

Toward Dependable and Controllable Wireless Networks

Saurabh Bagchi

Dependable Computing Systems Lab (DCSL)
School of Electrical and Computer Engineering
Purdue University

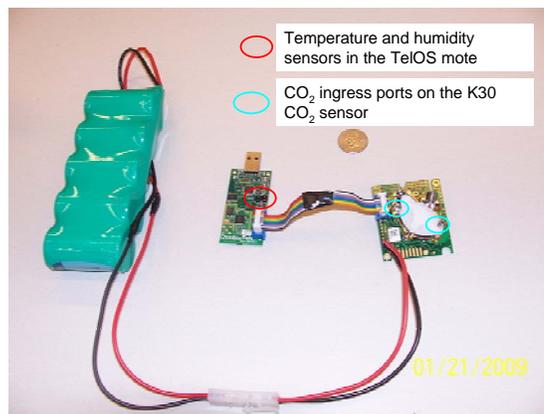


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System Model for Wireless Networks for this Talk

- Ad hoc wireless nodes
- Subset of nodes has sensing capability
- Short-range wireless communication capability
- Sometime placed in hard-to-reach places
- Meant for long time duration of unattended operation
- Nodes can move, but not very frequently



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Reliability Challenge: Detect, Diagnose, and Isolate

- **Problem Statement**
 - Nodes will fail, either transiently or permanently
 - Failure has non-local effects
 - Failure has to be detected quickly
 - Failures can be correlated spatially
 - Failing nodes have to be diagnosed and isolated
 - All this has to be done cheap; primarily, in bandwidth & energy
- **Achievements so far**
 - Tolerate failures through massive redundancy in deployment
 - Example: Directed diffusion for data distribution routing around failures [Govindan-Mobicom00]
 - Handle single (or uncorrelated) failures



Reliability Challenge: Detect, Diagnose, and Isolate

- **Achievements so far**
 - Distributed protocol for local detection
 - Example: Local monitoring [Khalil-DSN05]
 - Distributed protocol for local isolation
- **Research Challenges**
 - Handle failures without taking recourse to heedless redundancy
 - Sparse networks
 - Widely varying densities of nodes
 - Tolerate correlated failures
 - Failures depend on local phenomena and hence are correlated
 - Predictive property may be invoked based on sensed parameters
 - Broaden failure model
 - Not just fail-silent behavior
 - Failure behavior is quite erratic



Security Challenge: There are Spies in our Midst

- **Problem Statement**
 - As wireless networks become more than toys in our hands, the incentive for malicious behavior grows
 - Deal with compromised nodes without human intervention
 - Fast detection and isolation
 - Achieve this when there is no single trusted authority close-by
- **Achievements so far**
 - Efficient cryptographic means for encryption and authentication of unicast, multicast, and broadcast streams; efficient key management protocols
 - Example: Elliptic curve cryptography [Ning-IPSN08]
 - Use cryptographic techniques efficiently to build higher level secure protocols
 - Example: ODSBR secure routing [Curtmola-WiSE02]



Security Challenge: There are Spies in our Midst

- **Achievements so far**
 - (Limited) Handle insider compromised nodes
 - Build distributed reputation system; Reputation built up through direct and indirect observations [Das-SECON06]
 - A node's allowed functionality is determined by its reputation
- **Research Challenges**
 - Handle better the case of insider compromised nodes
 - Suppress false reputation reports
 - Sophisticated colluding adversaries, mobile adversaries, initial deployment in hostile environment
 - Build higher level primitives based on distributed reputation
 - Reason securely from low-level events to high-level knowledge
 - Assign trust measure to information from a node
 - Correlate information from multiple nodes suppressing erroneous reports
 - Reason to generate high-level actionable knowledge



Controllable Wireless Network

- **Problem Statement**
 - Sensing and actuating devices are connected over a wireless communication network
 - Controlling physical processes requires some flavor of real-time support
 - Perform resource management at each layer of the wireless network stack so that such guarantees can be met
- **Achievements so far**
 - Protocols that optimize for delay
 - Adapt to different delay requirements, at each hop
 - Protocols to re-program and re-task a wireless network
- **Research Challenges**
 - Some delay guarantees need to be given
 - All layers need to work together to provide these guarantees
 - Local control decisions should provide end-to-end guarantees

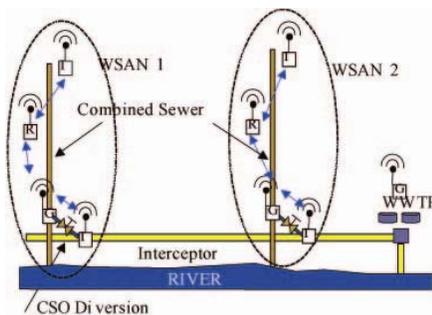


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Application Scenarios to Showcase your Protocols

- **Research Guideline**
 - Find some specific application that can benefit from your protocol
 - Domain-specific challenges of the application will spur technical innovation
- **Personal Experience: Indiana 21st Century project for wireless sensor actuator network to control waste water flows**



J. Koo, R. K. Panta, S. Bagchi, L. Montestrucque, "A Tale of Two Synchronizing Clocks," To Appear in Sensys, Nov 4-6, 2009.



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