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Comparative Analysis of Different Wireless Technologies

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Abstract— This paper gives brief understanding of different wireless technologies. Comparative analysis between them with the help of suitable pictures, graphs and tables. This paper covers different wireless technologies including Bluetooth, Infrared, Zigbee, NFC and Wi-Fi. Now a days, wireless technologies becoming more and more advance.In this era, it is more important to do analysis of these technologies to use these at it's maximum.

Index Terms— Bluetooth, Infrared, NFC, Wi-Fi, Wireless technology, Zigbee

I. INTRODUCTION

Wireless technology used to share the data, information between two or more points which are not physically connected. The communication distance between the points can be short, medium and long. Communication can be happened between few meters to kilometers range. The two points can be a mobile, tablet, Television, PDA, Computer, Laptop, wireless keyboard, mouse, GPS unit and many more. Through wireless technology, one can communicate and share the data in long range, which can not be possible through physical interface or wires. Wireless communication canbe possible via radio frequency, microwave and infrared. Technologies like Bluetooth, Wifi, Zigbee and NFC uses radio frequencies to communicate between two points whereas Infrared uses Infrared waves for communication. Using wireless technology, information can be exchange in long range, fastly and securely.

Different technologies used for different purpose according to its need. For example Bluetooth is used in mobile phones, tablets and laptops to send\receive data, sharing networks and listening audio. It's dependent on the need to use which technology where. Range is also a big factor to choose the technology. Whether we have to send the data in short distance or long distance. There are many factors on which we can compare these technologies and conclude that when and where these technologies will be more effective and useful.

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All the comparative analysis will be covered in more detail in this paper.

II. DIFFERENT WIRELESS TECHNOLOGIES

Bluetooth

Bluetooth is a short range wireless technology originally intended to replace the cable(s) connecting portable and/or fixed electronic devices. It's a technology standard using short range radio links. Bluetooth operates Frequency Hopping Spread Spectrum (FHSS) to avoid any interference. Bluetooth radios operate in the unlicensed ISM band at 2.4 Gigahertz using 79 channels between 2.402 GHz to 2.480 GHz.

A data channel hops randomly 1600 times per second between the 79 RF channels. Each channel is divided into time slots 625 microseconds long. The range of Bluetooth communication is 0-100 meters, dependent upon power of devices. Every Bluetooth device is classified in three classes (class 1, class 2, and class 3) dependent upon its range.

There are two types of data transfer between devices: SCO (Synchronous Connection Oriented) and ACL (Asynchronous Connectionless). There are different Bluetooth versions available in the market, which are designed for downward compatibility. Now days, Bluetooth is a common feature in many electronic devices including mobile phones, tablets, laptops etc.

Bluetooth technology works using two concepts. Bluetooth Protocol and Bluetooth profiles. Bluetooth protocol defines – how Bluetooth works and Bluetooth

profiles define – how to use Bluetooth. Bluetooth Special Interest group (SIG) has developed the Bluetooth Protocol stack. Main objective of this specification to achieve interoperability between different device manufacturer companies. There are many Bluetooth profiles like A2DP, AVRCP, DUN, PAN, HFP, HSP, FTP, PBAP, SDP, MAP, HID, HDP, OPP, OBEX, BPP, BIP etc. Every profile is defined for specific purpose. For example A2DP profile is used to listen audio.

Infrared

Infrared allows devices to communicate via short-range wireless signals. Through infrared, devices can transfer data bidirectionally. Infrared networks were designed to support direct two connections only, created temporarily as the need arises. Infrared have a frequency in the electromagnetic spectrum in the range just below that of red light. Objects radiate infrared in proportion to their temperature. The main reason for using IrDA had been wireless data transfer over the "last one meter" using point and shoot principles. Thus, it has been implemented in portable devices as mobile phones, laptops, cameras, printers, medical devices and many more. Main characteristics of this kind of optical wireless communication is physically secure data transfer, Line-of-Sight (LOS) and very low bit error rate (BER) that makes it very efficient.

Infrared, a direct or incoming network connection to a remote access server using an infrared port. Infrared technology is the use of the lesser frequency of light for electronic purposes. It needs the hindsight of touch or nearness. Infrared technology is used mainly in television remotes and low budget mobiles. They work through a processor and sensor and need both to be in plain sight of each other. If that is not done, the technology won't work. It works even on reflection and mirrors or water provide genuine reflectors for infrared technology. The general distance between the transmitter and receptor needs to be less than 10 meters.

Infrared radiation is traditionally divided into four categories based on the wavelength. Near Infrared: 750-1500 nanometers. Middle Infrared: 1500-6000 nanometers. Far Infrared: 6000-40,000 nanometers. Far far Infrared: 40.000-1milimeter.

The Infrared Data Association (IrDA) is an industry driven interest group that was founded in 1993 by around 50 companies. IrDA provides specifications for a complete set of protocols for wireless infrared communications and the name "IrDA" also refers to that set of protocols.

Near Field Communication (NFC)

Near Field Communication (NFC) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. NFC used in wide range including contactless transactions, data exchange and use other wireless technology like Bluetooth, wifi in easier way. Communcication is also possible between an NFC device and an unpowered NFC chip called a "tag". NFC builds upon Radio-frequency identification (RFID) systems by allowing two-way communication between endpoints, where earlier systems such as contactless smart cards

TABLE 1
COMPARISON BETWEEN 802.11/A/B/G STANDARD

	802.11a	802.11b	802.11g
Frequency Band	5 GHz	2.4 GHz	2.4 GHz
Speed	54 Mbps	11 Mbps	54 Mbps
Bandwidth	Less Interference, more bandwidth	Not as fast as other technologies	Faster than 802.11b
Range	Not as widely implemented, shorter range	Best over-all coverage range	better range than 802.11a and Less range than 802.11b

Table 1 shows comparison between different Wi-Fi standards

were one-way only. Since unpowered NFC "tags" can also be read by NFC devices, it is also capable of replacing earlier one-way applications.

NFC is set of short-range wireless technologies, typically requiring a distance of 4 cm or less. NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC always

involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication is possible, provided both devices are powered. NFC tags contain data and are typically read-only but may be rewriteable. They can be custom-encoded by their manufacturers or use the specifications provided by the NFC Forum, an industry association charged with promoting the technology and setting key standards. The tags can securely store personal data such as debit and credit card information, loyalty program data, PINs and networking contacts, among other information. The NFC Forum defines four types of tags which provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance. Tags currently offer between 96 and 4,096 bytes of memory.

NFC standards cover communications protocols and data exchange formats, and are based on existing radio-frequency identification (RFID) standards including ISO/IEC 14443 and FeliCa. The standards include ISO/IEC 18092 and those defined by the NFC Forum, which was founded in 2004 by Nokia, Philips and Sony, and now has more than 160 members. The Forum also promotes NFC and certifies device compliance.

Wireless Fidelity (Wi-Fi)

Wireless Fidelity (Wi-Fi) is a generic term that refers to the IEEE 802.11 communications standard for wireless local area networks (WLANs). Wi-Fi network connect computers to each other, to internet and to the wired network.

The 802.11 standard has been developed to enable wireless local area networking in either the 2.4 GHz or 5.2 GHz ISM bands (Industrial, Scientific, and Medical band) which is qualified by Federal Communications Commission (FCC). Specifically, the frequencies used by 802.11 fall in the unlicensed bands, these are frequency bands which anyone can use for radio communication (without a license). The exact frequencies used (and how they are used) depends on whether the system follows 802.11b, 802.11a, or 802.11g.

There are many security methods available, which is used to prevent wi-fi from unauthorized access or security threat. Most common security methods are Wireless Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA). WEP is one of the least secure method, which is replaced by WPA. WPA2 is advance version of WPA, which is more secure than WPA.

Both Wi-Fi and Bluetooth wireless technology share spectrum and will often be located in close physical proximity to one another. Wi-Fi and Bluetooth both occupy a section of the 2.4 GHz ISM band that is 83 MHz-wide. So Interference is possible. Due to this data packets get corrupted and are resend again and again. During Interference, when transmitting data on Asynchronous Connection-Less (ACL) links, it will degrade data throughput as more packets need to be resent. However, when using Synchronous Connection Oriented (SCO) links to transmit time-sensitive information such as voice, packets can be lost.

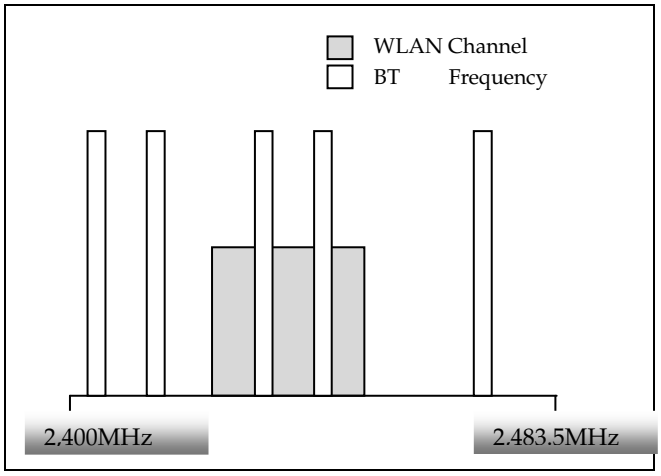

Fig. 1. BT-Wifi Channel Interference

Figure 1 shows BT/Wifi channels. Bluetooth uses Frequency Hopping Spread Spectrum (FHSS) and is allowed to hop between 79 different 1 MHz-wide channels in this band at a rate of 1600hops/s. Wi-Fi uses Direct Sequence Spread Spectrum (DSSS) divides 83 MHz into 11 channels with 22MHz wide. Channels do not hop or change frequency and remains centered on one channel. Bluetooth uses AFH(Adaptive Frequency Hopping) which classifies good and bad channels so that bad channels are avoided and replaced by pseudo-randomly selecting out of the remaining good or free channels.

ZigBee

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area network. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones.

ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates.

ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.

Zigbee bases itself on the IEEE 802.15.4-2003 specifications which lay down standards for the Physical and MAC layers. The protocol stack is completed by adding Zigbee's own Network and Application Layers. Drawing analogies from the OSI protocol stack simplifies the study of Zigbee protocol. ZigBee devices are of three types – ZigBee Coordinator (ZC), ZigBee Router (ZR), and ZigBee End Device (ZED).

ZigBee Alliance is a group of more than 300 companies including industry majors like Philips, Mitsubishi Electric, Epson, Atmel, Texas Instruments etc. which are committed towards developing and promoting this standard. The alliance is responsible for publishing and maintaining the ZIgbee specification and has updated it time and again. The manufacturers which are members of the Alliance provide software, hardware and reference designs to anyone who wants to build applications using Zigbee.

III. Comparative analysis

Wireless technologies can be compared on the basis of different benchmarks. Table 2 gives summary of main differences among the five wireless technologies. For example Wifi provide high data rate, while Bluetooth and ZigBee gives lower data rate.

Frequency Band

Bluetooth, Wifi and ZigBee works in 2.4 GHz ISM (Industrial-Scientific-Medical) band.Bluetooth uses frequency hopping (FHSS) with 79 channels, while ZigBee uses direct sequence spread spectrum (DSSS) with 16 channels and 2 MHz bandwidth. Wi-Fi uses DSSS (802.11), complementary code keying (CCK, 802.11b), or OFDM modulation (802.11a/g) with 14 RF channels. Infrared uses 875 nm whereas NFC works at 13.56 MHz frequency.

Data rate

Bluetooth works in the range of 1-100m, Infrared 0.2-1m, NFC less than 0.2m, Wifi 100m and Zigbee 1-100m. Bluetooth data transfer rate is 3 Mbit/s, Infrared 4 Mbit/s, NFC 424 Kbit/s, Wifi 54 Mbit/s and Zigbee 250Kbit/s. Maximum number of nodes supported in Bluetooth network is 8(1 master + 7 slave), Infrared - 2, NFC - 2, Wifi – 2007 and Zigbee greater than 65000.

Security

Wireless technologies use different encryption and authentication methods to securely transfer the data. Bluetoth uses E0 stream cipher for encrypting the data whereas in Infrared encryption is not used. NFC uses AES encyprion me thod, Wifi uses RC4 stream cipher and Zigbee uses AES block cipher for encrypting the data.
In Bluetooth authentication is done using shared secret key, no authentication is done in Infrared, NFC uses in-built authentication, Wifi has different authentication method and Zigbee uses CBC-MAC.

IV. Conclusion

This paper is not prepared to show which the best wireless technology is. This paper describes what the differences between various wireless technogy are and which technology fulfils the needs of particular user. Comparison is based on frequency band, range, data transfer rate, modulation type etc.

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Orthogonal frequency division multiplexing), COFDM (coded OFDM), MB-OFDM (multiband OFDM), M-QAM (M-ary quadrature amplitude Modula

TABLE 2

DIFFERENCE BETWEEN WIRELESS TECHNOLOGIES

Standard	Bluetooth	Infrared	NFC	Wi-Fi	ZigBee
Governing Body	Bluetooth SIG	Infrared Data Association	NFC Forum	Wifi Alliance	ZigBee Alliance
IEEE Specification	802.15.1	802.11	802.2	802.11a/b/g	802.15.4
Frequency Band	2.4 GHz	875 nm +-	13.56 MHz	2.4 GHz, 5 MHz	868/915 MHz, 2.4 GHz
Standard Range	1-100m	0.2-1m	< 0.2 m	100m	10-100m
Number of RF channels	79	50	1	14	1/10, 16
Max number of nodes	8	2	2	2007	>65000
Data Transfer Rate	3 Mbit/s	4 Mbit/s	424 Kbit/s	54 Mbit/s	250 Kbit/s
Modulation type	GFSK	pulse	ASK	BPSK, QPSK, COFDM, CCK, M-QAM	BPSK (+ ASK), O-QPSK
Spreading	FHSS	PPM	NA	DSSS, CCK, OFDM	DSSS
Basic Cell	Piconet	Point to Point	Point to point	BSS	Star
Encryption method	E0 stream cipher	NA	AES	RC4 stream cipher (WEP), AES block cipher	AES block cipher
Authentication	Shared secret	NA	In-built	WPA2	CBC-MAC
Data Protection	16-bit CRC	16-bit CRC	32-bit CRC	32-bit CRC	16-bit CRC

Table 2 shows difference between wireless technologies

Wireless Sensor Networks (WSNs) and Wireless Multimedia Sensor Networks (WMSNs) consist of wirelessly interconnected sensor nodes which can collect, deliver and process information in different application areas. Power Consumption in these networks is a major problem. Some of the applications include landslide detection, glacial monitoring, wildlife tracking, health care, military applications, environmental monitoring and a large number of applications to robotics, â€œinternet of thingsâ€ projects. This paper will illustrate the fundamental characteristics of WSN followed by different power cons... A comparison of different queuing disciplines for different scenarios using simulation was presented for performance evaluation [11]. By varying the queuing disciplines the parameters like End-to-End Delay and Traffic received for live streaming video were presented.The use of network connecting devices plays an important role in the network design.Â The choice of network simulator is very important for accurate simulation analysis. A comparative study of two network simulators: OPNET Modeler and NS-2 for packet level analysis was presented in [15]. Both discrete events and analytical simulation methods were combined to check the performance of simulator in terms of speed while maintaining the accuracy. The terminals have access to different wireless technologies at the same time and the terminal able to combine different flows from different technologies[4,6,7]. Each network responsible for handling user-mobility, while the terminal make the final choice among different wireless/mobile access network providers for a given service.Â 3.2. Comparative quotient between 5G and 4G 4G and 5G wireless access technologies offers Ethernet speed on mobile devices to experience the. triply play services as explained above. LTE and WiMAX are two different technologies to achieve 4G defined speeds. The irony is that as wireless technology advances the level of service that consumers expect also rises accordingly. In recent years, an increasing proportion of electronic devices such as smartphones, tablet PCs, digital cameras, and digital home entertainment systems include WLAN connectivity using Wi-Fi technology. Wi-Fi technology includes a range of WLAN standards including IEEE 802.11a, 802.11b, 802.11g, 802.11n, and 802.11ac.Â Each validation scope includes one or more test items that involve a functional or comparative analysis of one key component of wireless performance. Using this methodology, Allion analyzes the strengths, weaknesses, opportunities, and potential threats to wireless AP devices. I. Conductive Throughput Test. understanding of different wireless technologies. Comparative analysis between them with the help of suitable pictures, graphs and tables. This paper covers different wireless technologies including Bluetooth, Infrared, Zigbee, NFC and Wi-Fi. Now a days, wireless technologies becoming more and more advance.In this era, it is more important to do analysis of these technologies to use these at itâ€™s maximum. Index Termsâ€” Bluetooth, Infrared, NFC, Wi-Fi, Wireless technology, Zigbee I. INTRODUCTION Wireless technology used to share the data, information between two or more points which are not physically connected. The communication distance between the points can be short, medium and long.