

Topic 06: Sensor Networks: Myth versus Reality

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ICTP-ITU School on Wireless Networking for
Scientific Applications in Developing Countries

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Sensor Network Protocol Design

1. Protocol design depends on **application needs**
 - Consider these during the design
2. Wide variety of simplifying **design choices**
 - Explore all design choices

Dependence on Application Requirements (1 of 6)

- **What to sense?**
 - What phenomenon? What sensor?
 - Decides the power consumption of the sensor
 - Wide range possible
 - E.g. Humidity: 6.5 nAH, Thermistor: 0.35 pico-AH
 - Compare: Packet-Tx: 20 nAH
 - (Numbers from GDI paper, WSNA'02)
 - Other examples: accelerometers for low frequency, today's precision pollution sensors

How does it compare with radio power consumption?

Dependence on Appln. Reqmts. (2 of 6)

- **What is the nature of the expected traffic?**
 - How often to sense?
 - GDI: once in five minutes
 - Industrial motor monitoring: once a day at 50-100Hz
 - How often to **send** the data to a sink?
 - Bridge monitoring: once in a few days is alright
 - Volcano monitoring: online collection useful
 - What is the **quantity** of data?
 - GDI: few bytes per 5 min
 - Volcano monitoring: a few MB per quake sample
 - What is the nature of data **fidelity** requirement?
 - GDI, Redwood: alright to lose a few samples
 - Bridge, volcano monitoring: all samples crucial for data analysis

**MAC, routing,
transport
design depend
on this**

Dependence on Application Requirements (3 of 6)

- **Nature of topology**

- How many nodes?

- Volcano monitoring: 16 nodes
- GDI, Redwood, Industrial monitoring: few tens
- Bridge monitoring: 100-200 imaginable

- Over what region?

- Industrial monitoring: indoor, few rooms
- GDI, Redwood: outdoor environment, foliage
- Bridge monitoring: outdoor, many LOS links
- Volcano monitoring: mostly LOS links

**How many hops?
What is the
nature of link
behaviour?**

Dependence on Application Requirements (4 of 6)

- **Can sensors operate independently or is global coordination required?**
 - Not all applications require global coordination!
 - Redwood deployment: collected data at the end
 - Pollution monitoring:
 - Each node can collect data independently and store
 - To be retrieved later
 - Bridge monitoring:
 - Only data from within a bridge span is correlated

Dependence on Application Requirements (5 of 6)

- **How long should it run?**
 - Some applications may have short term usage
 - E.g. short term analysis of bridge's health
- **Is form factor a constraint?**
 - If not, large batteries, high-gain antennas can be used
- **Is cost a constraint?**
 - If not, GPS for synchronization, more powerful nodes
- **Is power a constraint?**
 - In some settings, esp. indoors, power may not be a factor at least for some nodes

Dependence on Application Requirements (6 of 6)

- **Is time synchronization required? At what granularity?**
 - Will decide the complexity of the **synchronization** protocol
- **Is location information required? At what granularity?**
 - No clear statement has been made thus far for any real application (to my knowledge)
- **Is mobility required?**
 - Few real applications have demonstrated a need

Design Choices (1 of 3)

- **Wired sensor networks**
 - Viable option in some cases
 - If wireless, need to be clear on reasons
- **Connection to power outlet**
 - May be possible at least for a subset of the nodes indoors
- **Large batteries**
 - When form factor is not a constraint
 - Can side-step several issues arising from lack of power

Design Choices (2 of 3)

- **Some nodes with far greater power, CPU, memory**
 - Imaginable in most situations
 - Many application deployments have used this approach
- **Directional antennas**
 - Increase range, reduce number of hops
 - Perhaps a single hop network!
 - Many application deployments have used this
- **GPS at some locations**
 - Time synchronization issues side-stepped

Design Choices (3 of 3)

- **Centralized design/algorithms**
 - Single sink => single point of failure anyway
 - Scaling to a few hundred nodes should not be a big issue
- **Multiple channels, multiple radios**
 - If interference an issue, use multiple channels & radios
 - 802.15.4 has 16 channels at 2.4 GHz
- **Planned deployment instead of ad-hoc**
 - Many deployments planned anyway
 - Planned => avoid unnecessary complexity

A Critique of Sensor “Networks”

1. Protocol design depends on **application needs**
 - But protocol papers have **little/no description** of appln.
2. Wide variety of simplifying **design choices**
 - But **narrow set** of design choices actually considered
3. Evaluation results will depend on **parameters**
 - But evaluation parameters typically **not justified**
4. Networking issues should emerge from **real applns.**
 - Very **few issues articulated** thus far

Whither Sensor Networks?

- **Application driven design** required
 - Some applications have been deployed
 - But no application paper talks about any serious networking problem in-depth
 - Amount of work in protocol design: disproportionately huge!
 - **Main flaw:** looking for general solution to begin with!
- Alternative: **bottom-up** approach
 - Specific solution-1, specific solution-2, ...
 - Then look for generality from specific solutions