Feasibility Analysis of Zigbee Protocol in Wireless Body Area Network

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ABSTRACT
In this paper, we describe feasibility analysis of Zigbee protocol in Wireless Body Area Network (WBAN). We use NS2 to simulate data from oscilloscope as model for physiological signal from sensor to WBAN's server. Four sensors were mounted in patient body and send the data simultaneously to the server using Zigbee protocol. Simulation result shows that packet loss, throughput and delay of the data transmission using Zigbee protocol is feasible to use in WBAN's data transmission.

Keywords
Zigbee protocol, WBAN, Telemedicine,

1. INTRODUCTION
Telemedicine system can be interpreted as a technique / method to perform medical procedures in the overall distance. In the implementation, telemedicine telecommunications infrastructure needed to connect the parties involved in the telemedicine (doctors, patients, pharmacists and others). The simplest form of telemedicine is the consultation between patients with a doctor using telecommunications services. In this mode, the doctor can only determine the patient's diagnosis of the complaint could not check the condition of the patient directly. To ensure valid diagnosis, where doctors can examine the patient's physiological signals, needed a mechanism to acquire the patient's physiological signals and send them via telecommunications networks. Telemedicine system like this would require a series of sensors to acquire physiological signals from the patient and sent to doctor's

PC. If there are several sensors mounted on the patient's body and simultaneously send a physiological signal data, sensor networks will be required. Series of sensors mounted on the body which must be integrated in one network so you can easily set in the data transmission.

A body-centric network, so-called BAN-Body Area Network, can be formed by integrating these devices on a human body (or its proximity). If BAN is implemented wirelessly, so we call it WBAN-Wireless Body Area Network. WBAN, with sensors consuming extremely low power, is used to monitor patients in critical conditions inside hospital. Outside the hospital, the network can transmit patients' vital signs to their physicians over the Internet (or private networks) in real time. In WBAN implementation, some parameters must be considered such as chosen platform. After we chose the platform, we have to measure the other network parameters such as delay time, packet loss, throughput and so on.

2. WBAN USING ZIGBEE
Wireless body area sensor networks (WBANs) are well suited to increase telepresence, as they can provide specific information about an individual's behavior without using complex laboratory equipment and without interfering with the person's natural behavior [11]. WBANs are generally built around several sensing devices wirelessly linked together using narrow-band radio communication [12]. Recent developments in the field of wireless networks have generated many new commercial wireless communication platforms based on different protocols and technologies (*Wi-Fi, WiMax, Bluetooth, Zigbee, UMTS, UWB*) [13]. These technologies offer a wide range of characteristics in terms of speed, transmission range, power requirements, connectivity, and cost. The choice of wireless network architecture for a WBAN application is context and sensor dependent.

The use of a WBAN system in telemedicine context calls for a small, reliable, low-power platform capable of seamlessly integrating several modules. The Zigbee technology was designed for this type of application. The IEEE 802.15.4 physical radio standard operates on the 2.4-GHz unlicensed band over 16 channels, and the network layer supports topologies such as star, tree, and mesh. Depending on the power output and environmental characteristics, transmission distances range from 10–100 m [14].

ZigBee's main advantage is its ability to be configured in so-called mesh networks with wireless nodes that are capable of multi-year battery lives. In a mesh topology, each node is in direct communication with its immediate neighbor; if a node fails, messages are automatically rerouted a sort of miniature Internet. ZigBee also supports more efficient star topologies, in which central access points talk to the nodes.

ZigBee is actually the network protocol, security, and application layers for one type of network that can run on radios conforming to the 802.15 standard of the Institute of Electrical and Electronics Engineers Inc. (IEEE), an umbrella that also covers Bluetooth and other types of wireless personal area networks (WPANs). The physical layers for ZigBee transmitters are described in IEEE 802.15.4 and were approved in 2006.

Table 1. Possible BAN/WBAN platformsWireless technologies and possible BAN/WBAN platforms [1]

Technology	Transfer Rate	Range	BAN/WBAN
WiFi	11 – 54 Mb/s	30 – 50 m	PDAs
WiMax	45 – 70 Mb/s	100 m – 50 km	Portable computers
Bluetooth	57 kb/s – 3 Mb/s	100 m	iMotes
Zigbee	20 -250 Mb/s	100 m	MiCaz, Telos
UMTS	50 kb/s – 2 Mb/s	5 – 100 km	Mobihealth
UWB	54 kb/s – 48 Mb/s	1 – 10 km	Magnet

The Zigbee protocol was designed to be optimal for the control and sensor application space. It is less complex than Bluetooth, has superior power management (2 AA battery can have ZigBee module last over years) , supports many more nodes per network, has lower latency, lets devices join the network more quickly, and wakes up in milliseconds instead of seconds. These of advantages of Zigbee, make it become the right platform for WBAN's application.

3. MODELLING AND SIMULATION

The simulation of WBAN in WSN network using IEEE 802.15.4 was conducted by *Network Simulator 2* (NS2). The inputs for the simulation are describe below.

3.1 Topology

Mesh topology is chosen in the simulation because each sensor is directly connected to the PAN coordinator. That's why no routing protocol used in scenario. Topology is selected with 4 sensor nodes and 1 PAN coordinator. All of the sensor nodes attach on 1 patient but located in different coordinates. Topology used in the simulation can be seen in Figure 1.

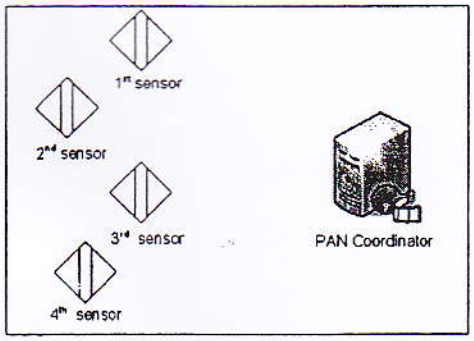

Figure 1. Network topology used in scenario

3.2 Scenario

The input parameters for the simulation are presented in Table 2.

Table 2. Input Parameter for Simulation

Parameter	Spesification
Distance between nodes	± 25 meter
Packet size	30 bytes
Packet rate	5 Kbps
Duration	900 s
Propagation	Two Ray Ground
Routing protocol	None

These inputs are used in the scenario for measuring: packet loss, throughput and delay between sensor nodes to PAN coordinator.

Delay = propagation delay + transmission delay + queuing delay

$$\text{Packet loss} = \frac{\text{packets that fail to reach their destination}}{\text{all packets sent from source}} \times 100\%$$

$$\text{Throughput} = \frac{\text{successful packets reaching their destination}}{\text{all packets sent from source}} \times 100\%$$

4. SIMULATION AND ANALYSIS

4.1 Delay

Each sensors yield different delay, as shown in table 3.

Table 3. Delay from Sensor to server

Source	Destination	Delay (ms)
1	0	0.352034
2	0	0.352031
3	0	0.352033
4	0	0.352032

The average delay for all sources is calculated as 0.3520325 ms. It means that each node only needs to transmit directly to destination because the routing protocol is disabled. The delay will increase if we use routing protocol such as AODV for finding path from source to destination.

4.2 Packet loss

Each nodes has packet loss when sending the packets, as shown in table 4.

Table 4. Packetloss from all nodes

Source	Packetloss (bytes)	Percentage (%)
0	101640	1.65595445
1	87150	1.4198783
2	85080	1.38615313
3	93690	1.52643026
4	96900	1.57872871

From the tracing file during simulation, it shown that drop packets caused by failed connection establishment in TCP connection. This happened because of low signals from the source to destination. None of the packets contain data is drop during the transmission.

4.3 Throughput

The received packets for each node presented in table 5 :

Table 5. Throughput from all nodes

Source	Throughput (bytes)	Percentage (%)
0	6036210	98.34404555
1	6050700	98.5801217
2	6052770	98.61384687
3	6044160	98.47356974
4	6040950	98.42127129

From table 5, we can infer that throughput from each sensors and PAN coordinator yield in for about 98% from overall packets transmitted. And the packets received are data, which means that Zigbee protocol is reliable enough to be used as network technology for WBAN.

5. SUMMARY

The average delay for all sources is calculated as 0.3520325 ms

Drop packets caused by failed connection establishment in TCP connection, furthermore it's also caused by low signals from the source to destination.

Throughput from each sensors and PAN coordinator yield in for about 98% from overall packets transmitted, means that Zigbee protocol is reliable enough to be used as network technology for WBAN.

6. REFERENCES

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