Center for Embedded Networked Sensing

GeoNet: A Platform for Rapid Distributed Geophysical Sensing

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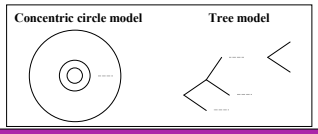
Introduction: GeoNet to predict time and locations of earthquakes

Anatomy of an earthquake

- **An earthquake = (Foreshocks , Main earthquake , Aftershocks)**
  - **Foreshocks:** may occur before an earthquake, low value on the Richter scale
  - **Main earthquake:** identified when the vibrations reach a peak value
  - **Aftershocks:** a series of shocks following the main earthquake
  - The magnitude of the aftershocks reduce as time passes



Existing models of earthquakes

- **Concentric circle model**
  - Adequate for large-field motions
- **Tree (Markov chain) model**
  - More accurate for near-field motions: suitable for earthquake predictions
  - However, yet to be corroborated by spatially extensive measurements

Use of WSN to study tree model

- **Rapidly deployed large-scale WSN to measure vibrations (GeoNet)**
  - Quickly deploy nodes after foreshocks
  - Deploy 100-1000 nodes at a separation of 0.5-1Km
- **Technology applicable to structural monitoring**

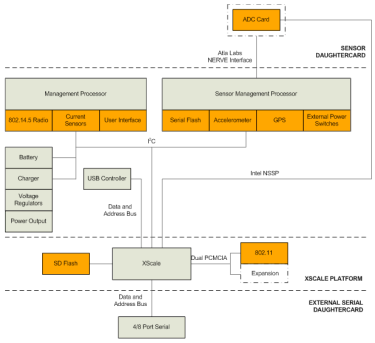
Problem Description: Construct a hardware-software platform for GeoNet

Requirements of the GeoNet platform

- **A need for tools to enable rapid deployment of WSN**
  - **Limited time:** A limited time is available to deploy node after noticing foreshocks
  - **No routing:** Tools such ping and iperf do not work without routing in a multi-hop network
  - **No fairness:** Existing tools do not guarantee fairness while collecting network statistics
- **A need of power-efficient wireless sensor node**
  - Earthquakes can cause damage: GeoNet nodes need to last at least for a week on batteries
  - Existing nodes are not energy efficient: they use high power processor for simple operations and high power radios for small control packets
- **A need of network-time in the absence of GPS reception**
  - GPS is unavailable in tunnels, canyons, and in buildings
  - A network time with accuracy greater than 1msec is required

Proposed Solution: A platform composed of suitable hardware and software for GeoNet

AENSbox from Aevena



- **AENSbox**
  - Multi-radio and multi-processor based node
  - Power-efficiency via selection of optimal radio and processor
- **Radios:**
  - IEEE 802.11 and IEEE 802.15.4
  - Use of 802.15.4 radio for short beacon packets
  - Use of 802.11 radio for long data packets
- **Processors:**
  - Intel PXA255 XScale: for analyzing, compressing, and transmitting sensory data to sink node
  - 2x Texas Instrument MSP430F1611: control 802.15.4 radio and sample seismic sensor data
  - Combination of processors and radios allows for sleep scheduling of XScale processor for greater power savings

A service to schedule transmissions in time

- **Transmissions scheduling is suitable to carry traffic generated by rapid deployment tools**
  - All nodes need to forward link and state information
  - All the transmissions occur in a periodic manner
  - Provides fairness: each node receives equal share of medium access

Rapid deployment tools for large-scale WSN

- **Tools to visualize network statistics**
  - From all nodes in real time
  - Statistics such as ETT, ETX, node health, estimated bandwidth, etc.

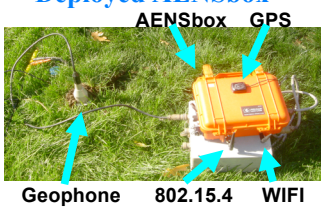
System software for Aensbox

- **Duty-cycle processors and radios for energy efficiency, e.g. duty cycling Xscale processor**
  - XScale processor to sleeps, while MSP processor sampls and stores data in serial flash
  - Wakeup XScale processor when serial flash is full
  - XScale processor transfers data to disk or forwards data towards sink

Time synchronization service

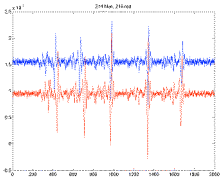
- **Provides network-wide time**
  - Use of synchronous reception property of wireless communication to synchronize time
  - Useful where GPS is unavailable

Deployed AENSbox



AENSbox Data Sampling

- **Data sampling and synchronization between two AENSboxes:**



Stargate-2 as an alternative hardware

- **Multiple radios viz. 802.11, 802.15.4, and bluetooth**