http://vehicular.cs.ucla.edu/

http://netelab.cs.ucla.edu/

C-VeT: UCLA Vehicular Testbed

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Goals

- Provide:
  - A "Planet Lab Inspired" platform to support car-to-car experiments in various traffic conditions and mobility patterns
  - A shared virtualized environment to test new protocols and applications
  - Full Virtualization Through Xen (featuring a shared testbed)
  - MadWiFi Virtualization (with on demand exclusive use)
  - Large Scale Experiments through Emulator.
- Allow:
  - Collection of mobility traces and network statistics
  - Experiments on a real vehicular network
  - Provide a platform for Urban Sensing and Intelligent Transportation Systems
  - Deployment of innovative V2V V2I applications in several areas including Info-mobility, Environmental Monitoring, Infotainment, and Homeland Defense application

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Why a Campus?

- Campus Environment Very similar to a small city
  - Police Cars
  - Busses
  - Service Cars
  - Private Cars
  - Urban Scenario (Low Raise/High Raise buildings)
  - Street Lights
  - Stop Signals
  - ....
- Additional Features:
  - Campus Mesh Coverage
  - Full control of the network
  - Fully customizable platforms

Why C-VeT is different from Others?

- C-VeT Vehicles are **CAMPUS** operated, on the road more than 16 hour very day.

- C-VeT will have:
  - 30 Campus operated vehicles (including bus and facility management vehicles).
  - Phase 1: 8 Facility Management + 4 Housing Vehicles
- Exploitation of "on a schedule" and "random" campus fleet mobility patterns

- Systemic Trace and pollution data Collection:
  - 30 Commuting Vans
  - Measure freeway motion patterns (only tracking equipment installed in this fleet).
- Opportunistic Network
  - Ad Hoc,
  - Mesh Infrastructure
  - Wimax
  - 3G
- Integration of C-VeT with a Data Center Emulator for larger scale experiments ~200 emulated Nodes.

The Technology

- Wireless Connectivity
  - DSRC Radio access
  - IEEE 802.11 a/b/g/n with MadWiFi
  - Open Platform Programmable MIMO Radios
  - WiMax Coverage
- Sensing Platform
  - Environmental:
    - CO_2, NOX, SO_2, PM2.5 and Black Carbon sensors.
    - Traffic Light as actuators
  - In Vehicle sensing
    - OBD2/CANBUS interface
    - Driver Behavior
    - Navigators

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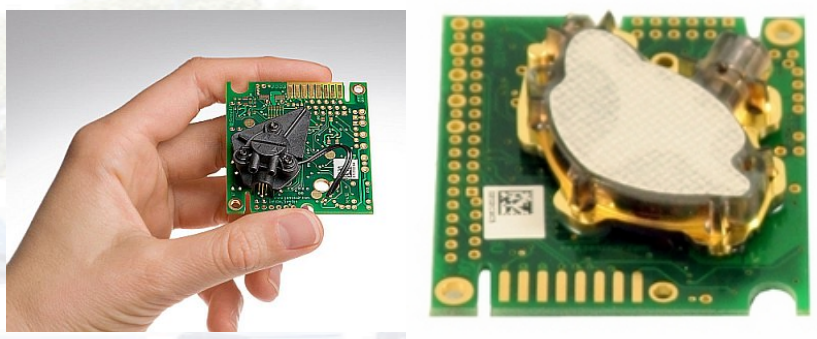
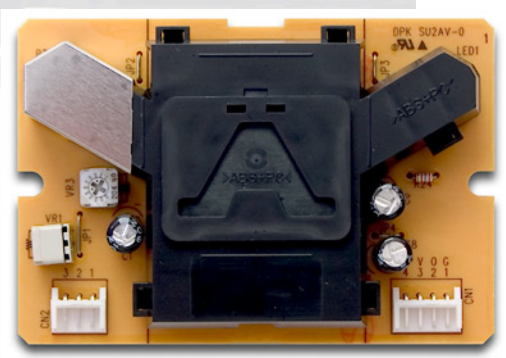
Sample Equipment

- Environmental Monitoring Applications

Communication Engine



CO2/Temperature/Umidity sensors



Particle Sensors

Black Carbon Meter

NOX/Ozone Sensors

Cameras

- Three class of nodes:
  - Actual nodes installed in Vehicles
  - Cappucino PC-Platform with several instances of the C-VeT Virtual Machine running on the actual Facility vehicles.
  - Emulated Nodes Installed in the Laboratory
    - Instances of the C-VeT virtual Machine sitting in our Lab computing cluster. For the user those nodes will appear as regular vehicles. → **Write code ONLY ONCE.**
    - The OSI Layers 3 to 6 will be the same as in the C-VeT VM installed in the actual facility vehicles.

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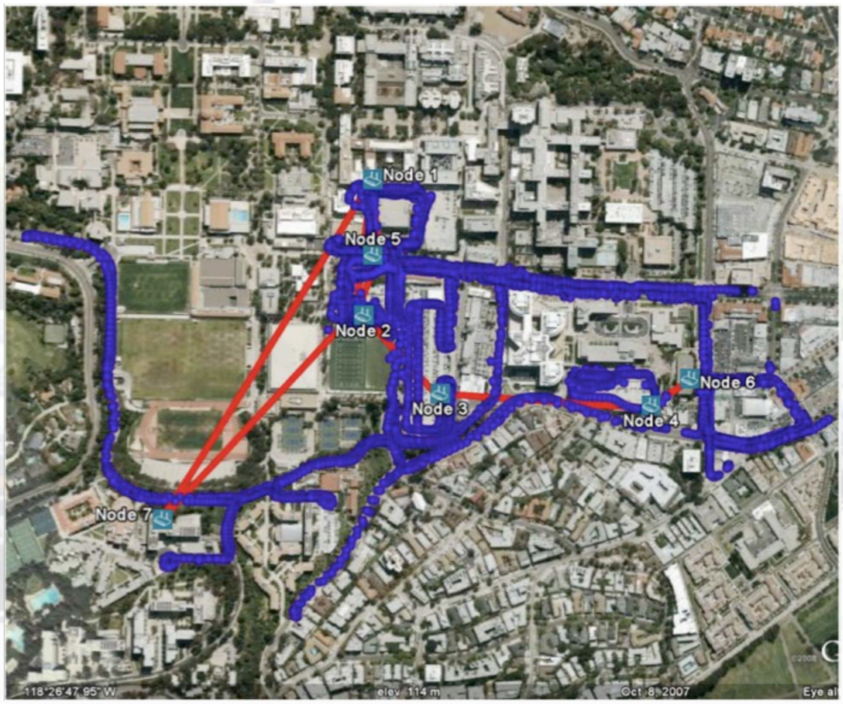
Testbed Sharing:

- Ok, UCLA is building a Testbed but why should I care?
  - Access to the C-VeT testbed will be granted through web interface and remote shell
  - Web interface for user registration and management
- How I will be able to use, RTT could kill my development:
  - Downloadable virtual appliance and SDK for a streamlined software development.
  - Web Streamlined experiment deployment and monitoring.
  - Remote access to C-VeT node's VMs through web interface or VNC

Campus Mesh Overview



- Phase I: Coverage of South Campus.
- Pase II: Full Campus Coverage

Campus Mesh Overview

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Now we have a testbed and so What?

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Research topics

- Info Mobility
- Urban Sensing
  - Environmental Protection
  - National Security
- Routing
- Network Security
- Cross Layer optimization
- Propagation Experiments
- Mobility management/Location service (virtualizable Overlay service - Planet lab inspired)
- Road safety

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Importance of System Integration

- Collaboration with City Authorities to deploy incentives for "Greener" cars:
    - Easier Access to City Centers
    - Access to Taxi-Lanes/Car-Pool Lanes
    - Discounted access for lower impact vehicles
- Intelligent Traffic Signals
    - Changes in the traffic flow
    - Changes in the timing
    - Tools

Importance of Mobility

- Classical Models Fail to describe reality:
  - Random Way Point
  - Constraint Random Way Point
  - ..
- Los Alamos Portland Traces showed the importance of Accurate models
  - 5X7Km downtown Portland
  - 16,6000 Cars
  - 1 second granularity traces
  - Mobility model derived from:
    - Extensive Census data
    - Custom Survey on Portland Citizens' activities
    - Cellular Automata based micro-mobility simulations.

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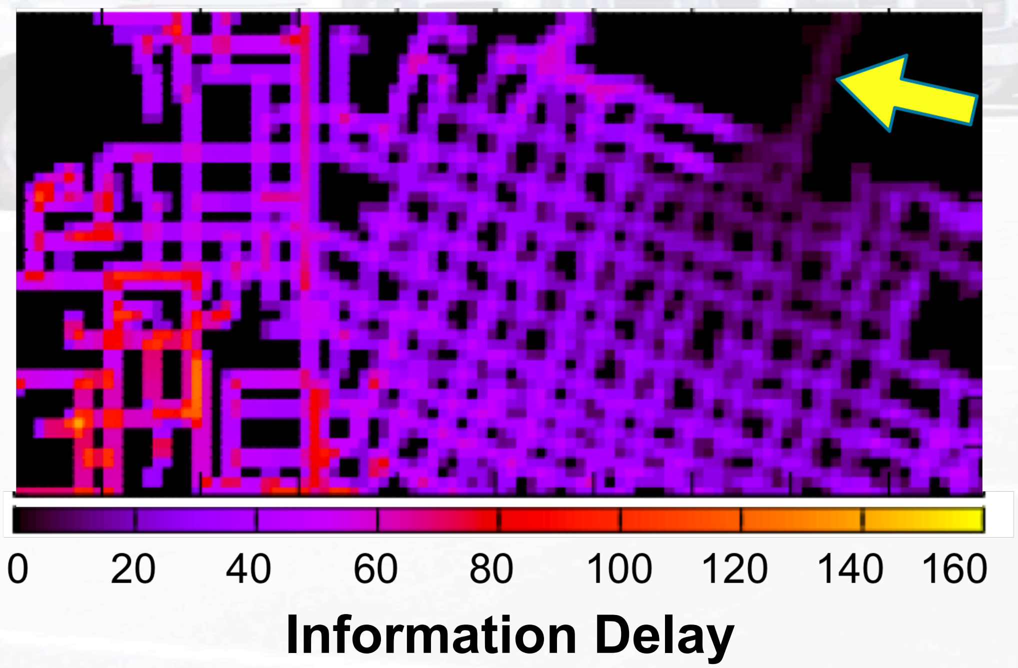
Info Mobility Simulation

- Mobility → Portland Model
  - Vehicles every 30 seconds broadcast they average speed and location for the last 30 seconds
  - The information is replicated by others vehicle with a probability inverse to the distance from the source



UCLA TR-09008,

Urban Sensor Grid

- Applications
  - Pollution Tracking
  - Treat Tracking
  - Illegal Dumping tracking
  - Pollution Monitoring
  - Traffic Management
- Vision:
  - **Government Vehicles** can be equipped with an **extensive sensor platform** to monitor the environment and report to the control center for tracking and management purposes.
- Challenges:
  - Protocols and models for Information Delivery
  - Cooperative sensing Intelligence (i.e. a treat is a treat and when is a false alarm?)
  - Distributed actuators (what I do when a problem is detected?)

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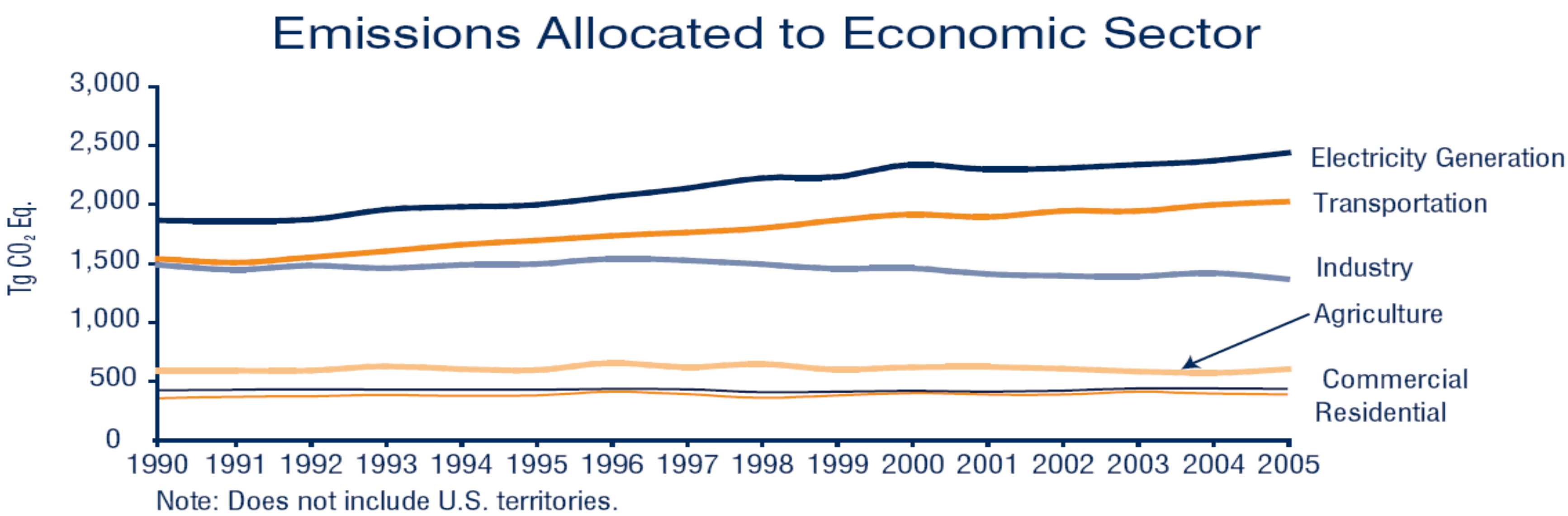
Pollution: Where Vehicle Stand?



Source: INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2005 (April 2007) Fast Facts USEPA #430-F-07-004

- Transportation Accounts for 28% of the TOTAL GREEN HOUSE GASES … RAISING …

NETWORK RESEARCH LAB. Computer Science Dept. UCLA

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ITC to support GHG Reduction …

- Reduce congestion, acceleration-deceleration
  - In Car Navigators are our Probes in the system
  - Communication uses to gather the information
  - Communication used to push the optimized Navigation path
    - Challenges in Path Optimization and Scalability
    - Cellular Choice in General but in some cases Opportunistic Networks could save the day.
  - Current technology based on in asphalt sensor too expensive to scale $100K for installation and $15K/year in Maintenance per intersection.
- Some advanced examples: Google Navigation
- Cyber Physical Interactions are the **Key.**

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… ITC to support GHG Reduction …

- ITS to reduce poor signal timing could reduce 1.315 MMT CO2/yr
  - Current Timing computed using Magnetic Spires, **NO or Limited** coordination between different traffic lights.
  - Time optimization is essential in reducing Idle but → NON LINEAR multi-dimensional Optimization problem!
  - Cars as Sensors could gather real-time information on traffic level and with the cost of an Access Point enable many traffic lights to become “smart”
  - Close Loop control between **traffic sensing** and Traffic Signals (lights and intelligent Signs) could lead to substantial emission and exposure reduction. Cars are the **SENSORS** intelligent traffic signs the **ACTUATORS**

Data: DOT/EPA 2007

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… ITC to support GHG Reduction …

- Reduce idling and encourage “eco driving” by drivers
  - Including the Vehicle in the Control Loop (OBD2 and beyond)
    - HIGH RESISTANCE FROM AUTOMAKERS
  - High pay-off potential
    - MBZ developed a “closed” system to keep vehicles at certain distance from follower and previous
      - 20% GAS SAVINGS just with a RADAR.
    - Honda can turn off part of the engine when is not needed (i.e. traffic light idle).
      - What if Traffic lights announce their status?

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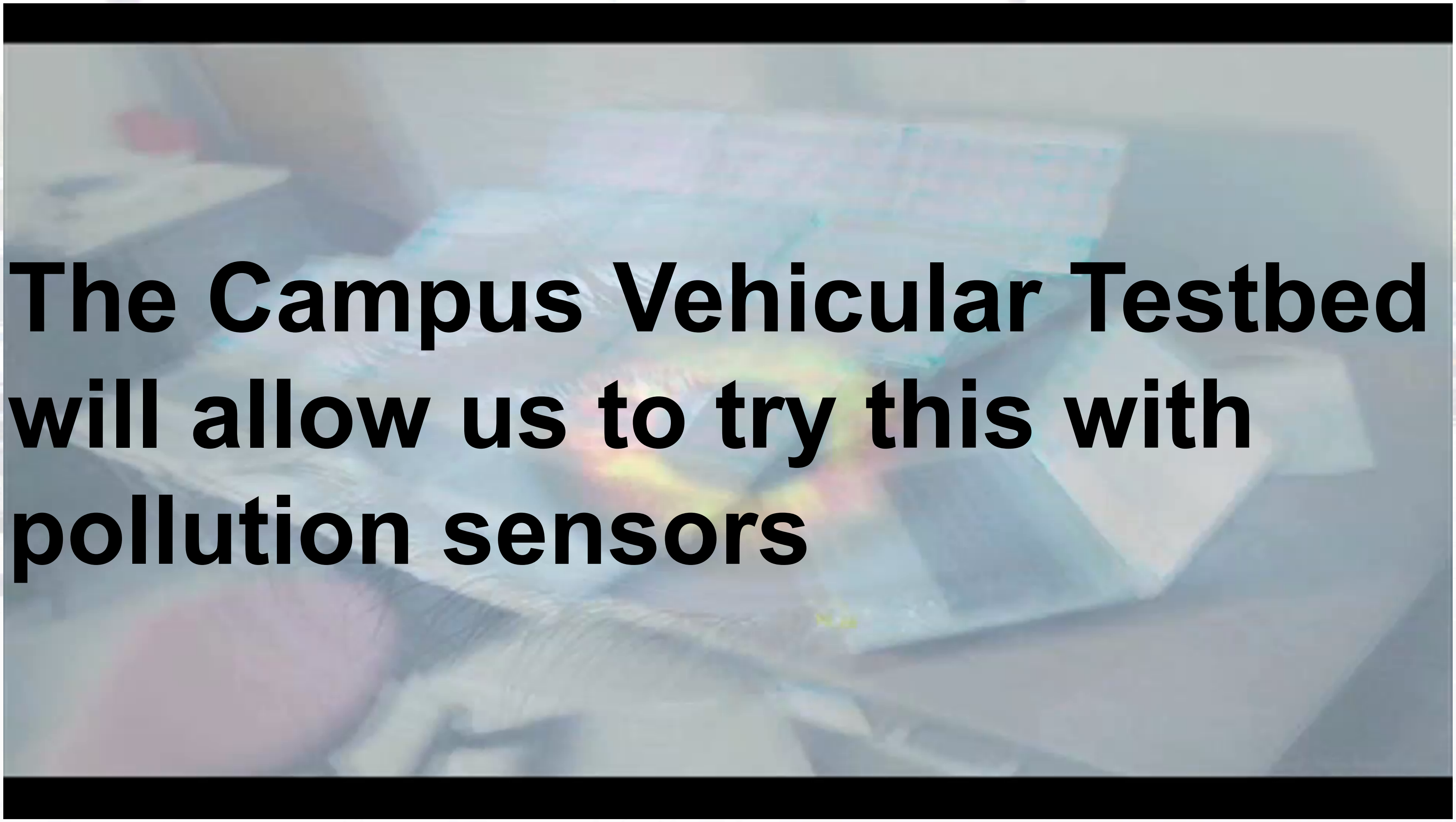
Pollution Management and Terror Prevention

A Common Approach!

A Concept Demo in Simulation



The Campus Vehicular Testbed will allow us to try this with pollution sensors

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Some Challenges

- Propagation Models
  - Corner Model – WONS 2009.
- Intermittent Connectivity
  - UCLA TR-090017 – Characteristics of Vehicular Networks.
    - Shows and quantifies intermittent connectivity on Portland Traces .
- Routing Protocols
  - PVRP Practical Vehicular Routing Protocol – Mobicom `09 work in progress paper.
    - A Disruption Tolerant Discovery/Routing protocols that exploits Maps
- Data Mining and Analysis
  - GPS data extraction for Maps – Mobisys 09 Submission
  - GPS extraction for Traffic management
- Close Loop Optimization with Actuators
- Initial on-the-road experiments.
  - VTC 08, ViVec 08, Mobisys 07 poster session.

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Few Preliminary Experiments

- Initial Experiment in 2008.
  - 4 Vehicles
  - OLSR Routing
  - Video Streaming application
- This is the routing map.

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THANKS