

An Overview of Bluetooth Technology and its Communication Applications

Madhvi Verma^{†*}, Satbir Singh[†] and Baljit Kaur[‡]

[†]Dept. of ECE, GNDU RC, Gurdaspur, India

[‡]Dept. of Electronics, NIELIT, Chandigarh, India

Accepted 06 May 2015, Available online 10 May 2015, Vol.5, No.3 (June 2015)

Abstract

Bluetooth is a new RF short-range wireless technology which is designed for wireless communication between different devices. There is increase in popularity of Bluetooth technology and is being accepted in today's world. There are organizations which are doing research on Bluetooth technology, but very few of their research analysis provide a balanced view of the technology, describing its implications for businesses, pros and cons. In this paper analysis have been done keeping in mind various perspectives of the Bluetooth technology. The analysis starts with a description of the technology in terms of its network infrastructure, hardware and software. Then it is continued by the Error corrections and retransmission. The analysis is done on macro analytical view including the business implications, advantages of this technology, its role in the global third generation (3G) wireless schemes. The finally it concludes with the applications and future potentials of Bluetooth.

Keywords: Bluetooth; Bluetooth architecture; Frequency-hopping spread spectrum (FHSS); Logical Link Control and Adaptation Protocol (L2CAP); Personal digital assistants (PDA); Service Discovery Protocol (SDP).

1. Introduction

We have all experienced the problem which arises when connections are made between peripheral and computer or connection between the electronic devices. Thus the companies of telecommunications needed to develop an opened, low cost interface to make easier the communication between devices without using cables. Bluetooth is a wireless technology having very short range designed enabling communication between the devices like computers, entertainment systems and other electronic devices without the use of cables and connectors. There is a strong need for a better way for all the electronic devices to communicate with each other, in order to make the aforementioned systems, computers and/or related equipments, more users friendly. Portable computers, cellular telephones, personal digital assistants (PDAs), and a variety of other devices can be connected using low-power, short-range wireless links is describe by the technology specifications. Frequency-hopping spread-spectrum (FHSS) is use by Bluetooth technology for communication. The frequency used is 2.4 GHz all over the world. Bluetooth (Ericsson trademark) takes its name from

Harald Blatland (Bluetooth), a Danish king born in AD 908. The technology was developed by an Ericsson-led consortium, including Toshiba, IBM, Nokia and Intel. In early January 2000, the technology was further promoted by the Bluetooth Special Interest Group (SIG) comprised of 1371 member companies.

In this paper firstly we will discuss a microanalysis of Bluetooth Technology .The microanalysis of Bluetooth describes the technical details such as interference handling, error control , security, hardware, software and connectivity . Further we will explain the broader perspective, describing the various Bluetooth applications, implementation issues, performance against competing technologies, advantages and disadvantages. Some predominant health and safety concerns are also discussed as cellular telephones are a key application area for the technology. Further, the paper discusses the role of Bluetooth in the global 3G wireless. Further paper discusses about the future scope of the technology.

2. Bluetooth Technology: A Microanalysis

Bluetooth is the technology which allows the devices to communicate with each other, synchronize data with each other, and connect to the Internet without the use of cables or wires. To add Bluetooth functionality to a computer or other host device a Bluetooth radio and base band controller can be installed on a device that

*Corresponding author **Madhvi Verma** is a M.Tech Scholar; **Satbir Singh** is working as Assistant Professor and **Baljit Kaur** as Project Engineer

links to an integrated on a system board, a Universal Serial Bus (USB) port, or a PC Card. These components are shown in Fig. 1

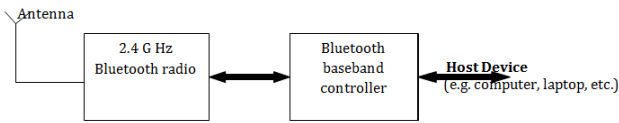


Fig.1 Bluetooth components

A. Technology overview of Bluetooth

In this section the technology specification have been explained .The Bluetooth technology is divided into two specifications: first is the core and second is the profile specifications. How the technology works is explained by the core specification, how to build interoperating devices using the core technologies is explained by the profile specification. Bluetooth air interface works on a antenna power of 0 dBm (1 mW) and be extended up to 20 dBm (100 mW) worldwide. This interface complies with ISM band rules up to 20 dBm in America, Japan, and most European countries. Frequency hopping method is used to spread the energy across the ISM spectrum in 79 hops displaced by 1 MHz, starting from 2.402 GHz and stopping at 2.480 GHz. The Bluetooth Special Interest Group is working to harmonize this 79- channel radio .These 79 channel radio are working globally and has initiated changes within Japan, Spain, and other countries. An electronic conversation determines whether they have data to share or whether one needs to control the other, whenever Bluetooth-capable devices come within range of one another. There is no need for the users to press a button or give a command, the electronic conversation occurs automatically. The devices form a network once the conversation has initiated. The basic communication unit consists of the frame consisting of a transmit packet followed by a receive packet shown in Fig 2. Each packet consists of multiple slots of 625 microsec. The Bluetooth frame hops at 1600 hops/s. Multislot frames will allow higher data rates because of the elimination of the turnaround time between packets and the reduction in header overhead. For example, single-slot packets can have a maximum data rate of 172 kbps, while a five-slot, one multislot frame will support a 721-kbps rate in the five-slot direction with a 57.6- kbps rate back channel in the one-slot direction.

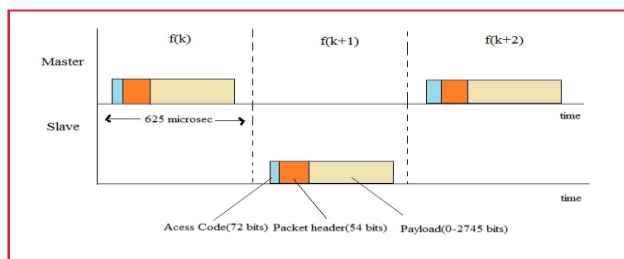


Fig.2 Bluetooth Frame

B. Network architecture

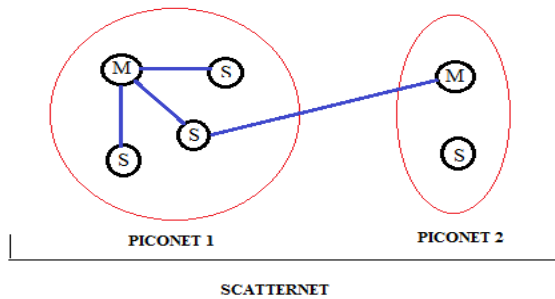
There is normally peer-to peer communications between Bluetooth devices in which each Bluetooth device is consider equal. In the network architecture of Bluetooth we use a term piconet that means two or more devices link into a small ad hoc network. In piconet one of the communicating device acts as the Master and the other devices act as slaves, this is for consider when the a piconet connection. The communicating devices are synchronized to the hopping sequence and master’s clock in a piconet.

The Piconets can begin with two communicating devices, for example laptop and cell phone and may include maximum of eight devices. Users can automatically establish a connection with other Bluetooth device which is within its Bluetooth range. Bluetooth also allows automatic data synchronization among the communicating devices. In one piconet there can be only master device. This is because of the reason that Bluetooth technology supports both point-to- point and point-to-multipoint connections. Two or more piconets linked together forms a scatternet and one device in each piconet acts as a bridge between the two or more piconets formin a scatternet A scatternet. The piconets and scatternet is shown in Fig. 3. The radio or device is is assigned a 3 bit Active Member Address as soon as the device joins a piconet and thus allows other device on the piconet to address it and starts communication. The master must then take a radio and “park” it on the piconet as soon the piconet has eight radios active. This device releases its AMA for an 8-bit Passive Member Address (PMA) but stays coordinated with the piconet. The AMA which has been released can be assigned to other communicating devices who wish to join the network. The combination of AMA and PMA allows over 256 devices to actively be present on a piconet but only the eight devices with the AMAs can actively transfer data. Bluetooth wireless devices can link to a wired network through a bridge-type access device. The access device (also called an access point) includes a Bluetooth transceiver and baseband controller, the circuitry to convert information from the Bluetooth format to Ethernet format, and interface circuitry to connect the bridge device to the wired network through a cable. Mobile users with wireless connections can roam about and use the wired network resources while in the range of an access device.

C. Software architecture

Bluetooth devices use the Host Controller Interface (HCI) as a common interface between the Bluetooth host and the Bluetooth core in order to make different hardware implementations compatible. The Logical Link Control and Adaptation Protocol (L2CAP) help to interface base-band services to Higher-level protocols like the Service Discovery Protocol (SDP), RFCOMM (emulating a serial port connection) and the Telephony

Control Protocol (TCS). Segmentation and reassembly to allow larger data packets to be carried over a Bluetooth baseband connection issues are taken care by the Logical Link Control and Adaptation Protocol. The available services and their characteristics when, e.g. devices are moved or switched off are found out by SDP.



LEGEND : M =Master ,S= Slave

Fig.3 Piconets and Scatternet

The users having Bluetooth devices are connect to the other neighboring devices in a wireless manner via Service Discovery Protocol. Bluetooth wireless device users gets on-demand services is the main characteristics of the Service Discovery Protocol. The process that enables system developers to employ the Saluation architecture for service discovery in Bluetooth short-range radio frequency (RF) networks was defined by the Bluetooth Special Interest Group (SIG), in July, 2000. Moreover, new Bluetooth requirements, that comprises of Saluation and universal plug and play is being developed by SIG. This is described how to use other service discovery technologies. The Service discovery architecture will come into prominence with the popularity of mobile commerce technology, this is the believe of other authors. Other authors . The protocol stack is shown in Fig 4.[12] . Protocol stack comprises of the radio layer at the bottom forming the physical connection interface. The baseband and Link Manager Protocol (LMP) control and establish links among the Bluetooth devices .Hardware/ firmware implements these three bottom layers .The Bluetooth hardware and upper protocol (L2CAP) interfacing is done by the host controller layer. When the L2CAP is present in software, then only the host controller is required.

D. Error corrections and retransmission

Forward error correction (FEC) and an automatic repeat request (ARQ) schemes for corrupted or missing data are the error correction schemes are used by Bluetooth technology. The number of retransmitted data packets is reduced by the Forward error correction. The packets are flexible which permit the use of FEC. The FEC can be eliminated to reduce overhead in case the errors are infrequent. A header is

present in every packet in which link information is present. FEC protects the packet headers so that the bit errors can be survived. A 1-bit positive acknowledge (ACK) or negative acknowledge (NAK) is used by the Bluetooth ARQ scheme, indicating whether the data arriving at the receiving station matches the transmitted data. When there is no error in both the header error check and the cyclic redundancy check (CRC) then transmitting station gets an ACK. If there is error then transmitting station gats a NAK and retransmission of data takes place. Voice channels use an encoding scheme called continuous variable slope delta (CVSD) modulation that is immune to errors except in noisy environments. Voice transmissions are strictly real time, i.e. lost or damaged packets are never retransmitted.

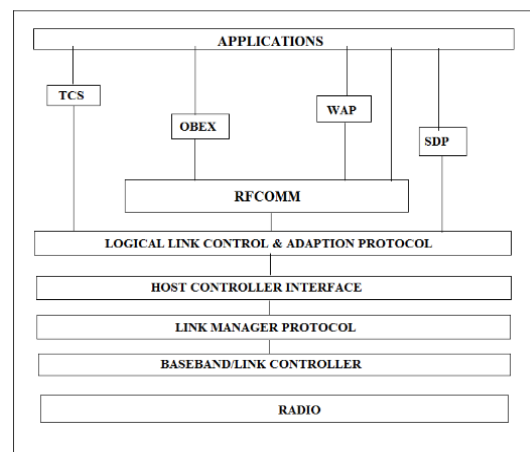


Fig.4 Bluetooth Protocol Stack

3. Bluetooth Technology: A Macroanalysis

Bluetooth is used in a wide range of mobile devices because of its versatile nature. Many of the Bluetooth-equipped devices are available today and and of the products based on Bluetooth are in progress. Many Bluetooth applications are described below. Bluetooth has a strong competition with other wireless connection devices like IrDA, Ultra Wideband Radio, etc. This segment discusses about the application of Bluetooth and comparison with other standards.

A. Bluetooth Applications

The earliest application of Bluetooth that became popular was wireless control of and communication between a mobile phone and a hands free set. Further application of bluetooth are Wireless control of and communication between a mobile phone and a Bluetooth compatible car stereo system, Wireless control of and communication with tablets and speakers such as iOS and Android devices and Wireless Bluetooth headset and Intercom. Idiomatically, a headset is sometimes called a Bluetooth. Other application is Wireless streaming of audio to headphones without capabilities. Wireless networking

between PCs in a confined space and where little bandwidth is required. Wireless communication with PC input and output devices, the most common keyboard and printer. The above application enables the devices to continuously communicate with each other and share the required information. There could be a dramatic impact on businesses and consumers. Customers might be able to synchronize their shopping list with a current map of the store and get directions to each product in Bluetooth-networked stores. Hand-held computers can be used for making purchases by accessing Internet-based payment systems. With the help of Bluetooth technology, at the business centre, hotel guests could more easily use equipment such as printers. Bluetooth could allow for low-cost voice calls in an exclusive facility, such as a frequent-flier lounge at an airport. The airline could give the customers special rates on calls from Bluetooth handsets instead of making them call from fixed-line phone or rack up long distance charges on their own cell phones. The caller can be linked to the airline's own network connection through the wireless local area network (LAN). The user can be notified of incoming e-mail via the telephone, and can even read the titles of e-mails on the telephone screen. Users can also write e-mails while traveling on an aircraft, and have them sent automatically upon powering up a mobile telephone, once back on the ground. At home, the phone functions as a portable phone (fixed line charge). When on the move, it functions as a mobile phone (cellular charge). It also functions well with no telephony charge when the phone comes within range of another mobile phone with built-in Bluetooth wireless technology.

B. Comparison with Other Technology

Bluetooth application could allow cardiac patients being monitored through their mobile phones. Instead of being confined to local area networks within the hospital, patients can be anywhere within the range of their Bluetooth compatible mobile phones. A Bluetooth device could turn picks up signals directly from the patient's heart monitor and convey it to the mobile phone and relays the information to the monitoring system present in the hospital. The complex and tedious task of networking between the computing devices yet have the power of connected devices is done by Bluetooth network installed in the office. Workers can connect to the network anywhere within the office.

All of peripherals of the office are connected in a wireless manner. PCs or notebooks connections can be made without troublesome cable attachments to the printers, scanners and faxes. Any selected documents and electronic business cards can be instantly exchanged with selected participants through Bluetooth in meetings and conferences. Local Bluetooth connections also facilitate E-mail, Internet, and Intranet access. A Bluetooth PDA or notebook can

connect with a local access point. They access e-mail or internet through a Bluetooth-compatible cellular telephone. Bluetooth can be used in projectors in conference rooms. The presenter will be able to send the presentation over a Bluetooth network to the handheld or notebook computers of all listeners so that the listeners will be able to follow the presentation on their own computers, annotate it, and store it for future access. Bluetooth has made easy for Business travelers to send and receive e-mails. Bluetooth allows a DECT phone to ring and answer calls on behalf of a nearby mobile phone. Real-time location systems (RTLS), are used to track and identify the location of objects in real-time using Nodes or tags attached to, or embedded in the objects tracked, and Readers that receive and process the wireless signals from these tags to determine their locations using Bluetooth technology. Personal security application on mobile phones for prevention of theft or loss of items. The protected item has a Bluetooth marker (e.g., a tag) that is in constant communication with the phone. If the connection is broken (the marker is out of range of the phone) then an alarm is raised. This can also be used as a overboard alarm. A product using this technology has been available since 2009. Calgary, Alberta, Canada's Roads Traffic division uses data collected from travelers' Bluetooth devices to predict travel times and road congestion for motorists.

Technology	Comparison with bluetooth	
	Advantages	Disadvantages
IrDA	Reliable Inexpensive Higher Capacity	Line of Sight Compatibility One to One Only
Cable synchronizing	Low Interference Higher capacity	Needs special hardware One-to-one only
Wireless LAN	Higher capacity Larger number of simultaneous users	Bulkier hardware More expensive Higher power consumption Compatibility
Home RF	High user per net	Reliability Security
UWB Radio	Higher Capacity Low Power Consumption	Complex Size not known

C. Bluetooth: Advantages

There are three important features of Bluetooth from the user's point of view. Firstly, the user does not have to worry about the cables to attach all components as the technology is wireless technology. Bluetooth is inexpensive, it is the second feature of technology. By the end of 2002, it should only add \$5 instead of \$15. Third and the last, it is simple to use. Without any user

input the devices find one another and starts communicating. Bluetooth has made cellular telephones hands-free less susceptible to regulation for use in automobiles in the field of cellular industry. Bluetooth headset has protected the user's brain from the higher levels of RF radiation emitted by the cellular telephones. Bluetooth has also helped the manufacturers of other portable devices. Such as ,it is difficult to keep the electronic devices having database synchronized . With Bluetooth, anytime one of these devices comes into proximity with another, they will communicate and synchronize their databases to make sure that both devices contain the most recent information.

4. The future of Bluetooth

There will be worldwide implementation of Bluetooth technology, in the near future. Workplace can be influenced in the following ways: More efficient configuration of workplace because there will be less use of cables and wires. Workers will have embedded in their ID badge a chip that will automatically log in /out their computers .The same badge will give them access to copy machines, fax machines, computer terminals, etc., throughout building. If the worker is not on the desk, phone calls can be rerouted them. Computer schedule, documents, e-mail, and all other information can seamlessly be synchronized. In late June 2000, Troy XCD and InTechnology announced a partnership that would enable hotel guests with Bluetooth-enabled computers or cell phones to wirelessly print to in-room printers/faxes/ copiers. They will also add the ability to connect to the Internet and LANs. Thus, the use of Bluetooth can help transparent communication between all electronic devices. The producing price of Bluetooth chips is decreasing thus the associated software is decreasing, the devices could be implemented in low-cost products such as computer mice, remote controls, kitchen appliances, and lot more . In coming future Bluetooth technology could also be implemented in many public places such as hotels, other heavy traffic locations, airports and train stations,. This will enable people to stay updated with business and personal information. It will allow workers to work at the office, at home, or on the road without any decrease in efficiency because they have all the information they need through their ubiquitous connectivity. Finally Bluetooth is half duplex technology and research is going on in full duplex data, file, image and voice transmission so as to increase the speed of communication.

Conclusion

Bluetooth technology is very important technology that can make communication within the range between the devices possible without the use of wires. Bluetooth is being used in blurring the boundaries between home, the office, and the outside world. Bluetooth promises a seamless connectivity which

makes it possible to explore a range of interactive and highly transparent personalized services. However, there are some issues to be sorted out. One potential problem being faced by Bluetooth is that hardware for it is being created faster than software. A report by Aegis Systems says that Bluetooth, other wireless networking systems, microwave ovens, outdoor broadcast units, and radio-based CCTV units may all interfere with each other. Another potential drawback is speed. Bluetooth sends information at about 725 kbps. The advantages of Bluetooth appear to far outweigh the disadvantages and it is becoming a reality. Already many Bluetooth pilot products have rolled into the market backed by big vendors, which is a very healthy sign for the acceptance of the technology . It will gain economies at the production level, over the long term as multiple connection ports will be replaced with a single Bluetooth module.The Bluetooth SIG has defined favorable adoption terms, including open, royalty-free availability of the specification, and is playing an important role in spreading the technology. Most analysts believe that Bluetooth technology will eventually sky rocket. It is estimated that 75% of all mobile devices will support Bluetooth.

References

- J. Wakefield (April 1999), Bluetooth: what is the potential? Analysts Disagree, ZDNet UK News,. <http://www.zdnet.co.uk/news/1999/14/ns-7758.html>.
- Anonymous (1998), Bluetooth—the universal radio interface for ad hoc, wireless connectivity, Ericsson Review 3,.
- Anonymous, Bluetooth facts and fantasies, IBM. http://www.pc.ibm.com/europe/pcnews/bluetooth _ facts _ and _fantasies.html.
- Anonymous (January 2000), Bluetooth White Paper 1.1, AU-System,. <http://www.ausystem.com>.
- J. Haarsten (1988), Bluetooth—the universal radio interface for adhoc wireless connectivity, Ericsson Review 3 (4) 1 – 5. Islam, S., Ammourah, B., & Mahmoud, M. Location Based Computation Sharing Framework for Mobile Devices.
- Bluetooth SIG (1999), Beginners Guide to Bluetooth.
- Erasala, N., & Yen, D. C. (2002). Bluetooth technology: a strategic analysis of its role in global 3G wireless communication era. *Computer Standards & Interfaces*, 24(3), 193-206.
- Anonymous, Bluetooth, The Bluetooth Specification, v.1.0B [referred 2000-03-15] .
- R. Frazier (April 20, 2000), Bluetooth a Boon for Wireless Devices, Cable News Network,. <http://sidebar.cnn.com/2000/TECH/computing/04/20/bluetooth.idg/index.html>.
- B. Hammersley (January 15, 2001), The Wireless World Comes of Age, Times, London
- Ajit Samasgikar, ReFinder (2013), Instrumentation Technology Department, B. V. B. College of Engineering & Technology Vidyanagar, Hubli, Karnataka,
- R. Mettala (Aug. 1999), Bluetooth White Paper, Bluetooth SIG, Document No. 1.C.120/1.0,. available at <http://www.bluetooth.com>.
- (January 2015)Headphones Unboxed. [headphonesunboxed. com](http://headphonesunboxed.com). Retrieved 9.
- Anonymous (June 22, 2000), TROY Group and InnTechnology partner to bring Bluetooth wireless printing to hospitality industry, Business Wire, Bluetooth SIG Inc., United Kingdom, (2010)Hypertag.com. Hypertag.com. Retrieved 4 September (August 2010)Real Time Location Systems. clarinox. Retrieved 4. (March 2009)Tenbu's nio is kind of like a car alarm for your cellphone, OhGizmo.com.
- (26 November 2012. Retrieved 11 July 2013) Wireless waves used to track travel times | CTV Calgary News. calgary.ctvnews.ca.