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BAN- Implementation

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Abstract: With the ever decreasing size/miniaturization of electronic devices, lower power consumption and these electronic devices becoming less expensive, the idea (once a prophecy) of a full-fledged Body Area Network (BAN) is becoming a reality. The basic idea behind Body Area Networking or BAN [1] is that electronic devices like sensors, processors; Networking devices like switches, routers and connectivity devices like Bluetooth module, Wi-Fi module etc… are placed at the nodes of the human body. Certain wireless protocols and routing protocols are used to wirelessly inter connect these nodes and choose the optimum route for packet data transfer between them respectively. The ability to share data increases the usefulness of intra-body embedded personal information devices [2], providing features not possible with independent isolated devices. In this paper we are using 3 sensors- Heartbeat sensors, body temperature sensor and pressure sensors. These sensors actively measure the real time biological parameters of a human body and the information is exchanged between these sensors at the node using wireless connectivity like Bluetooth. The information flow or traffic flow is regulated and proper route selection process is carried out using dynamic routing protocol like OSPF. The output of these devices is monitored using smartphone installed with third party android application.

Keywords: decreasing size/miniaturization of electronic devices, lower power consumption and these electronic devices becoming less expensive, wireless protocols, routing protocols, Heartbeat sensors, body temperature sensor and pressure sensors, Bluetooth, OSPF, third party android application.

I. INTRODUCTION

Body Area Networking has many commercial and scientific applications which are suited to the 21st century world.

Few of the applications are mentioned below:

- Healthcare/fitness monitoring
- Performance analysis of athletes
- Physiological parameter analysis of players during training and pre-game/match fitness analysis
- Military and Defense
- Personal information sharing
- Interactive gaming
- Or a mixture of the above applications

Body Area Networking is a field of networking which has taken shape due to the improvement or changes in the following

- Miniaturization of electronics devices
- Light weight devices
- Lower power consumption
- Ever increasing processing speed
- Parallel processing
- Multi core processing environment
- Wireless protocols
- Improved dynamic routing protocols
- Improved sensor technology
- Improved NVRAM and flash memory

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In this paper we make use of body temperature sensors, heartbeat sensors and foot sensors(or array of pressure sensors). The body temperature sensors are placed under the armpit of a human being to measure the human body temperature on a timely basis(in ^{o}F or ^{o}K). The heartbeat sensor measures the heart rate in beats per minute (bpm) and is plugged to the ear-lobe and can also be worn as a wrist watch. The foot sensors or array of pressure sensors or placed at the bottom of the foot and usedto analyse gait of a person. All these 3 sensors share the data and resourcefully interconnected.

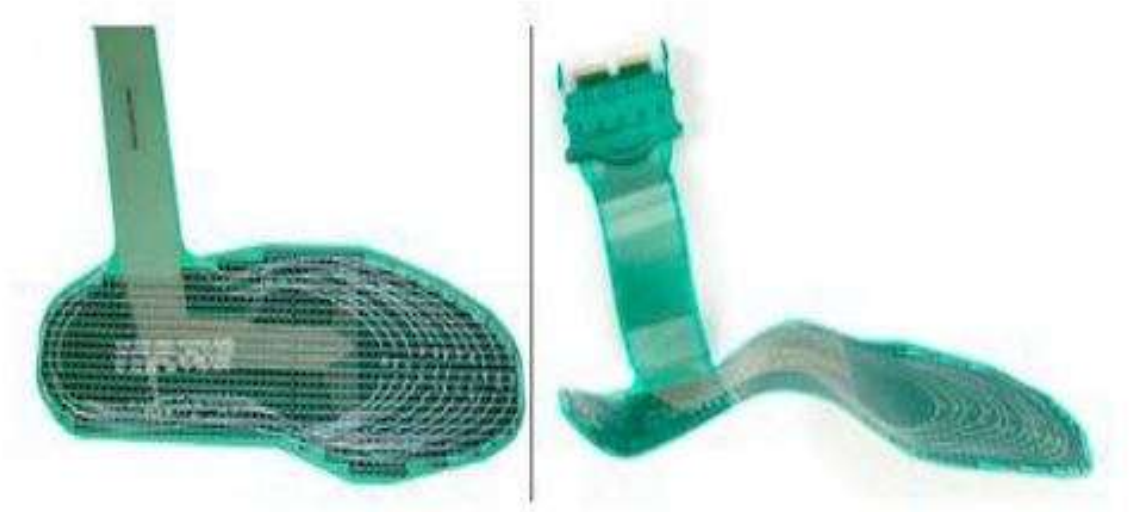

Figure 1 shows a wearable foot sensor for gait analysis

Figure 2 shows force sensors and potential pressure points for gait analysis

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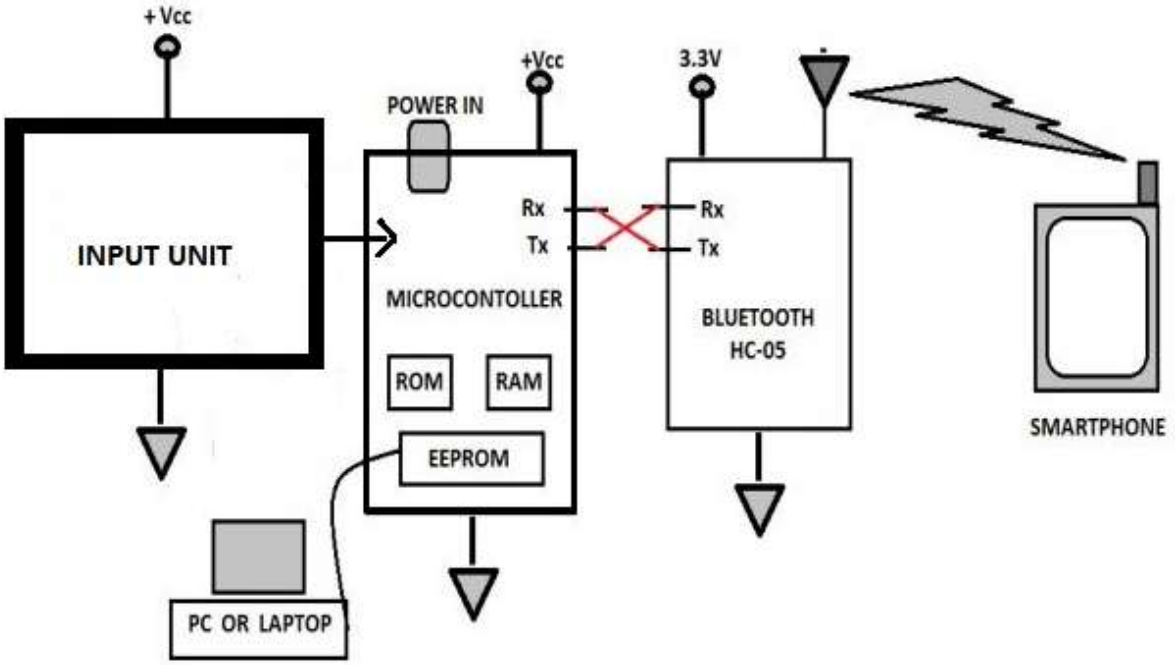

Figure 3 shows the flow of signal from input to processor and to the output unit.

II. SENSORS AND PROCESSING UNIT

A sensor acquires a physical quantity and converts it into a signal suitable for processing. A sensor maybe responsive or sensitive to one or more physical quantities like temperature, pressure, humidity etc. In this paper we are using 3 different sensors which are placed at the nodes of a body. They are

- Body temperature sensors
- Heartbeat sensors
- Pressure sensors

i. Body temperature sensors are used to measure the human body temperature and we have placed it in a strategic position i.e.; at the armpit. The body temperature is measured in ^{o}F or ^{o}K.
ii. Heartbeat sensors measure the heartbeat of a person in beats per minute and is placed at the wrist or plugged to the earlobe.
iii. Pressure sensors are embedded on to the foot-bottom of the human being for gait analysis. Pressure sensors can be a single foot sensors or an array of pressure sensors placed at pressure points of interest of the foot- bottom as shown in figure 1 and figure 2 respectively.

Following are the parameters to be considered while choosing a sensor.

A. Environmental factors

- Temperature range
- Humidity effects
- Corrosion
- Size
- Overage protection
- Susceptibility to EM interfaces
- Ruggedness
- Power consumption
- Self-test capability

B. Economic factor

- Cost
- Availability
- Lifetime

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C. Sensor characteristics

- Sensitivity
- Range
- Stability
- Repeatability
- Linearity
- Error
- Response time
- Frequency response

The sensor input at the nodes is fed to an ADC unit for sampling and quantization. Analog to Digital conversion is essential for, the microprocessor/microcontroller processes only digital data. A code is dumped into the processor or microcontroller and it functions accordingly. The output of the ALU unit is digital in nature and may or may not be converted to analog for display at the output unit. DAC is used for the above purpose. Figure 3 shows the flow of signal from input to processor and to the output unit.

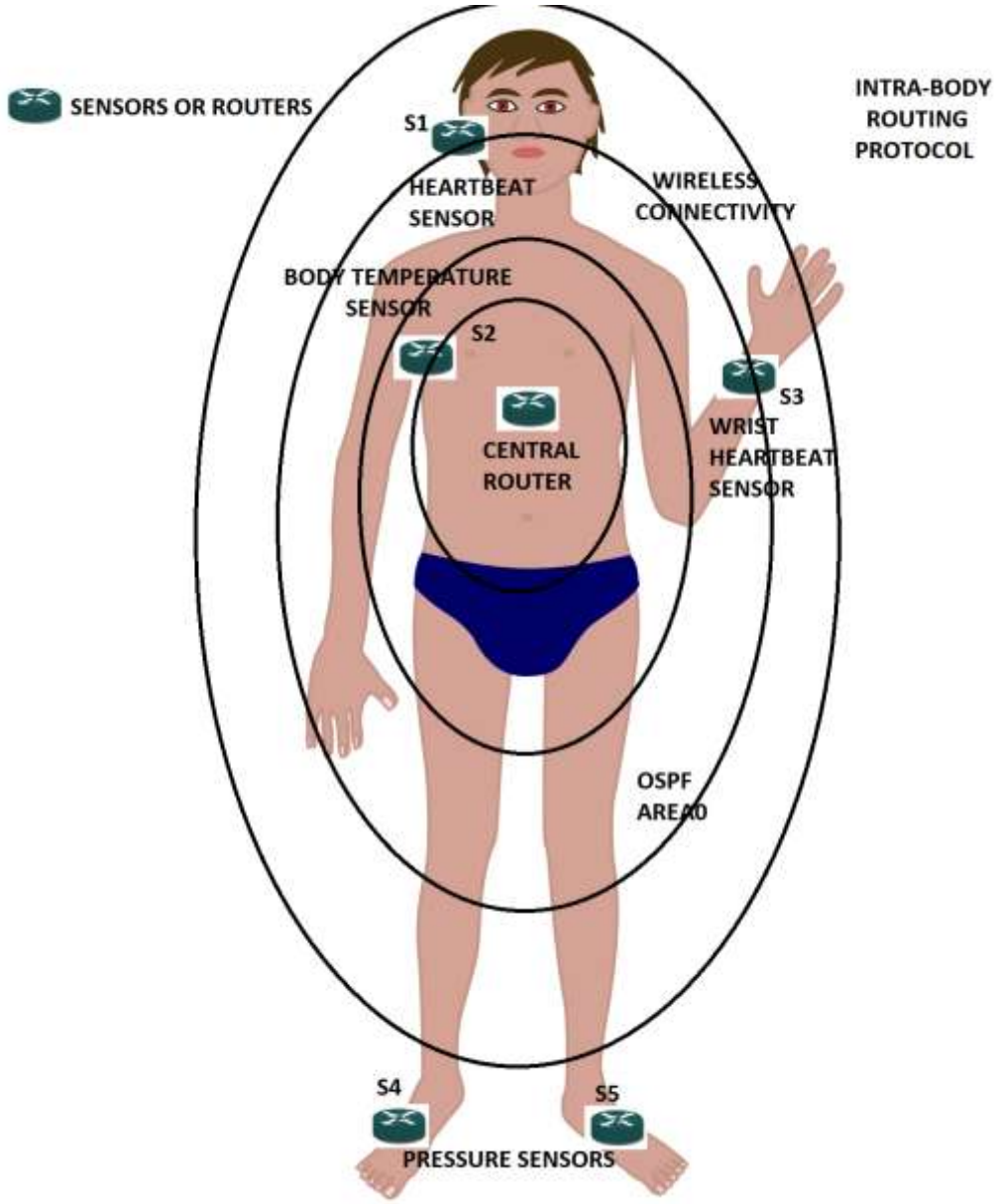

Figure 4 shows the network of interest with nodes and wireless connectivity

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III. CONNECTIVITY AND ROUTING PROTOCOL

We have placed the sensors at the nodes. The major challenge now is their connectivity. We used Bluetooth to wirelessly connect the sensors at the nodes, sensors to the microcontrollers and the sensors to the output display unit. When wireless connectivity is used in Body Area Network(BAN), it is called Wireless Body Area Network (WAN). Wireless connectivity is preferred because it avoids

Tangling of wires
- Signaltapping
- Use of long and rigid wires
- Consumption of too much space due to interconnectivity

And it has the following advantages
- Reduces the space occupied by wireless connectivity
- Only one frequency or a unique frequency can be made use of for one independent/autonomous Human Body
- ACLs can be applied to enhance security
- Encryption can be carried out easily.
- Password and pairing can be carried out to avoid line tapping or intrusion.

It is not enough to wirelessly connect the sensors at the nodes and other electronic components alone. There must be a base routing protocol (dynamic or static) to enable sharing of data between the sensors, microcontrollers, transducers and other electronic components. We have used Open Shortest Path First (OSPF) [3] routing protocol as the dynamic routing protocol. OSPF uses Link State Advertisements (LSAs) and Dijkstra's shortest path first algorithm. OSPF neighborship can be established between different components at the nodes [4]. Figure 4 shows the network topology of the proposed project

IV. RESULTS AND FINDINGS

When the ICMP echo [5] packets were sent from the central router to all the sensors with star topology, the success rate was 100%. Figure 5, Figure 6, Figure 7 and Figure 8 shows the ping results of s1,s2,s3 and s4 respectively, in an effort to ping from/to the central router. Five packets were sent and all five were successfully received back.

```
S1(config-if)#
S1(config-if)#^Z
S1#
S1#
S1#
S1#
S1#
*Aug 19 23:07:43.867: %SYS-5-CONFIG_I: Configured from console by console
S1#ping 10.1.12.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/22/36 ms
S1#
```

Figure 5

```
S2(config-if)#^Z
S2#
S2#
S2#
S2#
S2#
S2#
S2#
*Aug 19 23:05:51.091: %SYS-5-CONFIG_I: Configured from console by console
S2#ping 10.1.12.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/49/68 ms
S2#
```

Figure 6

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Figure 7

Figure 8

V. CONCLUSIONS

In this paper we have provided a basic architecture of an intra-body communication or Intra-BAN using sensors like body temperature sensors, heart beat sensors and pressure sensors for body temperature monitoring, heart beat monitoring and gait analysis respectively. We have made provisions for wireless communications between the sensors at the nodes using Bluetooth and also an ability to choose the optimum path in the network between the source and the destination. In the next paper an effort will be made to connect more bio-medical sensors both for monitoring and response to thresholds (reflexes).

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