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Computer Networks and Distributed Systems

(Research Paper)

BlueTooth

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1. Introduction

Nowadays, there are a lot of devices that make used by us to achieve different goal or purpose. And most of the device needs communication between them and wire is the medium that transmit the data. But as all of us known, handling wires is a messy and fuzzy jobs especially when the free space of environment is limited. Furthermore wires are prone to many physical damage and distortion such as mouse bite. Wires also have another problem that is compatibility. Wires are categorized to different gender and size if the size and gender are not compatible then they cannot be connected.

All the problems mentioned above can be solved by BlueTooth. BlueTooth is a new technology that are deigned to replace cable and solve all the above problems cause by cable. BlueTooth also known as short range wireless communication technology. BlueTooth is a short range, low cost and small enough to be embedded to different device and machine. BlueTooth is also economical because it is cheap enough to be implemented in various devices. BlueTooth cost only around 5 dollars per unit. Furthermore, BlueTooth not only support data transmission but also voice transmission which make it can be used in more area and usage. Typical BlueTooth typical effective communication range is 10 metres but the range is extensible to 100 metres. BlueTooth use radio frequency as communication medium to connect those devices equipped with BlueTooth. May be someone will question is the frequency used by BlueTooth is globally available. The answer is absolutely yes, BlueTooth is globally available to be used because BlueTooth use a set of globally available frequencies that is 2.4GHz to 2.5GHz. As long as the transceivers used by Bluetooth sit between 2.4GHz and 2.5GHz, they can choose the appropriate segment.

The ordinary idea of BlueTooth is to replace cable but then people realize BlueTooth can do more than that. More and more ideas are emerging, for example Bluetooth chips in freight containers to identify cargo when a lorry drives into a storage depot. And with technology of BlueTooth, those devices equipped with BlueTooth can form a personal area network.

Therefore, BlueTooth become an important and crucial technology in the future. So we need have more understand about BlueTooth. And the purpose of this research paper is to explore and understand more deeply about the BlueTooth Technology.

During the development of this research paper, I have faced some difficulties and problems. There are getting the resources for this paper, summarize and analyze finding, getting a main point out of a long story and etc.

And now let me introduce to you the structure of this research paper. This research paper is built up by 7 sections there are introduction, overview, advantages, problems and solutions, issue, conclusion and reference. Section 1 Introduction briefly introduces BlueTooth and the structure of this paper to all the audience. In Section 2 Overview explain about the overview of BlueTooth. Section 3 Advantages introduces and explains the advantages of BlueTooth. Section 4 Problems and solutions explain and discuss the problems faced by BlueTooth and the respective

solutions. Section 5 Issues review and comment on the problems and solutions discussed in section 4. And Section 6 Conclusion concludes and summarizes all the topics discussed in the previous sections. Finally Section 7 Reference list all the reference used in this paper.

2. Overview

2.1Device Identity

For each and every BlueTooth, there is a unique address assign to it for the purpose of identification. [2] Each Bluetooth device has a unique forty-eight-bit binary Bluetooth Device Address (BDA) burned into its Read Only Memory during the manufacturing process. This address cannot be easily changed by the end-user. The BDA is usually hexadecimal format such as 00:D0:B7:03:2E:9F is a valid BDA [2].

But BlueTooth also have an operator-configurable user-friendly name for the purpose of easier recognize by end user (human). For example valid user-friendly names are Ken Pc, John PDA and etc. The user friendly name can be easily change by user.

2.2Network

[3]The Bluetooth concept is centered on point-to-point connections or point-to multipoint connections with small networks called Piconet. Each Piconet holds up to eight active units [3]. One Piconet is build from 1 master and up to seven slaves which contribute to the total of eight units. [5]The master-slave principle is used to initiate and control the traffic between devices in a Piconet. The master is responsible for defining and synchronizing the frequency hop pattern in his Piconet [5]. The combination of more than one Piconet is known as a Scatternet. In a Scatternet, a master in a Piconet can be a slave in another Piconet.

2.3Connection Scenario

The scenario below demonstrates the sample simplified connection of BlueTooth device. [2]Joe's PC is a Bluetooth-aware computer running an application that needs access to a FAX.

1. Joe's PC performs a search of the Bluetooth Neighborhood (a Device Inquiry) and determines that there are four Bluetooth devices in the vicinity.
2. Joe's PC queries each of the four nearby devices to determine which services they provide (a Service Discovery). Ann's Computer offers the FAX service.
3. Joe's PC sends a FAX connection request to Ann's Computer.
4. Ann's Computer evaluates the request and determines that Joe's PC is permitted to use the FAX service, PROVIDED THE CORRECT PASSWORD IS SUBMITTED.
5. Ann's Computer queries Joe's PC for the password (Authentication).
6. Joe's PC returns the correct password and the FAX connection is established.
7. Joe's PC uses the FAX on Ann's Computer as if it were a local device on Joe's PC.

After Joe's PC is finished using the FAX service the connection between it and Ann's Computer is disconnected. Some Bluetooth services disconnect automatically, others must be closed manually [2].

2.4Error Control

BlueTooth use FEC (forward error correction) and ARQ (Automatic repeat request) to control error. There are 2 types of FEC used, there are 1/3 rate FEC and 2/3 rate FEC. [5]The purpose of the FEC scheme on the data payload is to reduce the number of retransmissions. However, in a reasonably error-free environment, FEC creates unnecessary overhead that reduces the throughput. Therefore, the packet definitions have been kept flexible as to whether or not to use FEC in the payload. The packet header is always protected by a 1/3 rate FEC; it contains valuable link information and should survive bit errors.

An unnumbered ARQ scheme is applied in which data transmitted in one slot is directly acknowledged by the recipient in the next slot. For a data transmission to be acknowledged both the header error check and the cyclic redundancy check must be free of error; otherwise a negative acknowledge is returned [5].

3. Advantages

3.1Wireless

As you know, BlueTooth is wireless technologies that replace cable. And wireless is one of the strength of BlueTooth. Wireless mean without cable. Without the limitation of cable have increase level of mobility because cable have limited the movement of the device. And nowadays, mobility becomes more and more important because being in business means being on the move. For example, a businessperson can always access to the internet at anywhere with internet connection supply without rely on the cable with the aided of a notebook equipped with BlueTooth.

Nowadays, networking become more and more crucial and popular because it is been used in not only at industrial area but also at home. And in networking, the most difficult and fuzzy job is handling cables. This also increase the flexibility of the arrangement of the computer because not need to worry about where the cable will go. With the aid of BlueTooth, networking becomes easier than before.

BlueTooth wireless connection also provides an automatic and unconscious connection between devices. Unlike some of the wireless technology which required line of sight to establish and maintain connection, BlueTooth not only do not required line of sight to maintain connectivity but also can go through wall. With this features, Bluetooth can further increase and enhance flexibility and ease of use.

3.2Low Cost

Another strength of BlueTooth over other wireless technology is cost. BlueTooth is a low cost wireless device if compared to other wireless device. BlueTooth only cost around 5 dollar each. Due to low cost factor, a lot of peripheral, devices and machine can be equipped with BlueTooth without putting a high cost. Furthermore, the small size of BlueTooth also makes it easier to be embedded or attach to different devices and peripherals.

3.3BlueTooth Logo

Every new technology will always have a group of peoples working and doing research on it, Bluetooth is not the exceptions. The group of people working on BlueTooth technology is known as BlueTooth SIG (*Special Interest Group*). The BlueTooth SIG is form by Nokia, IBM, Intel, Motorola, Ericsson, Toshiba, 3Com, Lucent, HP and etc. The primary objective of Bluetooth SIG is to promote and develop BlueTooth technology. BlueTooth SIG also develops a logo program. The objective of this program is to validate the compatible and interoperability BlueTooth with the other devices. In other words, those devices that have labeled the BlueTooth logo is certified and tested can be compatible and interoperate with BlueTooth. With this program, the consumers have no uncertainty in the device interoperability with BlueTooth. Therefore, consumers can identify those devices or peripherals that can interoperate with BlueTooth easily in the market.

3.4Minimal Noise Interference

BlueTooth operate on ISM (*Instrumentation, Scientific and Medical*) band frequency range from 2.4 GHz to 2.5GHz. This band is globally available, this make BlueTooth globally available to be used. This band reserved for the purpose of instrumentation, scientific and medical.

BlueTooth have minimal noise interference because Bluetooth use frequency hopping spread spectrum technique to transmit data. This technique hopping up to 1600 hops per second between all the channels in ISM band. Due to the frequent hopping rate, the interference is minimized.

3.5Minimal Power Usage

BlueTooth is been designed to be consume low power. And this feature have make BlueTooth very easily to be attach to different device because no extra cable is needed to supply power to BlueTooth. One of the factors BlueTooth can be designed small in size is because of the low power consumption. BlueTooth consume 0-20 dBm (1 milliwatt to 100 milliwatts) to transmit data depending on the transmission range.

[3]Bluetooth recognizes three power classifications: Class 1 has the minimum power output of 0dBm (1mW), which may be increased to a maximum of 20dBm (100mW), although this increase requires power control. Class 2 defines a minimum output power of - 6dBm (0.25mW), which is a nominal output power of the usual 0dBm and has a maximum of 4dBm (2.5mW). In class 3 transmitter powers is simply 0dBm (1mW) [3].

BlueTooth is been designed to used the radio power dynamically. In other words mean BlueTooth use radio power actually required. For example, if the receiver located very near then the transmitter immediately modifies its signal power to suit the exact range. Furthermore, the BlueTooth will automatically shift to low power mode as soon as the transmission volume become low. All these factors have make BlueTooth a low power consumption device.

There are three low power mode, there are sniff, hold and park mode. [5] In the Sniff mode, both master and slave periodically sleep and “sniff” for certain time

intervals which have been previously negotiated. The Hold mode can be used when no data needs to be transmitted for long time intervals (e.g. several minutes). An internal timer determines when the unit will be reactivated. The Park mode releases the 3 bit member address. This mode can be chosen when the unit does not participate in data transmission but wants still to be synchronized to the frequency hopping [5].

4. Problem and Solutions

4.1Range

As mentioned above, a typical BlueTooth range is 10m. But some of the people complain this range is not adequate enough to be used. However, BlueTooth technology is only designed to replace cable. And also it main role is to establish or connect a PAN (Personal Area Network) and not LAN (Local Area Network).Therefore 10 meter range is actually adequate for normal usage purpose. Furthermore, BlueTooth range can be further extend to 100 meter by using class 1 radio power. And with 100 meter range extension, the range problem of BlueTooth is overcome or solved.

4.2Security

The term security means the protection against unauthorized access, steal of data and etc. BlueTooth use air as a medium to transmit data, it have given the opportunity the data be receive or steal by other device located near by.

The solution for security problem is data encryption and authentication. [2]The Bluetooth specification allows for encrypted transactions using a key size of up to 128 bits [2]. With data encryption technique, even the data is been receive by the unauthorized device. It also cannot make use of the data because it does not know the decryption method. An encrypted data is just only rubbish if not decrypted. Only the receiver can make use of the data because only the receiver knows the decryption technique.

[2]Authentication requires a passkey from the remote device attempting to access the local device. An audible and/or visual warning notifies the local operator that a remote device is attempting to access the system [2]. If invalid passkey is given then the access is denied. The disadvantage of authentication is the passkey must be protected. Furthermore, with frequency hopping spread spectrum technique which make the unauthorized access to BlueTooth device almost impossible. [4] In fact, according to the U.S. military a connection link hops across 79 channels is considered to be secure enough by itself [4].

4.3Inteference with Wi-Fi (802.11b)

Most communication medium suffers from interference and BlueTooth is not an exception. BlueTooth use air and ISM band as a medium to transmit data. But Wi-Fi also use ISM band as a medium to transmit data. Let me explain briefly about Wi-Fi before I continue with this point, Wi-Fi is also a wireless communication technology that is primarily used in LAN connection which cover longer range but also consume more power than BlueTooth. Therefore, interference can occur between BlueTooth and Wi-Fi. Interference can cause data lost and data error.

The solution for the problem above is frequency hopping spread spectrum technique which applies by BlueTooth. As mentioned in section 2.4, frequency hopping spread spectrum technique hopping up to 1600 hops per second which effectively reduce the interference with Wi-Fi. [1]A theoretical study by Ericsson was done to understand the impact on a Bluetooth radio in the presence of a Wi-Fi network. It was determined the maximum degradation of throughput under the worst-case scenario was 22% [1]. Furthermore, BlueTooth use shorter data packet to transmit data so the interference is again reduced.

Other than that, microwave oven also can interfere with BlueTooth radio frequency. But [1]with its frequency hopping spread spectrum radio scheme, microwave ovens will only have an impact on Bluetooth in a limited range of its total frequency spectrum according to a study done by Ericsson[1].

4.4Less channel in certain country

As mentioned above, BlueTooth use ISM band which is globally available. With 100% certainty, this band is globally available but the number of channels available in different countries various from each other. Most of the countries have 79 channels available in ISM band. But certain countries have lesser channels available in this band such as Spain, France and Japan. The number of channels available has direct relationship with performance of BlueTooth. This is because BlueTooth use frequency hopping spread spectrum technique which hops within different channels in ISM band. Therefore the lesser channels available, the performance of BlueTooth is reduce.

The solution for this problem is through the effort of BlueTooth SIG to negotiate with the relevant authorities. [1]The Bluetooth SIG is actively working with the various country authorities to harmonize the spectral allocation worldwide and good progress has already been made toward this goal [1]. With these efforts, the numbers of channels have increase in those countries.

5. Issues

5.1Range

BlueTooth typical range is 10 meters and can be extend to 100 meters. This range is adequate for the PAN purpose. But as I mentioned in section 1, BlueTooth offer mobility to end-user. So a user can work with a BlueTooth enabled PDA connected to a network while walking to a destination. But what happen when the user reach the boundary of the coverage range of BlueTooth. The user wills probably lost connection with the network.

Nowadays, end-user would always desire a continuous and reliable connection service because user feels frustrated when connection interrupts. Therefore when the BlueTooth enabled device almost reach out of the coverage area. A message or signal should be issued to acknowledge the user that the device is almost out of coverage range. Then the user would take the appropriate actions. The actions include either remaining the connection or disconnecting from the network. By implementing this suggestion, the user would not surprise why the device suddenly disconnect.

5.2Security

As discussed above, BlueTooth used encryption, authentication and frequency hopping spread spectrum technique to protected BlueTooth from unauthorized access. But these security protection techniques are still not adequate because the hacking technique is increase from time to time. Therefore the security protection technique should be always review and improved to protect against unauthorized access. And there should be a technique that detects those unauthorized devices that connect to BlueTooth and can disconnect unauthorized access device immediately.

Another alternative solution to overcome this problem is to lock the suspected unauthorized access device. Any device that are detected suspicious to be steal info or data then a signal is send by the BlueTooth device to the unauthorized access device to lock the BlueTooth device used by the hacker. The locked device need to be unlocked within 2 hours else the device will be permanently lock and can not be used any more. Therefore, the suspected personnel need to either bring the device to the person who locks his device or his device remains useless. If it is the first situation then the owner can verify either the personnel has steal data or not then the appropriate action can be taken by the owner. If the personnel do not steal data then the BlueTooth is unlocked by the owner BlueTooth device. The 2 important points for this suggestion are the lock command cannot issue by user only by the BlueTooth itself to avoid misuse and the locked device can only be unlocked by the original BlueTooth device that lock the device.

5.3Interference

Although the current BlueTooth device has a very low interference rate but in the future the interference rate might increase due to the increase of usage in the ISM band. To handle this problem, the hopping rate of the frequency hopping spread spectrum technique should increase to decrease the interference else the interference will be increase tremendously. Therefore research and development should be done on the frequency hopping spread spectrum technique to increase the hopping rate. Other than that, the numbers of channels in ISM band also should be increase to make the frequency hopping spread spectrum technique more efficiently reduce the interference.

5.4User-friendliness

Many may question, BlueTooth provide so much advantages and strength why it is still not so popular and commonly used? The answer is the factor of user-friendliness. BlueTooth is still not a user friendly technology. It still require complex configuration by end-user. Furthermore, most of the users do not have the habits of reading user manual. Therefore, after the user try the first and second attempt to configure but also fail then they probably would not try the third attempt.

So BlueTooth still need to be developing as a more user-friendly technology. It would be great if it can become a plug and play technology and device which mean when a BlueTooth is plug into a machine or peripheral then it can be used without any manual configuration. If configuration is required, it should be as simple as possible.

6. Conclusion

As a nutshell, BlueTooth is a short range, wireless and low cost cable replacement technology. BlueTooth provide various advantages over other wireless technology like low cost, low power, minimal interference and etc. But Bluetooth also has it own problems. BlueTooth problem are range, interference, security and lesser channel in certain country. All the above problems have been discussed and solution provided in section 4. But there are also certain issues that need to be discussed include range, security, interference and user-friendliness.

The main and strongest advantage of BlueTooth is cost. Each BlueTooth device only cost 5 dollars which make it affordable to be embedded in different peripherals and device without increase heavy burden in cost. Therefore the cost of BlueTooth device should remain unchanged or not to be increase no wonder whatever change or development in BlueTooth technology, because it is the main advantages over other wireless technology.

There are also some problems in BlueTooth technology include range, interference, security and lesser channel in certain country. Among them, the main problem is security because destructive is always easier than constructive. A best security protection technique will also have it own limitation or weakness to be attacked by the hacker to thief data because the hacking technique is improving every day. So the protection technique should also be improved and given attention from day to day and not only when the data is lost.

I have list 4 issues in section 5. There are range, security, interference and user-friendliness. Not just only the 4 issues with BlueTooth there are also other issues relating with BlueTooth. But among the 4 issues, I would like to give more attention on user-friendliness. A technology or device is useless or not valuable if the user do not accept it. Therefore user-friendliness is the main issue that needs to be solved in order to be accepted by end user. As I suggest in section 5.4, BlueTooth device should be develop as a plug and play device. If this cannot be achieve, then the configuration should only required an easier interaction from user such as an installation program for software that only required the user to click the next button.

As I mentioned many times, BlueTooth is only a cable replacement technology. BlueTooth itself does not provide much benefit or advantages to our life, but the idea of making full utility of BlueTooth technology. In other words, Bluetooth is just like a computer which is a dumb terminal while idea is the software that makes the computer much more useful. Without software (Idea), computer (BlueTooth) is just a dumb terminal that can only perform some arithmetic calculation. For example, BlueTooth can be used to monitor a patient status by attach BlueTooth to every patient. When a patient need emergency operation then he or she can make use of BlueTooth to contact a nurse or doctor. As a conclusion, Idea is the core enabler of BlueTooth technology. BlueTooth still need more, continuous and long term concentration and development from SIG to become a mature and user-friendly technology.

This paper has presented an overall and brief explanation on BlueTooth technology. Firstly, the paper introduces BlueTooth technology and the structures of this paper. Then, the paper explains briefly on BlueTooth device identity, network and

connection scenario. Then it provides several advantages of BlueTooth technology. After that, the problems of BlueTooth are discussed. Subsequently, I have point out certain issue relating to BlueTooth technology by my own creative thinking. Finally I conclude all the point in conclusion.

This research paper does not conclude all areas or issues regarding BlueTooth technology. There are still areas and issue that are not presented in this research paper. So to understand further about BlueTooth more reading about BlueTooth need to be done. I believe in the future BlueTooth will become a common technology that is used by every single family.

(3973 words)

7. Reference

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