IrMC: Infrared Solutions for Mobile Communications

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Abstract

Infrared data transfer using IrDA (Infrared Data Association) protocols is becoming increasingly important for mobile communications devices such as pagers and cellular phones. This paper addresses the new IrMC (IrDA Mobile Communication) standards from IrDA, including IrOBEX for object exchange (including vCards, vCalendars, etc.), IrCOMM for infrared modem functionality, Ultra for connectionless data exchange, and RTCON for real-time voice over infrared.

1.0 Introduction

IrMC (IrDA Mobile Communications) is a set of four protocols proposed by the Mobile Communications Working Group of the Infrared Data Association (IrDA). This group is fundamentally concerned with IrDA communication between telecom devices, such as pagers and cell phones and is primarily comprised of companies involved in the production of these devices. Leading companies include Motorola, Ericsson, Nokia, NTT DoCoMo and Hewlett-Packard.

The original IrMC specification was approved in October 1997, and included three broad classes of interactions between mobile communication devices.

1) **Atomic Information Exchange**. This refers to the exchange of discrete, self-contained chunks of information between two devices. For example, one device may need to give an electronic business card to another (vCard) or perhaps an appointment (vCalendar) or a note of any type. IrOBEX is the transfer protocol used for these kinds of information exchange. If a device is severely resource constrained, it may use an even lighter, connectionless mechanism for exchanging chunks of information. This protocol is referred to as Ultra, and is similar in many respects to IrOBEX. IrOBEX is described in Section 2.0. Ultra is described in Section 3.0

2) **Stream-Oriented Information Exchange**. This refers to the use of a telecom device as a medium for transmitting a potentially bi-directional stream of information

between two devices. For example, a cellular phone may establish an infrared communication link with a laptop, allowing the laptop to discover it as a new modem, install it, and then dial out on the cell phone. The cell phone would then act strictly as an intermediary, and provide a stream-oriented form of information exchange. The protocol used for this type is exchange is IrCOMM, which is described in Section 4.0.

3) **Real-time Information Exchange**. This refers to use models in which real-time constraints are severe. In telecom devices, the main usage for this type of information exchange is in transmitting voice over IR. The protocol used for this exchange is RTCON (Real-time Transfer CONtrol), which is described in Section 5.0.

At the time the IrMC specification was approved, it was understood that telecom devices (such as pagers and cell phones) would interact with non-telecom devices (such as PDAs and laptops). However, the characterization of various infrared interactions laid out in the IrMC document are now viewed as extremely valuable, independent of the involvement of a traditional telecom device. Hence, it is increasingly important for mobile devices of all types to support the IrMC specification. This is particularly true in the Atomic Information Exchange class of protocols.

2.0 IrOBEX

IrDA Object Exchange (IrOBEX) can be viewed as essentially “HTTP for IrDA”. IrOBEX was designed to resemble HTTP, and it leverages whatever it can from this internet protocol, adding capabilities that relate to the unique environment of IrDA. This protocol was first approved by IrDA in January 1997, and is the approved way of moving blobs of information over IrDA. Because of the increasingly common use of IrOBEX, interoperability between IrDA devices is improving rapidly.

IrOBEX is best used in situations where objects of some kind need to be moved from one device to another. For example, two devices exchange phone and address information, or calendar information as vCard and vCalendar objects. Or a handheld scanner captures a graphics image and beams it to a laptop to manipulate. Both of these are classic uses for IrOBEX.[1]

One of the strengths of IrOBEX is its notion of an IR Inbox. The inbox is used to receive objects from another device using IrOBEX. The receiving device can then determine what to do with the object based on its type or content. The inbox provides a generic way for devices to push an object to another device without any understanding of the receiving device or what it may do with the object.

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[1] Because of its universal applicability for object movement, IrOBEX is a required protocol for devices seeking IrReady interoperability certification, whenever such a device engages in atomic information exchange.

2.1 Levels of Support

IrMC defines four levels of support for exchange of vCards, vCalendars, and other electronic information. The levels of support graduate from simple push of an object to another device's inbox, to full synchronization capabilities. The IrMC specification defines these mechanisms for phone book, note, calendar and message databases.

2.1.1 Level 1 support

The first level involves the basic ability to put an object (such as a vCard) from one device to another. At this level, a device at least has the ability to push an object from one device to another, which is useful at a minimal level. The receiving device knows from the name of the object, which database to store it in. The Palm III is one of many devices that incorporate this type of exchange for various types of objects.

2.1.2 Level 2 Support

The second level requires the ability to read and write all entries in one device from the other device. For example, a device could obtain all of the vCards stored in another device's phone book. With this level of support, mobile device databases such as the phone book, message and calendar, can be backed-up and updated using a host device.

2.1.3 Level 3 Support

The third level requires the ability to index the objects on the target device, such that a hierarchy of objects can be formed. With this capability, a device may more efficiently update the database objects on the mobile device.

2.1.4 Level 4 Support

The fourth level requires that the two devices be fully able to synchronize their objects one with another. At this level of support, two devices support database modification logging and other features that provide tremendous power to synchronize the databases in very intelligent ways.

The strength of these mechanisms for exchanging information is that these schemes are common for all IrDA telecom devices, regardless of manufacturer. So, for example, two cell phones from different manufacturers may still exchange information in meaningful ways off the shelf. That brings a tremendous opportunity for interoperability.

3.0 Ultra

Some telecom devices are severely limited in their memory constraints. The Ultra protocol guidelines were originally approved October 1997. The motivation for Ultra was to create a mechanism for pushing objects using an IrOBEX Put, but without the overhead involved in establishing and maintaining a connection. Since its approach is connectionless, Ultra is only useful for atomic information exchange.

The Ultra protocol is written using the connectionless services of IrLAP (IrDA Link Access Protocol). Because it is connectionless, there are no retries or error correction involved. The user must be aware of the signs of success, because the software will not automatically recover in the event of a problem. The model is similar to a TV remote control. The user pushes the button, and if the channel doesn’t change, he pushes it again. A similar level of user intervention is required for Ultra to be successful. But for devices that are severely constrained in memory, and that are willing to settle for level 1 support only, Ultra provides an important capability.

4.0 IrCOMM

IrCOMM implements the Stream-Oriented Information Access of IrMC. IrCOMM is probably the oldest high-level IrDA protocol, having been approved in November 1995. It was designed to provide legacy support for applications that already run over COM ports. For example, assume we have a PDA (such as a Palm III) with a cradle that plugs into the serial port of a computer. The desktop software for this PDA already runs over this physical COM port to the PDA cradle. If you wanted to enable synchronization from your desktop to your PDA via IrDA, you could enable the PDA with IrCOMM, and then simply redirect my desktop’s COM port to the virtual port provided by IrDA. In this situation, you can now synchronize between your PDA and your desktop without introducing any changes to your desktop software. This is an example of a legacy application for IrCOMM.

The IrMC specification does not describe IrCOMM in any greater detail, and points the reader to the IrCOMM specification. This is because of the legacy nature of IrCOMM. If you have a laptop that already supports a dial-up modem, an IrCOMM connection from your laptop to your cell phone will not require any additional support on the laptop, beyond IrCOMM. IrCOMM will redirect the communication from the dial-up program to the IrDA port, instead of to the physical COM port.

IrCOMM supports the following modes: 9-Wire, 3-Wire, 3-Wire Raw (also sometimes referred to as IrLPT), and Centronix.

5.0 RTCON

RTCON (Real-time Transfer and Control) was first approved in October 1997, but has only recently become a significant issue for manufacturers of cell phones. RTCON is used to permit cell phones to universally connect with in-dash speaker phones in automobiles. Using RTCON, a cell phone can be placed in a cradle in a car, and an infrared link can be established between the speaker phone mechanism in the car and the cell phone. This permits driving and talking without holding a cell phone (which is illegal in some parts of the world—most notably Japan and parts of Europe). The call is made with the cell phone, but the voice data in the phone is transferred via infrared with the in-dash speaker phone. This permits users to use their normal cell phones without having to have a special cell number specifically for their car (with accompanying duplicated fees). Control capabilities allow the user to control the phone, including making phone calls, without handling the phone.

5.1 RTCON Hardware Requirements

One of the limiting factors for the spread of RTCON has been the availability of suitable, specialized hardware, designed to support its features. The following are specific hardware requirements that must be in place before considering implementing RTCON.

5.1.1 ADPCM Sound hardware

RTCON is designed to support multiple codec types. Currently, only ITU-T G.726 32 Kbps ADPCM is supported, creating sound packets every 20 ms with 80 bytes stuffed into each transmitted frame. RTCON must have good buffering for the incoming and outgoing sound bytes. The ADPCM hardware reads and writes sound bytes every 0.250 ms.

The CPU should not have to service the sound hardware at this rate. A sound FIFO or DMA setup that allows 80 incoming and outgoing bytes will allow much greater flexibility when designing and coding the ISRs that will be running while RTCON is transferring sound data.

It is also desirable to be able to ascertain the number of bytes that have been received into the incoming ADPCM packet or transmitted from the ADPCM outgoing packets. The DMA buffer or FIFO needs to be able to be completely filled and emptied when they are serviced by the RTCON sound ISR. The sound hardware should have a register or setting that defines the number of bytes in the sound packets when the CPU is interrupted.

5.1.2 0.5 ms Turnaround Period

The RTCON turnaround period begins at the moment the device receives the last byte of a frame and ends when the device is ready to send the first byte of its response. The turnaround period must be no more than 0.5 ms, which is a severe restraint for an IrDA protocol. It is necessary to ensure that the full duplex real-time sound data will be available to be played on the outgoing ADPCM speaker hardware. This time includes all time spent processing the frame and preparing the data to be transmitted. The RTCON turnaround period is different than the IrDA "minimum turnaround time" and should not be confused with it.

The total time spent in the RTCON turnaround period depends on many hardware and operating system specific details including: interrupt latency, task switching time, maximum interrupt length, CRC generation, CPU clock speed, and bus width (to name a few). The RTCON software has to be designed to maximize the performance of the software. The design of the infrared framer as well as the design of the RTCON sound ISR must also be optimized so that the turnaround period can be less than or equal to 0.5 ms. The RTCON turn around time occurs once every 20 ms because of the speed of the ADPCM hardware.

5.1.3 Good Buffering of data for Infrared framer

The IR controller hardware should also be designed so the CPU does not have to handle each incoming and outgoing byte. A DMA transfer of the complete IR packet is the ideal situation. A FIFO of 128 or 64 bytes also works for RTCON use.

5.1.4 Interrupt Latency

Both the sound and infrared hardware should not be designed with the assumption that interrupt latency will always be low. The hardware should be designed to allow reasonable delays of the CPU in servicing the sound and infrared interrupt service routine (ISR). This will prevent the loss of any infrared or sound data because the ISR was not serviced fast enough. For example, if the infrared framer loses a byte because its ISR was not serviced at a critical moment, the data being sent from the other device will have to be retransmitted, thus causing a gap in the sound data.

5.1.5 Operating System Requirements

RTCON requires its operating system environment to be pre-emptive and multi-tasking, with some kind of events and/or messages, because of its real-time critical nature. It would be very difficult to implement RTCON on an embedded device without using these kinds of operating system features.

6.0 Summary

The IrMC specification from IrDA has identified key areas of functionality for mobile devices, including cell phones and pagers, but also extending into general purpose computing devices, such as PDAs and laptops. It incorporates a set of four protocols, included to accommodate three key types of information exchange: Atomic, Stream-Oriented, and Real-Time. Many manufacturers of mobile communication devices are currently incorporating these protocols in their new devices, and we will soon see IrDA-enabled phones and pagers exchanging information easily in varied ways. That kind of interoperability is a significant part of the promise of IrDA, and mobile communication devices are a very significant part of making that promise a reality.