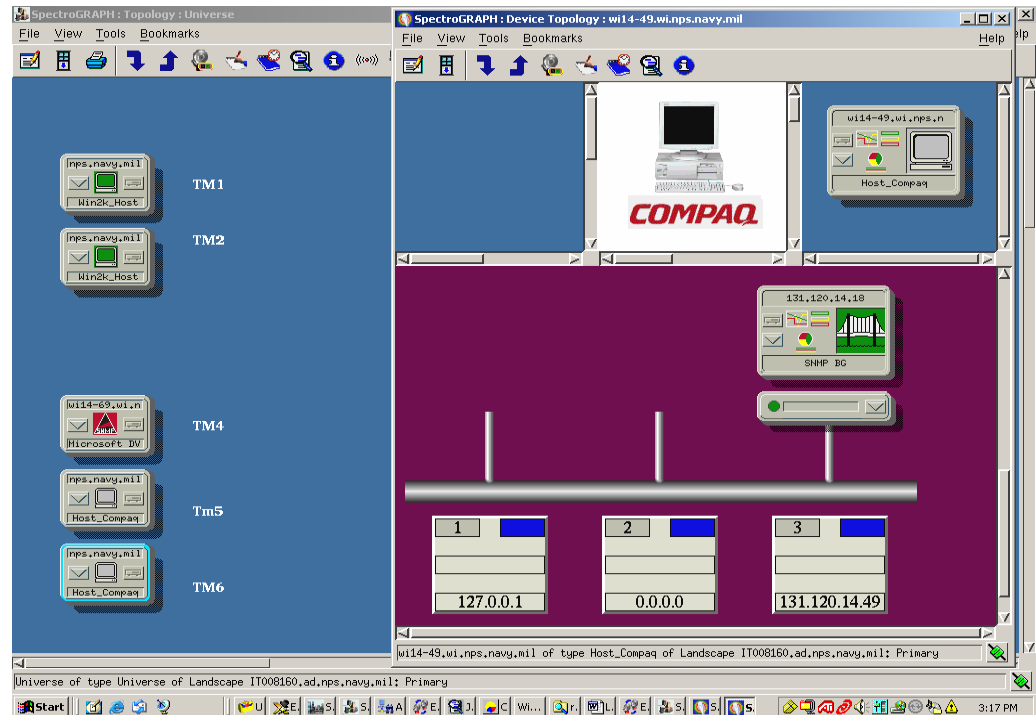
At the bottom of the workspace, there is a toolbar with buttons for "Brainstorming", "Documents", "Task List", "Schedule", "Links (1)", "Contacts", and "Add Tool". A "Send" button and an "Options" dropdown are also visible at the bottom right.

P2P Tactical Collaborative Environment Topology

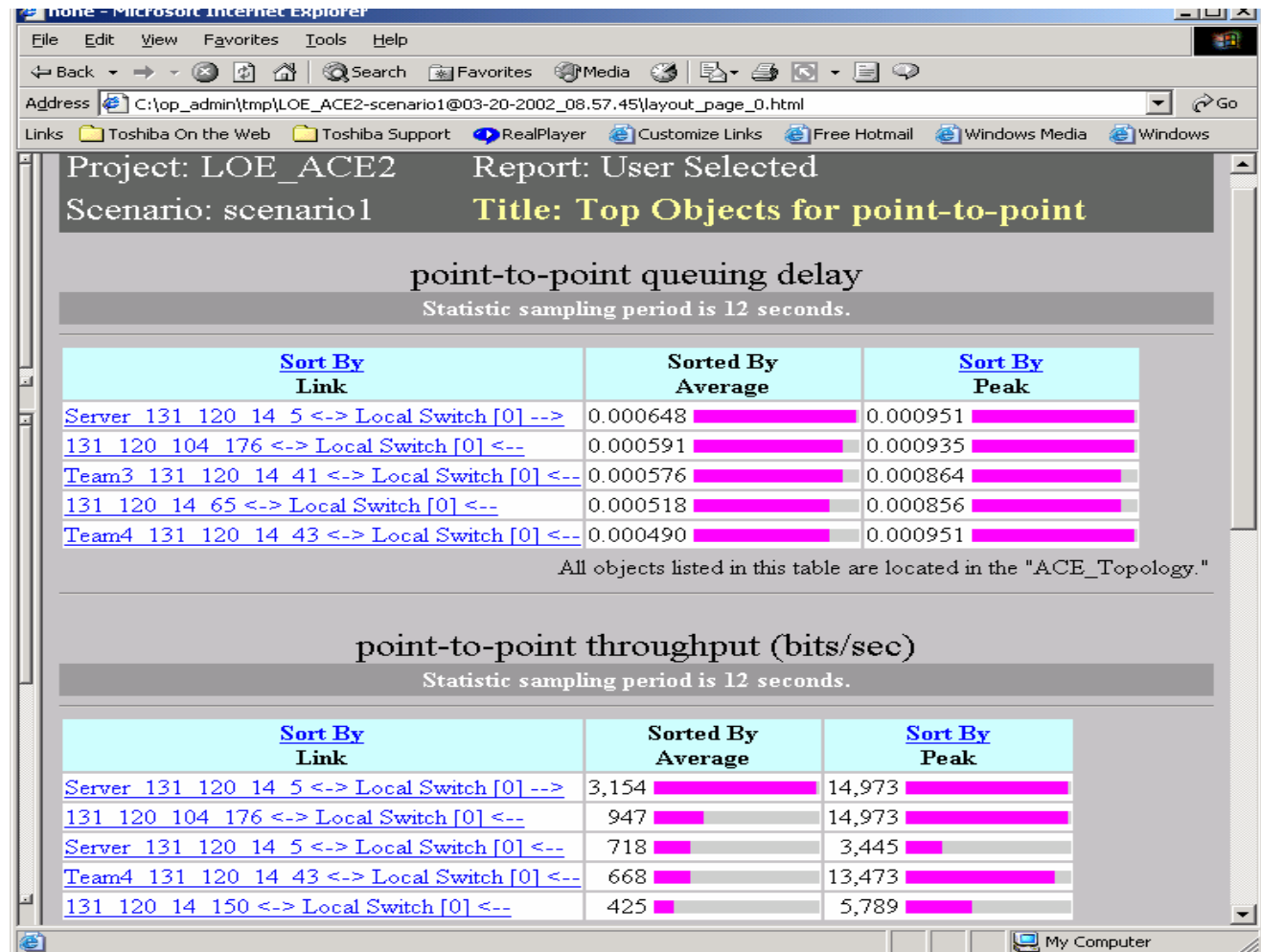


Tactical Operations Center View of P2P Collaborative Network

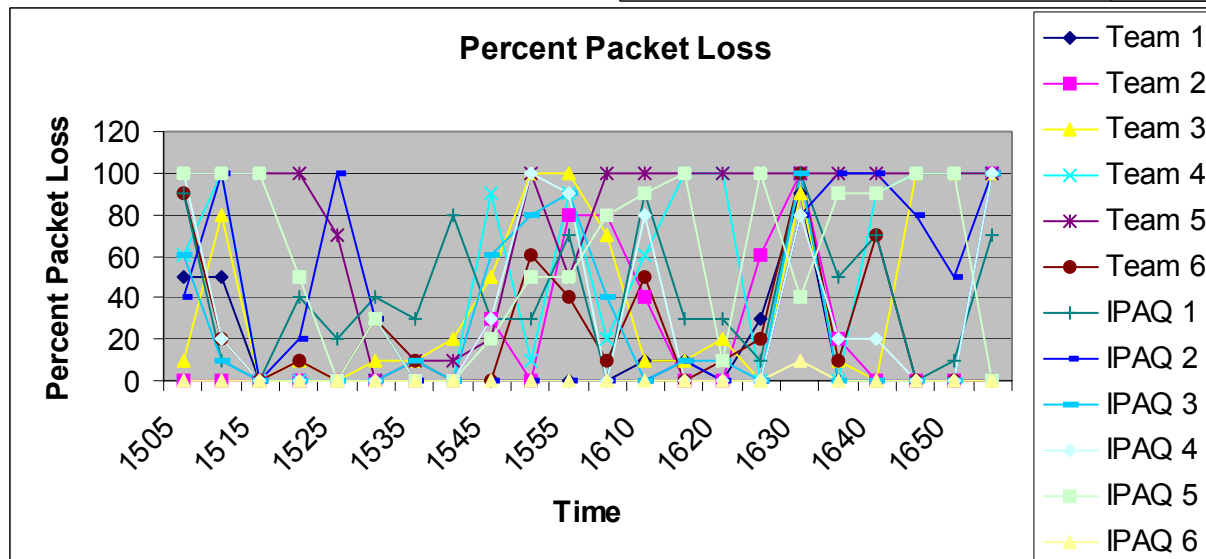
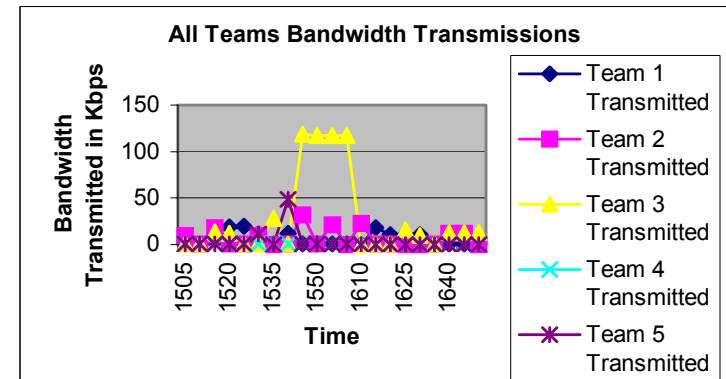
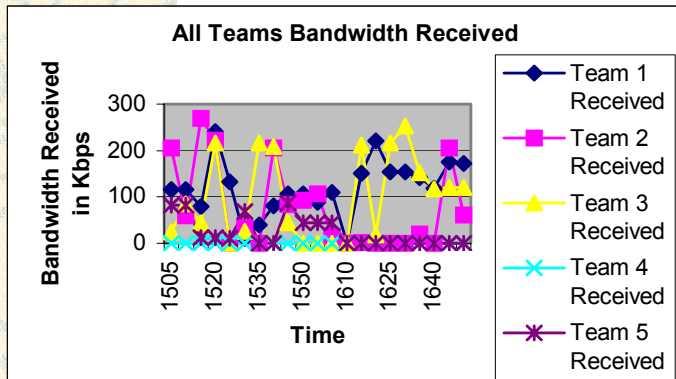
- Network Management System Snapshot of P2P Topology during the experiment
- TM1-TM5 are S&R team members mobile units

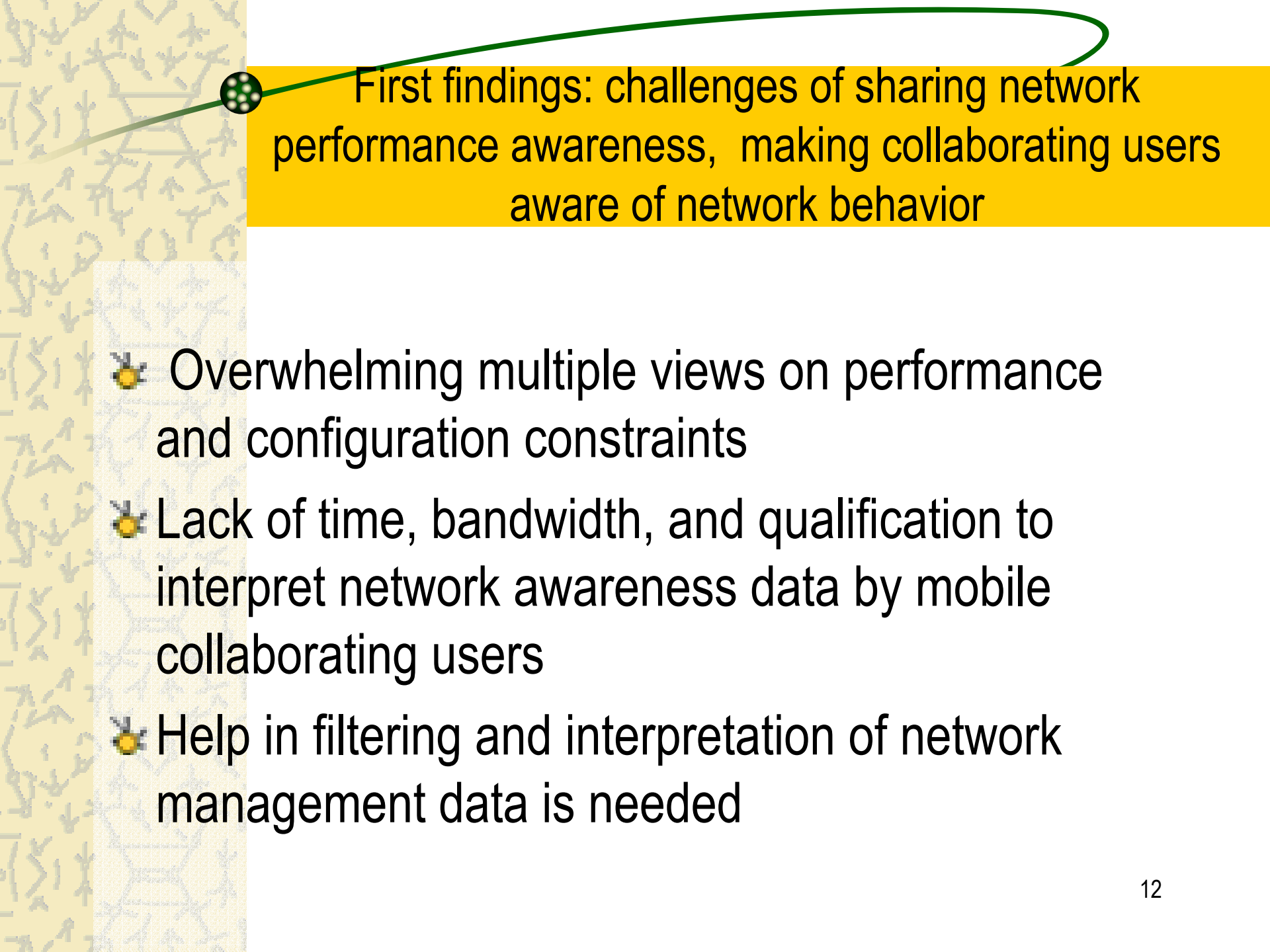


P2P Throughput Analysis



Monitoring bandwidth and packet loss: performance awareness feedback





First findings: challenges of sharing network performance awareness, making collaborating users aware of network behavior

- ❖ Overwhelming multiple views on performance and configuration constraints
- ❖ Lack of time, bandwidth, and qualification to interpret network awareness data by mobile collaborating users
- ❖ Help in filtering and interpretation of network management data is needed

Establishing P2P Networking Facilitator

- ✿ ***We observed self-organizing behavior of R&S team members in switching the modes of communication***
- ✿ ***The strongest and unexpected effect of self-organizing behavior emerged on the Tactical Operation Center site: the P2P team created system Facilitator***
- ✿ ***Facilitator interpreted and shared in fly selected network performance data in order to synchronize the voice and data sharing calls between the team members***

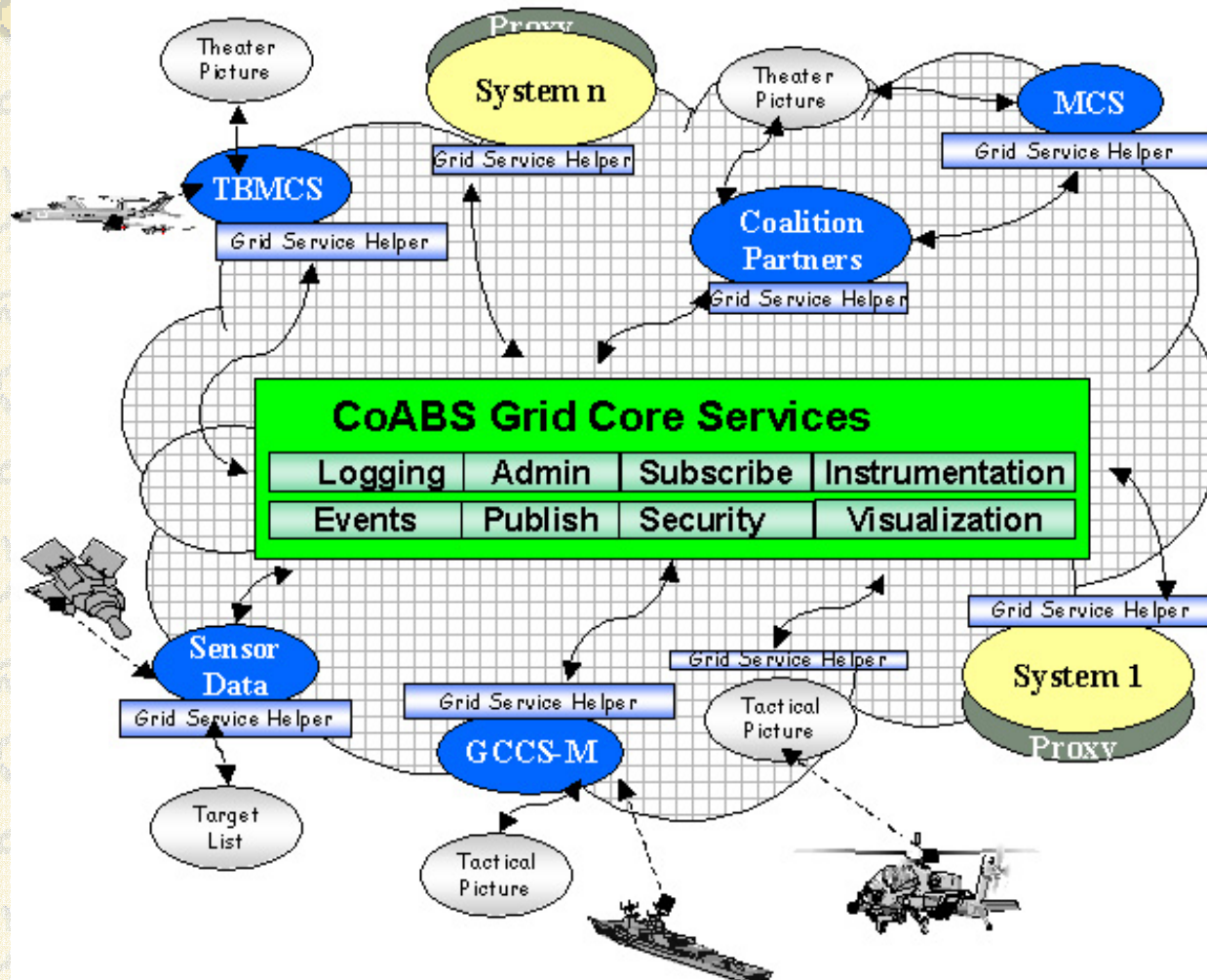


PACOM Experiment: Humanitarian Operations

Tactical Grid Nodes: MEU Members Augmented by Situational Awareness Agents

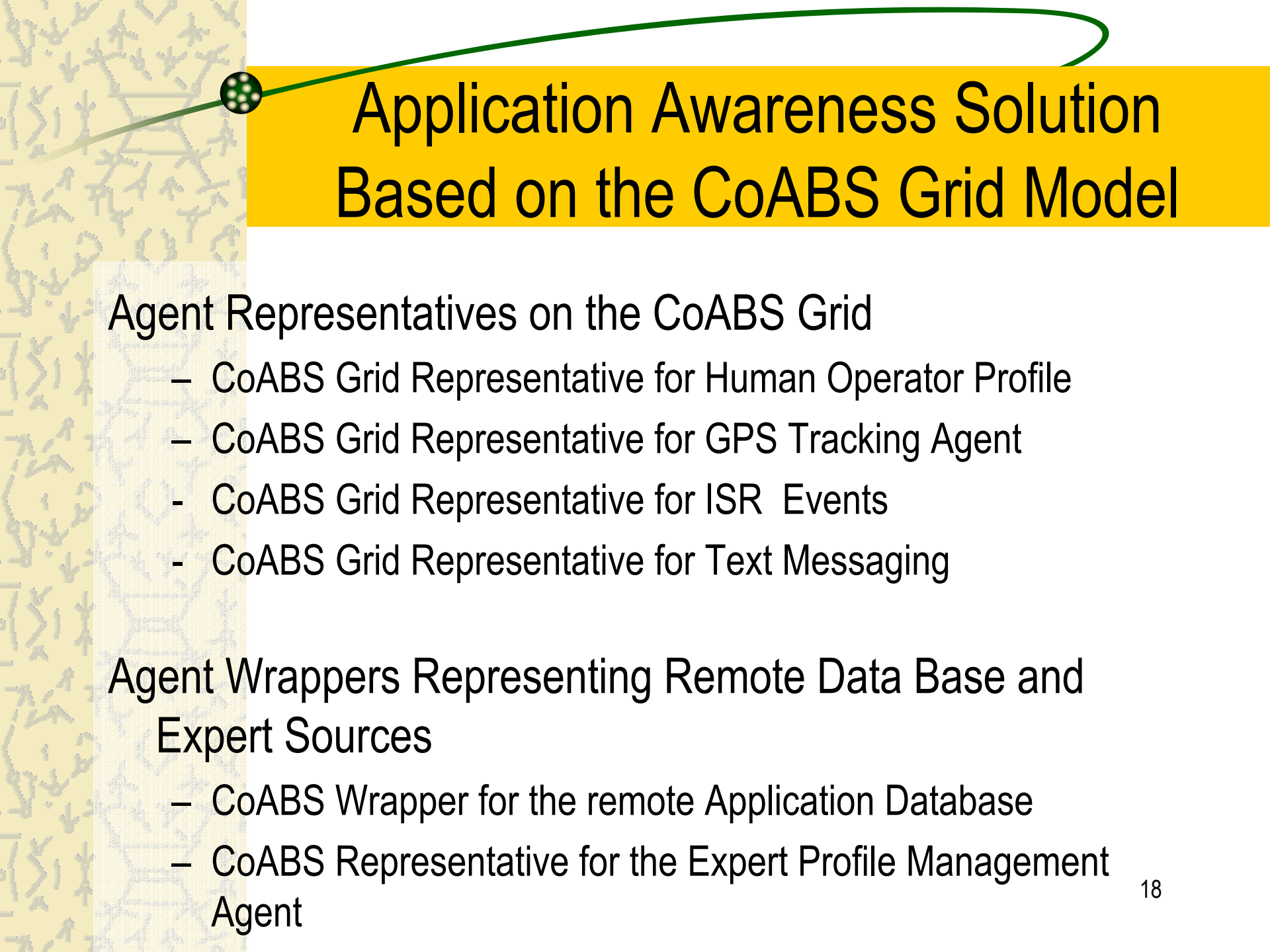
The screenshot displays a web browser window titled "TECHNICAL EVALUATION WORKSPACE - Web Links - Groove". The browser address bar shows the URL "http://131.120.179.99/loe/roccflash.asp". The main content area features a "ROCC Viewer" interface. On the left side of the viewer, there is a control panel with "Get GPS" and "Stop GPS" buttons, a "Map:" dropdown menu set to "Oahu, HI", and a "Message Box". Below these are "Info" and "Alerts" sections with various icons for "DP", "VAMD", "Weapon c", "Radd", "Detele Alert", "Medical", and "VWater". At the bottom of the control panel, it displays coordinates: "Lat.: 21°22.3038' N; 214 Long.: -157°50.0996' W; 165" and a "Logout" button. The main map area shows a topographic map of Oahu, Hawaii, with several tactical nodes marked by colored icons (red, blue, green) and numbered circles (9, 10, 11, 12). A red line connects two nodes, and a yellow radiation symbol is visible on the map. The interface also includes a "Members" list on the left, a "Conversation" section with "Hold-to-Talk" and "Show Chat" buttons, and a Windows taskbar at the bottom showing the "start" button and various application icons.

Improving the P2P Collaborative Node Status Awareness via the Agent Representatives: DARPA CoABS Grid Model



Different Agent Service Models

- ✱ **DARPA CoABS Grid:** CoABS Grid Scalability Experiments (Kahn and Cicalese)
- ✱ **NASA KAoS:** Human-Agent Teamwork and Adjustable Autonomy in Practice (Sierhuis, et. al.)
- ✱ **NOMADS:** Toward an environment for strong and safe agent mobility (Suri, et.al.)
- ✱ **DARPA Cougar** framework (<http://www.cougar.net>),
- ✱ **CORBA** (<http://www.omg.org>), and
- ✱ **Voyager** (<http://www.recursionsw.com/osi.asp>)



Application Awareness Solution Based on the CoABS Grid Model

Agent Representatives on the CoABS Grid

- CoABS Grid Representative for Human Operator Profile
- CoABS Grid Representative for GPS Tracking Agent
- CoABS Grid Representative for ISR Events
- CoABS Grid Representative for Text Messaging

Agent Wrappers Representing Remote Data Base and Expert Sources

- CoABS Wrapper for the remote Application Database
- CoABS Representative for the Expert Profile Management Agent

ROCC Team 1 Profile.

Team Information

Team Name:	Hezekiah Barge Jr.
Type of Contact:	Military
Rank or Position:	Major
Email address:	
Description:	
Color on the map:	Red

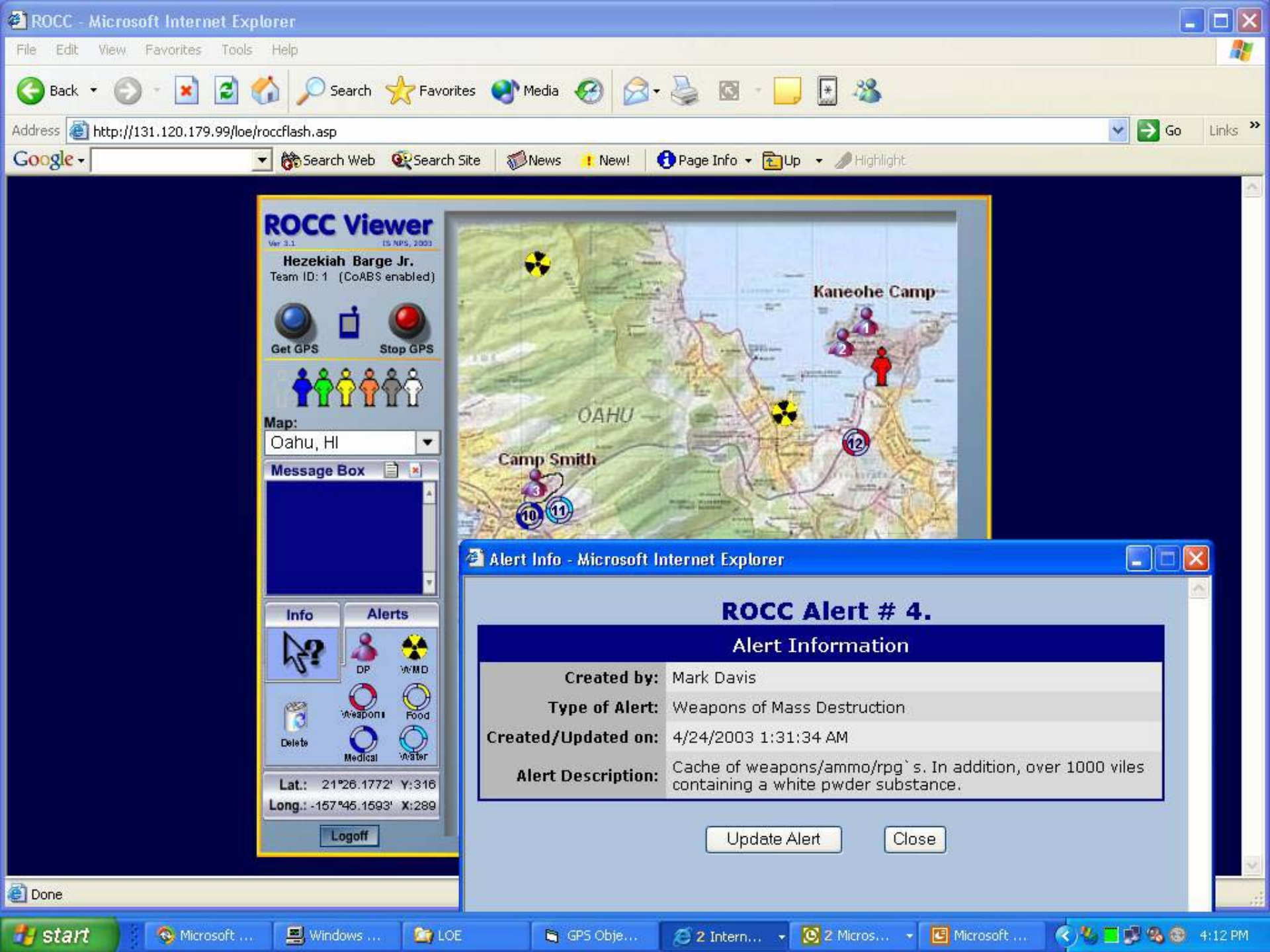
Communication Options

Phone/Mobile # :	
Pager Number:	
GROOVE Agent:	Installed
Wireless networking:	Enabled
Video Camera:	Enabled
CoABS Agent:	Registered with Grid Manager to provide: <ul style="list-style-type: none"> • Access to water supply DB
GPS Poster Device:	Equipped

Update Profile Close

Human Profile Representation on CoABS Grid





ROCC Viewer

Ver 3.1 15 NPS, 2003
Hezekiah Barge Jr.
Team ID: 1 (CoABS enabled)

Get GPS Stop GPS



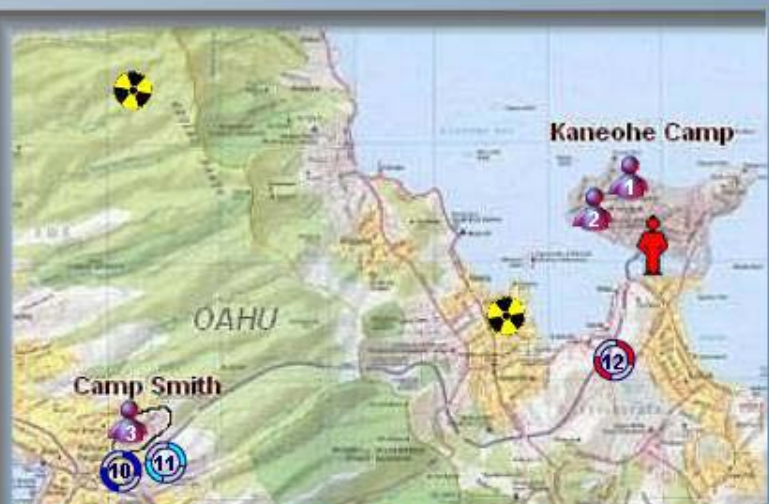
Map: Oahu, HI

Message Box

Info Alerts
DP WMD
Weapons Food
Delete Medical Water

Lat.: 21°26.1772' Y:316
Long.: -157°45.1593' X:289

Logoff



Alert Info - Microsoft Internet Explorer

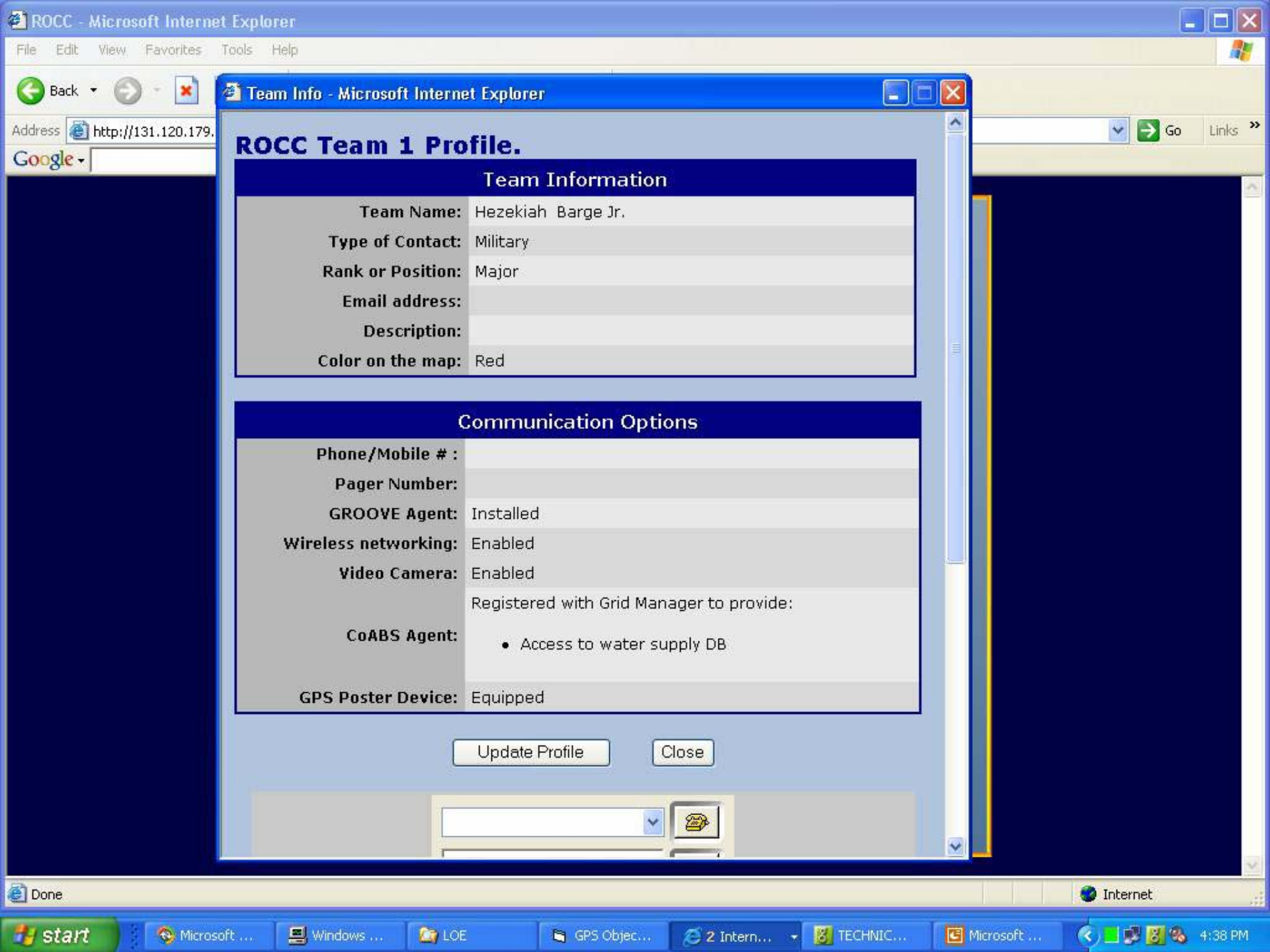
ROCC Alert # 4.

Alert Information

Created by:	Mark Davis
Type of Alert:	Weapons of Mass Destruction
Created/Updated on:	4/24/2003 1:31:34 AM
Alert Description:	Cache of weapons/ammo/rpg's. In addition, over 1000 viles containing a white pwder substance.

Update Alert

Close



ROCC Team 1 Profile.

Team Information

Team Name: Hezekiah Barge Jr.
Type of Contact: Military
Rank or Position: Major
Email address:
Description:
Color on the map: Red

Communication Options

Phone/Mobile # :
Pager Number:
GROOVE Agent: Installed
Wireless networking: Enabled
Video Camera: Enabled
 Registered with Grid Manager to provide:
CoABS Agent:

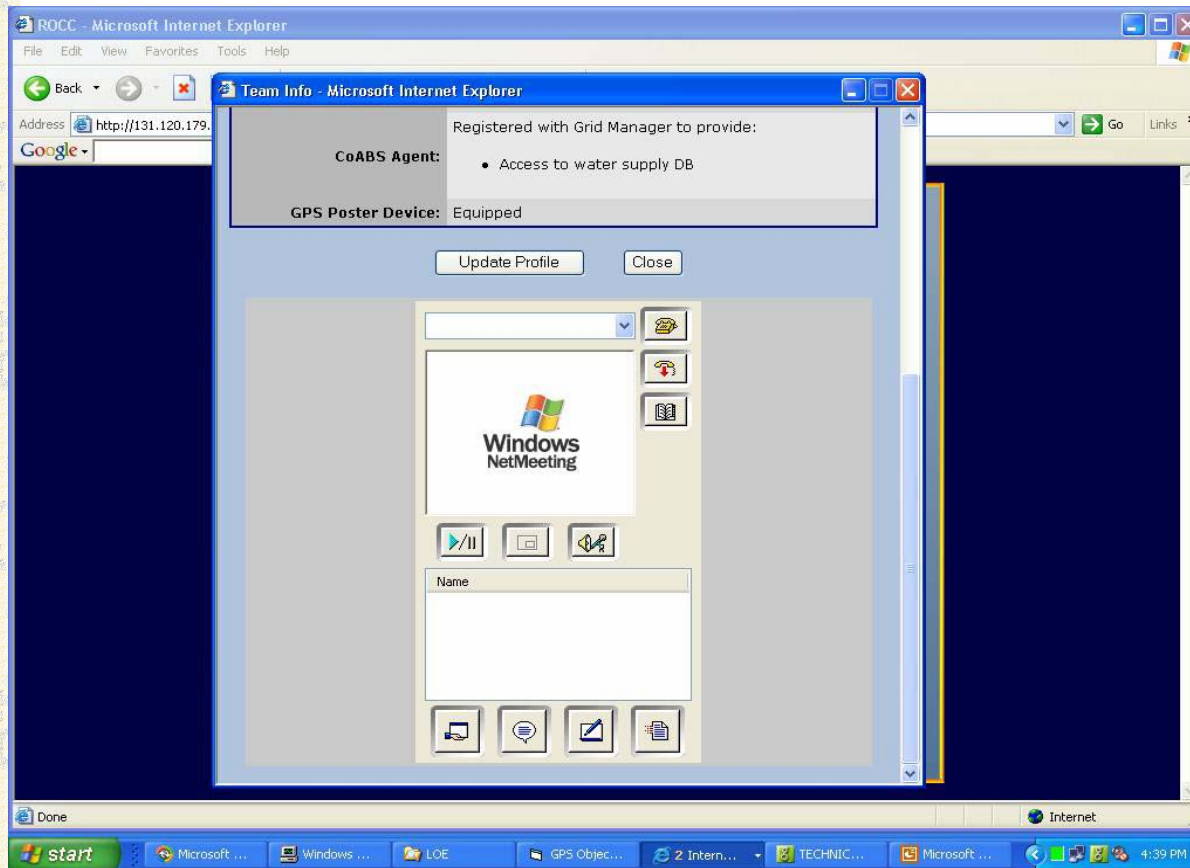
- Access to water supply DB

GPS Poster Device: Equipped

Update Profile

Close

MEU member profile with embedded video access



Displaced Person Alert

ROCC Viewer
Ver 3.1
Hezekiah Barge Jr.
Team ID: 1 (CoABS enabled)

Get GPS Stop GPS

Map: Oahu, HI

Message Box

Info Alerts

Lat.: 21°23.329'1" N; 157°45.4382' W; 282


Logoff

Alert Info - Microsoft Internet Explorer

ROCC Alert # 3.
Displaced Person Information

Created by: Tommy Testman Camp: Camp Smith

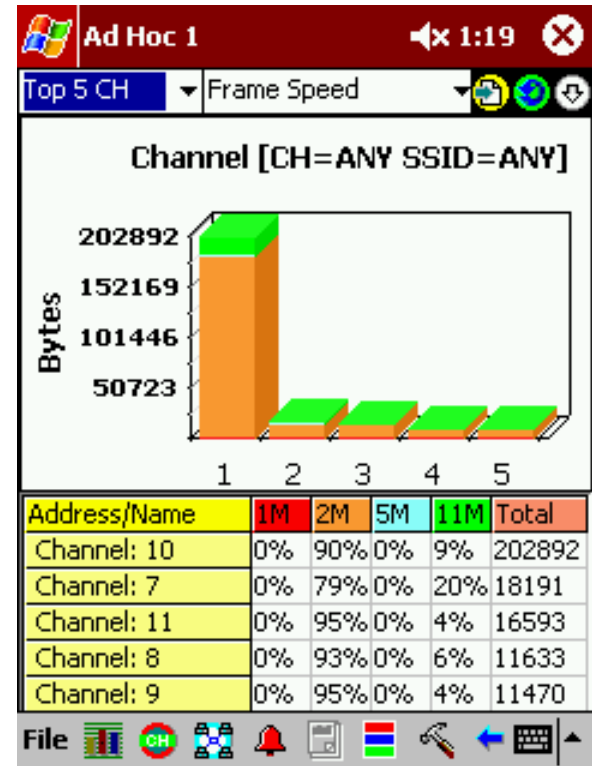
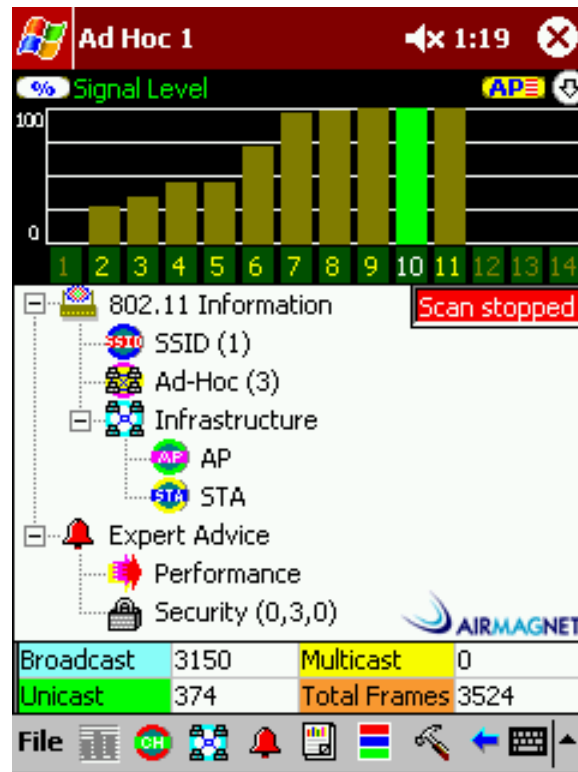
Displaced Person:



Fatima Tirkiti

Age: 25
Sex: Female
Marital Status: Married
Status: Missing Adult , need clothing , need medical assistance
Spouse Name: Muhammad Tirkiti
Home Origin: Tirkit
Comments: Not cooperating
Marked as: Not marked.
Created/Updated on: 4/22/2003 2:01:47 PM

Network Awareness Feedback: PDA View of Network Performance (“Micro NOC”)



Findings: CoABS Model Success and NA Feedback Problems

- ✦ **Bandwidth management for P2P Groove clients**
This issue appeared to be critical form of operational feedback to the team members. They frequently used “Micro NOC” feedback to identify the coverage and adjust their operations to the failing coverage.
- ✦ **Scalability through CoABS**
The experiments proved scalability of CoABS multiagent platform for maintaining P2P collaborative awareness. The MEU members were able to seed and respond to multiple surveillance events using the grid agents
- ✦ **Problems with rapid understanding of network behavior**
Interpretation of technical detail contained in the “Micro NOC” views appeared to be extremely inefficient, slowing down surveillance data sharing process. The network performance data should be filtered and delivered directly to the main Situational Awareness interface

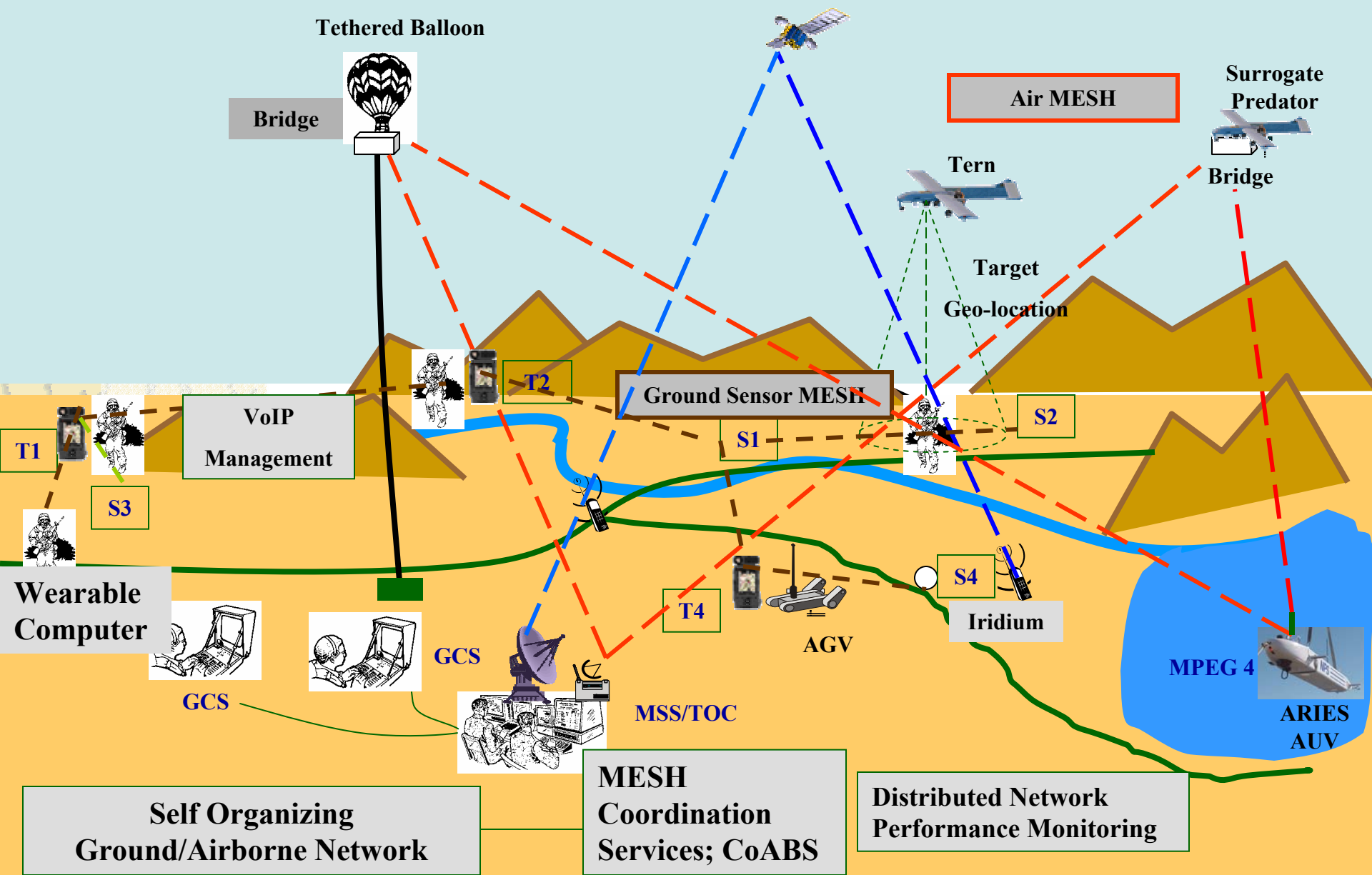


SOCOM Experiment: Sensor-UAV- Decision Maker Collaborative Grid

STAN: Surveillance and Target Acquisition Network

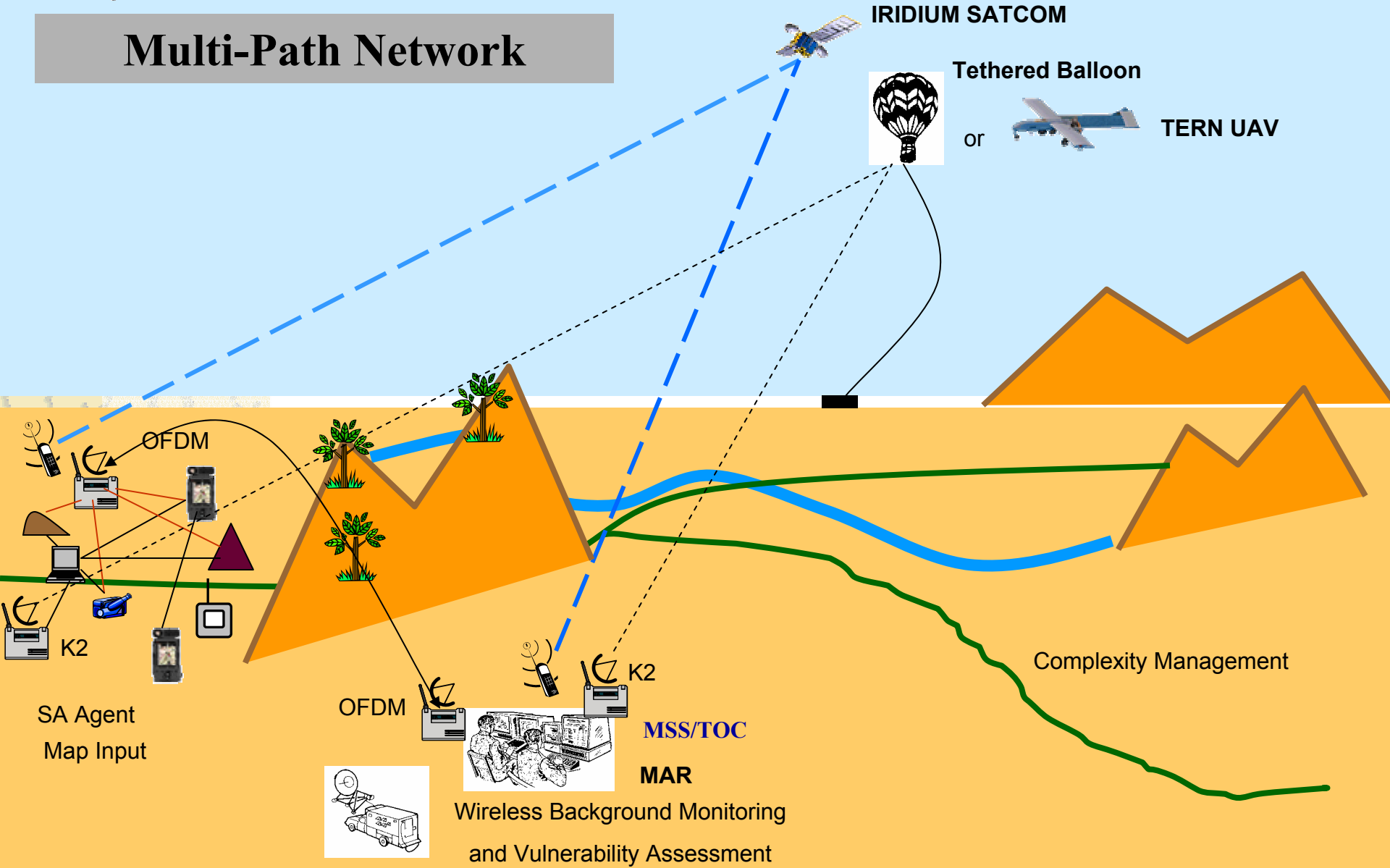
- ✦ Tactical Grid Collaborating Nodes: SOF unit operators, unattended ground sensors, UAVs, OFDM Towers, and TOC
- ✦ Long-haul terrestrial wireless (802.16) and airborne 802.11 data communications
- ✦ Multipath networking capabilities augmented by the Iridium satellite links
- ✦ Long-haul (30-100 mi) sensor/operator P2P mesh
- ✦ Ubiquitous video surveillance and shared SA

NPS with Contractor Team Support

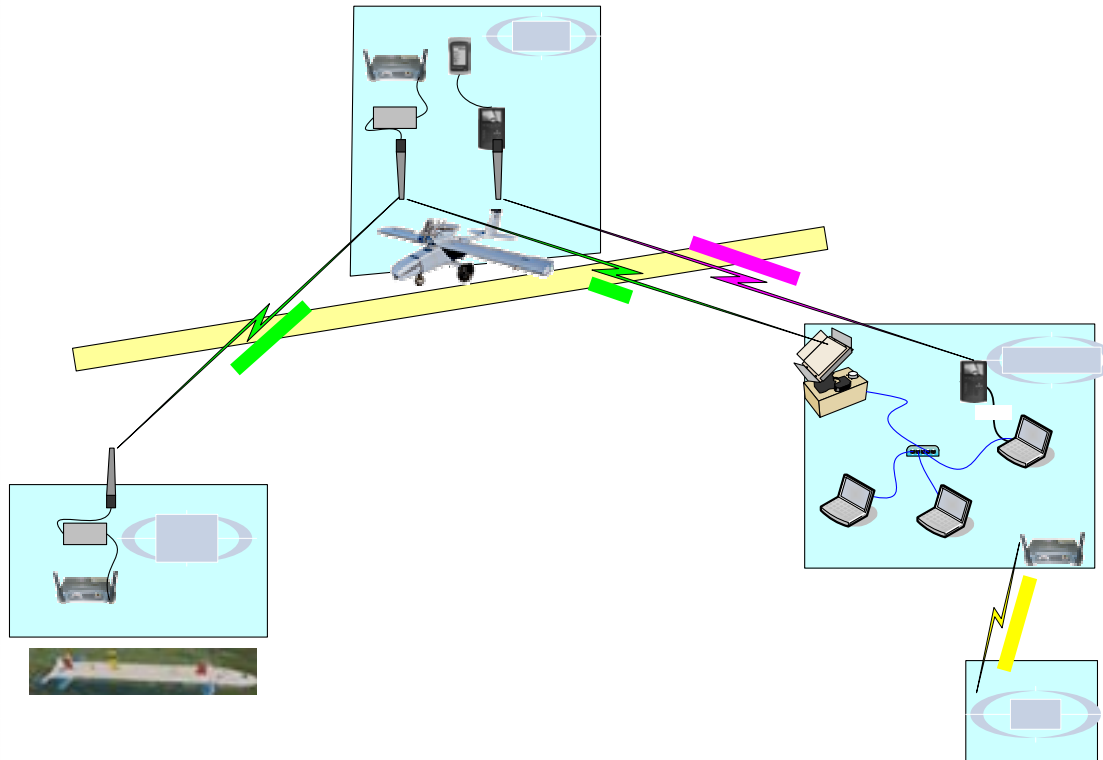




Multi-Path Network



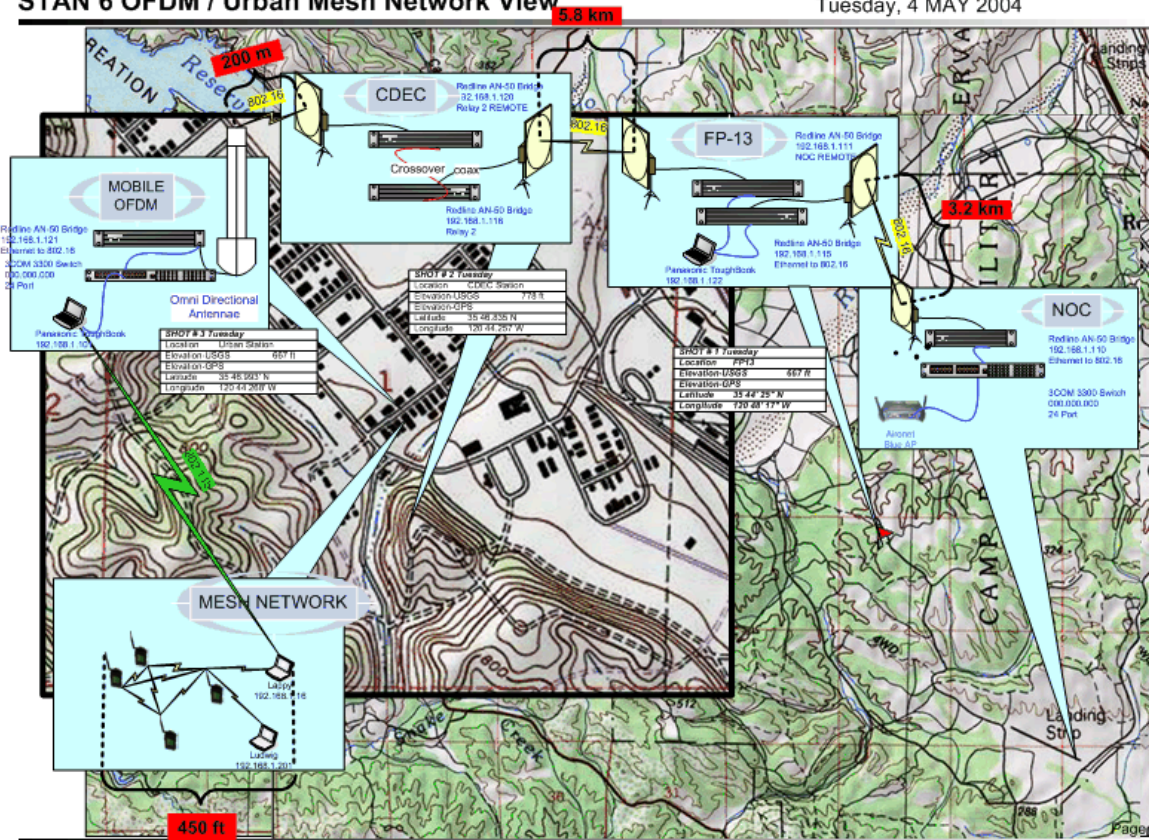
Networking with Unmanned Vehicles (designed by LCDR Axel Schumann, German Navy)



OFDM Components of Grid (designed by LT Ryan Blazeovich)

STAN 6 OFDM / Urban Mesh Network View

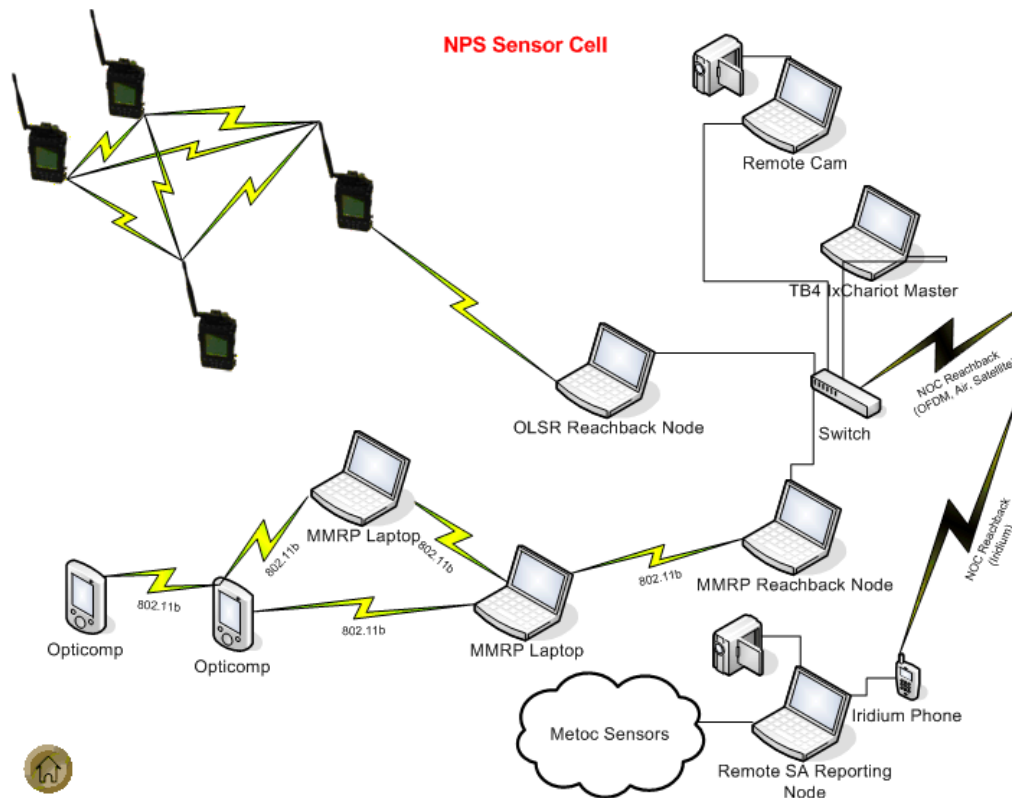
Tuesday, 4 MAY 2004



Sensor Cluster Mesh

(designed by LCDR Eric Bach)

STAN 6 Mesh Network / Sensor Cell Cluster Detail





Shared SA screen with Weather Station agent reporting to the Grid

Macromedia Flash Player 7

File View Control Help

Situational Awareness

SA View
Weath

Weather Station: 1108

Time: 5:49:42 PM

Wind speed: 0 m/sec
Wind direction: 354°
Barometric pres.: 823 hPa
Air temperature: 21.2°C
Relative Humidity: 14.3 %

Info Network Save

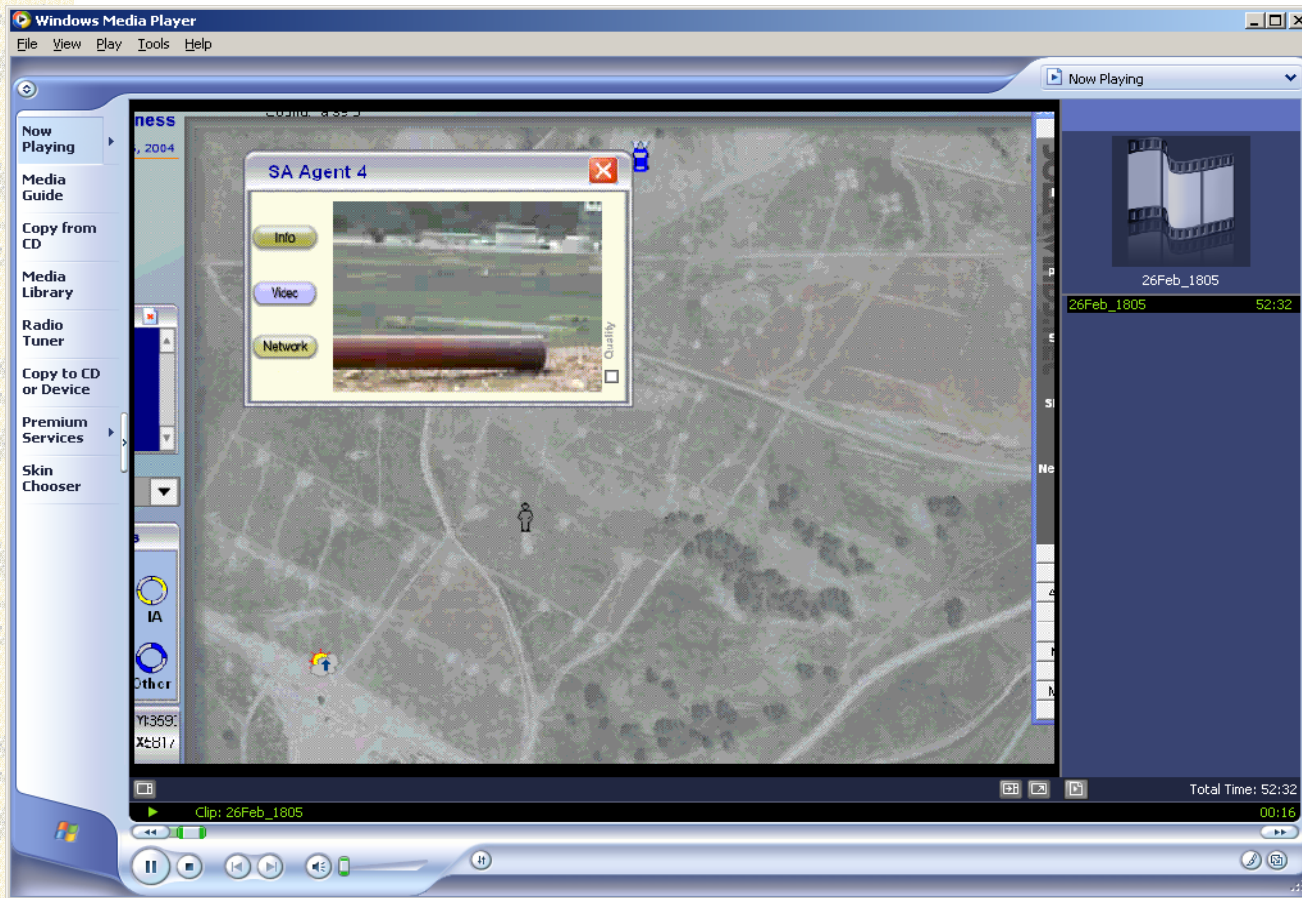
Map: Camp Roberts 5

Info	Alerts

Lat: 35°45.2338' N; Y: 110
Long: -120°48.8097' W; X: 67
Format: qq° Dmm.mmm

Quit

Situational Awareness with Video Sensor Agent reporting to the Grid

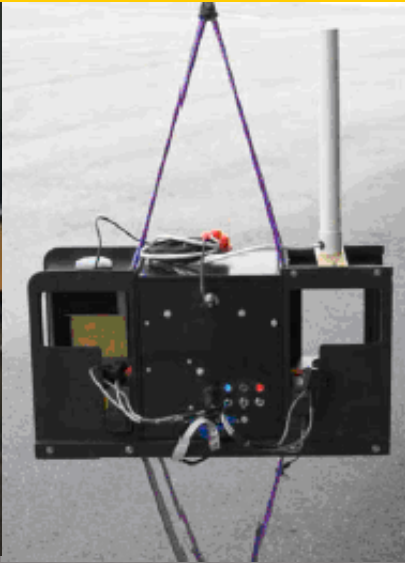


Grid NOC

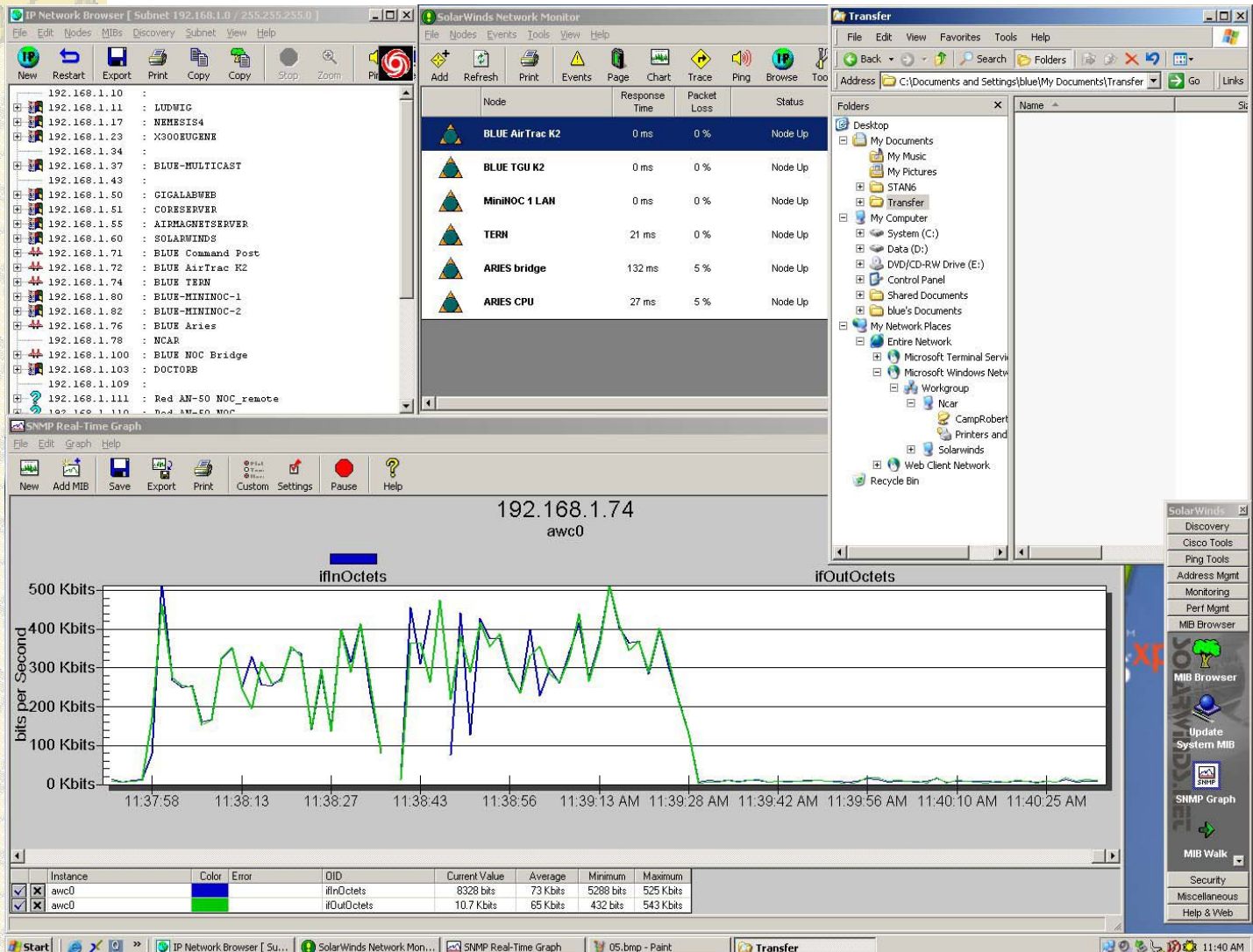




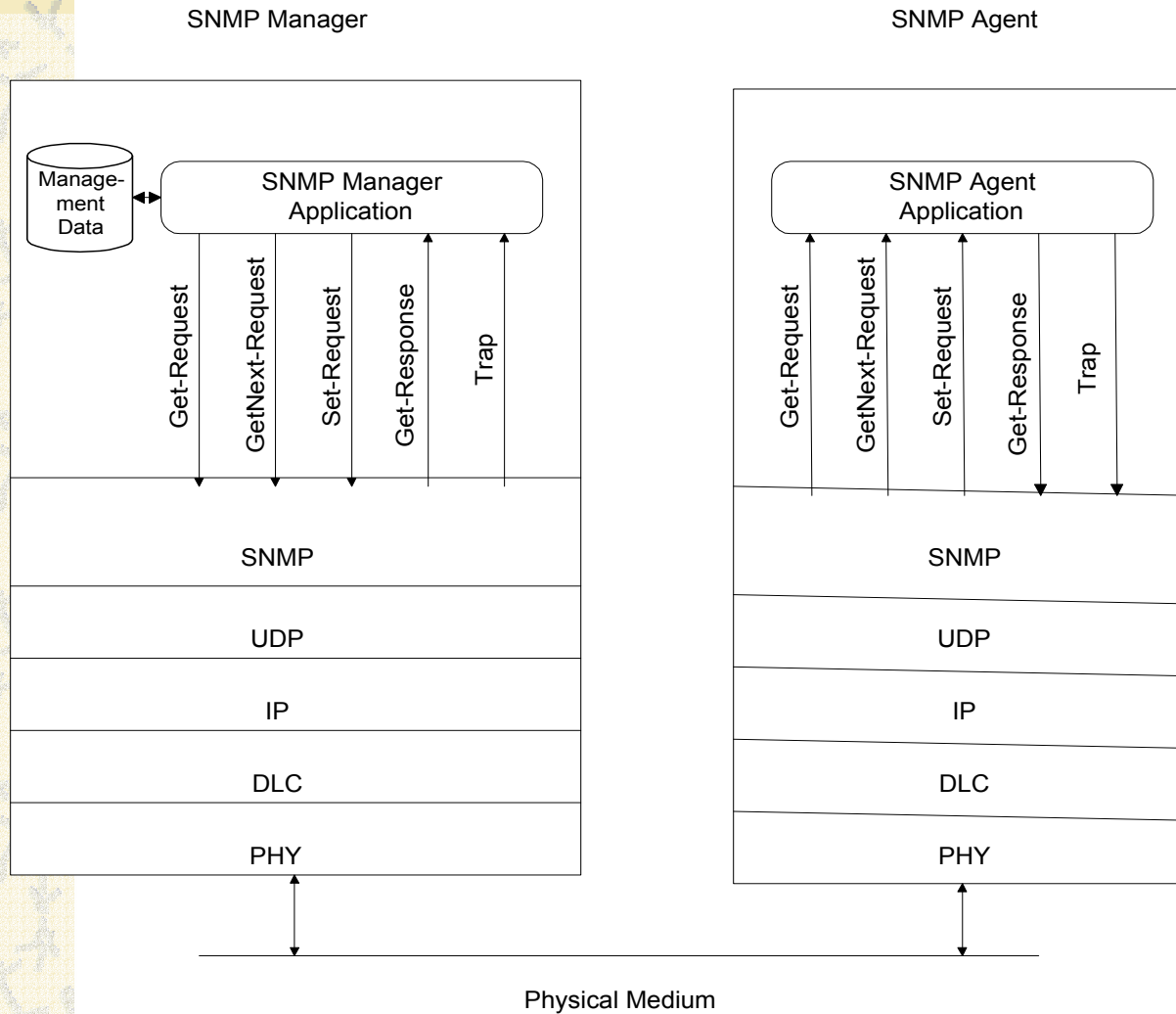
UAV Link Portable NOC



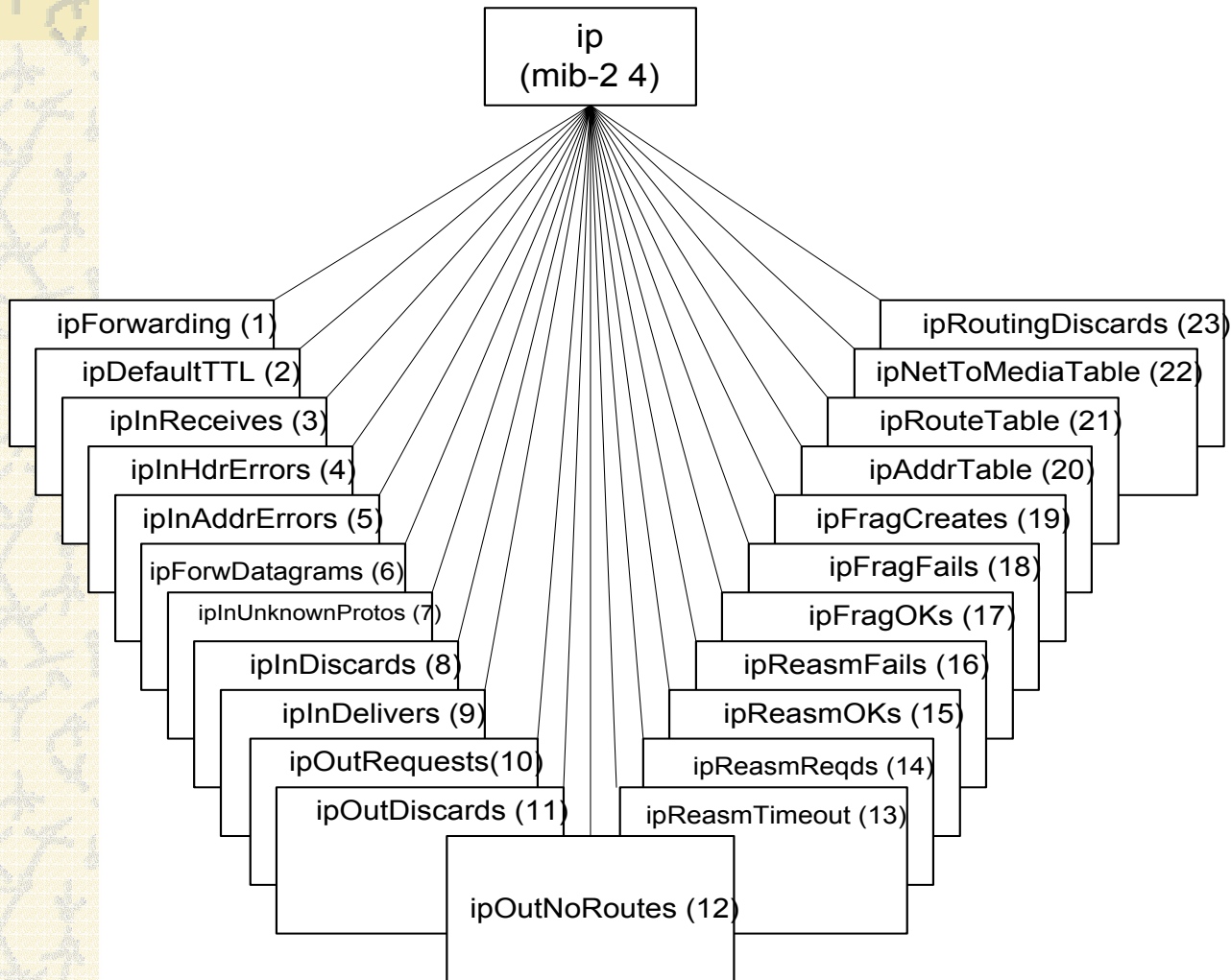
UAV Behavior as a Networking Node



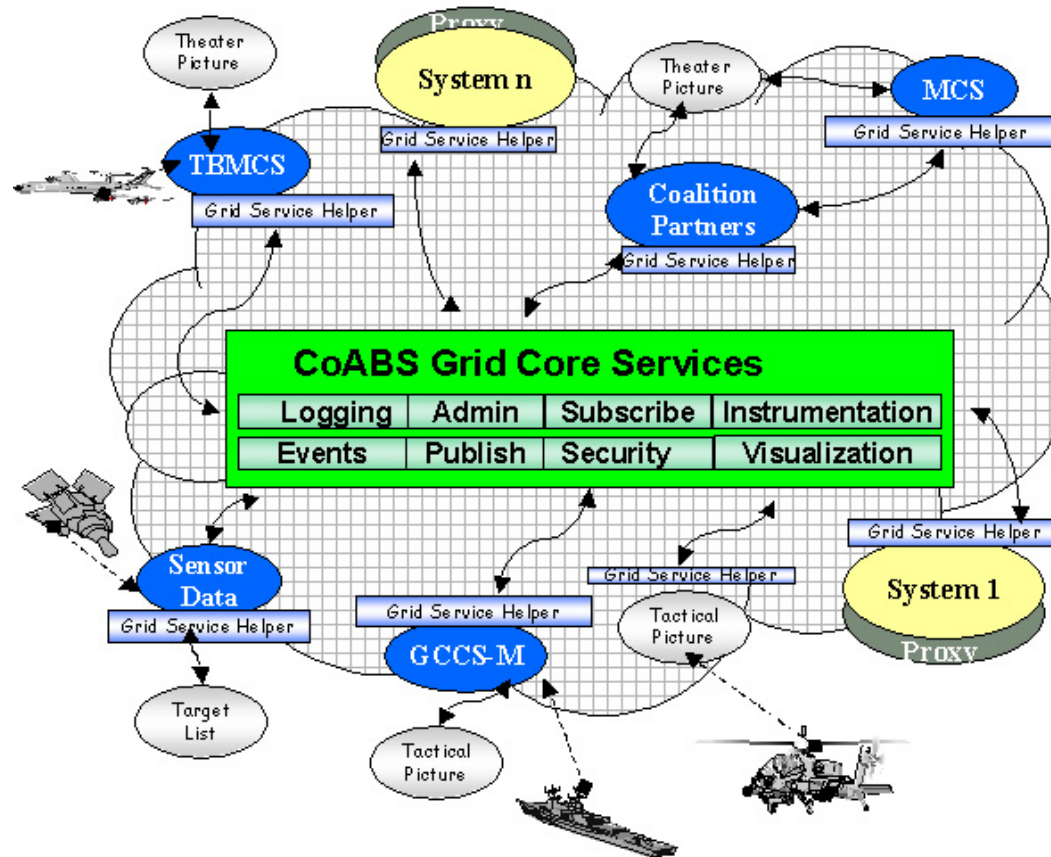
SNMP Agents for Network Mangement



MIBs that SNMP agents manage:

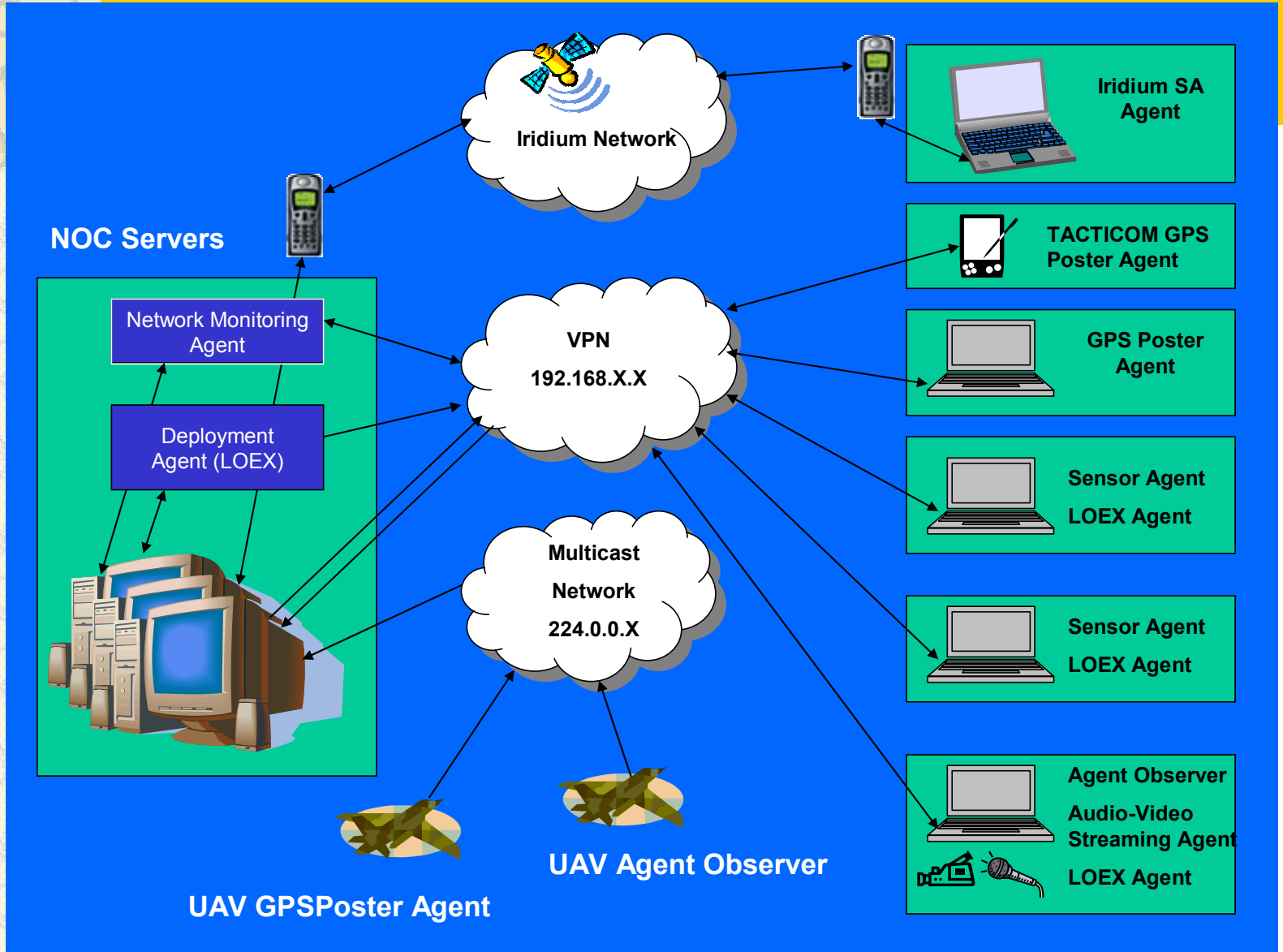


Network Awareness Solution: Extending SNMP communications to SA CoABS Services





STAN SNMP Agents Join the CoABS Services Environment





Combining Situational and Network Awareness in Grid Operation

Macromedia Flash Player 6

File View Control Help

Situational Awareness 13 Sound: true

SA Viewer, v5.1 15 NPS, 2004

TC3 Agent

Message Box

Sensor: TC3 Agent
Video motion detected.

Map: Camp Roberts 2

Info Alerts

Delete Alert

Lat: 35°45.9585'
Long: -120°46.3473'
Format: ddd°mm.mmmm

Quit

TC3 Agent (131.120.178.245)

Info Video Network

TC8 (131.120.176.50)

Node Network Status

Info Response time: <1 ms
Packet Loss: 0

Video Throughput IN: 9.85 Kbps
Throughput OUT: 3.94 Kbps

Network Packet Size: 181 Bytes

Sensor SNMP Agents Reporting to SA Grid

The screenshot displays a Macromedia Flash Player 6 window titled "Situational Awareness". The interface includes a map of California with several sensor locations marked. Three data windows are open, each showing "Node Network Status" for a specific sensor:

- BAE Voice:**
 - Response time: <1 ms
 - Packet Loss: 0
 - Throughput IN: 11.44 Kbps
 - Throughput OUT: 6.04 Kbps
 - Packet Size: 125 Bytes
- MAG2:**
 - Response time: <1 ms
 - Packet Loss: 0
 - Throughput IN: 1.46 Kbps
 - Throughput OUT: 0.16 Kbps
 - Packet Size: 120 Bytes
- AIR2:**
 - Response time: <1 ms
 - Packet Loss: 0
 - Throughput IN: 1.65 Kbps
 - Throughput OUT: 0.37 Kbps
 - Packet Size: 120 Bytes

The interface also features a "Message Box", "Map: Coast View", and "Info" buttons. The Windows taskbar at the bottom shows the start button and several open applications, including "Inbox - Micro...", "Shipped: trec...", "RE: Shipped: ...", "Macromedia F...", and "Document1 - ...". The system clock indicates 5:12 PM.

Summary

- ✦ It is feasible to design network aware collaborative P2P nodes based on the SNMP agents integration with SA CoABS middleware
- ✦ The current model is limited by human-in-the-loop solution
- ✦ To further automate self-organizing behavior of ISR sensor-DM grid QoS multiple criteria policies for agents are needed
- ✦ New level of awareness could be achieved by adding the human-centric solution: collaboration of TOC, vehicle NOC, UAV link NOC, man-portable NOC, etc

The slide features a decorative left border with a repeating pattern of chemical structures, including hexagons and arrows. A green swoosh line starts from a circular icon containing five white dots on the left edge of a yellow horizontal band and curves across the top of the slide. The word "Questions?" is written in a large, bold, black font on the yellow band.

Questions?