Implementation and Experimentation of Industrial Wireless Sensor-Actuator Network Protocols

Mo Sha, Dolvara Gunatilaka, Chengjie Wu, Chenyang Lu
Cyber-Physical Systems Laboratory
Department of Computer Science and Engineering
WSANs

- Wireless sensor-actuator networks (WSANs) has been adopted by process industries.
- Different from traditional WSNs with best effort services
  - Strict timing requirement
  - Highly reliable communication

Courtesy: Emerson Process Management
WirelessHART

- Industrial WSAN standard for process monitoring and control
- IEEE 802.15.4 physical layer
- Multi-channel TDMA MAC layer
- Support source and graph routing
- Centralized network manager
  - Collect topology
  - Generate routes
  - Generate transmission schedule
  - Disseminate schedule
Open Challenges

➢ Abundant theoretical results on industrial WSANs


➢ Scarce experimental research on industrial WSANs.

➢ Lack of open-source implementation of industrial WSANs.
Protocol Implementation

- TinyOS 2.1.2 on CC2420X radio stack

- Multi-channel TDMA MAC
  - 10 ms time slot
  - 2 ms at the beginning of the slot for time sync error and channel switching delay
Protocol Implementation

- Field devices are synchronized using FTSP during Sync period
  - >95% of devices can be synchronized with errors less than 2ms
  - 60-node testbed with network diameter = 4

- CCA Interface to support dedicated and shared slot
  - Dedicated slot - one transmission per channel
  - Shared slot - multiple transmissions contend for a channel

- Single-path source routing and multi-path graph routing.

- ~19 KB ROM and ~1.6 KB RAM
Experimental Routing Study

- Evaluated on a 60-node testbed.
- Graph routing is more resilient to noise at the cost of latency and energy.
Conclusion

- Industrial WSAN is an important area of research.
  - Killer app of sensor networks!
  - Yet scarce experimental research!

- We implemented WirelessHART protocols in TinyOS.
  - Enabler of experimental research on industrial WSANs.

- Experimental routing study on a 60-node testbed.

- Source code will be released soon!

http://cps.cse.wustl.edu