An Investigation into Intra-vehicle Sensor Networks

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• Sensor networks
  – ‘motes’ sensing environment and talking to each other through low-power radios

• Goal
  – Construct a wireless sensor network on a car

• Motivation
  – Wireless replacement of ‘wiring harness’
  – Wireless ‘clamp-on’ diagnostics tools
High Level Approach

- Two Experiments
  - Initial ‘Packet Loss’ Test
    - Test packet loss between many points in a car
    - Determine appropriate communication parameters
  - Full-up Build/Test
    - Build ‘final’ system
    - Baseline in a controlled environment
    - Then drive around testing it
Packet Loss Test

• Process
  – Place a pair of motes on the car
  – Send some packets
  – Measure loss
  – Repeat ad nauseum

• Results
  – Generally pretty good!
  – Some loss, but not significant in light of criticality (or lack thereof)
  – Out-of the box single-hop messaging is okay!
Full-up Build (the Plan)

- Process
  - Write mote code
  - Write front-end code
  - Test Run in the lab
  - Hook it all up (3 sensor motes + 1 base station mote) to my car and drive around
Full-up Build (the Reality)

- Process
  - Write mote code
  - Try to program mote and realize that the programming board doesn’t work anymore
  - Freak out
  - Purchase Timeshare on Wei’s programming board
  - Try to program mote and realize that sensorboard driver is incomplete
  - Freak out some more
  - Hack together new sensorboard driver out of spare parts
  - Try to program mote and realize that I am now reading photocell instead of thermistor
  - Call it ‘good enough’
  - Write front-end (Java! Yay!)
  - Test Run in the lab
  - Hook it all up (3 sensor motes + 1 base station mote) and drive around
More Pictures!
Full-up Build Results

• Packet loss worse than desktop baseline, but similar to initial test
  – <10% for a mote tied to the top of the engine

• Average of 6-7 measurements/second is easily attainable
  – >10/s likely with a little more ‘smarts’

• Main Result: 50 minutes of data showing it sensing

Note: Not real data.
Conclusions/What’s Next?

• Conclusions
  – No fundamental barrier against intra-vehicle sensor networks
  – Packet loss could be reduced further, but sufficient for non-mission-critical application

• What’s next?
  – Sensing motes need to be able to be retasked
  – More sensors! Custom Sensors!
  – Better mounting (i.e. less reliance on fishing line)
  – Graduation…?
Lessons Learned

• Sensor Network programming, namely TinyOS/NesC, is harder than it probably should be
  – Though some things are trivial (retransmissions)

• Don’t switch major programming platforms in the middle of a project (duh)
  – Linux to OS X; TinyOS 1.1.x to 2.0; raw RS232 to USB; sanity to madness

• “It’s a hardware problem”
  – Bad programming boards, no driver support, incorrect schematics
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