Wireless Communications Applications in Surface Transportation

2012 Indo-American Frontiers of Engineering Symposium
National Academy of Engineering

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March 2nd, 2012
Tenure: What it Does to you

Before Tenure
Tenure: What it Does to you

After Tenure
Incident Mgmt: Interactions with Real-World Systems
Traffic Incident Management System

Information Flows

- Road network conditions
- Traffic images
- Incident information

Emergency Vehicle
- On-board EV Incident Management Communication
- Incident status

Emergency Management
- Decision support information

Other Traffic Management
- Road network conditions + incident information + incident response status + resource deployment status + traffic images
- Incident information + resource deployment status + remote surveillance control
- Incident command
- Information presentation
- Incident command inputs
- Incident information + incident response status
- Rail incident response status
- Logged vehicle routes
- Incident information

Information Service Provider
- Event plans

Event Promoters
- Event plans

Roadway
- Traffic flow + traffic images
- Video surveillance control + traffic sensor control

Other Roadway
- Roadway equipment coordination

Maintenance and Construction Management
- Incident information + maint and constr resource request
- Incident information + maint and constr resource response

Other MCM
- Maint and constr resource coordination

Traffic Management
- TMC Incident Dispatch Coordination/Communication
- TMC Incident Detection

Other Emergency Management
- Incident response coordination + incident command information coordination
- Incident response status + incident information

Transit Management
- Incident information + maint and constr resource request + incident response status

Other MCM
- MCM Incident Management

Rail Operations
- Incident information + maint and constr resource request + incident response status

Emergency Personnel
- Incident information + maint and constr resource response

Rail Operations
- Maintenance and construction information coordination

Other Emergency Management
- Incident response coordination + incident command information coordination
- Incident response status + incident information

Incident Command
- Incident status

Emergency Response Management
- Event plans
Introduction-ITS Communications

- On-line highway traffic management needs
  - Faster
  - More efficient and
  - Reliable communication technologies

- Wired communication has been the most popular choice

- It is changing with
  - Advancement in wireless technologies
  - Needs
Issues with Wireless?

- Reliability
- Cost
Selection of Communication Technologies

- Agencies’ needs, future plan and resources available?
- Each communication alternative varies
  - Bandwidth
  - Transmission Range
  - Data Rate
  - Reliability
  - Cost
Wireless Options—Short Range

- WiFi
  - Wireless Fidelity
  - IEEE 802.11a/b/g/n

- WAVE/DSRC: IEEE P1556
  - WAVE
    - Wireless Access in Vehicular Environments
    - IEEE P1609
  - DSRC
    - Dedicated Short-Range Communications
    - IEEE 802.11p
Wireless Options-Long Range

- WiMAX
  - Worldwide Interoperability for Microwave Access
  - IEEE 802.16

- 3GPP
  - 3rd Generation Partnership Project
  - Cellular/mobile
Why WiMax

A globally rising wireless communication technology

- High-speed broadband access
- Easy extension to suburban and rural areas
- Broad coverage
Field Performance Study of a Regional WiMAX Network for Roadway Traffic Control and Management

In collaboration with
West Virginia High Technology Consortium Foundation
WiMAX Field Study Tasks

- Field performance evaluation of a regional WiMAX network
- Feasibility of WiMAX for a wireless sensor based traffic surveillance system
A typical WiMAX network consists of two parts
- Base station
- Client radio

Complex environmental factors can affect the network performance

Impact of environmental factors on WiMAX have not been systematically studied
WiMAX Characteristics

- Theoretical performance
  - Max link rate is up to 70 Mbps
  - Coverage range > 10 miles

- Cost information:
  - Base station: $11,000 to $125,000
  - Client radio: $2,200
WiMax Testbed

Fairmont, WV

Fairmont BS3

Verizon BS2

Research Center BS1

Fairmont, WV
Experimental Setup

- **Fixed Operation Test**
  - Stationary Locations
  - Client radio: Airspan EasyST

- **Moving Car: Mobile Operation Test (very low speed)**
  - 25 mph
  - Client radio: M-A/COM

- **Network Testing Tool:** Iperf for throughput measurement
**Mobile Operation Test**

- Developed Coverage Measurement and Visualization Tool

  Visualization tool included:
  - Time/Date GPS Location
  - Vehicle Speed
  - Signal-to-Noise Ratio (SNR)
  - Received Signal Strength Indication (RSSI)
- Client radio subscribed to Fairmont base station
- Within a 2 mile distance
Client radio specifications affect network performance

**Mobile Operation Test**

**Radio #1**
- SNR: 21.7
- US Mode: QPSK3/4
- DS Mode: QPSK1/2
- Velocity: 10.2 mph
- Altitude: 1131.9 ft
- Distance to BS: 2594.7 ft

**Radio #2**
- SNR: 35.3
- US Mode: 64QAM3/4
- DS Mode: 16QAM3/4
- Velocity: 9.7 mph
- Altitude: 1164.7 ft
- Distance to BS: 2597.1 ft
WiMAX Study Conclusions

- Performance is impacted by
  - Base station location
  - Altitude of base station
  - Terrain
  - Foliage coverage
  - Client side radio specifications
WiMAX Study Conclusions

- Suitability for supporting traffic sensor network
  - Potential to support throughput requirements of ITS devices
  - Potential to support broadband communication requirements for future ITS applications

- Regional WiMAX network
  - Benefits to multi-agency resource utilization: DOTs, polices, emergency services
  - Increased benefits as more and more ITS components come on line
Clemson's Integrated Intelligent Transportation Platform (IITP)

U.S. DOT Connected Vehicle Technology Challenge Winner
Components

1. Functionality

2. Technologies

3. Business Model?
Functionality

- Safety
- Electric Vehicle (EV) recharging
- Plug-In Hybrid Electric Vehicles (PHEVs)
- Road usage fee collection
- Real time route planning
- Commercial/private industry applications
<table>
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<td>WiFi/DSRC</td>
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<td>3GPP</td>
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<td>Wired</td>
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Business Model?

Private or public investment?
IITP Summary

- Integrates wireless communication technologies
- Identifies most suitable technology
  - Context
  - Availability
  - Cost
- Supports numerous types of applications
- Addresses infrastructure funding issues
A Recent Distinction
Questions?
Thank you!