IrDA Implementation, Instant Solution and Certification

Dr. Keming W. Yeh (Yr2001, 2000 Chair, 2010 CoChair: IrDA Test/Inter-Op Committee),
Dr. Lichen Wang (Yr2001, 2000 Chair, 2010 CoChair: IrDA Technical Committee)

ACTiSYS Corp., 921 Corporate Way, Fremont, CA94539
Tel: +1-510-490-8024, Fax: +1-510-623-7268, E-mail: kyeh@actisys.com,
www.actisys.com

INTRODUCTION

In the past 6 years since the formation of Infrared Data Association (IrDA), the industry has gone through hype to bottom and now, reemerge as a strong, mature technology solving well defined mobile connectivity needs. It is not just wireless, but with complete specifications from Physical, Protocol To application layers. It has also established itself as the leading organization that can effectively and quickly develop useful application protocol specifications, which are licensed by Bluetooth, and 3GPP international standardization organizations. Recent example includes OBEX (Object Exchange: vCard, vCalendar, vNotes, vMessage, vBookmark) and is now developing wireless e-payment application standards, IrFM (Infra-red Financial Messaging system). In this short history, IrDA has also progressed through three generations; SIR-115.2Kbps, FIR-4Mbps, VFIR-16Mbps and an impressive installation base of more than 325M units of mobile devices cumulated by end 2000. It grows at more than 50% annual rate seeing it proliferated from notebook PC, PDA, digital camera, printer, industrial data terminal, portable instrumentation, to smart cellular phones and e-toys.

BACKGROUND

The IrDA stack has three mandatory protocol layers, Physical Layer (IrPHY), Infrared Link Access Protocol (IrLAP) and Infrared Link Management Protocol (IrLMP). On top of these, there are many optional layers. Tiny Transport (TinyTP) is one of them and is often needed to support other upper layers such as IrCOMM, IrLAN, IrTranP, Obex, and IrMC.

IrDA PHYSICAL LAYER

The Physical Layer consists of an IR transceiver, an encoder/decoder, a serializer/deserializer and a framer. The IR transceiver converts electrical signals to and from IR signals. The serializer/ deserializer converts the serial bits to and from bytes. The framer assembles and dissembles IrDA frames by adding or removing the frame wrapper to or from the payload and generates or checks the CRC error checking. IrDA compliant IR transceivers are available from many component manufacturers. They fall into two categories, the FIR or IrDA-1.1 transceivers, and the SIR or IrDA-1.0 transceivers. The former can handle data rates of up to 4 Mbps, while the latter can only handle data rates of 115.2 Kbps or below. There is also the MIR at 1.152 Mbps. There are various mode switching schemes of SIR-MIR-FIR among FIR transceiver modules. This causes many problems and will soon be standardized at 16 Mbps.

For data rates of 115.2 Kbps or blow of IrDA1.0, encoder/decoders are available from many component manufacturers. Most of these encoder/decoders are designed to interface directly to traditional UART that performs the serialization/deserialization functions. In most cases, the framer function is usually handled by software.

For the higher data rates of IrDA-1.1, the encoder/decoder, the serializer/deserializer, and the framer are often integrated into the same digital chip. Most of these chips need DMA support in the system.

When the framer function is handled by software, it must satisfy the latency requirement of the

UART. To handle the framer receive function, it can be quite demanding on the CPU. A FIFO in the UART receiver can alleviate the problem at peak demand, but it does not help the average demand.

Note that all IrDA stacks must support 9.6 Kbps data rate. All other rates are optional.

IrDA PROTOCOL SOFTWARE LAYERS

IrLAP, IrLMP as well as optional upper protocol layers are almost always implemented in software They can be integrated into a monolithic unit for the sake of code size and execution efficiency. Or they can be modular and clearly separated from each other for the sake of clarity, portability and ease of maintenance.

Simple I/O devices need CPU services only when called by application programs or when external events interrupt. But in addition to those, IrDA software layers need CPU services to perform error recovery, to maintain the integrity of the IR link, and to enforce or comply with the media access rules.

Most IrDA software layers are defined in terms of multiple concurrent events driven finite state machines. The events that drive these state machines include application program requests, framer input/output interrupts, timer expirations, as well as actions of other state machines. Consequently, a multi-task or multi-thread environment is most convenient for implementing these software layers. In the absence of such an environment, a programmable hardware timer with a fairly low interrupt priority can be used to thread the state machines.

The reason that this interrupt priority to be low is to avoid generating latency problems for other hardware interrupt service routines which may be time critical.

From the protocol point of view, IrLAP, IrLMP and most upper layers are not very time critical. Latency of up to tens of milliseconds can be tolerated and still compliant with IrDA standards. However, effective data rate will suffer, especially at high raw data rate. At 115.2 Kbps, it takes 177 milliseconds to transmit a 2 KB frame. A 10 milliseconds delay will degrade the effective data rate by 6 percent. At 4 Mbps, it takes 4 milliseconds to transmit a 2 KB frame. The same 10 milliseconds delay will degrade the effective data rate by 250 percent.

IrDA STACKS AND APPLICATIONS

As stated in the previous section, many optional features in the IrDA stack are mandated by the application intended. Here is a few real life examples.

Digital Camera

IrTran-P is the standard upper layer for digital camera. IrTran-P in turn requires IrCOMM, and TinyTP to be included. At IrLMP layer, multiplex mode is not needed. At IrLAP layer, Primary capability is needed due to the desire to be able to transfer digital pictures to peers and printers. The optional high speed data rate is desirable.

Medical Monitoring Device

Small amounts of data/program need to be up/down-loaded to/from PC's. IrCOMM 3 wire raw is sufficient. Thus TinyTP and IrLMP multiplex mode are not needed. At IrLAP layer, Secondary capability is sufficient.

Industrial Portable Data Terminal

Just like the medical device, small amounts of data/program need up/down-loaded to/from PC's. IrCOMM 3 wire raw is sufficient. Thus TinyTP and IrLMP multiplex mode are not needed. At IrLAP layer, Secondary capability is sufficient.

In some cases, the modem status and control lines need to be supported. Instead of IrCOMM 3 wire raw, the 9 wire cooked feature needs to be used. In this case, TinyTP is required too. IrLMP multiplex mode is not needed.

Printers

IrLPT is the de facto standard for printers. TinyTP and IrLMP multiplex mode are not needed. At IrLAP layer, IrCOMM 3 wire raw can be used to substitute IrLPT. Alternatively, IrCOMM 3 wire or 9 wire cooked, or parallel port can also be used. In the latter case, TinyTP is required but IrLMP multiplex mode is still not needed.

If the printer is intended to print pictures from digital cameras, IrTran-P, IrCOMM, and TinyTP are required. IrLMP multiplex mode and Primary capability are still not required.

General IrDA-to-RS232 Docking Station

IrCOMM 9 wire is sufficient. TinyTP is required but IrLMP multiplex mode is not. At IrLAP layer, Secondary capability is sufficient.

Cell Phone or Smart Phone

IrMC is the standard upper layer for this kind of devices. Obex is included as part of IrMC. TinyTP is required but IrLMP multiplex mode is not. At IrLAP layer, Secondary capability is sufficient unless printing capability is also wanted.

Pager

A subset of IrMC (including Obex) is sufficient. TinyTP is required but IrLMP multiplex mode is not. At IrLAP layer, Secondary capability is sufficient unless printing capability is needed.

IR Modem

IrCOMM 9 wire is sufficient. TinyTP is required but IrLMP multiplex mode is not. At IrLAP layer, Secondary capability is sufficient.

PDA

There are three major operating systems; Palm OS from Palm Computing Inc., EPOC from Symbian (Psion) and Windows CE from Microsoft. All have built in IrDA protocol stack and matching host PC link software using IrDA stack in Windows O.S. IrObex is often included and used heavily.

Legacy Instrumentation and Meter

IrCOMM 3 wire raw is sufficient. Thus TinyTP and IrLMP multiplex mode are not needed. At IrLAP layer, Secondary capability is sufficient.

INSTANT IrDA SOLUTION

For many devices, mobile and of handheld size or stationary and larger host systems, it is very desirable to have self-content IrDA external adapter or internal PCB that can be attached to these target devices and instantly turns it into IrDA enabled, and better yet, IrReady certified.

An example of such IrDA intelligent adapter would contain IrDA transceiver, digital encoding/decoding chip and micro-controller with on-chip full IrDA protocol stack, housed in a small package. Useful features of such self-content IrDA module should include:

1) “IrReady” certified, or even “IrDA Reference Product” certified.

2) Has full IrDA protocol stack, primary and secondary that can be hardware jumper selectable or software programmable.

3) Has selectable flow control option.

4) Has selectable UART data speed.

5) Has selectable data length, parity and control line extension modem parameters.

6) Has selectable power source option; AC power, DC power at 5V/12V/up to 30V,

7) Has selectable optical window orientation to facilitate easy installation as internal PCB against the front panel of the host system.

An example of exactly such product is the ACTiSYS Intelligent RS232 adapter, ACT-IR100S. It has been successfully utilized in a wide variety of embedded, non-Windows O.S.

systems and enabled many very useful and productive wireless data exchange applications. Detail information may be obtained from website (www.actisys.com/product showcase).

“IrReady”Certification Program - Background

IrDA set up Test Council (IrDA-TC) in 1997 to assure useful IrDA inter-operability and good out-of-box user experience.

Five IrDA Certification Test Labs have been authorized by IrDA-TC in July 1998 to develop test procedures and to test Reference Products and DUT's. Each Test Lab may claim to be capable of Inter-Op Test only or both Inter-Op and IrDA Compliance Tests. The latter capability is required to qualify the Reference Product for each device category.

Test Lab. will test and recommend "Golden Reference Product" for each device category that meets IrDA Physical (BER, emission intensity, detection sensitivity, rise-fall-jitter-latency time and pulse width), and Protocol Spec. as well as pass the Inter-Op test. IrDA-TC will review the test report submitted by the Test Lab. If passed, it will recommend to the IrDA full Board of Directors which will review and if approve, inform the IrDA office. The IrDA office will issue "IrDA Reference Product" certification documents and list the product on the IrDA web site.

To receive “IrReady” certification, a DUT must pass the IrPHY (BER, Intensity, Sensitivity, Timing), IrProtocol and Application Profile (Point-and-Shoot, IrWW, IrMC, etc.) tests at somewhat relaxed criteria.

“IrREADY” CERTIFICATION: BER (Bit Error Rate) AND TEST FRAME

Most of the hardware components such as the IR transceiver, the encoder/decoder or the integrated IrDA I/O chip are often tested by the component manufacturer to be IrDA compliant. Each software layer of course can also be individually tested to be IrDA compliant. However, when all these IrDA compliant components are put together, unexpected result may happen.

Once the engineering phase is done and manufacturing phase starts, there are many possibilities at the assembly line too. Also, after the manuf. phase is done and the products are shipped, there remains the field service issue of screening test in the field or at service centers.

Methods for system testing must be planned and designed into the IrDA implementation, not an afterthought. A good system test methodology is essential to facilitate both engineering, the production and field service.

Most of engineering mishaps usually are "in the area between the Physical Layer and IrLAP". Production mishaps usually are "confined to Physical Layer only". Consequently, a very simple and effective system test is to access the optional test frame feature of IrLAP, particularly the test frame feature within a connection.

The test frame feature is very simple to implement in the device under test. This can usually be accomplished by "adding only 6 lines of C codes! (attached here)". If implemented, a specially programmed tester tool can fully exercise the Physical Layer and IrLAP layer in the device under test (DUT) automatically. This test can range from very thorough for engineering study or QC diagnosis to very speedy for production, quality control or field screening. Both fashions are especially useful for Inter-op test among different IrDA device classes.

Anybody who can implement IrDA stack can write it in 10 seconds! For such little effort and no overhead, one can enable such effective and convenient testing in the phases following the engineering implementation. We therefore, recommend that the Test Frame in the IrLAP layer to be mandatory.

Test Frame Source Code

The source codes to effect such efficient Test Frame implementation is listed as follows:

When the station is playing the secondary role in Normal Response Mode (NRM) and an incoming frame is received, one normally checks the following:

a) the CRC is correct b) the C/R bit is set c) the connection address is intended for this station

If the incoming frame passes all these, one then examines the Control field and takes the appropriate action accordingly. This can be implemented as a chain of "if (...) {...}", "else if (...) {...}", ..., "else {...}".

To implement the test frame option, one needs to add the following code to that chain:

```
  else if (frame_buffer[1] == 0xF3)
 /* test frame + P bit received */
  { frame_buffer[0] &= 0xFE
 /* clear the C/R bit */


 transmit(frame_buffer, incoming_size); /*
 bounce it back with C/R bit cleared */ }
```

The procedure "transmit(...)" calculates the CRC and sends the frame out. The very first bit in the frame buffer (i.e., the C/R bit) is changed, thus the outgoing CRC will be totally different from that of the incoming frame.

The Test Frame is now a mandatory feature in both IrLAP 1.0 and IrLAP 1.1. For example the IrLAP 1.1 State Chart for Secondary Role State Machine, NRM(S) in Section 6.12.4.1, under: Current State = RECV Event = Recv u:test:cmd:P

There are two alternative Actions. Alternative 1 is: Wait-Minimum-Turnaround-Delay send u:test:rsp:F Start-WD-timer

And alternative 2 is:
Wait-Minimum-Turnaround-Delay
Send s:rr:rsp:Vr:F Start-WD-timer

After either alternative Actions are taken, Next State = RECV

We suggest to use alternative 1 instead of alternative 2. That is, respond with u:test:rsp:F, and not s:rr:rsp:Vr:F.

EXAMPLE OF IrREADY TEST REPORT

IrReady BER Test Report for: A FIR-Enabled Device

A) Subject: To test IrDA BER (Bit Error Rate) of DUT (FIR-Enabled Device)

B) Principle: Use the calibrated IrDA Reference Testers and IrLAP-Test Frame to test the DUT.

C) Test Setup:

1. **REF Station:**

Test Hardware: a) Desktop PC with ACT-IR2000B/L Tester. b) Desktop PC's mainboard super I/O Chip = Winbond 83977TF

Test Software: ACT-IR2000B/L Test software: ACT IR9003SW running under DOS on desktop PC.

2. **DUT Station:**

Test Hardware: a) DUT (FIR-Enabled Device) connected to a desktop PC.

Test Software: IR monitor running under Win 98SE with FIR-Enabled Device drivers-version 1.22

3. **Test Distance:**

a) Minimum distance = 0 cm (Near Field Source test). b) Maximum distance = 100cm (Far Field Source test, FIR/MIR).

c) Maximum distance = 158cm (Far Field Source test, SIR).

4. Test Angle: 0°, Left 15°, Right 15°, Up15°, Down15° at each distance point.

5. AC Power source: AVR (Automatic Voltage Regulator) 1KVA UPS (PHOENIXTEC A-500)

D) Test Method Description:

1. Use ACT-IR2000B/L Tester:

a) IR2000B/L connected to desktop PC and IR9003SW test software running under DOS on desktop PC.

b) NFS (Near Field Source) test: Use the reference IR2000L dongle with Irradiance = 500mW/sr at 0cm to test 4M ~ 9.6K bps.

c) FFS (Far Field Source, FIR/MIR) test: Use the reference IR2000L dongle with Irradiance = 100mW/sr at 100cm (=10uW/cm²) to test 4M & 1.152M bps.

d) FFS (Far Field Source, SIR) test: Use the reference IR2000L dongle with Irradiance = 100mW/sr at 158cm (= 4uW/cm²) to test 115.2K & below.

1. Test File 1 (FIR test) = (256 Bytes/frame x 20 frames x 8 Bits x 4 Test patterns) x 611 Test cycles = 100M bits (10^8 bits).
2. Test File 2 (SIR test) = (256 Bytes/frame x 4 frames x 8 Bits x 1 Test patterns) x 1221 Test cycles =10M bits (10^7 bits).

E) Other Reference Documents:

1. User's manual: ACTiSYS FIR/MIR/SIR tester, ACT-IR2000B/L.
2. User's manual: ACTiSYS FIR/MIR/ SIR test software, IR9003SW.
3. User's manual: ACTiSYS IR3000M/SW.
4. IrDA document: Test and Inter-Op Guideline.

F) Discussion:

1. NFS Test: Testing Max. Saturation Tolerance:

a) IrDA Physical spec. for testing max. saturation tolerance capability at maximum signal strength of 500mW/cm² or 500,000uW/cm²:

b) We tested 500mW/sr (NFS for min. distance) at 0cm the 4M bps failed and unstable, so we set min. distance at 1cm and no error. This means DUT can tolerate max signal strength without error at smaller signal strength of 500mW/cm²/(1cm/1cm)²= 500mW/cm².

2. FFS Test: Testing Max. Detection Sensitivity:

a) IrDA-FIR/MIR Physical spec. for testing max. detection capability at minimum signal strength of 10uW/cm^2: A REF. Tester of fixed light intensity of 100mW/Sr will generate such min. signal at distance of SqRoot(100mW/(10uW/cm^2))= 100cm.

b) We tested 100mW/sr (FFS for max. distance) at 120cm, 110cm, 100cm, 90cm, 80cm, 70cm, 60cm and 50cm but 4M bps failed and unstable over 80cm, so we set max. distance at 75cm and no error. This means DUT isn't passed IrPHY test and can only detect without error at equivalent larger signal strength of 17.78uW/cm². X = 100mW/(75cm)^2 = 17.78uW/cm^2.

c) This may be caused by the Pin diode sensitivity alignment or transceiver IC detection circuitry of the transceiver module, or the USB controller IC or its device driver software-timing problem.

d) IrDA-SIR Physical spec. for testing max. detection capability at minimum signal strength of 4uW/cm²: A REF. Tester of fixed light intensity of 100mW/Sr will generate such min. signal at distance of SqRoot(100mW/(4uW/cm²))= 158cm. It is seen that DUT showed no error at such distance and min. signal strength and pass SIR BER spec.

CONCLUSION

The IrDA implementation of the published Standards have progressed from the stabilization of device driver and better price of FIR hardware components in 1997, to the easier implementation and ready availability of SIR/FIR protocol stacks in 1997/1998, to the issues of inter-operability, testability and field service testing tools being addressed in 1998/1999. New implementation of IrDA devices will benefit from the experience and methodology and testing procedures established during the past several years.

In the past 18 months, IrDA has also gone from being the mainstream wireless connectivity technology to being challenged by Bluetooth and the bad publicity of not easy to use. Some notebook models even removed the IrDA port for lack of users. It is more apparent now that IrDA on notebook or desktop PC has the following problem; difficulty to set up, not easy to use, very slow transfer rate than listed, not inter-operable among IrDA devices.

Now, IrDA is in the process of major transformation and has re-emerged as a mature and value-loaded solution technology. It maintains the following advantage over other wireless technologies:

1) The smallest, cheapest, fastest, most power efficient wireless connectivity solution.
2) No concern or extra cost with security, radiation interference, health issues.
3) Recognized by international standards bodies: JEIDA, 3GPP, IEEE, etc.
4) Mobile handheld devices will keep IrDA.
5) New IrDA growth found in new device categories: cellphone, e-toys (e.g. Sony pocket station), public phone (e.g. 400,000 units in 5 years by NTT in Japan), medical device (e.g. pocket EKG) and consumer devices (e-wallet). People really use it.
6) New IrDA application standards-IrObex, IrMC, IrWW (smart wrist watch), IrFM are being actively developed and promoted. Some were licensed by Bluetooth and 3GPP
7) Windows 2000 has significant IrDA enhancement; Plug and play, intuitional, fast, built-in IrDA application-layer.
8) Already implemented in Windows 95/98/2000/ME/CE, Linux, Mac OS.
9) Major inter-operability, “IrReady” certification program in full force.
10) Effective enabling tool set (like ACTiSYS IR100S, intelligent RS232 adapter or PCB) is ready to enable many types of devices to instantly benefit from IrDA wireless data transfer with Palm, WindowsCE-pocket PC, smart cellphone, and other mobile devices.