Context-based simulator for sensor networks in domestic environments

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Outline

- Introduction
  - Smart homes
  - Types of sensors
- Wireless Sensor Networks
  - UC Berkeley motes and TinyOS
- Simulating sensors
  - Based on high-level description of scenarios
  - Implementation example: TinyOS motes

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Smart Homes

- Augment home with sensors
  - Support individuals with health problems
    - Elderly living alone at home
    - Patients with heart condition
  - Improve lifestyle
    - Smart fridge keeps track of items in fridge
    - Smart phones ring only in room where addressee is present

Types of sensors

- Video cameras
- Location
- Light
- Sound
- Temperature, humidity
- Pressure
- Motion detection
- Acceleration

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Wireless sensor nodes

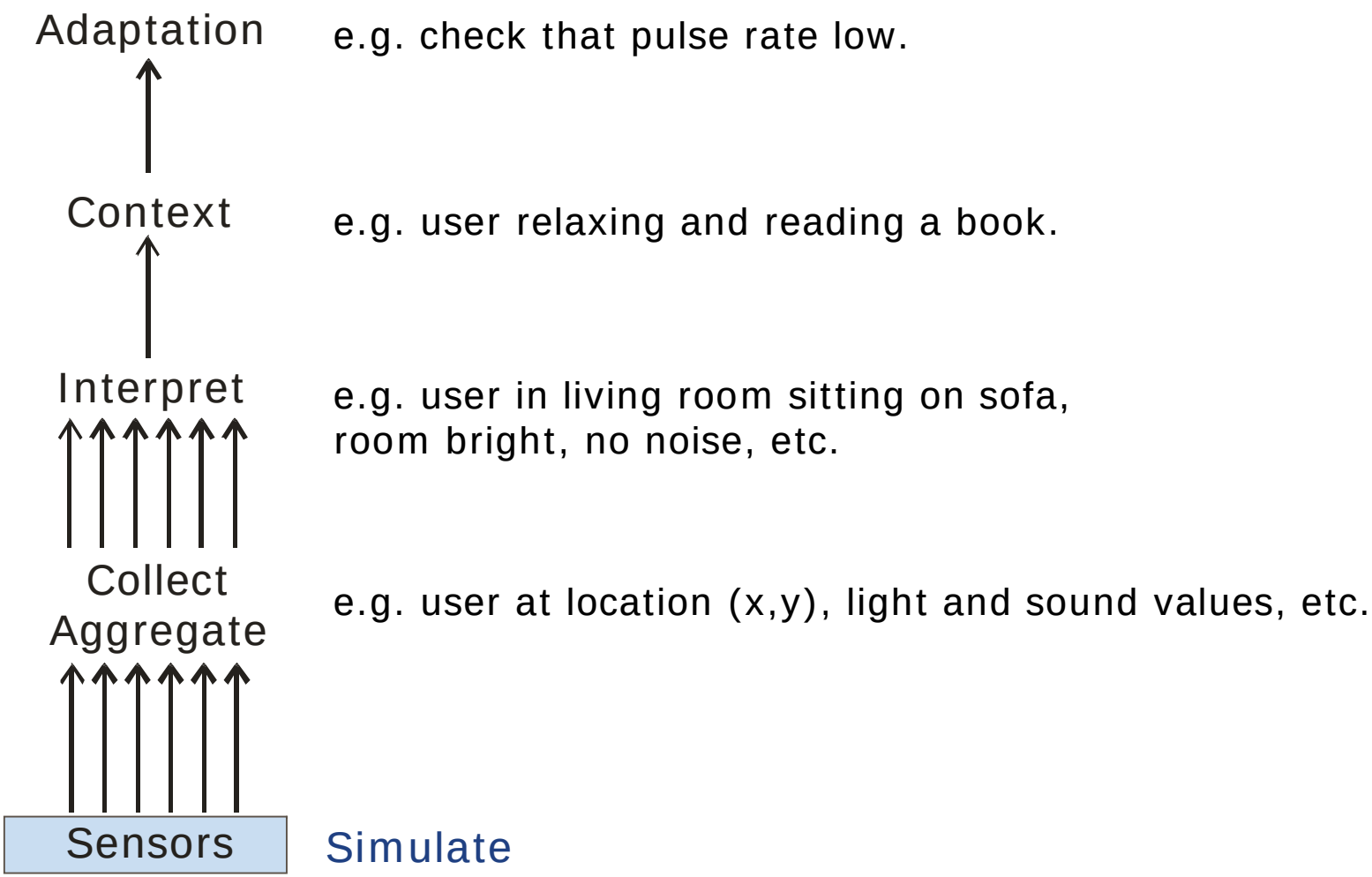
Wireless sensor nodes

- Resource-constrained devices with
  - Processor
  - RAM, EEPROM
  - Radio transmitter/receiver
  - ADC and DIO ports for sensors
  - Battery with limited power

Wireless sensor nodes: Example

- UC Berkeley mote (MICA2)
  - Processor: 8bit 20MHz microcontroller
  - Program flash memory: 128KB
  - RAM: 512KB
  - EEPROM: 4KB
  - Radio: ISM Bands, ~40Kbps
  - 10 bit ADC ports + DIO
  - Battery life depends mainly on communication

Using sensor data in context-aware applications



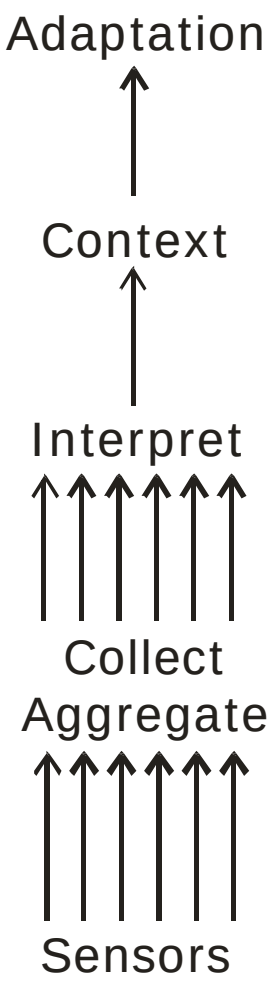
Why simulate?

- Controlled environment with reproducible sensor data.
- Physical limitations of available space and sensors (cost).
- Testing context-aware application with real-life sensor data is tedious.

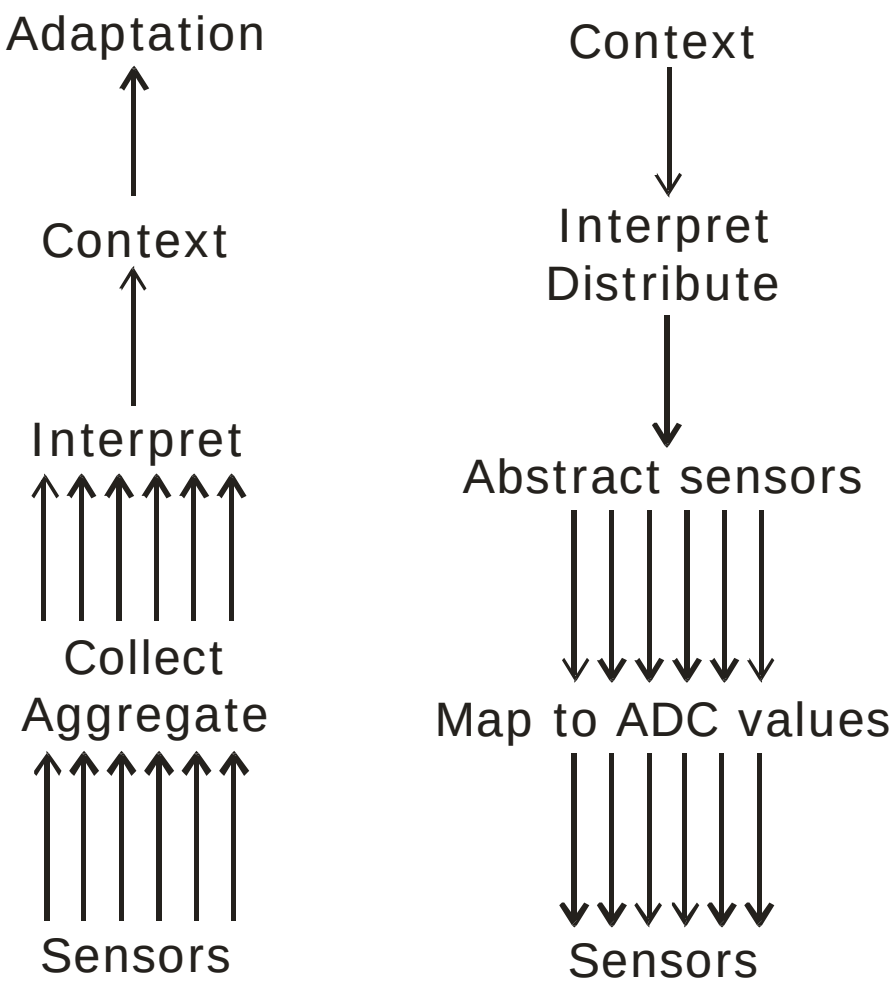
Goals of simulation

- Produce “virtual” sensor data such that application logic can be adequately tested.
- Simulator invisible to application.
  - Application can run on simulator without modifications.
- Simulator configuration input are high-level.
  - People’s activities (context).

Simulating data from context



Simulating data from context



e.g. user relaxing and reading a book.

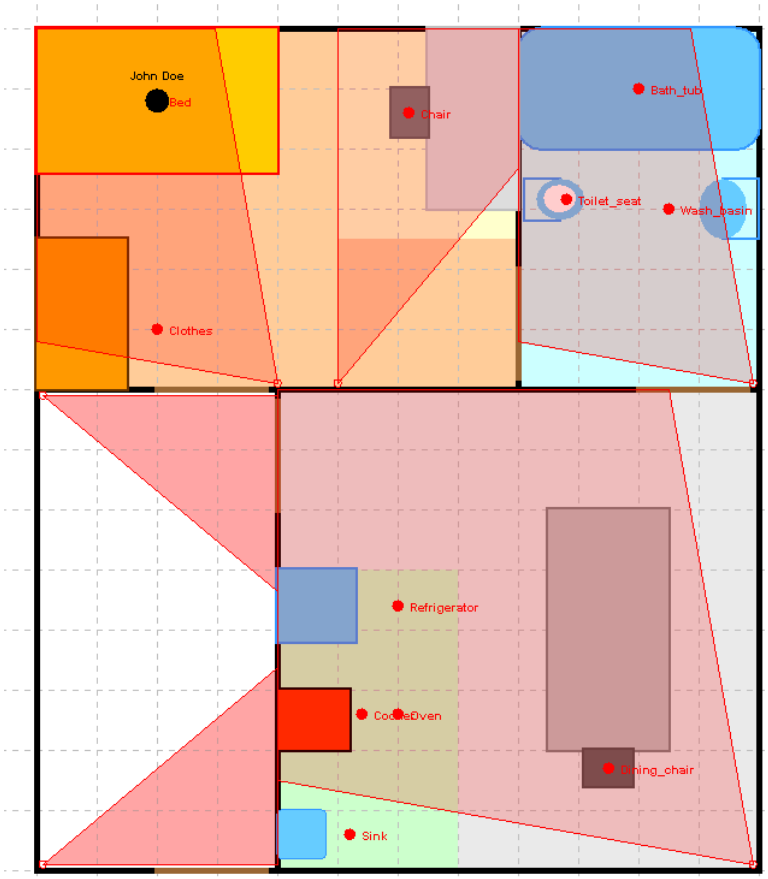
e.g. user in living room sitting on sofa, room bright, no noise, etc.

e.g. pressure on sofa pressure sensors in Newton, quiet noise level

e.g. 10-bit values on ADC ports of motes

How simulate

- Separate home topology from activity scenarios



John Doe
- Sleep
- Get up
- Brush teeth
- Get Dressed
- …

Allows people's activities scenarios to be executed on different home topologies

Home topology

- 2D map with
  - Walls/doors
    - Determine valid paths of people
    - Affect detection range of sensors
  - Sensors
    - Detect people, e.g. motion detection, sound, pressure sensors in chairs/bed.
    - Environment
  - Rooms
    - Areas with a context, e.g. bedroom, bathroom
  - Hotspots
    - Locations where activities take place.

Activities description

- Defines people
- Defines their activities
  - Each activity takes place at a Hotspot
    - Hotspot is only a well-defined location given an instance of a home topology
    - An activity usually has a default hotspot, e.g. “Brushing teeth” takes place at wash basin in bathroom
  - Executing an activity causes the person to move from the previous Hotspot to current Hotspot
  - Activity has duration
  - Activity determines sensor data produced

Sensor data

- Sensors produce data knowing
  - Complete home topology
  - Complete schedule of activities of people
  - Current location of people in home
    - A location also has a context, e.g. bedroom
  - Current activity of people
    - Hotspot location
    - Duration of activity

Implementation example

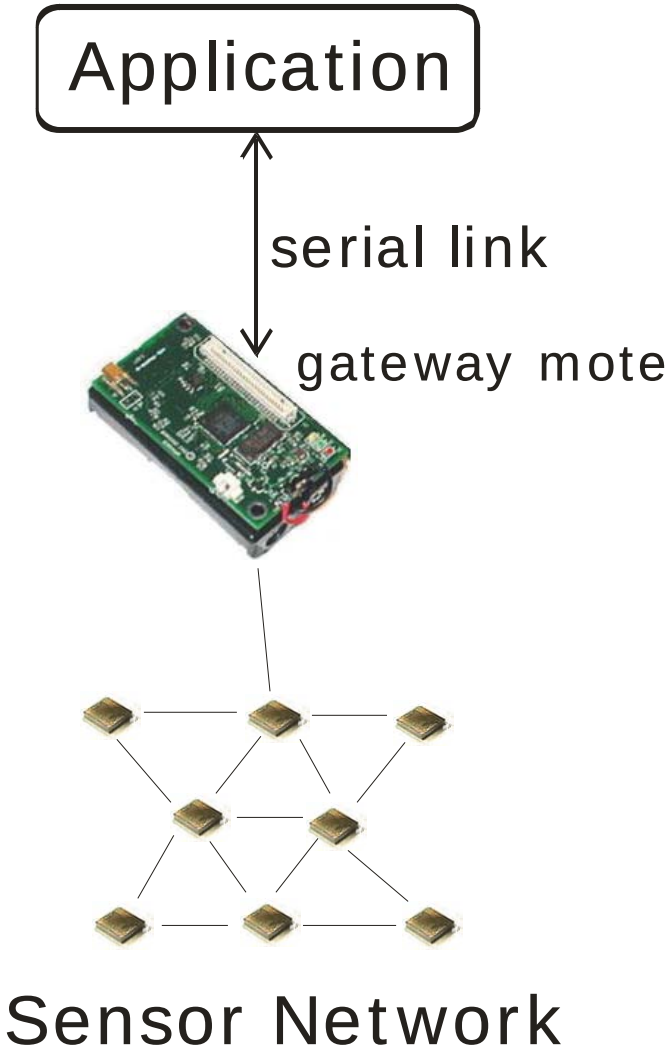
- UC Berkeley motes
  - Support most types of sensors
  - Run TinyOS (component-based application programming environment)
  - TinyOS Simulator: TOSSIM

TOSSIM

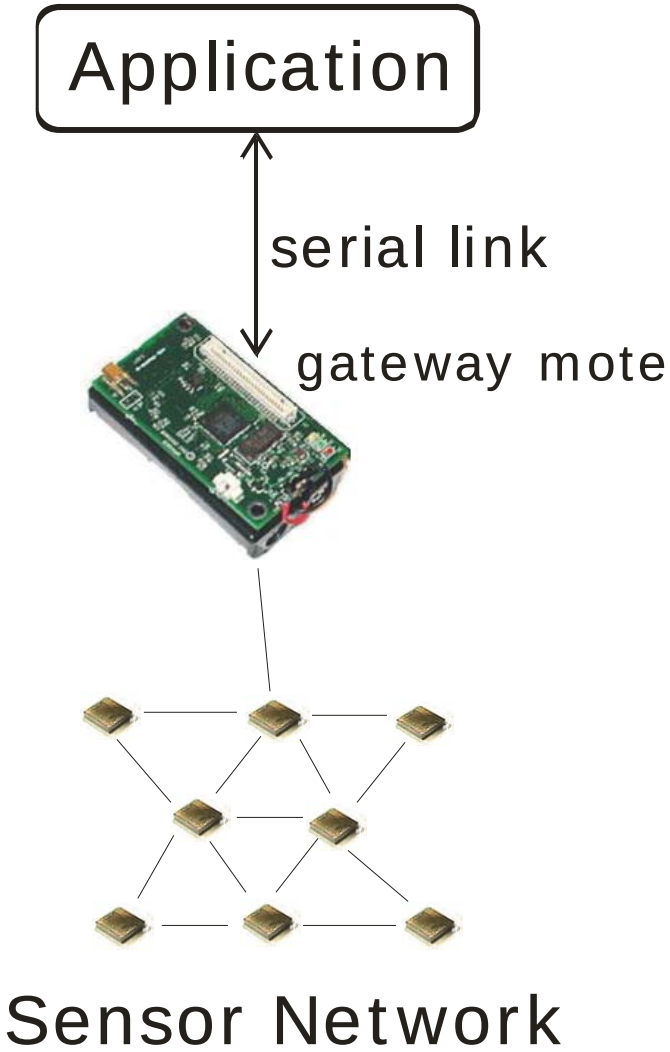
- Simulates a network of motes
- Bit-level simulation of motes' operation and communication
- ✘ Too low-level to implement activities scenarios

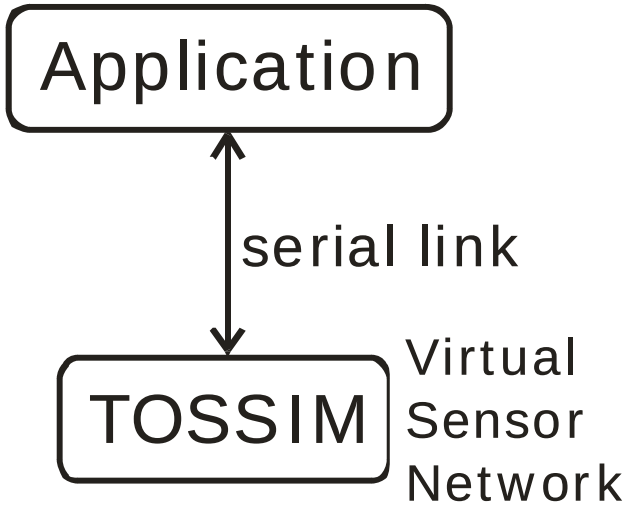
- ✓ TOSSIM execution can be "steered" by an external application

Motes

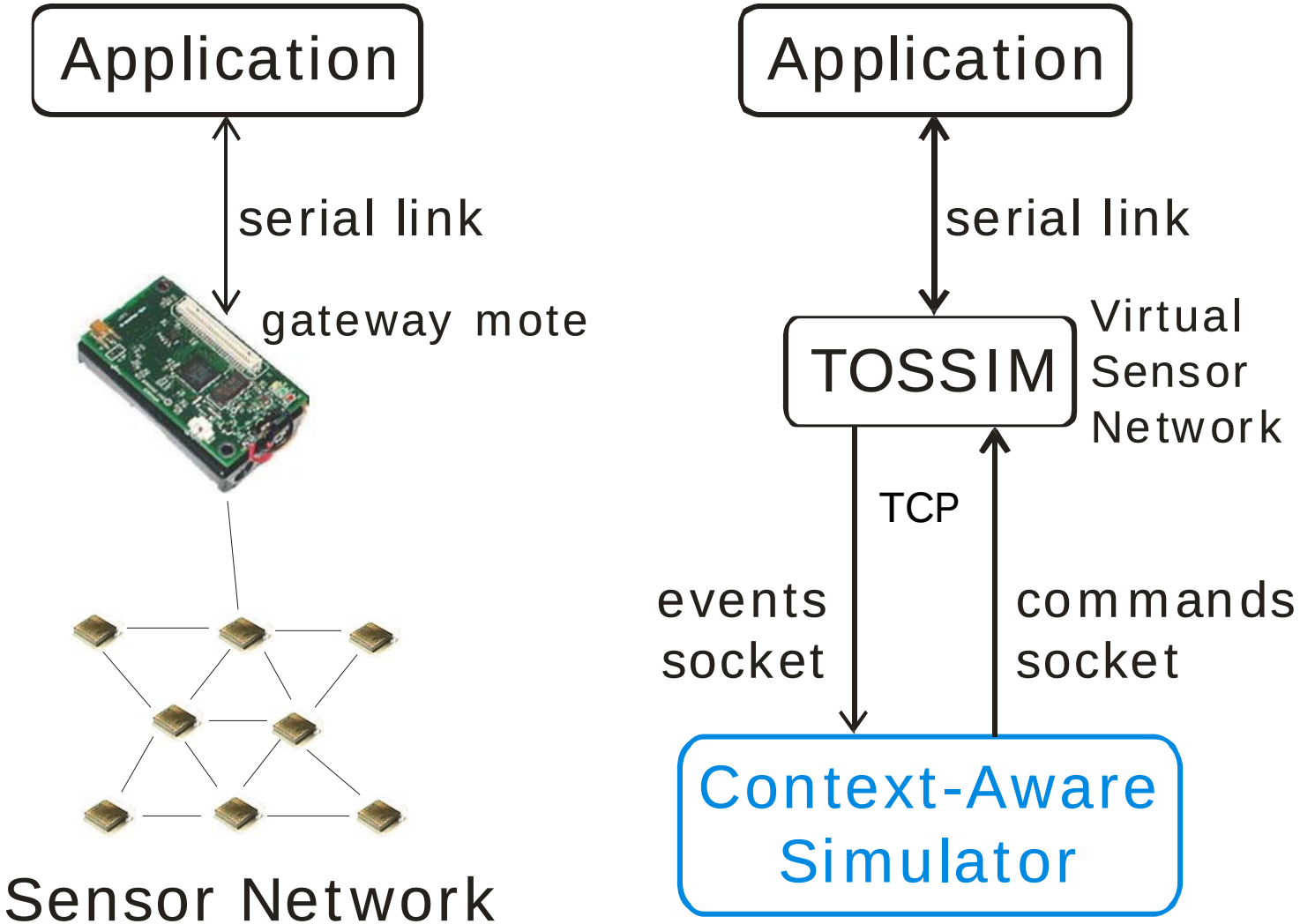


TOSSIM


Application
serial link
gateway mote
Sensor Network


Application
serial link
TOSSIM
Virtual
Sensor
Network

Context-level simulation



TOSSIM ports

- Event port
  - Notifies external app of execution events
- Command port
  - Set sensor data read on motes
  - Change location of sensors
  - Activate/Deactivate motes (simulate failures/upgrades)

Conclusions

- Need to simulate sensor data involved in smart home scenarios
- Existing simulators too low-level
- Our simulation framework allows configuration at activity context level
- TinyOS example: simulator invisible to application

The End