UMass DieselNet and related projects

Brian Neil Levine

with Banerjee, Brennan, Burgess, Burns, Chen, Kostadinov, Sorber, and Zhao, Ammar, Corner, Zegura

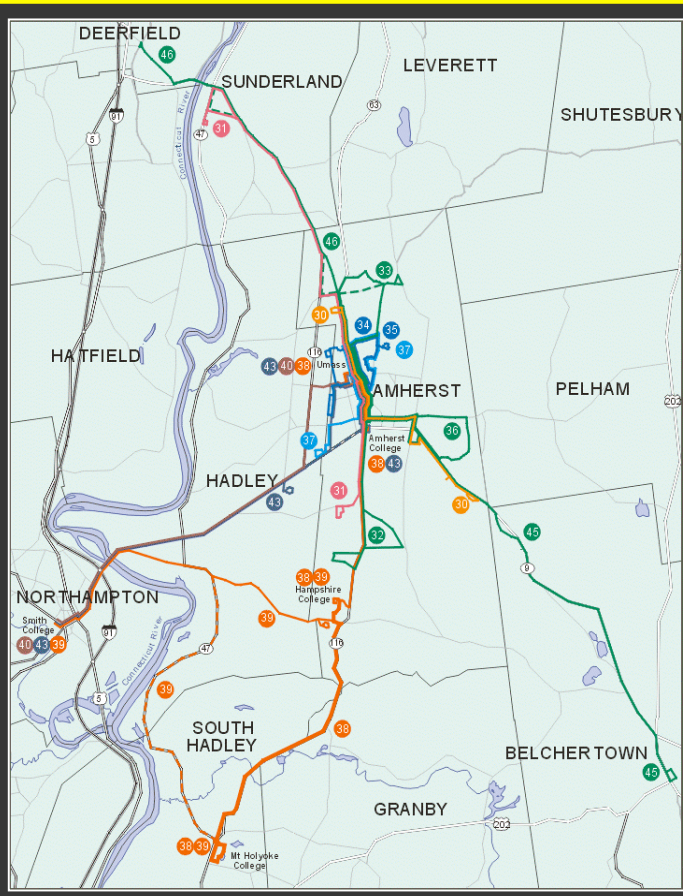
University of Massachusetts Amherst

Overview

- DieselNet operational testbed
- Traces of DieselNet for research
  - Characteristics
  - Two examples (MaxProp and MORA)
- Expanding the Network:
  - Throwboxes
  - Diversifying the network
  - Sensor net DTNs

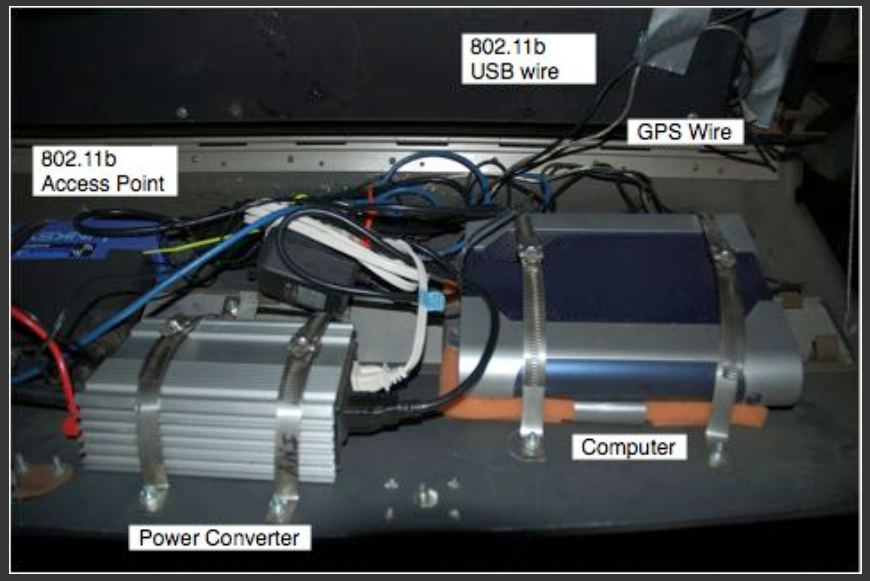
UMass DieselNet

- Operational since May 2004 with 5 buses. Now 40 buses.
  - Bus routes span 150 sq. miles.
  - Town center (4sq miles) is hub of network.
- Each bus:
  - Linux computer
  - 256M
  - USB 802.11b adapter
  - 802.11b AP
  - GPS receiver
  - 40GB hard drive.



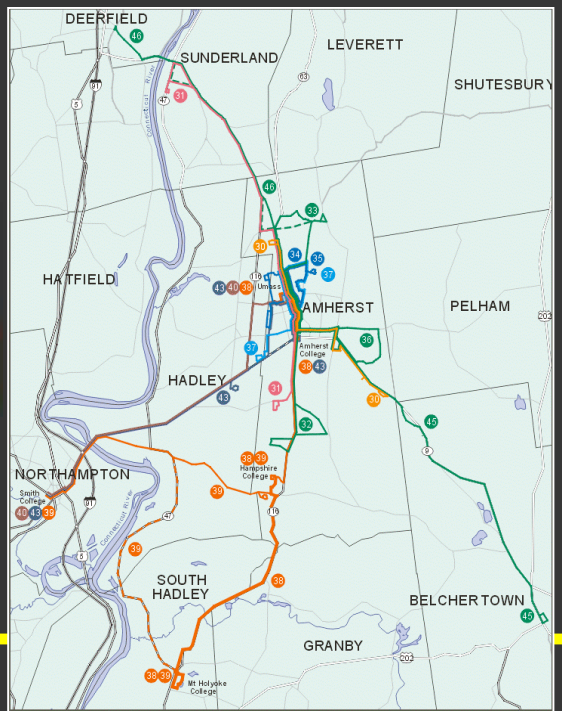
150 sq mi

UMass DieselNet

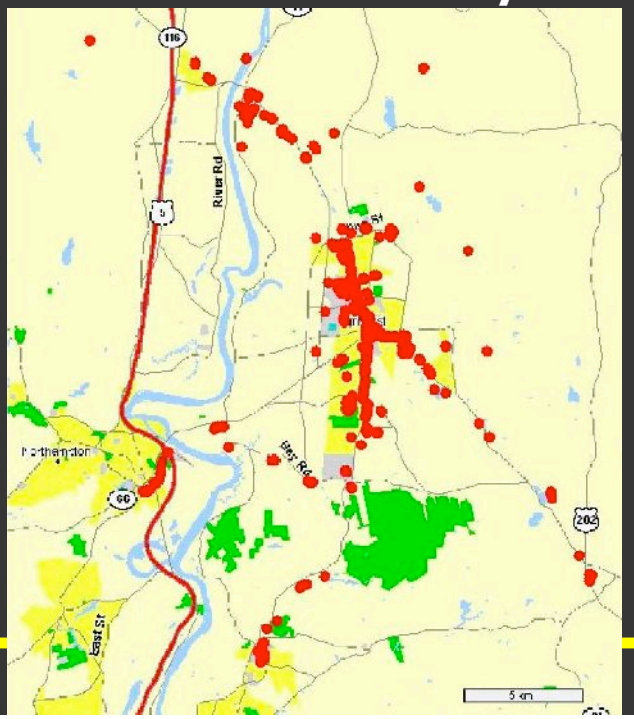


Mobility and Transfer traces

- The buses contact a central server when ever they are in range of an open 802.11 AP (set up by others).
- They upload information about bus-to-bus transfers, GPS logs, and download software updates.
- Traces of 60 days of DieselNet operation are on the web
  - http://prisms.cs.umass.edu/diesel

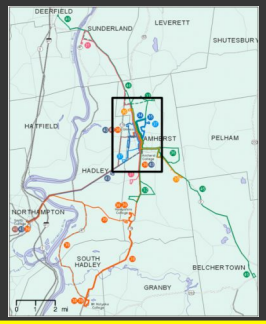


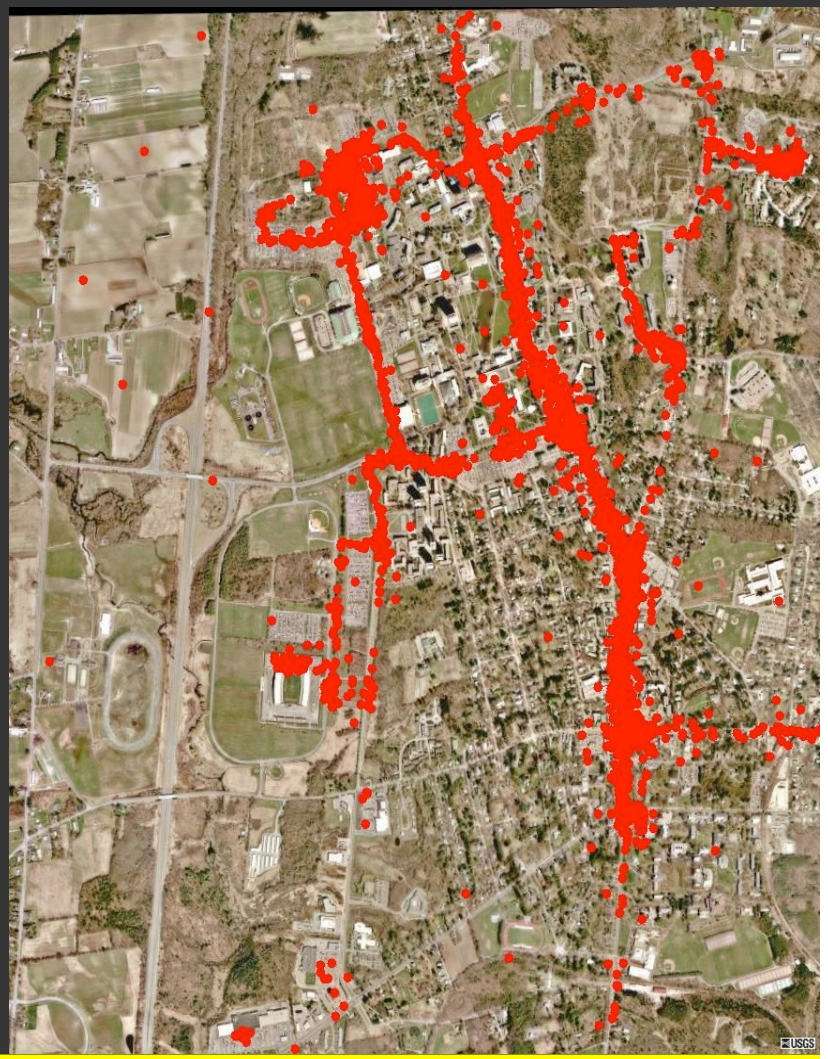
APs in the Valley



Transfer Opportunities

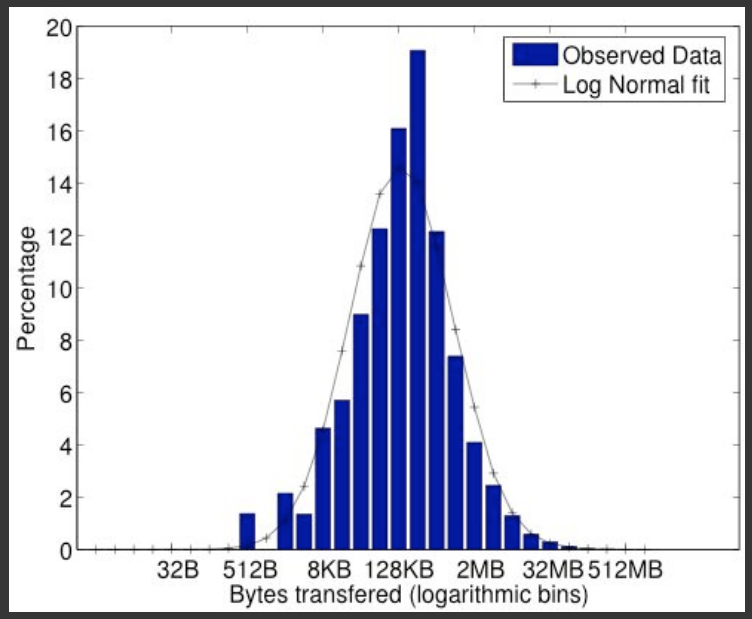
- Red dots show actual bus-to-bus transfers during a one-month period.
    - Map shows zoom of Amherst downtown and UMass campus
- For each transfer we record the duration, transferred data, location (and now speed and direction of each bus).
- Currently we send random data to fill available time; John's code supports applications (see Friday's talk)



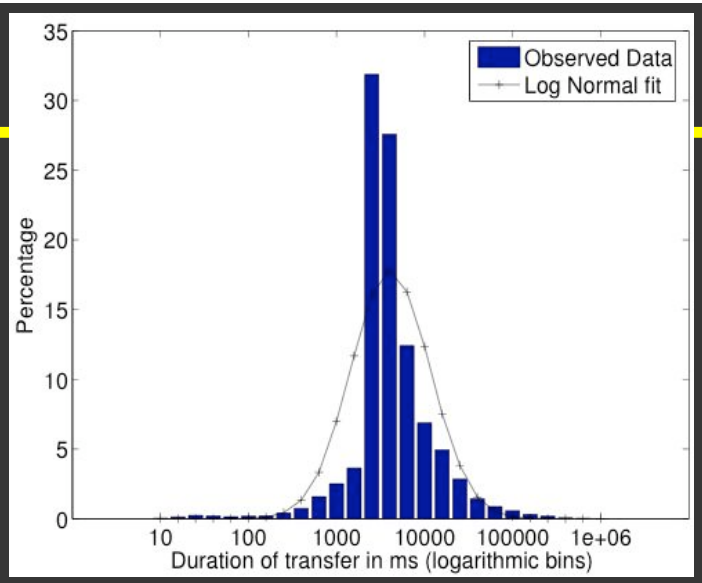


Measurements

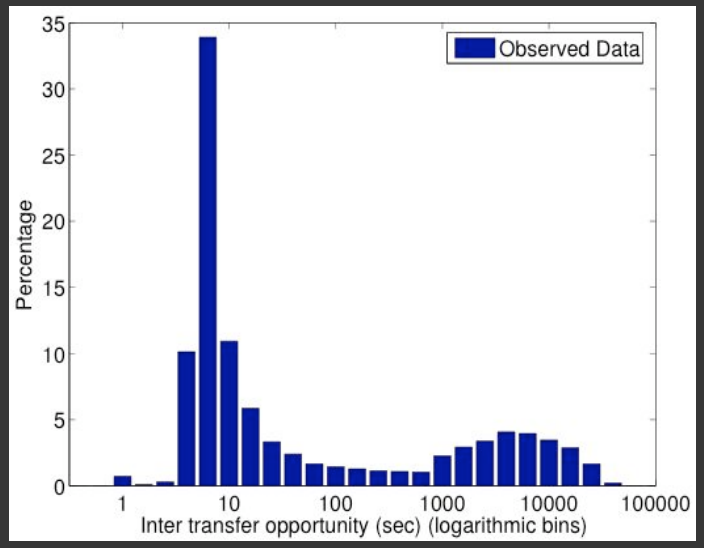
- Buses log their status via available access points (and update software).



Bytes transferred



Transfer duration



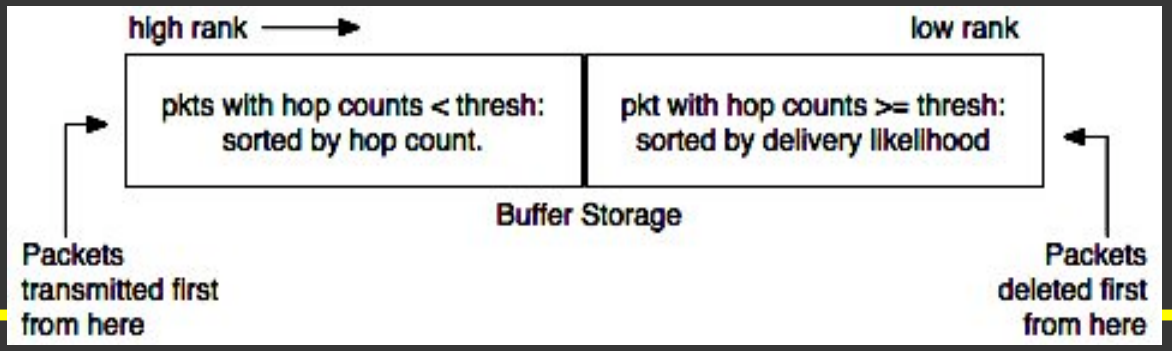
Inter-transfer opportunity time

Ex. 1: MaxProp Routing Protocol

MaxProp uses several mechanisms to route packets in a DTN:

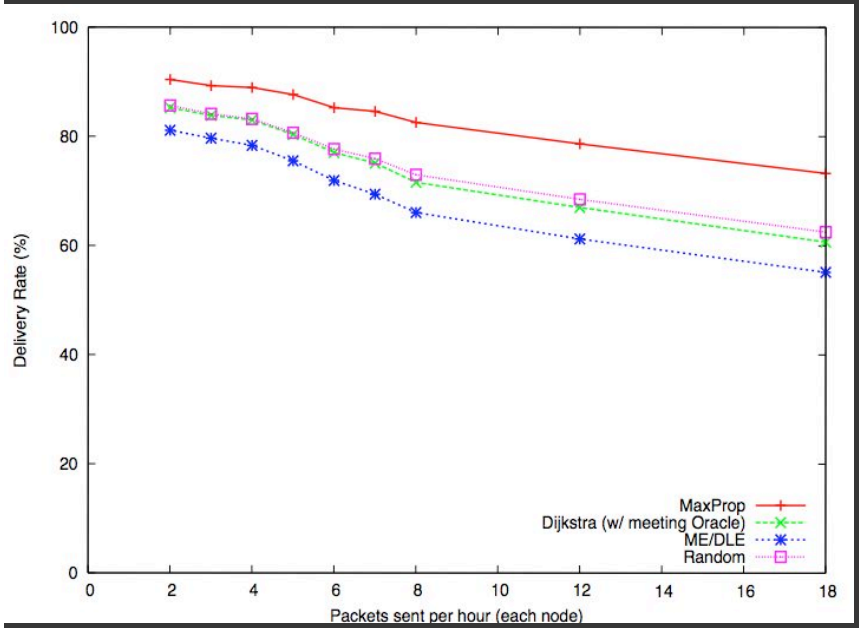
- At each TransOpp, packets are scheduled in an order based on:
  - Likelihood of delivery to destination
  - Packets with low hop-counts are prioritized.
- When storage is low, packets are deleted in reverse order.
- MaxProp reports delivery of packets globally, to clear buffers.
- Hoplists reduce repeated propagation

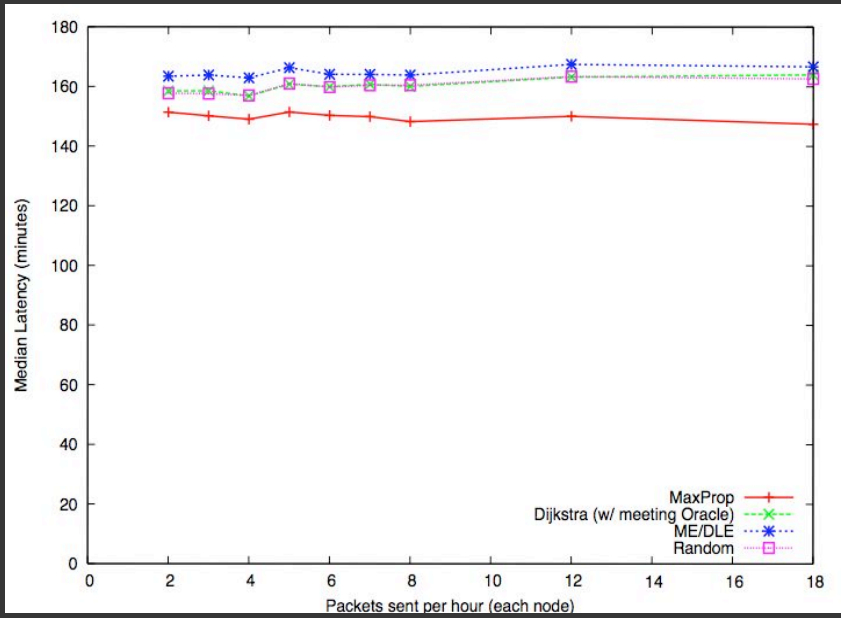
- Results show all mechanisms contribute to effective routing.



DieselNet Traces

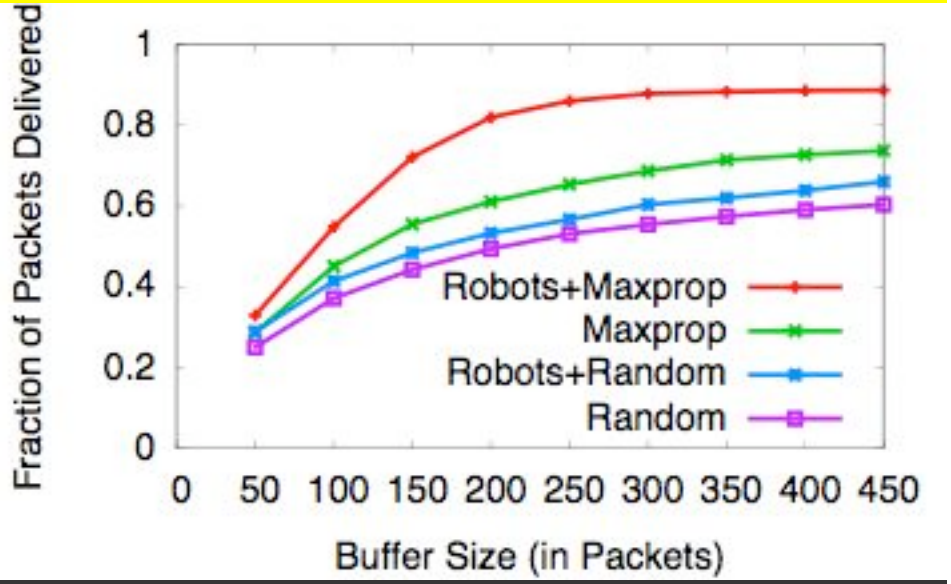
- DieselNet traces allow us to compare our protocol's performance to existing work.
  - 18 packets per hr, 10k packets, unlimited buffer
- Performs better than delivery likelihood alone, random, and Dijkstra's with meeting oracle (which can't avoid congestion)

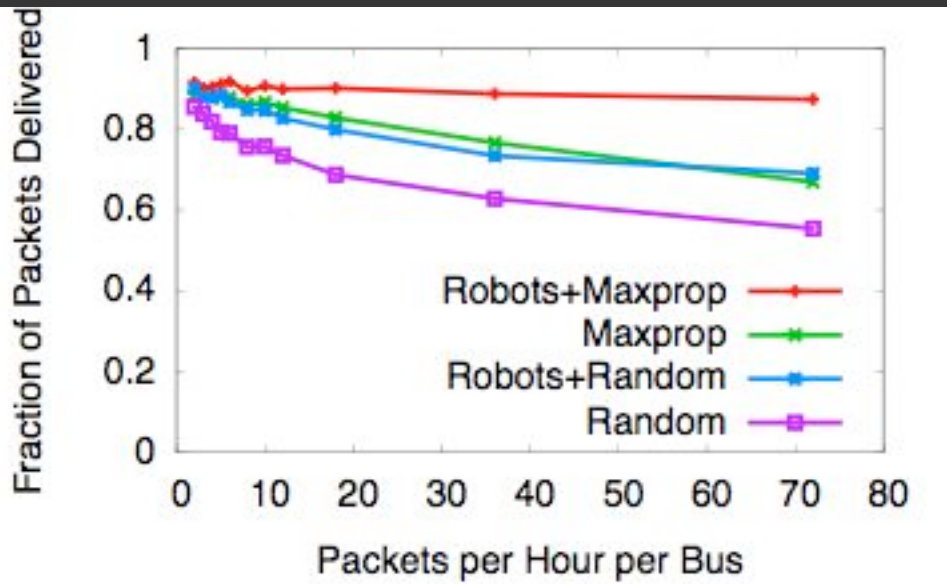




Ex. 2: Multi-Objective Robotic Assistance

- Robots (e.g., blimps) move within a DTN improve performance.
- MORA determines robots' movements to maximize several objectives by visiting peers with:
  - Most previously unseen messages
  - Most messages that haven't been replicated
  - Visit peer with highest avg delivery latency
  - Visit peer least visited
- Graphs show improvement of adding robots to MaxProp and Random.





Expanding DieselNet

Expanding DieselNet

- Throwboxes
  - Small, stationary, Solar/battery powered
- Diversifying the network
  - Addition of 1 square mile Mesh in Amherst
  - Addition of non-scheduled vehicles
    - Town safety vehicles
- DTN Sensor net on Wood Turtles

In development: Throwbox

- Power Management: Intelligently switches boards/radios to complete tasks.
  - Buses hail the Throwboxes --- we never to miss a transfer opportunity and we don't deplete our battery.
- **[See Mostafa's talk in this session]**
- Multi-platform HPM device:
  - TelosB mote (sensor)
    - 900 MHz Maxstream Xtend (hailing radio)
    - 8 Mhz microcontroller
  - Stargate
    - 802.11b CF card
    - 400Mhz PXA255 Xscale
    - 64 MB RAM
- Java 1.3
  (currently runs all DieselNet code)
- AA rechargeable batteries / Solar power

Diversifying DieselNet

- 1-square mile of a college town.
  - 9 Cisco 1500 access points form mesh (linked to cisco routers, etc)
  - Existing 40 buses
  - 5 DieselNet nodes with Cisco 3200 routers in Town vehicles
  - 5 stationary Throwboxes placed in Town
- Heterogeneous network allows levels of disruption:
  - *Mini*: temporary disconnection from mesh (due to mobility)
  - *Medium:* partitions in mesh (due to failure)
  - *Large:* entire mesh fails (e.g., blackout)
  - *Extended:* when mesh is out of range

- Diverse network of
  - Mobility (scheduled/unscheduled),
  - Nodes (mobile/stationary),
  - Power (grid/diesel/solar),
  - Radio range (802.11/Maxstream)
  - Storage (40G down to 512M)

Goals:

- traces of workload, mobility, transfers, failure
- test placement of throwboxes
- develop applications

DTN sensor net

- Monitoring the habitat of wood turtles.
- Primary goal is to collect GPS information, temperature, sunlight intensity, and turtle "dating".
- Turtles equipped with 6 MHz Mica-2 dot (4k RAM), short-range radio (CC1000: ~30m, ~30kbps), battery, solar cell, custom charging/measurement board.
- Weighs less than 50 grams (< 70g required!)

- Developing a **highly** constrained and energy efficient DTN system for mobile sensor networks.
  - To Propagate GPS and other readings back to a base station using DTN.
- Automatically adapts to current and future solar conditions.

Lots of Students

- DieselNet:
  - John Burgess
- Protocols:
  - MaxProp: [John Burgess, et al, INFOCOM 2006]
  - MORA: [Brendan Burns et al, INFOCOM 2005]
- Throwboxes:
  - Nilanjan Banerjee, Yang Chen, Jacob Sorber, Wenrui Zhao, Matt Brennan
- Turtles:
  - Nilanjan Banerjee, Jacob Sorber, Matt Brennan, Alex Kostadinov
- Alert Team:
  - Mostafa Ammar, Mark Corner, Brian Levine, Ellen Zegura

Summary

- Challenges
  - constrained transfer opps (DieselNet);
  - Add constrained power (Throwboxes);
  - Add constrained size and resources (Terrapin Net)
- Goals:
  - Real mobility and transfer traces (with real quirks)
  - Vital for trace-based research and real experiments (e.g., placement throwboxes)
  - Integration of DTNs into Mesh networks
  - Working on getting real workloads
- DieselNet traces available on our web site
  - http://prisms.cs.umass.edu/diesel