Wireless Sensors Network Based Smart Home to Care Elder People

Subhas Mukhopadhyay
Massey University
New Zealand

DL cum Keynote Presentation, September, 2010
Where is New Zealand?
My city is Palmerston North
Massey University
Registry Bldg
PN Campus
Wellington
Albany
IEEE Sensors Council

ANNOUNCEMENTS

- **IEEE SENSORS 2010**: 20th IEEE Conference on Sensors
  November 1-4, 2010, Waikoloa, Big Island, Hawaii

- **Call For Nominations for Council Awards**
  The Call for nominations for four Sensors Council awards is open. The deadline is August 15, 2010. Nominations are to be sent by email to Dr. Vladimir Lumelsky, lumelsky@ieee.org. For more detail and for nomination forms, see [here](http://www.ieee.org/sensors).

- **1st IEEE International Conference on Smart Grid Communications**
  October 4-6, 2010, National Institute of Standards and Technology (NIST)

- **Impact factor: The Sensors Journal’s Reputation Keeps Growing!**

- New tutorial - Terahertz Sensing Technology

- NEW member society joined the Sensor Council, IEEE Antennas and Propagation Society 2008

- IEEE Sensors Journal Announces Sensors Letters

- IEEE Sensors Journal Subscription Information

- IEEE Sensors Journal Issues - Table of Contents, Abstracts, Full Papers

- IEEE Committee on Earth Observation, ICEO
  - Please visit the ICEO home page: www.iceo-earth.org and the ICEO online magazine www.earthzine.org

---

IEEE SENSORS COUNCIL

- IEEE Sensors Council Member Societies
- 2010 Sensor Council Committee members
- IEEE Sensors Council Constitution
- IEEE Sensors Council Bylaws
- IEEE Sensors Council Policies and Procedures
- IEEE Sensors Job Descriptions

--

IEEE Sensors Council Publications

- Sensors Journal
- Proceedings of IEEE SENSORS

- IEEE Constitution
- IEEE Bylaws
- IEEE Policies
- IEEE Code of Ethics

---

http://ewh.ieee.org/tc/sensors/
IEEE Sensors Council

- Distinguished Lecturer from May 1, 2010
- IEEE Sensors Conference 2009
- IEEE Sensors Journal – AE
- Guest Editor for special issues
  - Intelligent Sensors
  - Sensors Systems for Structural Health Monitoring
  - Cognitive Sensors Network
Outline of the presentation

* Sensors
  * Smart Sensors
    • Sensor Interfaces
    • Introduction to Wireless Sensors
  Network based Home Monitoring for Eldercare
Sensor

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

A sensor generates an electrical signal related to a physical, biological or chemical parameter.

A good sensor obeys the following rules:

1. Is sensitive to the measured property
2. Is insensitive to any other property
3. Does not influence the measured property
Many Sensors

<table>
<thead>
<tr>
<th>Measurand</th>
<th>Transduction Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Properties</strong></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>Piezoresistive</td>
</tr>
<tr>
<td>Temperature</td>
<td>Thermistor, thermo-mechanical, Thermocouple</td>
</tr>
<tr>
<td>Humidity</td>
<td>Resistive, capacitive</td>
</tr>
<tr>
<td>Flow</td>
<td>Pressure change, thermistor</td>
</tr>
<tr>
<td><strong>Motion Properties</strong></td>
<td></td>
</tr>
<tr>
<td>Position</td>
<td>E-mag, GPS, contact sensor</td>
</tr>
<tr>
<td>Velocity</td>
<td>Doppler, Hall effect, optoelectronic</td>
</tr>
<tr>
<td>Angular velocity</td>
<td>Optical encoder</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Piezoresistive, piezoelectric, optical fiber</td>
</tr>
<tr>
<td><strong>Contact Properties</strong></td>
<td></td>
</tr>
<tr>
<td>Strain</td>
<td>Piezoresistive</td>
</tr>
<tr>
<td>Force</td>
<td>Piezoelectric, piezoresistive</td>
</tr>
<tr>
<td>Torque</td>
<td>Piezoresistive, optoelectronic</td>
</tr>
<tr>
<td>Slip</td>
<td>Dual torque</td>
</tr>
<tr>
<td>Vibration</td>
<td>Piezoresistive, piezoelectric, optical fiber, sound, ultrasound</td>
</tr>
<tr>
<td>Presence</td>
<td>Tactile/contact</td>
</tr>
<tr>
<td></td>
<td>Proximity</td>
</tr>
<tr>
<td></td>
<td>Distance/range</td>
</tr>
<tr>
<td></td>
<td>Motion</td>
</tr>
<tr>
<td>Biochemical Identification</td>
<td>Biochemical agents</td>
</tr>
<tr>
<td></td>
<td>Personal features</td>
</tr>
<tr>
<td></td>
<td>Personal ID</td>
</tr>
</tbody>
</table>
Sensor Output

• Analog
  - 4-20 mA current loop
  - ±10V DC
  - ±100 mV
  - +5 V, +10 V
  - Audio (0-20 kHz) AC
  - Ultrasonic (20 kHz-1 MHz) AC
  - ...

• Digital
  - Parallel (bytes, words with hand-shaking), TTL, Open collector Tristate, line driver/receiver interface devices
  - Discrete (5V, 24 V, differential line driver logic)
  - RS-232C
  - RS-422
  - RS-485
  - IEEE-488 (GPIB)
  - Ethernet
  - USB
  - Firewire
  - FieldBus
  - ...
Sensors vs Sensing System
Force Sensor vs Bed Monitoring System

Force Sensor

Characteristics

Placement

Presentation, September, 2010
Current Sensor vs Electrical Appliance Monitoring System

Intelligent Sensor Unit
- **Power Supply**
  - Current Transformer & circuitry
  - Microcontroller
  - RF Module
Interdigital Sensor vs Domoic Acid Detection System
Smart Sensors:

Smart sensors are an extension of traditional sensors to those with advanced learning and adaptation capabilities. The system must also be re-configurable and perform the necessary data interpretation, fusion of data from multiple sensors and the validation of local and remotely collected data. Smart sensors therefore contain embedded processing functionality that provides the computational resources to perform complex sensing and actuating tasks along with high level applications.

The functions of a smart sensor system can be described in terms of compensation, information processing, communications and integration. The combination of these respective elements allow for the development of smart sensors that can operate in a multi-modal fashion as well conducting active autonomous sensing.
According to Global Industry Analysts, Inc., the world smart sensors market is projected to reach US$7.8 bn by 2012.

Even though the economic crisis is dominating, the demand for “smart sensors” is continuously increasing in all areas (BizAcumen, Inc).
Intelligent Sensors

Intelligent sensor is the sensor that has one or several intelligent functions, such as self-testing, self-identification, self-adaptation etc.

What does it make a sensor to be intelligent?

Very often it means a presence of microprocessor or microcontroller.
Survey on Smart / Intelligent Sensors

Definition:

Functional definition: Sensor with any intelligent function as self-identification, self-validation, self-testing, self-adaptation etc.

Technological definition: Combination of sensing element, analog interface circuit, ADC and bus interface

Self-checking definition: Sensors with only self-checking (self-calibration, self-validation) function

IEEE 1451 definition: IEEE 1451 compatible sensor
Survey results on Smart / Intelligent Sensors

- 61%: Smart Sensor Definition
- 18%: Functional definition
- 7%: Technological definition
- 7%: All definition is OK
- 6%: Other definition
- 1%: Self-checking definition
- 1%: IEEE 1451 definition
Another survey

What is your topic of interest in Sensors related research?

Ans: Smart sensors and systems

An integrated smart sensor and system containing all sensing elements along with wireless communication and power management.
Wireless Sensors Network - WSN

Wireless Sensor Network

Gateway Node

Wireless Sensor Node

User
What are WSN?

- Large number of heterogeneous Sensor devices spread over a large field.
- Wireless sensing + Data Networking. Group of sensors linked by wireless media to perform distributed sensing tasks.
Applications of WSN

- Military,
- Environmental, Health (Scanning), Space, Exploration,
- Vehicular Movement,
- Mechanical stress levels on attached objects etc.
• Precision agriculture
• Environment comfort & efficiency
• Smart homes
• Alarms, security, surveillance.
• Disaster management
• Health Care
• Traffic Management
• Transportation safety
• Land mine Detection

Applications (contd.)

Earthquake Response
Manufacturing
Wind Response
Sensor Augmented Fire Response
Elder Care
Characteristics of wireless sensor networks

Networks of typically small, battery-powered, wireless devices. On-board processing, Communication, and Sensing capabilities.

**WSN device schematics**
Involved Technologies

Sensor Network

- Computational Power
- Network Technology
- Sensor Technology
Challenges in WSN’s

- Energy
- Computation
- Communication
- Scalability
- Fault Tolerance
- Power Consumption
Current research problems in WSN

1. Network lifetime maximization
2. Energy efficient routing
3. Reliable event detection and transfer
4. Optimization among multiple, conflicting objectives
5. Bringing flexibility into the application-specific design of WSNs
### Summary of Wireless Protocols

<table>
<thead>
<tr>
<th>Standard</th>
<th>ZigBee (IEEE 802.15.4)</th>
<th>BlueTooth (IEEE 802.15.1 WPAN)</th>
<th>WiFi (IEEE 802.11 WLAN)</th>
<th>WiMax (IEEE 802.11 WWAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range</strong></td>
<td>100 m</td>
<td>10 m</td>
<td>5 km</td>
<td>15 km</td>
</tr>
<tr>
<td><strong>Data rate</strong></td>
<td>250-500 kbps</td>
<td>1 Mbps-3 Mbps</td>
<td>1Mbps-450 Mbps</td>
<td>75 Mbps</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>2.4 GHz</td>
<td>2.4 GHz</td>
<td>2.4, 3.7, and 5 GHz</td>
<td>2.3, 2.5 and 3.5 GHz</td>
</tr>
<tr>
<td><strong>Network Topology</strong></td>
<td>Star, Mesh, Cluster Tress</td>
<td>Star</td>
<td>Star, Tree, P2P</td>
<td>Star, Tree, P2P</td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td>Wireless Sensors (Monitoring and Control)</td>
<td>Wireless Sensors (Monitoring and Control)</td>
<td>PC based Data acquisition, Mobile Internet</td>
<td>Mobile internet</td>
</tr>
</tbody>
</table>
Overview of our research

- Why Do We Concern About Elder Care?
- Overview of existing research
- Underlying Research that Makes Things Work
- Do Elderly People Accept This Technology?
- Where Do We Go From Here?
A few recent news headlines (taken from New Zealand newspapers)

• Dead couple lay in home for 13 days
• Old tenant lay dead in flat for more than 10 days
• Elderly man lay dead for days
• Old woman found starved in flat

• Neighbours’ concern lead to body find (Dead body found after 9 days)
Population Ageing

There are currently **510,000** people over the age of 65 yrs in New Zealand.

In the United States alone, the number of people over age 65 yrs is expected to hit 70 million by 2030, almost doubling from 35 million in 2000.
Consequences Are ..... 

- Expenditures of the US for health care will project to rise to 17.9% of the GDP ($2.9 trillion) by 2015.

- Many elderly people are forced to consigned to expensive retirement homes.

- Many elderly people choose to stay at home also for privacy/dignity issues.
Why Do We Concern About Elderly Care?

• Because our parents are the next in line to be qualified as elderly, and then we are next to the next in line.

• Can advances in sensing cum instrumentation technology, embedded controller, wireless communications – enable elderly people to regain their capability of independent living?

We believe the answers are Yes!
Current on-going research

* University of Missouri-Columbia
  (Tiger Place – Smart Home for the Elderly)

• University of Virginia (Assisted Living Oriented Information Systems)

• University of Alabama in Huntsville
  (Patients Monitoring Using Personal Area Networks)

• UC Berkeley (Great Duck Island on Environmental Monitoring)
A few patents on the topic


Figures from one reported patent
Commercial situation

Is there any commercial system available so that you can buy and use to monitor elderly people?

- Part of the system available such as panic button, text message for a particular event and so on.
- Expensive system under special order may be possible.
Objective of our research

1. Design of a SMART Home for the elderly

2. A SAFE, SOUND and SECURED Living Environment

3. No camera or vision based system

4. A low-cost system that can be affordable by almost everyone.
Functional Block Diagram

- **Device #1** → **Sensor Unit #1**
- **Device #2** → **Sensor Unit #2**
- **Device #n** → **Sensor Unit #n**
- **Sensor Unit #1** ↔ **Sensor Unit #2**
- **Sensor Unit #1** ↔ **Sensor Unit #n**
- **Central Controller Unit** ↔ **Cellular Modem**
- **Central Controller Unit** ↔ **PC**
- **PC** ↔ **RS232**
- **Cellular Modem** ↔ **RS232**
The Initial System

“SAM: Nana hasn’t used the kettle all morning.”

Presentation, September, 2010
Addition of non-electrical appliances
Addition of Flow sensor for water use monitoring
The Fabricated System

“SAM: Nana hasn’t used the kettle all morning.”
Electrical Appliance Monitoring Unit

- Sensor Unit (SU)
  - Power Supply
  - Current Transformer & circuitry
  - Microcontroller
  - RF Module
  - LED Display
Current Sensing circuit

Current Transformer Circuitry

- DAC
- 1kΩ
- 1kΩ
- 120Ω
- LM329
- 5V

External Interrupt

Phase
Neutral
Earth

Appliance

Phase
Neutral
Earth
Water-use Monitoring Unit based on Flow Sensor

- Flow sensor used to measure the flow of water
- Schematic showing circuit of module with flow sensor
Fabricated Prototype

Flow Sensor connected to module connected to development board

Wireless Module

Flow Sensor

LED Display

Silabs Development Board
Bed Monitoring Sensor

Force Sensor

FlexiForce Sensor

+5V

S

1

2

3

R1 1K

Pot 0.5 10K

LM311N

U1

C 100 nF

R2 1K

E INTO to Microcontroller

R1 220K

+5V
Fig. Characteristics of the force sensor
Prototype Unit

C8051F020 Development Board

Bed Monitoring Sensor Unit

LED Display
Setting Up The Sensor Unit

- The Sensor Unit is strategically placed in order to eliminate the temporary loading effects

- Computer Aided Design of the Bed Monitoring Sensor Unit
Experimentation and Determination of Sleep Quality
Interfacing of sensors to microcontroller

- Bed Sensor 1
  - Amplifier / Signal conditioning
- Bed Sensor 2
  - Amplifier / Signal conditioning
- Bed Sensor 3
  - Amplifier / Signal conditioning
- Bed Sensor 4
  - Amplifier / Signal conditioning

- 
  - Amplifier / Signal conditioning
  - Amplifier / Signal conditioning
  - Amplifier / Signal conditioning

- LCD Display
- μController
- ADC
- RF Transmitter

Diagram showing the interconnection of sensors, amplifiers, signal conditioning, LCD display, μController, ADC, and RF Transmitter.
## Experimental results with human

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Reading S1 (kg)</th>
<th>Reading S2 (kg)</th>
<th>Reading S3 (kg)</th>
<th>Reading S4 (kg)</th>
<th>Total weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only Bed</td>
<td>10.3</td>
<td>10.4</td>
<td>10.3</td>
<td>10.5</td>
<td>41.2</td>
</tr>
<tr>
<td>Elderly in the middle</td>
<td>18.4</td>
<td>15.2</td>
<td>23.6</td>
<td>26.9</td>
<td>84.1</td>
</tr>
<tr>
<td>Elderly on one side</td>
<td>19.3</td>
<td>16.5</td>
<td>26.2</td>
<td>22.2</td>
<td>84.2</td>
</tr>
<tr>
<td>Elderly on another</td>
<td>14.0</td>
<td>21.3</td>
<td>18.5</td>
<td>30.5</td>
<td>84.3</td>
</tr>
<tr>
<td>Child in the middle</td>
<td>13.5</td>
<td>14.3</td>
<td>16.9</td>
<td>17.0</td>
<td>61.7</td>
</tr>
<tr>
<td>Child on one side</td>
<td>14.6</td>
<td>10.5</td>
<td>21.6</td>
<td>15.1</td>
<td>61.8</td>
</tr>
<tr>
<td>Child on another</td>
<td>12.2</td>
<td>13.4</td>
<td>13.7</td>
<td>22.4</td>
<td>61.7</td>
</tr>
<tr>
<td>Adult on middle</td>
<td>18.7</td>
<td>20.8</td>
<td>36.7</td>
<td>33.8</td>
<td>110</td>
</tr>
<tr>
<td>Adult on one side</td>
<td>25.2</td>
<td>14.2</td>
<td>45.5</td>
<td>25.3</td>
<td>110.2</td>
</tr>
<tr>
<td>Adult on another</td>
<td>13.7</td>
<td>22.5</td>
<td>25.8</td>
<td>48.1</td>
<td>110.1</td>
</tr>
<tr>
<td>Adult lying diagonally</td>
<td>17.2</td>
<td>20.5</td>
<td>28.2</td>
<td>44.3</td>
<td>110.2</td>
</tr>
<tr>
<td>(S4-S1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult lying diagonally</td>
<td>21.5</td>
<td>17.4</td>
<td>44.8</td>
<td>26.5</td>
<td>110.2</td>
</tr>
<tr>
<td>(S3-S2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis of results at steady state condition

$S_1$ : Signal from Sensors#1.
$S_2$ : Signal from Sensors#2.
$S_3$ : Signal from Sensors#3.
$S_4$ : Signal from Sensors#4.

$S_{avg} = \frac{(S_1 + S_2 + S_3 + S_4)}{4}$; $S_{avg}$ is the average signal.

If $(S_1 + S_2) > 2 \times S_{avg}$; the head is at $(S_1, S_2)$ side.
If $(S_3 + S_4) > 2 \times S_{avg}$; the head is at $(S_3, S_4)$ side.
If $(S_1 + S_3) = (S_2 + S_4)$; the person is sleeping in the middle of the bed.
If $(S_1 + S_3) > (S_2 + S_4)$; the person is sleeping in the right side of the bed.
If $(S_1 + S_3) < (S_2 + S_4)$; the person is sleeping in the left side of the bed.
Transient response

- Person sleeping on the bed is having some movement
- Person sits down on the bed from sleep
- Person gets down from the bed from sleep
- Person has some shivering feeling while sleeping on the bed
Communication Strategy
Sensor’s placement in a typical house-hold
### Monitoring the appliances

**S.A.M.**

<table>
<thead>
<tr>
<th>Appliance Status</th>
<th>Last Monitored Active at</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettle</td>
<td>07:02 AM</td>
</tr>
<tr>
<td>TV</td>
<td>07:07 AM</td>
</tr>
<tr>
<td>Lamp</td>
<td>09:15 PM</td>
</tr>
<tr>
<td>Bed</td>
<td>06:48 AM</td>
</tr>
<tr>
<td>Water</td>
<td>Checking...</td>
</tr>
</tbody>
</table>

**Active Sensors**

<table>
<thead>
<tr>
<th>Active Sensors</th>
<th>Active Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettle</td>
<td>If the Kettle has not been used between 7:00am and 8:00am then txt 0211231234.</td>
</tr>
</tbody>
</table>

**Monitoring**

- **Start Monitoring**
- **Stop Monitoring**
- **View Log**

---

**DL cum Keynote**

Presentation, September, 2010
Appliances
Communication success rate as a function of distance in home environment
Abnormal Behavior Detection

1. Install the Sam Software package
2. Relate each sensor to an Appliance
3. Do you know enough about the monitored persons habits?
   - Yes
     - Enter a series of rules into the rule set
   - No
     - Utilise the automatic logging feature
GUI for Sensor Setup

Sensor Information

- **Sensor 1**: Radio
- **Sensor 2**: Microwave
- **Sensor 3**: Toaster

For example, sensor 1 could be a microwave, toaster, TV etc.

Number of Sensors:

1 2 3 4 5 6

- Update Sensors
- Undo Changes
Rule creation wizard

Step 1

The first step is to select the appliance you wish to create a rule for. You should have already configured the appliance / sensor detail under the sensors tab. If you haven’t please cancel this wizard and do so.

Reading Lamp

You have selected the Reading Lamp, this appliance is configured as sensor 2 please ensure this information is correct before continuing.
Immediate rule creation window for rule type 1

If the **TV** has not been used between 7:30 am and 10:00 pm then send the following text message to 0211231234
Monitoring the appliances

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Status</th>
<th>Last Monitored Active at</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettle</td>
<td>Active</td>
<td>07:02 AM</td>
</tr>
<tr>
<td>TV</td>
<td>Active</td>
<td>07:07 AM</td>
</tr>
<tr>
<td>Lamp</td>
<td>Inactive</td>
<td>09:15 PM</td>
</tr>
<tr>
<td>Bed</td>
<td>Inactive</td>
<td>06:48 AM</td>
</tr>
<tr>
<td>Water</td>
<td>Checking...</td>
<td></td>
</tr>
</tbody>
</table>

Active Sensors

- Kettle

Active Rules

- If the Kettle has not been used between 7:00 am and 8:00 am then text 0211231234.
Activity Log viewer

S.A.M - Log

Activity Log Viewer

Please select the day you wish to view the log for.

12/08/08

Open

Activity Log Viewer

Heat Gun was inactive at 11:14.54AM.
Heat Gun was inactive at 11:15.18AM.
Lamp was inactive at 11:15.24AM.
Nothing was inactive at 11:15.28AM.
Heat Gun was inactive at 11:15.34AM.
Lamp was inactive at 11:15.38AM.
Nothing was inactive at 11:15.43AM.
Heat Gun was inactive at 11:18.42AM.
Lamp was inactive at 11:18.46AM.
Nothing was inactive at 11:18.51AM.
Heat Gun was inactive at 11:18.56AM.
Lamp was inactive at 11:19.1AM.
Nothing was inactive at 11:19.6AM.
Heat Gun was inactive at 11:19.12AM.
Lamp was inactive at 11:19.16AM.
Nothing was inactive at 11:19.21AM.
Heat Gun was inactive at 11:19.26AM.
Lamp was inactive at 11:19.30AM.
Nothing was inactive at 11:19.36AM.
Heat Gun was inactive at 11:19.42AM.
Lamp was inactive at 11:19.46AM.
Nothing was inactive at 11:19.51AM.
Heat Gun was inactive at 11:19.56AM.
Lamp was inactive at 11:20.0AM.
Nothing was inactive at 11:20.5AM.
Heat Gun was inactive at 11:20.12AM.
Lamp was inactive at 11:20.16AM.
Nothing was inactive at 11:20.21AM.
Heat Gun was inactive at 11:20.36AM.
Lamp was inactive at 11:20.41AM.
Heat Gun was inactive at 11:21.47AM.
Lamp was inactive at 11:21.51AM.
Nothing was inactive at 11:21.56AM.
Heat Gun was inactive at 4:48.50PM.
Heat Gun was inactive at 4:53.13PM.
Detection of daily life pattern and abnormal behavior

Start

Get Status from sensor #1

Is it Active

Yes

Get Status from sensor #2

Is it Active

Yes

Compare the status of sensor with the person's habit

Is it Normal Activity

Yes

Abnormal condition #1

No

Abnormal condition #2

No

Abnormal condition #3

No

Abnormal condition #n

No

Note Abnormal condition/s and compare with the mentioned rule and previous stored Data

Is it abnormal Activity

Yes

Generate a warning message to send text message

Wait for 1 minute and input from person under monitor

In case of no input from person

Send Text Message

Initial Data Gathering Phase

Getting the status from appliances and comparing with persons habits Phase

Final Decision Making Phase
Do Elderly People Accept This Technology?

A survey (with related questionnaire) has been conducted among many elderly people in New Zealand and India

Using camera and vision based system : NO

Using unobtrusive sensors : YES

Trial has been conducted in New Zealand, both in retirement home and as well as at personal home.
Possible Commercialisation

- Currently one Auckland based company has shown interest for pilot testing and is undergoing

- One US company has contacted and would like to get our prototype

- One Indian company would like to get our design to manufacture it.
Where do we go from here?

- Improve the Instrumentation System
  - Smart Measurement System to reduce the size of the sensing system

- Building on the present system
  - Incorporate additional household sensor
  - Optimum Number of Sensors selection

- Integrating the cellular modem into the Controller
- Making the whole system COGNITIVE
Future Sensor Concept
Future work: Zigbee Protocol

C8051F020 and PC connected with XBee through Serial Interface

Performance Specification:

<table>
<thead>
<tr>
<th>XBee</th>
<th>XBee-PRO</th>
<th>Performance Specification (contd.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Output: 1 mW (0dBm)</td>
<td>10 mW (+10 dBm)</td>
<td>Supply Voltage: 2.8 – 3.4 V</td>
</tr>
<tr>
<td>Indoor range: 30 m</td>
<td>90 m</td>
<td>Transmit Current: 45 mA @ 3.3 V</td>
</tr>
<tr>
<td>Outdoor range: 90 m</td>
<td>1.6 km</td>
<td>Receive Current: 50 mA @ 3.3 V</td>
</tr>
<tr>
<td>Operating frequency: 2.4 GHz</td>
<td></td>
<td>Power Down Sleep Current: &lt; 10 µA at 25 ºC</td>
</tr>
<tr>
<td>Interface Data Rate: Up to 115.2 Kbps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A Discussion on Wireless Power and EM Radiation

Power Output: 1 mW (0dBm) [XBee]  10 mW (+10 dBm) [Bee-PRO]

Radiation Thermometry: All surfaces at room temperature radiates infrared radiation at frequencies of about 30 Thz and at rates of 500 W/m2.

We would freeze to death without this radiation.

Photon Energies: Electromagnetic radiation is absorbed one photon at a time. To do damage to a molecule, such as DNA or a protein, the energy must be sufficient to break chemical bonds. UV radiation is dangerous.

Energy $E = h \nu$; $h$ is the Planck constant $= 6.626 \times 10^{-34}$ J-s

The energy of RF photon at 1 GHz $= 6.62 \times 10^{-25}$ J

The energy of RF photon at 1 THz $= 6.62 \times 10^{-22}$ J

The energy of a visible photon (555 nm) $\sim 4 \times 10^{-19}$ J

The energy of a UV photon (250 nm) $\sim 8 \times 10^{-19}$ J

Photon energies are 10,000 to 1,000,000 times smaller than those of visible lights.
CONCLUSIONS

• A smart home to care elderly people based on wireless sensors.

• The system doesn’t use camera or vision based system and thus acceptable to elderly community.

• The integrated system is able to support people who wish to live independently.
This is to certify that

Anuroop Gaddam
Massey University, New Zealand

advised by Subhas Chandra Mukhopadhyay
and Gourab Sen Gupta

has gotten THE FIRST PRIZE
in the 2007 Digital Signal Processing Creative Design Contest.

Cheng-Sheng Tu
Minister
Ministry of Education, TAIWAN
Smart monitor for elderly

Sensors and computers are coming close to doing what good neighbours used to do – checking that elderly people living alone have turned the TV off at night and cleared the letterbox daily, and calling for help if they notice a problem.

A team at Massey University’s school of engineering and advanced technology is completing refinements to its SAM (selective activity monitoring system) that will send a text message alarm if a home’s occupant doesn’t do what they normally do.

The prototype has already won an award, the Digital Signal Processing creative design contest, judged in Taiwan in November last year.

The challenge now, says associate professor Subhas Mukhopadhyay, is to find a volunteer to test the smart digital home system in a real situation, and an aged care housing or home support group to get involved.

“Quite often we are appalled by news headlines such as ‘Elderly man lay dead for days in his home’ or ‘Woman found starved in flat’,”

But the reality is that more and more elderly people are choosing to live privately and independently even though they and their families know there are risks, he says.

SAM aims to use microtechnology to manage the risks non-invasively.

The SAM technology has been developed to monitor use of household appliances and call for help if use patterns change. It’s launched graduate student Michael Sutherland into a career with Fisher and Paykel’s medical division, and now provides doctoral student Anuroop Gaddam with a specialist topic.

SAM sensors can be fitted inside wall sockets where the toaster or electric kettle is plugged in, or to the television and subject to further

By Janine Rankin
janine.rankin@msl.co.nz

been turned on to boil water for a hot drink by a certain time in the morning, if the television isn’t turned on and off again in the evening, or the person doesn’t get out of bed in the morning.

Dr Mukhopadhyay says the system will be more acceptable to elderly people who value their privacy than movement sensors or blatantly intrusive cameras.

There is no one person constantly monitoring the occupant’s movements, just the software, that will only text for help if patterns change and the audible alarm isn’t overridden.

Another advantage is it doesn’t depend on a person being conscious, recognising a problem, and being physically able to push a button for help. The text will be launched even if the person has fallen and is unconscious.

It’s then up to the caregiver or family member on the receiving end of the text to respond.

The sensor units look likely to cost $40 to $50 at the moment, but that price would come down with mass production.

Computer science professor Hans Guesgen is already working on ways to further refine the system to make sense of complex behaviours that are demonstrated by elderly people experiencing some degree of cognitive impairment.

The “ambient intelligence” would be able to alert caregivers to patterns...
Thank You

Questions or Comments?

DL cum Keynote
Presentation, September,
2010