Title
SYS1: Avrora: Scalable Sensor Network Simulation with Precise Timing

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Avrora: Scalable Simulation of Sensor Networks with Precise Timing

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Introduction: Sensor networks are hard to develop and test

- Debugging microcontroller programs is hard
  - Narrow debugging interface to hardware
    - Interface to chip is narrow and does not allow complex interaction with the executing program in real time
    - Presence of debugging code influences results
  - Intricate, low-level code
    - Driver code for various hardware sensors and communications devices
  - Subtle timing interactions
  - Longer development cycles due to reprogramming

- Distributed network behavior
  - Behavior of code depends on environment
    - Can depend on input to sensors and communication with outside world
  - Distributed, multi-hop communications
    - Routing algorithms
    - Data mining
  - Detailed network monitoring difficult
    - Lots of sensors, lots of communication
    - Microsecond level phenomenon
    - Complex interactions

Problem Description: Accurate simulation of sensor programs requires precise timing

High Accuracy needed

- Cycle-level phenomenon
  - Software control of radio hardware device
  - Sleep behavior, interrupt behavior
  - Measure time-dependent quantities such as channel utilization, access latency
- Previous approaches don’t scale well
  - Synchronization of nodes every clock cycle
  - Each device simulated adds work every clock cycle
  - Poor performance for large networks

Proposed Solution: Efficient, parallel, cycle-accurate simulation with Avrora

Parallel machine-code simulation

- Map one thread per node
  - Allows parallelism in simulation
- Synchronization Interval approach
  - Periodically synchronize threads to preserve order and timing of communications
- Wait For Neighbors approach
  - Node waits for all neighbors that can influence its operation to pass a specific point in global simulation time

Results

- Cycle-accurate AVR simulator
  - Efficient execution of program code
  - Accurate timing of program interaction with devices
- Device and Radio simulation
  - Timers, UART, SPI, CC1000
  - Important for correct program simulation
- Whole network simulation
  - Nodes sense, compute, and communicate, with full monitoring capabilities
- Profiling and Monitoring
  - Flexible extension points allow for detailed monitoring of program execution without changes to simulator

Avrora allows sophisticated program profiling to be performed during simulation without loss of precision, and with fully cycle-accurate results.

Simulator comparison

Performance

- Avrora
  - Better than other simulators
  - Scalable and flexible

Simulation

- Avrora
  - Better than other simulators
  - Scalable and flexible

Channel Utilization

- Avrora
  - Better than other simulators
  - Scalable and flexible

Number of Nodes

- Avrora
  - Better than other simulators
  - Scalable and flexible