# Effect of Data Type on Point to Point Bluetooth Link

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## Abstract

This paper gives an informative overview about Bluetooth technology (which has become a standard for wireless connectivity), through connecting two computers as wireless nodes using Bluetooth technology. Three types of data (text, audio, and image) are transferred through the specified connection. Then, distance and throughput are tabulated. The practical results with the effective distance for each data type are given and discussed.

## الخلاصة:

يقدم هذا البحث نظرة معلوماتية على تكنولوجيا (البلوتوث) التي أصبحت مقياس للربط اللاسلكي من خلال ربط حاسبتين مع بعضها كعقدتين لاسلكيتين بأستخدام تكنولوجيا (البلوتوث). تم نقل ثلاث أنواع من البيانات هي : النصوص والصوت والصورة عبر الربط مدار البحث. وتم بعد ذلك حساب المسافة والسرعة على شكل جداول. وقد تم تحديد ومناقشة النتائج العملية مع المسافات المؤثرة لكل نوع من أنواع البيانات.

# 1. Introduction

In 1994, Ericsson in Sweden launched an initiative to study a low-power, low-cost radio interface between mobile phones and their accessories. After three years, In 1997, Ericsson approached various manufacturers of mobile electronic devices to discuss the development and promotion of this short range wireless radio link as Ericsson alone wouldn't be able to produce such technology if it wouldn't be compatible with other vendor's equipment [1]. Thus in 1998, Ericsson, IBM, Intel, Toshiba and Nokia formed the Special Interest Group (SIG) for the promotion and development of Bluetooth technology. The first silicon Bluetooth was also ready in 1998. As we can see that the SIG included two market leaders in mobile telephony, two in laptop computing and one in digital signal processing technology. The biggies being in the game gave an impetus to thousands of companies to join hands with the SIG for the endorsement and expansion of this technology [2].

Bluetooth is named after the 10th century Viking King Harald Blatand (Blatand meaning Bluetooth). He was instrumental in uniting the countries in the Baltic region like Sweden, Denmark, Norway and thus emerging as a powerful force. Bluetooth aims at uniting the computing and telecommunication world and so achieving the same greatness [3].

During the past two decades, the advancement in microelectronics and Very Large Scale Integration (VLSI) technology pushed down the cost of many consumer electronic products to a level which is affordable for the common man. The first quarter of 2001, saw the vending of about 32.5 million PCs. The sale of cellular phones reached 1 billion in 2005 [4]. With increase in the number of electronic devices, comes in the need of connecting them together for maximum interoperability and utilization. These devices connect with each other using a variety of cables, radio signals and infrared light beams, and an even greater variety of connectors, plugs and protocols. Bluetooth is devised to replace these

cables [1]. Bluetooth is a global standard for wireless connectivity. Bluetooth technology facilitates the replacement of the cables used to connect one device to another.

Bluetooth technology has the following features:

1- Cable replacement: replacing various types of cables and wires required for interconnectivity between various devices would enable users to use all electronic devices without wasting time and money.

2- Small size: the Bluetooth device is very small so that it can be attached to or built into any consumer product like the mobile phones without adding much to the weight of the system.

3- Low cost: Bluetooth is aimed to be a low cost device approximately $5 [5].

4- Low power: power consumption reduction is a key requirement for modern equipments (within 100 mW) as it is short range equipment and so it facilitates the use of small batteries for its usage.

5- Designed to operate in noisy frequency environments.

6- Bluetooth radio uses a fast acknowledgement and frequency hopping schemes to make the link robust [2].

## 2. Bluetooth Overview

Bluetooth is a short-range, low cost, and low power radio technology operating in the unlicensed 2.4GHz ISM (Industrial-Scientific-Medical) frequency band. It employs FHSS (Frequency Hopping Spread Spectrum) technique and implements stop and wait ARQ (Automatic Repeat Request), CRC (Cyclic Redundancy Check), and FEC (Forward Error Correction) to achieve high reliability on the wireless links and to alleviate the interferences caused by other radio technologies [6].

# Bluetooth Network Topology

## i. Piconet

Bluetooth devices can interact with one or more devices in several different ways. The simplest scheme is when only two devices are involved. This is referred to as point-to-point. One of the devices acts as the master and the other as a slave. This network is referred to as a piconet.

Piconet is any Bluetooth based network with one device functioning as the master device and one or more functioning as slave devices. A diagram of a piconet is provided in Figure (1). In the case of multiple slaves, the communication topology is referred to as point-to-multipoint. In this case, the channel (and bandwidth) is shared among all the devices in the piconet [7]. There can be up to seven active slaves in a piconet. Each of the active slaves has an assigned 3-bit Active Member address (AM_ADDR). There can be additional slaves which remain synchronized with the master, but do not have an Active Member address. These slaves are not active and are referred to as parked [7].
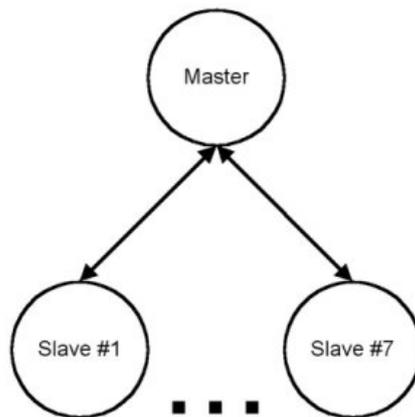


**Figure (1): Piconet Network Architecture**

## ii. Scatternet

For example on scatternet, there might be a piconet consisting a cellular phone to a PC, while the person in the neighbouring cubicle has another piconet consisting

his cellular phone, headset, and business card scanner to his laptop. A diagram is presented in Figure (2) below.

Because the two piconets are so close to each other, they have overlapping coverage areas. This scenario has been taken in consideration in the Bluetooth specification and is referred to as a scatternet. Slave devices in one piconet can participate in another piconet as either a master or slave. This is accomplished through time division multiplexing. In a scatternet, the two (or more) piconets are not synchronized in either time or frequency. Each of the piconets operates in its own frequency hopping channel while devices in multiple piconets participate at the appropriate time via time division multiplexing. In the example above, it would be possible to set the neighbour's business card scanner to also transmit information that is scanned to your PC, so that you will have visibility of his business contact information. This feature in Bluetooth standard causes security vulnerability [8].
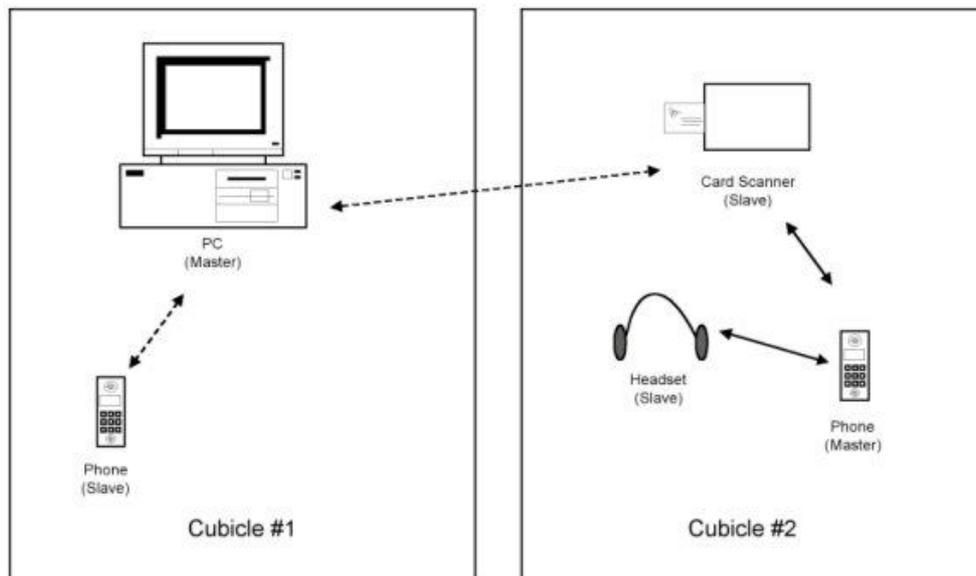


**Figure (2) : Scatternet Network**

## 2.2 Bluetooth Components

Any Bluetooth solution consists of four major components: antenna/RF component, Bluetooth hardware and firmware (baseband and link controller), Bluetooth software protocol stack, and the application itself [9].

## 3. Implementation of Point-to-Point Network Using Bluetooth

In order to connect two computers via Bluetooth-based connection, two different Bluetooth devices were required. A Bluetooth dongle version 2.0+EDR was attached to the USB port of the first PC. The second PC was a Dell laptop (true mobile 355) with a built in Bluetooth type 2.0+EDR.

The following steps are used in order to connect The mentioned above computers via Bluetooth:

Step 1: Assigning host name and workgroup to PCs.

Step 2: Connecting Bluetooth dongle to PC.

Step 3: Bluetooth instillation verification.

Step 4: Check whether the bluetooth dongle has been identified.

Step 5: Bluetooth device discovery.

Step 6: Starting a Personal Area Network.

Step 7: Pairing with another bluetooth-enabled computer.

Step 8: Bluetooth Network Connection.

## 4. Results Analysis

### 4.1 Results

The operation of the network was tested by transferring three types of data files: text file, sound file, and a file containing a static picture. Then the throughput was measured over different distances for the three types of data files. File transfer procedure was repeated while the distance between the computers was varied by 1 meter at a time, staring from a distance of 0 meters up to 10 meters. Error! Reference

source not found.) below lists the first set of results when a 1.05MB sound file was transferred. The table lists maximum throughput achieved over each specified distance. From the table it can bee seen that the closer the computers to each other the higher the transfer rate achieved. At the stage when the two computers were at about 10 meters apart, the link was dropped and hence the throughput plummeted to 0 bps.

**Table (1) Maximum Throughput Speeds over Different Distances for Transferring a Sound File**

| Distance (Meter) | Throughput (KB/Second) |
|---|---|
| 0 | 70.0 KB |
| 1 | 72.1 KB |
| 2 | 63.7KB |
| 3 | 57.5KB |
| 4 | 51.4KB |
| 5 | 42.6KB |
| 6 | 33.1KB |
| 7 | 27.2KB |
| 8 | 18.1KB |
| 9 | 7KB |
| 10 | 0KB |

Table (2) below lists the second set of results when a 166KB text file was transferred. The table lists maximum throughput achieved over each specified distance. From the table it can bee seen that the closer the computers to each other the higher the transfer rate achieved. At the stage when the two computers were at about 10 meters apart, the link was dropped and hence the throughput plummeted to 0 bps.

**Table (2) Maximum Throughput Speeds over Different Distances for Transferring a Text File**

| Distance (Meter) | Throughput (KB/Second) |
|---|---|
| 0 | 72.0KB |
| 1 | 74.1KB |
| 2 | 65.3KB |
| 3 | 58.5KB |
| 4 | 50.8KB |
| 5 | 46.3KB |
| 6 | 37.2KB |
| 7 | 23.0KB |
| 8 | 14.2KB |
| 9 | 8KB |
| 10 | 0KB |

Table (3) below lists the third set of results when a 529KB image file was transferred. The table lists maximum throughput achieved over each specified distance. From the table it can bee seen that the closer the computers to each other the higher the transfer rate achieved. At the stage when the two computers were at about 10 meters apart, the link was dropped and hence the throughput plummeted to 0 bps.

| Distance (Meter) | Throughput (KB/Second) |
|---|---|
| 0 | 70.0KB |
| 1 | 72.1KB |
| 2 | 61.2KB |
| 3 | 59.5KB |
| 4 | 54.6KB |
| 5 | 45.5KB |
| 6 | 33.0KB |
| 7 | 27.1KB |
| 8 | 12.2KB |
| 9 | 9KB |
| 10 | 0KB |

**Table (3) Maximum Throughput Speeds over Different Distances for Transferring an Image File**

## 4.2 Analysis

Three graphs have been plotted for the three different files used for bluetooth radio link testing. The graphs are shown below: graph1 at fig. (3), graph2 at fig. (4), and graph3 at fig.(5). From these graphs it can be seen that the operation of bluetooth personal network is not affected by the type of data being transferred, as these graphs are showing very similar characteristics to each other. It can also be seen from these graphs that the maximum throughput can be achieved when the two computers are placed at about 1 meter distance between them. At this point the maximum throughput reaches about 7.2kbps, which highlights the point that it is really a personal network which can conveniently replaces cables, such as mouse, keyboard, or headset cables so the user can have maximum freedom of movement without warring about his headset's cable gets snapped or tangled.

The graphs also show that at a distance of about 5 meters (mid maximum range) the throughput declines to about half the maximum achieved throughput. So, it can be inferred that the throughput decreases linearly with distance, as distance increases, throughput decreases in the same proportion.
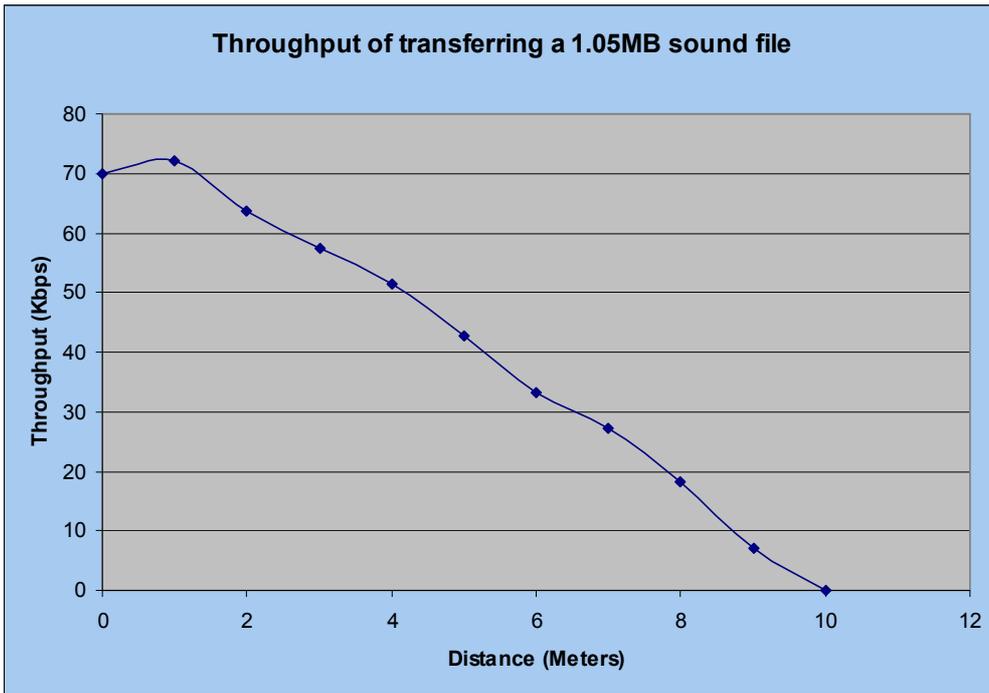
**Figure (3): Graph1: Throughput Characteristics vs. Distance for a Sound File Transfer**
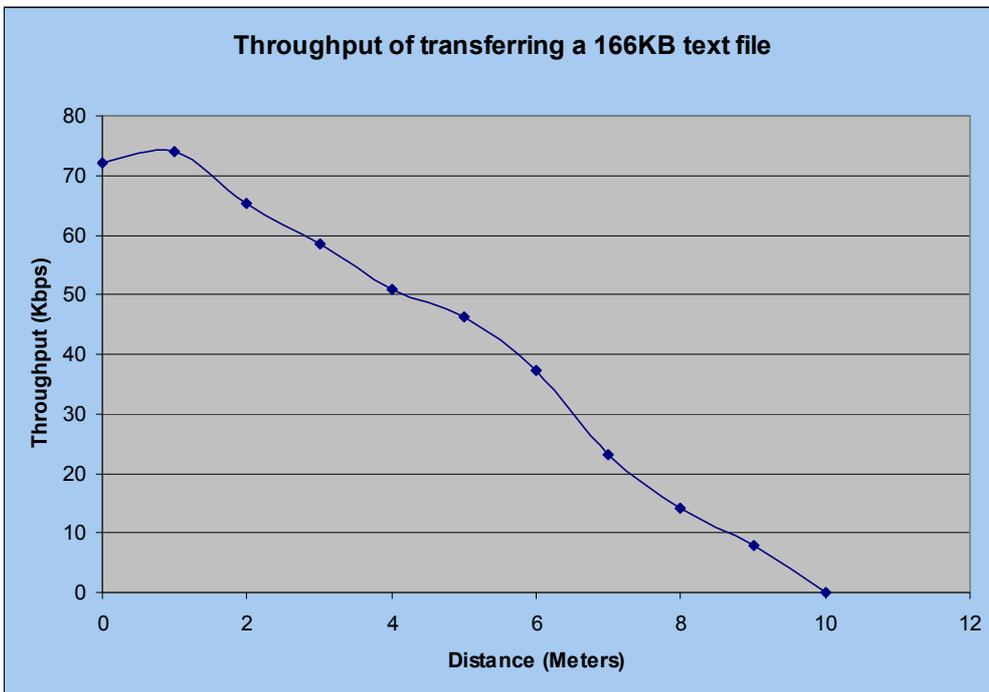


**Fig.(4) Graph2 : Throughput Characteristics vs. Distance for a Text File Transfer**

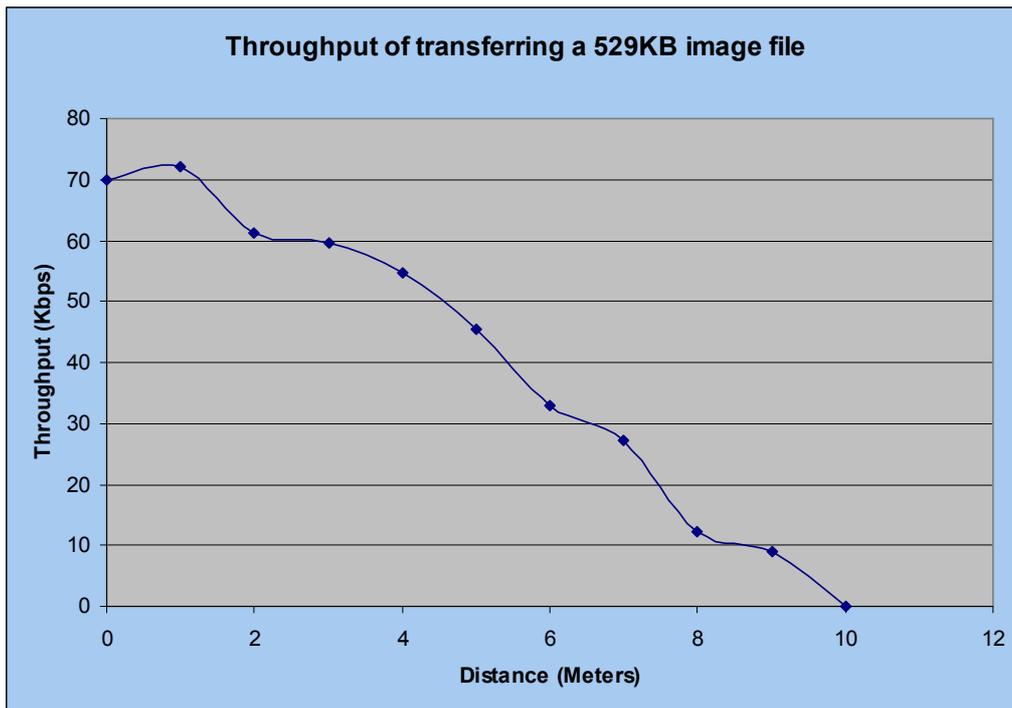**Throughput of transferring a 529KB image file**

**Fig.(5) Graph3 : Throughput Characteristics vs. Distance for an Image File Transfer**

Fig.(6) Graph2 at fig.(6) below depicts the three previous graphs superimposed on each other into one graph which clearly shows the similarity in behaviour of the radio channel irrespective to the type of data being transferred.
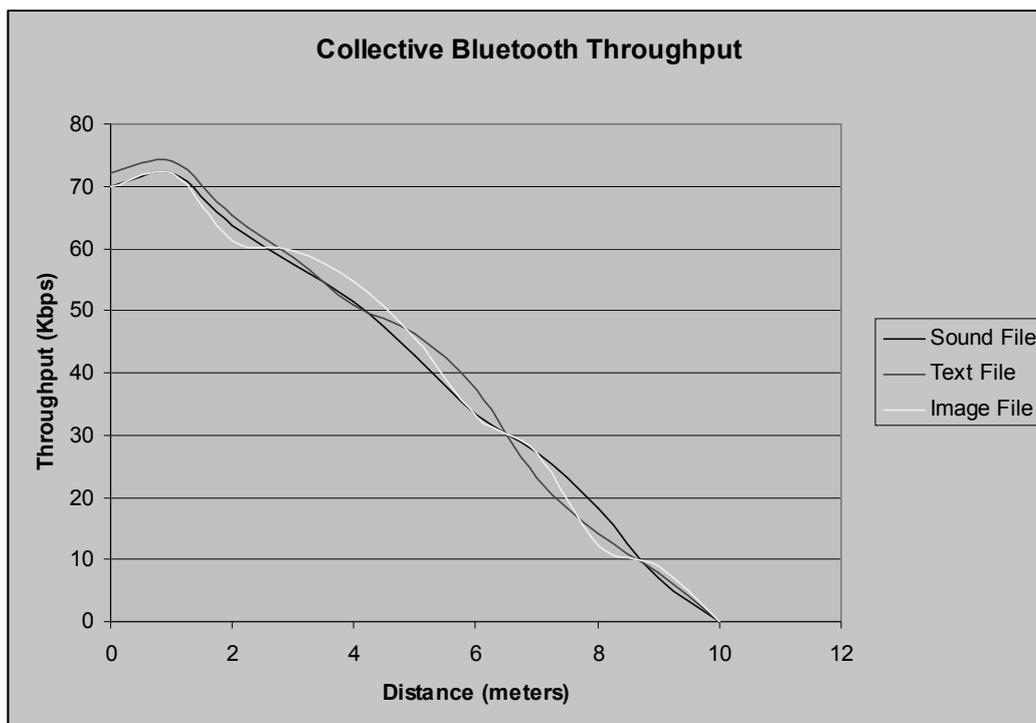


**Collective Bluetooth Throughput**

**Fig.(6) Graph2 : Different Media Data Types Transfer Over Bluetooth Link**

## 5. Conclusions

From this work some points can be inferred such as:-

a- Point-to-point link can be successfully established using Bluetooth technology. The transferred information across the wireless network can be of any type (text, voice, image, or video).

b- Type of data being transferred has no effect on the throughput or the range of the communication channel.

c- The maximum distance over which bluetooth operates is less than 10 meters, irrespective to data type.

d- Speed of Bluetooth channel decreases linearly with distance.

e- Maximum throughput can be achieved when the communicating devices are at about 1 meter apart from each other.

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