

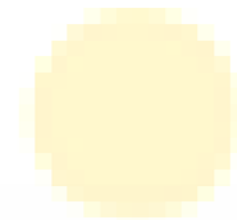
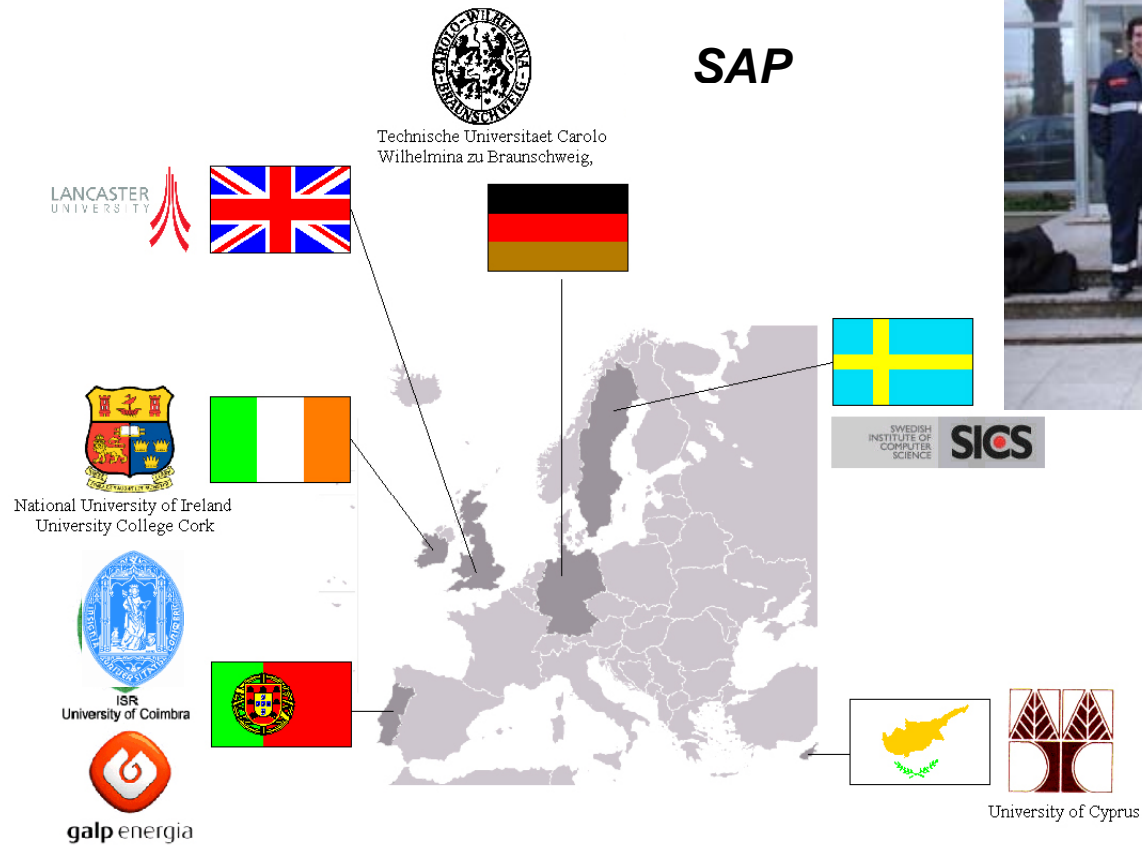


*Performance Control in
Wireless Sensor Networks*

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Partners



Technical Focus

- Research on wireless sensor networks (WSNs) has focused on crucial issue of energy efficiency
- GINSENG targets performance control
 - Key metrics: message delivery delay and reliability
 - Application context: networked monitoring and actuation
 - Outcomes are a comprehensive set of network protocols for performance control & debugging

Case Study – Petrogal Refinery

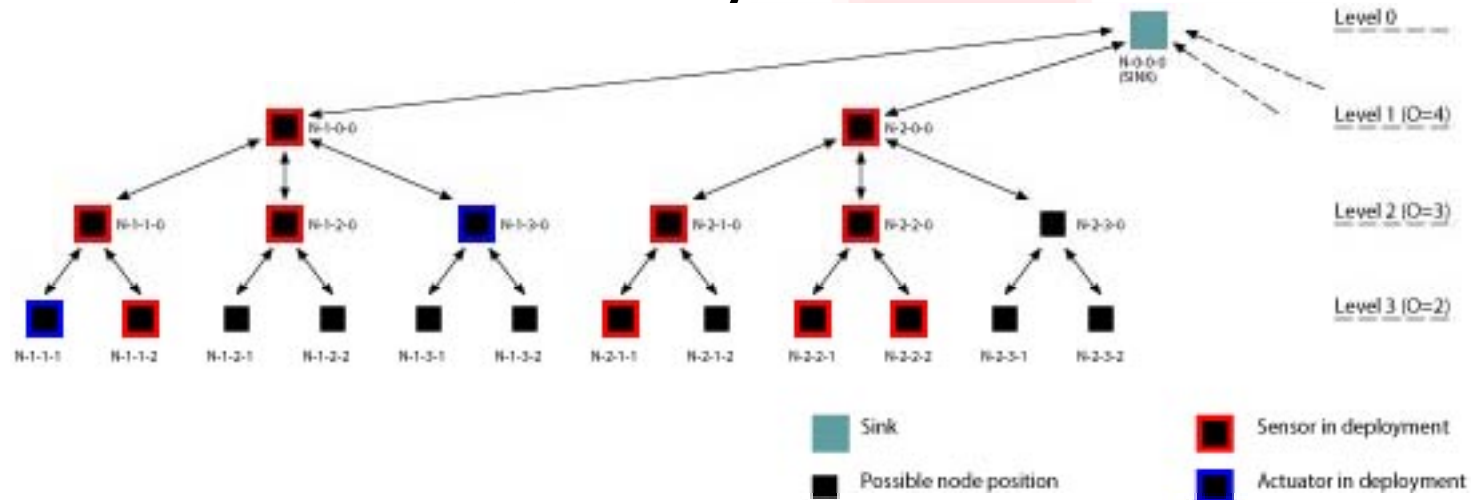
- Currently 35000 cabled sensors/actuators
 - Pressure monitoring in pipes; Temperature monitoring in pipes and tanks; Shut-off valves
- Refinery control
 - Indicatory system: monitoring of status and faults
 - Semi-automatic control (manual actuation); Automatic control system for control-loops
- Seeking solutions that offer lower deployment cost and greater agility

GINSENG Overall Approach

- Design a WSN system that is easy to analyze
 - Queuing in network is bounded
 - Tight delay bounds, easy to calculate
 - Sacrifice flexibility, e.g. bursty traffic
- Intentionally simple mechanisms
 - Exclusive TDMA, single-channel MAC, limited variability (global max. no. of retransmissions)

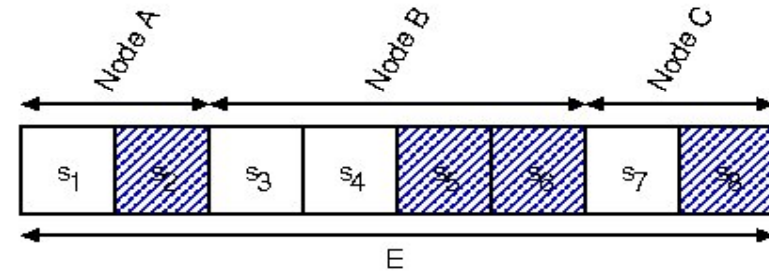
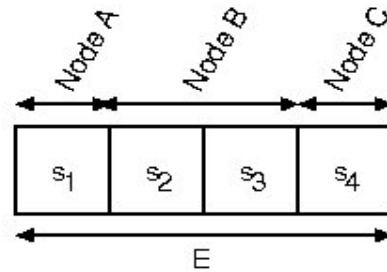
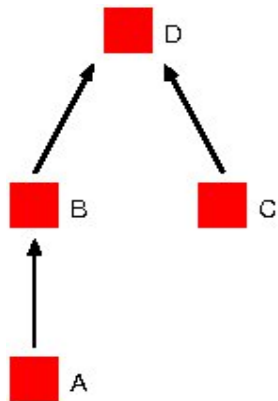
Two Selected Features

- GinMAC - a TDMA-based protocol provisioned for deterministic delivery



- Energy-efficient performance debugging
 - passive monitoring + probing
 - on-node storage and analysis

GinMAC Slot Assignments



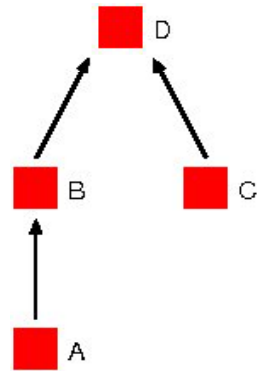
Topology

Schedule without re-transmission

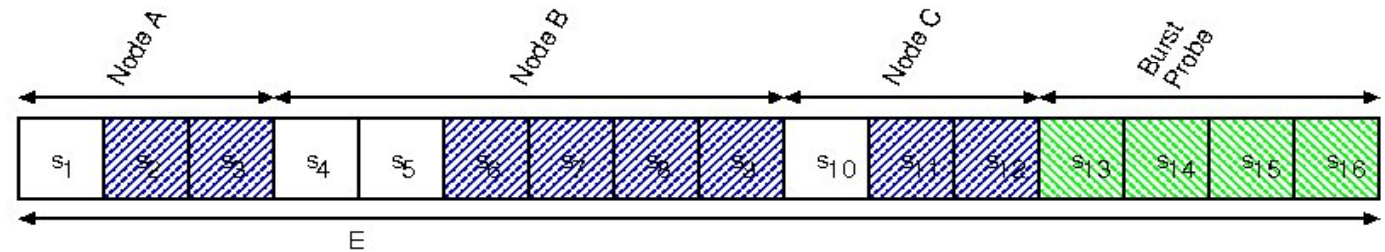
Schedule with re-transmission

- i) Basic slots for sending and forwarding data (One from each sensor to sink; One from sink to each actuator)
- ii) Fixed no. of retransmission slots per node
- iii) Unused slots to achieve low duty cycle and support dynamic topology (inc. limited mobility)

Burstprobe



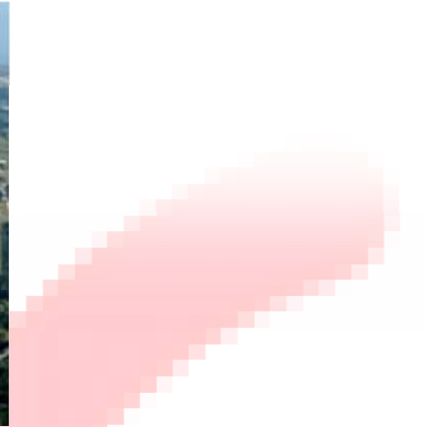
Topology



Schedule with re-transmission according to $B_{max}=2$ and $B_{min}=1$ and slots for BurstProbes

- Dedicated probe slots added to TDMA schedule, assigned periodically to nodes
- Link statistics on burst losses stored on flash until needed for debugging (eg to adapt no. of retransmission slots)

GINSENG Deployed System



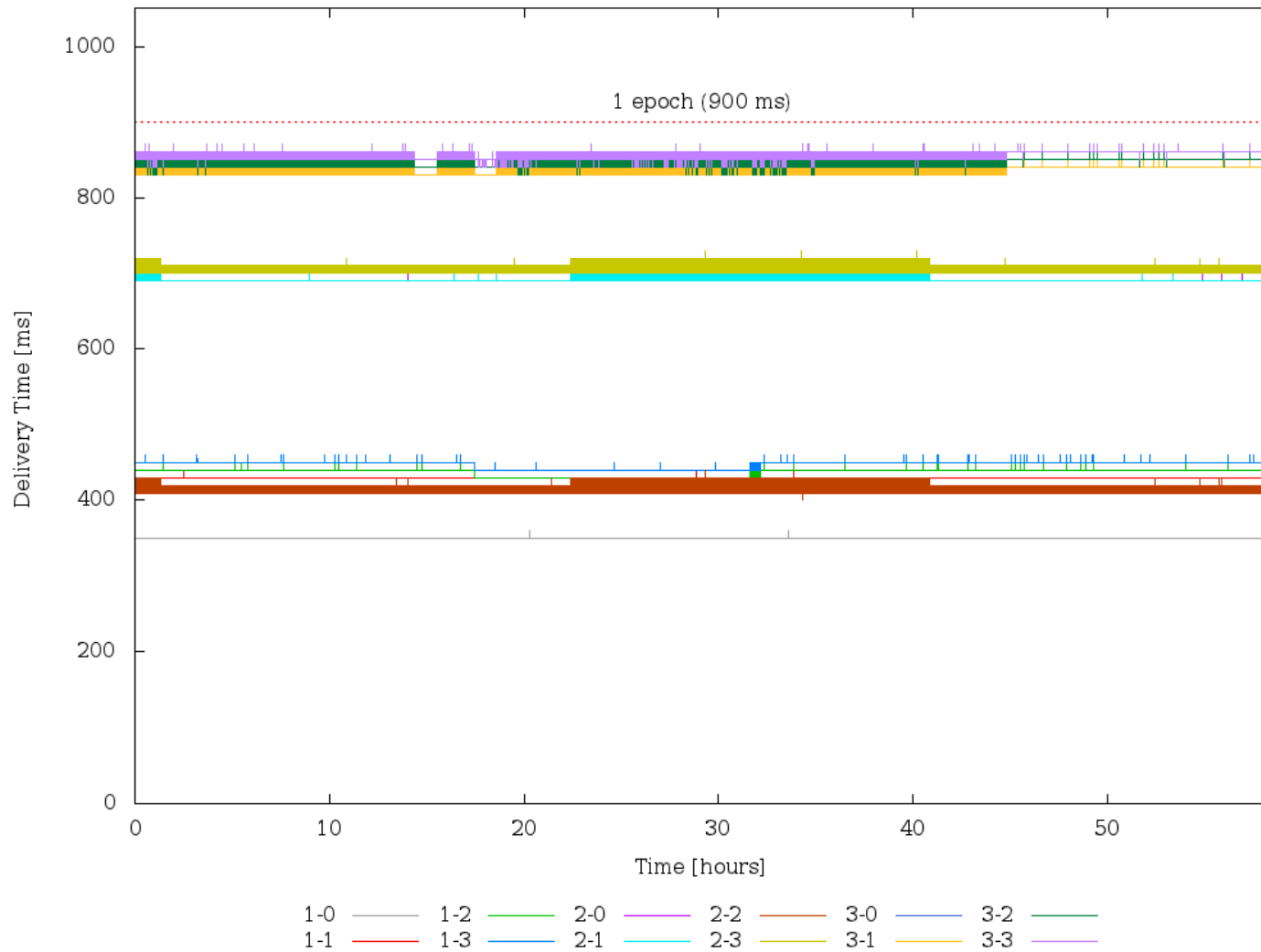
GINSENG Deployed System

- Two separate wireless sensor networks of approx. 30 nodes; limited mobility
- Most nodes connected to existing sensors and actuators, some as relays only
- ATEX-encased TelosB nodes (2.4GHz radio) with customised ContikiOS and protocol stack
- Back-end middleware for complex event processing and UIs for operations, configuration & lifecycle management

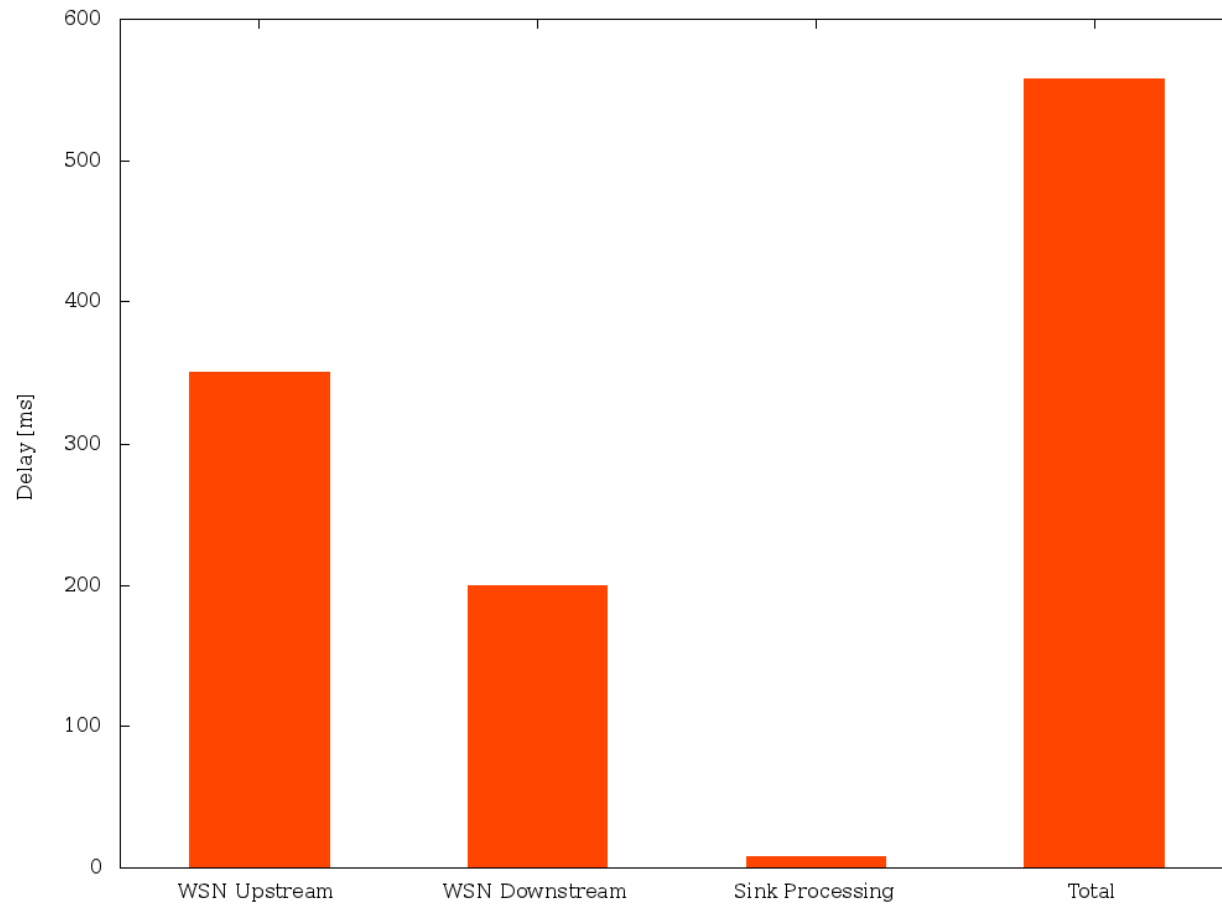
Performance Requirements

- Low transport delay
 - actuation and sensing 1-2 seconds
- High transport reliability
 - 100% if possible, 99.99% for some scenarios
- High sampling rates
 - Sampling frequency up to 1 Hz
- Small sample sizes
 - 32bit sufficient for most sensors and actuators

WSN Delay Timeline



Closed-Loop Delay (Sink)



Summary & Contacts

- A wireless sensor network solution that offers performance control
 - Working prototype for sensing and actuating at the Petrogal oil refinery
- We welcome contact from technology companies to explore licencing opportunities
- Follow up contacts:
 - Web: www.ict-ginseng.eu
 - Email: cjs@cs.ucc.ie

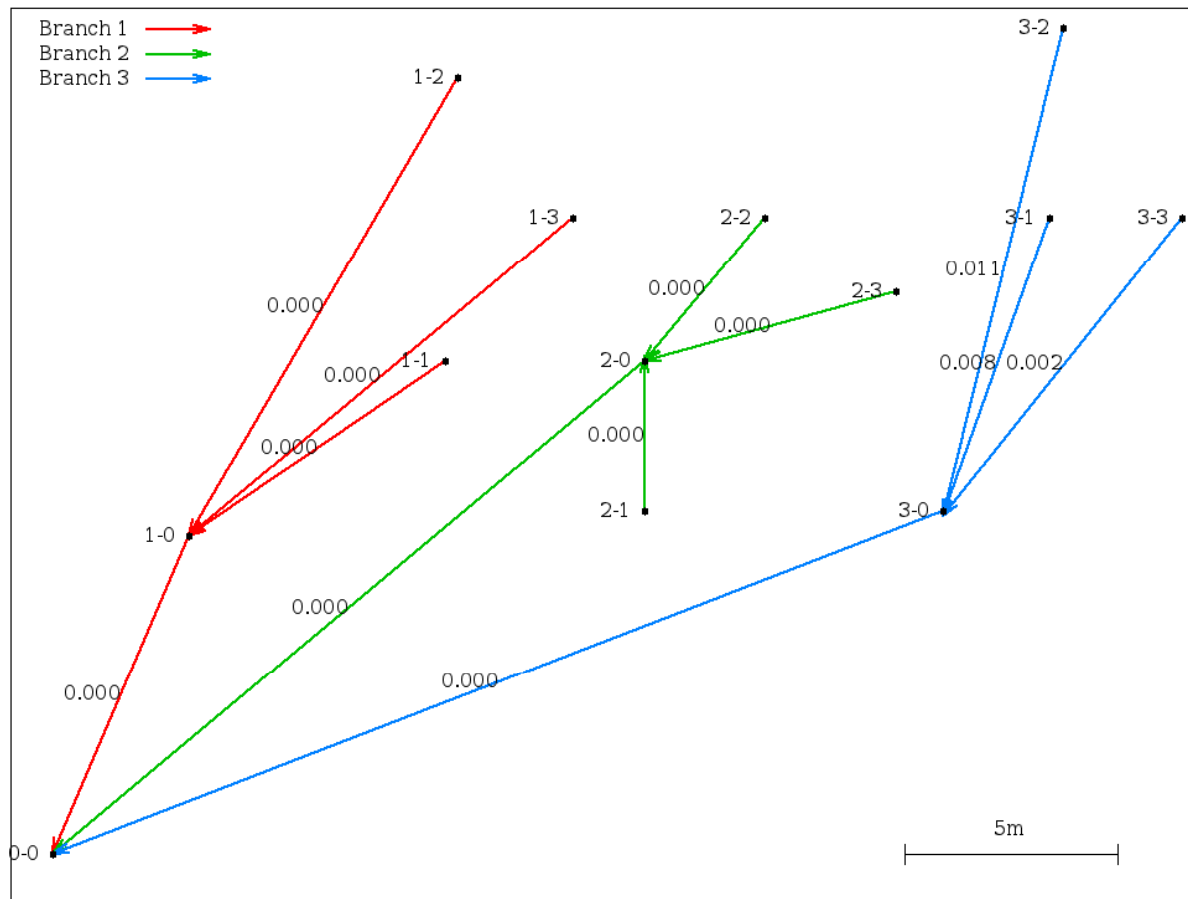
BACKUP SLIDES



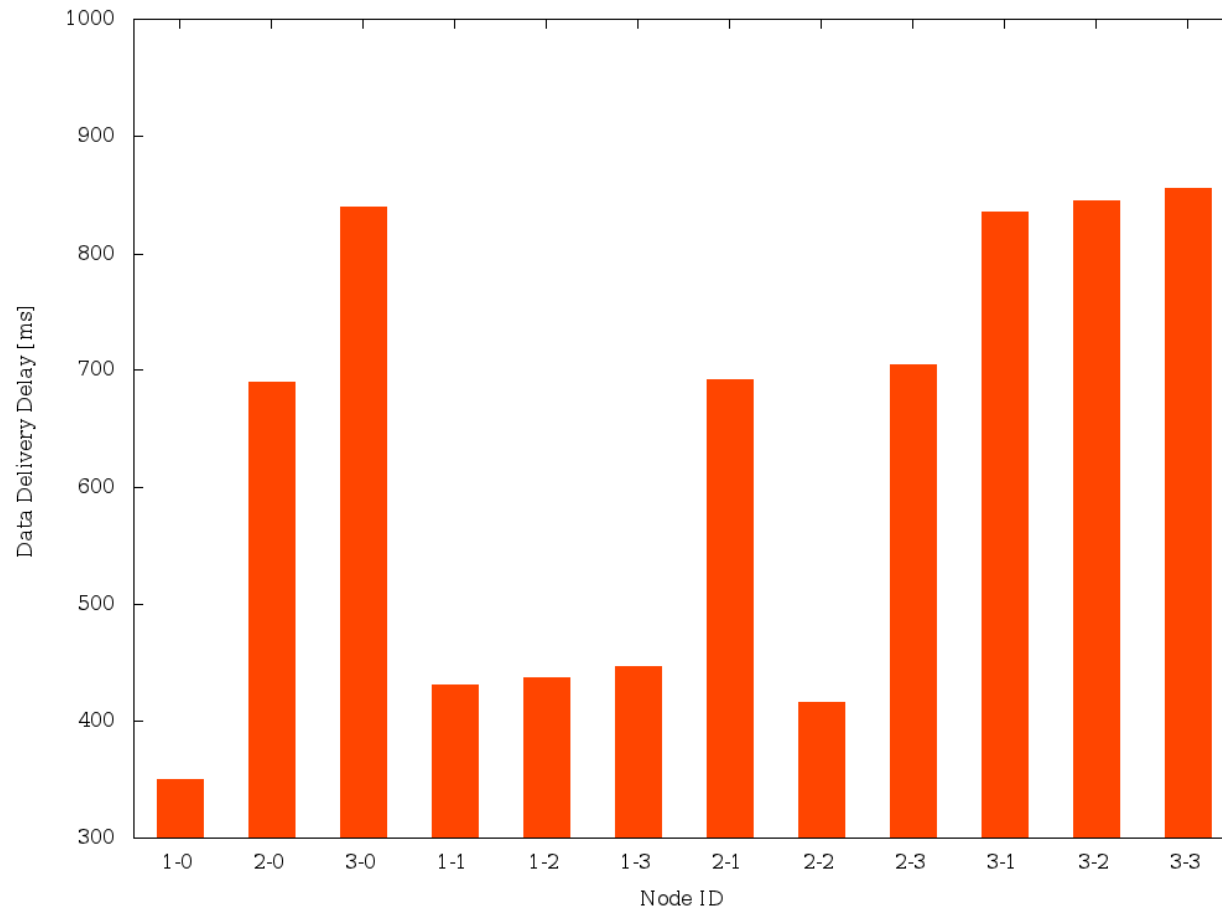
Summary Statistics

- Radio Duty Cycle
 - 1-hop (3.6%); 2-hops (1%)
- Link Quality
 - Best link 0.02% Loss
 - Worst link 1.12% Loss
 - Average link 0.20% Loss
 - 94% of “lost” packets were then successfully retransmitted by GinMAC

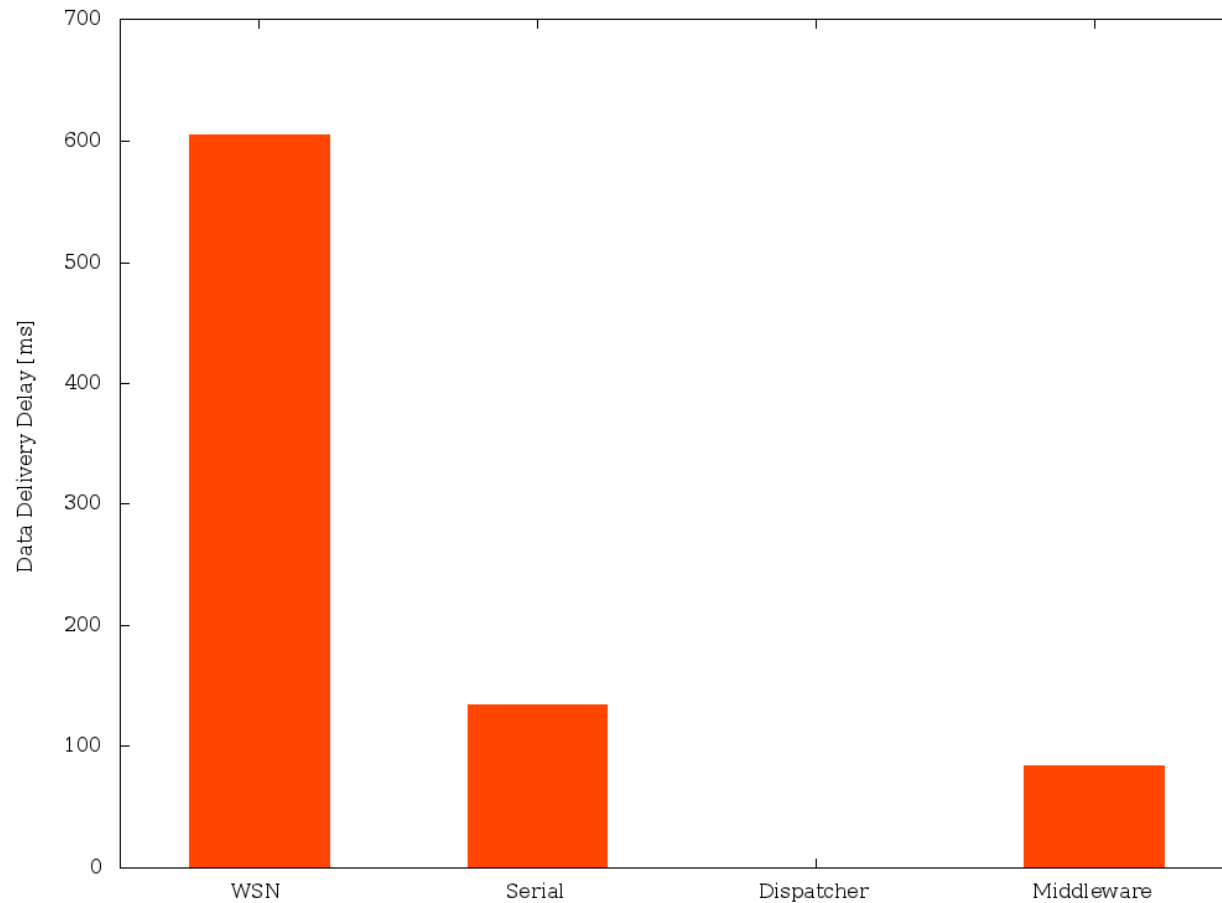
Network Topology (Network 1)



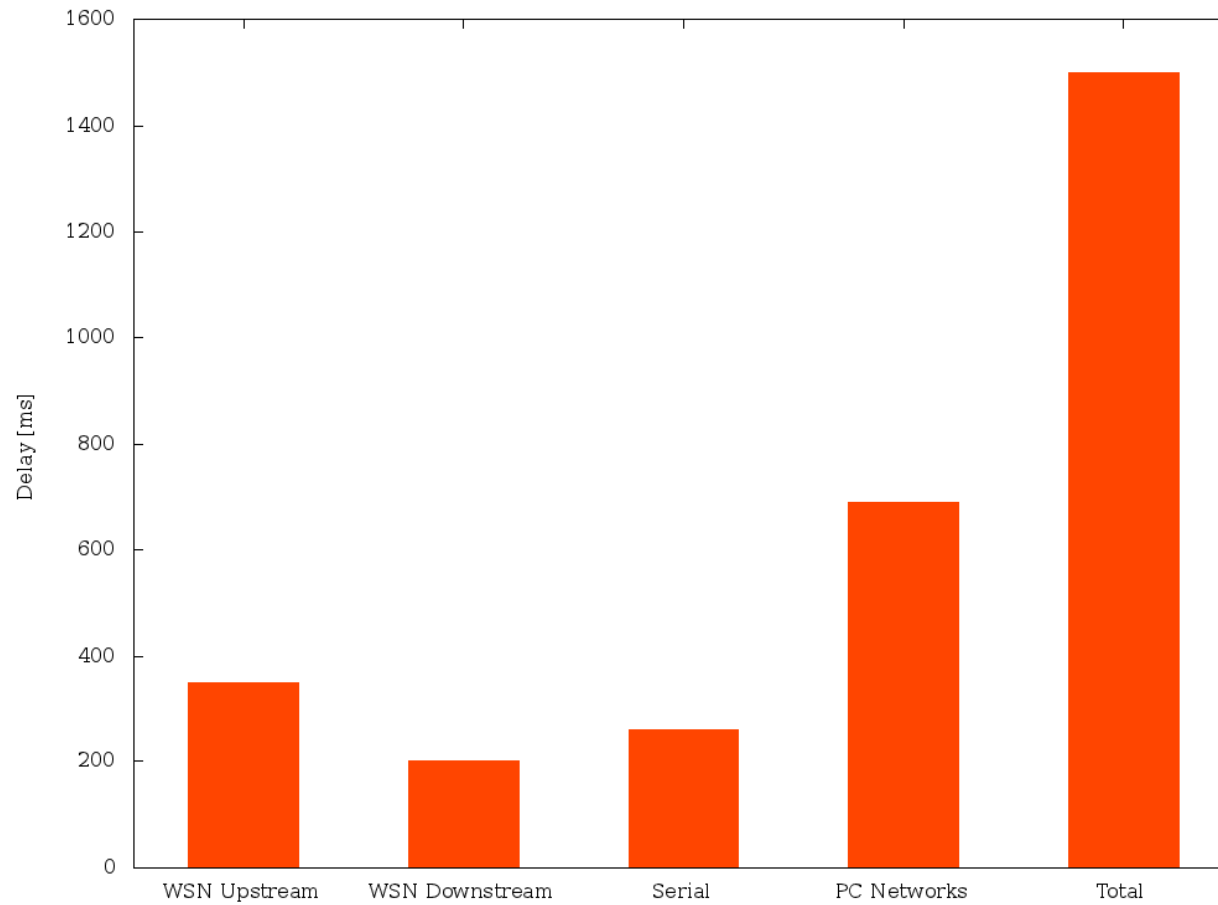
WSN Upstream Delay Summary



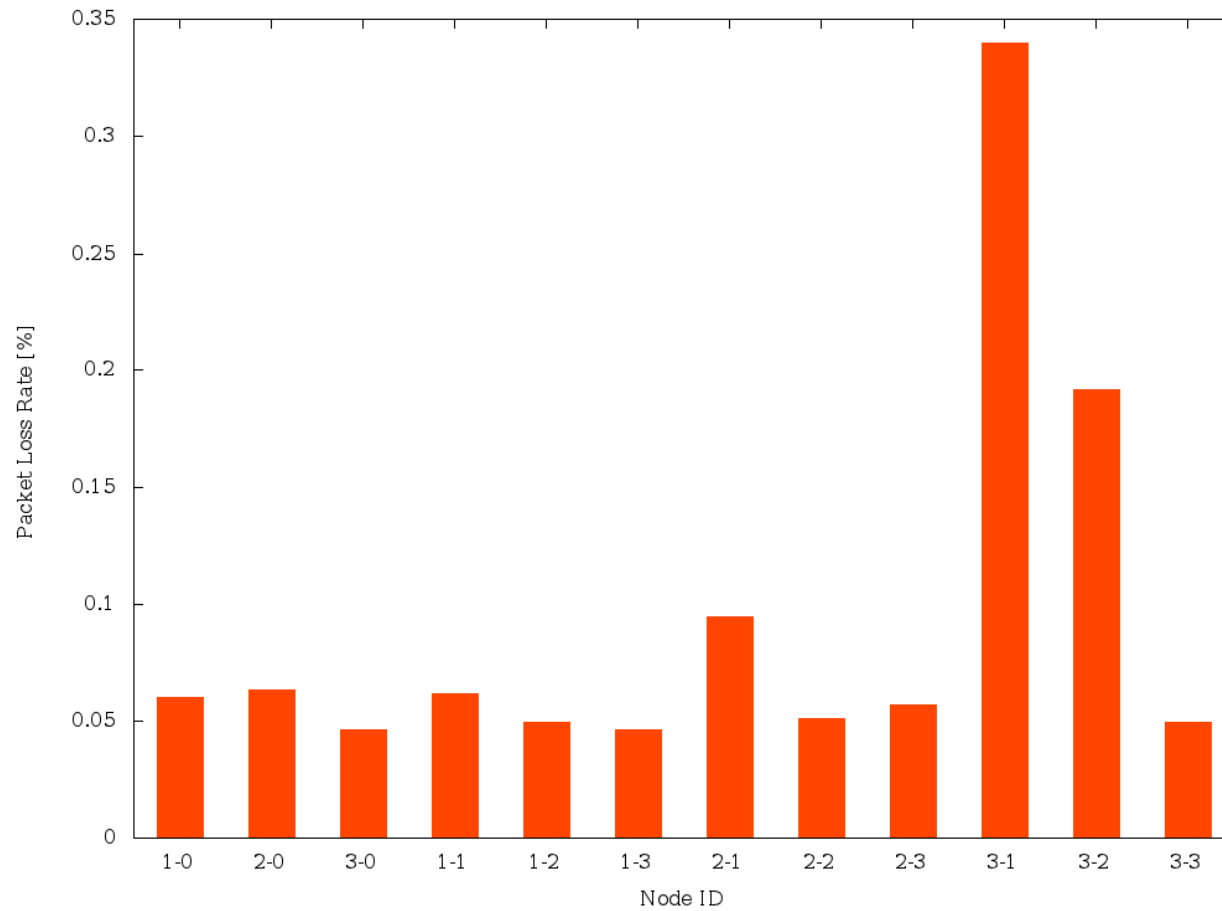
End-to-End Reporting Delays



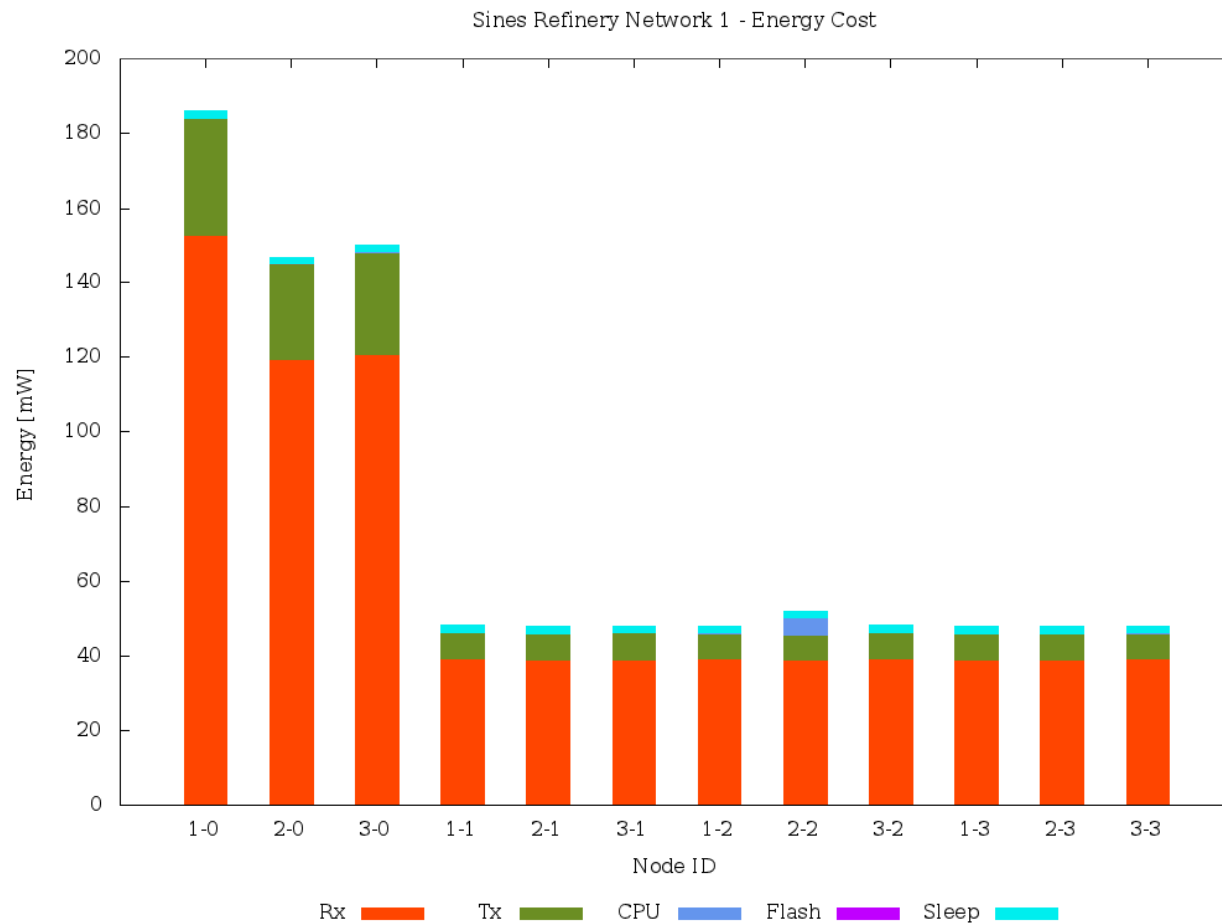
Closed-Loop Delay (Middleware)



WSN Loss Per Node



Node Energy Usage



Node Energy Usage

