

# On Sensor Data Simulation

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28th September 2009, Timișoara

# Agenda

Introduction

DS3 household sensors

DS3 implementation

Closure

## Introduction

DS3 household sensors

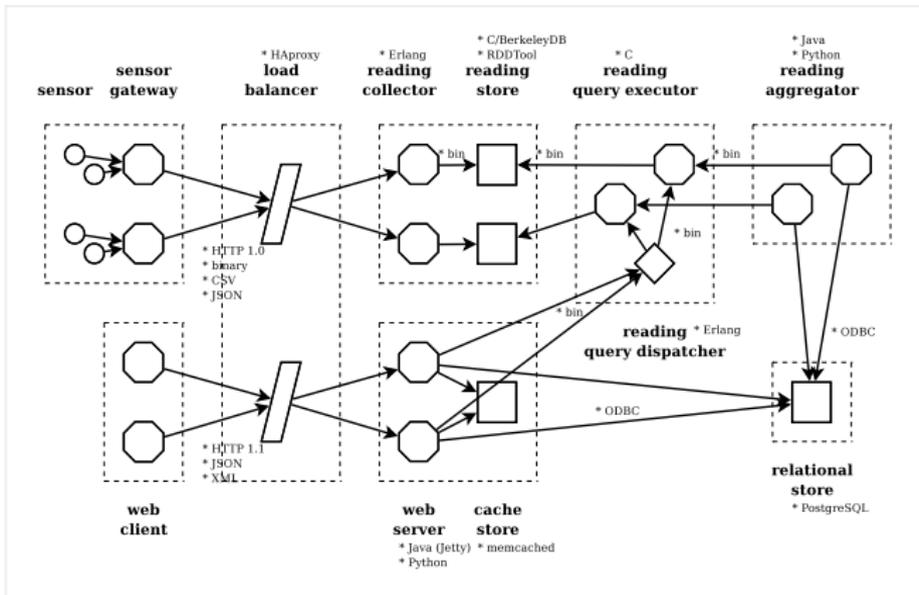
DS3 implementation

Closure

# DEHEMS objectives

- ▶ **DEHEMS** – *Digital Environmental Home Energy Management System*
- ▶ moves from energy usage monitoring
- ▶ towards **energy performance models**
  - ▶ not how much energy are you consuming!
  - ▶ but **how efficiently** are you using it?
  - ▶ what could you do to **enhance the performance**?
- ▶ thus **changing users behaviour** related to energy consumption

# DEHEMS architecture



# DS3 – DEHEMS Sensor Simulation System motivation

- ▶ in the context of the **DEHEMS** project
- ▶ we needed a **data generation tool** to
  - ▶ test and tune sensor readings storage and querying
  - ▶ (initially) replace the need of real world data
  - ▶ demo the platform to potential users
  - ▶ stres-test the entire system

# DS3 alternatives

- ▶ **WSN** – *Wireless Sensor Network* simulators
  - ▶ ns-2
  - ▶ SensorSim
  - ▶ SENS
  - ▶ EmStar
- ▶ but not suited because
  - ▶ they model real-world sensors
  - ▶ by focusing on environment, protocols, or hardware
  - ▶ and providing only low level of abstraction
  - ▶ but are hard to adapt and extend
  - ▶ have configuration and scalability problems (> 10 thousand sensors)
  - ▶ with no orientation towards end-users

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# Real spot energy consumption profile

- ▶ the primary input for the **DEHEMS** system
- ▶ contains data from
  - ▶ one household **energy consumption** sensor
  - ▶ one aggregated **temperature** from multiple sensors
  - ▶ one **gas meter**
  - ▶ and at least 9 **individual appliance** sensors

# Simulated spot energy consumption profile

- ▶ there is need for a high degree of realism
- ▶ must be generated very fast (it's a real-time simulation)
- ▶ it is based on two distinct simulation stages
  - ▶ gross direct simulation
  - ▶ detailed pattern based simulation

# Gross direct simulation (1)

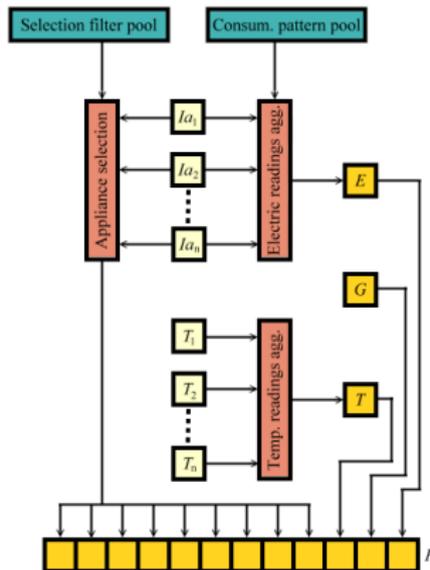
- ▶ for a good approximation of energy use we need
  - ▶ to know **active and standby consumption**
  - ▶ plus active and standby **time intervals**
  - ▶ (or a **mathematical model** for the energy usage)

## Gross direct simulation (2)

Household appliance	Active power (W)	Standby power (W)
Air conditioner	3250	15
Blender	300	0
Color TV	90	20
Computer (laptop)	30	5
Computer (PC)	90	10
Computer speakers	80	10
Economical light bulb	30	0
Electric blanket	300	0
Electric mower	1500	0
Electric fan	200	0
Iron	1000	30
Laser printer	45	10
Microwave	1000	10
Refrigerator	800	0
Standard light bulb	100	0
Toaster	850	0
Vacuum cleaner	730	0
Washing machine	500	0

# Pattern based simulation

- ▶ we require a set of energy consumption patterns
- ▶ and a pool of appliance selection filters



# Simulation output

- ▶ simulated data is encoded using **XML** or **JSON**

```
<msg>

  <date>
    <dsb>00030</dsb> <h>00</h><m>20</m><s>11</s>
  </date>
  <src> <id>00077</id> </src>

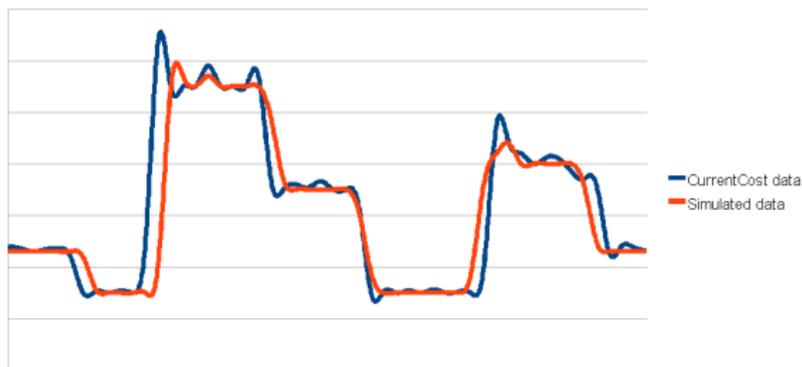
  <gene> <watts>168</watts> </gene>
  <tmpr> <celsius>24.8</celsius> </tmpr>
  <gas> <m3>0.008<m3> </gas>

  <ia1> <watts>46</watts> </ia1>
  ...
  <ia9> <watts>100</watts> </ia9>

</msg>
```

# Quality of simulated data

- ▶ comparison with real-world monitoring system
- ▶ (over a period of 30 minutes)



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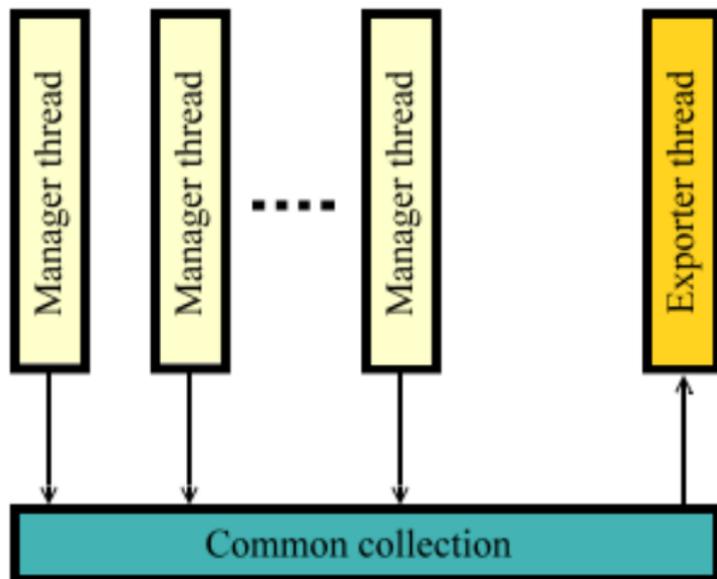
# Simulation approaches

- ▶ one process per sensor, multiple processes per node
- ▶ one thread per sensor, multiple threads per process
- ▶ **EDA** – *Event Driven Architecture* based

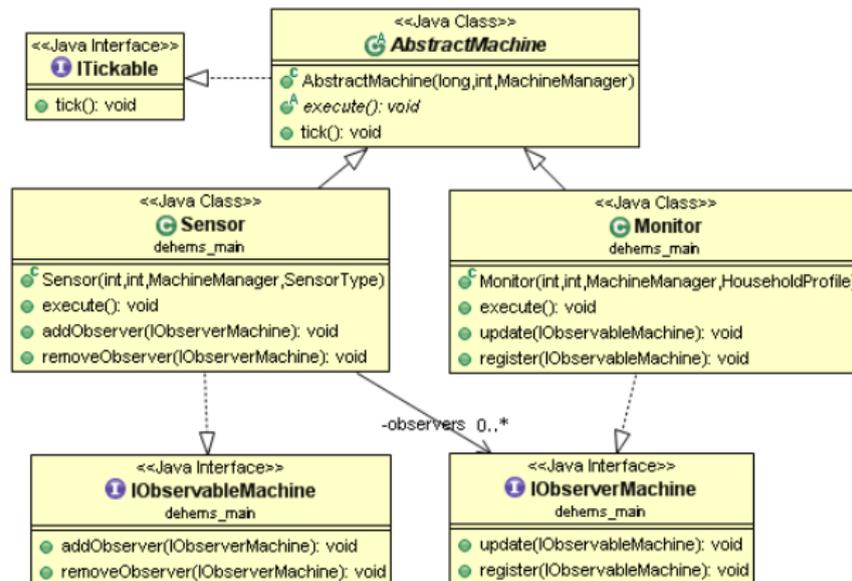
# EDA approach

- ▶ all simulated devices are **passive**
- ▶ and execute **atomic activities**
- ▶ triggered by a **heart-beat**
- ▶ devices are grouped in **pools**
- ▶ and communicate one with another by **message queues**

# Resources



# Light-weight framework



# EDA advantages

- ▶ **adptable** to execution hardware resources (especially CPUs)
- ▶ suitable for **large number** of simulated devices
- ▶ allows replacing simulated devices with real-world devices
- ▶ enables fault tolerance testing

## Performance tests

- ▶ on one node (2.6 GHz dual-core with 2GB RAM)
- ▶ we have simulated about **30 thousand households**
- ▶ each household with an average of 12 sensors
- ▶ (a total of **360 thousand sensors**)
- ▶ at a rate of 10 readings / minute / sensor
- ▶ by using **3 threads** for device simulation

Time interval (seconds)	65	305
Average total inserts	332094.4	1678241.7
Average inserts / second	5109.14	5505.71

Time interval (seconds)	605	1205	3605
Average total inserts	3409745.9	6751796.1	20307480.3
Average inserts / second	5635.94	5603.15	5633.14

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# Achievements

- ▶ developed a **light-weight** framework for sensor simulation
- ▶ allowing the researcher to **focus on high-level behaviour**
- ▶ and enabling **large scale simulations**

# Future work

- ▶ enable simulations to run on multiple nodes
- ▶ implement closer to real-life complicated sensor behaviours
- ▶ automated consumption pattern generation using **GA**
- ▶ use individual appliance consumption profiles
- ▶ add graphical interface to allow the user to define scenarios

# Questions

- ▶ questions?
- ▶ remarks?
- ▶ comments?