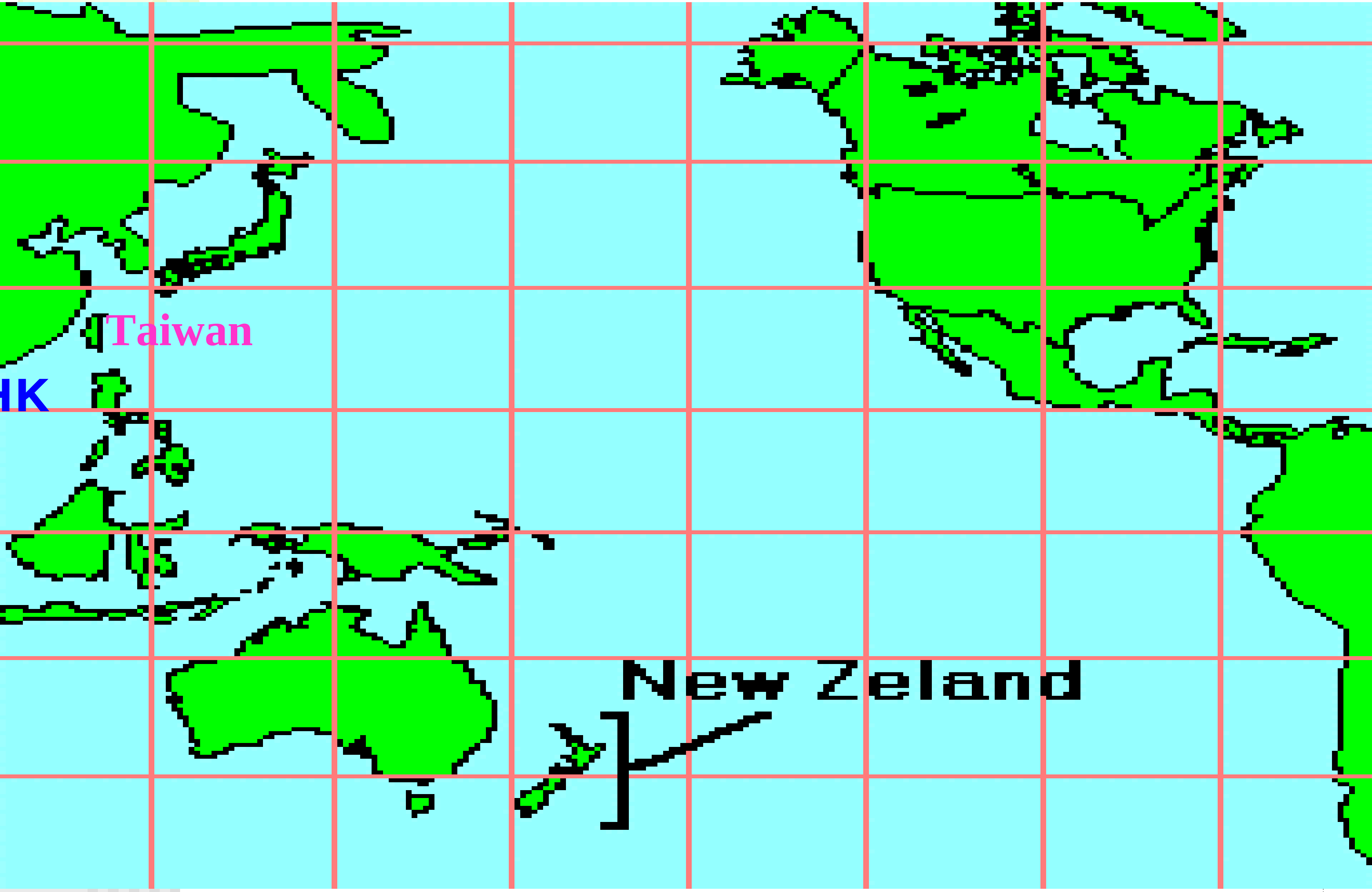
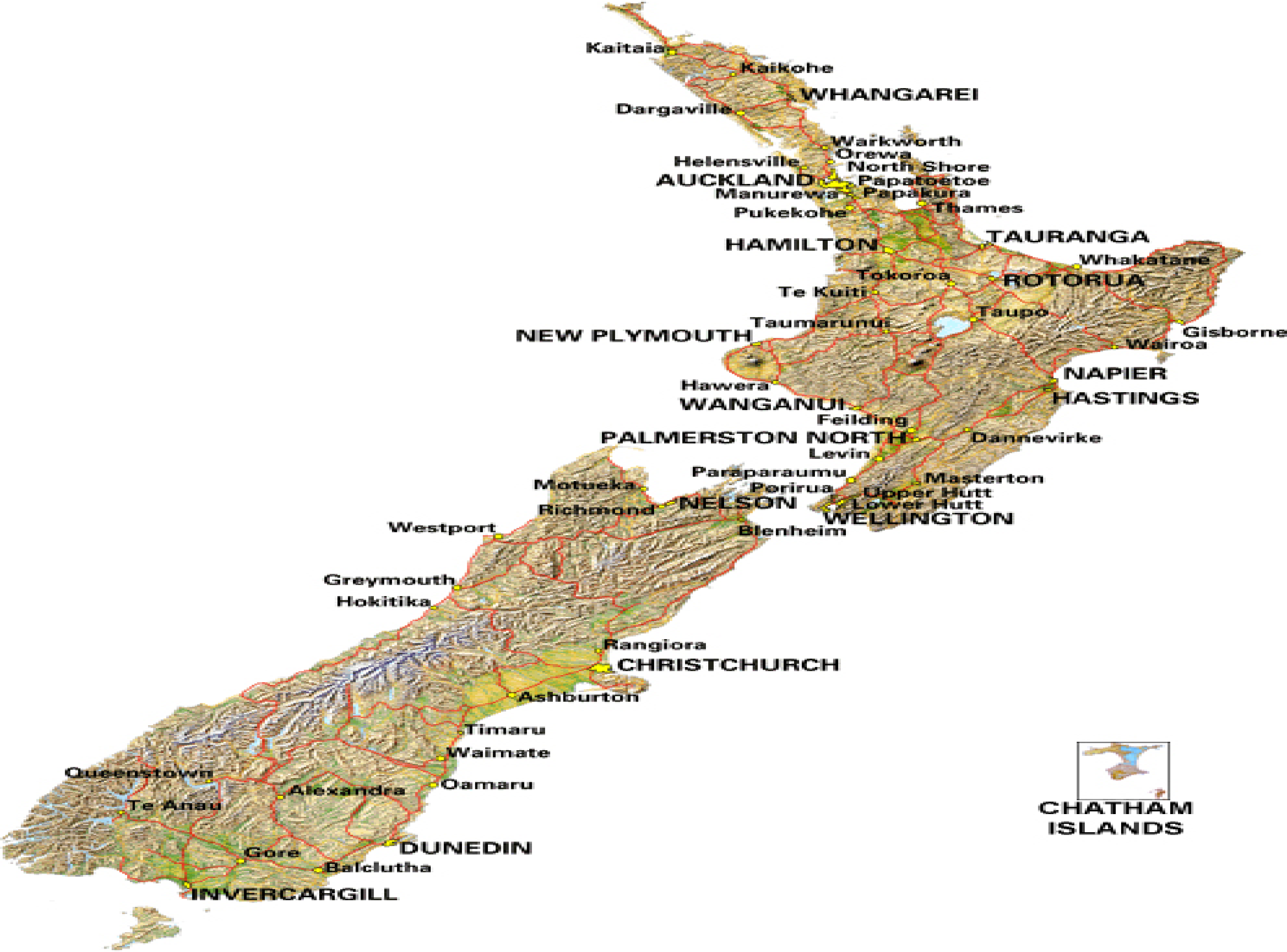
Wireless Sensors Network Based Smart Home to Care Elder People

Subhas Mukhopadhyay
Massey University
New Zealand

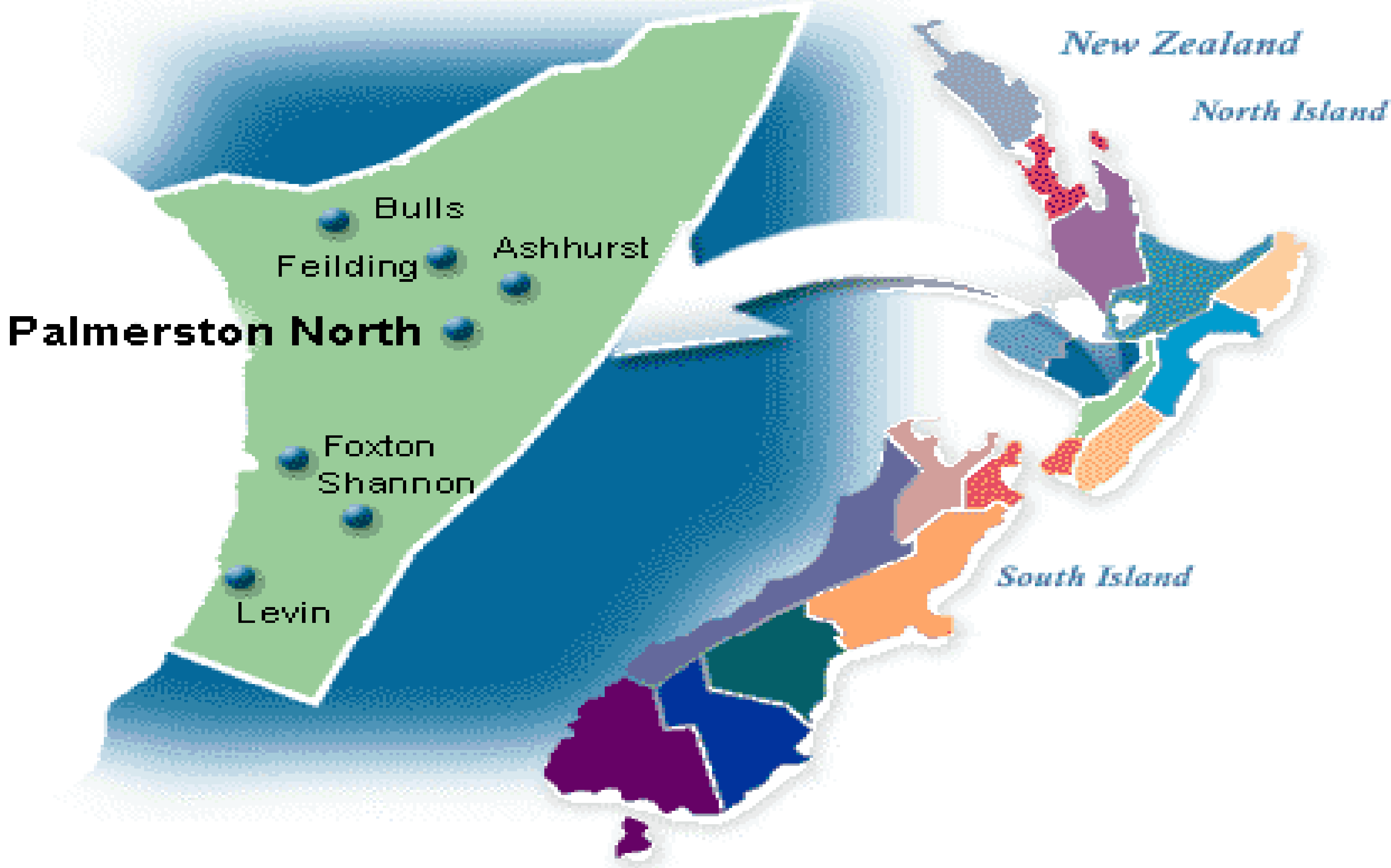
Where is New Zealand?





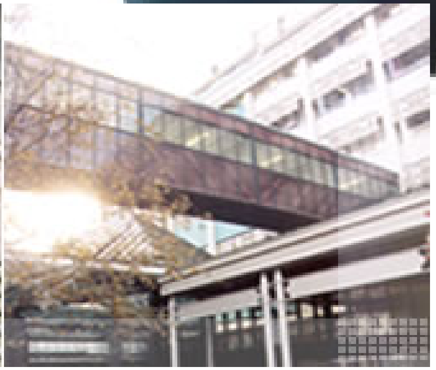
Kaitaia
Kaikohe
WHANGAREI
Dargaville
Warkworth
Orewa
Helensville
North Shore
AUCKLAND
Papatoetoe
Manurewa
Papakura
Pukekohe
Thames
HAMILTON
TAURANGA
Whakatane
Tokoroa
ROTORUA
Te Kuiti
Taupo
Taumarunui
NEW PLYMOUTH
Gisborne
Wairoa
NAPIER
HASTINGS
Hawera
WANGANUI
Feilding
PALMERSTON NORTH
Dannevirke
Levin
Paraparaumu
Masterton
Motueka
Porirua
Upper Hutt
Lower Hutt
Richmond
NELSON
WELLINGTON
Westport
Blenheim
Greymouth
Hokitika
Rangiora
CHRISTCHURCH
Ashburton
Timaru
Waimate
Queenstown
Oamaru
Alexandra
Te Anau
CHATHAM ISLANDS
DUNEDIN
Gore
Balclutha
INVERCARGILL

My city is Palmerston North







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IEEE Sensors Council

ANNOUNCEMENTS

- IEEE SENSORS 2010: - The 9th 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
- 1st IEEE International Conference on Smart Grid Communications
  October 4-6, 2010, National Institute of Standards and Technology (NIST) Gaithersburg, Maryland, USA, (co-sponsored by IEEE Sensors Council)
- Impact factor: The Sensors Journal's Reputation keeps Growing!
- New tutorial - Terahertz Sensing Technology
- NEW member society joined the Sensor Council, IEEE Antennas and Popagation Society, 2008
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- IEEE Sensors Journal Subscription Information
- IEEE Sensors Jorunal Issues - Table of Contents, Abstracts, Full Papers
- IEEE Committee on Earth Observation, ICEO
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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

	Measurand	Transduction Principle
Physical Properties	Pressure	Piezoresistive
	Temperature	Thermistor, thermo-mechanical, Thermocouple
	Humidity	Resistive, capacitive
	Flow	Pressure change, thermistor
Motion Properties	Position	E-mag, GPS, contact sensor
	Velocity	Doppler, Hall effect, optoelectronic
	Angular velocity	Optical encoder
	Acceleration	Piezoresistive, piezoelectric, optical fiber
Contact Properties	Strain	Piezoresistive
	Force	Piezoelectric, piezoresistive
	Torque	Piezoresistive, optoelectronic
	Slip	Dual torque
	Vibration	Piezoresistive, piezoelectric, optical fiber, sound, ultrasound

Presence	Tactile/contact	Contact switch, capacitive
	Proximity	Hall effect, capacitive, magnetic, seismic, acoustic, RF
	Distance/range	E-mag (sonar, radar), magnetic, tunneling
	Motion	E-mag, IR, acoustic, seismic (vibration)
Biochemical	Biochemical agents	Biochemical transduction
Identification	Personal features	Vision
	Personal ID	Fingerprints, retinal scan, voice, vision motion analysis

Sensor Output

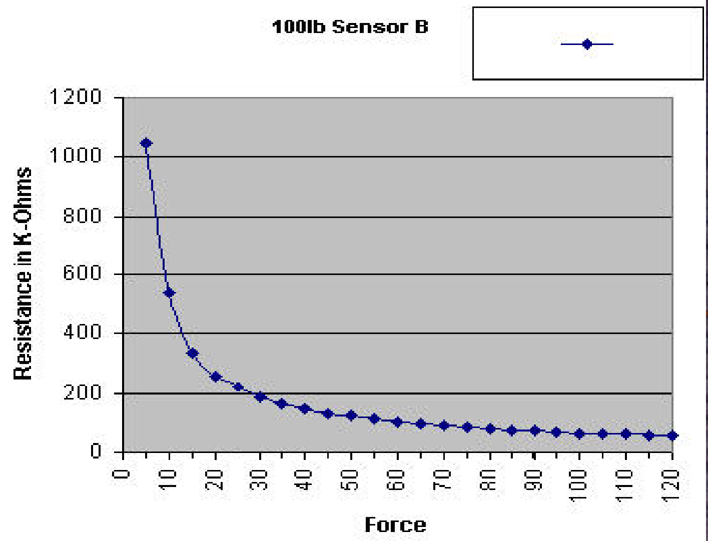
- **Analog**
  - 4-20 mA current loop
  - +- 10V DC
  - +- 100 mV
  - +5 V, +10 V
  - Audio (0-20 kHz) AC
  - Ultrasonic (20 kHz-1 MHz) AC
  - …

- **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
  - …

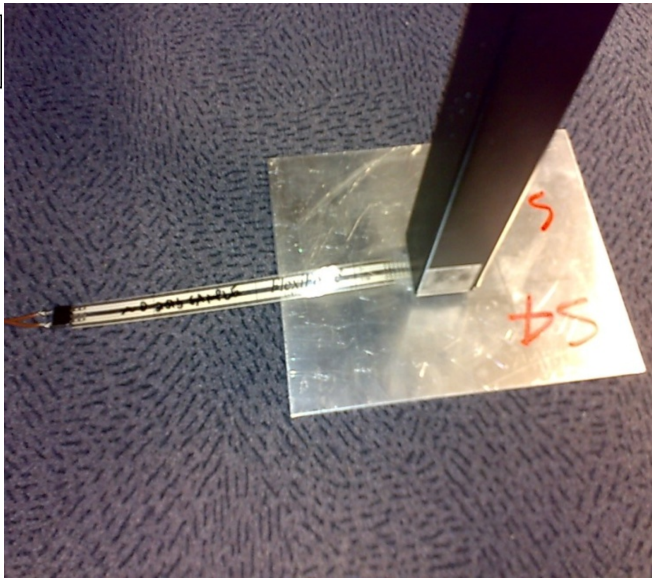
Sensors vs Sensing System

Force Sensor vs Bed Monitoring System

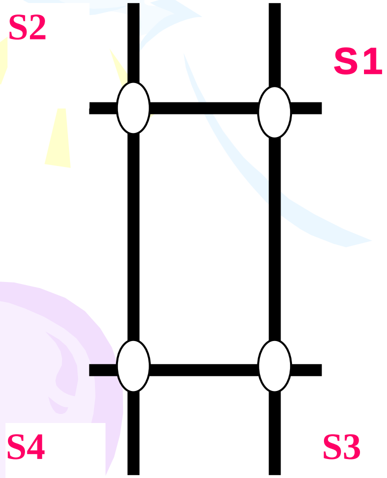
Force Sensor

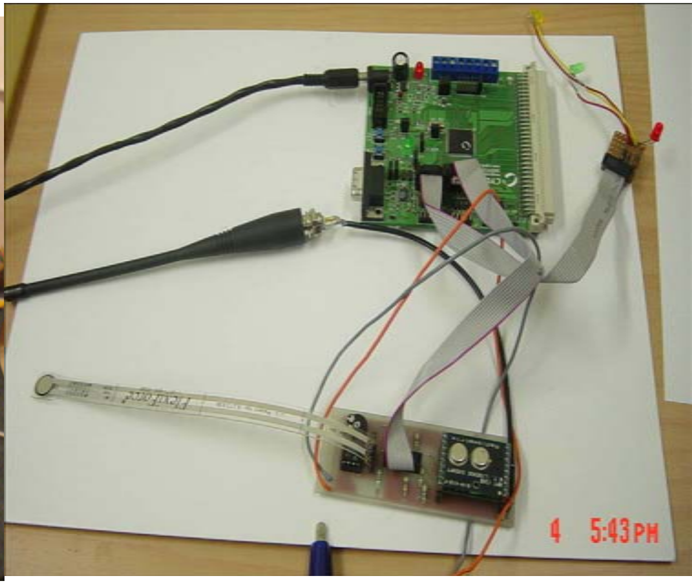


Characteristics

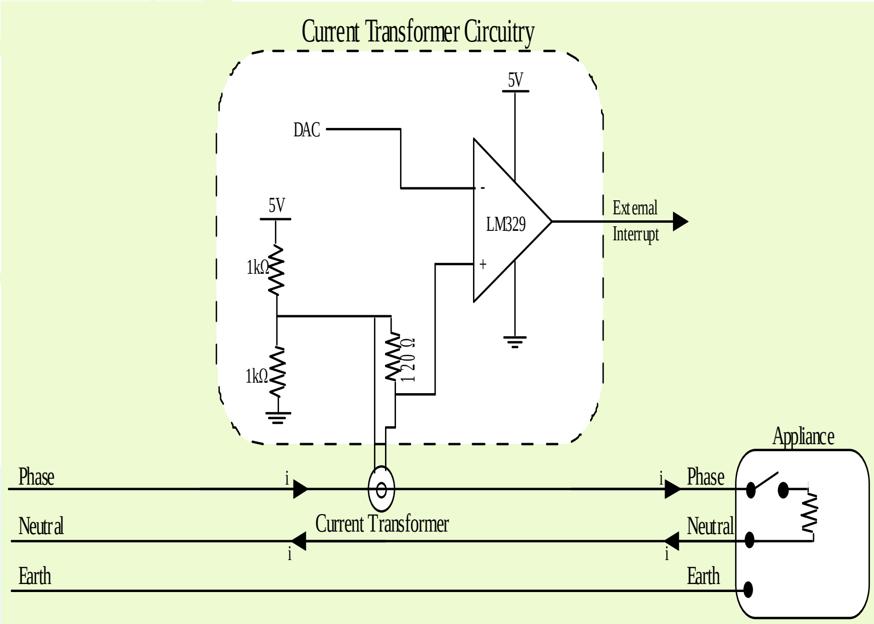


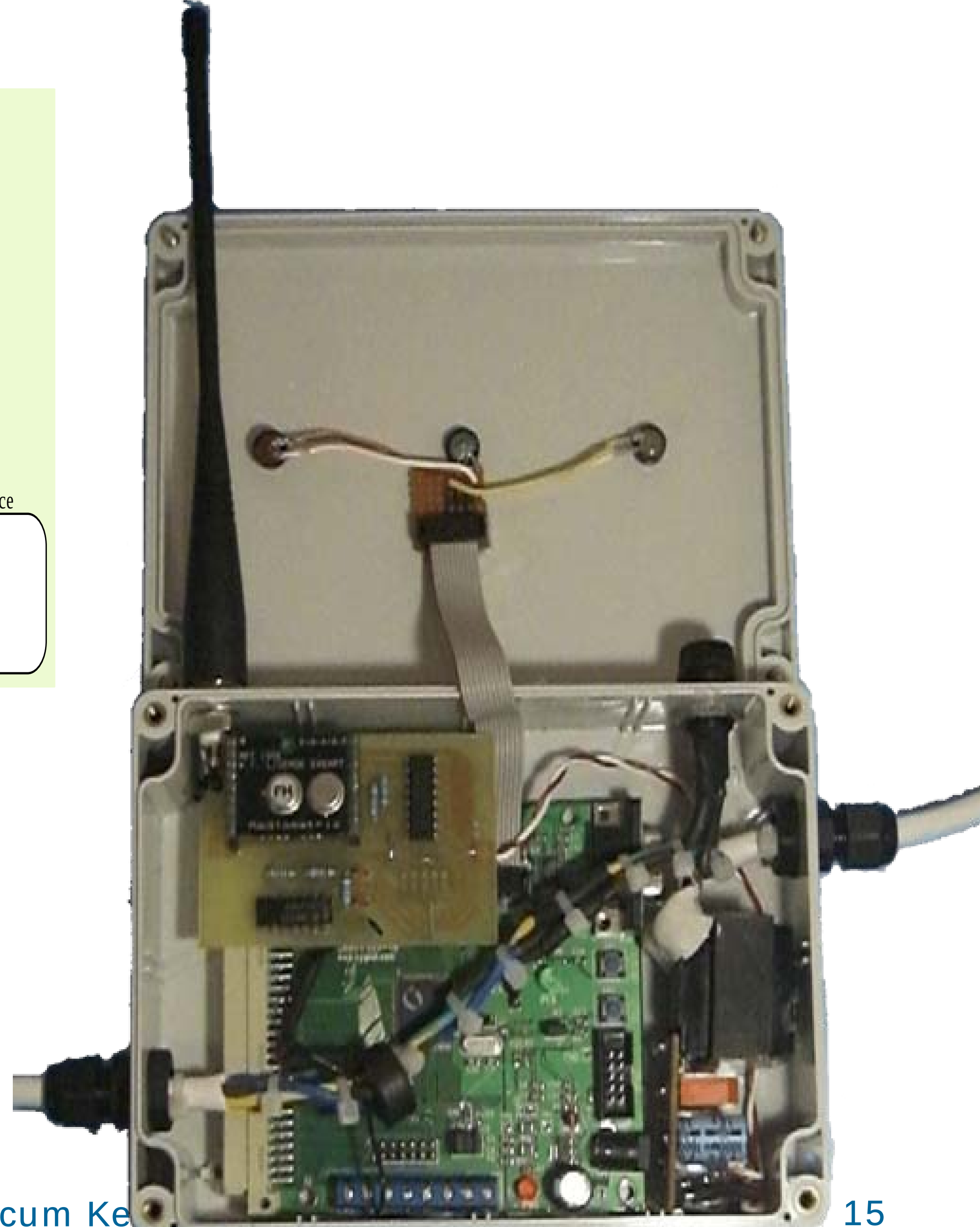
Placement





Current Sensor vs Electrical Appliance Monitoring System

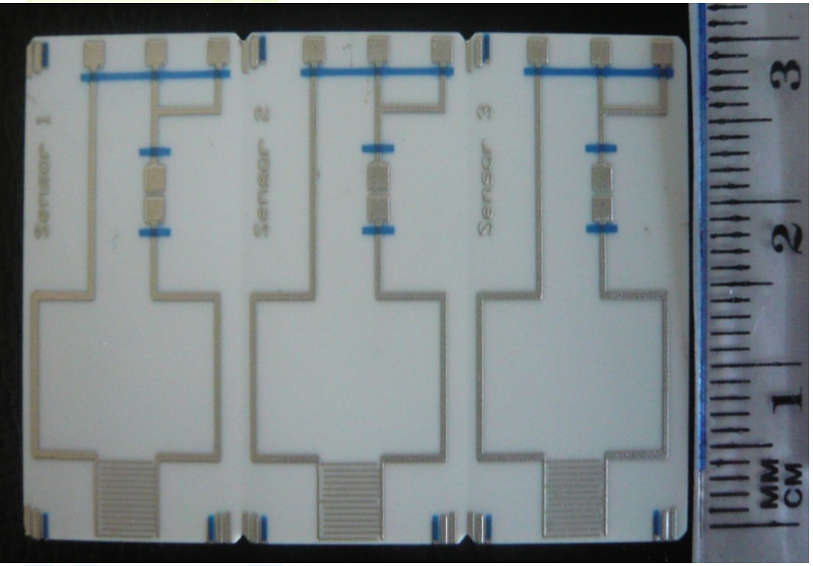


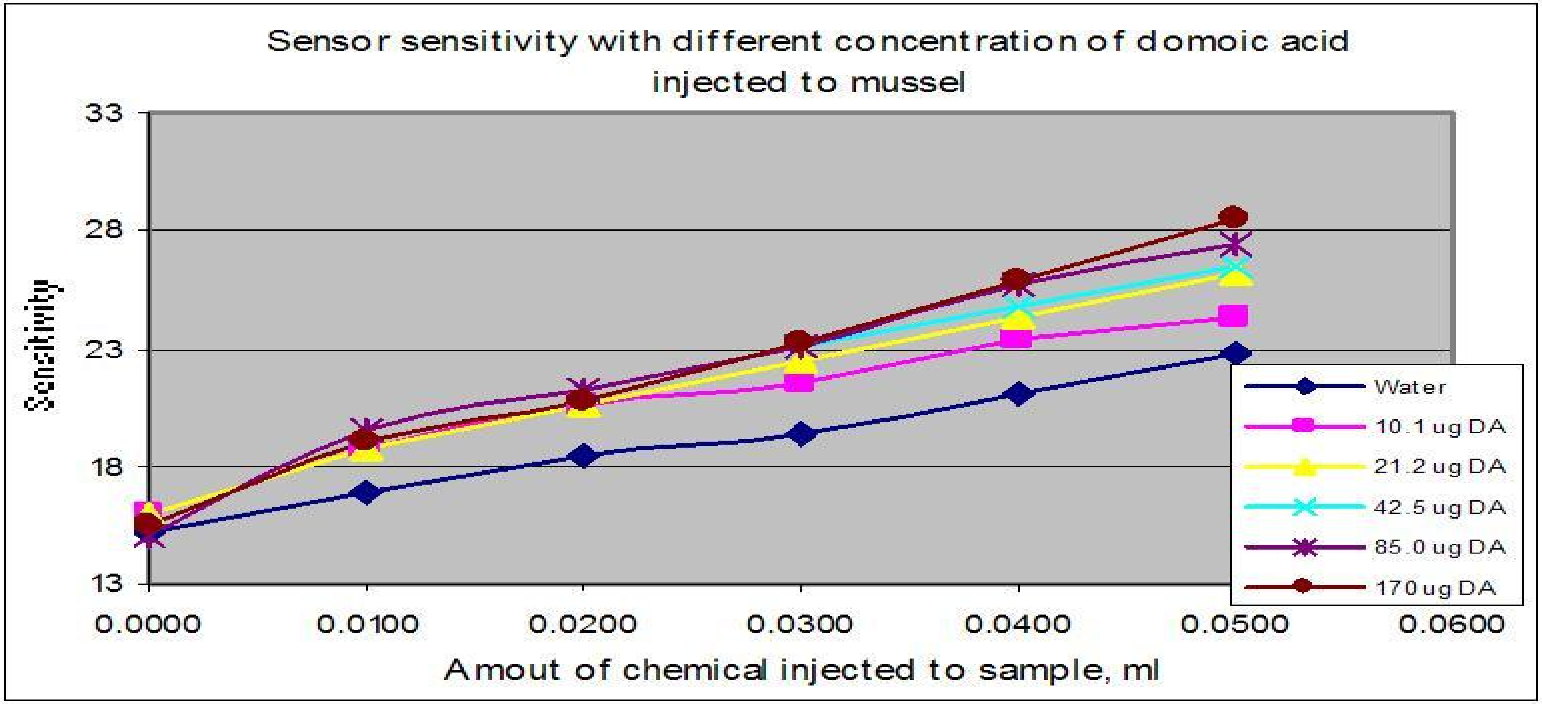


Intelligent Sensor Unit

- **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.

Smart Sensors: Market situation

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:

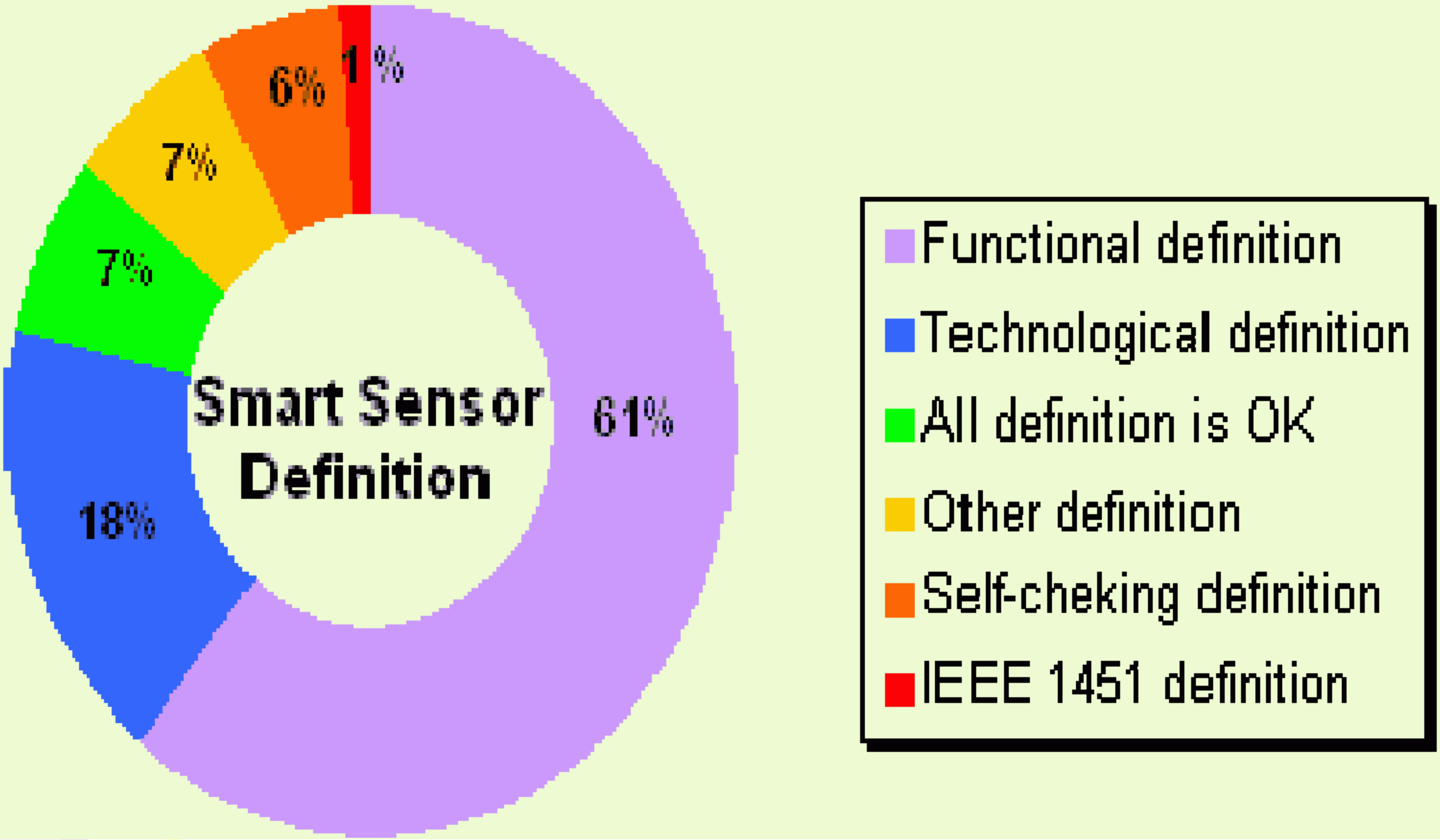
Functional definition: Sensor with any intelligent function as self-identification, self-validation, self-testing, self-adaptation etc.

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



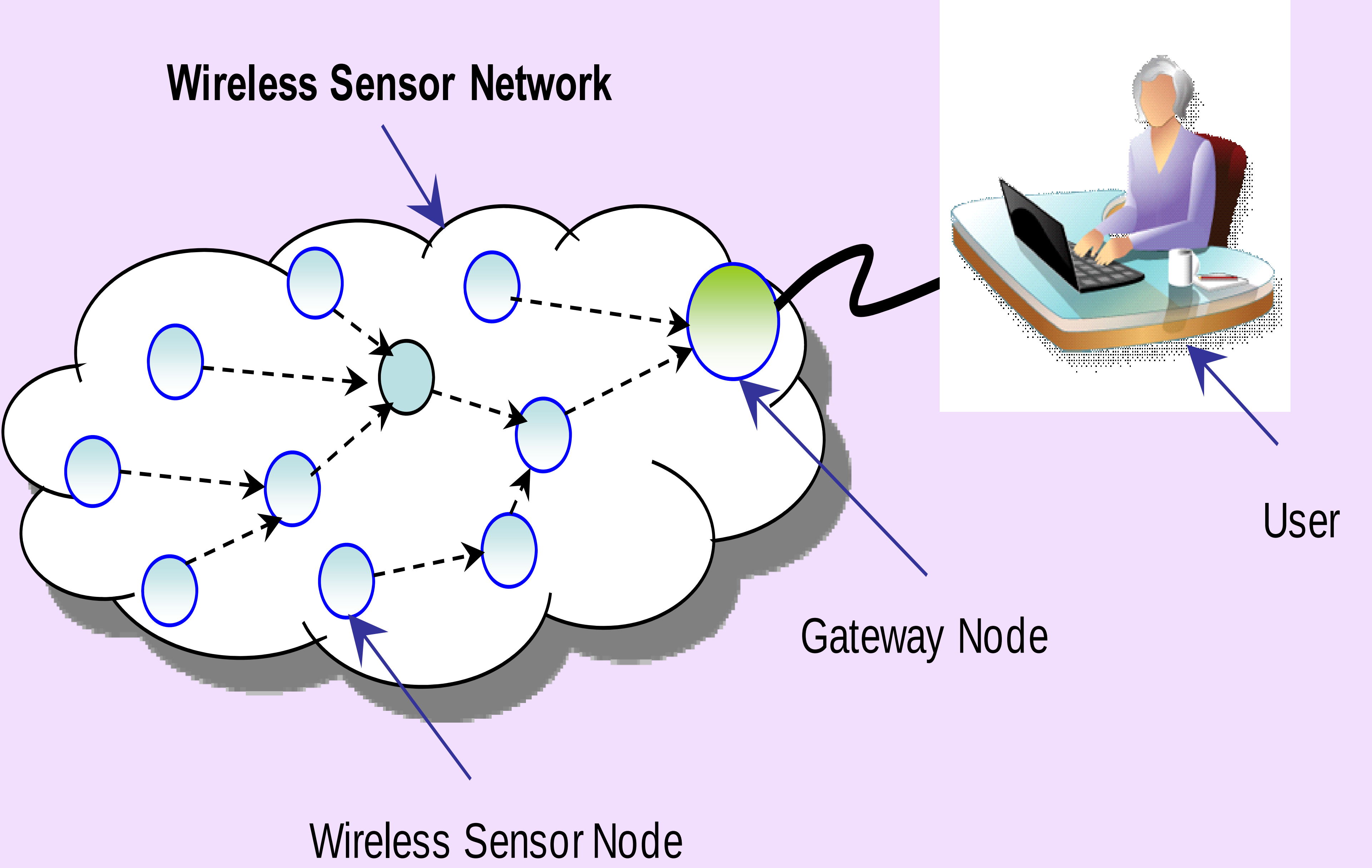
Another survey

What is your topic of interest in Sensors related research?

Ans: Smart sensors and systems

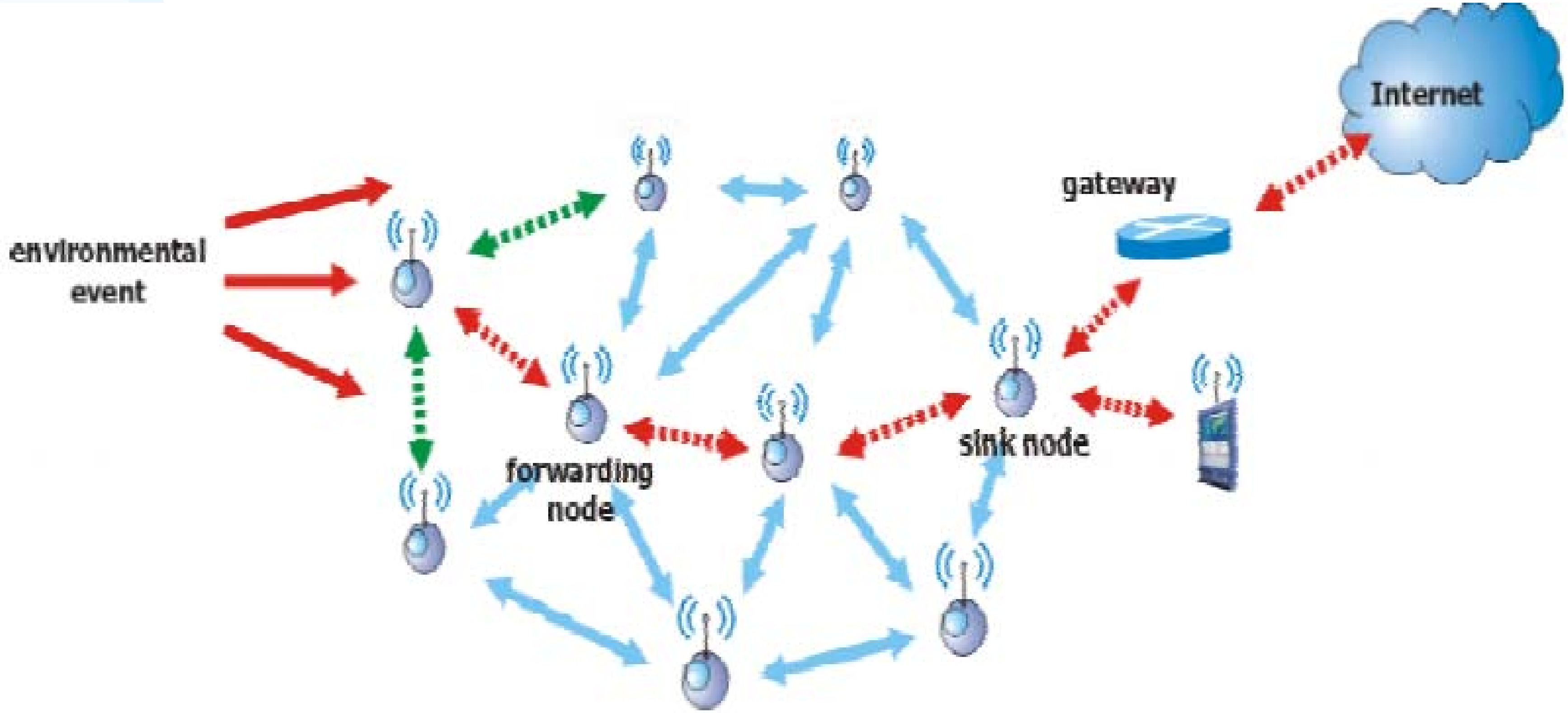
An integrated smart sensor and system containing all sensing elements along with wireless communication and power management.

Wireless Sensors Network - WSN



What are WSN?

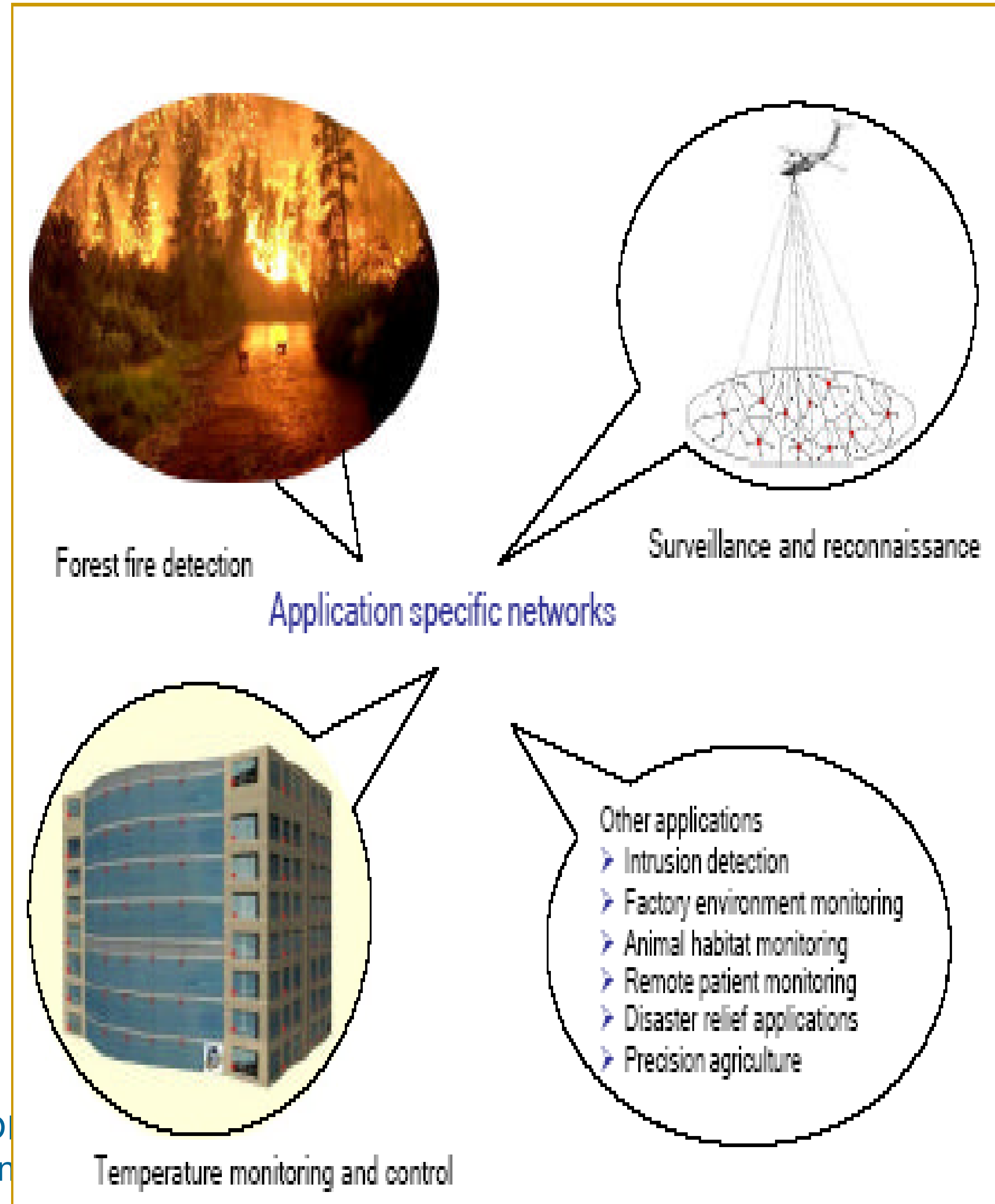
- Large number of heterogeneous Sensor devices spread over a large field.
- Wireless sensing + Data Networking. Group of sensors linked by wireless media to perform distributed sensing tasks



Applications of WSN

- Military, Environmental, Health (Scanning), Space, Exploration,

  Vehicular Movement, Mechanical stress levels on attached objects etc.



Applications (contd.)

- *Precision agriculture*
- *Environment comfort & efficiency*
- *Smart homes*
- *Alarms, security, surveillance.*
- *Disaster management*
- *Health Care*
- *Traffic Management*
- *Transportation safety*
- *Land mine Detection*

Sensor Augmented Fire Response

Earthquake Response

Manufacturing

Wind Response

Elder Care

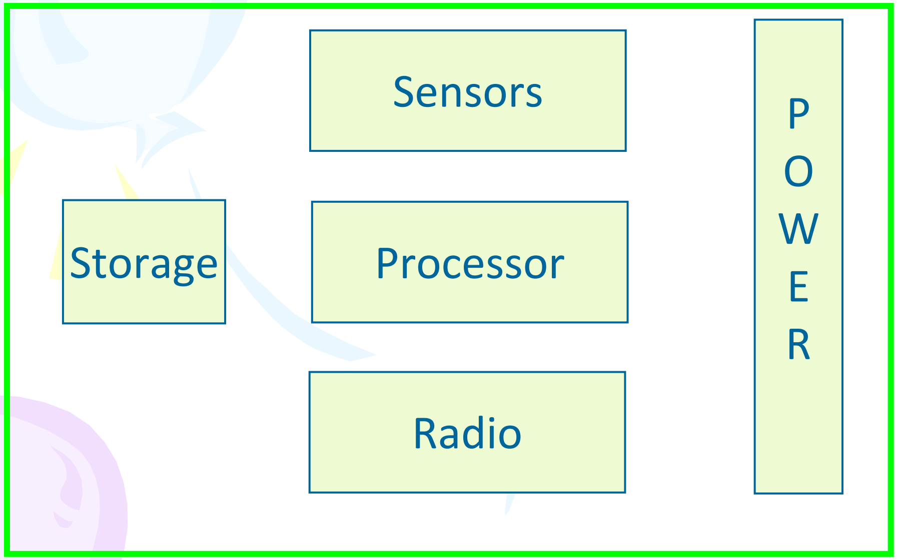
Characteristics of wireless sensor networks

Networks of typically small, battery-powered, wireless devices.

On-board processing,

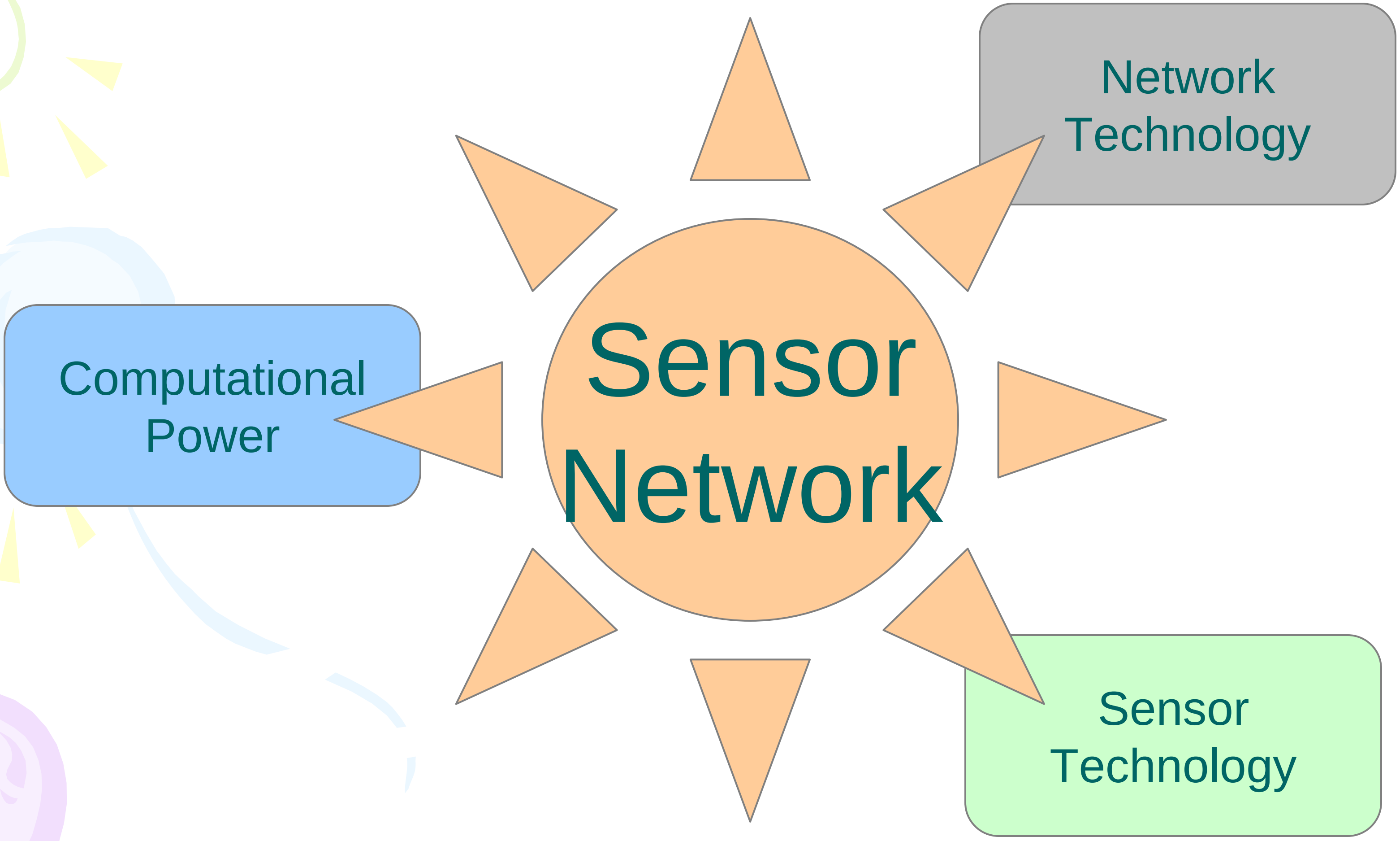
Communication, and

Sensing capabilities.



WSN device schematics

Involved Technologies



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

Standard	ZigBee (IEEE 802.15.4)	BlueTooth (IEEE 802.15.1 WPAN)	WiFi (IEEE 802.11 WLAN)	WiMax (IEEE 802.11 WWAN)
Range	100 m	10 m	5 km	15 km
Data rate	250-500 kbps	1 Mbps-3 Mbps	1Mbps-450 Mbps	75 Mbps
Band-width	2.4 GHz	2.4 GHz	2.4, 3.7, and 5 GHz	2.3, 2.5 and 3.5 GHz
Network Topology	Star, Mesh, Cluster Tress	Star	Star, Tree, P2P	Star, Tree, P2P
Applications	Wireless Sensors (Monitoring and Control)	Wireless Sensors (Monitoring and Control)	PC based Data acquisition, Mobile Internet	Mobile internet

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?

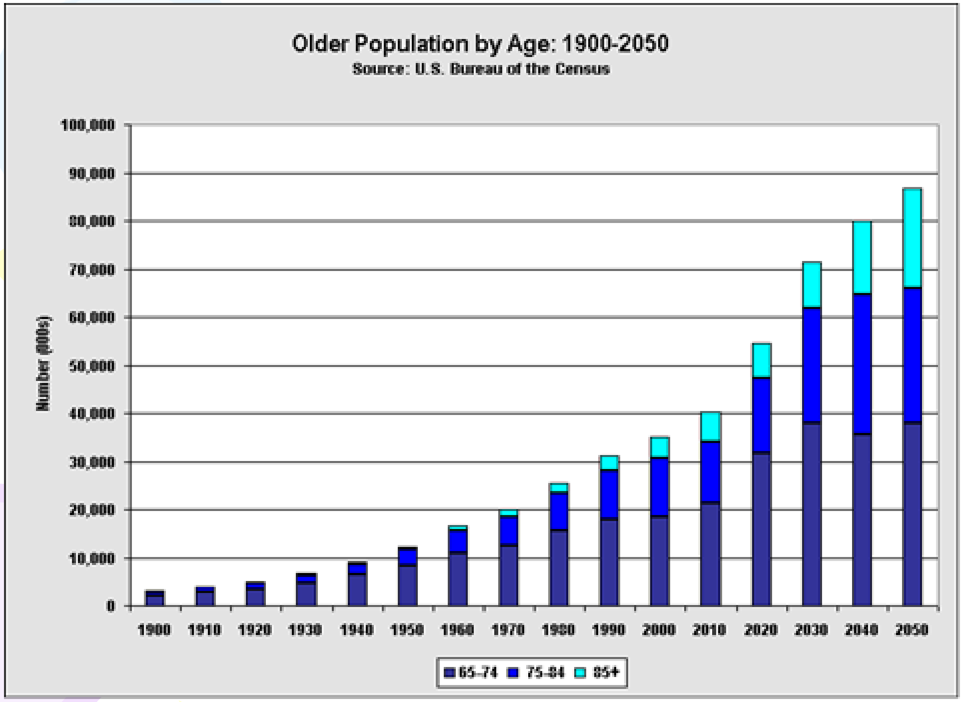
A few recent news headlines (taken from New Zealand newspapers)

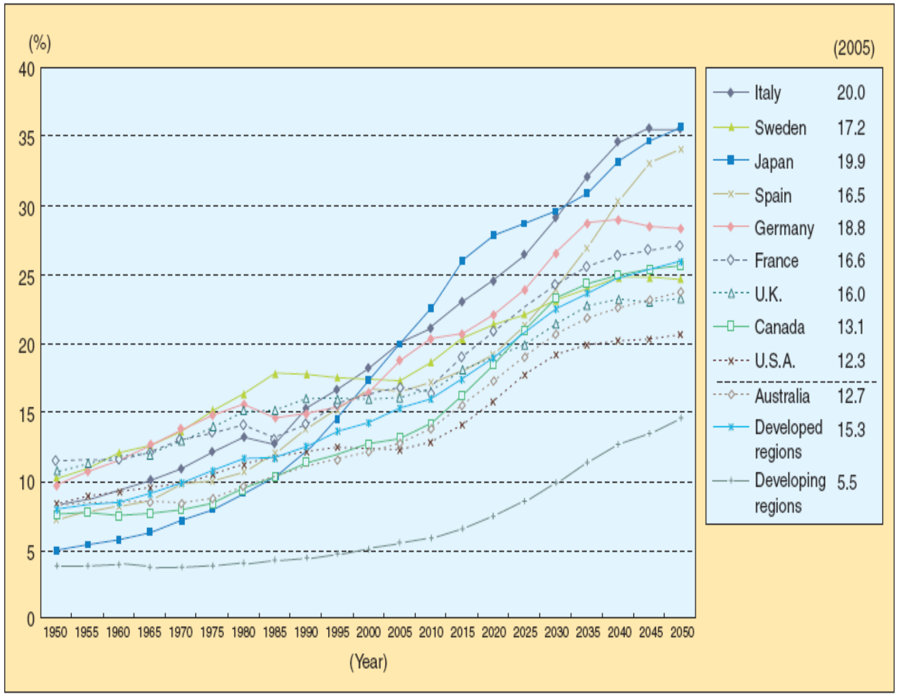
- Dead couple lay in home for 13 days
- Old tenant lay dead in flat for more than 10 days
- Elderly man lay dead for days
- Old woman found starved in flat
- Neighbours' concern lead to body find (Dead body found after 9 days)

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.



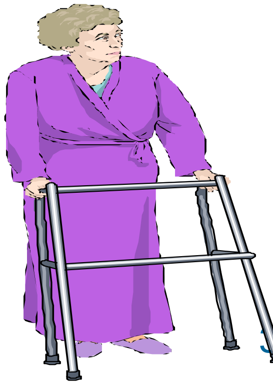


Consequences Are .....

- 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)

TIGER PLACE, Missouri

A few patents on the topic

[1] Cuddihy PE, Weisenberg JM, Ganesh M and Graichen CM, "System and method for determining periods of interest in home of persons living independently", US patent No. US7091865, 15th August 2006.

[2] Yoshiike N, Hattori A, Morinaka K, Inoue S and Tanaka S, "Home monitoring system for health conditions", European Patent No. EP1071055A1, 24th January 2001.

[3] Yoshiike N, Hattori A, Morinaka K, Inoue S and Tanaka S, "Home monitoring system for health conditions", European Patent No. EP1071055B1, 22nd December 2004.

[4] Yoshiike N, Hattori A, Morinaka K, Inoue S and Tanaka S, "Behavior determining apparatus, care system, care residence and behaviour information specifying apparatus and system", US patent No. US6796799, 28th September 2004.

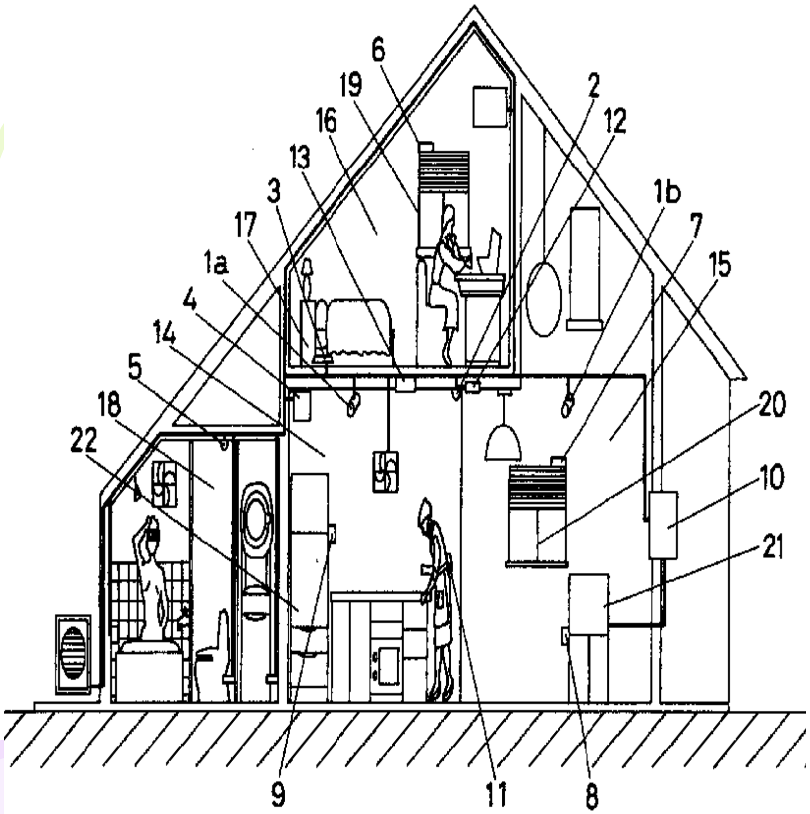
[5] Kiluk C, "Method in alarm system, including recording of energy consumption", US Patent No. US4990893, 5th February 1991.

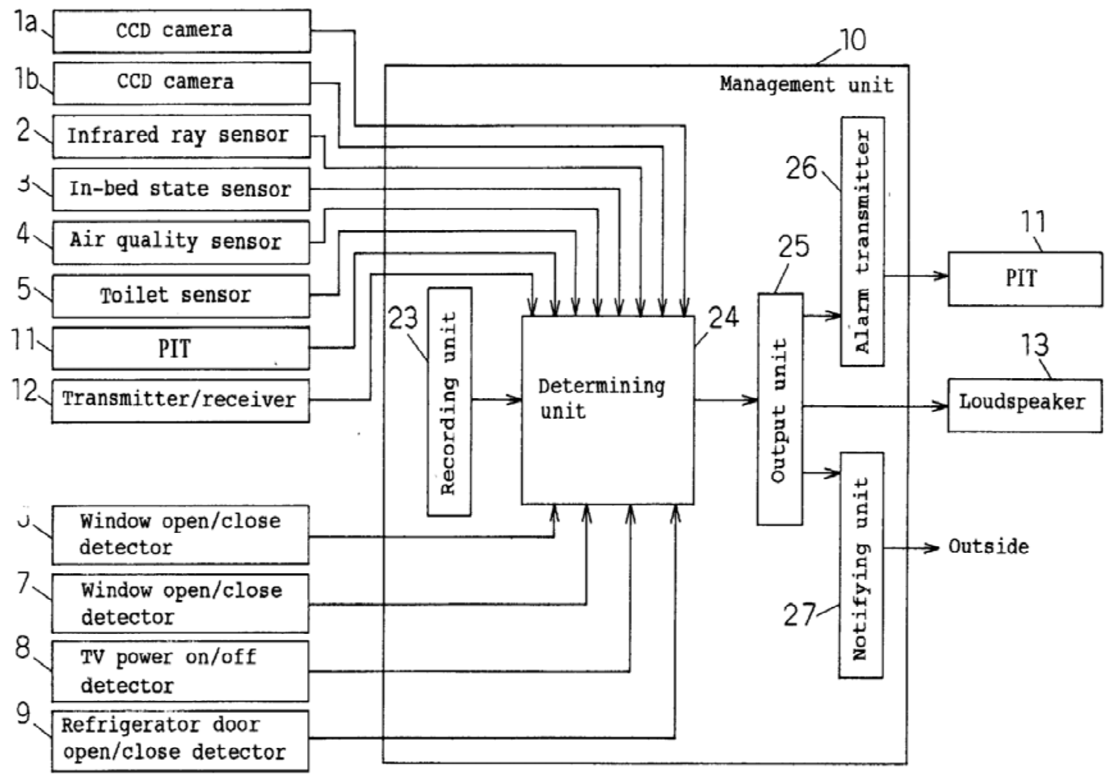
[6] Lane SS, Chadbourne C, Buller WT and Steiger SA, "Method of user monitoring of physiological and non-physiological measurements", US patent No. US6002994, 14th December 1999.

[7] Monroe DA, "Multimedia surveillance and monitoring system including network configuration", US patent No. US6970183, 29th November 2005.

[8] Davis-Havill JR and Walley JL, "Biomechanical monitoring apparatus". World Intellectual Property Organization, WO05120348A1, 22nd December 2005.

Figures from one reported patent





Commercial situation

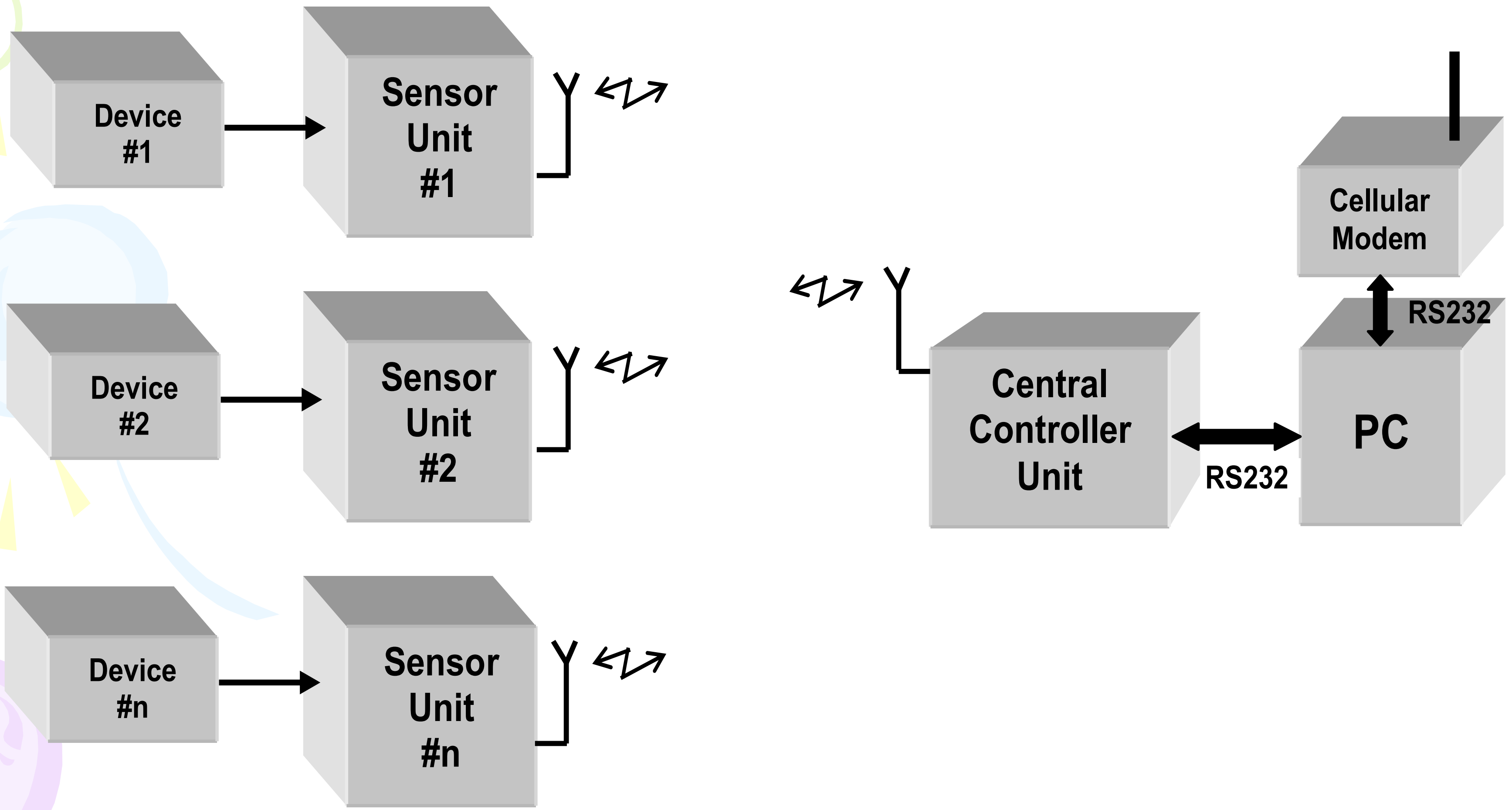
Is there any commercial system available so that you can buy and use to monitor elderly people?

- **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.**

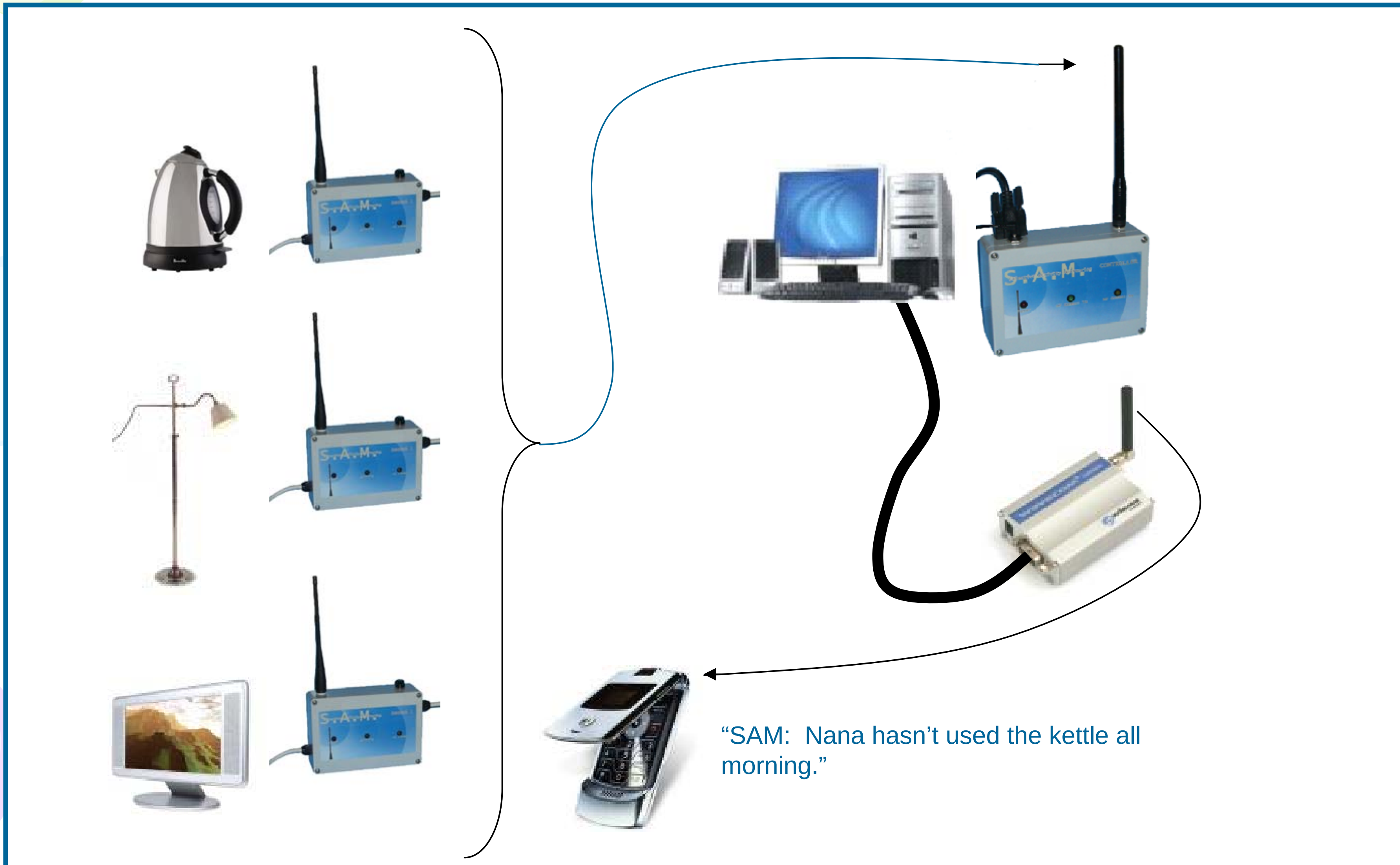
Objective of our research

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.

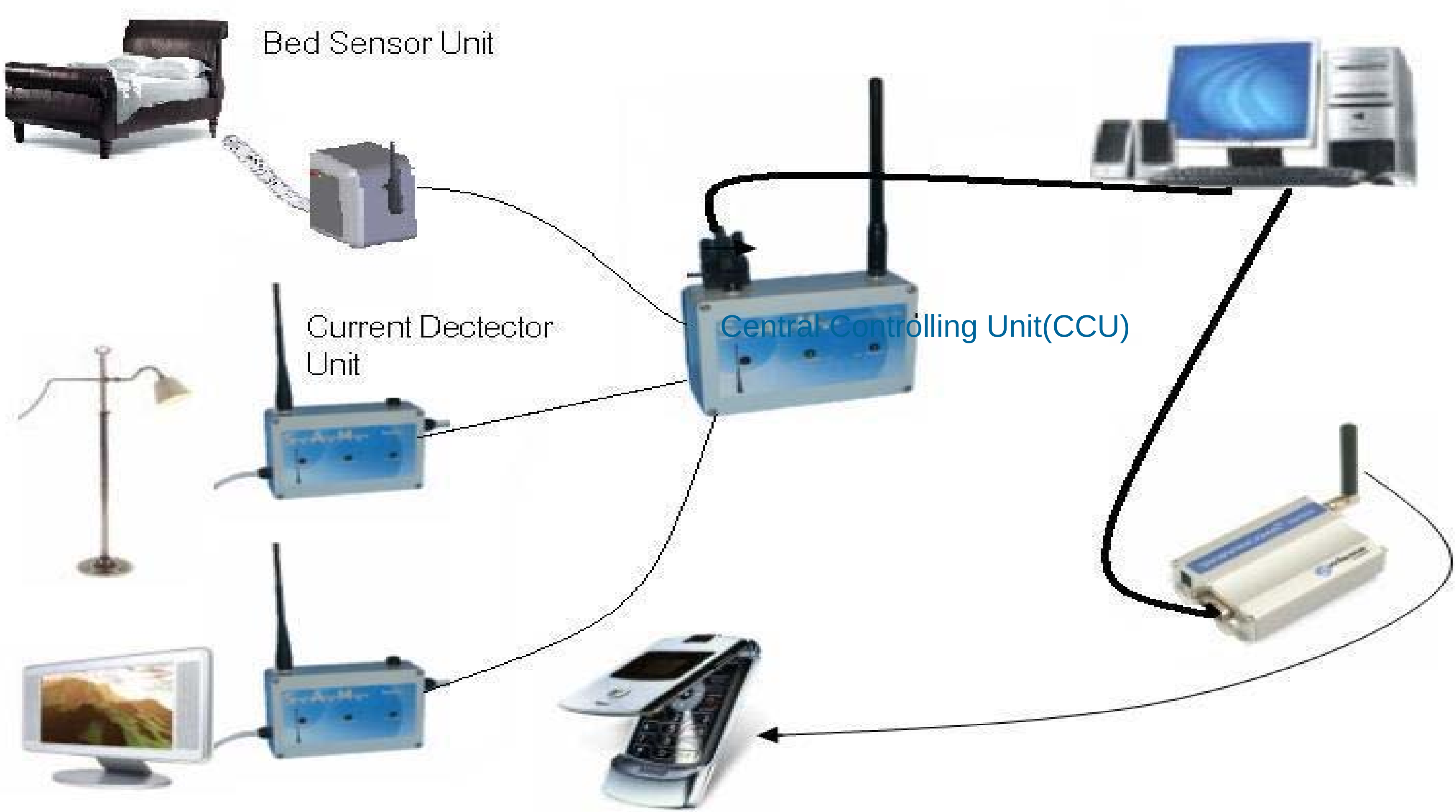
Functional Block Diagram



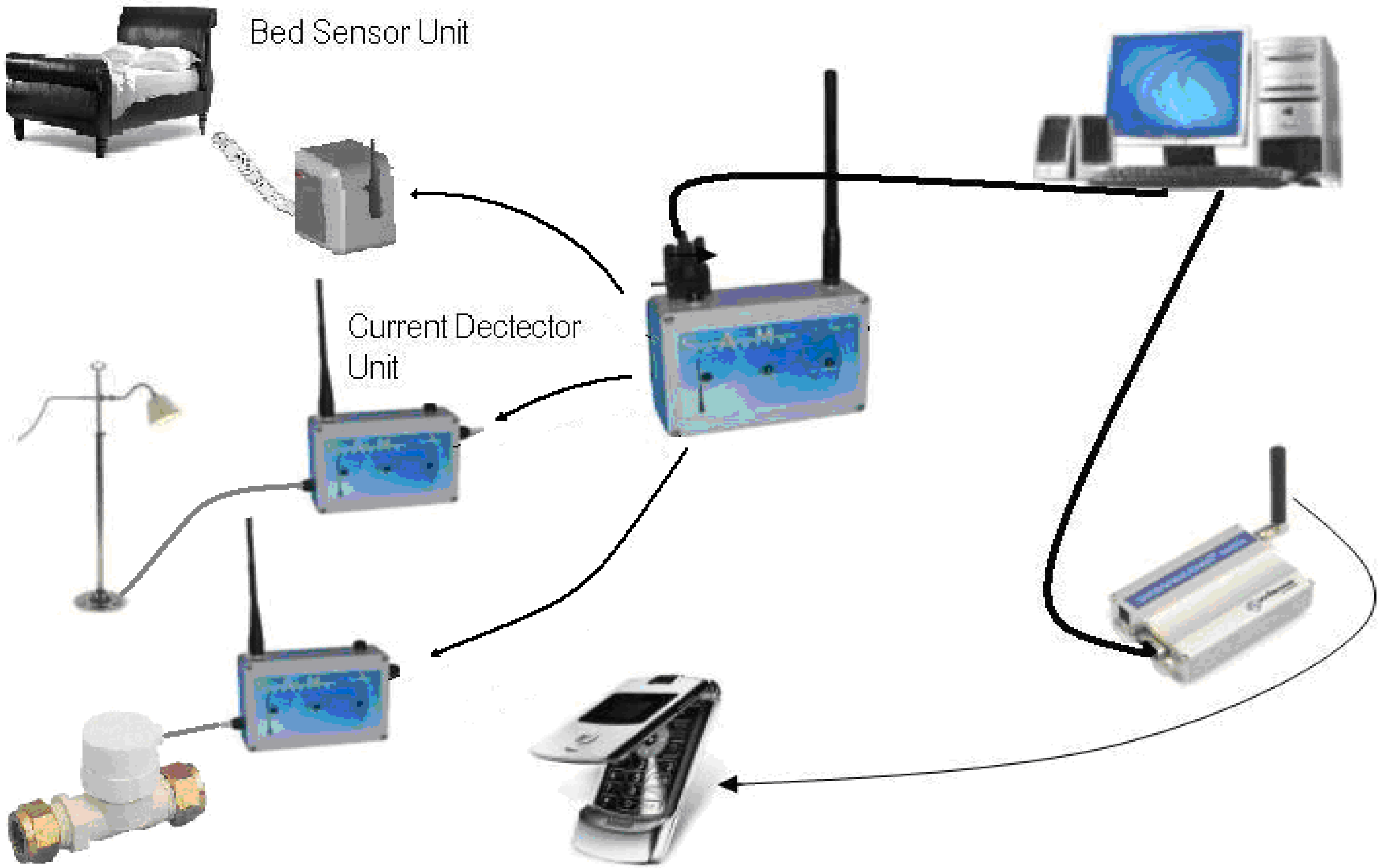
The Initial System



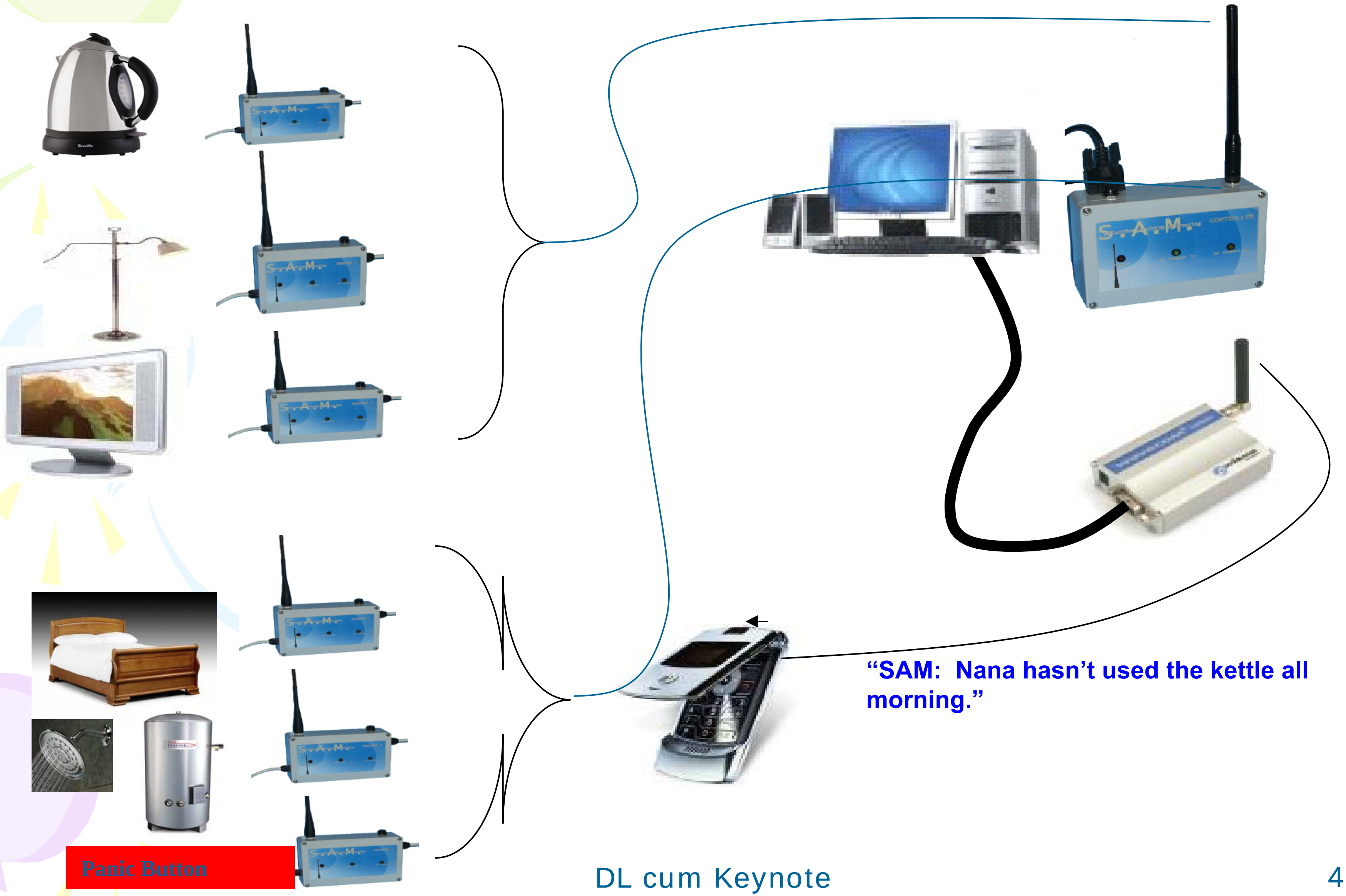
Addition of non-electrical appliances



Addition of Flow sensor for water use monitoring

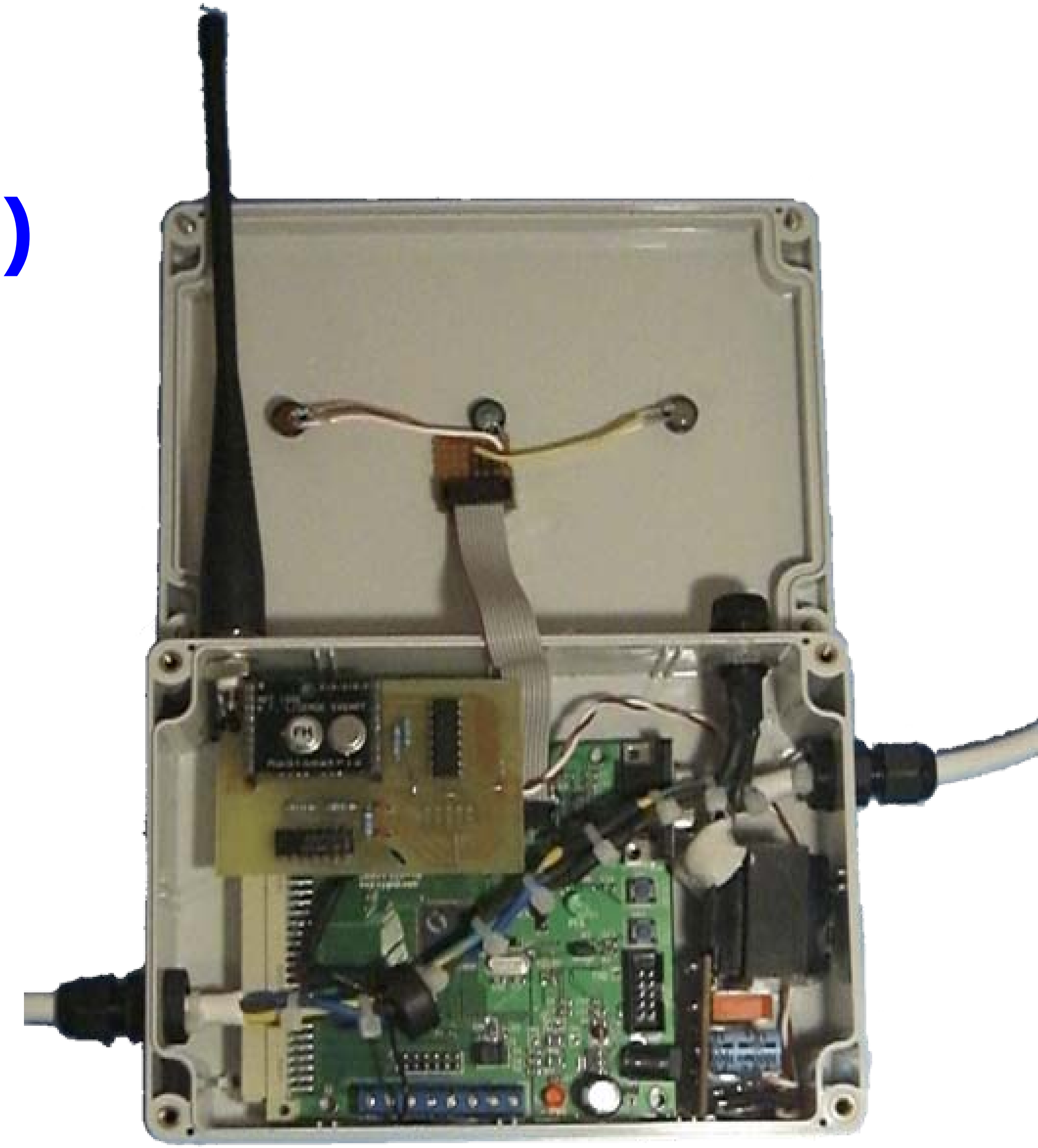


The Fabricated System

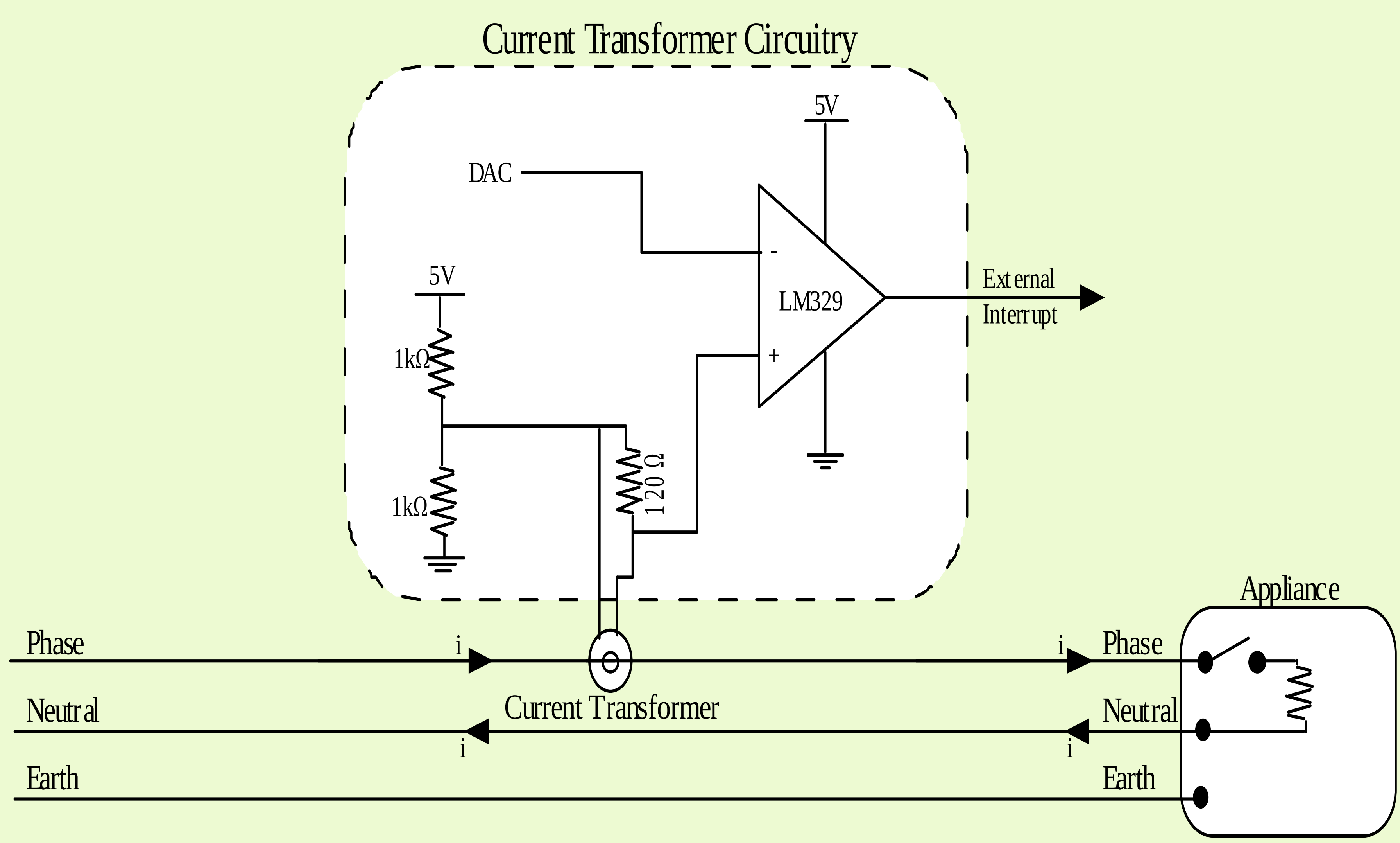


Electrical Appliance Monitoring Unit

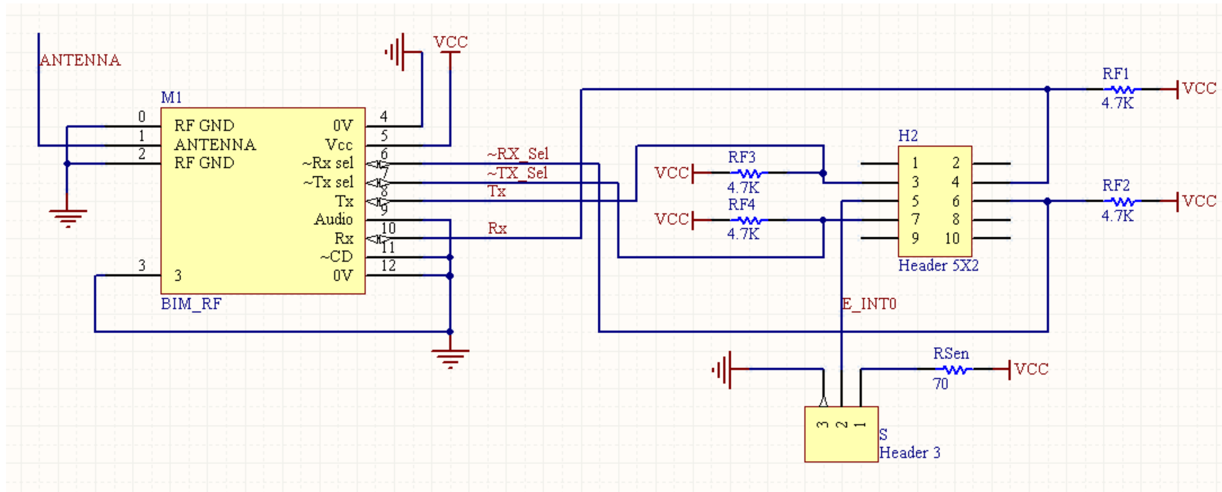
- **Sensor Unit (SU)**
  - Power Supply
  - Current Transformer & circuitry
  - Microcontroller
  - RF Module
  - LED Display



Current Sensing circuit



Water-use Monitoring Unit based on Flow Sensor



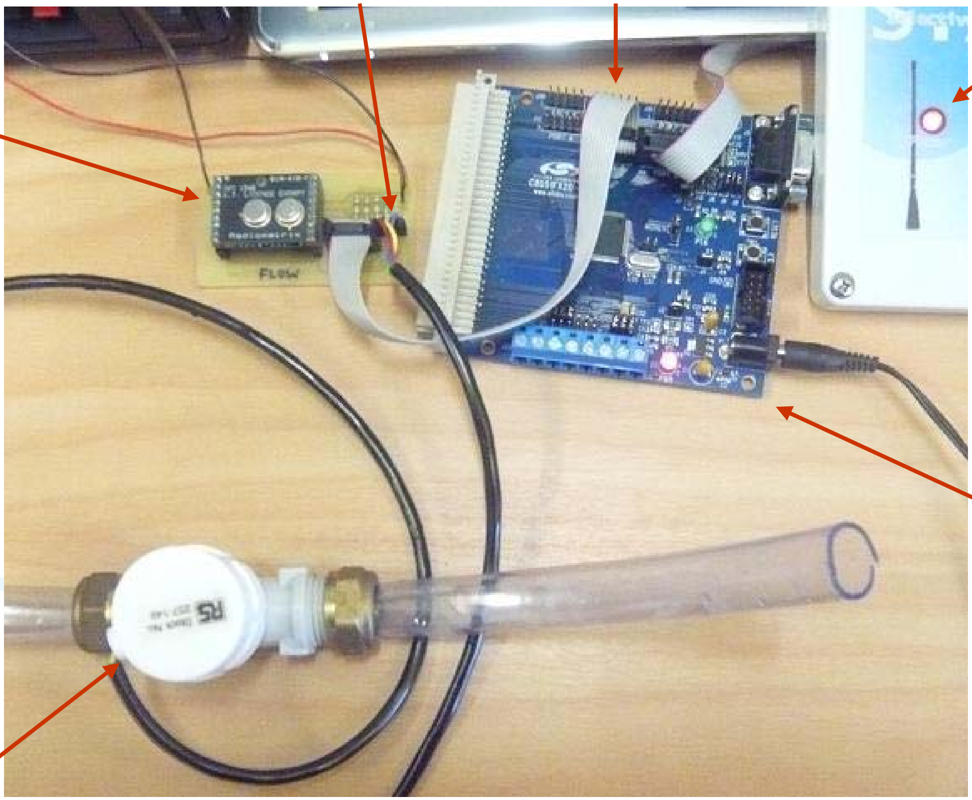
- **Flow sensor used to measure the flow of water**
- **Schematic showing circuit of module with flow sensor**

Fabricated Prototype

Flow Sensor connected to module connected to development board

Wireless Module

LED Display

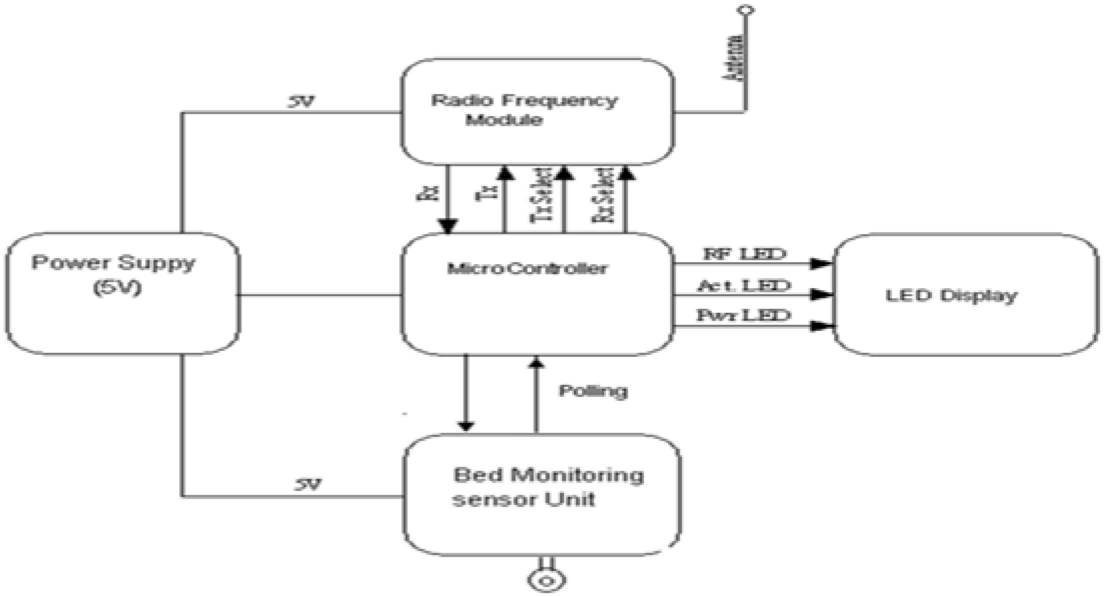


Silabs Development Board

Flow Sensor

Bed Monitoring Sensor

Force Sensor



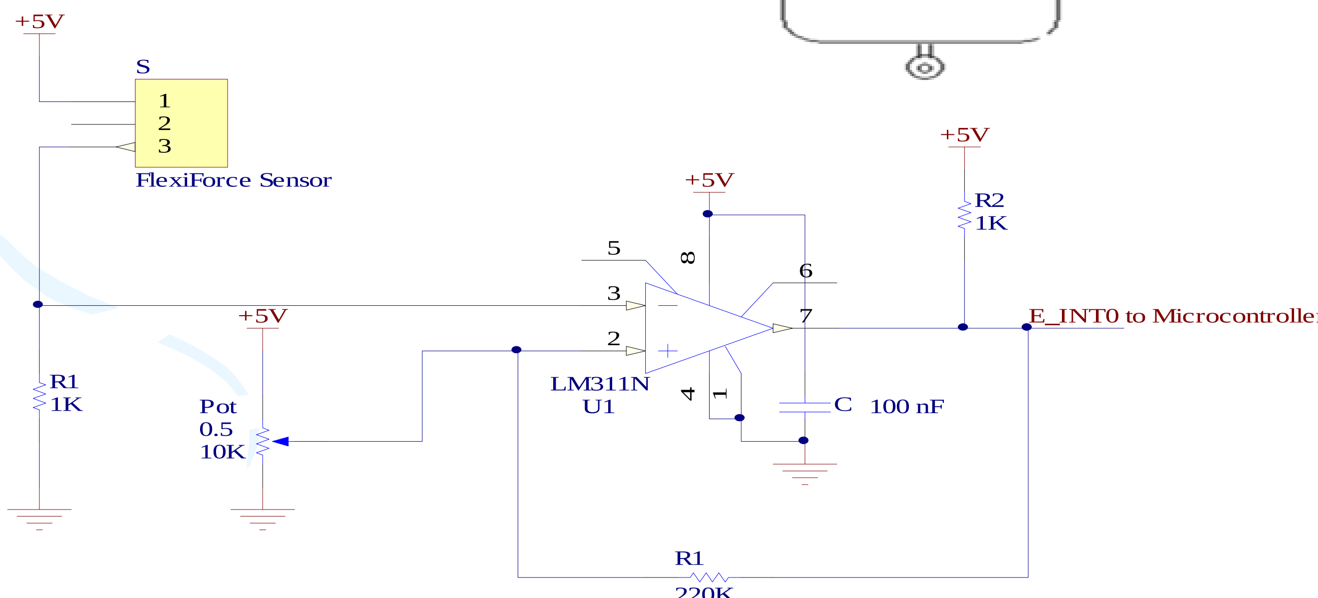
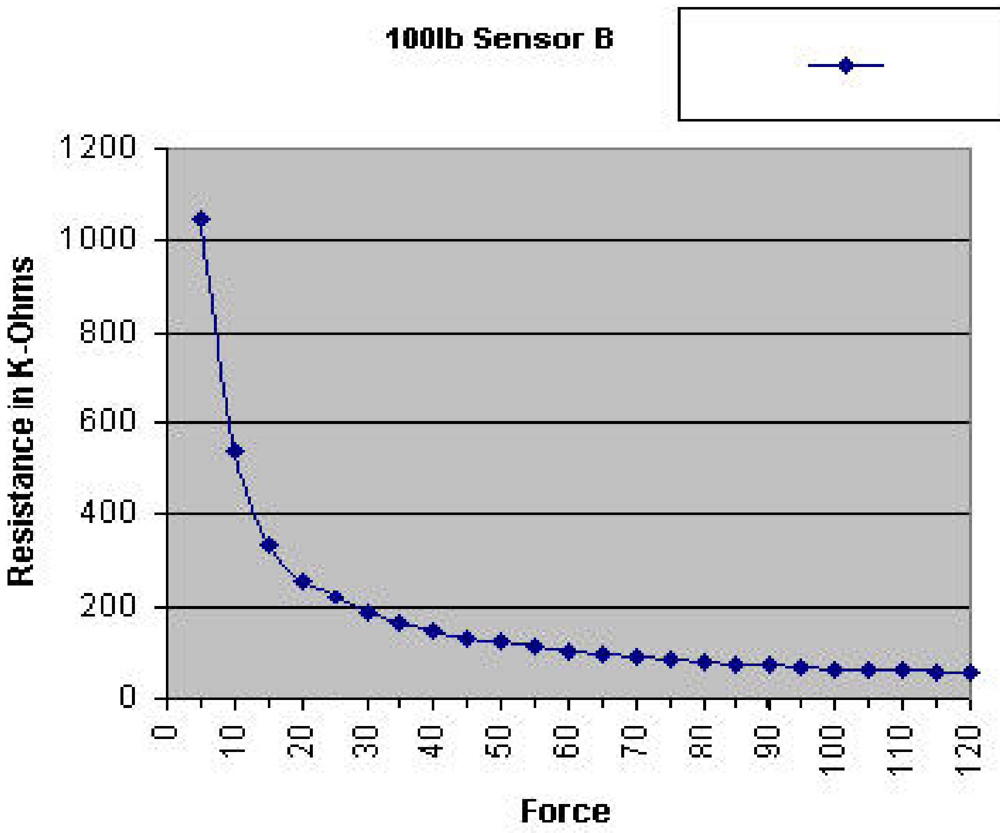
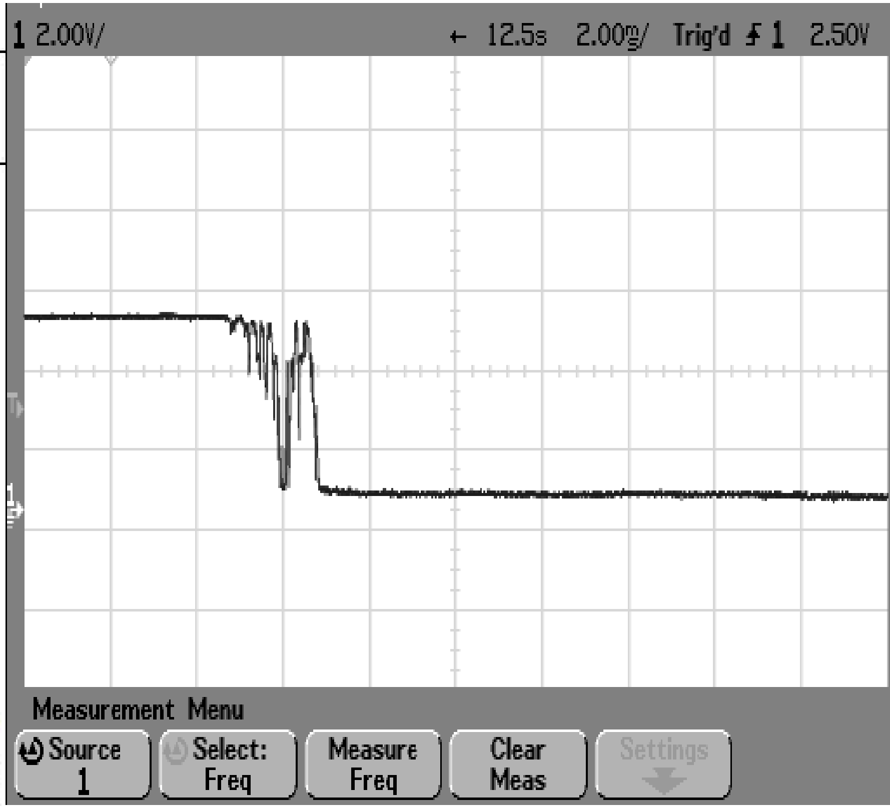


Fig. Characteristics of the force sensor

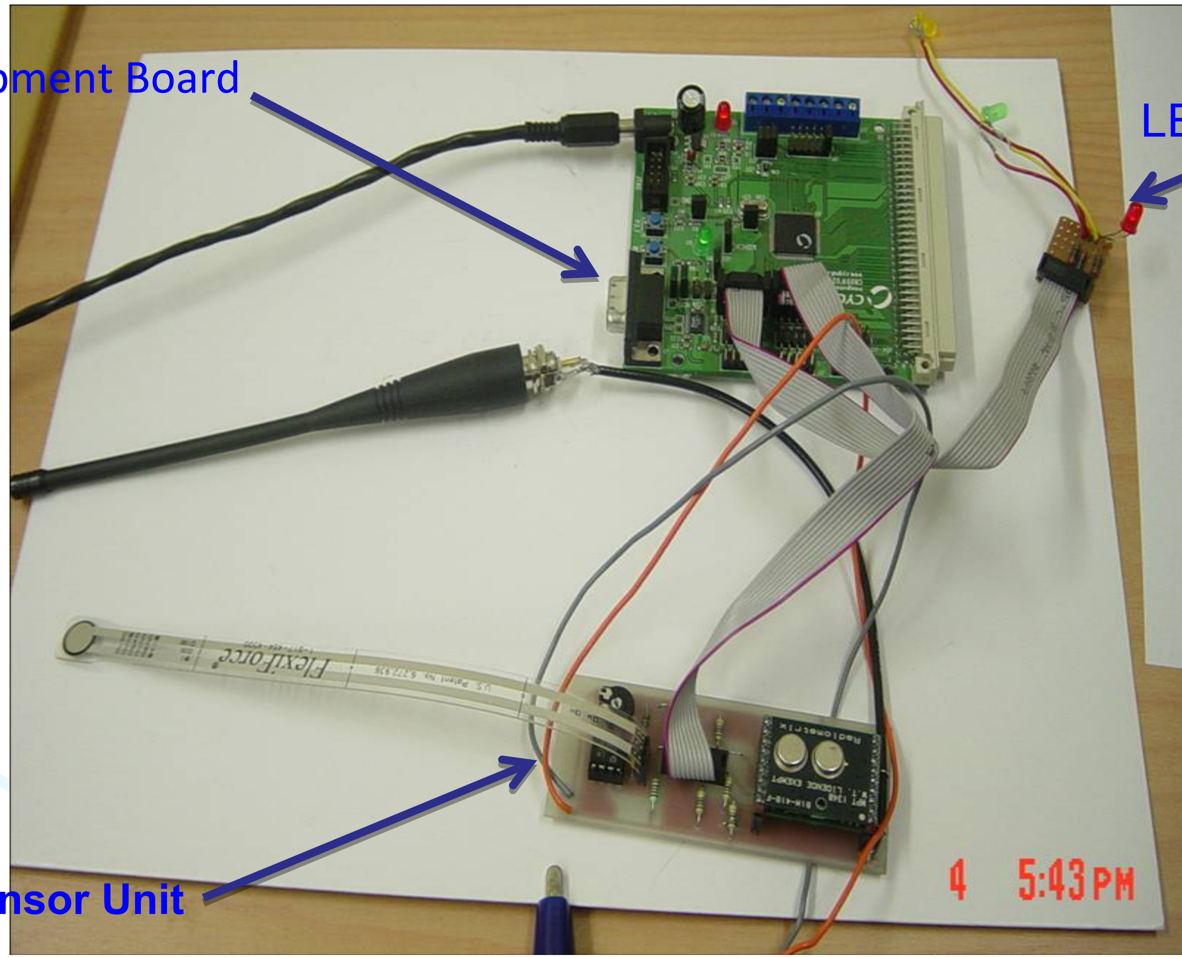




Prototype Unit

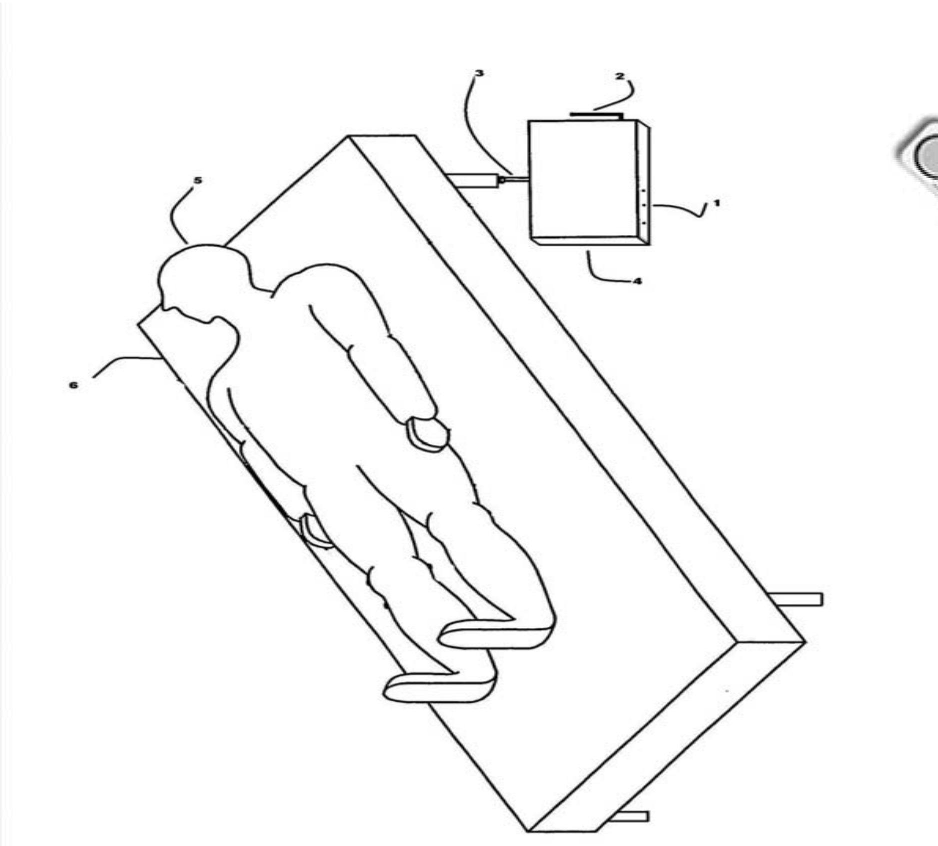
C8051F020 Development Board

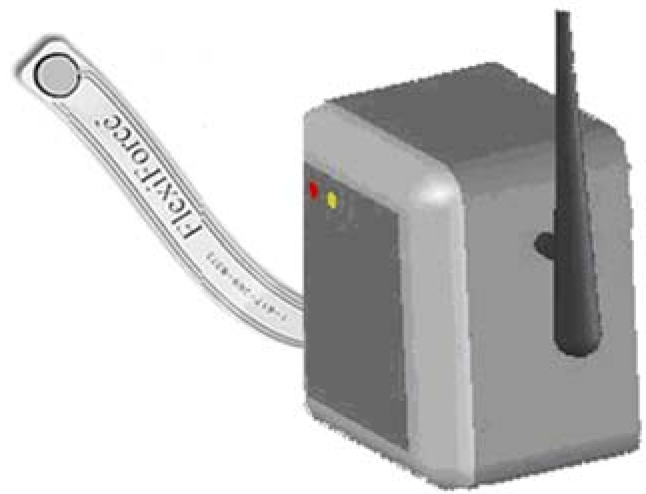
LED Display



Bed Monitoring Sensor Unit

Setting Up The Sensor Unit

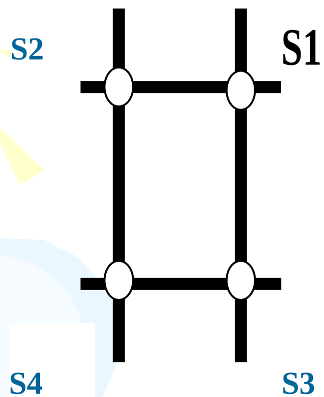




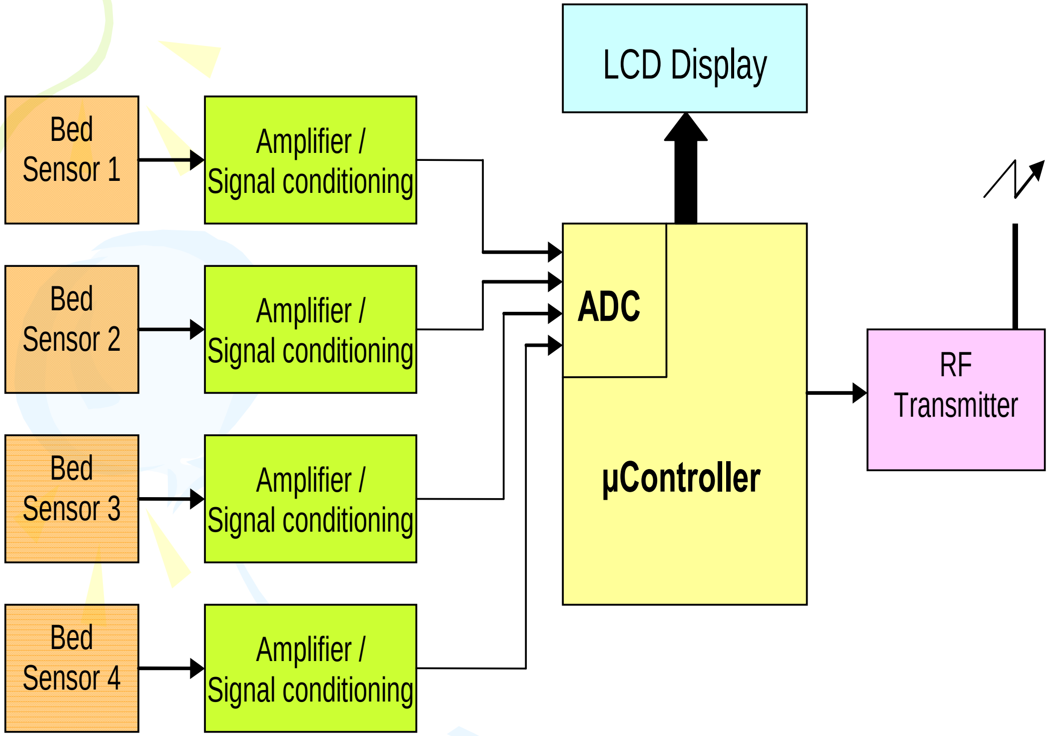
- Computer Aided Design of the Bed Monitoring Sensor Unit

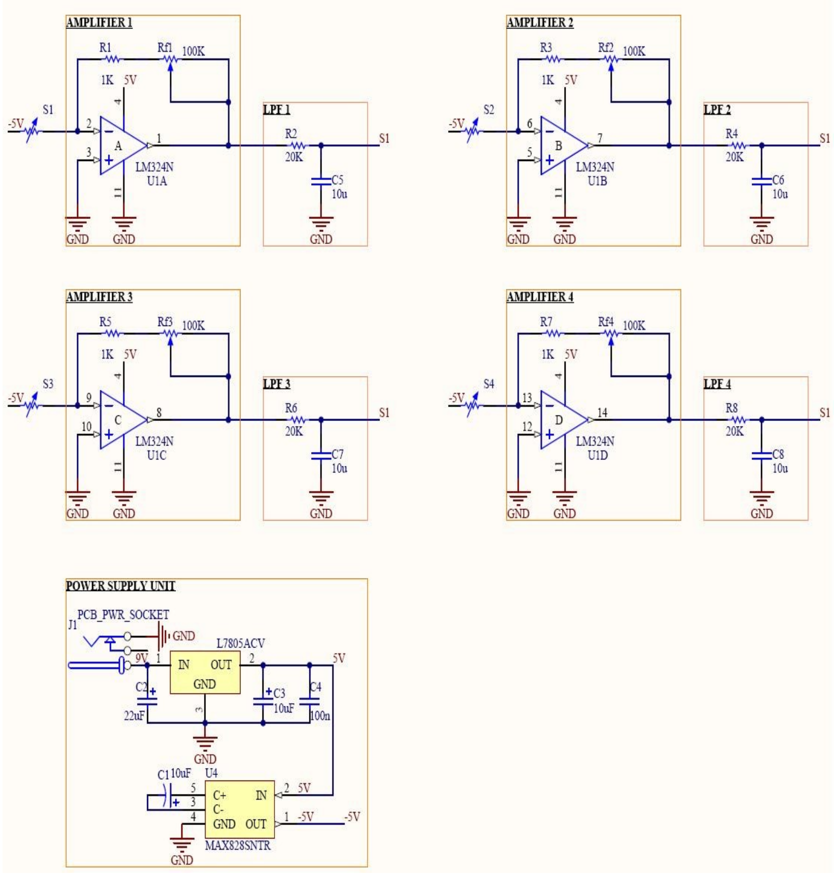
- The Sensor Unit is strategically placed in order to eliminate the temporary loading effects

Experimentation and Determination of Sleep Quality



Interfacing of sensors to microcontroller

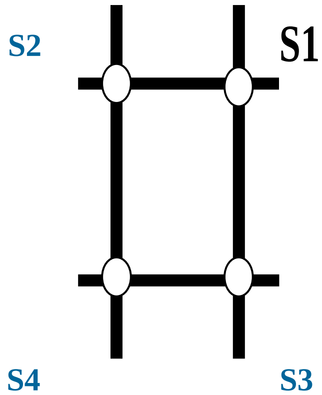




Experimental results with human

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

Analysis of results at steady state condition

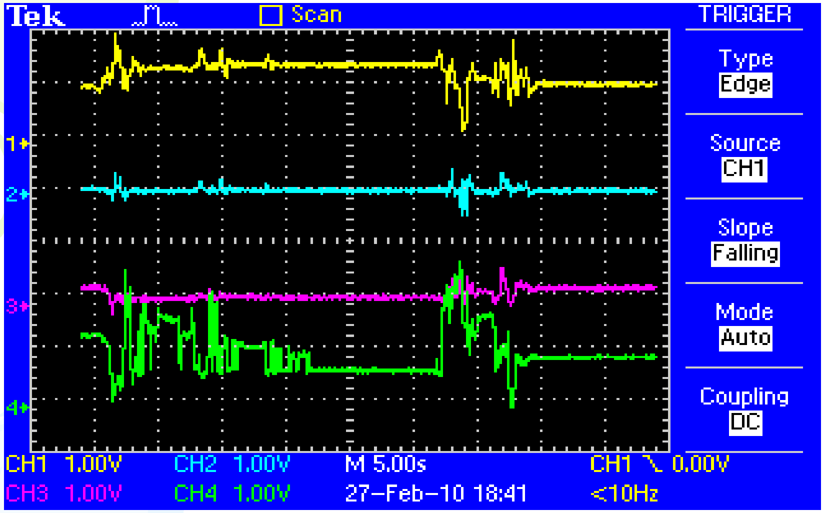


S1 : Signal from Sensors#1.
S2 : Signal from Sensors#2.
S3 : Signal from Sensors#3.
S4 : Signal from Sensors#4.

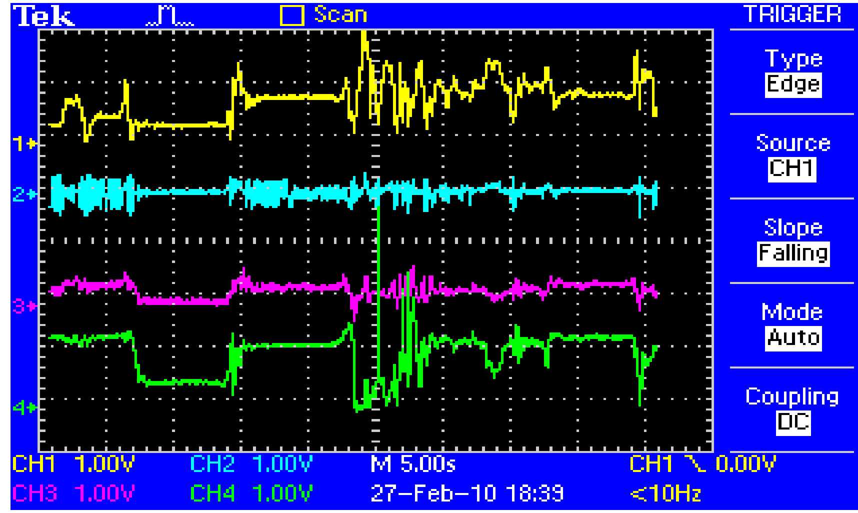
Savg = (S1 + S2 + S3 +S4)/4; Savg is the average signal.

If (S1 + S2) > 2* Savg; the head is at (S1, S2) side.
If (S3 + S4) > 2* Savg; the head is at (S3, S4) side.
If (S1 + S3) = (S2 + S4); the person is sleeping in the middle of the bed.
If (S1 + S3) > (S2 + S4); the person is sleeping in the right side of the bed.
If (S1 + S3) < (S2 + S4); the person is sleeping in the left side of the bed.

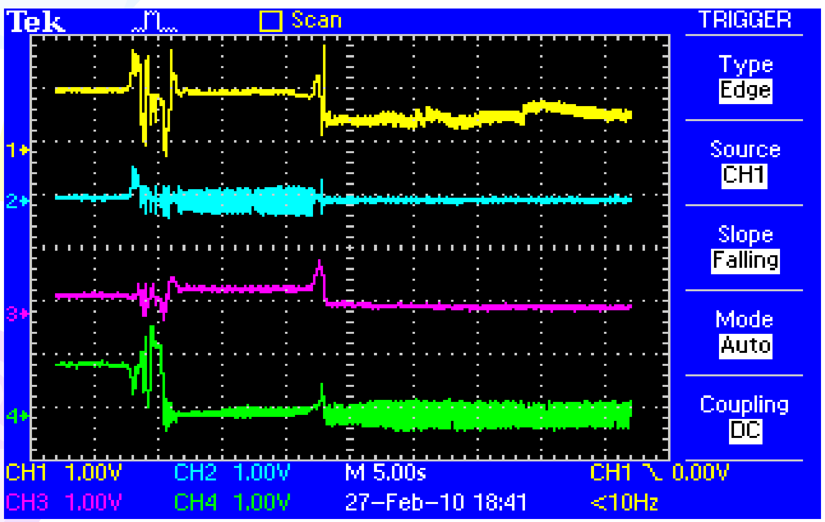
Transient response



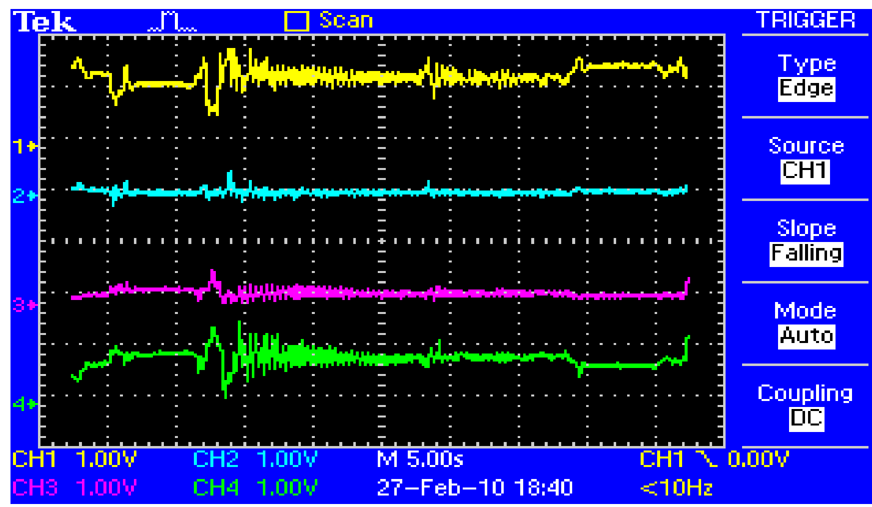
Person sleeping on the bed is having some movement



Person sits down on the bed from sleep

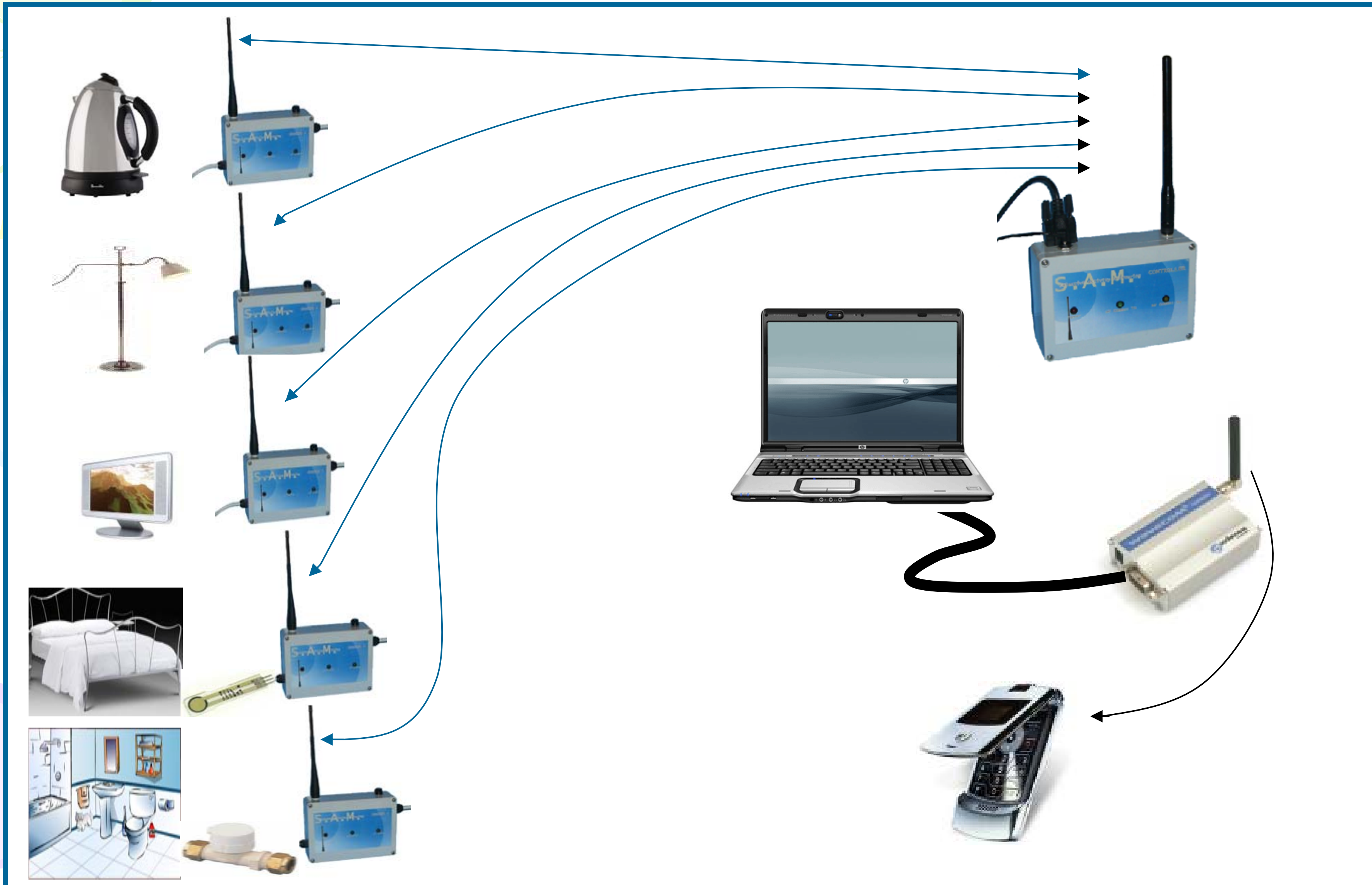


Person gets down from the bed from sleep



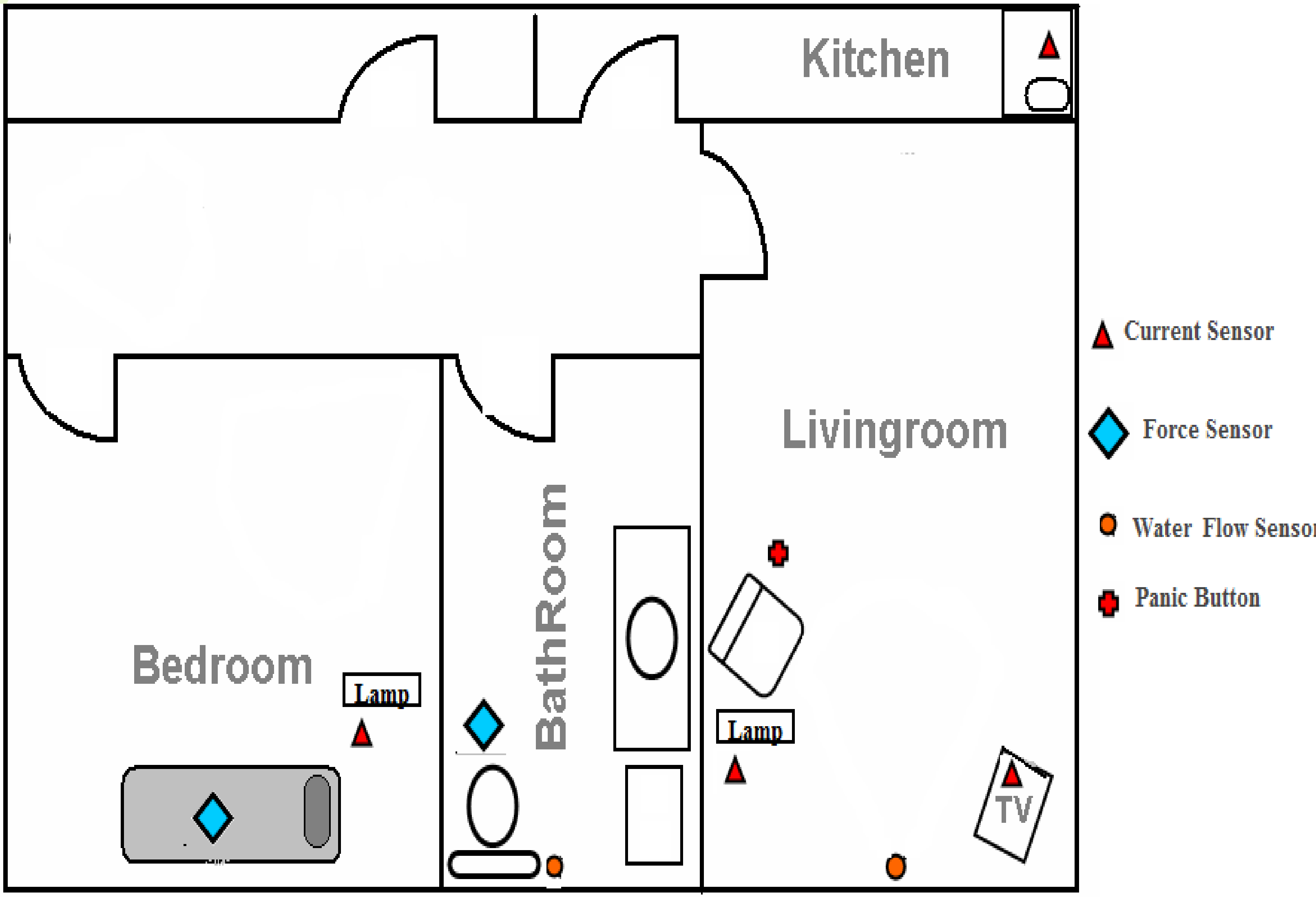
Person has some shivering feeling while sleeping on the bed

Communication

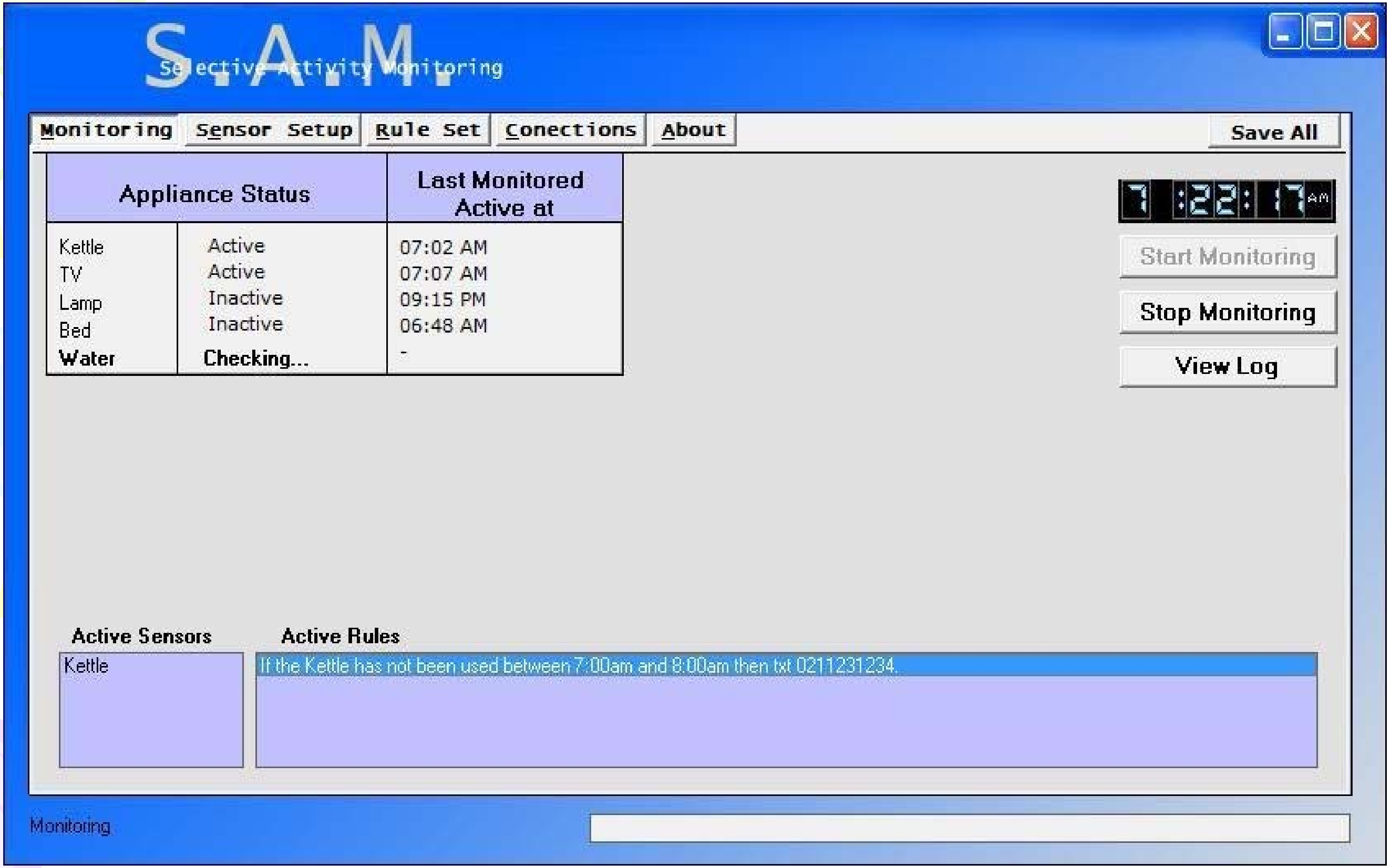


Communication Strategy

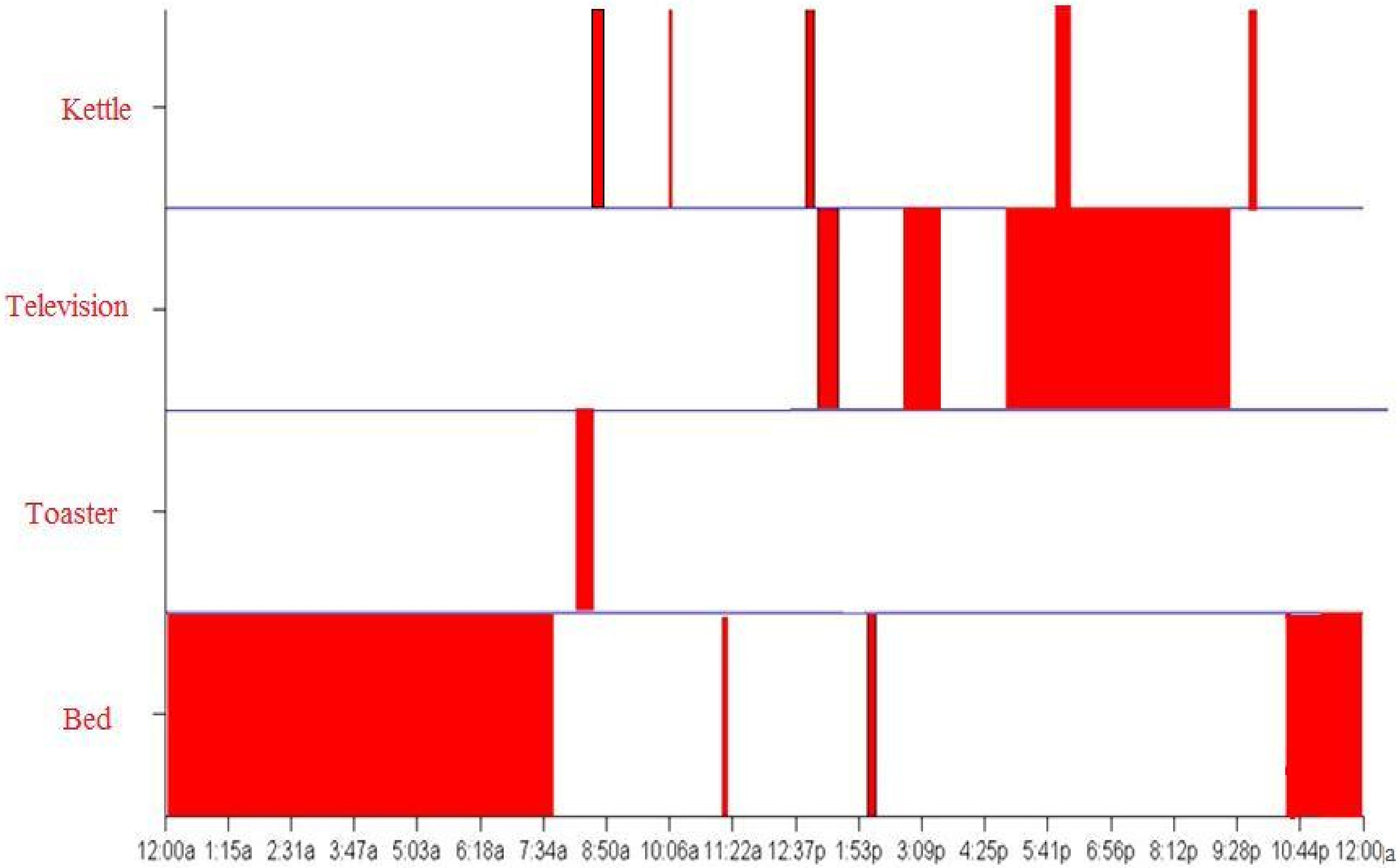
Sensor's placement in a typical house-hold



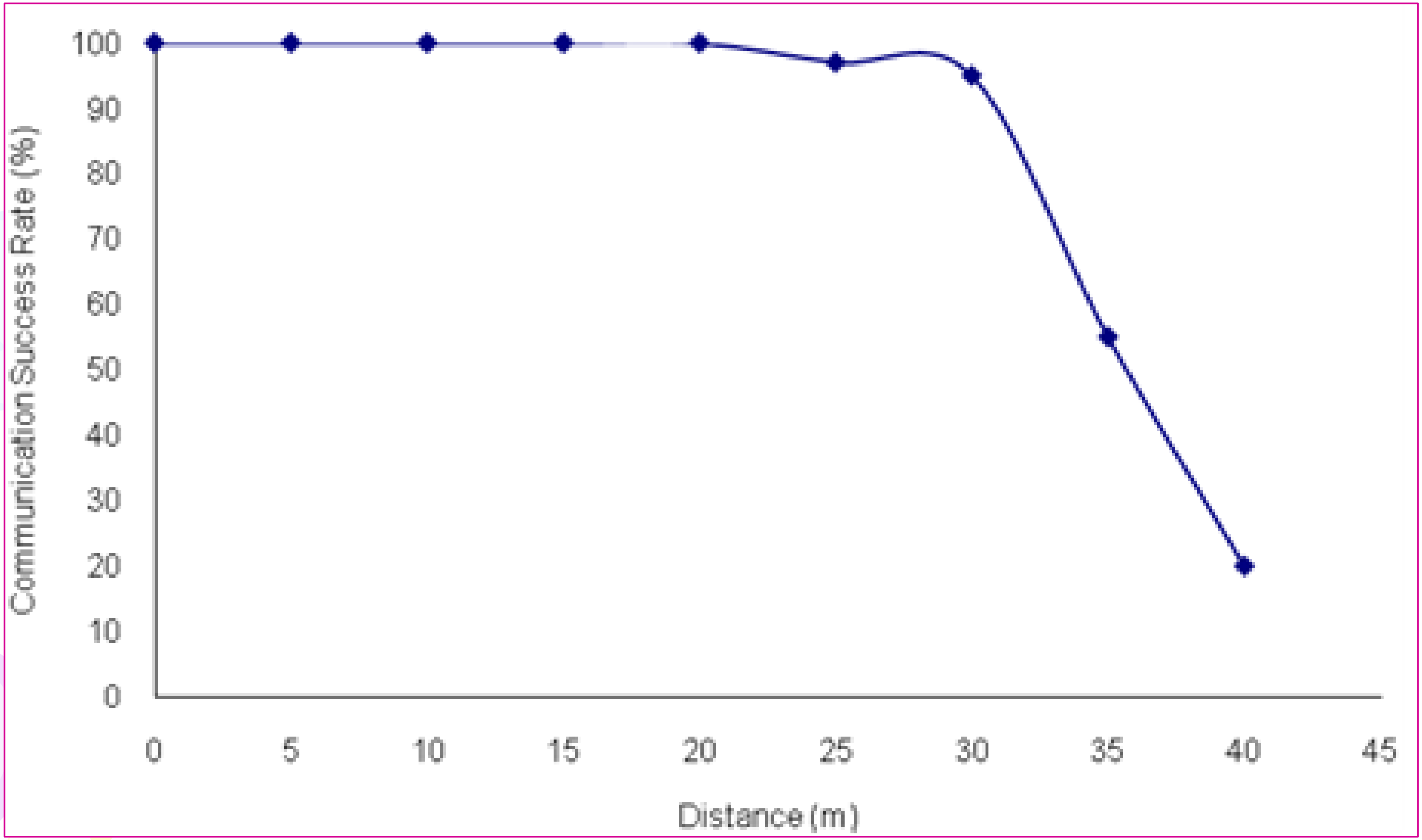
Monitoring the appliances



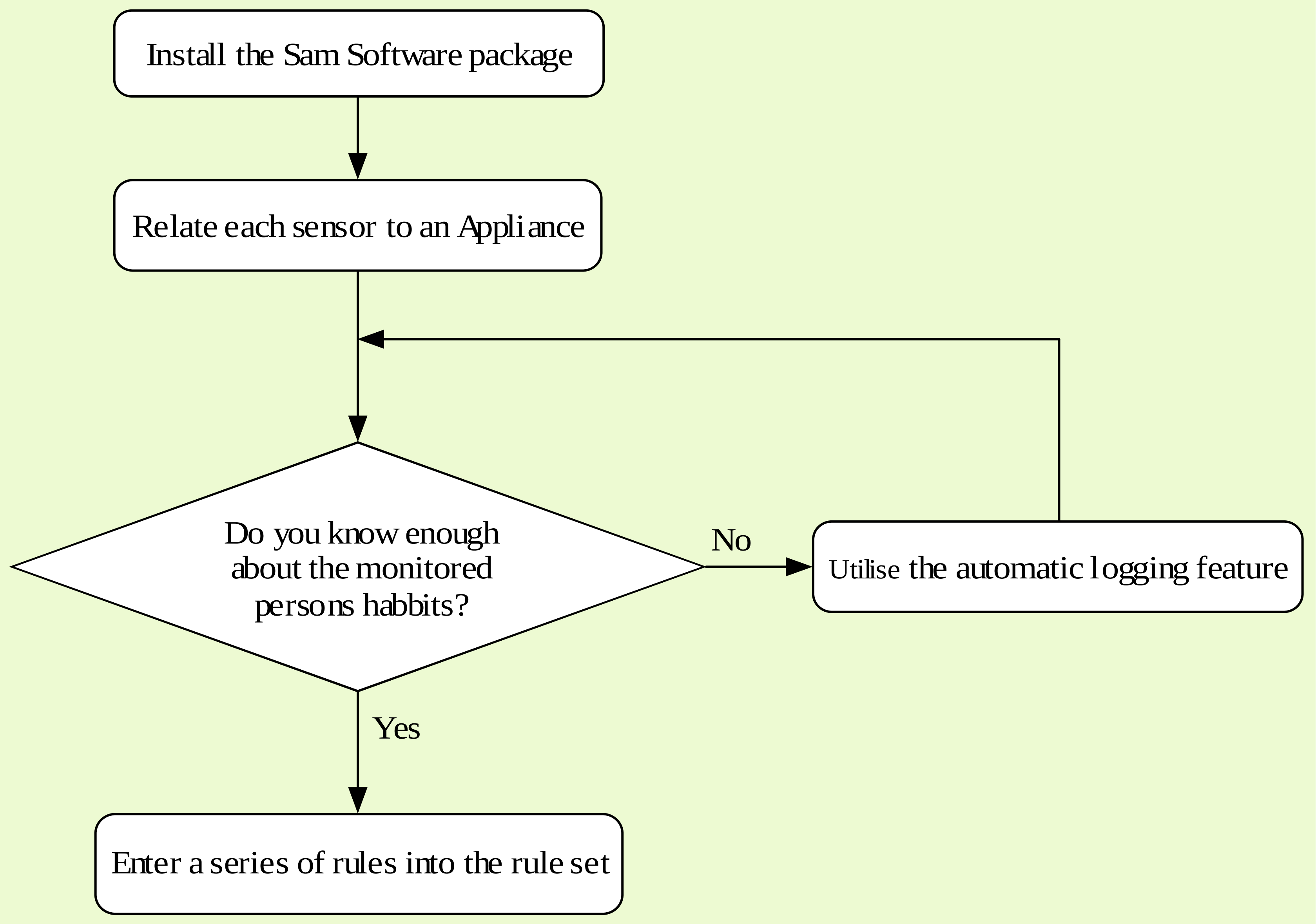
Appliances


Kettle
Television
Toaster
Bed
12:00a 1:15a 2:31a 3:47a 5:03a 6:18a 7:34a 8:50a 10:06a 11:22a 12:37p 1:53p 3:09p 4:25p 5:41p 6:56p 8:12p 9:28p 10:44p 12:00a

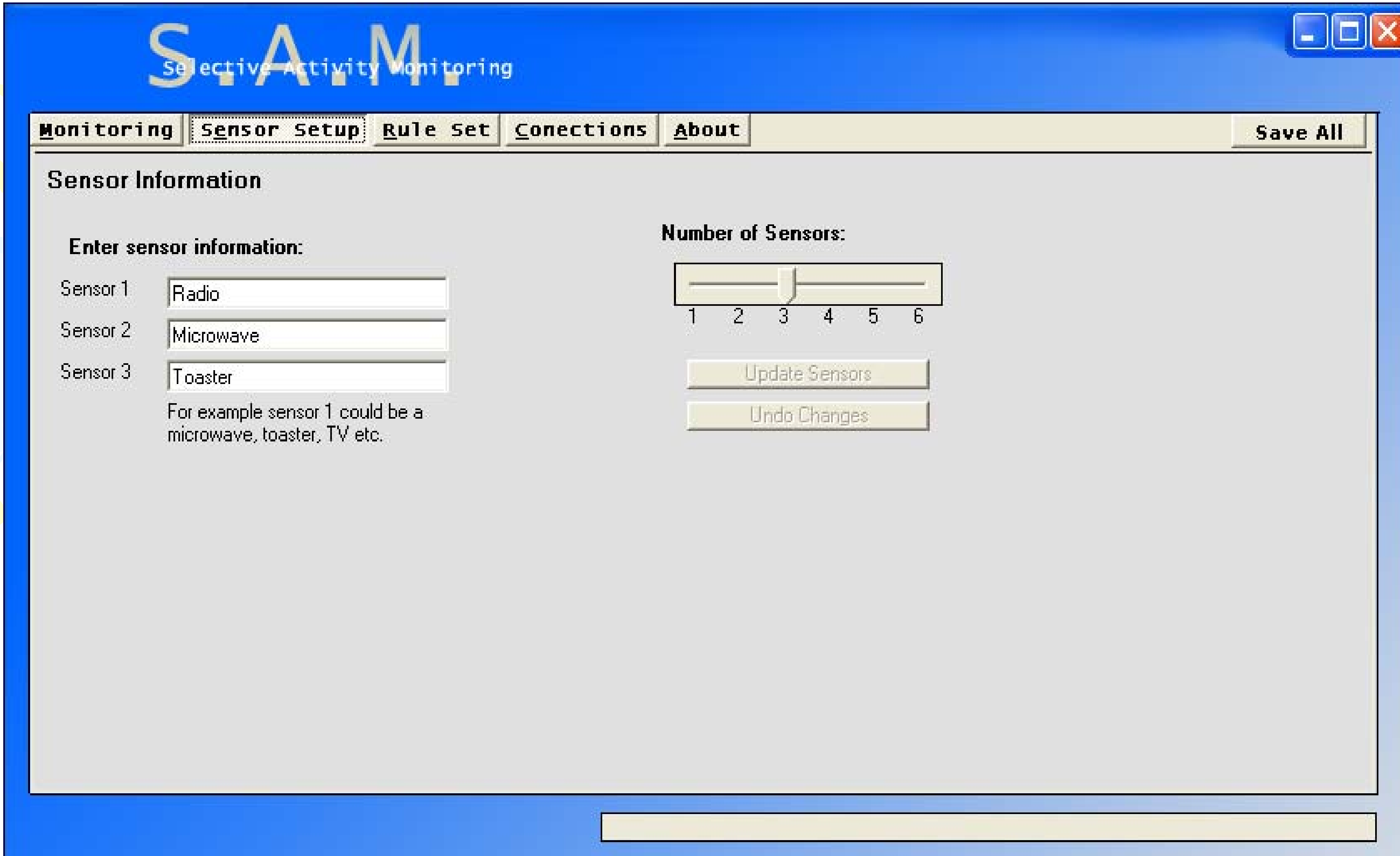
Communication success rate as a function of distance in home environment



Abnormal Behavior Detection

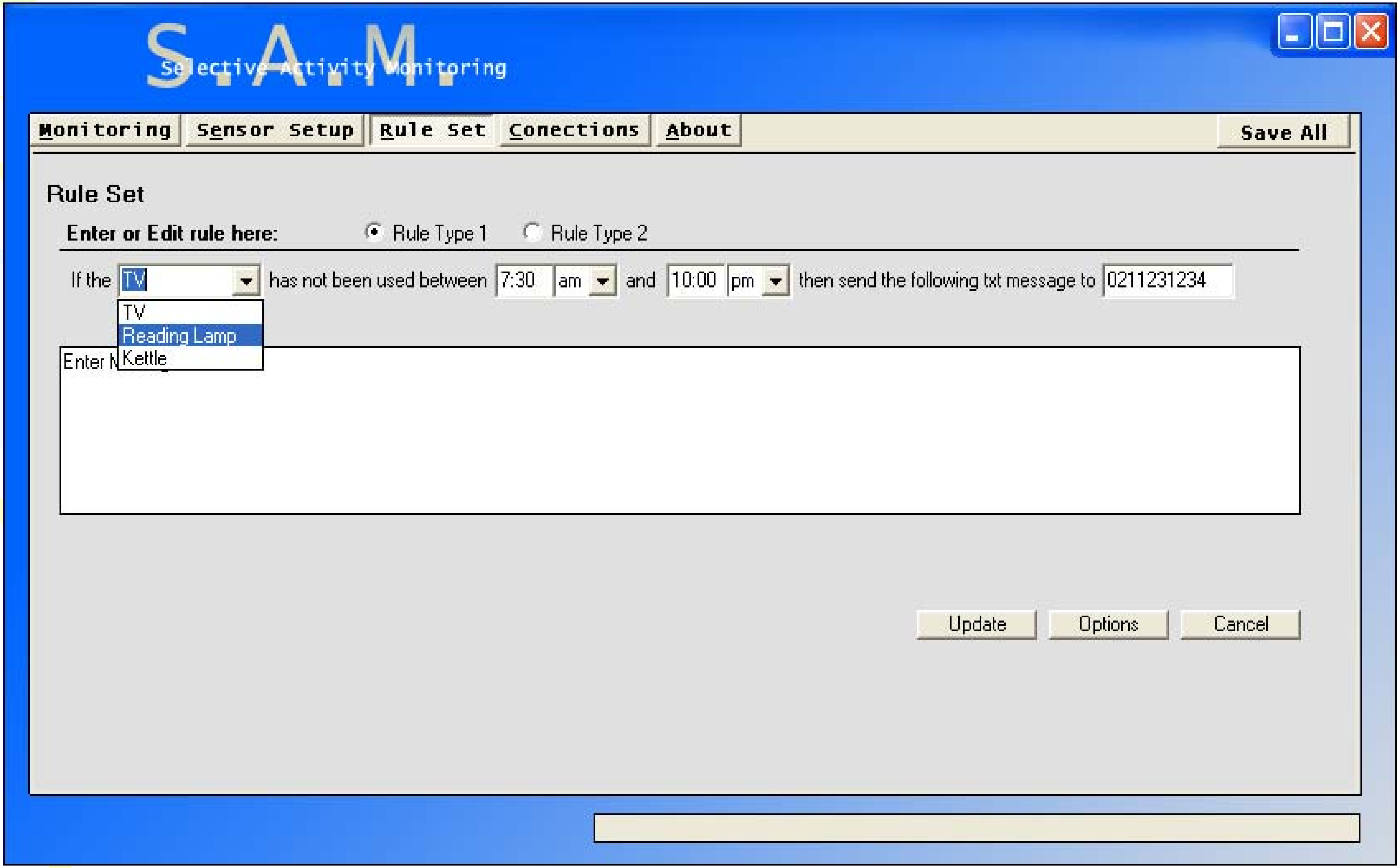


GUI for Senor Setup

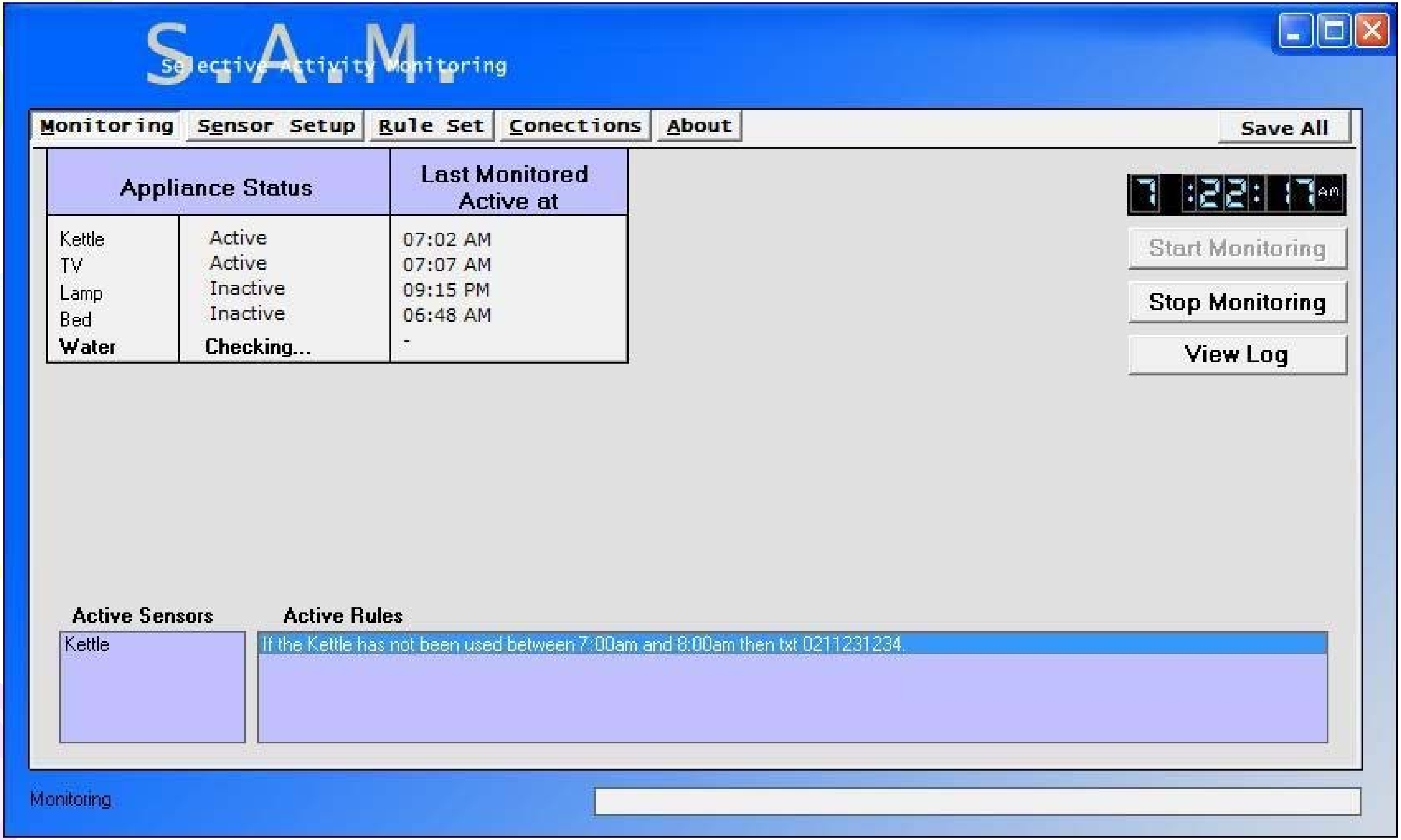


Rule creation wizard

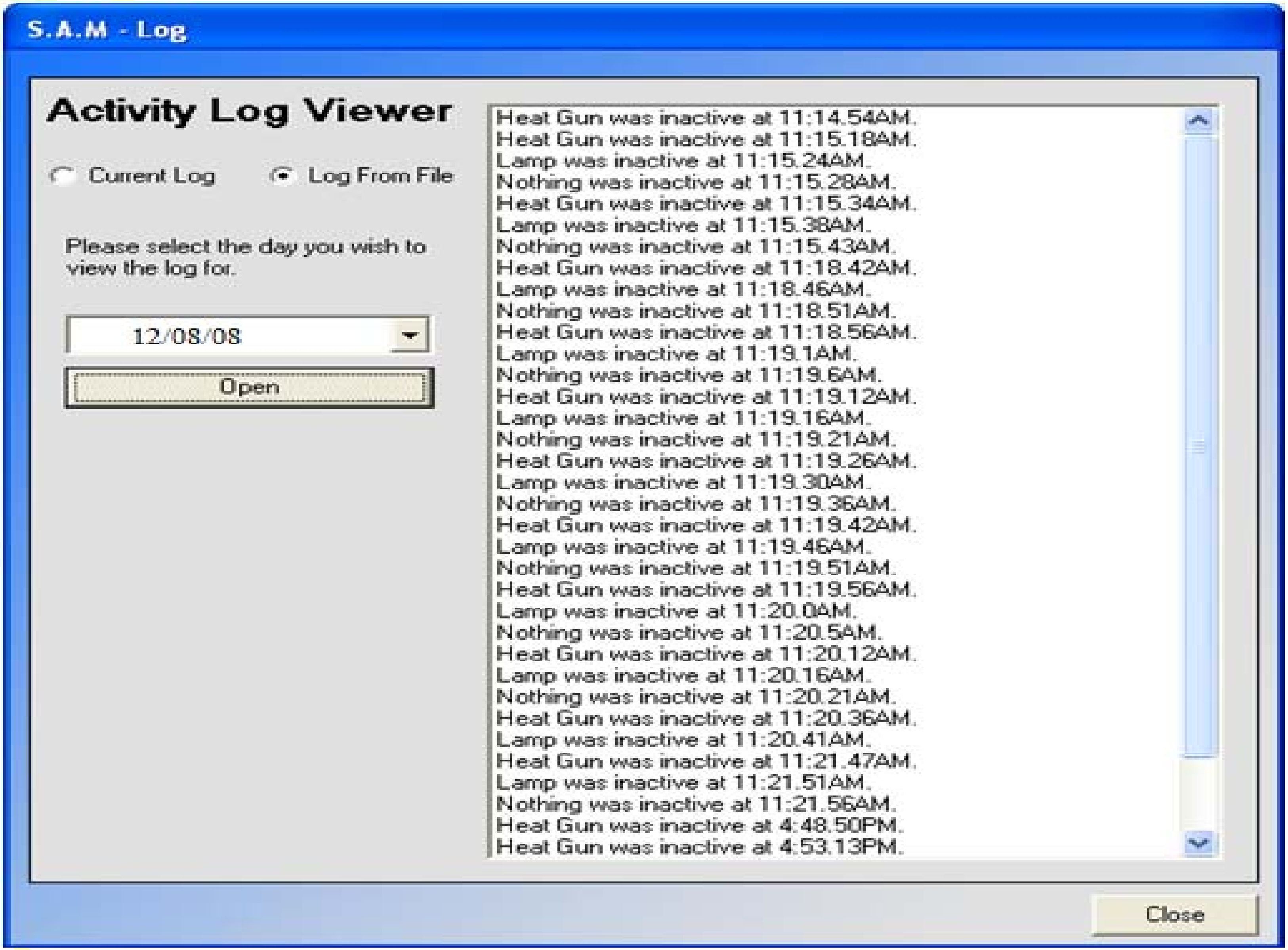
Immediate rule creation window for rule type 1



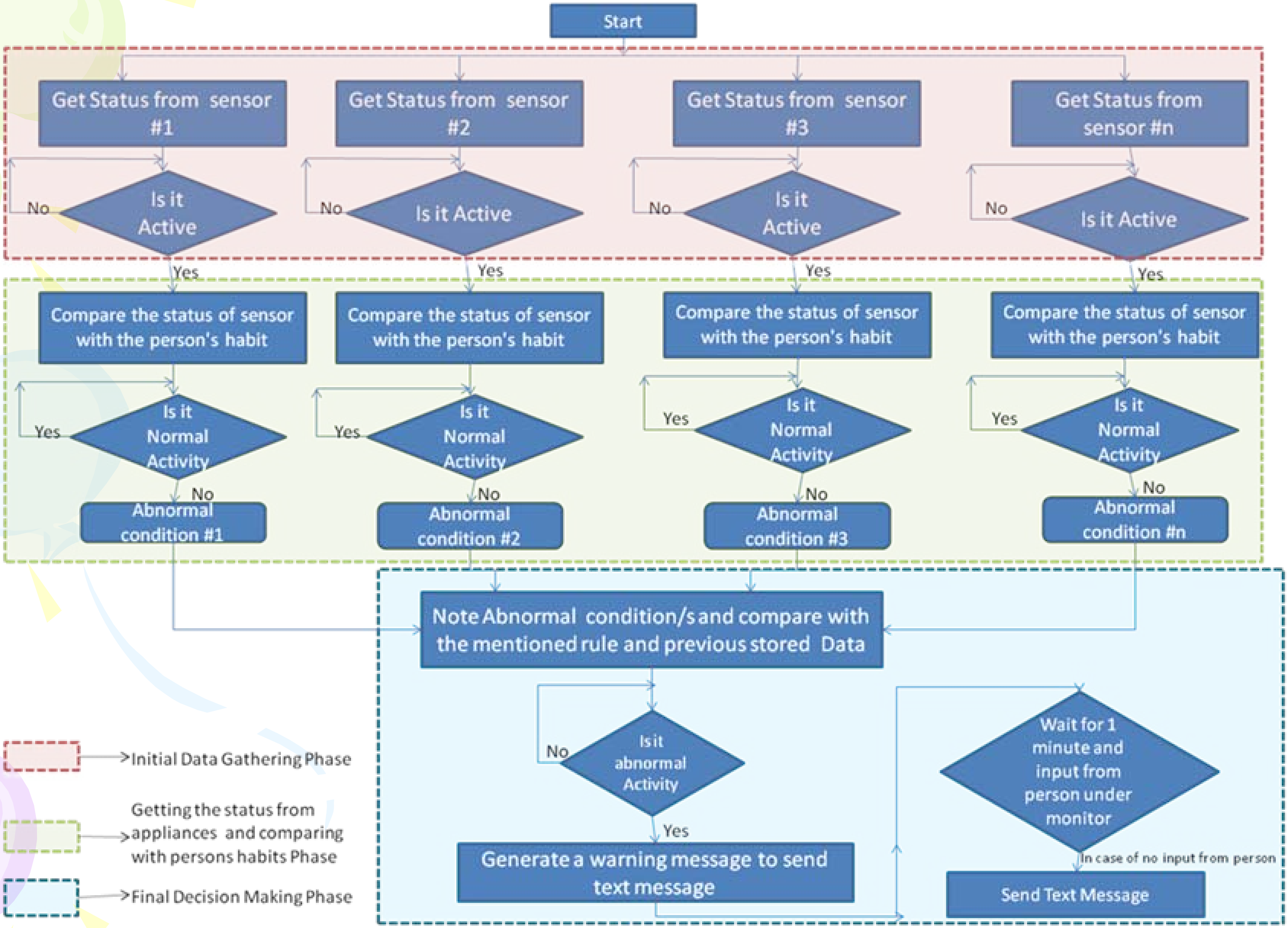
Monitoring the appliances



Activity Log viewer



Detection of daily life pattern and abnormal behavior



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.

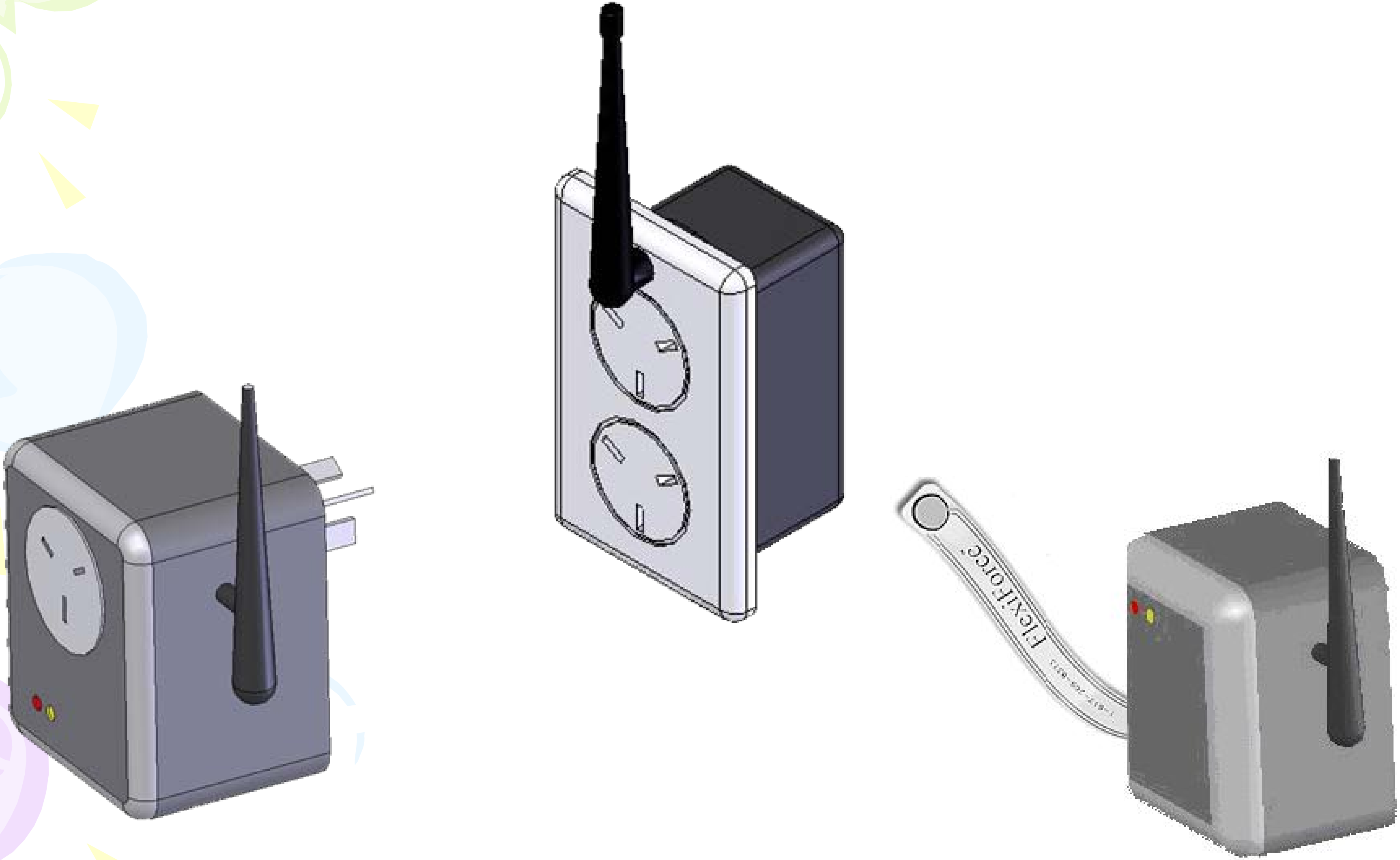
Where do we go from here?

- 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

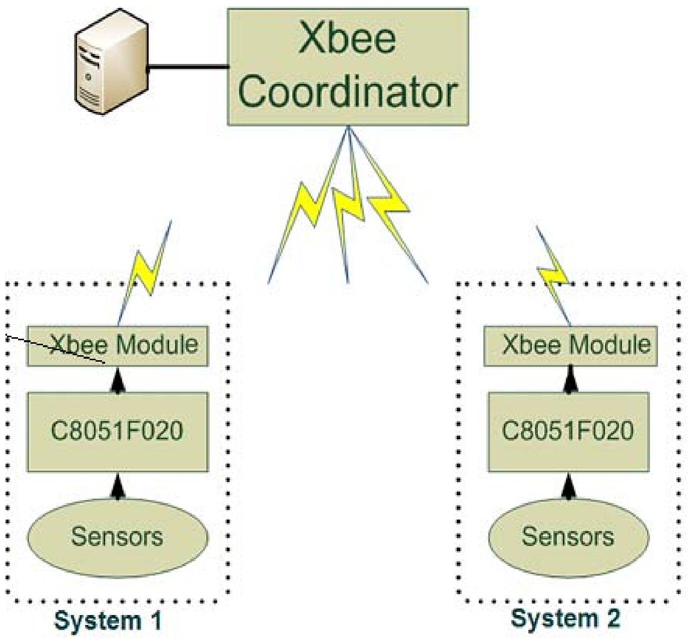
- Integrating the cellular modem into the Controller
- Making the whole system COGNITIVE

Future Sensor Concept



Future work: Zigbee Protocol

School of Engineering and Advanced Technology (SEAT)



C8051F020 and PC connected with XBee through Serial Interface

Performance Specification:

	XBee	XBee-PRO
Power Output:	1 mW (0dBm)	10 mW (+10 dBm)
Indoor range:	30 m	90 m
Outdoor range:	90 m	1.6 km
Operating frequency:	2.4 GHz	
Interface Data Rate:	Up to 115.2 Kbps	

Performance Specification (contd.):

Supply Voltage: 2.8 – 3.4 V

Transmit Current: 45 mA @ 3.3 V

Receive Current: 50 mA @ 3.3 V

Power Down Sleep Current:

< 10 µA at 25 °C

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 = $6.626 * 10^{-34}$ J-s

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

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

The energy of a visible photon (555 nm) ~ $4 * 10^{-19}$ J

The energy of a UV photon (250 nm) ~ 8 * 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.

2007 DSP Creative Design Contest

2007 Digital Signal Processing Creative Design Contest

November 16,2007

Award

This is to certify that

Anuroop Gaddam
Massey University, New Zealand

advised by Subhas Chandra Mukhopadhyay
and Gourab Sen Gupta

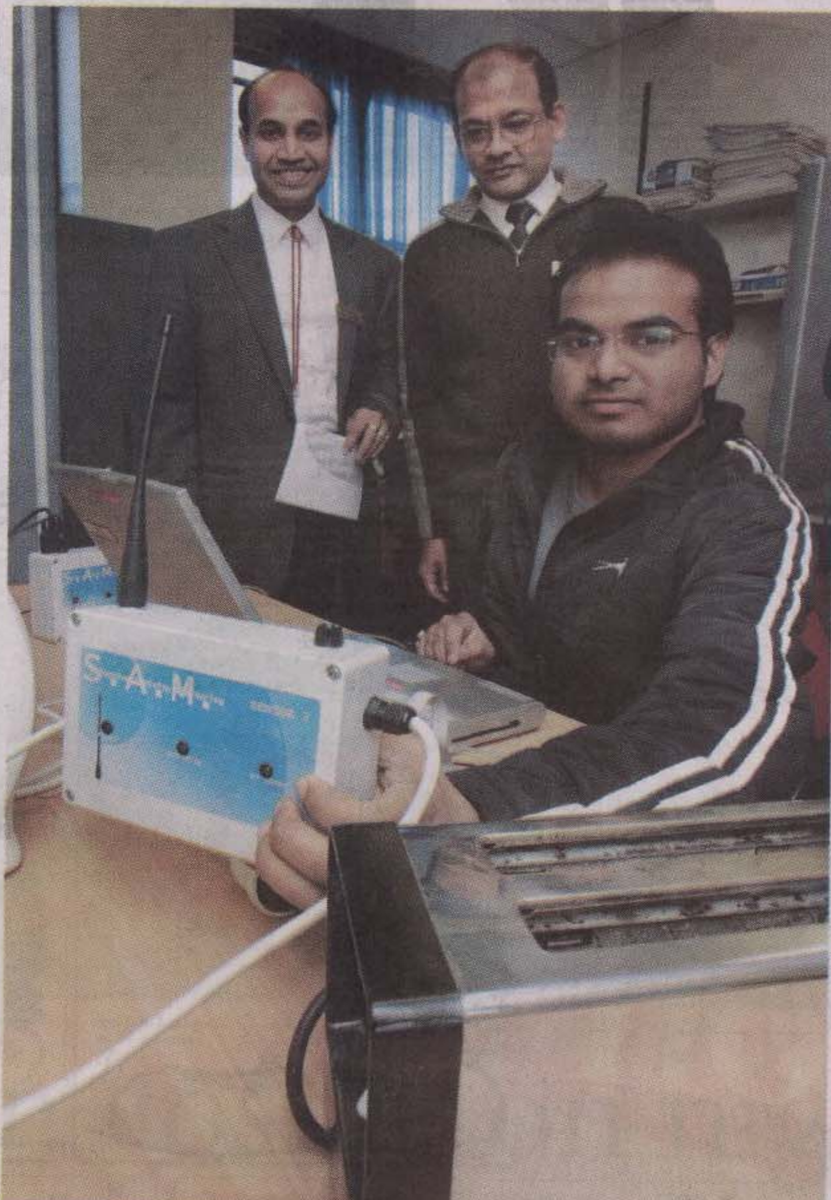
has gotten THE FIRST PRIZE
in the 2007 Digital Signal Processing Creative Design Contest.

MINISTRY OF EDUCATION 教育部

教育部 部長

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 Paykell'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

Thank You

Questions or Comments?