Implementation of Decentralized Damage Localization in Wireless Sensor Networks

Fei Sun

Master Project

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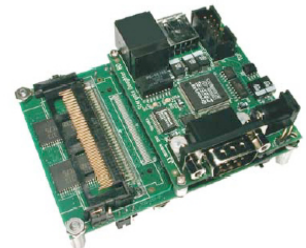
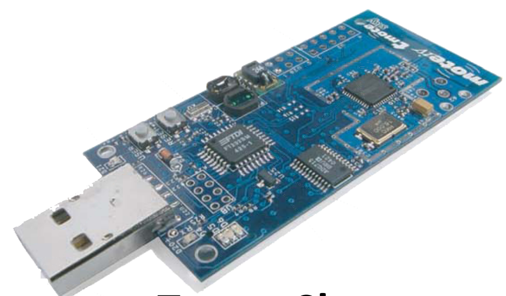
Wireless Sensor Network

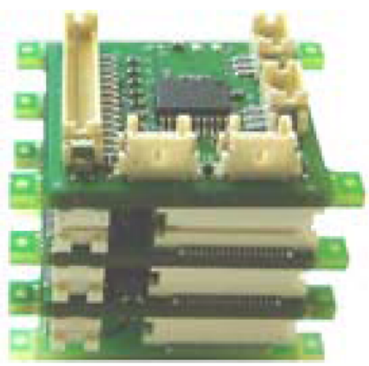
Mica2 & Mica2dot



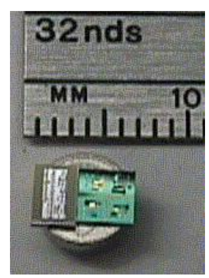
Stargate



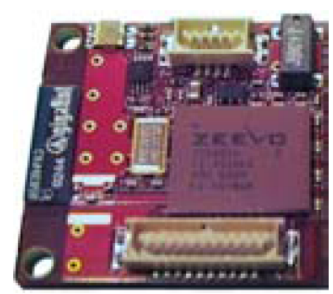
Tmote Sky



NMRC 25mm cube



Smart Dust



Intel iMote

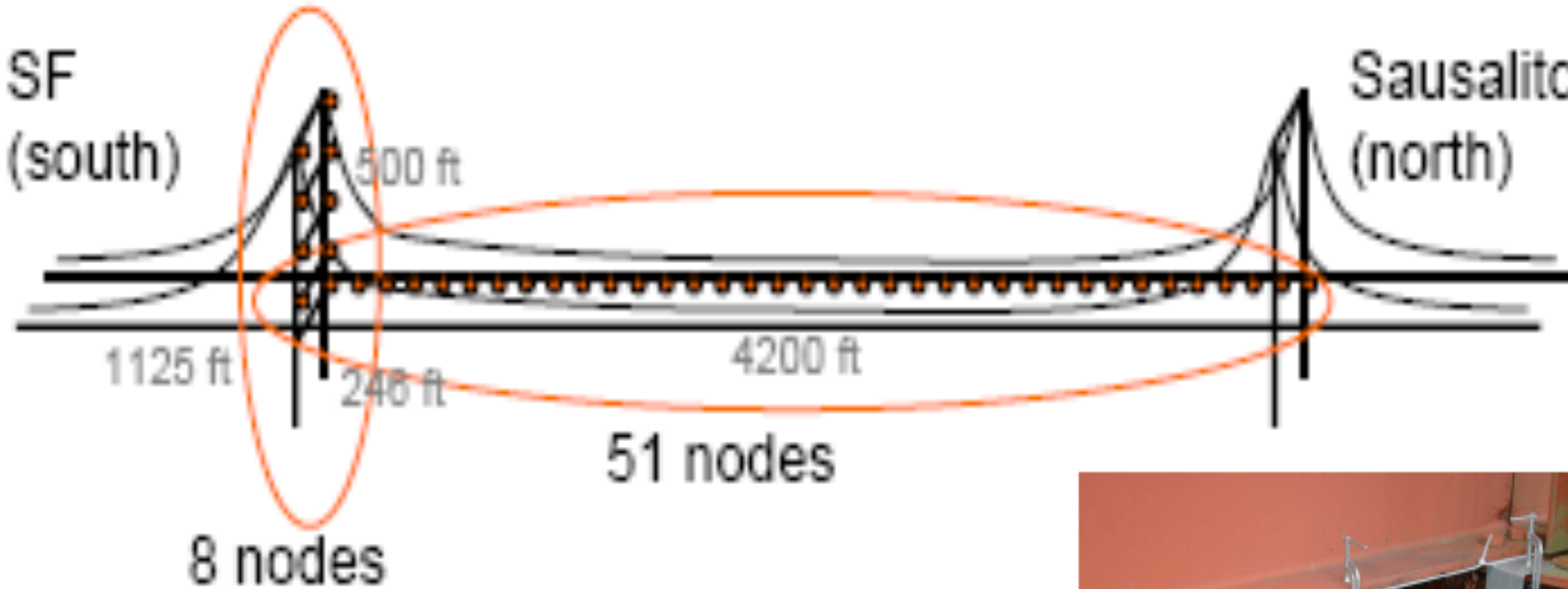
Structural Health Monitoring

- A Civil Engineering technique used to determine the condition of structures
  - e. g. buildings, bridges
- Detect and localize damage using vibration sensors

Motivation and Challenges

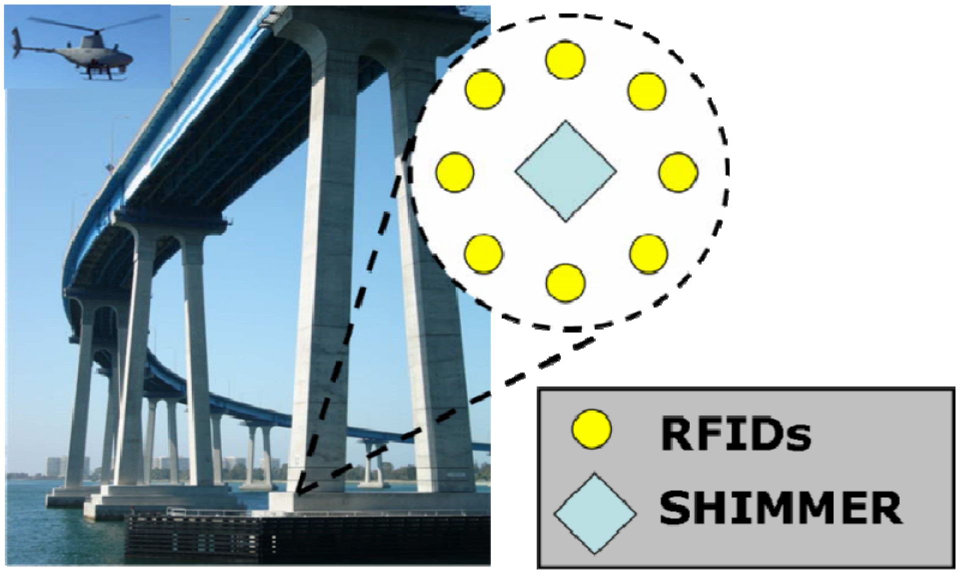
- Wired sensor deployment is expensive
- Wireless deployments can be:
  - Cost efficient
  - Higher density
  - More flexible

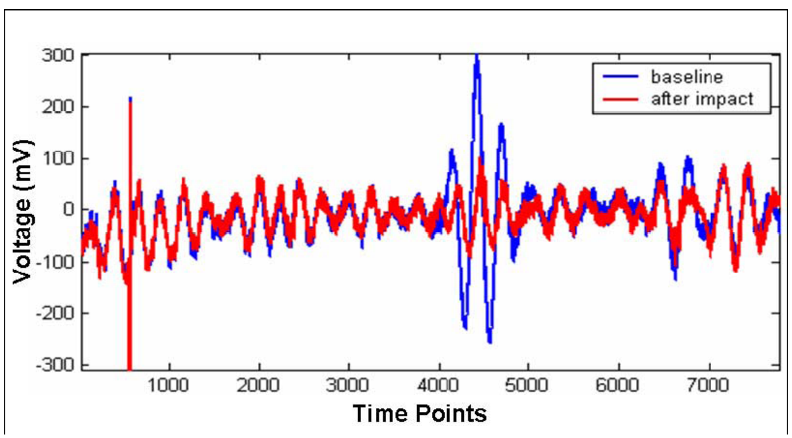
Related Work - Golden Gate Bridge

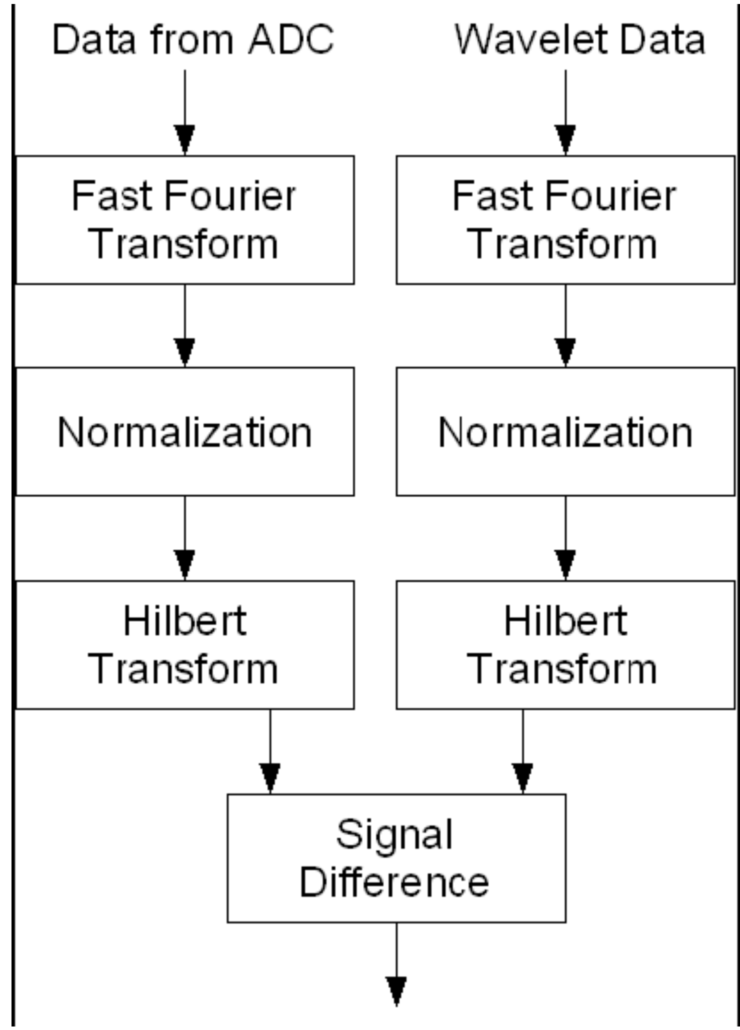


GGB project by UC Berkley

Related Work - SHIMMER





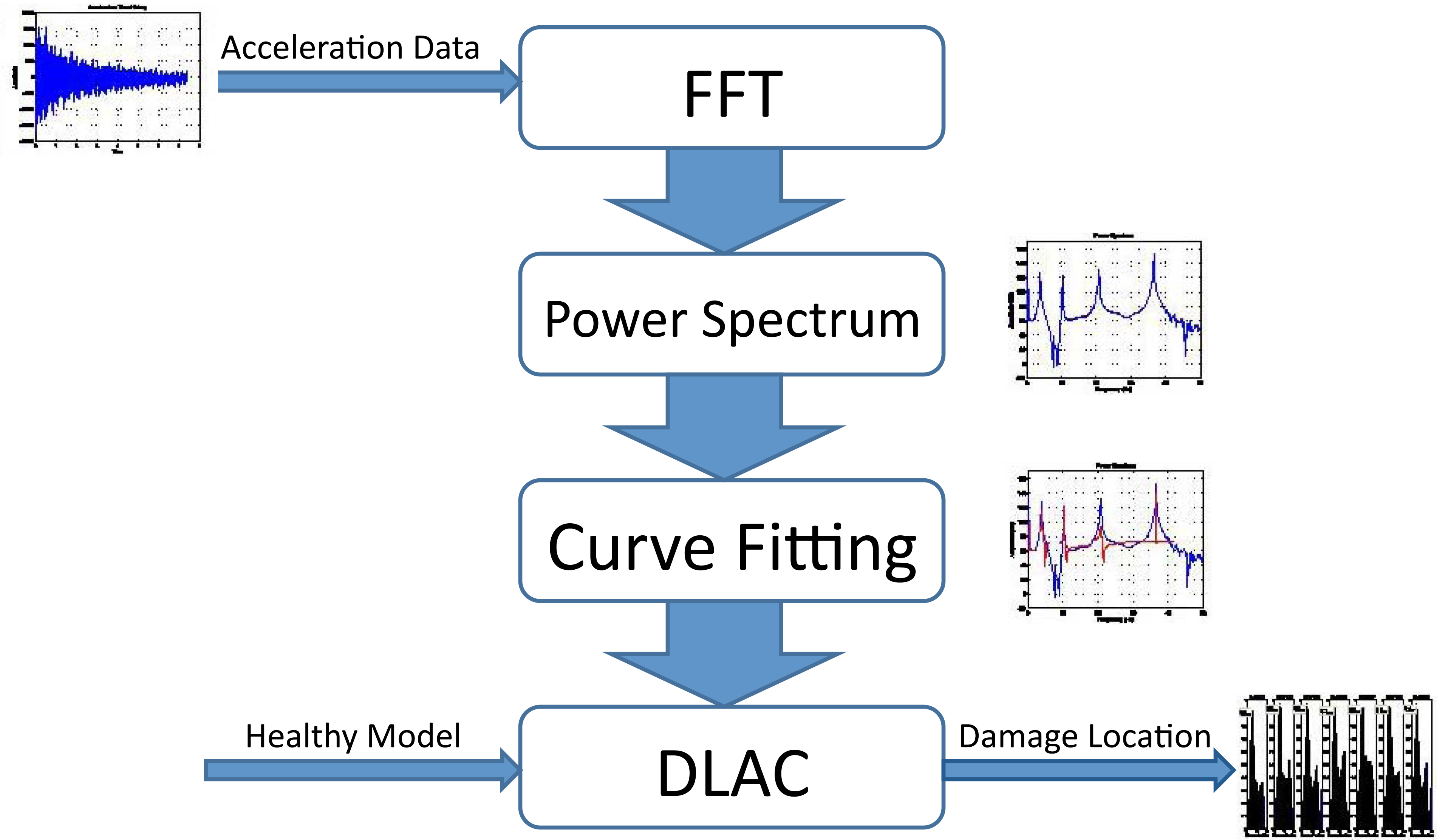


SHIMER project by the Los Alamos National Lab

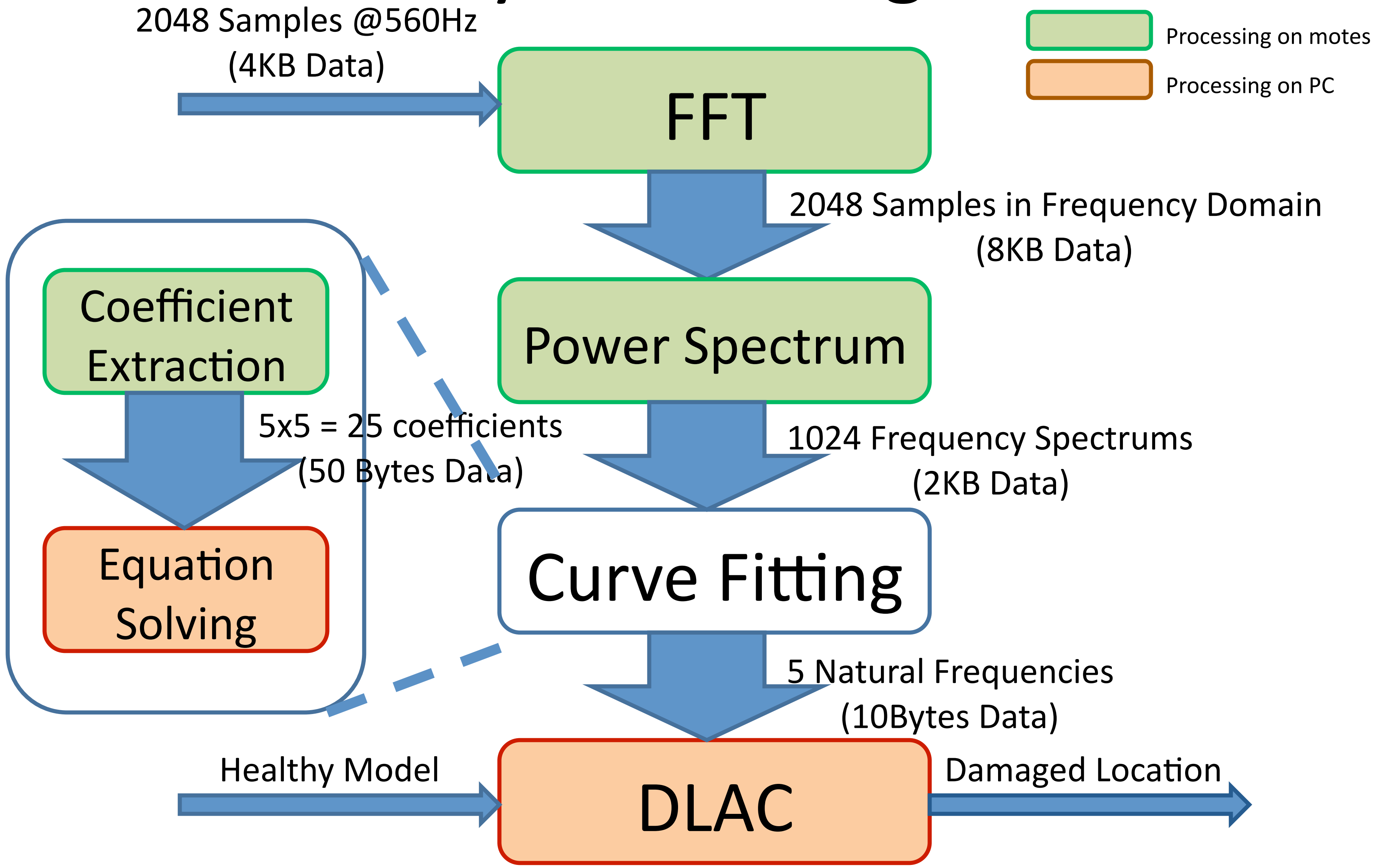
Problem Description

- Damage **localization** in addition to detection
- Limited Resource on WSN node
  - Limited memory ⟵
  - Limited transmission bandwidth ⟵
  - Limited power supply
- Unreliable wireless connectivity ⟵

DLAC Algorithm



System Design



Implementation

- Hardware
  - Intel Mote 2
    - 32-bit 416 MHz CPU
    - 32MB RAM
  - Intel ITS400 Sensor Board
    - LIS3L02DQ 3-Axis Accelerometer
- Software
  - TinyOS
  - NesC

IMote2

ITS400 Sensor Board

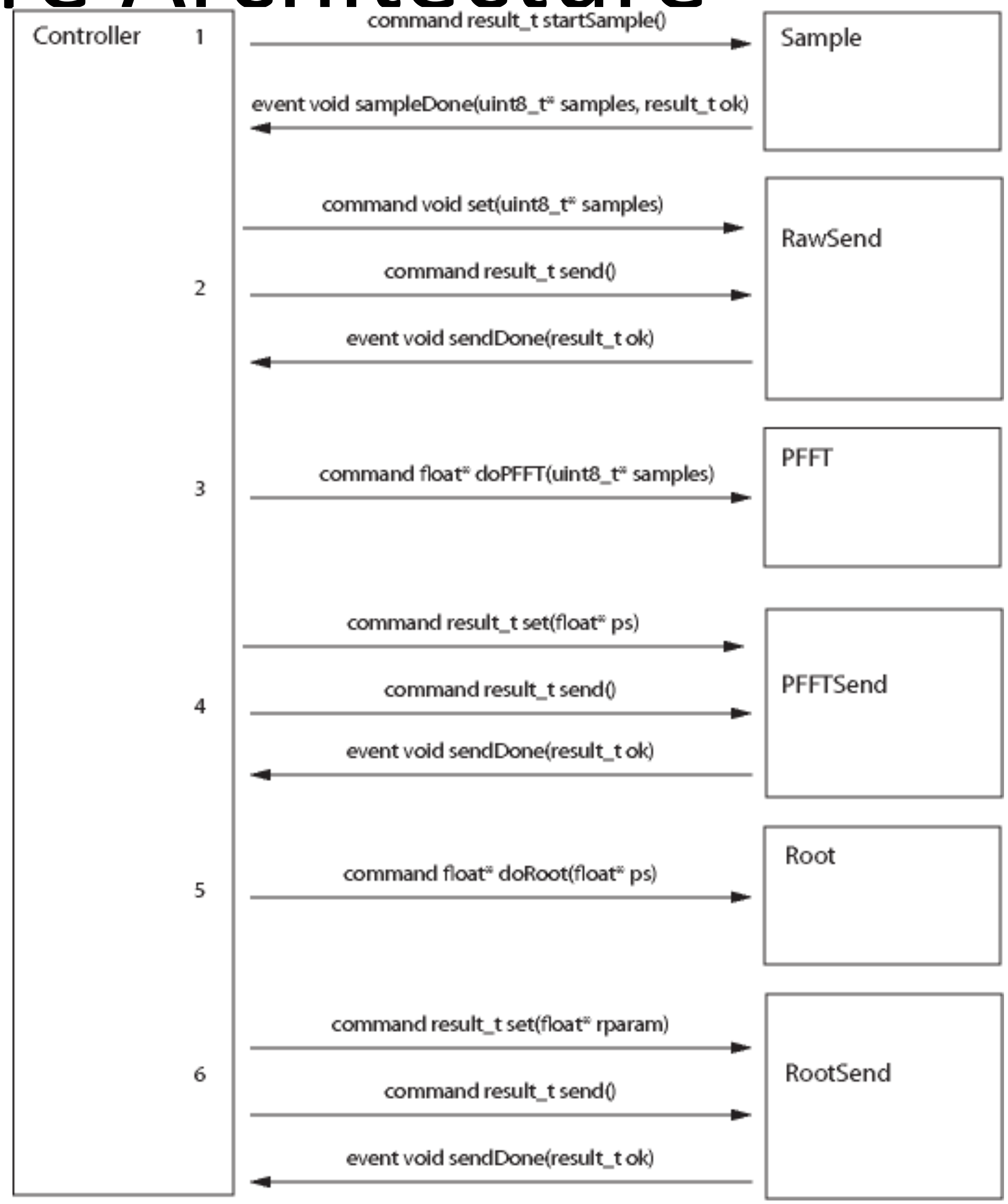
Software Architecture

• Reliable data transmission done through ARQ

• Average on the power spectrums to reduce noise

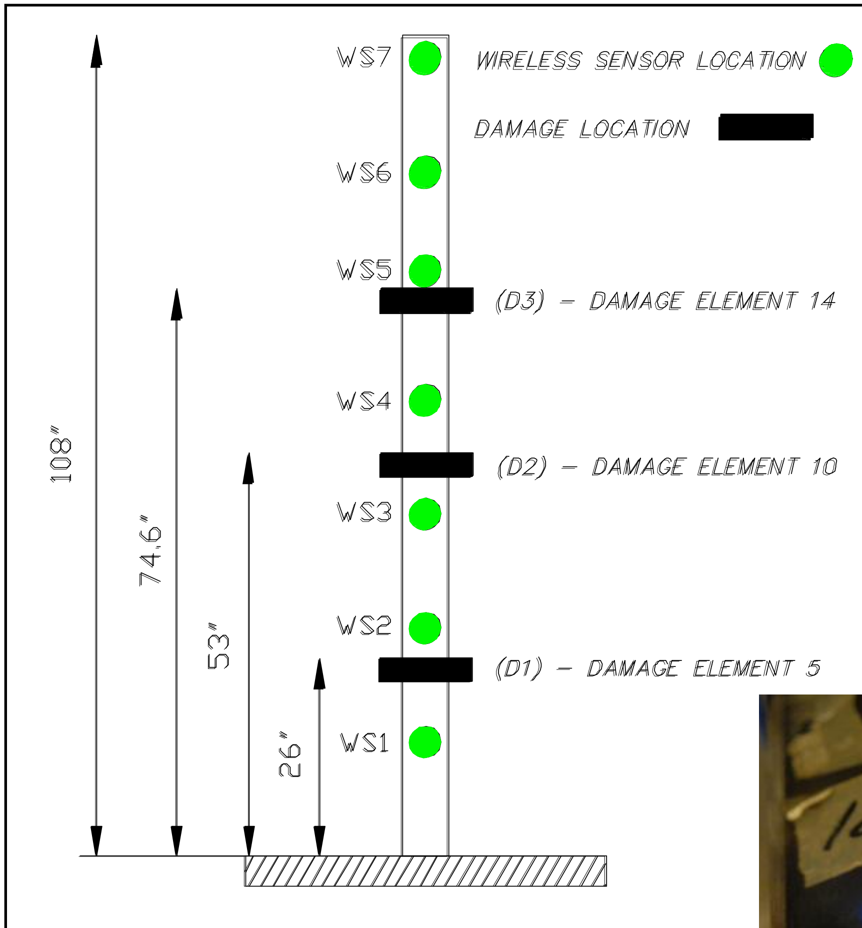
• Often times, the sensor board driver crashes and never returns a sampleDone event

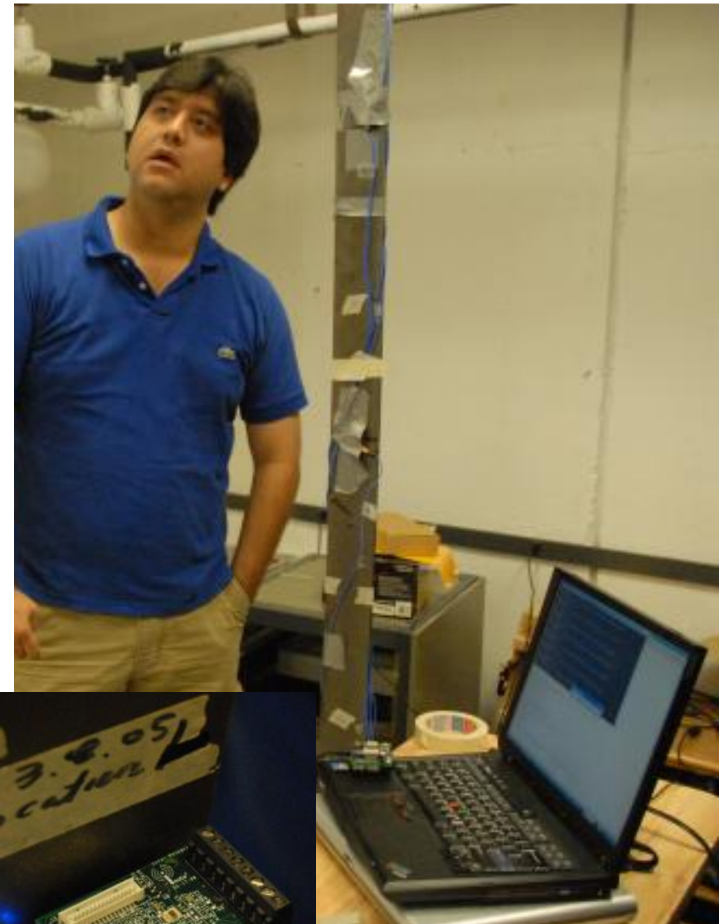
  • Time out timer used to detect and bypass such scenario



User Control Interface

The Beam Test

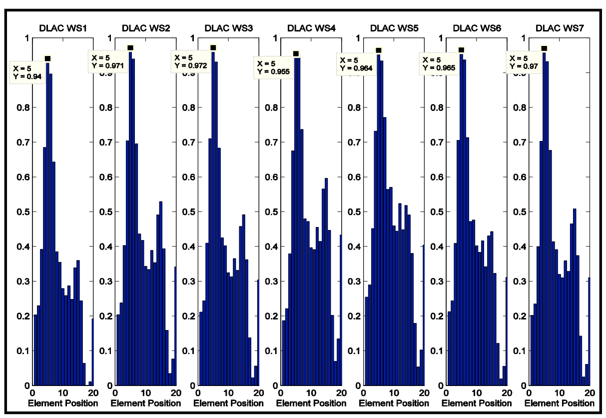




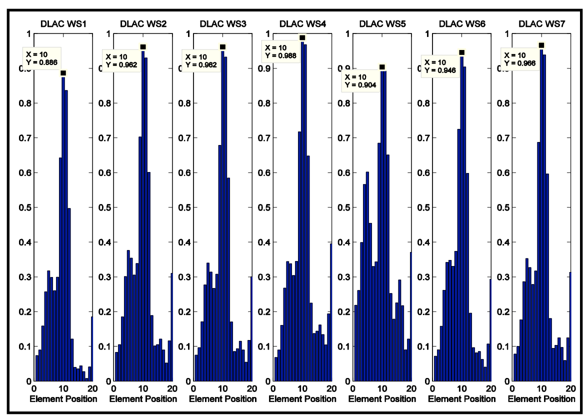
The beam structure
in the Earthquake Lab

Beam Results

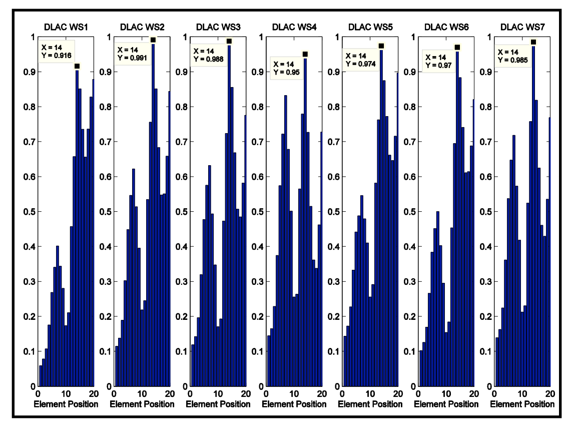
- Successful damage detection and localization for **all** damage scenarios
  - With correlation measurements >90% at the damaged positions



Damage Location #5

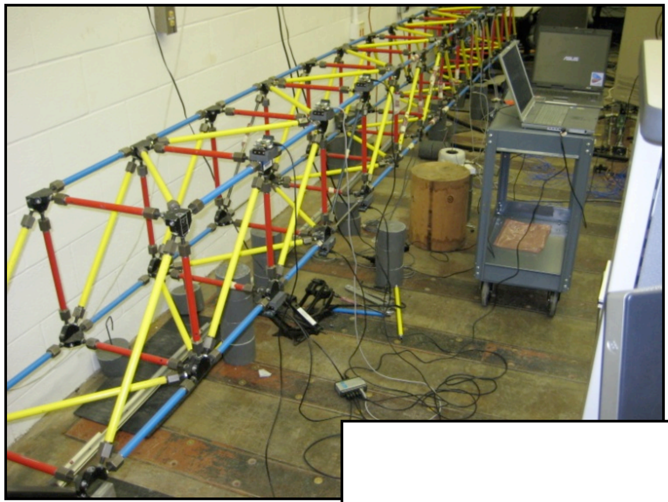


Damage Location #10

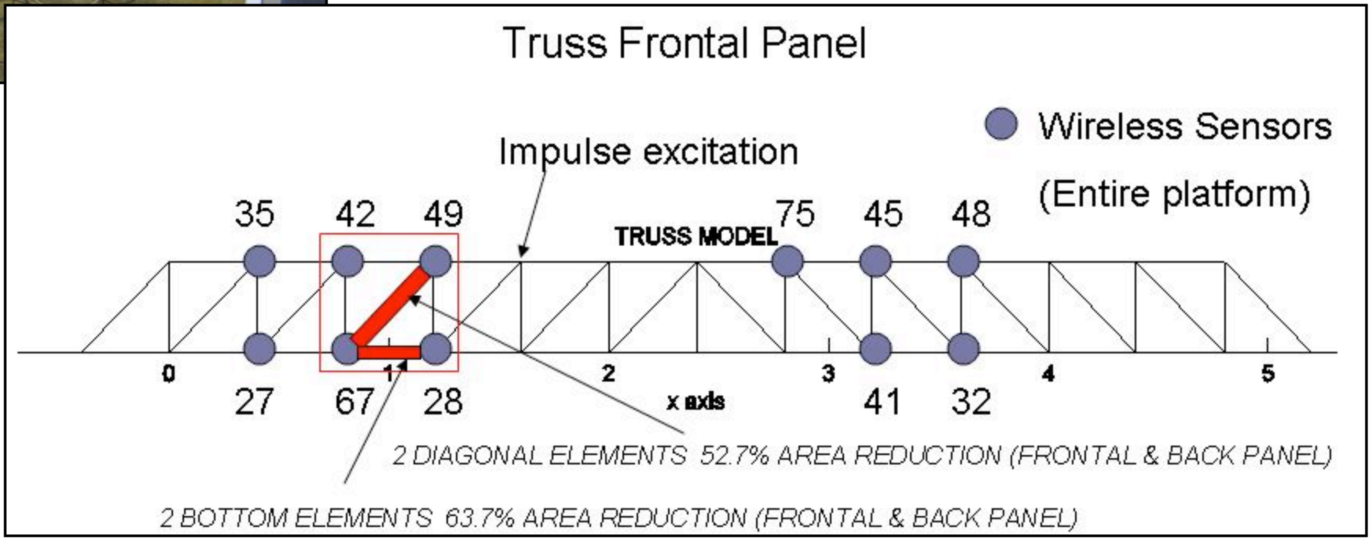


Damage Location #14

The Truss Test

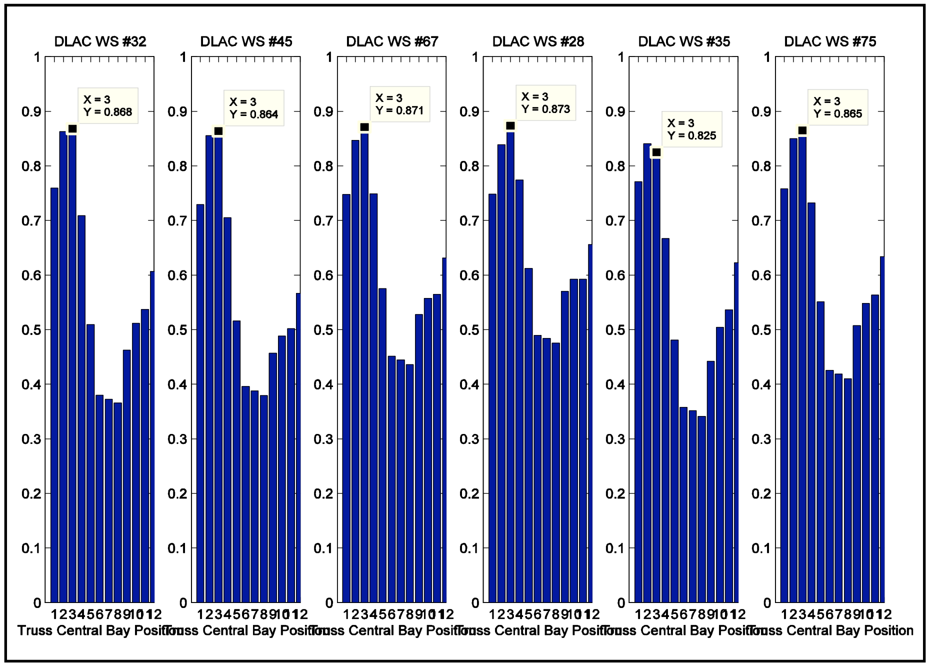


The truss structure at UIUC



Truss Results

- Successful damage detection and localization for **all** damage scenarios
  - With correlation measurements >85% at the damaged positions



Damage Location #3

Conclusion

- Design and Implementation of a SHM damage detection and localization technique on WSNs
  - correlation-based and decentralized
- Successful damage localization for two sets of experiments
- Future Work:
  - Debug sensor failure
  - Power Management

Appreciation

- Dr. Chenyang Lu
- Dr. Shirley Dyke
- Nestor Castaneda
- WUSTL WSN Group
- WUSTL Earthquake Lab
- Dr. Tomonori Nagayama