Environmental Comfort for Smart Buildings

Networked Embedded Systems
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Goal

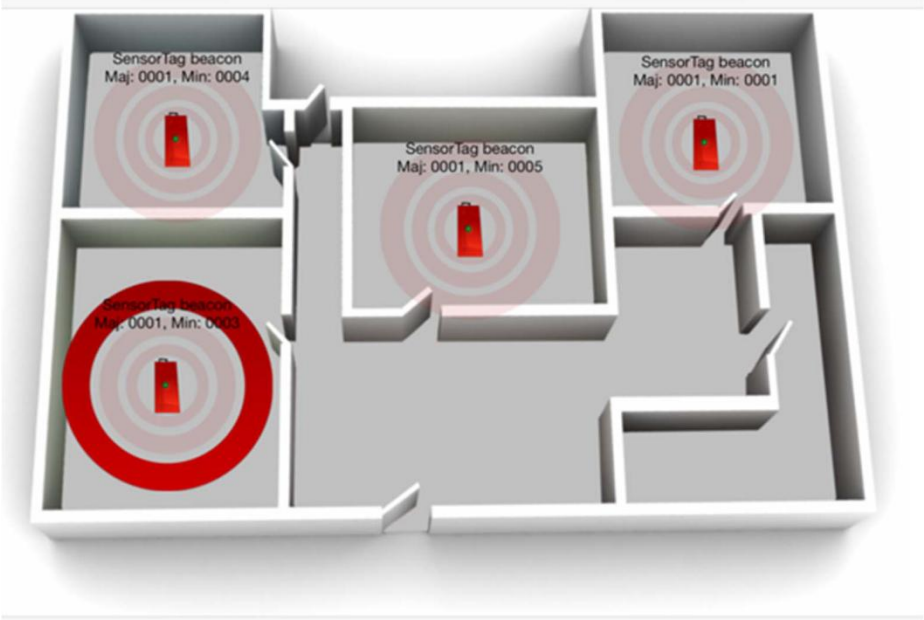
- Reach maximum comfort of the building occupants
  - Localize occupants
  - Measure comfort
  - Compare subjective judgments with impartial sensor measurements
  - Take decisions
  - Actuate the action

Choosen approach

- Architectural model
  - Centralized server: it register all the measurements and opinions
- Internal organization
  - Single layer
- Networking protocols
  - Standardized protocols (CoAP, HTTP)
- Heterogeneity
  - Possibility to support different heterogeneous technologies for sensing

Localization

- Use smartphone application to detect the information of the location
- Possible solutions:
  - iBeacon
  - QR code



Measure Comfort

- Android Application
  - “Sviluppo di un’applicazione Android per la rilevazione del comfort ambientale”, Francesco Paolo Culcasi
- Users express their opinion about *temperature* and *enlightenment*
- Evaluations $V = \{v: v \in \mathbb{Z}, v \in [-3;+3]\}$
- The reasoning is performed among the evaluation given over the last half an hour by occupants of the room

Wireless Sensor Network (1 /3)

- RPL network
- Sensors are energy hungry, that is why they have to stay idle for the most of the time
  - Duty cycle
- Gateway performs the role of an Info station
  - It retrieves actions in place of sensors
  - It sends sensors' measurements to the server
- Internet Gateway on the Border Router (DODAG root) implemented in Californium

Wireless Sensor Network (2/3)

- Each sensor
  - Register their presence issuing a CoAP POST request to the resource “register” of the Gateway
  - Become inactive
    - From now on the gateway periodically checks one (or more) of them has to become active
- The Gateway periodically update the information on empty/filled rooms
  - It notifies the transition (inactive -> active, or vice versa) to the sensor, via a CoAP POST request to the resource “activate” of the interested sensor, specifying the mode (on/off)
- Gateway also notifies “active” sensors for the action to take in order to accomplish the occupants opinions
- Each active sensor have to periodically measure temperature and light intensity and send to the Gateway

Wireless Sensor Network (3/3)

- Each sensor works by means of 3 phases, defined as Contiki proto-threads
  1. Init (all the LEDs are fixed ON)
     - Initialize REST engine and CoAP engine
     - Activate CoAP resources
     - Initialize variables
     - Start registration procedure to the Gateway (server_ipaddr)
  2. Idle (only red LED is fixed ON)
     - Nothing (the sensor is waiting for Gateway to become active)
  3. Active (red LED blinking, other two LEDs depend on actuation decision)
     - Once every N (20) seconds activate temperature and light sensors
     - Send measurements to Gateway
     - Wait for the Gateway to issue decisions to actuate

Reasoning

- Building Energy Management System
- The decision to take for light and heating systems of every room depends on the
  - Mean Value (MV) among last evaluations of each user for a specific room within the last half hour
- The decision has to take place only the first time that a new opinion is detected
  - The reasoning process is performed only when at least one *dirty* (i.e. new) opinion is present
  - Such a decision is marked as non-*dirty* after it has been used to execute an action

Actuating

- To simulate the decision taken
  - Green LED for temperature
  - Blue LED for light
- Green/Blue are kept fixed for a period of time proportional to MV
  - LED is fixed ON if the MV is positive
  - LED is fixed OFF if the MV is negative