Introduction to Home Simulator

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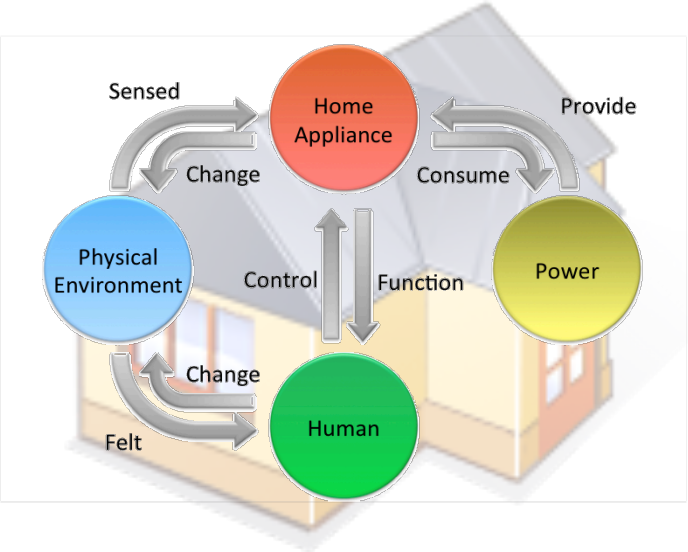
Agenda

- Brief introduction to home simulator
  - Motivation
  - Design
  - Implementation
  - Applications
- Future plan

About home simulator

- Built by Takashi OKADA
  - Ph.D. student(-2011.9)
  - Working at AIST(Advanced Industrial Science and Technology)

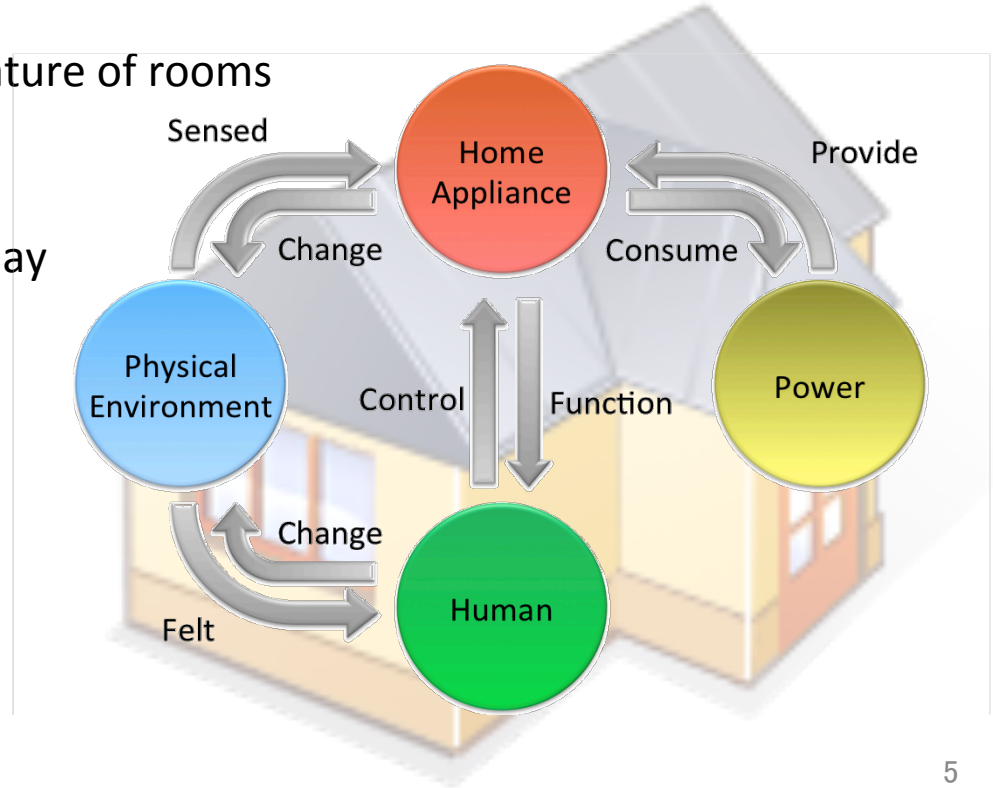


Motivation

- The effectiveness of newly introduced home appliance and services should be proved in advance.
  - Experimental homes are useful
- However…
  - Building experimental homes is expensive
  - It's not clear where the home should be.
  - There are too many home structure and configuration and a few experimental homes are not enough.
  - It is difficult to support newly emerging appliances because we don't know what will be needed at first.
  - The habit of residents vary.
  - The external environment are not stable and repeating same experiment is impossible.
- Realistic home simulator and user modeling
  - Changing parameters such as materials of wall
  - Changing home appliance algorithms
  - Changing life style of residents

Design – Overview

- Home Structure
  - Supporting many kinds of home structure
- Home Appliances and Sensors
  - Supporting realistic home devices
- Physical Environment
  - How to calculate the temperature of rooms
- Power Consumption
- Human Activity
  - What the residents do everyday

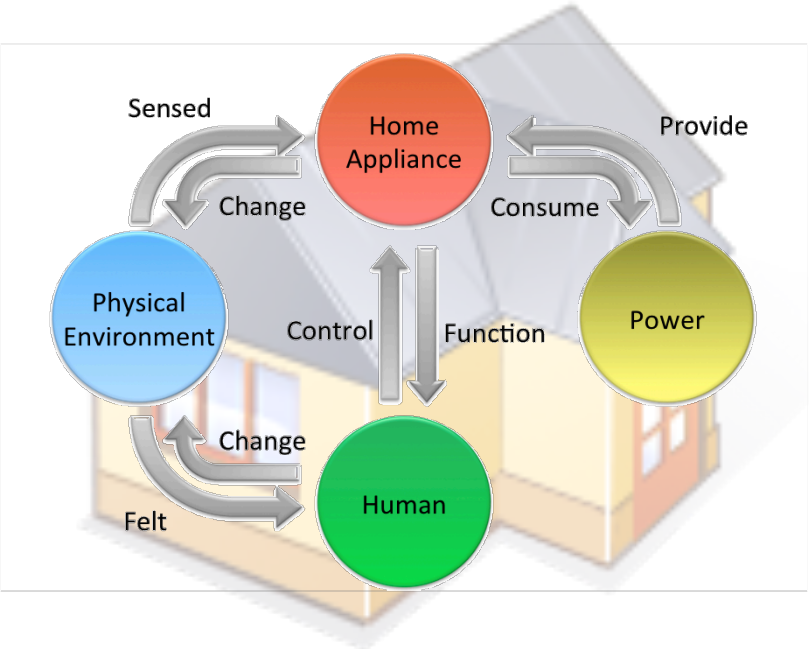


Design - Home structure

- Many parameters should be configurable
  - The connection between rooms
  - Room capacity
  - The material of walls
  - The size of windows
  - The size of doors

Design - Home appliance

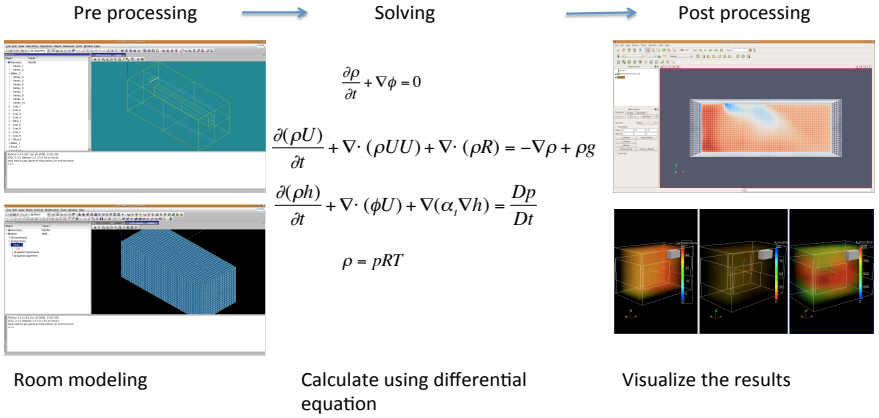
- Many appliances are emulated now.
  - Home Air Conditioner
  - Refrigerator
  - TV
  - Lighting
  - Context-aware devices
    - Motion sensor
    - Ambient Light Sensor

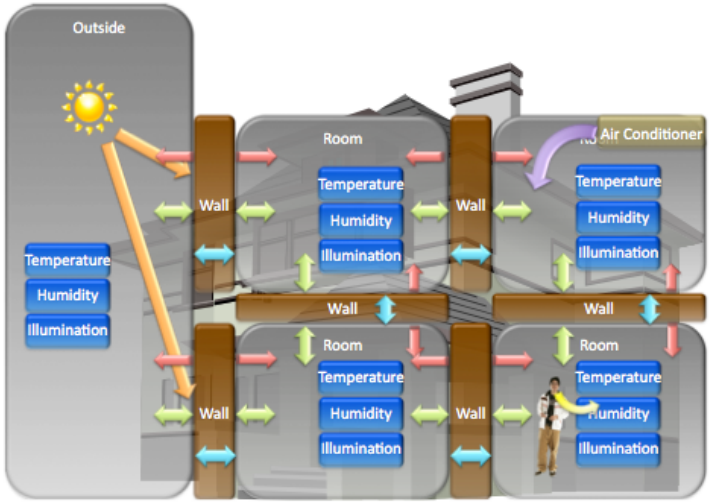


- ECHONET based interface is used.
  - ISO/IEC standard

Design – Physical Environment

- Temperature, humidity and illuminance of rooms
  - Emulated sensors measure the values
- Calculation methods
  - Computational Fluid Dynamics
    - Used to simulate TANS2 and it takes time too much
  - Thermal resistance
    - Graphs of rooms and walls as capacitors and resistances
    - Implemented in the home simulator



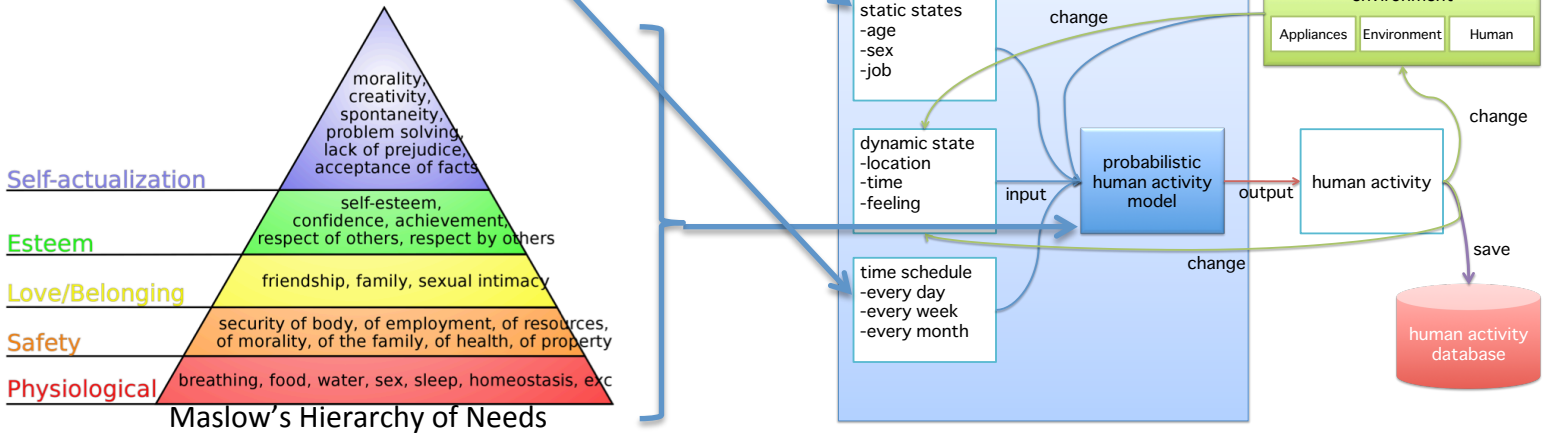


Design – Power Consumption

- Home appliances consume electric energy to work
  - Usually the algorithm of appliances are black-box
  - Modeling Air Conditioners is very difficult
    - Mathematical solving
      - Multiple Regression Analysis
    - Measuring the power consumption of real air conditioners and use it as the model

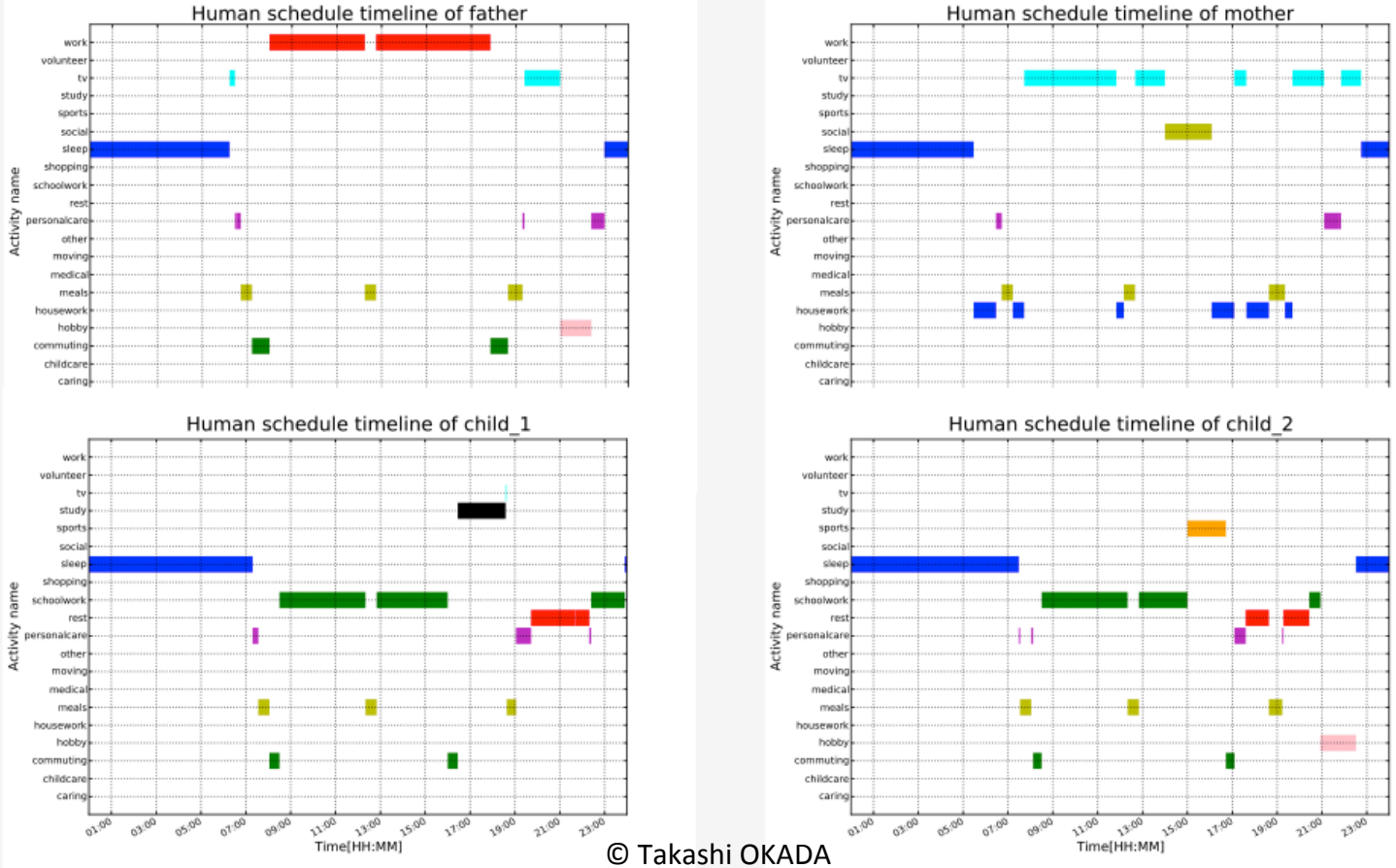
Design - Human Activity

- Schedules are computed previously
  - Duration times of activities are variables
- Reality is important
  - Population Census
  - Survey of Time Use and Leisure Activities
  - National survey on lifestyle by NHK
- The main algorithm is inspired by ``Maslow's Hierarchy of Needs''
  - Physiological desires such as sleeping and eating are more important than self-actualization.



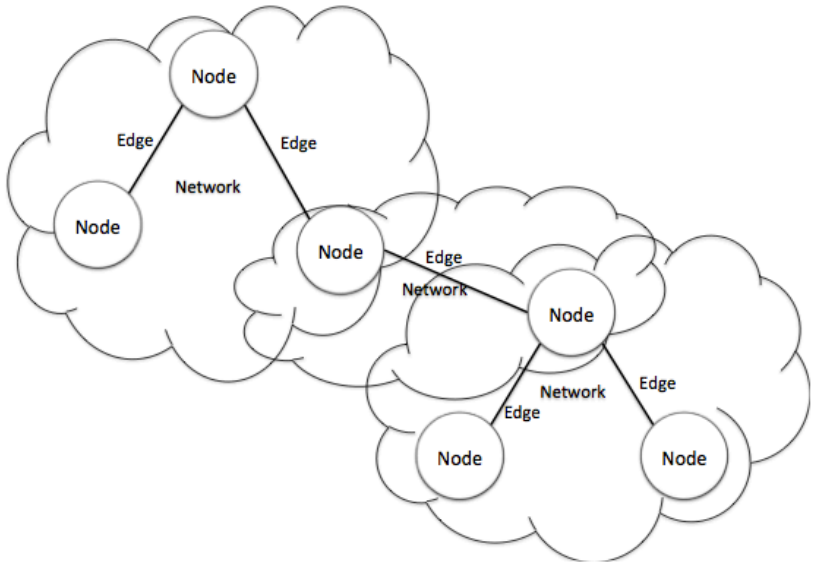
Design - Human Activity

- Schedule example
  - Father, Mother, two children

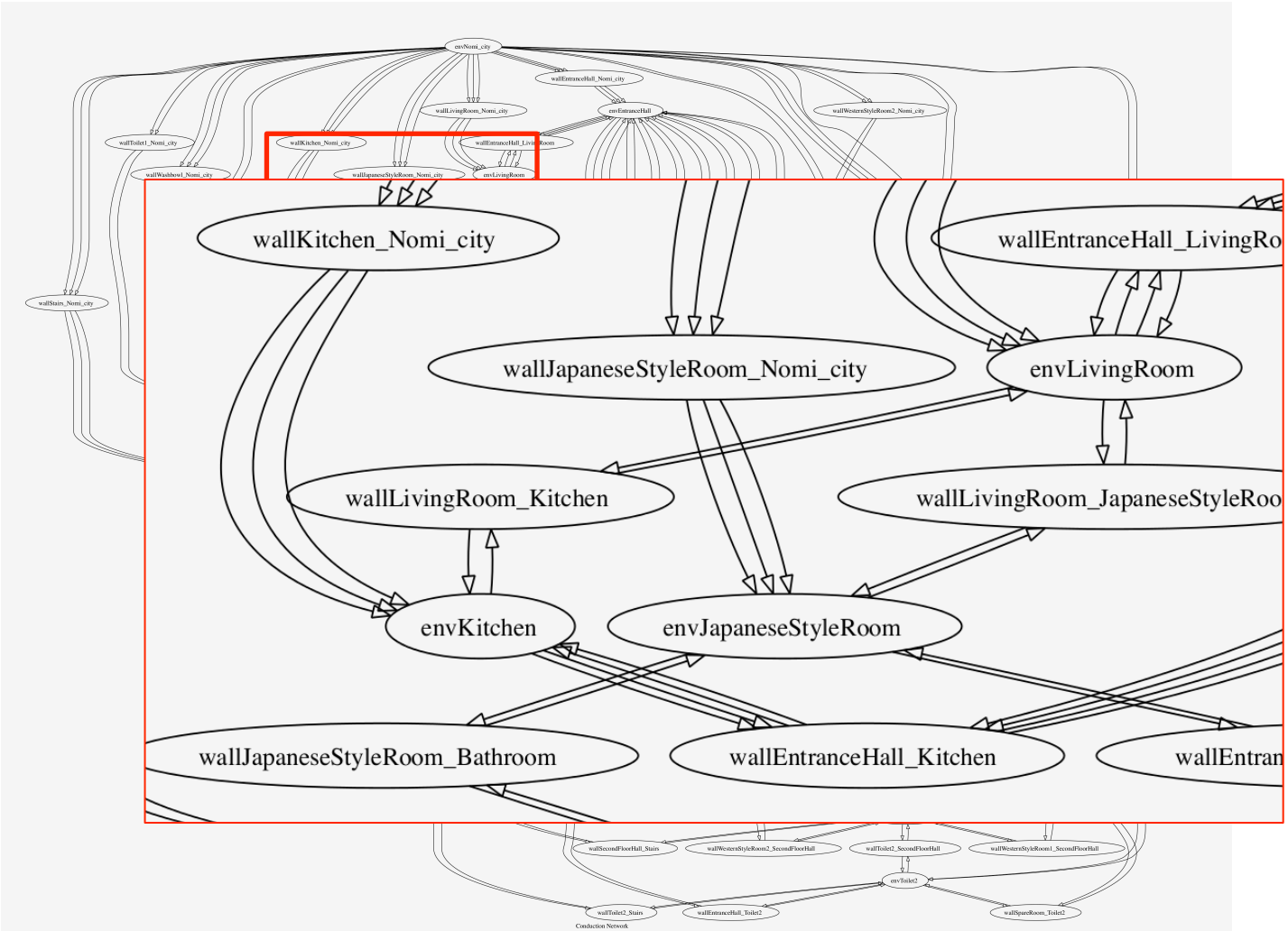


Implementation – Static modeling

- The structure of the simulator is Graph
  - Nodes, Edges, Networks
  - Nodes are connected by edges.
  - Data are transferred through edges while simulating
- An example
  - Room environment entity is connecting to…
    - Home Air Conditioner entity
      - Transferring thermal data
    - Adjacent room and hall walls
      - Exchanging thermal data
    - External environment entity
      - Transferring thermal data
    - Lighting entities
      - Transferring illuminance data

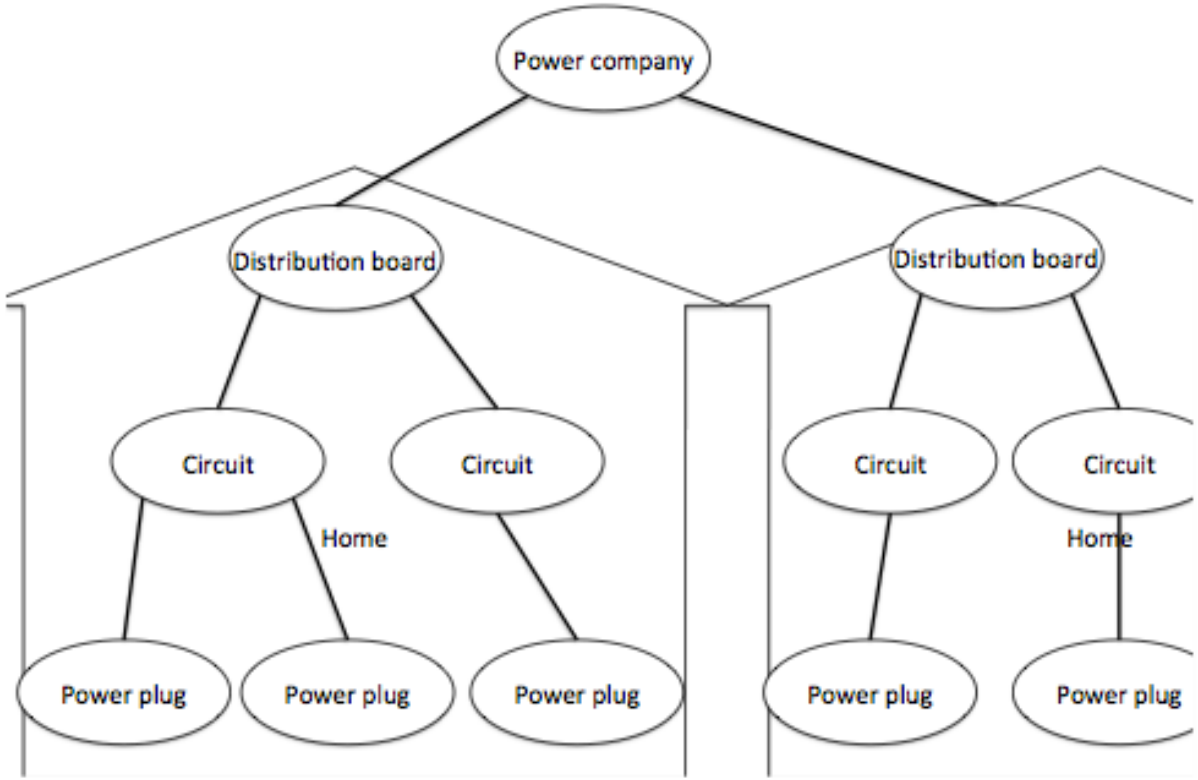


Implementation – Static modeling



Nodes related to thermal transfer (Thermal transferring network)

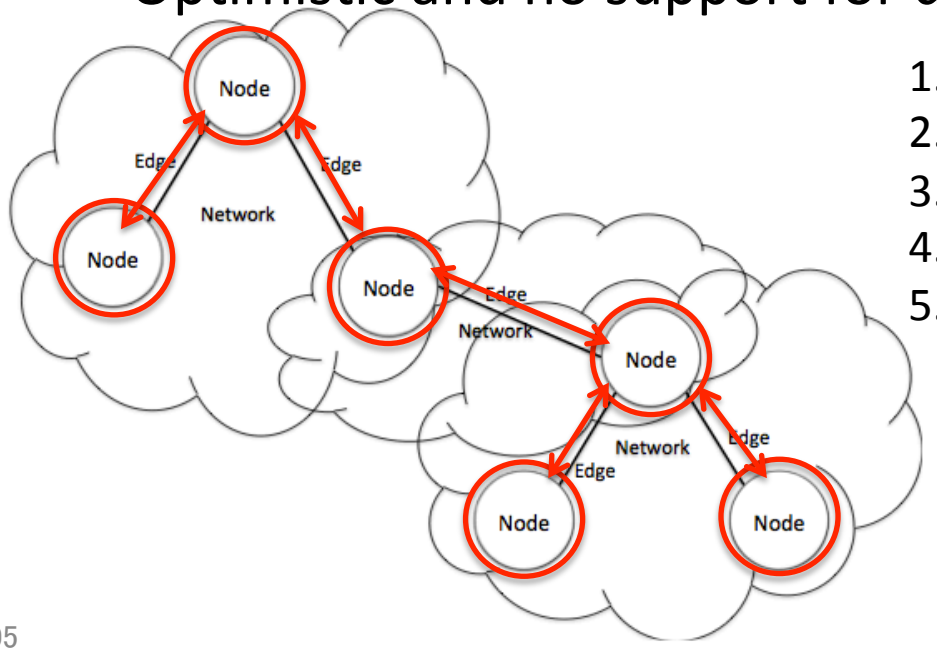
Implementation – Static modeling



Electric power distribution network

Implementation – Time management

- Simulation time
  - Time-stepped simulation
  - Real-time simulation is possible
    - Optimistic and no support for deadline violation



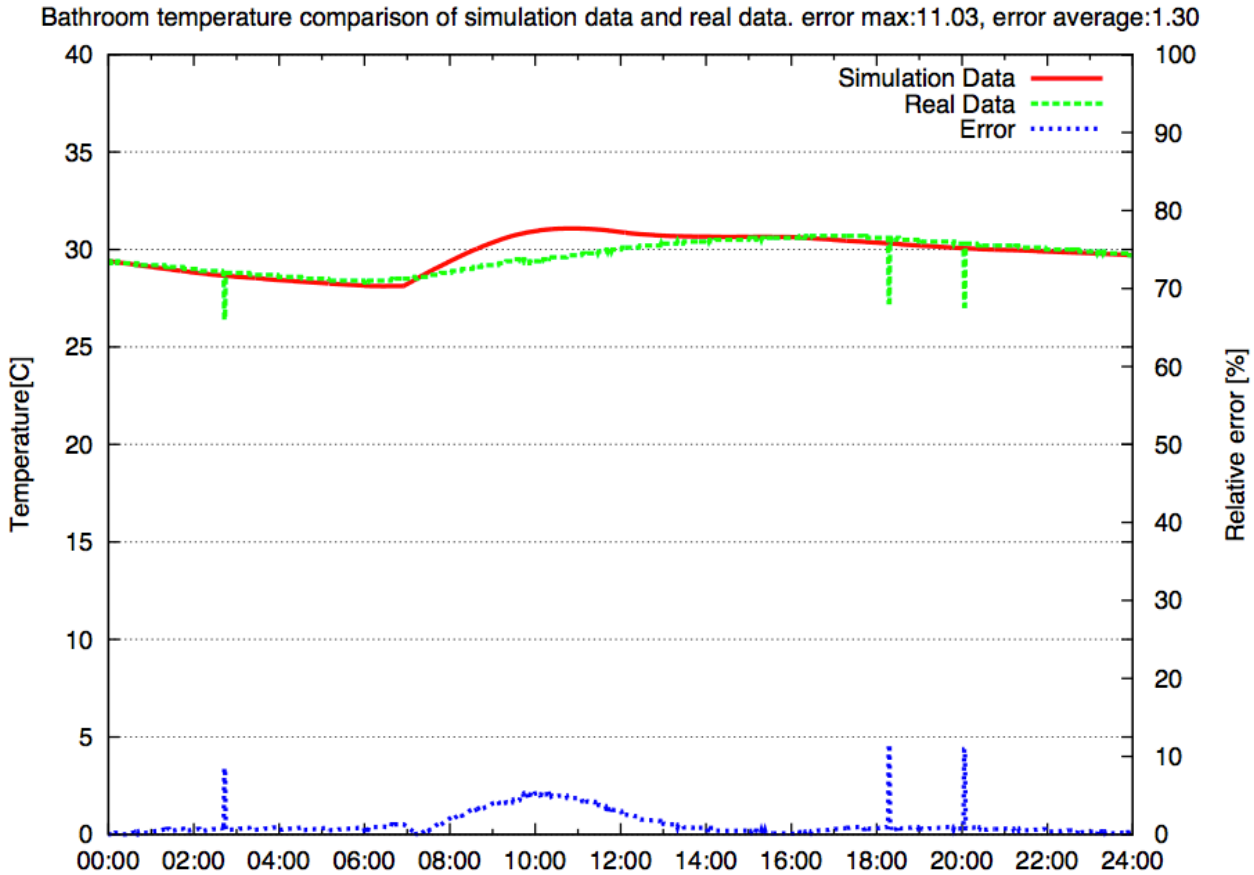
1. Calculate data to be transferred
2. Transfer or exchange data
3. Update internal variables
4. (Wait for the next interval)
5. Repeat all

Implementation - Environment

- Mac mini (Core2 Duo)
- Python
  - portable!!
    - Runnable in Linux, FreeBSD, and so on.
  - The performance should be poor but enough
  - Simulating 30 homes simultaneously is possible at least
  - The interval time is 20 seconds (configurable)

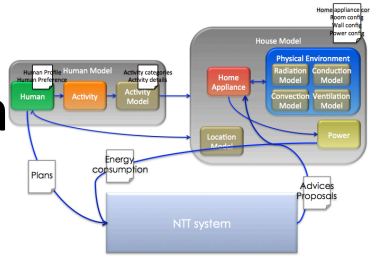
Correctness of home simulator

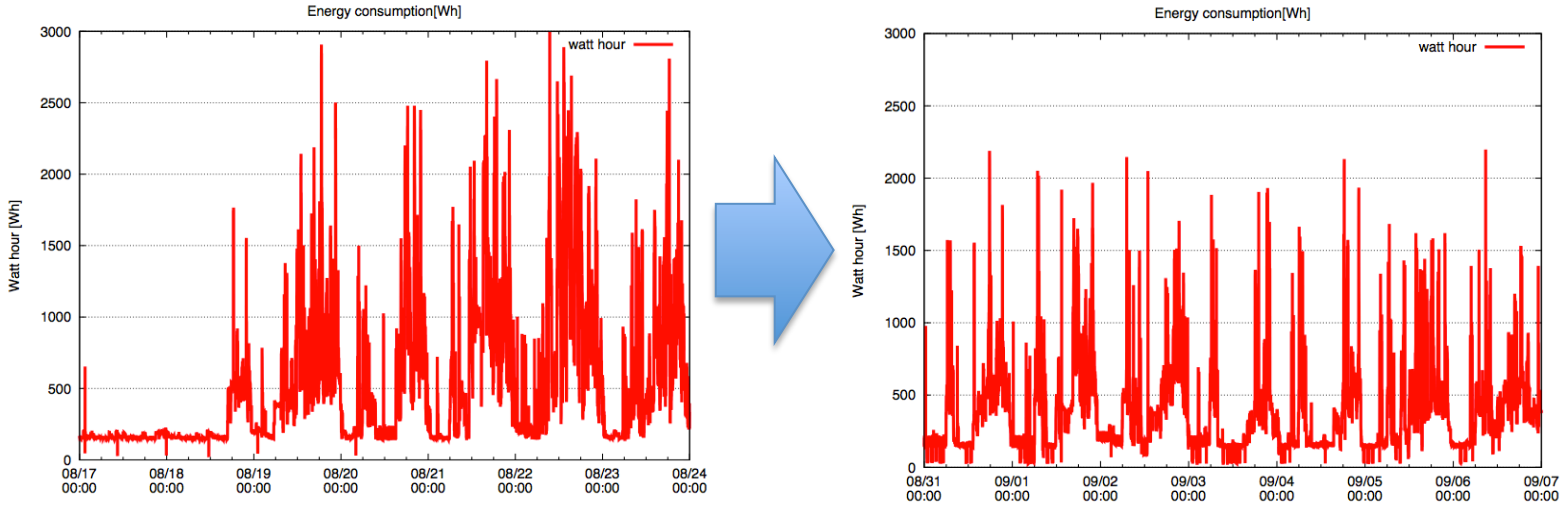
- Compared to iHouse (August)



Application Example

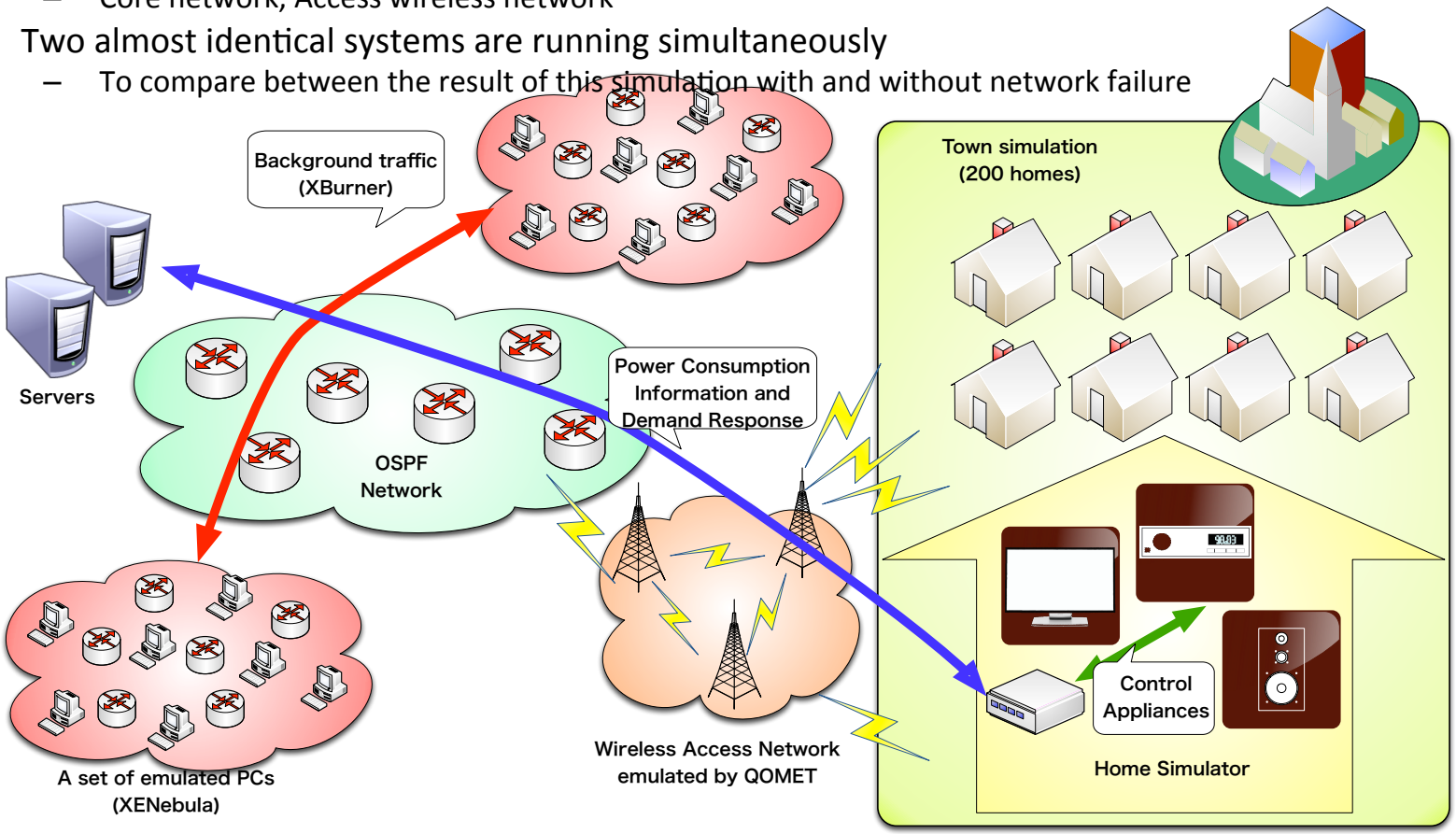
- HEMS with advice display feature
  - Feature quantity was calculated in advance using real data
    - Multiple Regression Analysis was used
  - Simulating homes at many locations in Japan





Collaboration with StarBED

- HEMS supporting Demand Response
- Network emulation by StarBED
  - Core network, Access wireless network
- Two almost identical systems are running simultaneously
  - To compare between the result of this simulation with and without network failure



Future plan

- Interface of simulator
  - Support new components constructed on different simulator
  - Mixture of real systems and simulated systems
    - iHouse and simulator
- Components for HEMS
  - Storage cell, fuel cell, photovoltaic, and so on
- Mathematical modeling
  - MATLAB/Simulink
  - Realize feedback loop
  - Verify system stabilization and safety
- Human body simulation

THANK YOU VERY MUCH!!