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Final Report Group 05

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WSN Final Report - Human Motion Detection

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1 Introduction to Wireless Sensor Networks

Wireless sensor networks (WSN) refers to a network of sensor nodes connected through wireless medium. WSN is usually a large network connecting even more than a thousand nodes. Sensor nodes are used to monitor, record and notify specific conditions at various locations. Conditions could be for example, temperature, humidity, wind or pressure.

Group of sensors linked by wireless media perform distributed sensing tasks. Each node has three components: sensing, processing, and communication. Networked sensors can continue to operate accurately in face of failure of individual sensors. Each sensor node operates autonomously with no central point of control in the network. Each node bases its decision on its mission [1].

The following figure shows a common scenario of communication between sensor network and the user monitoring the network through the sink node [2]:

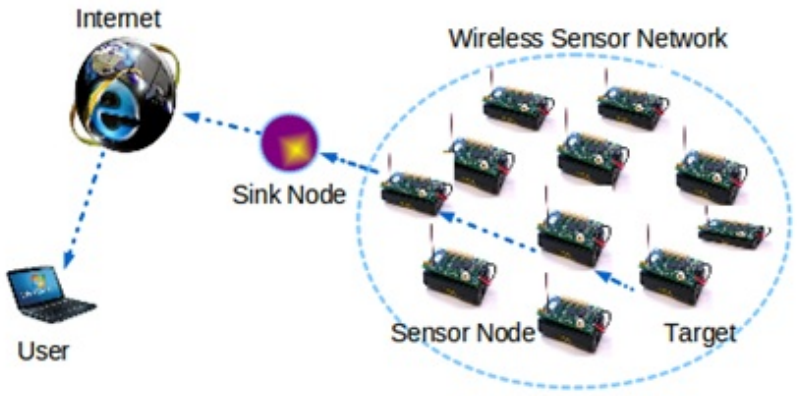

Figure 1.1: Wireless Sensor Network

2 Project Description

Wireless Sensor Networks today find their main usage in environmental monitoring problems or home automation systems. The aim of our project was to put these networks to use in a slightly different context, that of human motion detection. This sensing of moving human body was done in this project by using accelerometer sensors. We had to decide about the position and axis of the accelerometers that had to be placed on the human body. This was achieved by monitoring the data received by the sensors when put on the body. The sensors placed on the body built up a network on which a routing protocol was run. The basic purpose of the protocol was to forward the sensor data to a centralized monitor. Furthermore, an algorithm was implemented in order to increase the life of the network.

2.1 Why Wireless Sensor Networks ?

Wireless Sensor Networks offer distinct advantages over other similar approaches related to human motion detection. Some of the positives it provides include:

1. It avoids lot of wiring
2. It can accommodate new devices easily
3. It can be accessed through a centralized monitor

3 Project Design

The idea, as described above, was to detect human movements by using wireless sensor motes. Some of the poses that our "Human Motion Detection" system was able to recognize include:

1. Sitting
2. Standing
3. Lying
4. Kneeling
5. Crawling

The following figure shows the poses that we detected and monitored them through a wireless sensor mote (Gateway) on a PC. The motes were placed on chest, thigh and leg with different identification numbers assigned.

Figure 3.1: Human Poses Detected

4 Hardware and Software used

The network was setup using Berkeley motes from Crossbow. The programming was done on MicaZ motes. These motes have an Atmega128 micro-controller and can be integrated with a variety of sensors using a 51-pin connector to an external sensor board. The node uses a IEEE 802.15.4 communication chip (Texas Instruments CC2420) operating at 2.4 GHz. The motes are powered by two AA batteries.

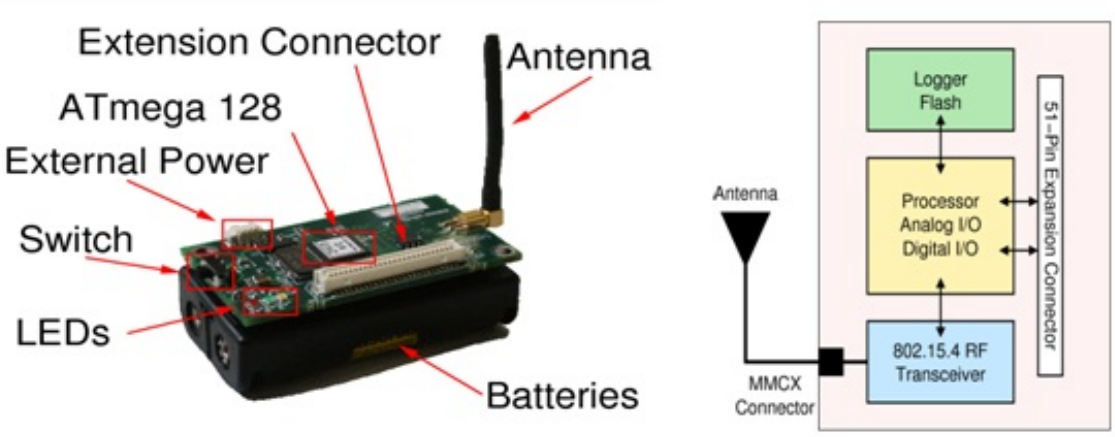

Figure 4.1: MicaZ Mote

These motes can be interfaced with a computer using a programming board that connects via a serial port. This interfacing is necessary for programming as well as for transferring data over UART. The programming board used was USB Programmer Board MIB520.

4.1 Sensor Board Used

The sensor board used was MTS310CB. It is a flexible sensor board with a variety of sensing modalities. These modalities include a Dual-Axis Accelerometer, Dual-Axis Magnetometer, Light, Temperature, Acoustic and Sounder. The Accelerometer readings were used to detect the human

Figure 4.2: USB Programmer Board MIB520

Figure 4.3: MTS310CB

body moves.

4.2 Software Used

In order to visualize the data received from the network motes we set up a Graphical User Interface using QT Creator.

5 Design Strategy

The sensor network setup consists of three nodes that have all been programmed with the same code. There is also a network gateway that serves as the communication mote between the network and the GUI run on PC.

The network motes are responsible for initial set up and for developing a routing path from each of them to the network gateway. The network gateway is programmed such that after its initial configuration at the start up, it only tries to receive the data traffic sent by the network motes. Furthermore, it also reacts when there is any update in the routing path within the network motes.

The design strategy deployed can be seen in the figure below. It is basically a Master-Slave based routing. The Master mote is responsible of forwarding the sensor data from all the motes of the network to the network gateway mote. The Master mote is selected on the basis of the battery voltage of the 2 cells each mote has.

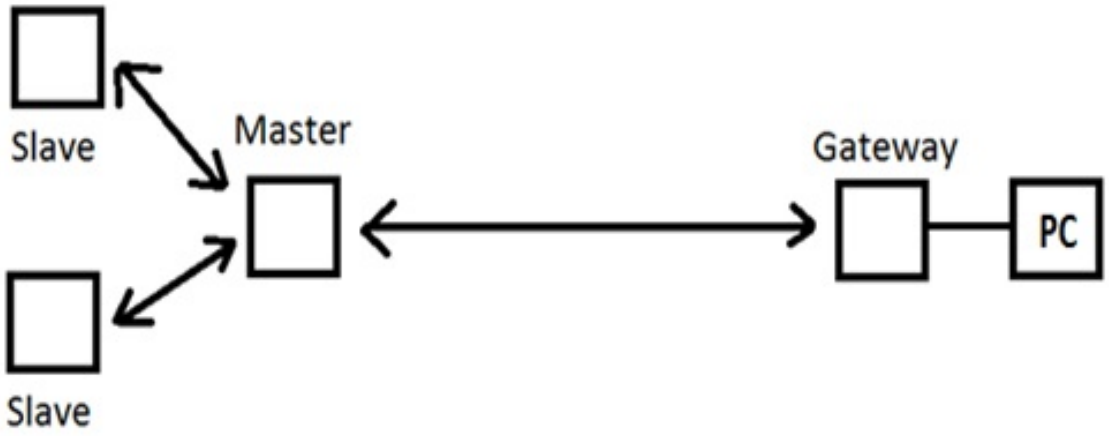

Figure 5.1: Design Strategy

It can be seen in figure 5.1 that the Slaves only communicate with the Master mote and there is no direct link set up between them and the gateway. The slaves forward all the sensor data to the Master who is only responsible to interact with the network gateway.

5.1 Routing Protocol Features

Some of the features of the implemented routing protocol can be broken down into following points:

- Dynamic Source Routing
- Master and Slave motes
- Messages from Slaves to Master
- Messages from Master to PC Gateway
- Low battery motes detection
- Master mote selection based on Battery Voltages of network motes
- Survivability of the network

5.2 Routing Protocol Implementation

The routing protocol implemented has the following three phases that are given below:

- Configuration Phase
- Data Transfer Phase
- Master Selection Phase

5.2.1 Configuration Phase

There are two phases of initial configurations in itself. The first phase is of Master configuration in which all the motes, except the Master mote, sends request to every other mote for acquiring the Master ID. The Master node sends its MAC ID to all the other nodes in the network including the Gateway node as well. This is shown in figure 5.2 below.

Figure 5.3 shows the second phase of configuration in which the Master sends request for Gateway MAC ID to all other motes. The Slaves also send request to the Master to send them the Gateway MAC ID. In response the Gateway mote sends its MAC ID to the Master mote and the Master mote forwards this Gateway ID to Slave motes within the network.

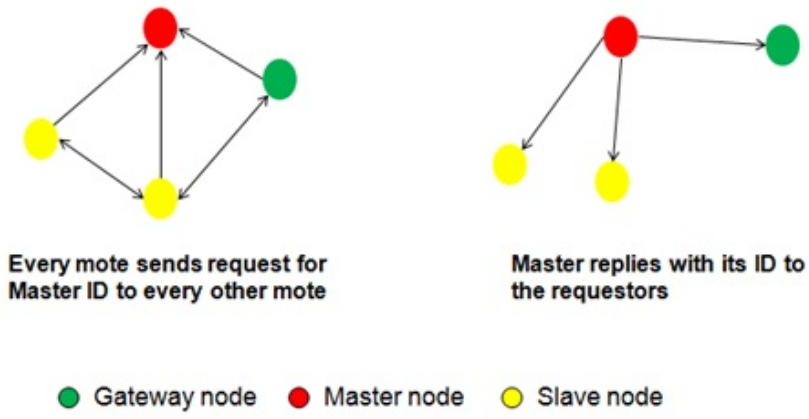

Figure 5.2: Configuration Phase (Master Configuration)

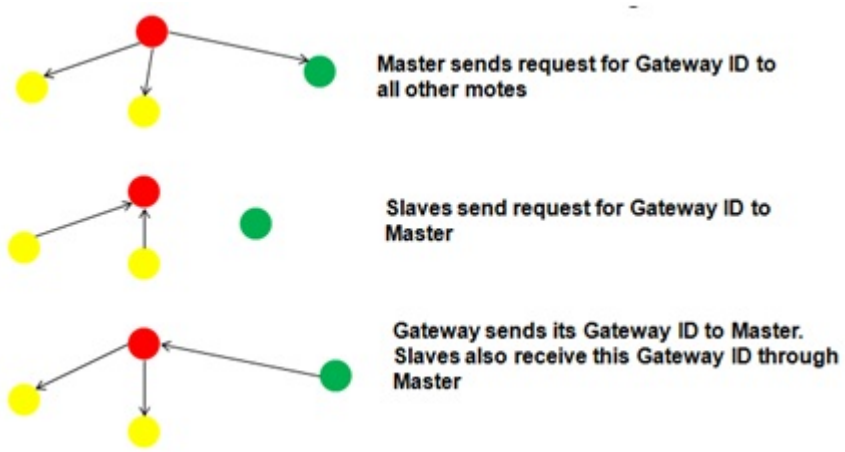

Figure 5.3: Configuration Phase (Gateway Configuration)

5.2.2 Data Transfer Phase

In the data transfer phase, the Slaves send their sensor data to the Master mote. The Master mote forward this data along with the sensor reading of its own accelerometer to the Gateway mote. This can be seen in Figure 5.4.

5.2.3 Master Selection Phase

In the Master selection phase we reconfigure the network routes. A new Master is selected based on the battery voltage of all the motes within the network. This new Master then communicates with the fixed network Gateway.

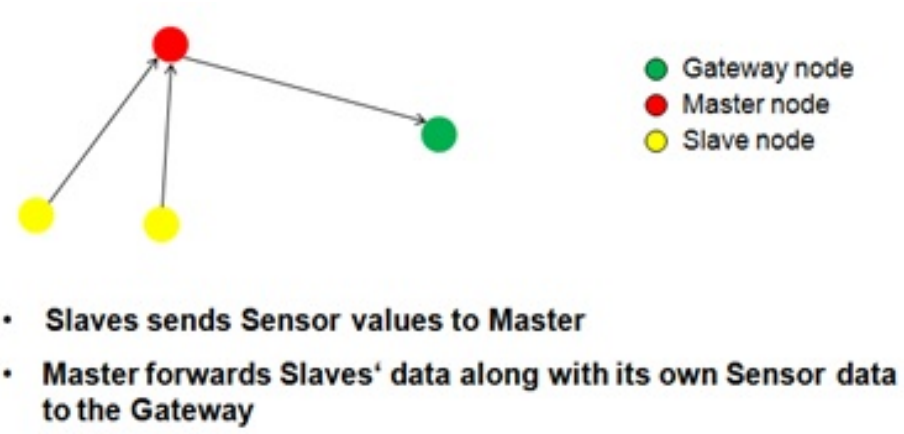

Figure 5.4: Data Transfer Phase

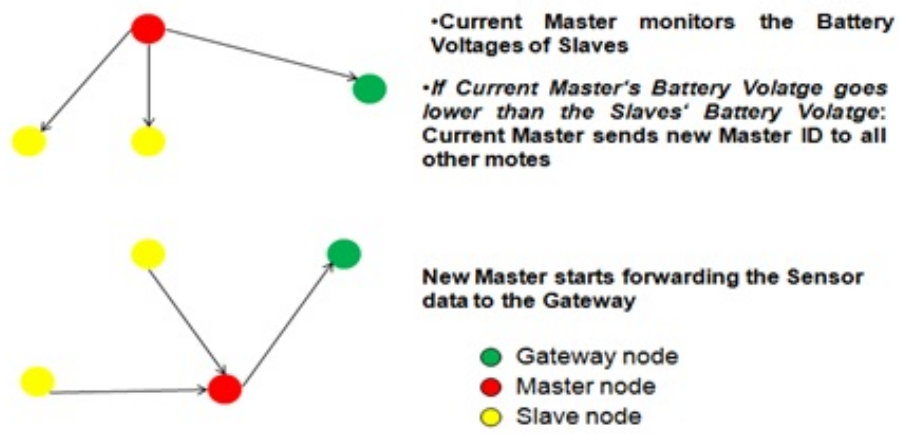

Figure 5.5: Master Selection Phase

Figure 5.5 shows the Master reconfiguration. The current Master monitors the battery voltage of Slaves. If current Master's battery voltage goes lower than the defined threshold of any of the Slave's voltage, then the current Master sends the new Master ID to all the motes including the Gateway. In our work we define the Master selection threshold as a multiplicative factor. If the current Master battery voltage goes lower than 5% of any of the Slave's battery voltage than we select that Slave as new Master.

6 Graphical User Interface

The following is the snapshot of the GUI developed in QT Creator. It shows the detection of the pose as "Lying". The Gateway mote is connected to the PC interface. The frame above shows the MAC IDs of the network motes as 1,2 and 3. Along with the IDs we can see the accelerometer values of its dual axis. It also shows the battery voltage of the motes. We set different thresholds on the Y-axis of the accelerometer in order to recognize the human pose.

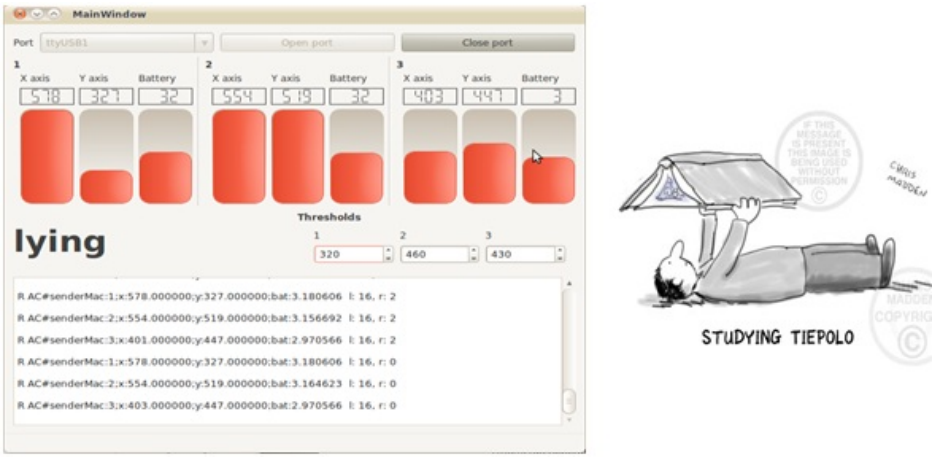

Figure 6.1: Graphical User Interface

7 Mote Direction

The following figure represents the direction of the motes placed on the human body with the sensor. It can be seen that the mote is in vertical direction and hence it is the only axis required to distinguish between different poses.

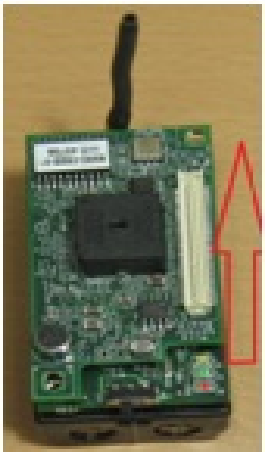

Figure 7.1: Mote Direction on Human Body

8 Project Success

Following are the tasks that we were able to achieve at the end of our work:

- Recognized Human poses
- Multi hop network
- Master-Slave approach to increase the life of the network
- Re-configurable network nodes
- PC-Gateway communication for GUI

9 Challenges

Following are the tasks that we were able to achieve at the end of our work:

- Not a very stable system (Human)
- Noise factor due to unwanted Human movement

A List of Figures

B Bibliography

[1] http://seminarprojects.com/thread-spins-spins-security-protocols-for-sensor-networks.

[2] http://virtual-labs.ac.in/cse28/ant/ant/8/theory.