Competitive Exams Bluetooth Functioning

Bluetooth has now established itself in the market place enabling a variety of devices to be connected together using wireless technology. Bluetooth technology has come into its own connecting remote headsets to mobile phones, but it is also used in a huge number of other applications as well.

Bluetooth technology originated in 1994 when Ericsson came up with a concept to use a wireless connection to connect items such as an earphone and a cordless headset and the mobile phone. The idea behind Bluetooth (it was not yet called Bluetooth) was developed further as the possibilities of interconnections with a variety of other peripherals such as computers printers, phones and more were realised. Using this technology, the possibility of quick and easy connections between electronic devices should be possible.

It was decided that in order to enable the technology to move forward and be accepted as an industry standard that it needed to be opened up as an industry standard. Accordingly, in Feb 1998, five companies (Ericsson, Nokia, IBM, Toshiba and Intel) formed a Special Interest Group (SIG) . Three months later in May 1998, Bluetooth was publicly announced with the first specification following on with the first release of the standard in July 1999. Later more members were added to the group with four new companies, Motorola, Microsoft, Lucent and 3Com, joining the group. Since then more companies have joined and the specification has grown and is now used in a large variety of products.

The name of the Bluetooth standard originates from the Danish king Harald Blatand who was king of Denmark between 940 and 981 AD. His name translates as “Blue Tooth” and this was used as his nickname. A brave warrior, his main achievement was that of uniting Denmark under the banner of Christianity, and then uniting it with Norway that he had conquered. The Bluetooth standard was named after him because Bluetooth endeavours to unite personal computing and telecommunications devices.

Bluetooth is a wireless data system and can carry data at speeds up to 721 Kbps in its basic form and in addition to this it offers up to three voice channels. Bluetooth technology enables a user to replace cables between devices such as printers, fax machines, desktop computers and peripherals, and a host of other digital devices. Furthermore, it can provide a connection between an ad hoc wireless network and existing wired data networks.

The technology is intended to be placed in a low cost module that can be easily incorporated into electronics devices of all sorts. Bluetooth uses the licence free Industrial, Scientific and Medical (ISM) frequency band for its radio signals and enables

communications to be established between devices up to a maximum distance of 100 metres.

RF System

Running in the 2.4 GHz ISM band, Bluetooth employs frequency hopping techniques with the carrier modulated using Gaussian Frequency Shift Keying (GFSK) .

With many other users on the ISM band from microwave ovens to Wi-Fi, the hopping carrier enables interference to be avoided by Bluetooth devices. A Bluetooth transmission only remains on a given frequency for a short time, and if any interference is present the data will be re-sent later when the signal has changed to a different channel which is likely to be clear of other interfering signals. The standard uses a hopping rate of 1600 hops per second. These are spread over 79 fixed frequencies and they are chosen in a pseudo-random sequence. The fixed frequencies occur at 2400 + n MHz where the value of n varies from 1 to 79. This gives frequencies of 2402,2404 ... 2480 MHz. In some countries the ISM band allocation does not allow the full range of frequencies to be used. In France, Japan and Spain, the hop sequence has to be restricted to only 23 frequencies because of the ISM band allocation is smaller.

During the development of the Bluetooth standard it was decided to adopt the use of frequency hopping system rather than a direct sequence spread spectrum approach because it is able to operate over a greater dynamic range. If direct sequence spread spectrum techniques were used then other transmitters nearer to the receiver would block the required transmission if it is further away and weaker.

Modulation

The way in which the data is modulated onto the Bluetooth carrier was also carefully chosen. A form of frequency shift keying known as Gaussian Frequency Shift Keying is employed. Here the frequency of the carrier is shifted to carry the modulation. A binary one is represented by a positive frequency deviation and a binary zero is represented by a negative frequency deviation. It is then filtered using a filter with a Gaussian response curve to ensure the sidebands do not extend too far either side of the main carrier. By doing this it achieves a bandwidth of 1 MHz with stringent filter requirements to prevent interference on other channels. For correct operation the level of BT is set to 0.5 and the modulation index must be between 0.28 and 0.35.

Transmitter Power Levels

The transmitter powers for Bluetooth are quite low, although there are three different classes of output dependent upon the anticipated use and the range required. Power Class 1 is designed for long range communications up to about 100m devices, and this has a maximum output power of 20 dBm, Next is Power Class 2 which is used for what are termed for ordinary range devices with a range up to about 10m, with a maximum output power of 4 dBm. Finally there is Power Class 3 for short range devices. This support communication only to about 10cm and it has a maximum output power of 0 dBm.

There are also some frequency accuracy requirements for Bluetooth transmissions. The transmitted initial centre frequency must be within ±75 kHz from the receiver centre frequency. The initial frequency accuracy is defined as being the frequency accuracy before any information is transmitted and as such any frequency drift requirement is not included.

In order to enable effective communications to take place in an environment where a number of devices may receive the signal, each device has its own identifier. This is provided by having a 48 bit hard wired address identity giving a total of 2.815×10^{14} unique identifiers.

Data Transfer

There are two ways in which data is transferred. The first is by using what is termed an Asynchronous Connectionless Communications Link (ACL) . This is used for file and data transfers. A second method is termed a Synchronous Connection-orientated Communications Link (SCL) . This is used for applications such as digital audio.

The ACL is enables data to be transferred via Bluetooth at speeds up to the maximum rate of 732.2 kbits/sec. This occurs when it is operating in an asymmetric mode. This is commonly used because for most applications there is far more data transferred in one direction than the other. When a symmetrical mode is needed with data transferred at the same rate in both directions, the data transfer rate falls to 433.9 kbits/sec. The synchronous links support two bi-directional connections at a rate of 64 kbits/sec. The data rates are adequate for audio and most file transfers. However the available data rate is insufficient for applications such as high rate DVDs that require 9.8 Mbit/sec or for many other video applications including games spectacles.

Data is organised into packets to be sent across a Bluetooth link. The Bluetooth specification lists seventeen different formats that can be used dependent upon the requirements. They have options for elements such as forward error correction data and the like. However the standard packet consists of a 72 bit access code filed, a 54 bit header field, and then the data to be transmitted which may be between 0 and 2745 bits. This data includes the 16 bit CRC if it is needed.

As it is likely that interference will cause errors, error handling is incorporated within the system. For asynchronous links packet sequence numbers are transmitted. If an error is detected in a packet then the receiver can request it to be re-sent. Error coding using a 16 bit CRC is also available. For the synchronous links packets cannot be re-sent as there is unlikely to be sufficient bandwidth available to re-send data and “catch up” However it is possible to include some forward error control.

Communication Nets

In order that Bluetooth devices may communicate with each other they form small clusters or nets. These are termed “piconets” and comprise up to eight devices. Within a piconet, one of the devices assumes the role of “Master” while the others become slaves.

If more than eight devices are available to join the net, eight are allowed in, and the others need to remain in an inactive standby state. They may be requested to join the net at a later state if required.

To enable a net to eb set up, the master transmits an enquiry message every 1.28 seconds to discover whether there are any other devices within range. If a reply is received then an invitation to join the net is transmitted to the specific device that has responded. After this the master allocates each device a member address and then controls all the transmissions.

All Bluetooth devices have a clock that runs at twice the hopping speed and this provides synchronisation to the whole net. The master transmits in the even numbered time slots whilst the slaves transmit in the odd numbered slots once they have been given permission to transmit.

As security is becoming an important issue, especially where links to computers are concerned, secure communications are possible over Bluetooth with the devices encrypting the data transmitted. A key up to 128 bits is used and it is claimed that the level of security provided is sufficient for financial transactions. However in some countries the length of the key is limited to enable the security agencies to gain access if required.

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