# Communication Technologies of Smart Phone Based Control Embedded Systems

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## Abstract

In this paper, we studied some communication technologies to select a suitable model interface which allowed users interaction with embedded systems by using Smart Phones.
***Keywords:*** *Smart Phone, Embedded Systems, Fiber Optics.*

## 1. Introduction

Recent years, embedded devices have been widely used in our daily life, More recently, the use of mobility has been explored for improving the networking facilities in the system. With the increasing development of embedded and network technology, more embedded systems are connected to Internet in order to manage embedded equipment more effectively, For that, a number of communication interfaces are available.

## 2. Overview

Remote communication is communication that is not face-to-face, which is convenience and control, speed of delivery, reduced preparation time, cost-effectiveness and reusability to the technology of control system consists of a number of embedded systems. Each embedded system can send real-time data to a central location from where the entire process control system can be monitored.

Embedded Systems talk with the outside world via user interface remotely with the help of a serial (e.g. RS-232, USB, I²C, etc.) or network (e.g. Ethernet) connection, which can display data Communication in a web browser on a Smartphone act as a remote control of embedded systems.

## 3. Embedded System Characteristic

Typical structure of embedded systems have four layers, the first three consisting of software and the fourth of hardware[1].
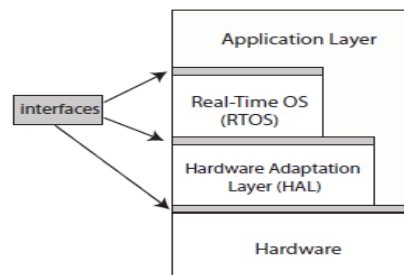


**Figure (1)**

Embedded systems have owned characteristics when comparing with general purpose computer, It designed to perform specific tasks in a particular computational environments consisting of software and hardware components. also have real-time performance constraints that must be met. Embedded systems are not always standalone devices; many of them consist of small computerized parts within a larger device that serves a more general purpose. As well they range from no user interface at all in systems dedicated only to one task, to complex graphical user interfaces that resemble modern computer desktop operating systems. Embedded devices have Monolithic approach requires re-implementing the functionalities, which have too small for component off-the-shelf technologies, in comparison with general purpose computer has Component-based software engineering (CBSE)

provides a mean to reuse the functionalities, which can provide a framework instead of technology.

A smart phone is a mobile phone with highly advanced features, a high-resolution touch screen display, Wi-Fi connectivity, Web browsing capabilities, and the ability to accept sophisticated applications. Smart phones don't fit into the general computing category because they are still highly specialized units [2]. They may be able to run applications.



**Figure (2)**

## 4. Communication Interface

Communication media used in local area network (LAN) technology is collectively known as Ethernet. The media and protocol standards that enable communication between networked devices over Ethernet are defined by IEEE 802.3. Ethernet transmit data over both copper and fiber cables, the maximum length ranges from 10Km while in fiber, from 10 Km to 70 Km. Traditional Ethernet operates at a speed of 10 Mbps, but the more recent standards push this speed to 100 Mbps (Fast Ethernet) or 1000 Mbps (gigabit Ethernet). In the future we will likely see 10 gigabit Ethernet (also known as 10G Ethernet) appearing in desktop PCs[3].

Wireless LAN standards (e.g. those defined by IEEE 802.11) use radio waves, or others use infrared signals as a transmission medium. Three forms of media use light energy to carry information: Optical fibers, Infrared, transmission and Point-to-point lasers[4]. Adding new technology VLC (Visible Light Communication).

**Fiber Optics:** Operates in the visible light spectrum, in the range from 1014Hz to 1015Hz[5], while in copper from 2Mb to 10Mb. It is flexible and provides cheaper bandwidth for long distance

communication, because light propagates through the fiber with little attenuation compared to electric cables. Fiber is also immune to electrical interference; there is no cross-talk between signals in different cables, and no pickup of environmental noise. A single fiber can carry much more data than electrical cables such as standard category 5 Ethernet cabling, which typically runs at 100 Mbps or 1 Gbps speeds. Also, theft prevention and Material cost of fiber are higher than copper cable, but it may be less expensive in the long run.

**Radio frequency** (**RF**): RF is a rate of oscillation in the range of around 3 kHz to 300 GHz. RF itself has become synonymous with wireless and high-frequency signals, describing anything from AM radio between 535 kHz and 1605 kHz to computer local area networks (LANs) at 2.4 GHz. However, RF has traditionally defined frequencies from a few kHz to roughly 1 GHz. If one considers microwave frequencies as RF, this range extends to 300 GHz[6]. (See figure 3)
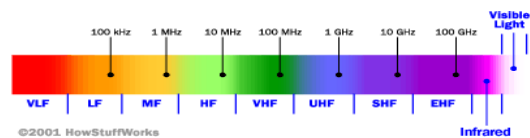


**Figure (3)**

A radio wave is an electromagnetic wave propagated by an antenna[7] and Line of sight not needed, beside transmitter power determines range. In the RF remote lighting kit, LED lighting is controlled using a remote controller through radio frequency. The use of RF remote control makes lighting control more comfortable. Because of dimming feature, total power consumption of lighting can be reduced depending on lighting usage[8].

**Infrared (IR)**: Wireless infrared communications refers to the use of free-space propagation of light waves[9]. Infrared light is radiation in the invisible to the unaided eye while "optical" refers to visible electromagnetic radiation. Lasers in the 1300 to 1700 nm range. IR wireless is used for short- and medium-range(Up to 10m), with data rates of 0.5 Kbps to 1Kbps communications and control, IR has indoor

communication beside bandwidth is unlimited. Infrared emitters and detectors capable of high speed operation are available at low cost. Their advantages easy to secure transmissions, no multipath fading and it prevents interference between links.

**VLC (Visible Light Communication) Light Fidelity (Li-Fi):** British researchers have transmitted wireless data at speeds of over 10 gigabits per second using LED lights. It is the latest breakthrough in the emerging field of Visible Light Communication (VLC)[10]. Wavelength between ~400nm (750THz) and ~700nm (428THz), distance range is 213m[11]. Visible light is also more energy efficient than radio signaling, can also be more secure than radio technology like Wi-Fi, also no interference, expected to be cheaper than Wi-Fi. But stays indoors.

**Network Interfaces**: Embedded systems could be provided with network interfaces and accessed by network such as Local Area Network wire (Ethernet) or wireless (WLAN). Such embedded systems are connected to a network, typically a network running TCP/IP (Transmission Control Protocol/Internet Protocol) protocol suite. Wireless technologies represent a rapidly emerging area of growth and importance for providing ubiquitous access to the network; WLANs based on the IEEE 802.11 standard are being implemented constantly in the houses and Broadband wireless (BW) is also a new merging wireless technology which is competing with Digital Subscriber Line.

The two most popular wireless technologies are Bluetooth and wireless local area networks (WLAN), which is more commonly known as Wi-Fi. The Institute of Electrical and Electronics Engineers (IEEE) defined the Wi-Fi network protocol IEEE 802.11a, 802.11b, and 802.11 g operating in the unlicensed radio bands of 2.4 and 5 GHz[12], with data rates of 11Mbps for IEEE 802.11b to latest Wi-Fi version can reach up to 250 Mbps . Based on the feature of middle range cover (<300 meter), Wi-Fi is predominantly used in campuses and enterprise buildings. A wireless router (see figure 4), which integrates a Wireless Access Point, Ethernet switch and internal router firmware application, is usually used to connect a group of wireless devices to an adjacent wired LAN [13]. Able to works at longer

distances and loaded with high quality security protocols makes Wi-Fi a more power consuming protocol than Bluetooth.



**Figure (4)**

The IEEE standardized Bluetooth which is known as IEEE 802.15.1 Bluetooth is a wireless personal area network (PAN) technology using a radio broadcast transceiver (microchips in each device a quasi optical wireless path) that enables short range peer-to-peer data transfer required. Bluetooth technology has a low-power mode and high integrated devices and operates in the unlicensed 2.4-GHz band, data rate is 1Mbps (Version 1.2 ) to 24Mbps(Version 4) but it is limited to short-distance(30m) communications. Bluetooth v4.2 was released on December 2, 2014[14]. Earlier versions of Bluetooth were encrypted and even now Bluetooth security is limited to key matching. Where in Wi-Fi, the security standards Wireless are Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA).

## 5. Results

A smart phone offers the ability to configure the device in your particular way. Generally, different features embedded system and General Purpose Computer in Table 1, Smart phone is able to run a complete operating system and provide a standardized interface with embedded systems by applying remote login application in all embedded devices.

Comparison between different technologies shown in Table 2, VLC and Wi-Fi can be used as a communications medium for ubiquitous computing, but Wi-Fi is better for outdoor Propagation in unlicensed bandwidth with long distance and high speed, Where in Li-Fi is Visibility, high Security, Harmless for human body and no regulation in optical frequency, but stays indoors and less coverage range than Wi-Fi.

**Table 1: Embedded System Vs General Purpose Computer**

| Feature | Embedded System | General Purpose Computer |
|---|---|---|
| Architecture | Monolithic | CBSE(Component based SE) |
| Objective design | Specific Task | Multiple Tasks |
| Real-time performance | have real-time performance | Some component have real time performance |
| Control | Completely by the device | By graphical user interface (GUI) |
| Program | Hardware programmed with particular applications. | may be able to run applications |

**Table 2: Comparison between Different Technologies**

| | Ethernet | Bluetooth | Wi-Fi | IR | VLC |
|---|---|---|---|---|---|
| Standard | IEEE 802.3 | IEEE 802.15.1 | IEEE 802.11 (a/b/h/g/n) | IrDA | IEEE P802.15 |
| Media | Copper, fiber (electrical, light) | RF | RF or IR | Invisible Light | Visible Light (fire or lamp) |
| Connection | Ethernet adapter (e.g. UTP, ST ) | Transceiver micro-chip / quasi optical (IrDA adapter) | Access point | Diode/LED | LED |
| Bandwidth | Copper, fiber (2Mb to 10Mb, 1014Hz to 1015Hz) | unlicensed 2.4GHz | unlicensed 2.4 and 5 GHz | Lasers 1300 to 1700 nm | 400nm (750THz) and ~700nm (428THz). |
| Data rate | 10 Mbps to 10 Gbps In future 100Gbps | 1Mbps to 24Mbps | 11Mbps to 250Mbps | 0.5 Kbps to 1Kbps | over 10 Gbps |
| Propagation | Wire | No need LOS (Line of sight) | Outdoor with LOS | indoor | No need LOS indoor |
| Security | Physically securing switches | Encryption /key matching | Security (WPA) | easy to secure transmissions | High Security |
| Power | Low | Low | High | Low | Low |
| Range | Copper, fiber (100m, 10Km to 70Km) | Short distance 30m | middle range cover (<300 meter) | Up to 10m | 213m with sunlight |
| electrical interference | Copper, fiber (No immune, immune) | No immune | No immune | immune | immune |
| Fading | - | multipath fading | multipath fading | no multipath fading | - |

## 6. Conclusions

Based on theoretical study, the results are shown that Wi-Fi wireless is accommodated interface in home and enterprise network. Smartphone is considered as remote control interacts with embedded devices. One of the important drawbacks of Li-Fi is that it can't penetrate obstacles. How over, it is considered to be one of the flexible wireless communication technology.

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