Coming Soon to a Car Near You: Wireless Access

Research and Prototype Experience on
Wireless Access for Vehicular Environment (WAVE) Technology

Weidong Xiang, Ph.D.
Center of Vehicular Communications and Networks
at University of Michigan, Dearborn
December 1, 2008

Outline

- Who are we ? **Laboratory Introduction**
- What is it ? **Overview of WAVE Systems**
- What is the challenge ? **Key Technologies**
- What we have done ? **Research Update**
- What is the next ? ***Commercialization***
- What if you are interest ? **Further Information**

Center for Vehicular Communications and Networks

Laboratory *at University of Michigan, Dearborn*

- **Our Research Objective**

We dedicate to developing and commercializing WAVE systems for intelligent transportation systems (ITS) and vehicular infrastructure integration (VII) by integrating our proprietary algorithms and patents.

- **Our Sponsors includes**

Introduction to WAVE Systems

- **Vehicular Communications and Networks** are usually regarded as dedicated short range communications (DSRC) or wireless access in vehicular environments (WAVE) systems. The later is based on the IEEE 802.11p standard, which is expected to ratified in 2009.

- **Key Technical Merits** include adopting orthogonal frequency-division multiplexing (OFDM) modulation scheme to achieve a data rate of 6-27Mbits/s operating over 5.850-5.925GHz band assigned by the FCC.

- **Main Applications** are ITS, high-speed communications and Internet access, safety and security enhancements.

Enhance Vehicle Safety through WAVE Technology

- **Severe Traffic Condition:** There are about 43,000 deaths on the highways each year, half of which occurred when vehicles left the road and passed through intersections. In a lot of metropolitans, one out of every three vehicles moves in a velocity that is half of its regular speed. Congestion costs 6-billion vehicle-hours nationwide per year. This painstaking situation necessitates the adoption of ITS supported by the Department of Transportation (DOT) for crash prevention, congestion relief and vehicle safety enhancement through WAVE Technology

- **WAVE technology** is a revolution solution for vehicle safety enhancement by providing drivers with early warning, perceive and assistance. It is an extension of humans natural sensing and realizes telesensing of vehicles. Working as probes, vehicles report timely traffic and road condition information to transportation agencies, which is shared by a large community.

WAVE Solution

- The WAVE system is a major ITS initiative that can enhance the transportation environment in the aspects of safety, management and data services in a fast speed with a less cost when compared to other strategies, such as expensive road infrastructure expansion.

- In the United States, DOT plans to equip every vehicle with a WAVE system and install a large number of road side units (RSUs) in the main roads and highways to make the WAVE service available.

- Information for safety enhancement and ITS.
- Internet access for data exchange and entertainment.
- Security and privacy

Example 1: Lane Change Warning

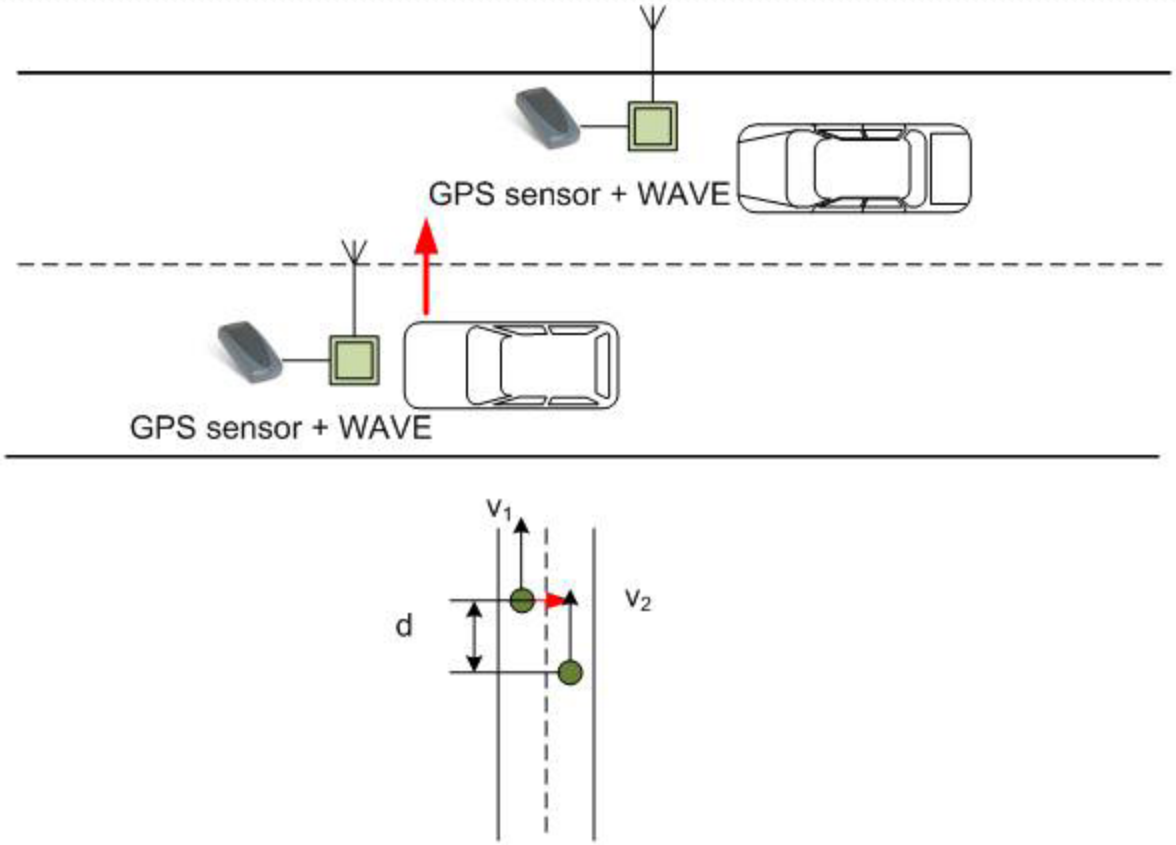


Fig.1 Lane change warning with the help of WAVE and GPS sensors

Example 2: Intersection Collision Warning

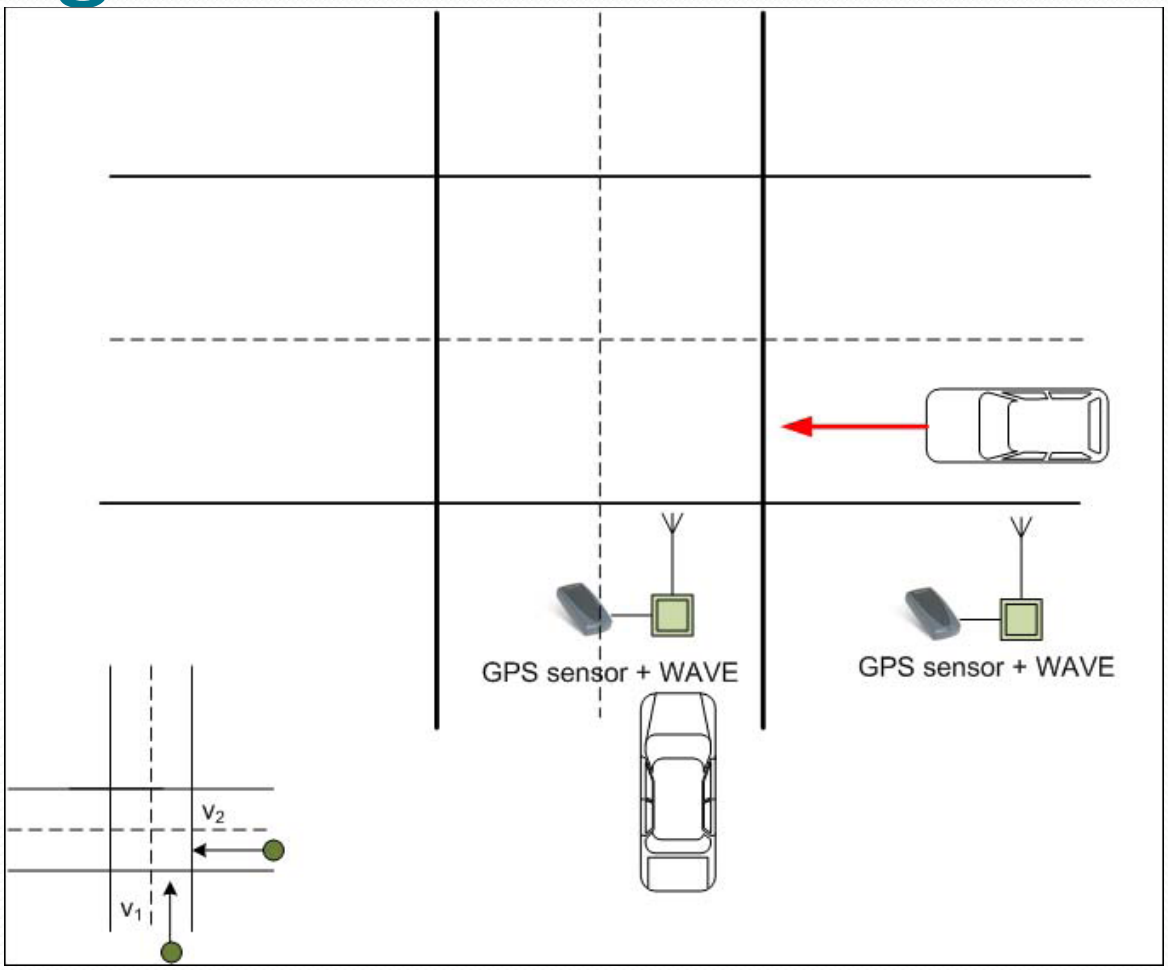


Fig.2 Intersection collision warning

Example 3: Braking and Hazard Warning

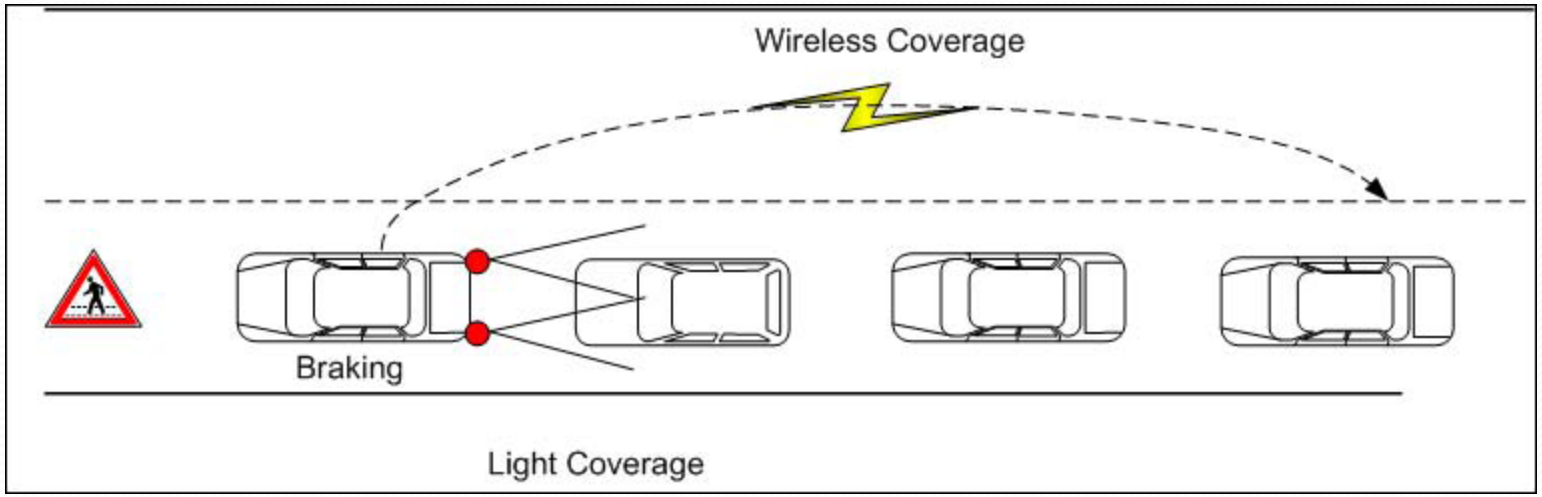


Fig.3 Braking and hazard warning

Example 4: Smart Traffic Light Control

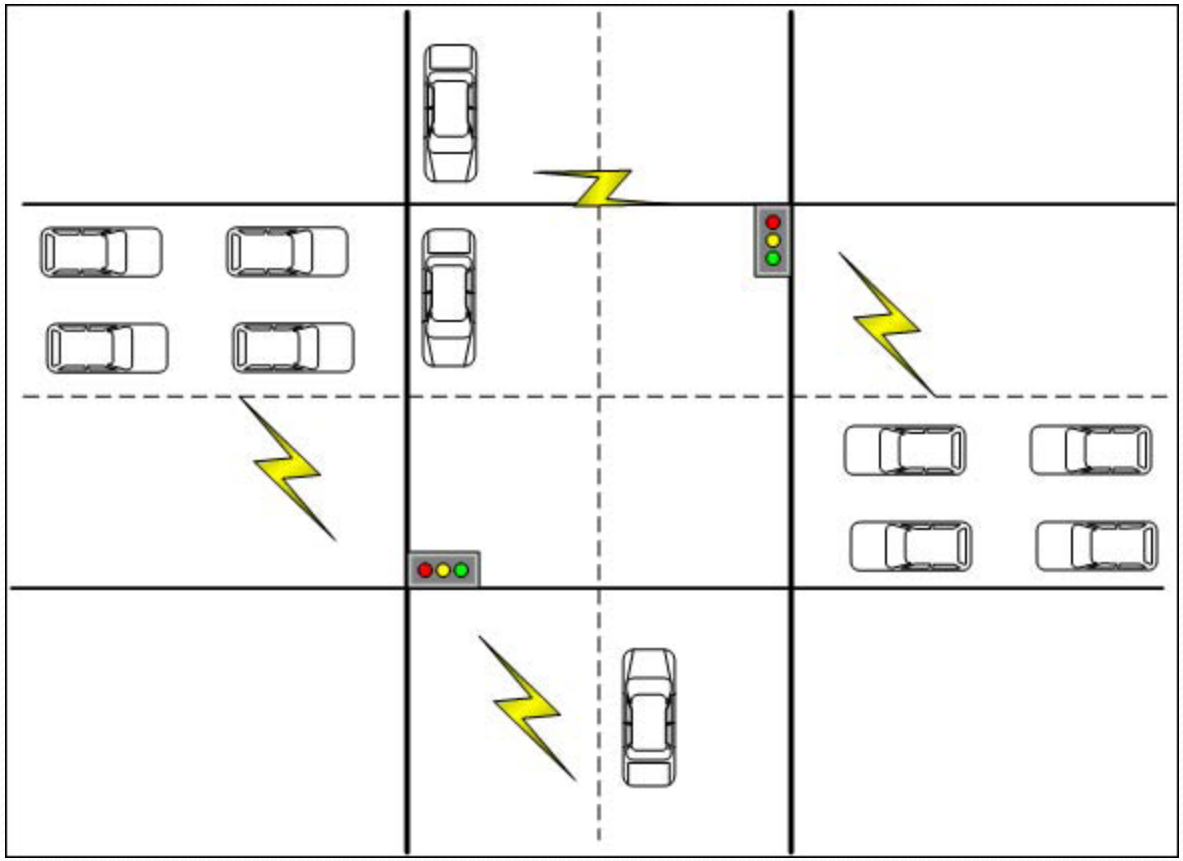


Fig.4 Smart traffic light control

Massive Market Perspective

- The massive market of WAVE systems will sustain several tier-one automobile suppliers.
- Thousands of workshops will be needed to install WAVE devices to existing billions of vehicles.
- WAVE systems will foster several WAVE services operators with similar sizes to those of existing cellular mobile communication providers.
- WAVE systems generate a fresh information industry based on vehicles, of which the magnitude and degree of its impacts on our society are substantial, multi-layered and profound.

Overview of Research

- We have 3+ years experience in WAVE research and leading in the prototype development in both the research and industry, including
  - A pending patent for Doppler shift compensation for vehicle environment.
  - Various international conference intensively recently (IEEE Tridentcom, IEEE VTC, IEEE Globecom)
  - A special issue on WAVE technology (EURASIP)
  - The first international conference on WAVE in December, 2008.
  - Development of a vehicular network simulator for system design, protocol evaluation and algorithm optimization based on GIS information and measured WAVE channel model

WAVE Transceiver Diagram

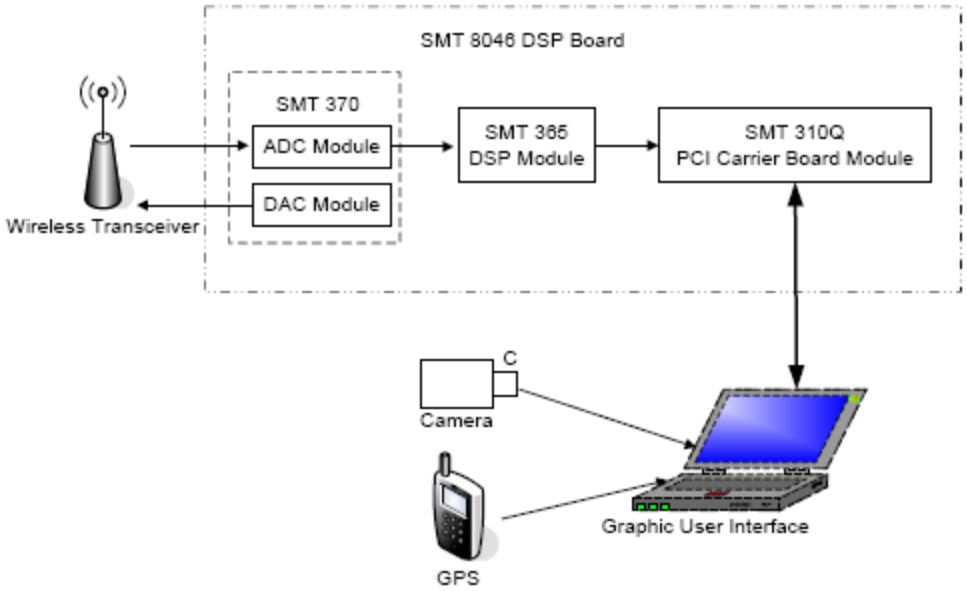


Fig.5 WAVE Transceiver Diagram

DSP Board: Picture

Fig.6 Sundance SMT8036 DSP Board

DSP Board: Specifications

- The DSP board consists of a TI C320C6416 (600MHz) based DSP module (SMT365) and a dual high speed ADC/DAC module (SMT370).
- SMT 365 has 6 20Mb/s communication ports, 4MB SRAM at 133MHz and 8M ash ROM (boot code).
- SMT 370 is dual channel high-speed ADC/DAC module. The module contains 2 14-bit ADCs sampling at up to 105MHz and dual 16-bit DACs sampling at up to 400 MHz. The core of SMT 370 is Xilinx Virtex FPGA integrating the main functions of the module.
- The SMT 310Q module serves as carrier board for hosting of module SMT 365 and SMT 370 in the standard PCI interface.

WAVE RF Front Ends

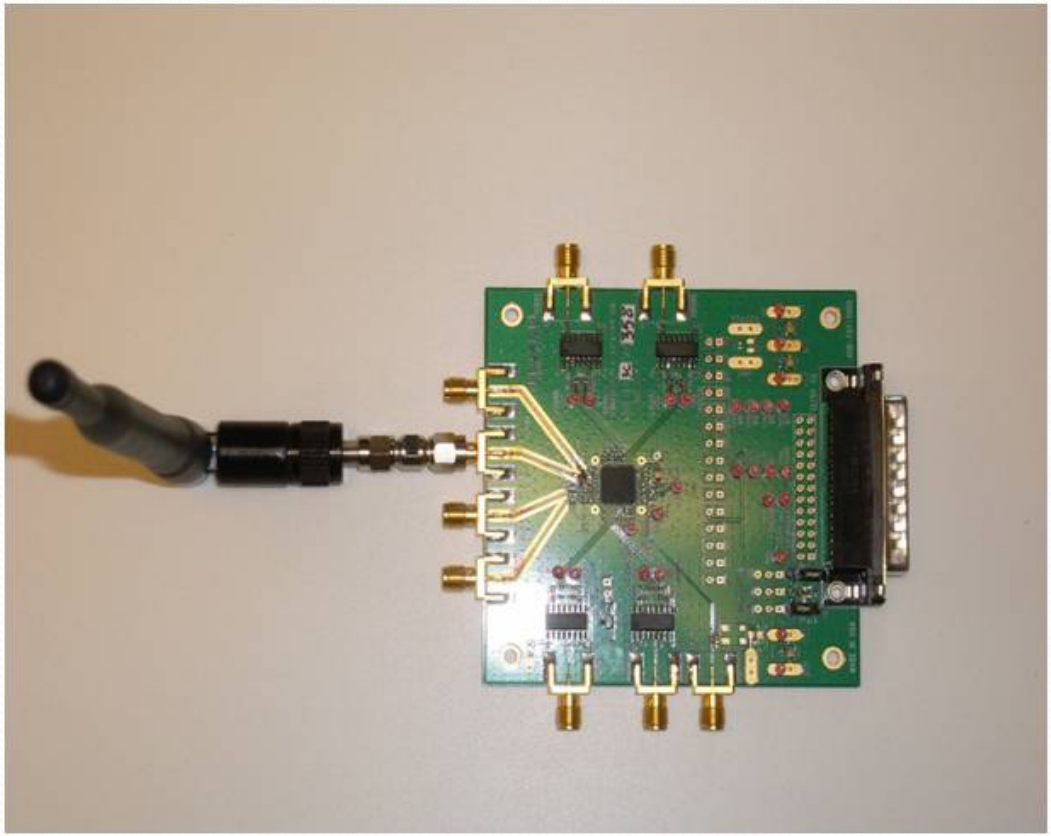
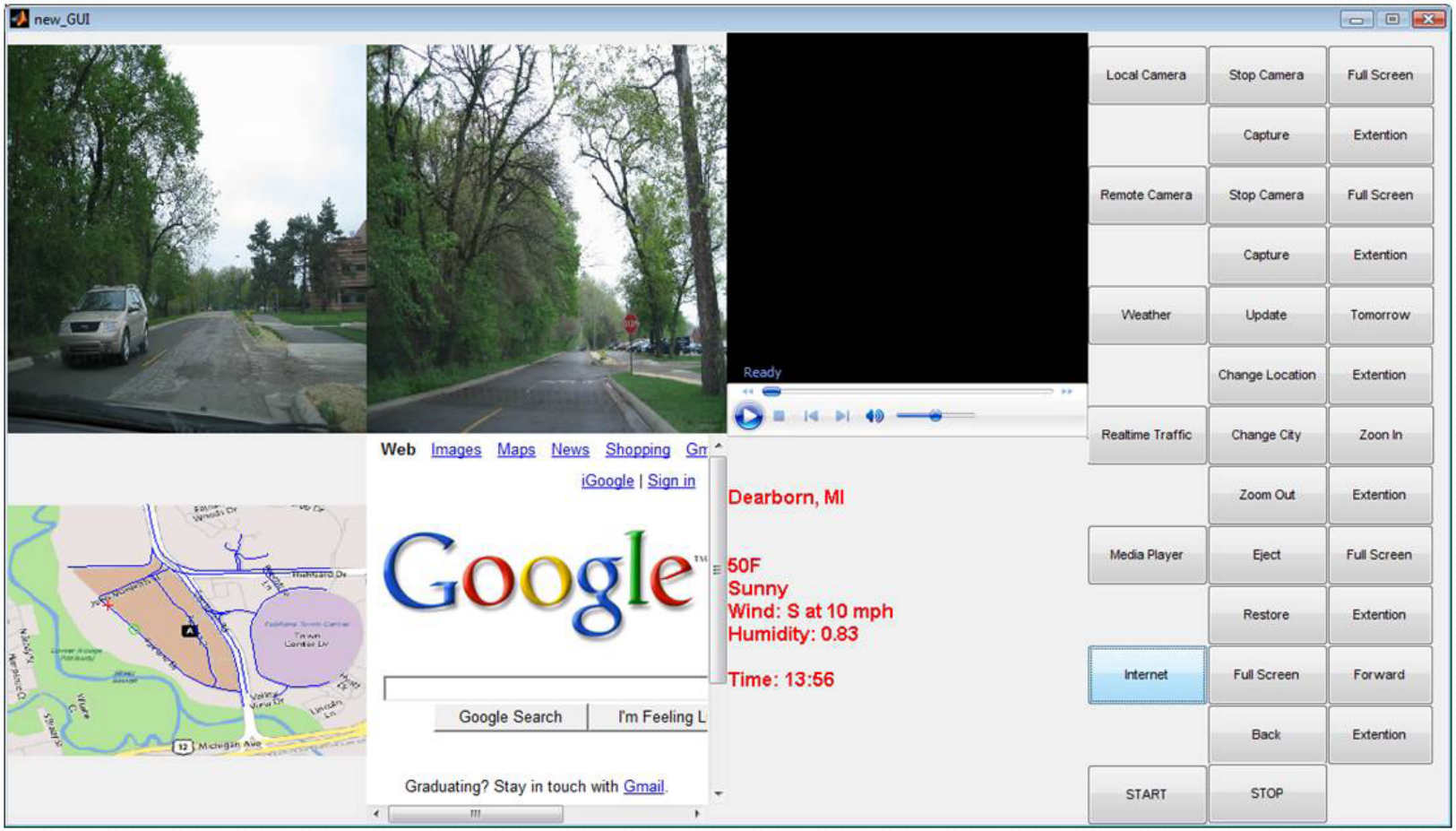


Fig.7 WAVE RF front ends

GPS Sensor

Fig. 8 Garmin Mobile 10x GPS sensor with Bluetooth interface. The interface protocol is NMEA 0183.

WAVE GUI


new_GUI
Ready
Web Images Maps News Shopping Gm
iGoogle | Sign in
Google
Google Search
I'm Feeling L
Graduating? Stay in touch with Gmail.
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50F
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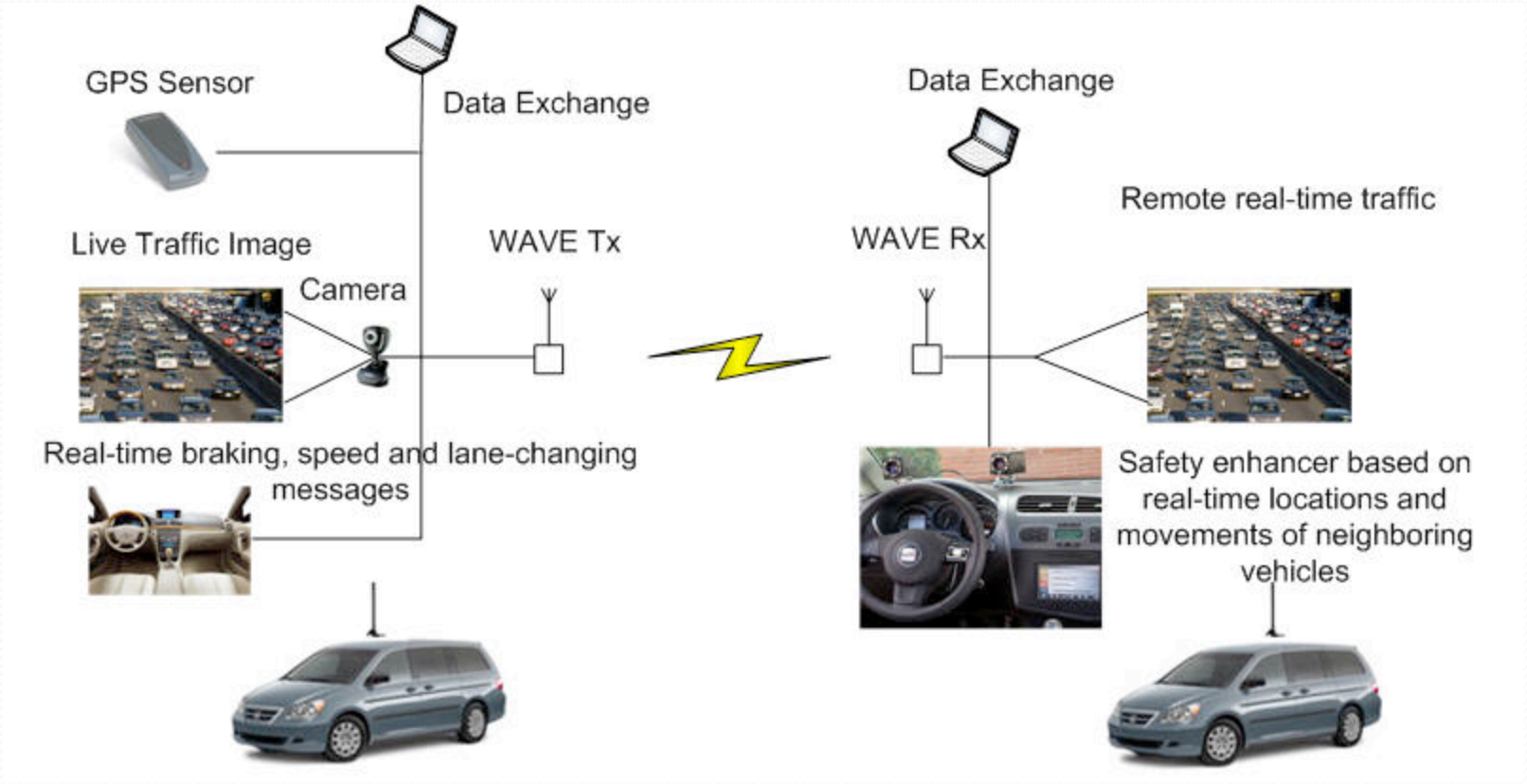
Time: 13:56
Local Camera
Stop Camera
Full Screen
Capture
Extention
Remote Camera
Stop Camera
Full Screen
Capture
Extention
Weather
Update
Tomorrow
Change Location
Extention
Realtime Traffic
Change City
Zoon In
Zoom Out
Extention
Media Player
Eject
Full Screen
Restore
Extention
Internet
Full Screen
Forward
Back
Extention
START
STOP

A WAVE Prototype

System Diagram

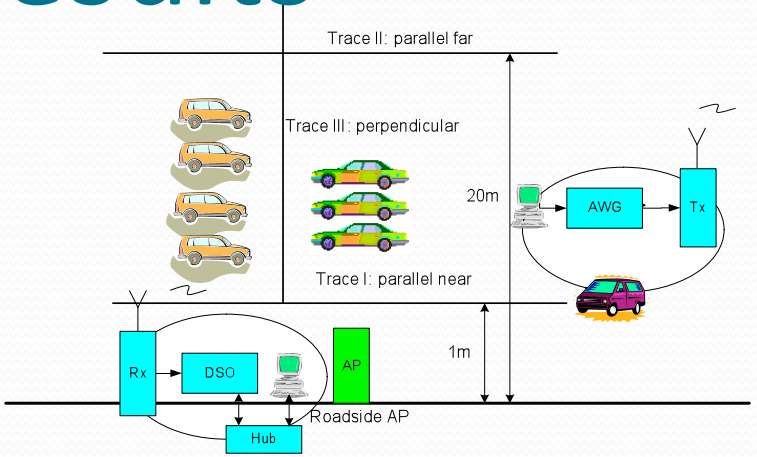


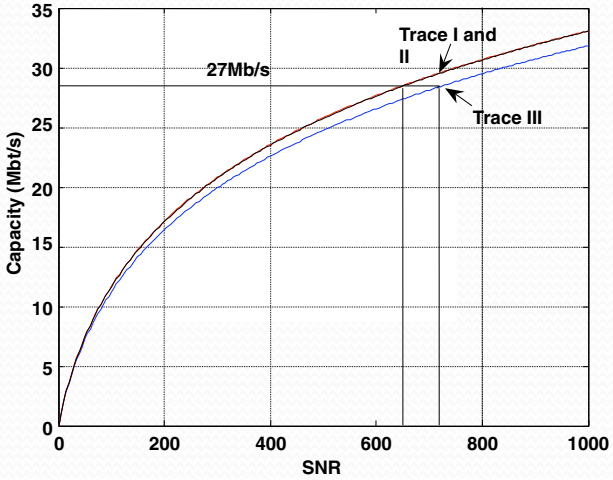
A WAVE Demonstration

http://www.vehi-com.com/

WAVE 2008.WMV

Preliminary Experimental Results



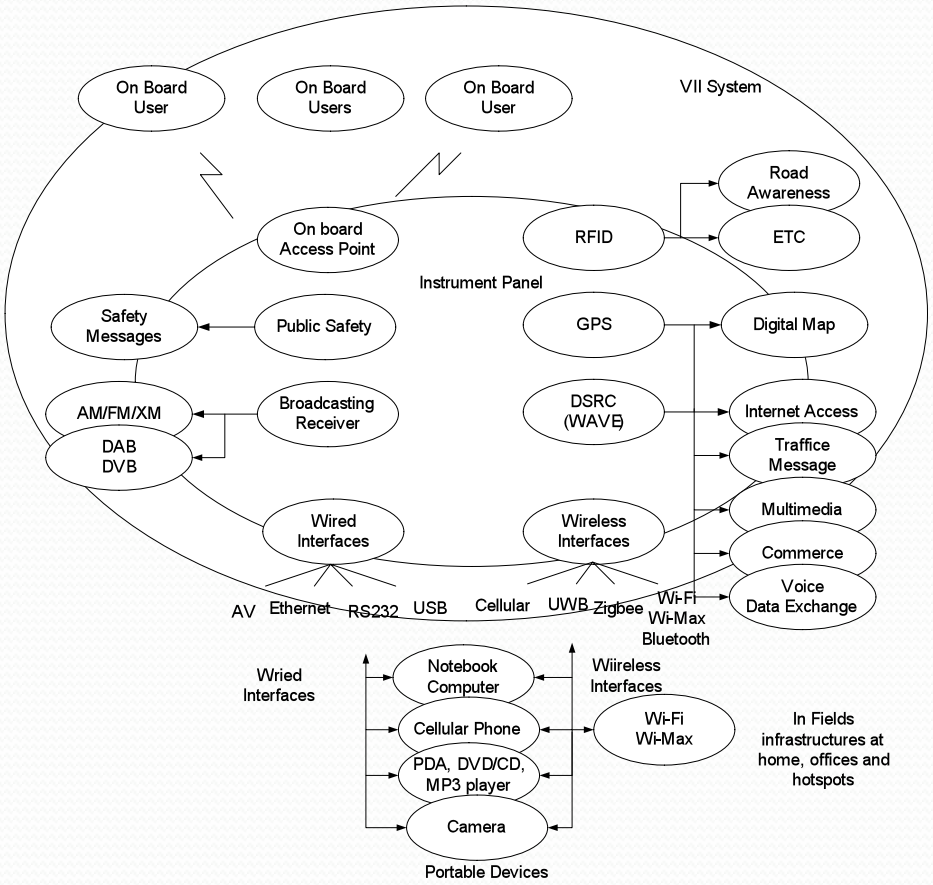


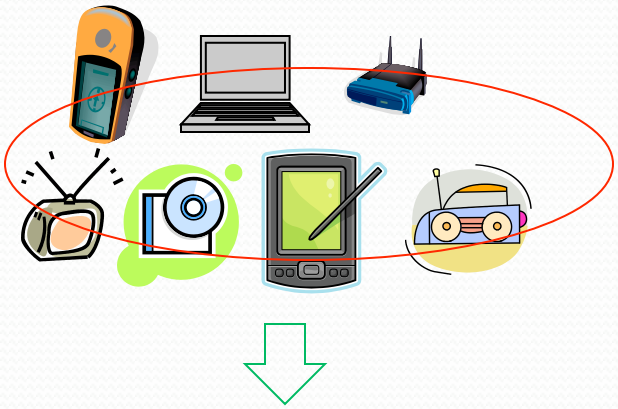
The SNRs needed to reach 27Mbs/s are 10dB larger than Gaussian channel due to fast-fading and time-varying mobile channels, which will be the main tasks of the patented algorithms integrated in prototype.

A Patent for Doppler Frequency Compensation

Invention 2007: Selected to be one of eight most significant inventions in 2007, the University of Michigan, Ann Arbor, October, 2007

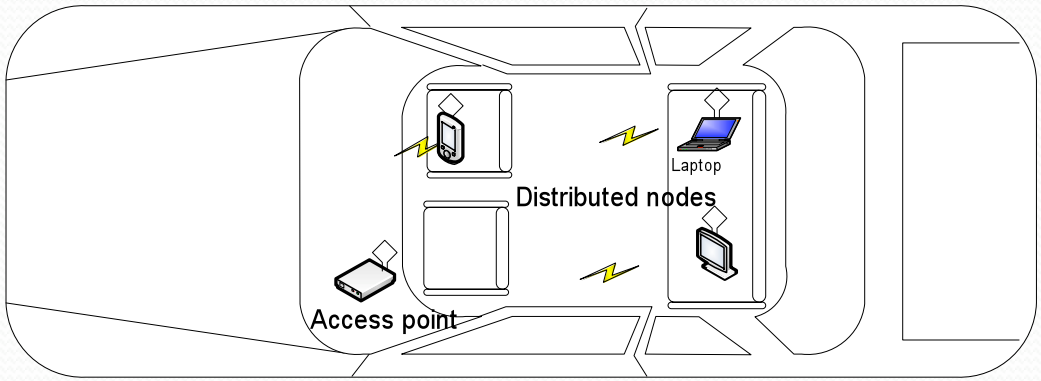
Vehicular Infrastructure Integration





Wi-Vi: Wireless Intra-Vehicle Infrastructure

We coined a popular name of **Wi-Vi** to represent the intra-vehicle infrastructure adopting ultra-wide band (UWB) radio, which is proposed to provide onboard passengers with high-speed wireless access to the Internet and Entertainment and thus turns the riding into a completely new experience.



Properties & Specifications

- **The requirements of intra-vehicles communications:**
  - **High-speed, >1Gbits/s**, for multimedia and Internet accesses
  - Duplex communications networks
  - Support real-time safety and traffic message and multimedia

- **Product specifications**
  - Low cost
  - Massive productivity
  - Easy to installation, maintenance, and update.
  - Flexibility of reconfiguration
  - Scalable for various vehicles and environments (temperature, high electromagnetic noise and interferences, and vibrations)

- **Extended Applications**
  - Airplane and ships
  - Military vehicles

Preliminary Results

- Vehicular UWB channel modeling

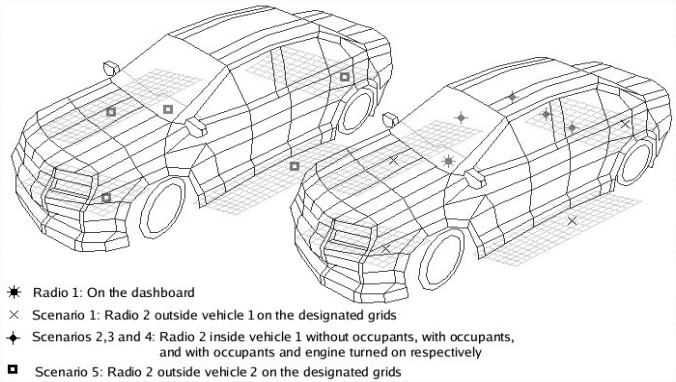
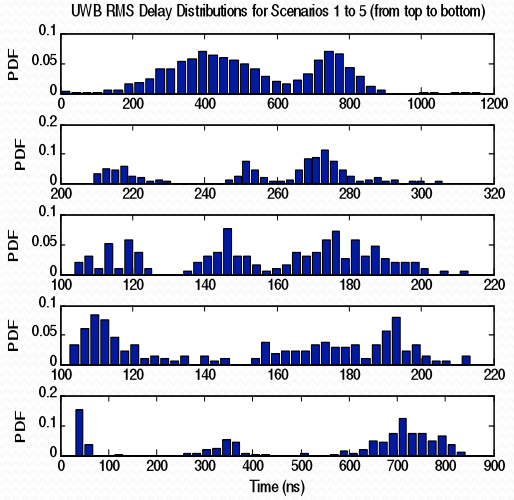
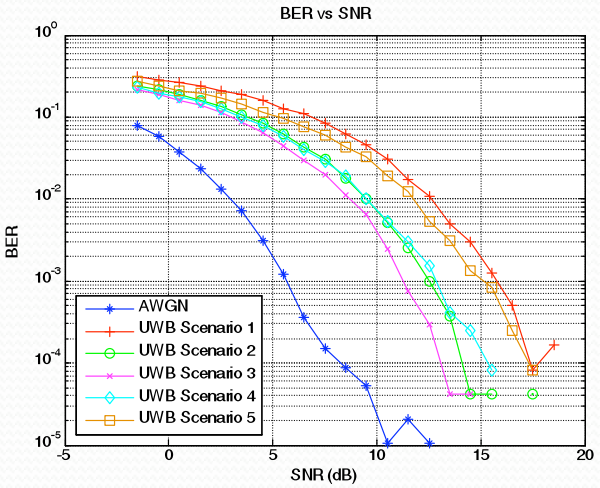


Fig.3 The illustration of the UWB channel measurement experiment within commercial vehicles





Highlights

- *Acquisition of Instruments for the Research of Applying Ultra Wide Band Based Wireless Networks to Vehicles for Communications and Controls,* NSF MRI , 2008-2011.

- Published the first in-vehicle channel modeling paper (*IEEE Journal of Selected Areas in Communications*)

- Redesign multiple-band (MB) OFDM Alliance (MBOA) signal format to realize greater than 1Gb/s data rate by adopting multiple input and multiple out (MIMO) technology.

Welcome to WAVE 2008

WAVE 2008

The First International Conference on
*W*ireless *A*ccess in *V*ehicular *E*nvironments

December 8-9, 2008
Dearborn, MI. 48128

Key Dates:
Submission Deadline: October 6, 2008
Notification Date: October 13, 2008
Final Manuscript Deadline: November 10, 2008

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The first international conference on Wireless Access in Vehicular Environments (WAVE) will be held on December 8-9 at the University of Michigan-Dearborn. WAVE 2008 will bring together leading researchers from industry, government and academia to discuss both the current state and future research directions in the following areas:

- WAVE/dedicated short range communications (DSRC),
- Vehicular networks and intelligent transportation systems (ITS)
- Vehicular infrastructure integration (VII)

This conference will be held at the University Michigan-Dearborn which is close to the research centers of many automotive OEM and supplier. This conference will provide insights into the strategic direction and technical challenges facing the industry. In addition, the program includes tutorials and demonstrations on cutting-edge WAVE research.

Call for Papers and Tutorials

We invite you to submit original papers and tutorial proposals on the following WAVE topics:

- Channel modeling, antenna and transceiver, signal processing;
- Advanced wireless technologies applied to vehicular networks: multiple input multiple output (MIMO)/space-time coding (STC), smart antenna/beamforming, coding, adaptive modulation, software radio and cognitive radio;
- System performance study and capacity analysis, mesh network/delay tolerance network (DTN) for vehicular networks, effective MAC protocols, routing algorithms and congestion control schemes, cross-layer design and optimization;
- Test bed/prototype activities for ITS and vehicular infrastructure integration (VII);
- Business modeling and market study, policy and management, development and deployment.

Submission Instructions

- Only relevant original papers that are not under review by any other conference or workshop will be considered.
- Each paper will receive a minimum of three reviews.
- Selected manuscripts will be considered to be published on the EURASIP Journal of Wireless Communications and Networks

Details about preparing and submitting your submission can be found at the following link http://groups.engin.umd.umich.edu/hpceep/wave2008/

Please send tutorial proposals to bennybing@ieee.org no later than November 3, 2008

Sponsored By:

WAVE 2008

December 8-9, 2008
University of Michigan -Dearborn
4901 Evergreen Road
Dearborn, MI. USA

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*W*ireless *A*ccess in *V*ehicular *E*nvironments

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Registration Fees

Students	$125.00
Regular Early	$225.00
Later	$275.00

Program to Include

Paper Presentations
Tutorials
WAVE Prototype Demonstration
Keynote Speaking

The first international conference on Wireless Access in Vehicular Environments (WAVE) will be held on October 27-28 at the University of Michigan-Dearborn. WAVE 2008 will bring together leading researchers from industry, government and academia to discuss both the current state and future research directions in the following areas:

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For more information please visit our webpage:

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