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Low Bit Error Rate Based Communication by IEEE 802.15.4

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Abstract: - The ever-expanding and explosive growth of the Internet over the last decade has led to an increasing demand for high-speed, ubiquitous Internet access. Broadband Wireless technologies are increasingly gaining popularity by the successful global deployment of the Wireless Personal Area Networks (Bluetooth- IEEE 802.15.1), Wireless Local Area Networks (WiFi- IEEE 802.11b), and Wireless Metropolitan Area Networks (WiMAXIEEE 802.16a). In this paper we have used the MATLAB Simulator to analyze the performance of IEEE 802.15.1, and IEEE 802.15.4 . The performance metrics measured in this study includes BER (Bit Error Rate). The results show how BER(Bit Error Rate) affects the performance of IEEE 802.15.1 and IEEE 802.15.4.

Keywords:- IEEE 802.11b, 802.15.1, 802.16a, Wi-Fi, Bluetooth, WiMAX, MANET, Matlab.

I. INTRODUCTION

The wireless technology provides wireless services like WLAN, WPAN, and Bluetooth etc. It allows spontaneous deployment and self-management. Bluetooth is a short range radio technology operating in the unlicensed ISM (Industrial-Scientific-Medical) band. The Bluetooth technology, as described in the specifications [4], is expected to be one of the most promising technologies for enabling ad hoc networks. Bluetooth specifications define ways for which each device can set up multiple connections with neighboring devices so that communication can be established. In this sense, Bluetooth devices spread in a geographic area can provide the missing extension to the various heterogeneous network infrastructures of wireless access.

Two wireless systems that have experienced the most speedy growth and wide attractiveness are the standard developed by IEEE for wireless local area networks (WLANs), identified as IEEE 802.11, and the Bluetooth as IEEE 802.15.1. Both these systems operate in the 2.4 GHz Industrial, Scientific, and Medical (ISM) radio frequency band (i.e., 2.400-2.4835 GHz). IEEE 802.11 WLANs are designed to cover huge areas such as offices or buildings. The fundamental building block of the network is the so-called Basic Service Set (BSS), which is composed of several wireless stations and one fixed access point. The access point provides connection to the wired

network [3]. WLANs operate at bit-rates as high as 11 Mbps and can use either a FHSS (Frequency Hopping Spread Spectrum) or a DSSS (Direct Sequence Spread Spectrum) [3,7]. In case of FHSS systems, hopping sequences span over 79 channels, each one 1 MHz wide; while, DSSS systems use a 11 chip Barker sequence and their bandwidth is roughly equal to 20 MHz [1,2,5].

Bluetooth can provide a bit rate equal to 1Mbps. A FHSS scheme is used at the physical level; each master chooses a different hopping sequence so that pioneers can operate in the same area without interfering with each other. Hopping frequencies range over 79 frequency channels in the ISM band, each of the channels being 1MHz wide. The nominal hop dwell time is equal to 625 s. Sequences are created by generating several sub sequences, each composed of 32 hops. The first sub sequence is obtained by taking 32 hops at random over the first 64MHz of the frequency spectrum; then the successive 32MHz are skipped, and the next sub-sequence is randomly chosen among the following 64MHz. The procedure is repeated until the hopping sequence is completed [4]. A TDD technique is used to transmit and receive data in a piconet: each packet transmitted in a slot corresponds to the minimum dwell time; slots are centrally allocated by the master and alternately used for master and slave transmissions.

II. WLAN

A wireless local area network (WLAN) is a wireless computer network that links two or more devices using a wireless distribution method (often spread-spectrum or OFDM radio) within a limited area such as a home, school, computer laboratory, or office building. This gives users the ability to move around within a local coverage area and yet still be connected to the network. A WLAN can also provide a connection to the wider Internet.

Most modern WLANs are based on IEEE 802.11 standards and are marketed under the Wi-Fi brand name.

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Wireless LANs have become popular for use in the home, due to their ease of installation and use. They are also popular in commercial complexes that offer wireless access to their customers (often without charge). New York City, for instance, has begun a pilot program to provide city workers in all five boroughs of the city with wireless Internet access.

The IEEE 802.11 has two basic modes of operation: infrastructure and ad hoc mode. In ad hoc mode, mobile units transmit directly peer-to-peer. In infrastructure mode, mobile units communicate through an access point that serves as a bridge to other networks (such as Internet or LAN).

Since wireless communication uses a more open medium for communication in comparison to wired LANs, the 802.11 designers also included encryption mechanisms: Wired Equivalent Privacy (WEP, now insecure), Wi-Fi Protected Access (WPA, WPA2), to secure wireless computer networks. Many access points will also offer Wi-Fi Protected Setup, a quick (but now insecure) method of joining a new device to an encrypted network.

III. INFRASTRUCTURE

Most Wi-Fi networks are deployed in infrastructure mode. In infrastructure mode, a base station acts as a wireless access point hub, and nodes communicate through the hub. The hub usually, but not always, has a wired or fiber network connection, and may have permanent wireless connections to other nodes.

Wireless access points are usually fixed, and provide service to their client nodes within range. Wireless clients, such as laptops, smart phones etc. connect to the access point to join the network. Sometimes a network will have a multiple access points, with the same 'SSID' and security arrangement. In that case connecting to any access point on that network joins the client to the network. In that case, the client software will try to choose the access point to try to give the best service, such as the access point with the strongest signal.

A. Peer-To-Peer

An ad hoc network (not the same as a Wi Fi Direct network) is a network where stations communicate only peer to peer (P2P). There is no base and no one gives permission to talk. This is accomplished using the Independent Basic Service Set (IBSS).

A Wi Fi Direct network is another type of network where stations communicate peer to peer. In a Wi-Fi P2P group, the group owner operates as an access point and all other devices are clients. There are two main methods to establish a group owner in the Wi-Fi Direct group. In one approach, the user sets up a P2P group owner manually. This method is also known as Autonomous Group Owner (autonomous GO). In the second method, also called negotiation-based group creation, two devices compete based on the group owner intent value. The device with higher intent value becomes a group owner and the second device becomes a client. Group owner intent value can depend on whether the wireless device performs a cross-connection between an infrastructure WLAN service and a P2P group, remaining power in the wireless device, whether the wireless device is already a group owner in another group and/or a received signal strength of the first wireless device.

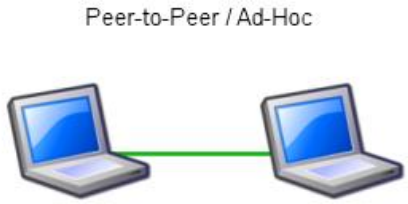

Fig 1. Peer to Peer Connection

A peer-to-peer network allows wireless devices to directly communicate with each other. Wireless devices within range of each other can discover and communicate directly without involving central access points. This method is typically used by two computers so that they can connect to each other to form a network. This can basically occur in devices within a closed range.

If a signal strength meter is used in this situation, it may not read the strength accurately and can be misleading, because it registers the strength of the strongest signal, which may be the closest computer.

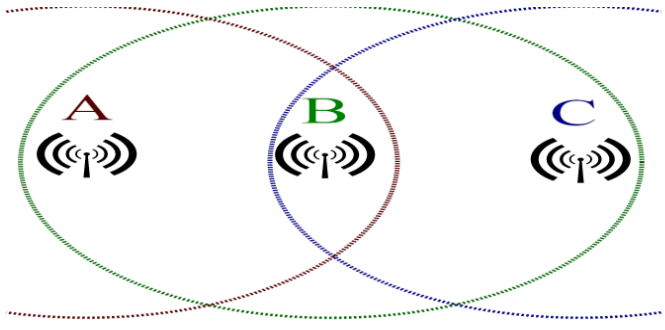

Fig 2. WiFi Hidden Station Problem.

IEEE 802.11 defines the physical layer (PHY) and MAC (Media Access Control) layers based on CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). The 802.11 specification includes provisions designed to minimize

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collisions, because two mobile units may both be in range of a common access point, but out of range of each other.

B. Bridge

A bridge can be used to connect networks, typically of different types. A wireless Ethernet bridge allows the connection of devices on a wired Ethernet network to a wireless network. The bridge acts as the connection point to the Wireless LAN.

IV. BLUETOOTH

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can be used at home, in the office, in the car, etc. This technology allows to the users instantaneous connections of voice and information between several devices in real time. The way of transmission used assures protection against interferences and safety in the sending of information. Between the principal characteristics, must be named the hardiness, low complexity, low consume and low cost. The Bluetooth is a small microchip that operates in a band of available frequency throughout the world. Communications can realize point to point and point multipoint.

Frequency Bands The standard Bluetooth operates in the band of 2,4 GHz. Though worldwide, this band is available, the width of the band can differ in different countries. This is the frequency of band of the scientific and medical industries 2.45 GHz (ISM*). The ranges of the bandwidth in The United States and Europe are between 2.400 to 2.483,5 MHz and it covers part of France and Spain. The ranges of the bandwidth in Japan are between 2.471 to 2.497 MHz. So the system can be used worldwide due to that the transmitters of radio covers 2.400 and 2.500 MHz and it is possible to select the appropriate frequency. This ISM* is opened for any system of radio and must take care of the interferences of monitors for baby, the controls for doors of garages, the wireless telephones and the microwave ovens (the source with higher interference).

The Bluetooth protocol stack is illustrated [11]. The Bluetooth specific protocols are SDP, L2CAP, Link Manager, Baseband, and the Bluetooth Radio. Our primary modeling focus is on the characteristics of the RF, Baseband, and L2CAP elements of the stack. Assuming maximum traffic density, it is the characteristics of these sub-layers that dictate network performance in the presence of mutual interference. The network unit in Bluetooth is called a piconet. A piconet consists of at least two nodes: a master and anywhere from one to seven slaves. The master defines the piconet's pseudo-random frequency hopping sequence and transmission timing, derived from the master's 48 bit address and clock value. The master controls the channel by polling the slave(s) and is always the first to transmit in the TDD cycle. Each slave may only transmit after successful reception from the master.

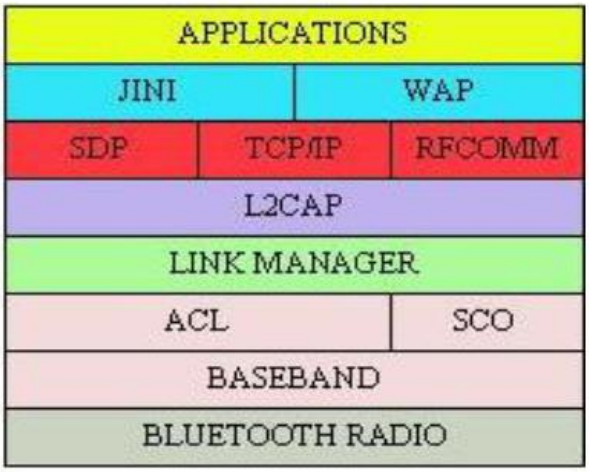

Fig 3. Bluetooth Protocol Stack

The Bluetooth Baseband sub-layer offers two data link layer transmission services, Asynchronous Connection Less (ACL) and Synchronous Connection Oriented (SCO). SCO is a symmetric point-to-point service in which the master transmits on reserved slots. The slave transmits in the following slot. This service was designed to support real time applications, especially voice. The ACL service utilizes a link level ARQ algorithm in which packets are retransmitted until a positive acknowledgement is received by the sender, insuring that ACL frames are not dropped in the physical channel [11].

Bluetooth Baseband utilizes optional Forward Error Correction for certain packet types. SCO supports 1/3 and 2/3 FEC, while ACL allows for 2/3 FEC only. The Logical Link Control and Adaptation Protocol (L2CAP) handle application multiplexing, segmentation and reassembly (SAR), and group abstractions. The Link Manager (LM), also called Link Management Protocol (LMP), is responsible for connection establishment, security, and control. LM messages are filtered out at the receiving node and are not sent up the protocol stack. The Service Discovery Protocol (SDP) identifies services available by or through a Bluetooth device.

A. *Scatter Net*

Scatter net is a group of independent and non-synchronized piconets that share at least one common Bluetooth device. Bluetooth devices must have point-to-multipoint capability to engage in scatter net communication. There may be a maximum of 10 fully loaded piconets in a scatter net [9]. There can be only 2 to 8 Bluetooth devices talking to each other. This is called a piconet. Among these devices, there can be only one master device, all the rest are slave devices. A device can belong to two piconets meantime, serving as slaves in both piconet or a master

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in one and slave in another. This is called a bridging device [11]. Bridging devices connect piconets together to form a scatternet:

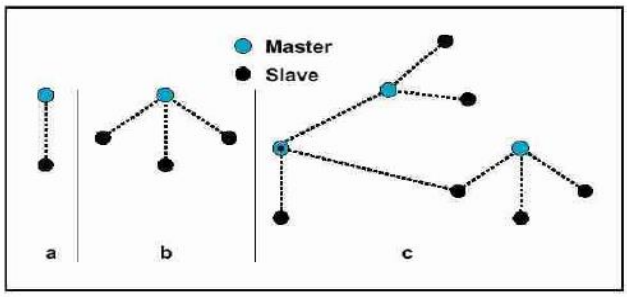

Fig 4. Single slave piconet (a), multiple-slave piconet (b) and scatternet (c)

B. IEEE 802.11b

The IEEE 802.11 standard [3,5,8] defines both the physical (PHY) and medium access control (MAC) layer protocols for WLANs. In this sequel, we shall be using WLAN and 802.11b interchangeably. In this work, we focus on the 802.11b specification (DS spread spectrum) since it is in the same frequency band as Bluetooth and the most commonly deployed. The basic data rate for the DS system is 1Mbps encoded with differential binary phase shift keying (DBPSK). Similarly, a 2Mbps rate is provided using differential quadrature phase shift keying (DQPSK) at the same chip rate of 11 × 106 chips/s. Higher rates of 5.5 and 11Mbps are also available using techniques combining quadrature phase shift keying and complementary code keying (CCK) [9,10]; all of these systems use 22MHz channels. The IEEE 802.11 MAC layer specifications, common to all PHYs and data rates, coordinate the communication between stations and control the behavior of users who want to access the network. The Distributed Coordination Function (DCF), which describes the default MAC protocol operation, is based on a scheme known as Carrier Sense Multiple Access, Collision Avoidance (CSMA/CA). Both the MAC and PHY layers cooperate in order to implement collision avoidance procedures [3,4]. The PHY layer samples the received energy over the medium transmitting data and uses a clear channel assessment (CCA) algorithm to determine if the channel is clear. This is accomplished by measuring the RF energy at the antenna and determining the strength of the received signal commonly known as RSSI, or received signal strength indicator. In addition, carrier sense can be used to determine if the channel is available. This technique is more selective since it verifies that the signal is the same carrier type as 802.11 transmitters. In all of our simulations, we use carrier sense and not RSSI to determine if the channel is busy. Thus, a Bluetooth signal will corrupt WLAN packets, but it will not cause the WLAN to defer transmission.

C. Interference Modeling

The 802.11 is generated by a separate independent block which allows us to control precisely the rate of 802.11 transmissions.

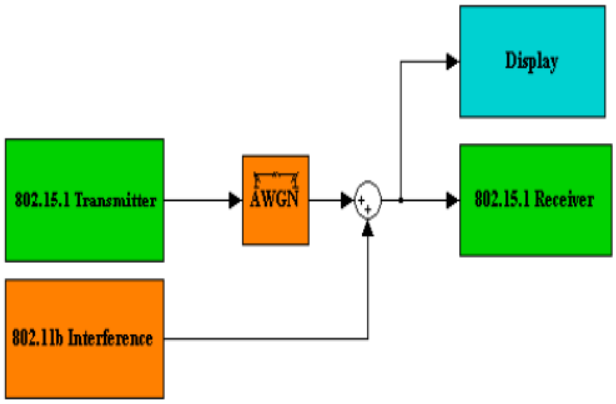

Fig 5. Interference Modeling

V. PROPOSED METHODOLOGY

IEEE 802.15.4 addresses the needs of Low-Rate Wireless Personal Area Networks (LR-WPAN). While other WLAN (e.g. IEEE 802.11.a/b/g) and WPAN (e.g. IEEE 802.15.1 and 802.15.3) technologies focus on providing high data throughput over wireless ad hoc networks, IEEE 802.15.4 is designed to facilitate those wireless networks, which are mostly static, large, and consuming small bandwidth and power. Therefore, the IEEE 802.15.4 technology is anticipated to enable various applications in the fields of home networking, automotive networks, industrial networks, interactive toys and remote metering.

VI. RESULTS

In the Results Session, showing the comparison for the IEEE 802.15.1 and IEEE 802.15.4. Figure 6 is showing the comparison for the 802.15.1 and IEEE 802.15.4 method with respective to BER (Bit Error Rate).

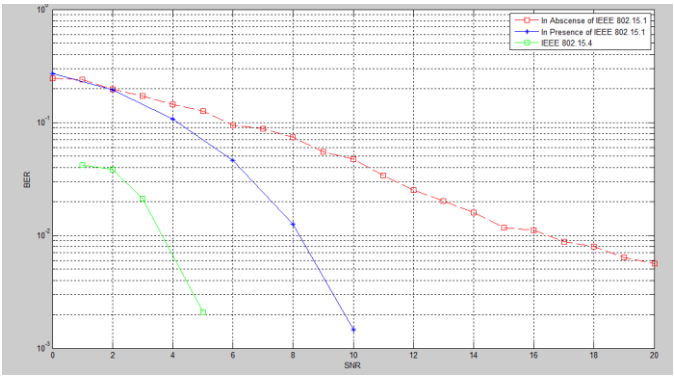

Fig 6 . Comparison Graph.

VII. CONCLUSION

Now a days there are many wireless sensor, monitoring and control applications which covers wide range for industrial and home markets. Such applications require lower data rates, longer battery life, low power consumption and less complexity than available from existing wireless standards like Wi-Fi and Bluetooth. So, there was a need for a standard based, interoperable wireless technology that adresses the above needs. In this regard, 802.15.4/zigbee has become the global sensor, monitoring and control network standard.

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