International Journal of Information and Computation Technology.
ISSN 0974-2239 Volume 3, Number 6 (2013), pp. 485-496

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Use of Infrared in Image Transmission from Mobile Phone to Television

S. Ranganatha Rao and Masha Chandrasekaran

SRM University, Chennai.

Abstract

Infrared technology allows computing devices to communicate via short-range wireless signals. Compatible devices can transfer files and other digital data bi directionally. In this paper the use of infrared radiation as a mode for high speed wireless digital communication is reviewed. The characteristics of the IrDA protocol upon which the proposed technology is based, are presented. . A discussion specific to the transfer of images from mobile devices to television sets follows, along with tentative strategies for the design of the hardware. A brief insight on the conversion of images in to digital format is presented. The speed constraints pertaining to the transfer of large size media are also discussed followed by the advantages and possible drawbacks of the proposed technology.

Keywords: Infrared, transceiver, IrDA, protocol, image transmission, IrTran-P.

1. Introduction

Theory is no use without practice – but a little theory helps to cast some light on the otherwise invisible phenomena of infra-red technology. As the World witnesses a massive evolution in the field of electronics and technology, it is necessary that access to information and communication across devices be simpler. Examples of emerging technologies in the field of IT and communication include quantum computing, 4G Cellular communication, Radio Frequency Identification etc. Infrared Technology, predominantly used in mainstream applications, has immense potential to enable communication with growing list of electronic devices. The infrared transmission technology used in computers is similar to that used in consumer product remote control units. The remote controls are used to issue commands from a distance to televisions or other consumer electronics such as stereo systems, DVD players and dimmers. Infrared is easily generated and doesn't suffer electromagnetic interference, so it is easily used in communication and control. The massive use of IR LEDs at TV/VCR remote controls and other applications, brought infrared diodes and transistors (emitter and receivers) at very low cost to the market. Although there are many advantages of Wi-Fi and Bluetooth technologies , which use radio waves of wavelengths longer than infrared light and frequencies ranging from 300 GHz to as low as 3 kHz, including lower cost, significantly more transmission range, ease of installation, Infrared serves for short-range, indoor communication and offers several significant advantages. In general, the infrared region includes wavelengths between about 700 nm and 100 µm. Infrared emitters and detectors capable of high speed operation are available at low cost. The infrared spectrum offers unlimited bandwidth that can penetrate through glass, but not through walls or other opaque barriers, so that infrared transmissions are confined to the room in which they originate. This signal confinement makes it easy to secure transmissions against eavesdropping, and it prevents interference between links operating in different rooms. Fraunhofer researchers are working on infrared wireless data transfer technology with the development of a “multi-gigabit communication module” that can wirelessly transfer data 46 times faster than Wi-Fi and 1,430 times faster than Bluetooth. Transfer of images from mobile devices to television using Infrared can be made feasible and implementable if the upcoming data transmission module is put into effect.

2. Infrared in Wireless Communication

Wireless communication allows the exchange of information between two devices without the use of a wire or cable. The application of Infrared radiation in this domain has served the purpose with optimum results. Changing television channels, opening and closing a garage door, and transferring a file from one computer to another can all be accomplished using Infrared technology. In all such cases, information is being transmitted and received using infrared energy. The natural sources of infrared radiation include the sun and the human body. Any bright source of light is a possible emitter of this radiation. Although radio and ultrasound waves have frequent applications in wireless communication, Infrared technology is highlighted because of its increasing presence in mainstream applications, and its advantages over other forms of wireless communication.

2.1 Infrared Link

Infrared link designs may be classified according to two criteria. The first is the degree of directionality of the transmitter and receiver. Directed links employ directional transmitters and receivers, which must be aimed in order to establish a link, while non-directed links employ wide-angle transmitters and receivers. Directed links focus on power efficiency while non-directed links are more convenient in terms of usage. It is efficient to combine these two links which results in a hybrid link.

The second classification depends upon the existence of an uninterrupted line of sight(LOS) path between the transmitter and receiver. LOS links rely upon such a path, while non-LOS links generally depend on reflection of the light from a reflecting surface. LOS link design maximizes power efficiency and minimizes multipath distortion. Non-LOS links provide efficient transmission in the presence of common barriers between the transmitter and receiver. A combination of non-directed and non-LOS link design can be employed to achieve robustness and efficient usage. Such a link is known as a diffuse link.

2.2 Modulation and Demodulation

The presence of other sources of infrared radiation such as natural sun light and fluorescent light, cause variations unrelated to the transmitted signal resulting in noise at the receiving end. It is necessary to modulate the signal of concern at a particular frequency to avoid interference and to make it stand above noise. With modulation, the IR light is made to blink at a particular frequency. Most communication systems are based on phase, amplitude, or frequency modulation. Another efficient technique is intensity modulation where the transmitted signal's intensity is modulated. Instead of using a demodulator at the receiving end, one can use direct detection using a photo sensor. The photo sensor current is proportional to the intensity of the received signal which is the modulating signal in the case of intensity modulation. Therefore, in order to provide efficient modulation and demodulation, most communication systems use intensity modulation with direct detection (IM/DD).The photo current is written as,

$$Y(t) = X(t) * Rh(t) + N(t)$$

Where, R is the responsivity of the receiving photodiode (A/W). The electrical impulse response c(t) is R times the optical impulse response h(t).

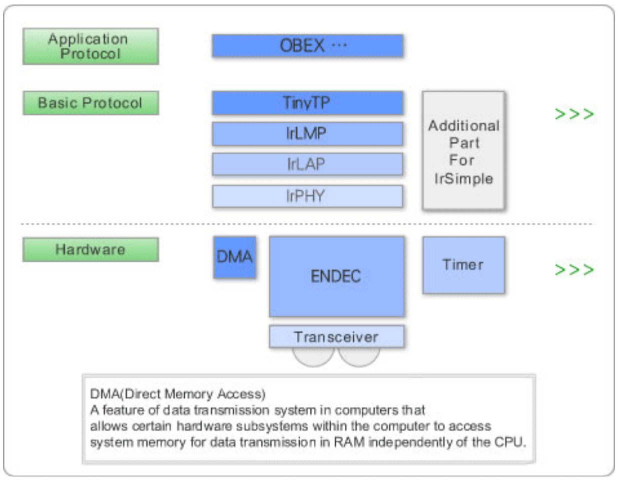
2.3 Transmitter and Receiver

The transmitter converts an electrical signal to an optical signal. The two most common types of transmitters are the light-emitting diode (LED) and semiconductor laser diode (LD). LEDs have a wide transmission range and are suited to non-directed links. In terms of safety it is efficient to use an LED than a laser diode, which has a narrow range of transmission. Laser diodes are advantageous in terms of high energy-conversion, high modulation bandwidth, and narrow spectral width. Although laser diodes over several advantages over LED, most infrared communication systems use LED due to the efficiency offered in the field of short-range communication.

A receiver does the opposite by converting an optical signal into electrical current by analyzing the photon incident on the surface of the detector. Silicon p-i-n photodiodes are ideal for wireless infrared communications as they have good quantum efficiency in this band and are inexpensive. Avalanche photodiodes are not used here since the source of noise is shot noise induced by light rather than thermal circuit noise.

3. IrDA Protocols

The Infrared Data Association, an organization of about one hundred member companies, has standardized low-cost optical data links. The IrDA link transceivers or ports, appear on many portable devices including notebook computers, personal digital assistants, and also computer peripherals such as printers. IrDA provides specifications for a complete set of protocols for wireless infrared communications. Main characteristics of this kind of wireless communication is secure data transfer, Line-of-Sight (LOS) and very low bit error rate (BER) that makes it very efficient.



Similar to the OSI or TCP/IP hierarchy, the IrDA has set certain standards or protocols to avail wireless communication using infrared signals. We refer to this protocol model in this paper for the transmission of images. The hierarchy retains the basic structure of the OSI model with the application layer at the top followed by the basic protocols involved and the hardware layer in the end. In order to provide efficient transmission in terms of speed the IrDA has invoked another set of protocols called IrSimple which avails high speed communication using this technology. An insight into the basic functioning of the above mentioned protocols is presented in the following paragraph.

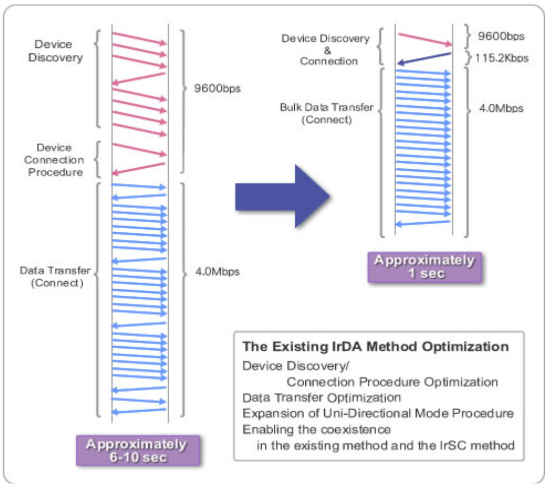
3.1 Hardware

1. **Direct Memory Access (DMA):** DMA is included in the hardware layer to enable the transmission of data directly between the device of concern and the main memory without continuous intervention by the processor.
2. **ENDEC:** It is a device in the hardware layer which acts as both an encoder and decoder of the input stream of data being transmitted.
3. **Timer:** The hardware layer also includes a basic timer device to measure time intervals upon transmission.
4. **Transceiver:** Converts electrical signals into optical signals, and vice versa.

3.2 Basic Protocols

1. IrPHY: **Infrared Physical Layer Specification** is the most essential physical layer of the IrDA specifications. It specifies modulation and coding techniques. It includes the link design definitions and also the Cyclic Redundancy Check.
2. IrLAP: **Infrared Link Access Protocol** is the second physical layer of the IrDA specifications above the IrPHY. It is similar in functioning to the Data Link Layer of the OSI model. The specifications mentioned in this layer include
   i. Access control
   ii. Discovery of potential communication partners
   iii. Establishing of a reliable bidirectional connection
   iv. Distribution of the Primary/Secondary device roles
3. IrLMP: **Infrared Link Management Protocol** is the third physical layer of the IrDA specifications which precedes the IrLAP layer and its functions include the provision of multiple channels and allowing service providers to register their services in order for the device in concern to avail these services.
4. Tiny TP: **Tiny Transport Protocol** is the final optional layer which lies on top of the IrLMP layer. It deals with the transportation of large messages and flow control management.
5. IrSimple: **IrSimple** (IrSC) is a high-speed infrared wireless communication system that does not make radical changes in the present IrDA system to emphasize the compatibility. It expands the system to maximize and optimize the potential of the existing hardware, which can improve the communication speed. The features of this system include the following:

i. Optimizes procedures for device detection, connection and disconnection.
ii. Optimizes data transfer.
iii. Expands unidirectional procedures.
iv. Allows coexistence of the conventional IrDA communication and the IrSimple high-speed communication



3.3 Application Protocol

1. OBEX: The **Object Exchange** protocol is the final protocol layer which provides the exchange of data and applications between infrared devices. It lies on top of the Tiny TP protocol.

The above mentioned protocols are the basic requirement for communication using infrared. A special protocol for the transfer of images incorporated by the IrDA has been included in this paper.

IrTran-P is used mainly to transfer images. It stands for Infrared Transfer Picture Protocol. Initially this protocol was used for transferring images from digital cameras to the web. This technology can be incorporated into mobile devices in order to serve the purpose of this paper. IrTranP uses the basic IrCOMM layer to open a reliable channel and provide a communication portal.

The above mentioned advancement in the IrDA protocol using IrSimple communication system can be implemented in the proposed technology of image transmission from mobile devices to television sets. This is to overcome the speed and size constraints that are encountered. What follows is a detailed review of image processing to meet the requirements for its transfer using infrared wireless technology.

4. Infrared in Image Transmission

Image transmission from mobile devices to television sets can be achieved by using Wi-Fi and Bluetooth technologies as well but the aim of this paper is to achieve the same using the existing software of infrared technology in television sets. A proposal is presented on the possible strategies to achieve this mode of communication and to enhance the rate of transmission. Our main focus is to view an image on a television set from a remote place using a portable device such as a mobile phone. We adhere to this method of transmission because of its flexibility, existing hardware and security.

4.1 Hardware Design Of The System

In this system, we try to implement an application that allows a user to remotely transfer and view images and multimedia in a television set using a cellular phone. This system will be a powerful and flexible tool that offers these services at any time, from a remote distance with the constraints of the technologies being applied. The proposed design is to implement this mode of transmission over an Android platform in a cell phone at thetransmitting end that gives instructions and commands to control the Infrared compatible devices.

The steps involved in the control unit of the mobile device which is concerned with the process of sending data to a television are enlisted below:

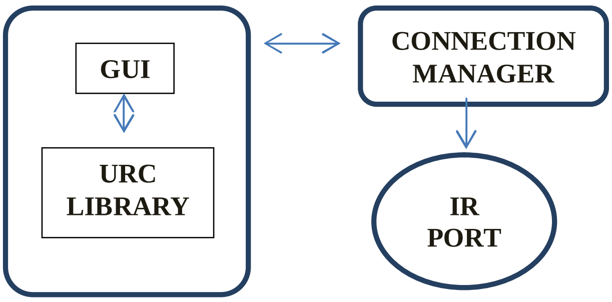
i. The user retrieves the specific command for a selected television set using Wi-Fi or GPRS.
ii. The mobile phone sends the commands for image transmission from Universal Remote Control (URC) library to the IR port.

iii. Connection manager that is inside the control unit issues commands to the concerned appliance.
iv. Connection manager checks for completion status and sends it back to the control unit.
v. The IR port transmits the commands in the specified format as explained in the following section.

4.2 Transmitting Section

The transmitter section consists of a mobile phone which will provide the following functionality:

i. It will allow the user to connect to the internet using Wi-Fi or GPRS.
ii. It will provide an option to connect with a specified television based on the specifications obtained.
iii. As soon as an image to be transferred is selected, a particular command will be converted into suitable format and will be sent to the receiver.



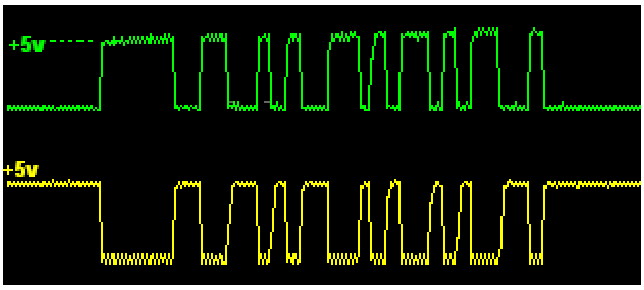
The mobile phone consists of a GUI (Graphical User Interface) and a Connection Manager. The GUI will convert an image into a suitable command format and will provide these command formats to the connection manager. The Connection manager will check whether the connection with the receiver is already established or not, if it is already established with a specified receiver it will directly send the commands to receiver otherwise it will initiate a connection with a specified receiver and once connection is established send the commands to the receiver. The platform for this application is Android and programming language is JAVA.

4.3 Receiving Section

The main components in the Infrared IR Receiver circuit include the phototransistor, which is a device that is used to capture the transmitted signal, and pass it along to the PIC 18F452, which is the microcontroller used in this project. The specific functionality that it offers us is the CCP module, capture and compare. This module can detect rising and falling edges on signals. An amplifier is used to invert the received IR signal and to amplify the signal so that it stays at either +5v or +0v depending on the current data of concern being sent from the transmitter.

The two wave forms show what the output looks like varying from +0v to +5v. The small ripples throughout the waveform are the 38 KHz carrier frequency.

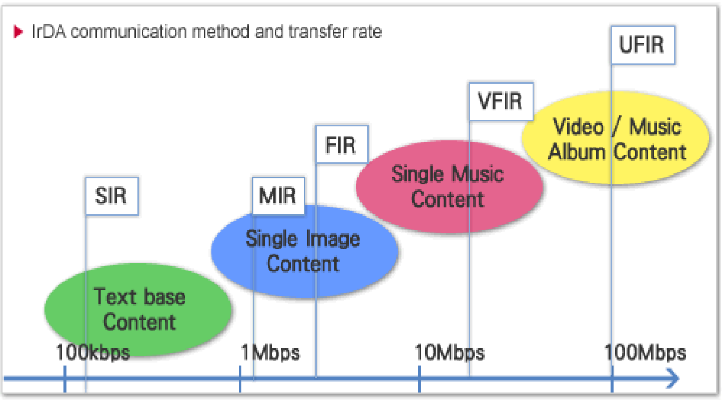
The way the IR communication works is, the mobile phone sends the message by blinking its IR LED for brief periods of time. The data is communicated by theamount of time each strobe lasts.In order to interpret the data, the lengths of the pulses sent from the mobile mustbe measured. The IR detectors output pin is naturally high, and when it detects an IR



Source it will go low. Each received signal is decoded by the microcontroller and since every pixel has its unique value attached, the receiver will be able to generate the image that is transmitted, which is displayed on the screen.

4.4 Software Design of the System

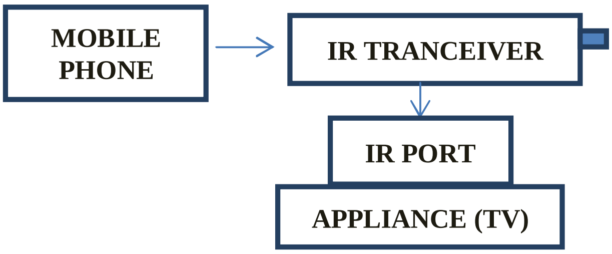
The IrDA infrared communication system has various communication speeds depending on the communication system which defines the IrDA physical layer.



The Infrared Data Association (IrDA) has developed four transfer rate standards for short range infrared data transmissions:

1. SIR (Serial Infrared) - 115.2Kbps, which is adopted in mobile phones and many portable devices.
2. MIR (Medium Infrared) - 1.152Mbps, which is rarely adopted.

3. FIR (Fast Infrared) - 4Mbps, which is adopted in laptops, digital cameras and mobile phones.
4. VFIR (Very Fast Infrared) - 16Mbps, which is supported by Windows.
5. UFIR (Ultra-Fast Infrared) – 100 Mbps, which is used for transfer of multimedia content



4.5 IrTran-P STANDARD

IrTran-P is placed on the upper layer of IrSIR, IrLAP, IrLMP, TinyTP and IrCOMM which is already established as IrDA standard specifications. SCEP (Simple Command Execute Protocol) and a bFTP

(Binary File Transfer Protocol) are necessary for exchanging an image between devices and mutually exchanging properties of the devices. An image format called UPF (Uni Picture Format) is exchanged on such an entity.

In IrTran-P, an operation which transfers picture data from a mobile phone is started by a sender.

1. **Operation by User :**

A user transmits the image with the use of "selection of a specific picture" and a "transmission button".

It is supposed that the device of a receiver is always in a receiving state.

2. **Establishment of Session by SCEP :**

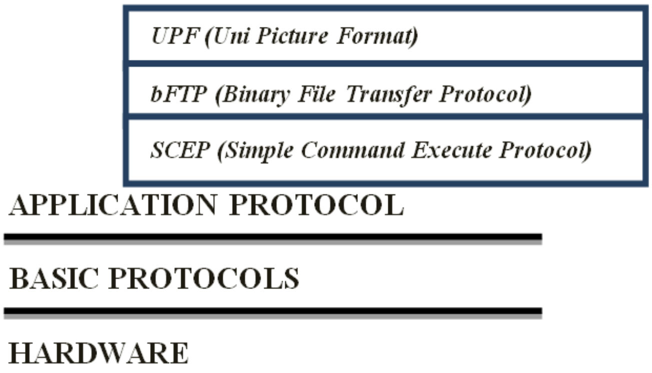
The mobile phone carries out a procedure by IrDA protocols and performs a connection for physical to IrCOMM layers of IrDA protocols. When a communication is established, SCEP makes a "session establishment request"from the sender towards the receiver.

3. **Query Operation by bFTP (Query function):**

When a session by SCEP is established, the mobile phone issues a Query request inorder to recognize picture processing functions of the receiver. The information mutuallyexchanged by the Query request includes the transmittable/receivable picture size, the picturecompression format and the basic picture size of the device. In IrTran-P, a mandatory format is defined among the picture data formats of both sides, wherebya picture can be reliably exchanged between device of different grades or manufactures.

4. Transfer of Picture Data by bFTP :

Transfer of picture data is started since the most appropriate picture format for both of the senderand the receiver is determined by Query. SCEP performs the data transfer at a high transmissionrate by making use of IrDA protocols.



5. Recent development in Infrared technology

Although radio-based Wi-Fi and Bluetooth technologies offer more versatility, Fraunhofer researchers dealing with infrared technology are working on the development of a "multi-gigabit communication module" that can wirelessly transfer data 46 times faster than Wi-Fi and 1,430 times faster than Bluetooth.

The new infrared module developed by Frank Deicke, a researcher at the Fraunhofer Institute, has a data transfer rate of 1 gigabit per second (Gbps), making it not only significantly faster than conventional Wi-Fi and Bluetooth wireless technologies, but also six times faster than a wired USB 2.0 connection. The small infrared module developed by Deicke specifically for the wireless transfer of large amounts of video between devices consists of hardware and software components. The hardware includes a transceiver about the size of a child's fingernail that contains a laser diode to send infrared light pulses and a photo detector to receive them. This optical component is able to send and receive light signals simultaneously.Because the light signals become weakened and distorted when traveling through the air, the researchers programmed error-correction mechanisms into the module, along with high-speed signal processing to overcome the bottleneck in the encoding of the data before transmission and subsequent decoding at the receiving device. As an optical technology, the module still requires a clear line of sight between the communicating devices, but Deicke says this isn't a problem as it was designed for transferring data between two nearby devices, such as a camera or smartphone and a PC or laptop. Having already achieved data transfer rates of 3 Gbps with his current model, he hopes that 10 Gbps speeds are not too far away.

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