"Comparative Analysis and interpretation of various short-range wireless technologies"

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ABSTRACT

With the development of more powerful sensors compared with traditional data sensors, in this paper the short range wireless sensors and modules like UWB and others are elaborated and analyzed, by which we could interpret the comparative discriminations between various wireless technologies adopted by the industry for the wireless communication. On the basis of this analysis, it is suggested that which wireless technology should be better to use for the industry and home automation networking and data communication purpose.

Keywords: UWB, Home RF, FHHS, Wi-Fi, Bluetooth, Zig Bee, Insteon, Infra red.

INTRODUCTION:

Wireless technologies are becoming more and more popular around the world. Consumers appreciate the wireless lifestyle, relieving them of the well known "cable chaos" that tend to grow under their desk. Nowadays, the world would virtually stop if wireless communication suddenly became unavailable. Both our way of life and the global economy are highly dependent on the flow of information through wireless mediums like television and radio. Cell phones have become highly available during the last decade. [1]

New wireless technologies are introduced at an increasing rate. During the last few years the IEEE 802.11 [2] technologies have started to spread rapidly, enabling consumers to set up their own wireless networks. This constitutes an important change in how wireless communications are made available to consumers. Wireless networks are no longer provided by big corporations alone, they can just as well be implemented by individuals. Our society is becoming more and more dependent on wireless communications as new areas of use are introduced.

Infrared Technology:-

IR wireless is the use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The shortest-wavelength IR borders visible red in the spectrum; the longest-wavelength IR borders radio waves.

IR wireless is used for short- and medium-range communications and control. Some systems operate in *line-of-sight mode*; this means that there must be a visually unobstructed straight line through space between the transmitter (source) and receiver (destination). Other systems operate in *diffuse mode*, also called *scatter mode*. This type of system can function when the source and destination are not directly visible to each other. IR wireless technology is used in intrusion detectors; home-entertainment control units; robot control systems; medium-range, line-of-sight laser communications; cordless microphones, headsets, modems, and printers and other peripherals. Unlike radio-frequency (RF) wireless links, IR wireless cannot pass through walls. Therefore, IR communications or control is generally not possible between different rooms in a house or between different houses in a neighbourhood (unless they have facing windows). This might seem like a disadvantage, but IR wireless is more

private than RF wireless. Some IR wireless schemes offer a level of security comparable to that of hard-wired systems. It is difficult, for example, to eavesdrop on a well-engineered, line-of-sight, IR laser communications link.

Home RF Technology:-

Home RF used frequency hopping spread spectrum (FHSS) in the 2.4 GHz frequency band and in theory could achieve a maximum of 10 Mbit/s throughput; its nodes can travel within a 50 meter range of an wireless access point while remaining connected to the personal area network (PAN). Home RF allowed both voice telephone signals and data signals to be exchanged over the same wireless network. Therefore, in Home RF, cordless telephones and laptops, for example, could share the same bandwidth in the same home or office. Available Home RF local area networks (LANs) supported 1.6 Mbit/s, relatively slow compared to technology marketed under the Wi-Fi brand name. For example, second generation 802.11b LANs supported 11 Mbit/s. 802.11n reaches a maximum of 600 Mbit/s. Several standards and working groups focused on wireless networking technology in radio frequency (RF). Standards include the popular IEEE 802.11 family, 802.16, and Bluetooth

Bluetooth Technology:-

The Bluetooth wireless technology is also spreading rapidly. The number of Bluetooth chipset shipped per year has doubled from 2002 to a total of 69 million chipset in 2003 [3]. Bluetooth applications become available; many consumers will already have Bluetooth devices and be ready to start using Bluetooth PANs (Personal Area Networks) where all their Bluetooth devices communicate with one another [4].

Bluetooth is an open standard for short range, low power, and low cost digital radio wireless communication [5].

Bluetooth is a current industry standard for short-range wireless connectivity. Bluetooth technology is widely used in consumer electronics for short-range wireless data transfer, like printers and digital cameras. It

operates efficiently within the range of 20-25 ft in the environment without WLAN equipments. Bluetooth signals operate in the same frequency range as Wi-Fi (802.11b, g) standard. This is the biggest disadvantage of it because of its interference with Wi-Fi signals. A Bluetooth enabled device is not being able to function efficiently in the vicinity of Wi-Fi signals. Bluetooth technology took many years to come into mass market but still is struggling to really prove its potentials. Bluetooth faces major challenges by upcoming Ultra-Wideband standard which has many advantages such as higher data-rate and capability to co-exist with other wireless standards.

Wi-Fi Technology:-

Wi-Fi (802.11a, b, g) – Wireless LAN technology is not new to us. It is been in the market for some years and now it is seen as mature wireless LAN solution that replaced Ethernet cables in many office and home networks. Ethernet provides 100 Mbps connection while Gigabit Ethernet is much more. Not comparable with Ethernet data-rate, Wi-Fi struggles to provide good data-rate for bandwidth hungry applications in LAN environment.

WLAN technologies are much better for LAN environment where network connectivity is more important than peer-to-peer file sharing. With maximum data-rate of 11 Mbps (802.11b), 22 Mbps (802.11a) and 54 Mbps (802.11g), WLAN is still not capable enough to handle Data vendor – provide high data rate with instant connectivity.

Zigbee Technology:-

Zigbee is a relatively new, wireless personal are network technology based on IEEE 802.15.4, with a transmission range of 100+ meters [6]. ZigBee based communication devices consume very little power and hence the battery life of 1000+ days is common. With low power consumption and less cost compared with Bluetooth and Wi-Fi, Zigbee is a promising technology for applications which are NOT too much bandwidth hungry. The reason includes more coverage area, less power consumption, and secure networking. Zigbee operates in the industrial,

scientific and medical radio bands – 868 MHz in Europe, 915 MHz in the USA and 2.4 GHz in most other countries in the rest of the world. UWB designed for multimedia file sharing and instant connectivity which Zigbee cannot promise. Range will be an issue for data vendor products with Zigbee technology.

Insteon Technology:-

It is a system for connecting lighting switches and loads without extra wiring, similar to the X10 standard, designed specifically to address the inherent limitations in the X10 standard but also to incorporate backward compatibility with X10. Insteon is designed to enable simple devices - such as light switches - to be networked together using the power line, radio frequency (RF), or both. All Insteon devices are peers, meaning each device can transmit, receive, and repeat any message of the Insteon protocol, without requiring a master controller or routing software.

Ultra-Wideband Technology:-

Ultra-Wideband is a proposed standard for short-range wireless communications that aims to replace Bluetooth technology in near future. It is an ideal solution for wireless connectivity in the range of 10 to 20 meters between consumer electronics (CE), mobile devices, and PC peripheral devices which provides very high data-rate while consuming very little battery power. It offers the best solution for bandwidth, cost, power consumption, and physical size requirements for next generation consumer electronic devices. UWB radios can use frequencies from 3.1 GHz to 10.6 GHz, a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz depending upon its centre frequency. Due to such a large signal bandwidth, FCC has put severe broadcast power restrictions. By doing so UWB devices can make use of extremely wide frequency band while emitting very less amount of energy to get detected by other narrower band devices. Hence, a UWB device signal cannot interfere with other narrower band device signals and because of this reason a UWB device can co-exist with other wireless devices. UWB is considered as Wireless USB – replacement of standard USB and fire wire (IEEE 1394) solutions due to its higher data-rate compared to USB and fire wire.UWB signals can co-exists with other short/large range wireless communications signals due to its own nature of being detected as noise to other signals. Under current FCC regulations, UWB signals used for commercial communications are capable of delivering very high data rates within short-ranges.

Comparative Study:-

Some Comparative parameters have been discussed as given below [7]

A. Radio Channels

Bluetooth, ZigBee and Wi-Fi protocols have spread spectrum techniques in the 2.4 GHz band, which is unlicensed in most countries and known as the industrial, scientific, and medical (ISM) band. Bluetooth uses frequency hopping (FHSS) with 79 channels and 1 MHz bandwidth, 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 (11 available in US, 13 in Europe, and just 1 in Japan) and 22 MHz bandwidth. UWB uses the 3.1-10.6 GHz, with an unapproved and jammed 802.15.3a standard, of which two spreading techniques, DS- UWB and MB-OFDM, are available.

B. Coexistence Mechanism

Since Bluetooth, ZigBee and Wi-Fi use the 2.4 GHz band, the coexistence issue must be dealt with. Basically, Bluetooth and UWB provide adaptive frequency hopping to avoid channel collision, while ZigBee and Wi-Fi use dynamic frequency selection and transmission power control. IEEE 802.15.2 discussed the interference problem of Bluetooth and Wi-Fi. Also, Sikora and Groza [8] provided quantitative measurements of the coexistence issue for ZigBee, Bluetooth, Wi-Fi, and microwave ovens. Shuaib *et al.* [9] focused on quantifying potential interferences between Zigbee and IEEE 802.11g by examining the impact on the throughput performance of IEEE 802.11g and Zigbee devices when co- existing within a particular environment. Moreover, Neelakanta and Dighe [10] presented a performance evaluation of Bluetooth and ZigBee collocated on an industrial floor for robust factory wireless communications.

C. Network Size

The maximum number of devices belonging to the network's building cell is 8 (7 slaves plus one master) for a Bluetooth and UWB piconet, over 65000 for a ZigBee star network, and 2007 for a structured Wi-Fi BSS. All the protocols have a provision for more complex network structures built from the respective

basic cells: the scatternet for Bluetooth, peer-to-peer for UWB, cluster tree or mesh networks for ZigBee, and the ESS for Wi-Fi.

Table: Shows the comparison between various wireless technologies on the basis of different parameters

	IR Wireless	Bluetooth	Insteon	Wi-Fi	Home RF	ZigBee	UWB (Ultra Wide Band)
Data Rate	20-40 Kbits/s 115 Kbits/s 4 & 16 Mbits/s	1 Mbits/s	3 M bit/s	11 & 54 Mbits/sec	10 Mb/s	20, 40, and 250 Kbits/s	50-100Mb/s, >500Mb/s expected in future
Range	<10 meters (line of sight)	10 meters	50 meters	50-100 meters	50 meters	10-100 meters	170 meters
Networking Topology	Point to point	Ad-hoc, very small networks	peer-to-peer	Point to hub	Ad-hoc, very small networks	Ad-hoc, peer to peer, star, or mesh	Point to point
Operating Frequency	380 MHz	2.4 GHz	1 GHz	2.4 and 5 GHz	2.4 GHz	868 MHz (Europe) 2.4 GHz (worldwide)	3.1-10.7 GHz
Complexity (Device and application impact)	Low	High	Low	High	Low	Low	Medium
Power Consumption (Battery option and life)	Low	Medium	Low	High	Low	Very low	Low
Typical Applications	Remote controls, PC, PDA, phone, laptop links	Wireless connectivity between devices such as phones, PDA, laptops, headsets	Scene and remote-control lighting, Security alarm interfaces and sensors Home sensors	Wireless LAN connectivity, broadband Internet access	Scene and remote-control lighting, Security alarm interfaces and sensors Home sensors	Industrial control and monitoring, sensor networks, building automation, home control and automation, toys, games	Industrial control and monitoring, sensor networks, building automation, home control Streaming video, home entertainment applications

Conclusion:-

According to the study and analysis of various wireless standards with a quantitative evaluation in terms of the transmission time, data coding efficiency, operating frequency, network topology, complexity, and power consumption. Furthermore, the radio channels, coexistence mechanism, network size, and security are also preliminary compared. Every wireless standard has its own applications, advantages and drawbacks depending on the parameters, but especially UWB is more effective and economical as compared to other short-range wireless standards.

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