



*Design and Implementation of
Intelligent Home Control Systems
based on Active Sensor Networks*

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Outline

- ✦ *Abstract*
- ✦ *Introduction*
- ✦ *Related work*
- ✦ *Active sensor network architecture*
- ✦ *Our implementation details*
- ✦ *Conclusion*

Abstract

- ✦ We suggest a new intelligent home control system based on a wireless sensor/actuator network.*
- ✦ We develop a new routing protocol LQIR to improve the performance of our active sensor networks.*
- ✦ This paper introduces the proposed home control system's design that provides intelligent services for users.*

Introduction(1/4)

✦ *Recent progress in the intelligent home control system :*

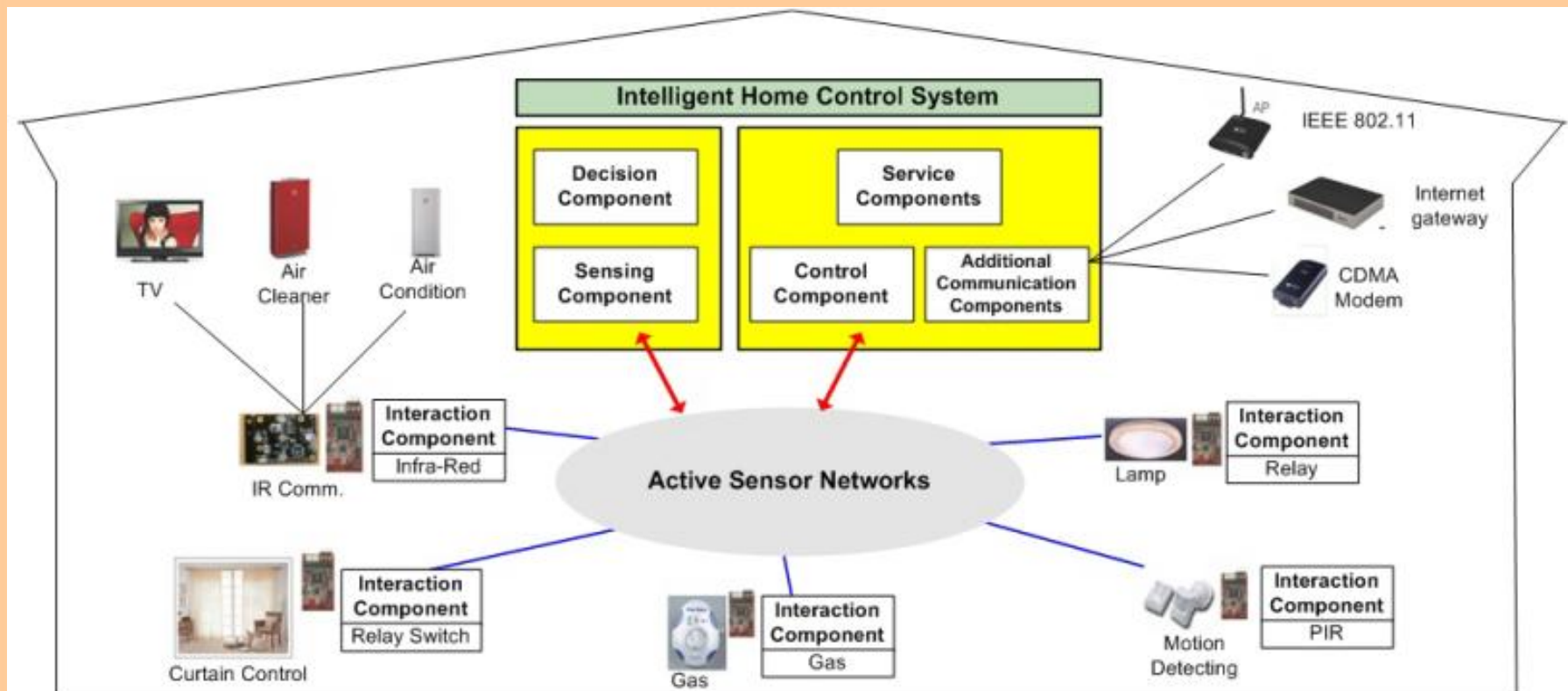
- ✦ *Low-powered micro device.*
- ✦ *Wireless communication technologies.*

✦ *To reduce complexity :*

- ✦ *It should be designed distributing various tasks into proper computational units.*

Introduction(2/4)

✦ *An overview of the proposed intelligent home control system.*



Introduction(3/4)

- ✦ We design an intelligent home control system that can assign tasks to suitable components.*
- ✦ Using a wireless sensor network with actuator functionality, Our system can :*
 - ✦ Automatically gather physical sensing information.*
 - ✦ Efficiently control various consumer home devices.*



Service Components & Decision Component

✦ *The home control system based on active sensor networks consists of various software components.*

✦ *Service Components:*

- *These components represent some ubiquitous home services provided by our system.*

✦ *Decision Component:*

- *The component recognizes the current home environment.*
- *The service components to select the appropriate service.*



Sensing Component & Control Component

- ◆ *Sensing Component:*

- *The component gathers sensing data and special event information.*
- *This sensing component provides this information to the decision component.*

- ◆ *Control Component:*

- *The component instructs special control commands to the deployed actuators.*
- *These provide methods to control and handle various consumer home devices.*

Interaction Component & Additional Communication Components

- *Interaction Component:*

- *Between our home control system behind a sink node and the active sensor networks deployed in a home domain.*

- *Additional Communication Components:*

- *These components manage some other networking technologies.*
- *These technologies leverage our provided home services to become more effective.*

Introduction(4/4)

- ✦ *The contributions of our work are as follows:*
 - ✦ *We propose a more intelligent home control system based on active sensor networks.*
 - ✦ *We develop a novel sensor routing protocol to gain adaptive control of smart sensors and actuators.*
 - ✦ *We implement hardware and software utilized in our system.*
 - ✦ *We show how real ubiquitous home scenarios operate and are implemented in our system.*

RELATED WORK

- ✦ *Based on their main contributions, try to classify them into three types:*
 - ◆ *Decision Support oriented.*
 - ◆ *Service Provision oriented.*
 - ◆ *Real Implementation oriented.*

- ✦ *This paper focuses on:*
 - ◆ *To efficiently distribute home control tasks to appropriate components.*
 - ◆ *Automatically manage consumer home devices.*

ACTIVE SENSOR NETWORK ARCHITECTURE

✦ *We address the active sensor network architecture utilized in the proposed home control system.*

- ✦ *Smart Sensors and Actuators.*

- ✦ *Interaction Component.*

- ✦ *LQIR (Link Quality Indicator based Routing Protocol).*

Smart Sensors and Actuators

✦ *Two types:*

✦ *A generic sensor:*

- *To detect the general physical sensing measurements.*

✦ *An actuator:*

- *It can directly control consumer home devices.*
 - ♦ *Relay switch module.*
 - ♦ *IR (Infra-Red) communication.*

✦ *They are managed by the Sensing Component and Control Component, respectively.*

Interaction Component

✦ Interaction Component:

- Gas detection.*
- Relay switching.*
- IR controlling.*

✦ They are design to distinguish these different capabilities and perform adaptive operations

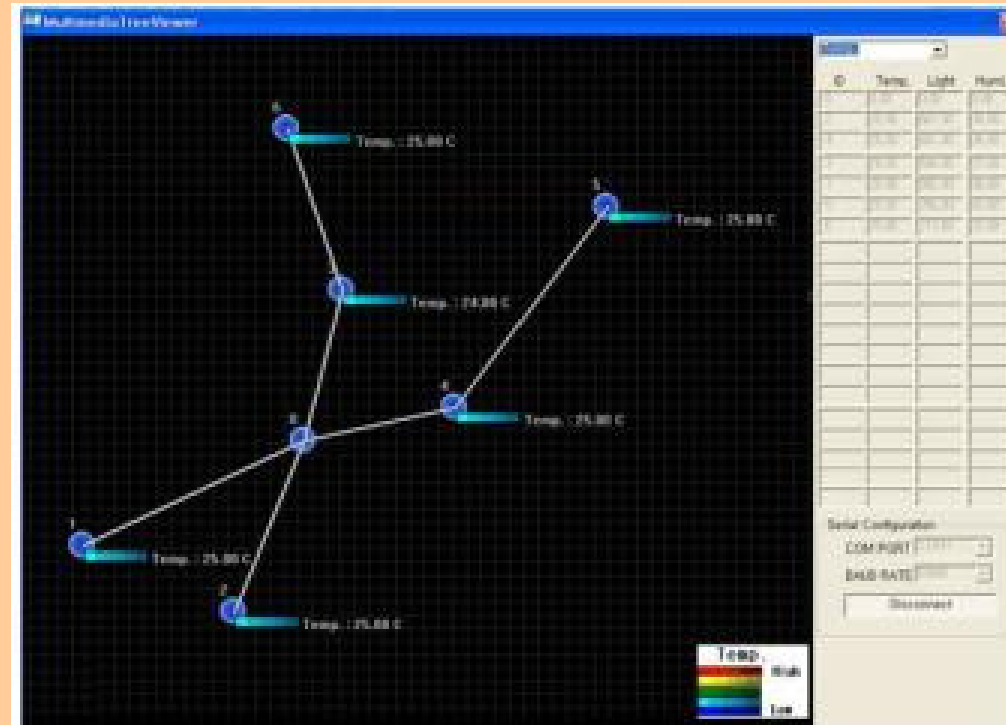
LQIR(1/2)

- ✦ *We develop a new tree-based routing protocol named as LQIR (Link Quality Indicator based Routing).*

- ✦ *The proposed tree-based LQIR works as follows:*
 - ✦ *Selects the special node having the best LQI value among neighbors.*
 - ✦ *Check neighbors' LQI lists whenever transmitting data.*
 - ✦ *Our home system can discern the routing path from the system to each smart node.*

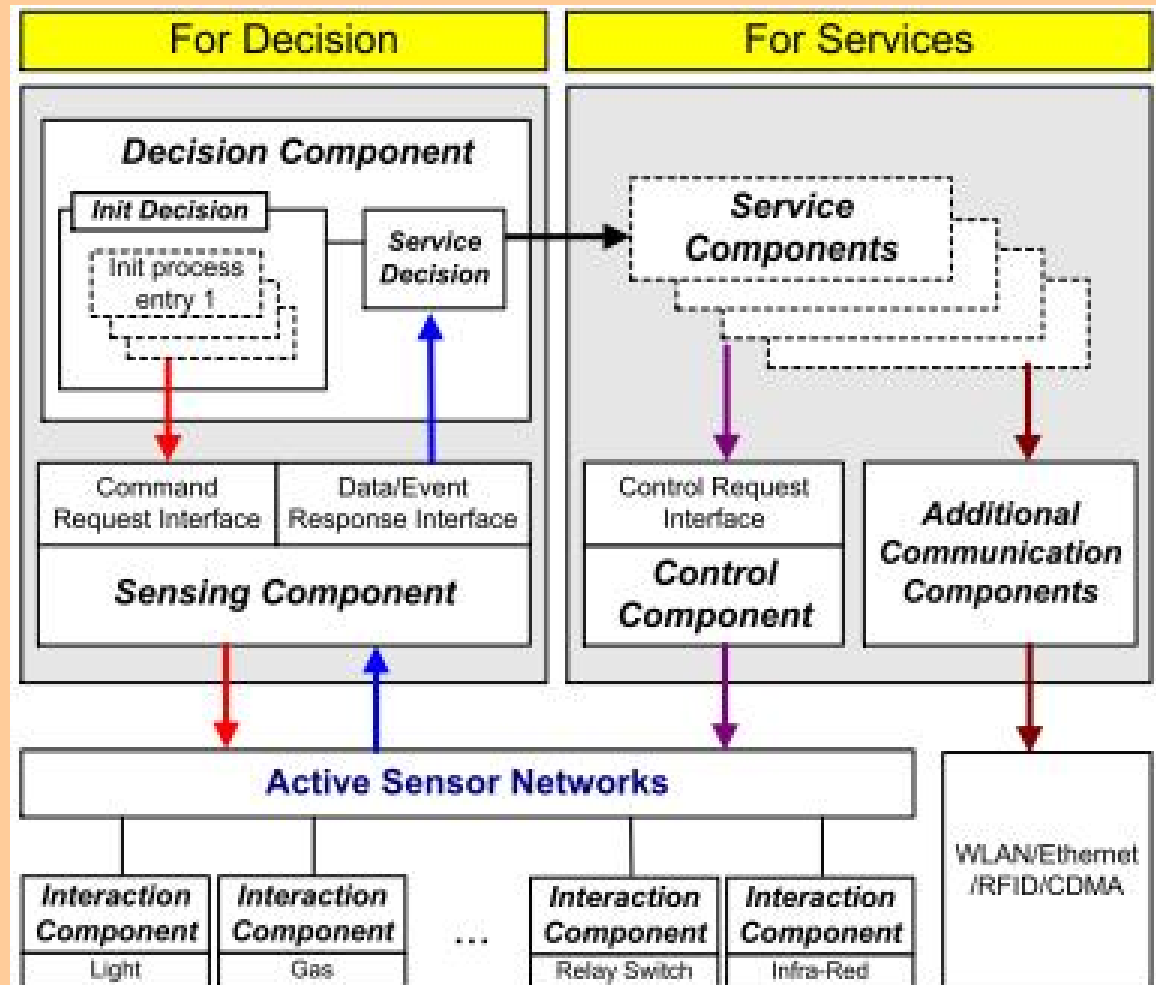
LQIR(2/2)

- ✦ Illustrates a snapshot of active sensor networks, captured by using our topology viewer program.



THE PROPOSED HOME CONTROL SYSTEM

✦ *The component architecture in our proposed home control system.*



Sensing Component

- ✦ *To receive and request the physical sensing data and specific events of interest from smart nodes.*

- ✦ *Our home system handles three packet types:*
 - ◆ *Set-Command packet:*
 - *It is generated either to request the physical sensing data .*
 - *To configure the special event to the generic sensor type nodes.*
 - *The packet is transmitted from the Sensing Component to the smart node's Interaction Component.*

Data packet & Event packet

- *The Data packet includes the general physical sensing information.*
 - *It is the response to the Set-Command packet generated from the Sensing Component.*
- *The Event packet informs about specific events:*
 - *Detecting a person's presence.*
 - *Locking the door.*
 - *Detecting the presence of dangerous gases.*

Decision Component

- ✦ Appropriate home services are selected by the Decision Component.*
- ✦ Based on the physical sensing information and events gathered by active sensor networks.*
- ✦ It is provided the Command Request and Data/Event Response interfaces by the Sensing Component.*

Control Component

- ✦ The Control-Command packet is a special command to control home device in actuator nodes.*
- ✦ The device is controlled according to the intentions of the service component.*
- ✦ All tasks, related to controlling consumer home devices, are handled by Control Component.*

Additional Communication Components

✦ *Additional Communication Components are constructed by:*

- ✦ *IEEE 802.3:*

- *Provide HTML web page browsing services.*

- ✦ *IEEE 802.11:*

- *The wireless AP.*

- ✦ *13.56MHz RFID and CDMA technologies .*

- *It can communicate with ISO 15693 and 14443A RFID tags simultaneously.*
- *Support SMS (Systems Management Server) service and voice communications with mobile phones.*

Service Components

✦ Three types:

- ✦ The home automation services (according to the weather):*
 - Air conditioners.*
 - Air cleaners.*
 - Curtain movements.*
- ✦ The home security services:*
 - Detects potential crimes.*
 - Prevents gas explosions.*
- ✦ The home management services via the Internet.*

OUR IMPLEMENTATION DETAILS

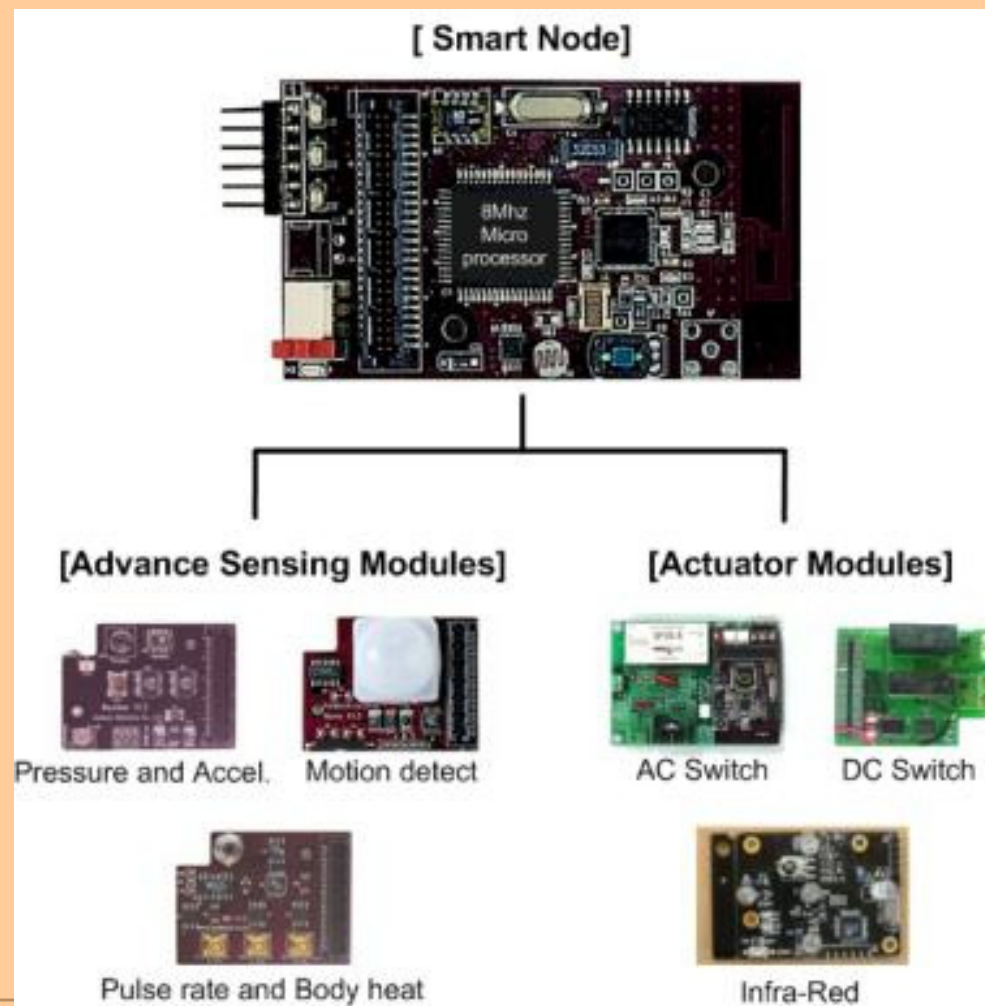
✦ *We have developed a smart node that has sensing, processing and networking abilities :*

- ✦ *Low power microprocessor.*
- ✦ *A narrow-band RF device.*
- ✦ *Support physical-layer functionalities of IEEE 802.15.4.*
- ✦ *A 50 pin connector.*

✦ *These options boards are managed by our OS-level libraries.*

Sensor/Actuator Node Implementation

✦ Sensor/Actuator Node Implementation.



Sensor/Actuator Functions and Real Deployment(1/4)

✦ Detecting gas:

- ✦ It is deployed near the gas valve to prevent a gas explosion.*



Gas valve



Detecting gas

Sensor/Actuator Functions and Real Deployment(2/4)

✦ *Detecting human movement:*

- ✦ *PRI sensors are used to detect human movement.*

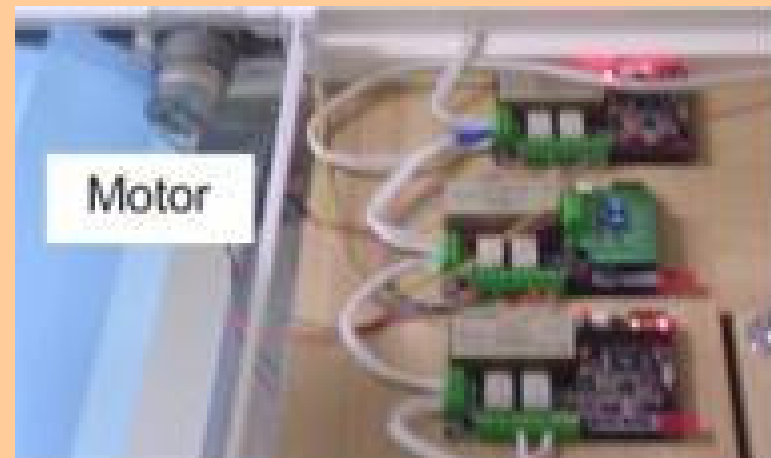
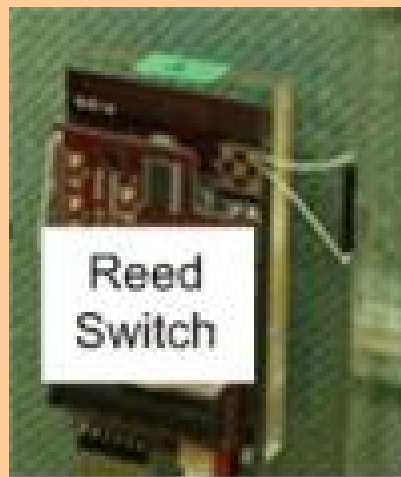


Sensor/Actuator Functions and Real Deployment(3/4)

✦ *Detecting window status:*

- ✦ *The magnetic reed switch is equipped with the window boundary to detect its status.*

✦ *Curtain movements:*



Sensor/Actuator Functions and Real Deployment(4/4)

✦ *Control lamp brightness:*



✦ *General sensing information:*

- ✦ *The home control system can gather such information from all home areas where smart nodes are deployed.*

Description of Intelligent Home Control Services(1/6)

- ✦ *RFID based door-lock service:*

- ✦ *Our system utilizes :*
 - ✦ *RFID card*
 - ✦ *RFID reader*

- ✦ *The home control system decides whether or not to open the door based on:*
 - ✦ *TAG ID in the RFID card.*



[Door Lock]



[RFID Reader Case]

Description of Intelligent Home Control Services(2/6)

- ❖ *Crime Detection:*
- ❖ *Movement detection sensors and image cameras can be utilized to detect crimes.*
- ❖ *These pictures are uploaded to the web-server*

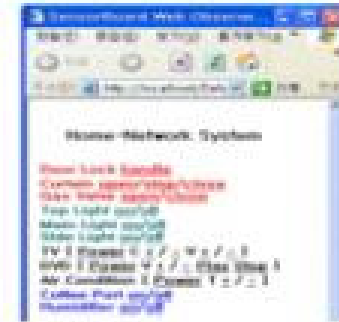


Description of Intelligent Home Control Services(3/6)

✧ *IR communication service via Internet:*

- ✧ *TV.*
- ✧ *DVD.*
- ✧ *Air conditioner.*
- ✧ *Air cleaner.*

✧ *The user can control these home devices using the web browser via Internet.*



[Web page of the home server]



[Connect to the home server by PDA]



Description of Intelligent Home Control Services(4/6)

✦ *Talking service with visitors when nobody in home:*

- ✦ *It supports a connection between inhabitant and visitors through the CDMA modem.*
- ✦ *The user can communicate using a cellular phone.*
- ✦ *Visitors respond using a mike and speaker in the door.*



Description of Intelligent Home Control Services(5/6)

- ✦ *Automatic control of air conditioner and air-cleaner service:*
 - ✦ *Using the Infra-Red node.*

- ✦ *It can deduce the proximate atmospheric conditions in the house:*
 - ✦ *Temperature.*
 - ✦ *Humidity.*
 - ✦ *Pressure.*



Description of Intelligent Home Control Services(6/6)

✦ Automatic curtain control service:

- ✦ The curtains are opened or closed according to the time of day.*

✦ Gas detecting service:

- ✦ It periodically checks gas in the atmosphere.*
- ✦ It reports the values to our home system to prevent gas explosion.*
- ✦ It instructs the gas valve actuator node to turn off the valve using its relay switch module.*

CONCLUSION

- ✦ *We address a new intelligent home control system based on active sensor networks.*
- ✦ *We implement the proposed system and develop related hardware and software.*
- ✦ *We will apply IEEE 802.15.4a standard technology in our home network systems to support location services.*

REFERENCES

- ✦ *Changsu Suh; Young-Bae Ko; Consumer Electronics, IEEE Transactions on Volume 54, Issue 3, August 2008 Page(s):1177 - 1184*



THANKS