Home Automation System

(IndeedNET Q5 Project Meeting)

Loughborough University

Content

Work Plan in Q5

- Task 2.6: Safety & security implementation (Corporate to task 3.3)
- Task 3.1: Integration of sensor/actuator networks
- Task 3.2: Integration of energy saving control
- Task 3.3: Integration of safety and security control
- Task 3.5: Lab testing
- Work Plan in Q6

Loughborough University

Integration of Sensor/Actuator Networks
(Task 3.1)

Loughborough University

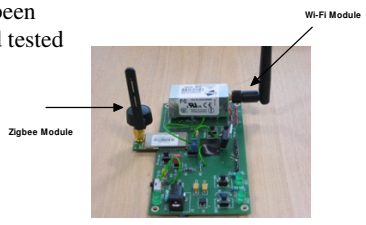
Wireless Light Switch

- The PCB design of the wireless light switch has been sent to a PCB manufacturer

Loughborough University

Zigbee & Wi-Fi Module

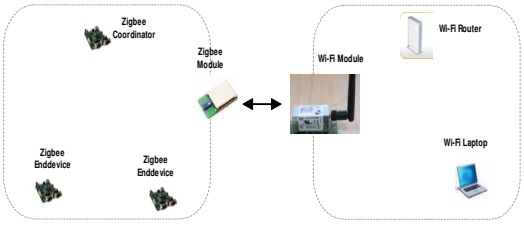
- Module has been produced and tested



Loughborough University

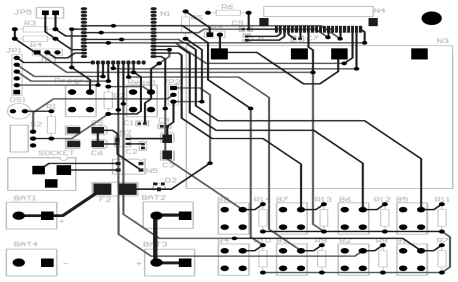
Zigbee & Wi-Fi Module

- Bridge between Zigbee network and Wi-Fi (Internet)



Loughborough University

Hardware Design of Local Controller Board



Loughborough University

Formation of Sensor/Actuator Network

- Available sensors:
  Temperature, light, humidity, flame, smoke and carbon monoxide sensors.
- Available actuator:
  Zigbee enabled radiator valve and light switch.
- Demonstration of sensor and actuator network has been done in task 3.5.

Loughborough University

Integration of Energy Saving Control
(Task 3.2)

Loughborough University

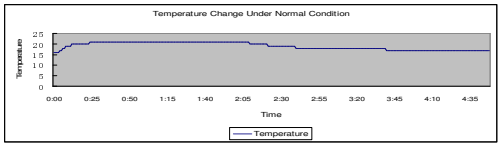
Energy Saving Control

- Intelligent proportional integral derivative control algorithm (PID) has been applied to control room temperature at a desired level.
- PID algorithm test has been finished
- Home energy management system design

Loughborough University

Test of PID Control Algorithm

- Test of nature temperature change for parameters setting



Start Temperature (c)	Stop Tmperature (c)	Time (min)
16	17	3
17	18	2
18	19	3
19	20	4
20	21	12
21	21	90
21	20	15
20	19	12
19	18	18
18	17	60

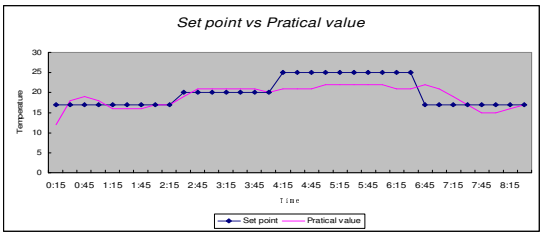
Temperature Increment Temperature Decrement
Temperature Stable

Waiting period during increment = error * 3
Waiting period during decrement = error * 1

Loughborough University

Test of PID Control Algorithm

- Curve of temperature change relative to set point



Loughborough University

Test of PID Control Algorithm

- The use of radiator valve during the test

State	Setpoint (c)	Practical Valve Opening Degree	Theoritical Valve Opening Degree
↑	17	13	17
↑	20	25	25
↑	25	50	37
↓	17	14	17

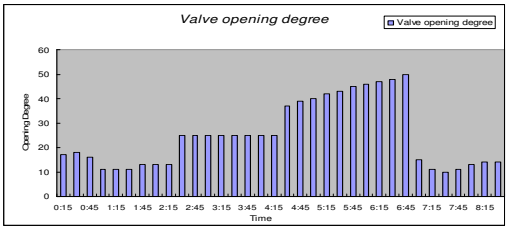
↑ Temperature Increment ↓ Temperature Decrement

$$\text{Theoritical Valve Opening Degree} = \frac{\text{CurrentTemperature-MeasurementLowLimit}}{\text{MeasurementUpLimit-MeasurementLowLimit}} * \text{MaximumValveOpeningDegree}$$

Loughborough University

Test of PID Control Algorithm

- Histogram of valve use



Loughborough University

Test of PID Control Algorithm

Factor	Description
Water	The specific heat of the water affects the speed of temperature change
Air	The specific heat of the air affects the speed of temperature change.
Room Condition	The material and structure of the room affect the performance of heat preservation.
Waiting Period	The decision of how long a waiting period can be is difficult to be done since a lot of factors need to be considered. Although we did a pre-test to decide what parameters can be used, they are still not suitable for all conditions. For example, a different season may cause a different speed of temperature change.
Error Area	The division of error area is for intelligent control use. It depends on the accuracy of the temperature sensor. A suitable division can help the system avoid unnecessary adjustment as soon as possible.

Loughborough University

Home Energy Management System Design

- Main functions of the home energy management system

1. Operation for routine settings.

2. Keep records for energy consumption and provide to users using comprehensible interface after intelligent analysis.

3. Deal with urgent events (switch off power, send out alarm, etc.)

Loughborough University

Home Energy Management System Design

- Two main parts from logical view

1. Communication part
   - ----Easy implemented Zigbee network
   - ----Unlimited extension
   - ----Reliable signal transfer
2. Control part
   - ----Implemented by micro-processor
   - ----Intelligent management schema

Loughborough University

Home Energy Management System Design

- Challenges of intelligent management:

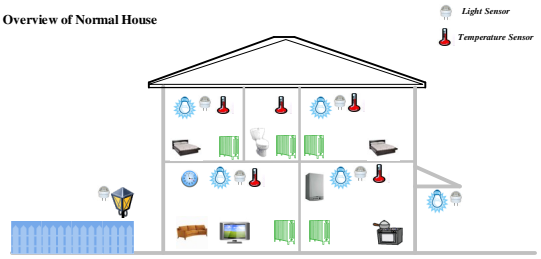
----Decision making is difficult to be made. System does not know whether to operate devices (switch on/off, open more/less, etc). Hard to make algorithm suitable for general purpose.

----It is more meaningful to empower users with information at teachable moments rather than automating much decision-making using “smart” or “intelligent” control (Stephen.S.Intille).

----Lack of common protocols for managing various devices

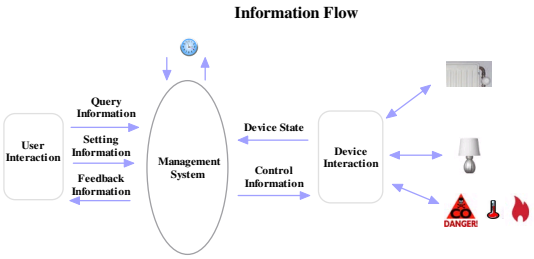
Loughborough University

Home Energy Management System Design



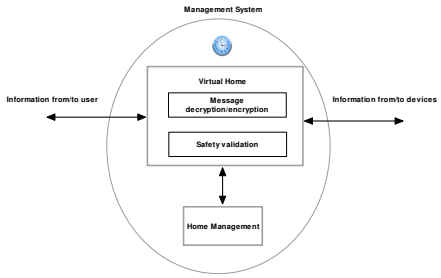
Loughborough University

Home Energy Management System Design



Loughborough University

Home Energy Management System Design



Loughborough University

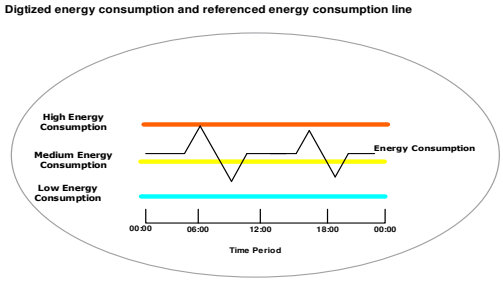
Home Energy Management System Design

- Scheduled by real-time clock
- Obtain devices information by regularly/urgently
- Digitize energy consumption using device information

  ----light-on-duration * electricity-bill-rate, etc.

Loughborough University

Home Energy Management System Design



Loughborough University

Integration of Safety & Security
(Task 2.6 & 3.3)

Loughborough University

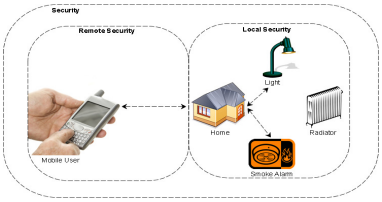
Home Security System

- The indeedNET project strives to provide a home automation system which provides:
- Security – Users must be able to interact with their home automation system in a secure manor. To achieve this the system must transparently provide:
  - Authentication – Only allow legitimate users to access the system.
  - Confidentiality – Prevent any third parties from accessing and viewing communications between users and the system.
  - Integrity – If a third party intercepts a communication between the user and system they should not be able to modify it without detection.
- Safety – The changes to home automation devices requested by users must be checked for any safety implications before they are implemented and the appropriate feedback provided to the users.

Loughborough University

Home Security System

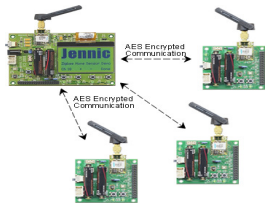
Home security can be viewed as local security and remote security



Loughborough University

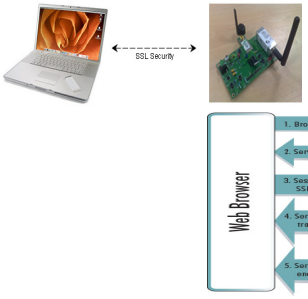
Local Side Security Technical Implementation

Local Side



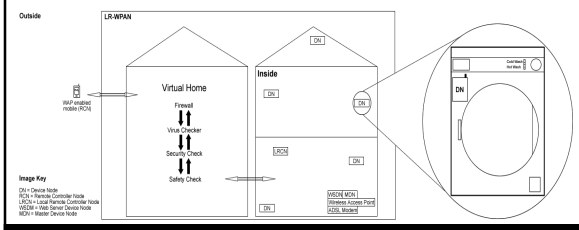
Loughborough University

Remote Side security Technical Implementation



Loughborough University

The indeedNET home automation system incorporates a virtual home which analyses incoming commands. Only those commands that are known and are inside a set of safe bounds are executed within the real system.



Loughborough University

Lab Testing
(Task 3.5)

Loughborough University

Lab Testing

- Prototype of the IndeedNET system has been demonstrated in EMH on 4th March and in Loughborough Holywell Park on 17th April.
- Valuable feedbacks:
  1. Mobile phone access for local/remote control.
  2. Consideration for usability
  3. Consideration for remote diagnosis when the system maintenance is required.

Loughborough University

Work Plan in Q6

- Task 3.3: Integration of safety and security
  ----Implement safety and security control in both of home portal and home wireless sensor/actuator network
- Task 3.4: Integration of IndeedNET system
  ----Integrate sensor/actuator network, energy saving control and safety/security control
- Task 3.6: On-site test house testing
  ----Install & Test the IndeedNET system in the on-site test house

Loughborough University

Questions ?

Loughborough University