ZigBee-based alarm system for pervasive healthcare in rural areas

Communications, IET Publication Date: February 2008 Volume 2
Cassas, R Marco, A Plaza, I Garrido, Y Falco, J

Student: Chen, Zong-Ren
Adviser: Dr. Tsai, Lian-Jou
Outline

- Abstract
- Introduction
- Description of the Method
- Mobile End-Device
- ZigBee Characteristics
- Network Architecture
- System’s flow diagram
- Energy Consumption
- Conclusions
In this paper, a alarm system suitable for pervasive healthcare in rural areas is presented.

The alarm system takes advantage of ZigBee.

Small, long battery life, and large coverage region.
Introduction

- The aging population problem
- What is their need
- What’s the problem of stay in the home

Table 1: Age and sex profile of the residents of Fortanete (2005 census)

<table>
<thead>
<tr>
<th></th>
<th>Under 25 years</th>
<th>25–65 years</th>
<th>65–80 years</th>
<th>Over 80 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>men</td>
<td>24</td>
<td>76</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>women</td>
<td>14</td>
<td>46</td>
<td>31</td>
<td>9</td>
</tr>
<tr>
<td>total</td>
<td>38</td>
<td>122</td>
<td>65</td>
<td>17</td>
</tr>
</tbody>
</table>
Description of the Method

- Development of Mobile End-device

- The system what is enable to those in need to receive assistance and easy to operate it for user

- Create a communication infrastructure (point-to-point link with user’s device)
  - Telephone line and GSM modem have problem about cost efficiency
  - Cell phone and PDAs to exchange data via bluetooth, but bluetooth is more consuming
  - Using WiFi that is large for device
Mobile End-Device (1/2)

- The devices to detect the user’s status via triaxial accelerometer
- Its function has three mode
  - Active mode
  - Rest mode
  - Deep monitoring mode
Mobile End-Device (2/2)

- It is necessary to optimise the time spent in active and rest mode for maximize the lifetime of the device
- It is periodically to measure acceleration and every 10s to poll its parent
- Sampling and processing their outputs take 3ms
- Polling the neighbor/relative takes 20ms
ZigBee Characteristics (1/3)

- Remote or internal control, standard defines network topologies: star, cluster tree and mesh
- ZigBee has active (transmit/receive) or sleep mode
- ZigBee devices will be more ecological than WiFi saving megawatts at full deployment
  - WiFi RX power is 667 mW on 100 devices/home & 50000 homes/city = 3.33 MW
  - ZigBee power is 30 mW on 100 devices/home & 50000 homes/city = 150kW
ZigBee Characteristics (2/3)

- Range: 50m typical (5-500m based on environment)
- Extremely low cost and Ease of implementation
- IEEE defines two types of devices
  - Full function device (FFD)
    - Any topology
    - Able to be Network Coordinator, Router, and End device
    - Can talk with any other device
  - Reduced function device (RFD)
    - Only star topology
    - Only can be End device
    - Only talk with Coordinator or Router
    - Simple implementation
ZigBee Characteristics (3/3)

- ZigBee
  - Sleep mode change to active = 15ms typically
  - Active channel access time = 15ms typically
  - 2+ years from ‘normal’ batteries

- Bluetooth
  - Sleep mode change to active = 3s typically
  - Active channel access time = 2ms typically
  - Power model a mobile phone (regular daily charging)

- ZigBee devices can quickly attach, exchange information, detach, and then go to deep sleep to achieve a long battery life.
Network Architecture (1/5)

- A ZigBee-compliant network following mesh topology
- The nodes in the network have three different roles
  - coordinator
  - Routers
  - MED
Network Architecture(2/5)

- The coordinator initiates the network that is the sink for all the data and connect to a central computer.
- Routers maintain a routing table to address data packets and exchange data with the mobile devices.
- A mesh of routers form a backbone (with coordinator), with MEDs connected in star.
- MED carried by people transmit data and receive messages from the coordinator.
Network Architecture (3/5)
The paper uses two different types of antennas:
- Directional antenna (21*21 cm)
- SMD antennas (2*7 mm)

Directional antennas are used to cover straight streets or to reach sites located far from the coordinator.

SMD antennas are used in portable devices and routers.

<table>
<thead>
<tr>
<th></th>
<th>SMD Johansson</th>
<th>SMD Johansson</th>
<th>Directional Fractus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>best, m</td>
<td>worst, m</td>
<td>m</td>
</tr>
<tr>
<td>SMD Johansson</td>
<td>155</td>
<td>120</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td>best</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMD Johansson</td>
<td>120</td>
<td>70</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>worst</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Network Architecture (5/5)
System’s flow diagram (1/2)

- **POLLS SENSORS**
  - **NO Activity during last hour in ACTIVE mode**
    - Set DEEP MONITORING mode (go to Sleep)
  - **Normal Activity Pattern in REST mode**
  - **Possible Fall Pattern**
    - Set ACTIVE mode (go to Sleep)

- **POSSIBLE ALARM SITUATION**
  - **Timed wake up**:
    - 2 s in Rest mode
    - 0.25 s in Active mode
    - 0.1 s in Deep Monitoring mode (also sets high sensitivity)
  - **Large Acceleration detected**
    - Long Button push
  - **Set REST mode (go to Sleep)**
    - Button Pressed before 10 seconds
    - NO Button Pressed before 10 seconds

- **SLEEP**
  - **Raise ALARM**

ESLab
Southern Taiwan University
System’s flow diagram (2/2)

ALARM RAISED
  Addressed by ZigBee Network to the Local Management Centre
  Connect to the Regional Management Centre over Internet
  User’s Neighbor/Relative Supporting List

Can handle the alarm
  NO
  Wam Local Responsible

YES
  ALARM ATTENDED LOCALLY
    Serious alarm
      HEALTH SERVICE
  ALARM ATTENDED
    NO
Energy consumption (1/2)

- When it sampling and processing the output about the accelerometer data
  - That is a current consumption of 95.7µA/s in active mode
  - That is a current consumption of 22.7µA/s in rest mode

- When it polling the neighbor/relative
  - That is a current consumption of 70µA/s in active mode
  - That is a current consumption of 70µA/s in rest mode
Energy consumption (2/2)

- The paper uses a 3V battery with 1000mAh capacity.
- It will provide more than 8 months of continuous monitoring in active mode.

<table>
<thead>
<tr>
<th></th>
<th>Current in active mode</th>
<th>Current in sleep mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>microcontroller</td>
<td>6 mA</td>
<td>5 μA</td>
</tr>
<tr>
<td>wireless transceiver</td>
<td>30 mA</td>
<td>10 μA</td>
</tr>
<tr>
<td>accelerometer</td>
<td>500 μA</td>
<td>2 μA</td>
</tr>
</tbody>
</table>
The approach provides security to the users, enabling them to move freely in their habitual environment: home and surroundings.

The system has obvious benefits, but it can also invade the users’ privacy.

The use of ZigBee give the village with a wireless infrastructure that enables the integration with many other systems that might potentially improve the users’ quality of life; for example control of the environment and remote medical monitoring.
References

- ZigBee Alliance: ‘ZigBee Standard’, 2006
Thanks for your listening