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SAMPL: A Simple Aggregation and Message Passing Layer for Sensor Networks

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Sensor Andrew

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Sensor Andrew

A Living Laboratory for Infrastructure Sensing Technologies

Goal: Make Carnegie Mellon the most sensed campus

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Current Deployment Statistics

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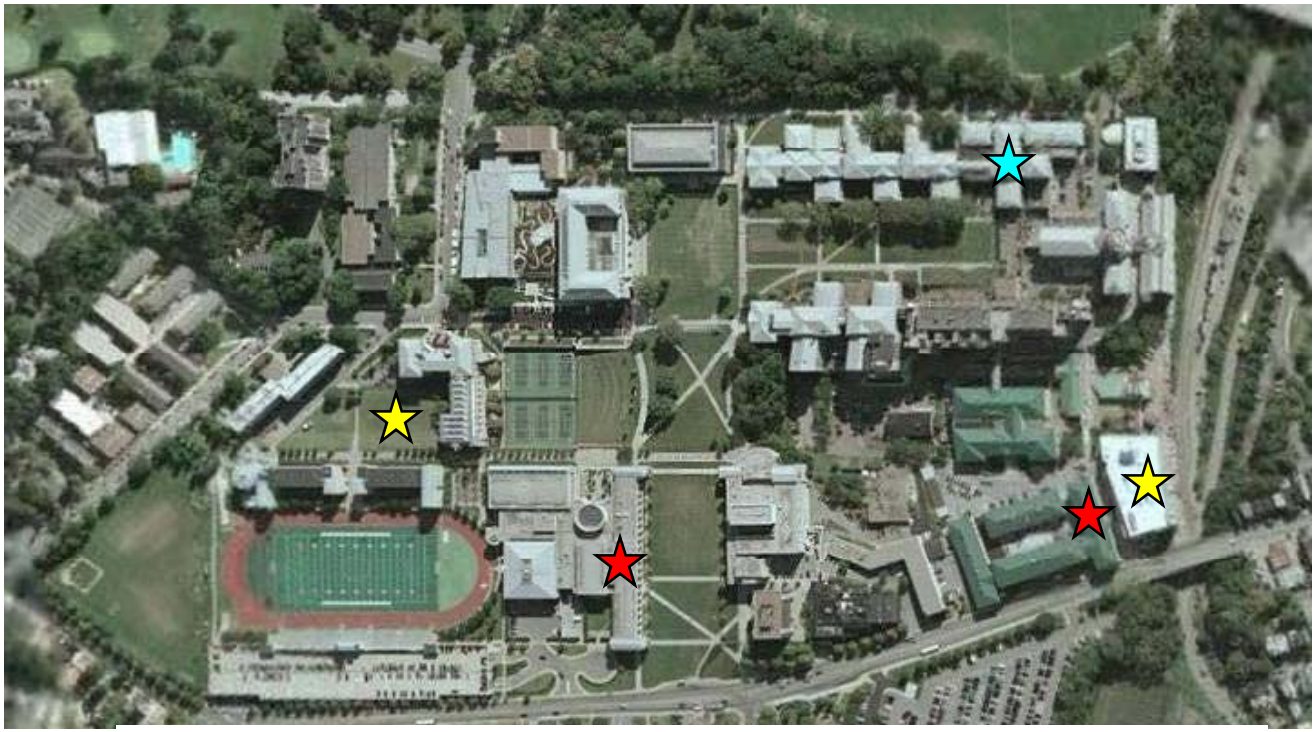

Key (Number of Sensors per Node Type)

★ = 1 ★= 2 ★= 3

Current Status: 1500 Sensor Points deployed across campus (over 7 months)

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Infrastructure Monitoring

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BACnet

Health monitoring and maintenance for buildings on campus

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“Green” - House

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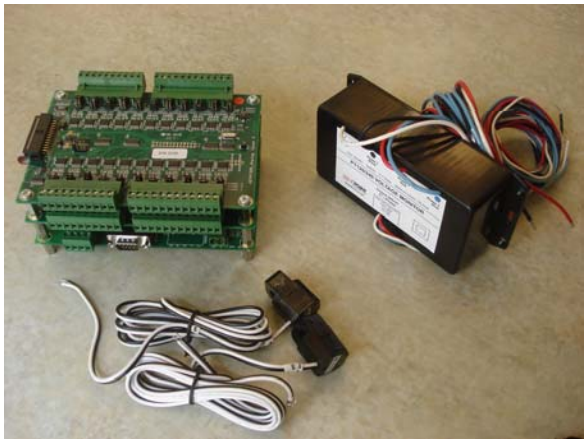

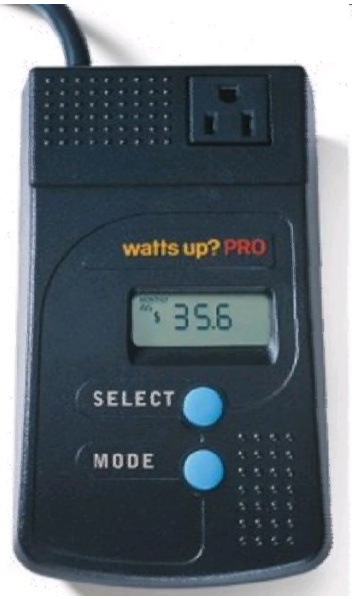

Total Household Energy Consumption in the US: 10.6 Quadrillion BTUs

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Solar House

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Hobo Sensors

Outfitting the on-campus solar challenge test-bed with Wireless HVAC

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Access Management

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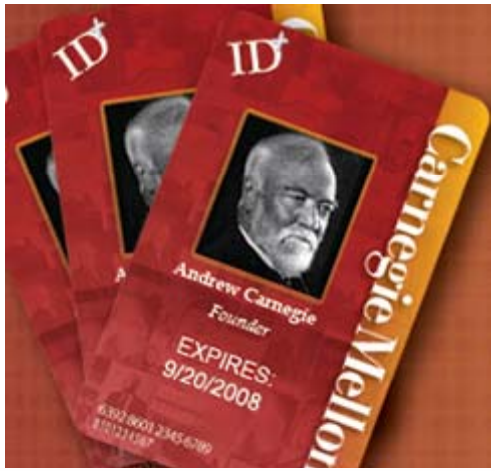
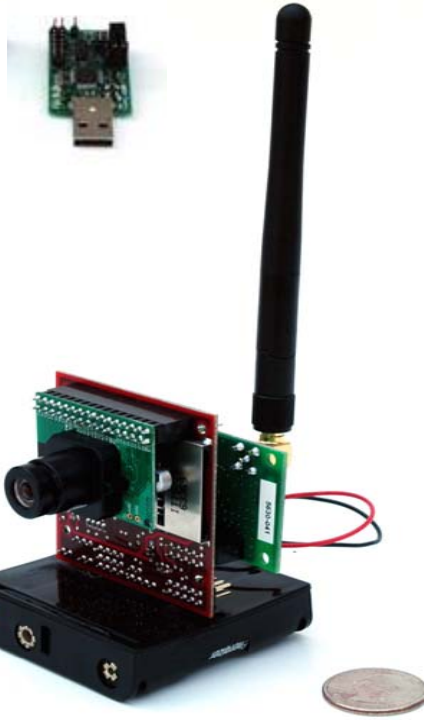
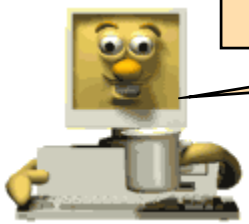




Intelligent “ID” cards for access to buildings on campus



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Localization Services

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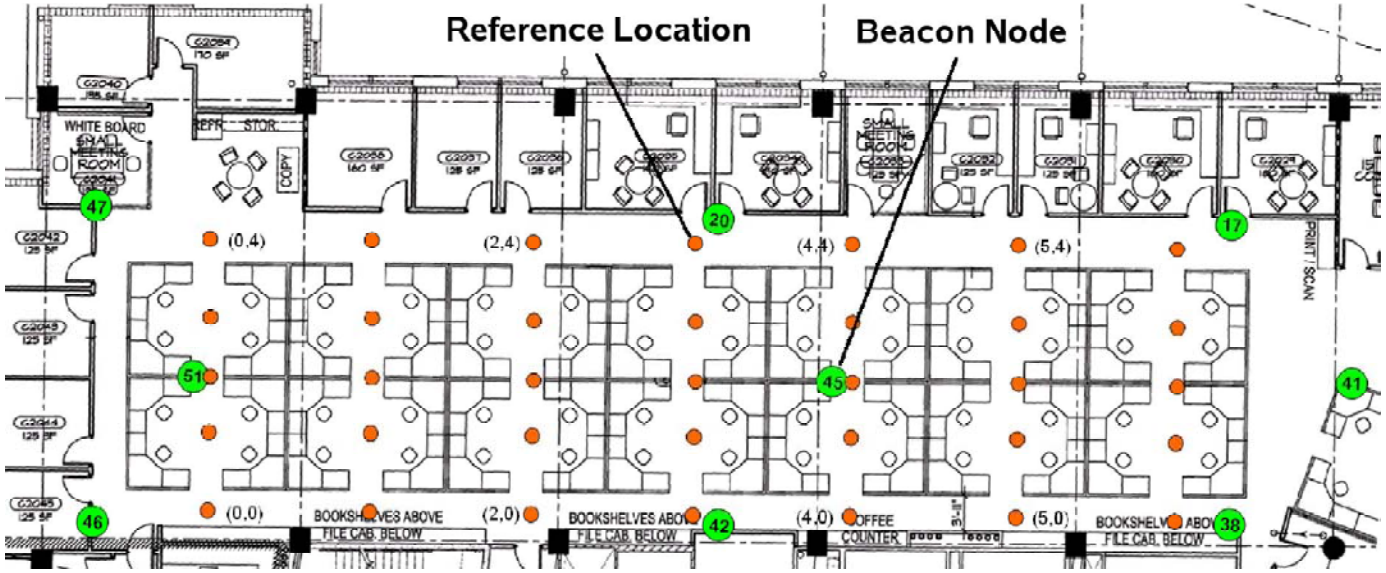

Where to get “fresh” Pizza?
Where is the nearest Rest-Room?
Which conference room is free?
Is this Coffee fresh?
OMG!!! Can’t find class room!!!

Localization services for both Humans and Robots

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Hardware Infrastructure

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Sensor Andrew also provide infrastructure support for other technologies

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“Big” - Picture

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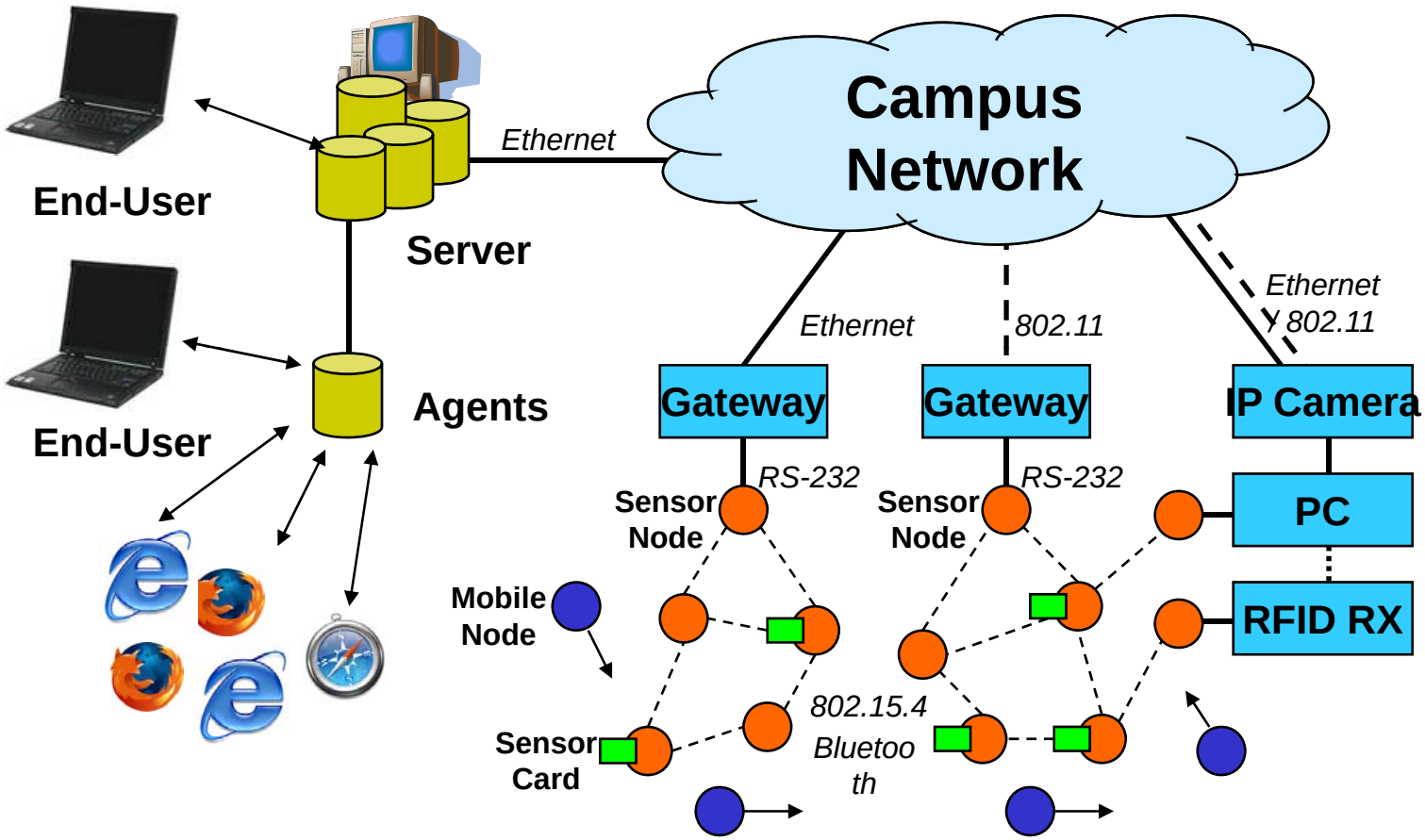

** Protocols listed are examples*

Sensor Andrew provides a complete infrastructure for ubiquitous sensing/control

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“SAMPL” - Picture

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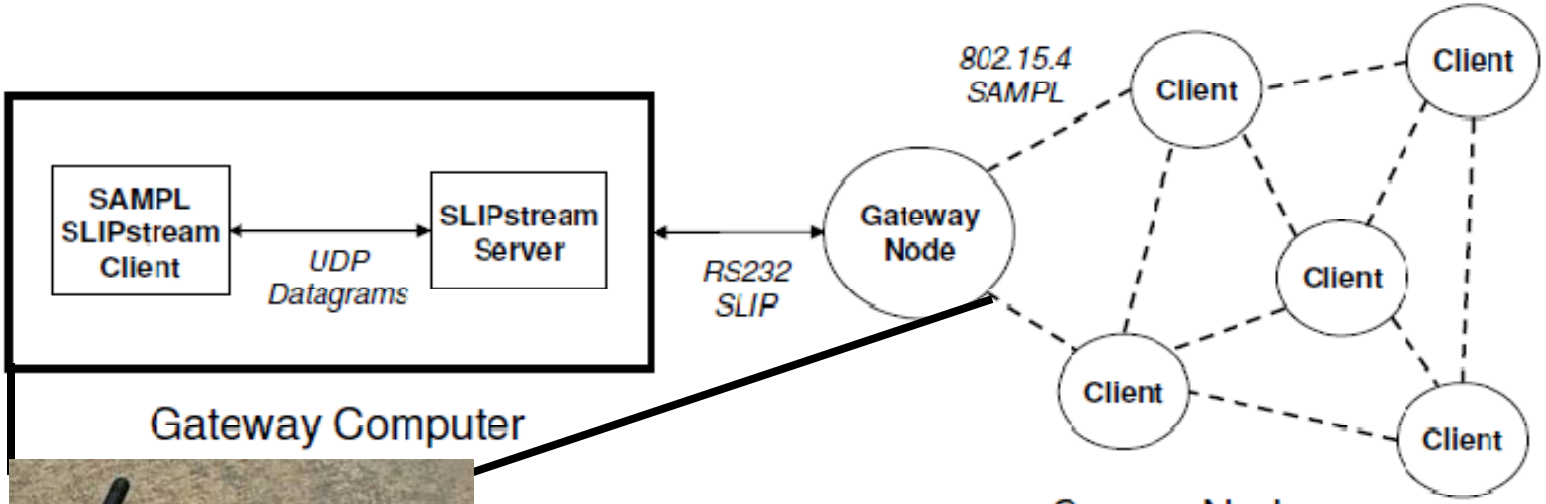

Gateway acts as a bridge to the Internet and uses an XMPP infrastructure

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“SAMPL” - How?

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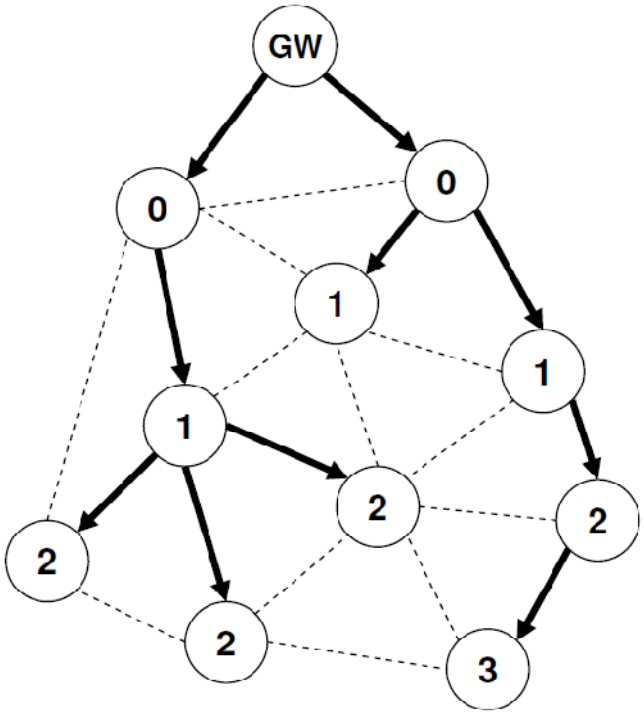
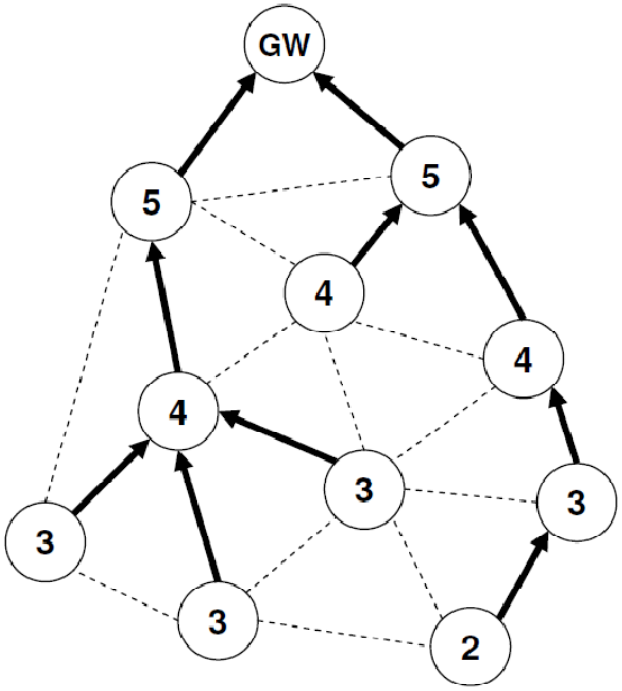


Flash Configuration



Data Report

Flashing re-establishes paths. Level-delayed data report enables aggregation

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Why – “SAMPL”?

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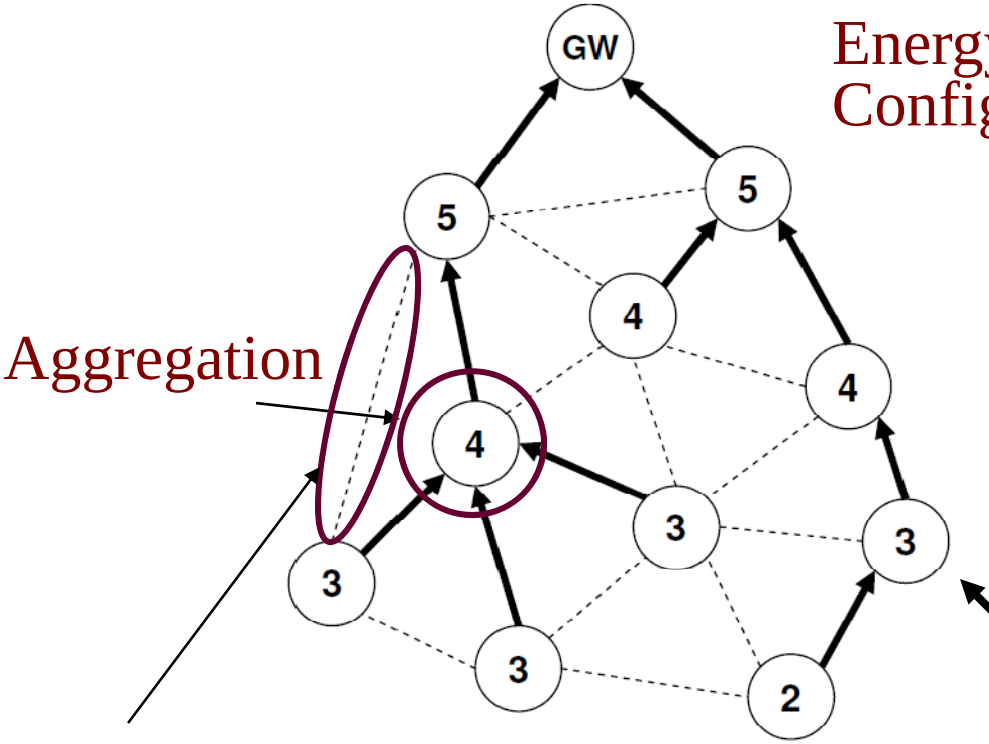

Energy Efficient:
Configurable sleep duration

Mobility Support
Wait for next Flood

Robustness
- Paths re-establish with each Configuration Flash
- Weak paths are removed during each Flash

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Configurability

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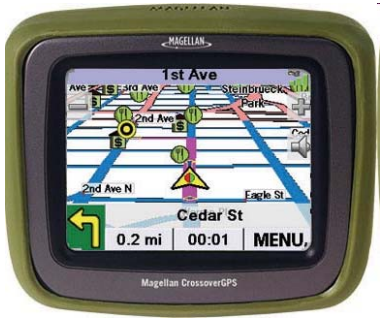

Adaptability & Budgeting: Mandatory for long-term sustainable sensor networks

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Visibility

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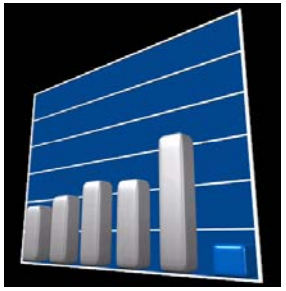
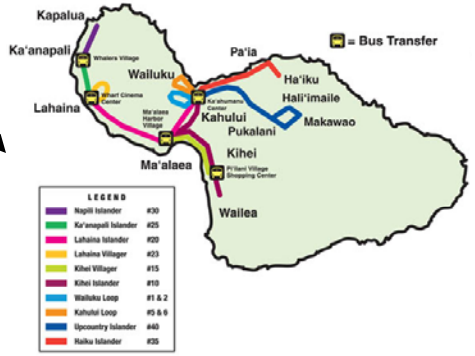
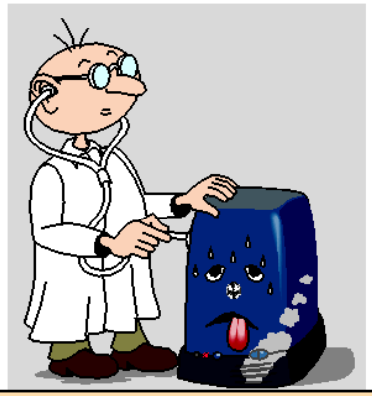
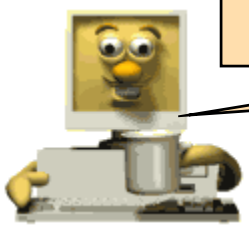






Accurate Accounting – Enables lifetime prediction and maintenance schedules



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Deploy

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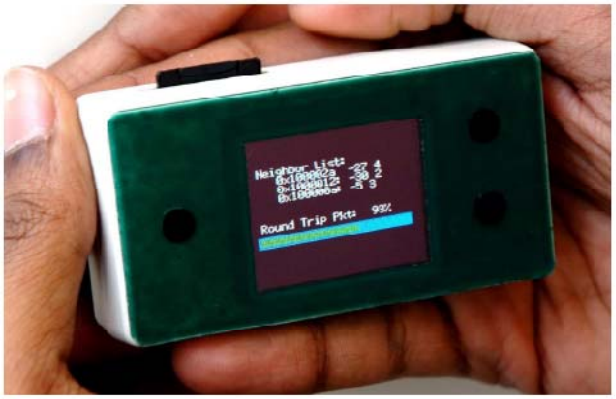

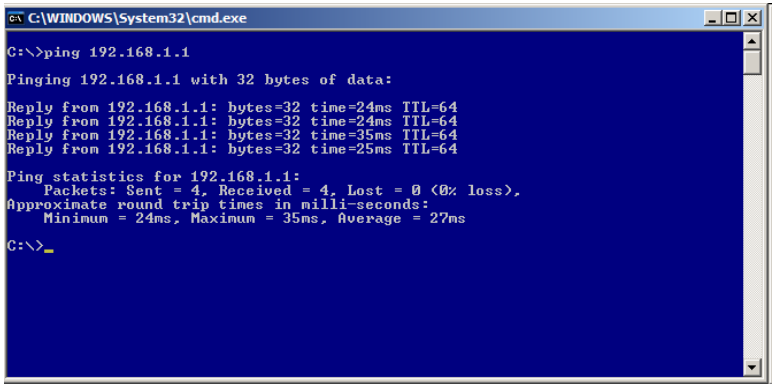

Deployment issues – Practical problem of ensuring wireless coverage

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Debug

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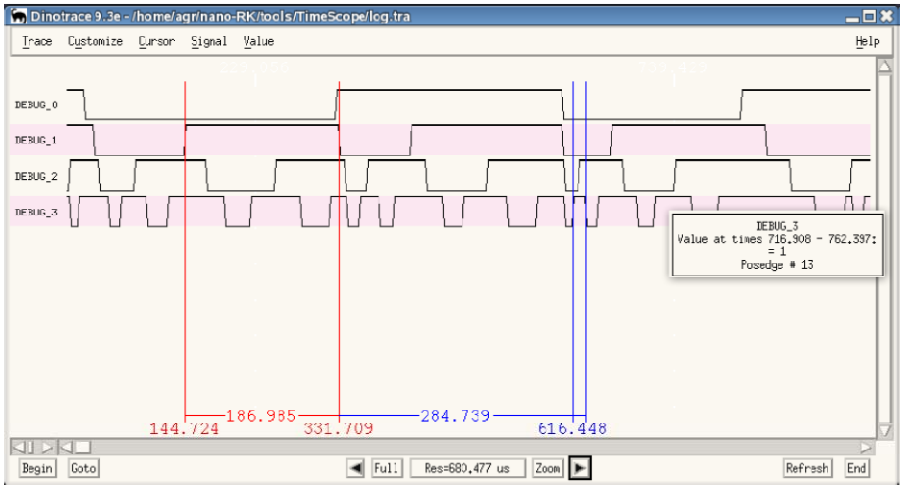
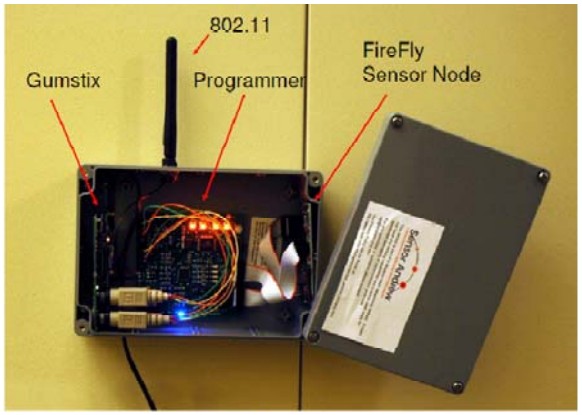
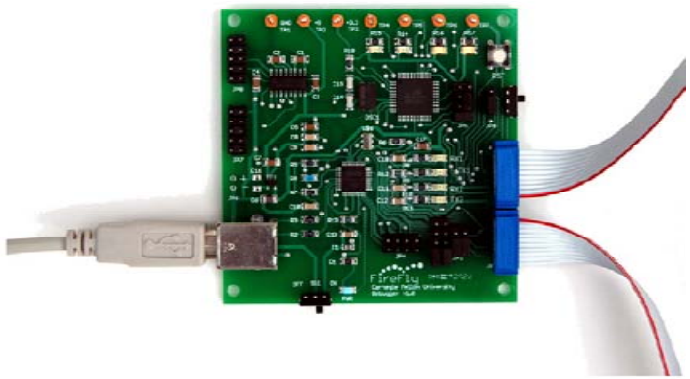
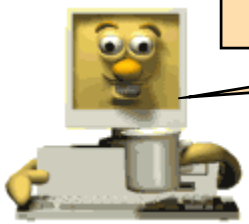






Run-time Visibility - key aide in a successfully developing Sensor Andrew



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Monitor Health

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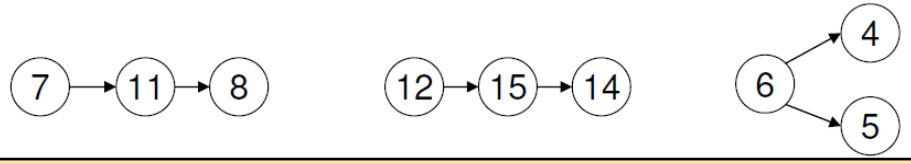
Nodes N_i

Nodes N_j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	89														
2		282													
3			210												
4				309	4	5									
5					115	4									
6						92									
7							67	6			6				
8								80			12				
9									98						
10										116					
11							17	18			89				
12												72			4
13													172		
14														86	154
15												6			77

$$z_{i,j} = \frac{(\hat{P}_i - \hat{P_{i|j}}) - (P_i - P_{i|j})}{\sqrt{\frac{\hat{P}_i(1-\hat{P}_i)}{n_i} + \frac{\hat{P_{i|j}}(1-\hat{P_{i|j}})}{n_j}}}$$



Correlated packet loss helps identify the bottlenecks in the network

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Diagnose

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Find the weakest links of the chain

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Re-enforce

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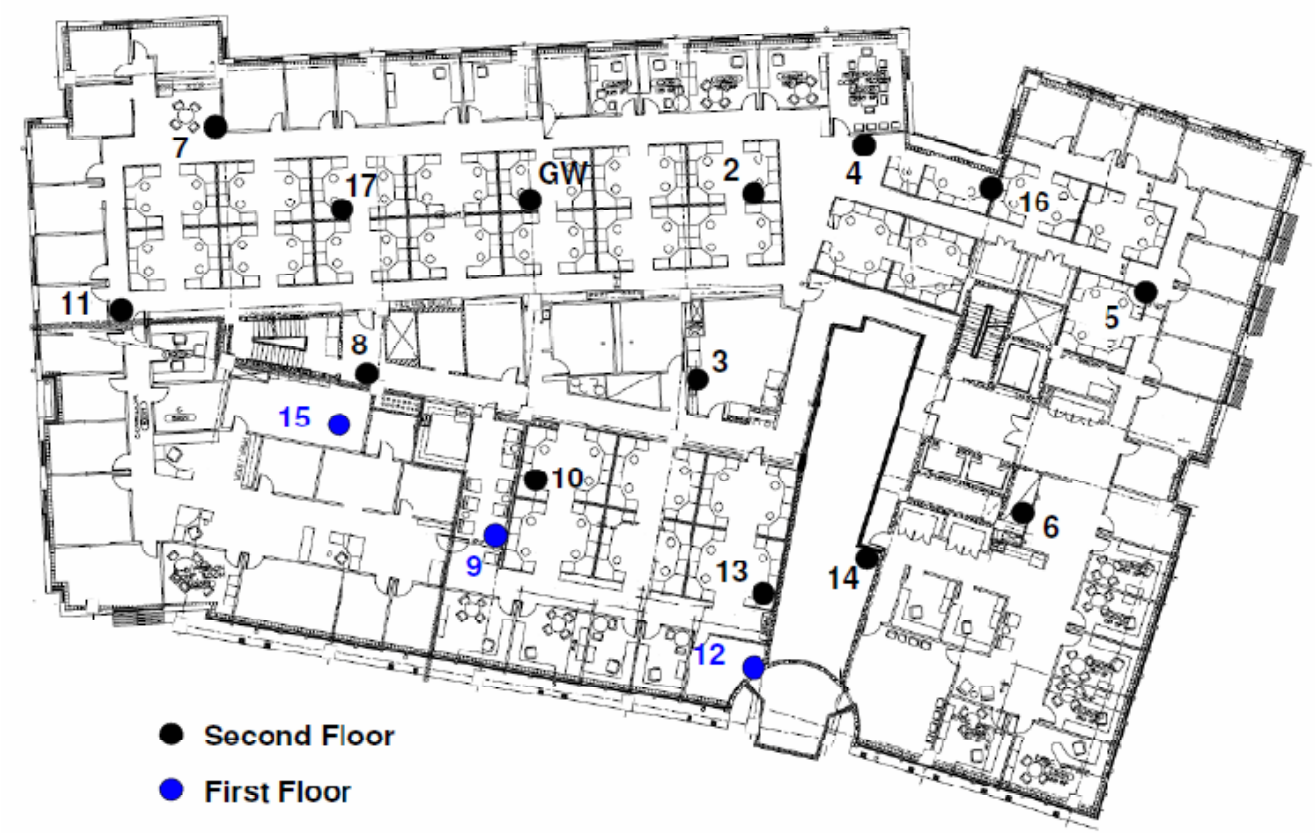

Fortify the network by “strategically” adding nodes

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Evaluate

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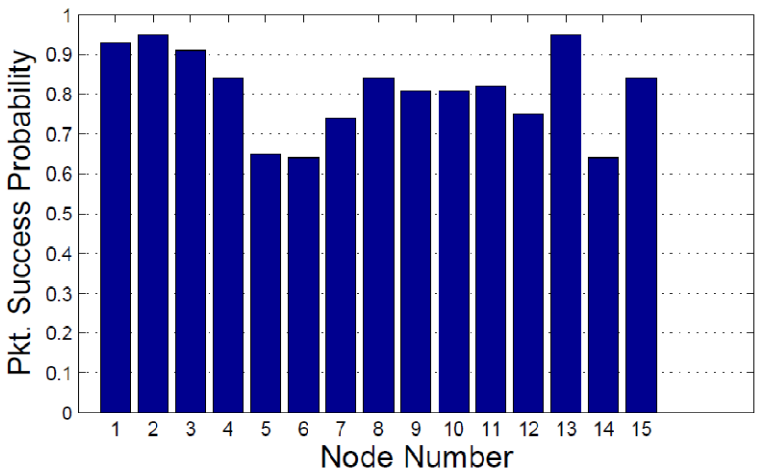
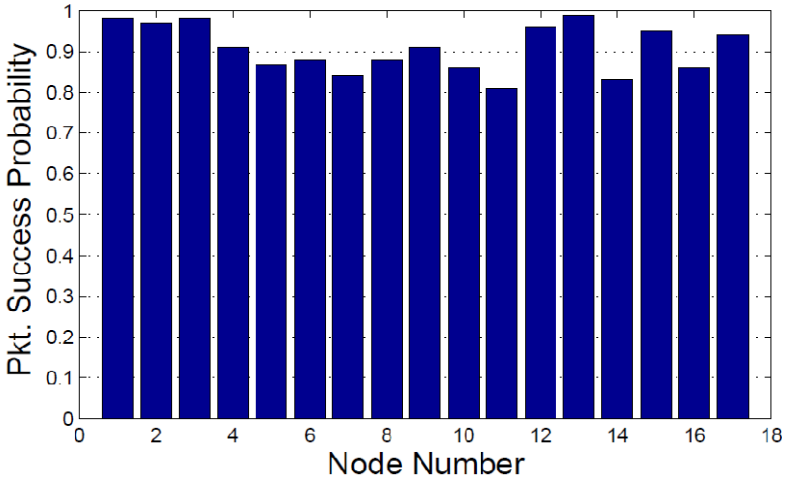


Before Re-Enforcement



After Re-Enforcement

12% improvement from an average packet delivery rate of 82% to 94%

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Conclusions

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- Key features of SAMPL
  - Configurability, Visibility, Mobility support and Energy efficiency
  - Flexibility to support a diverse-set of applications
    - Civil-engineering research, Robotics applications, Mobility studies
- Large-scale and Long-term deployment
  - 1500 sensing points deployed over a seven month duration
  - Efficient techniques to ensure coverage
  - Mature infrastructure for diagnostics and debugging
- SAMPL provides infrastructure support for Sensor Andrew

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Demo

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- For more details:
  - http://www.nanork.org
  - http://sensor.andrew.cmu.edu
- Questions:
  - agr@andrew.cmu.edu
  - klakshma@andrew.cmu.edu
  - raj@ece.cmu.edu

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