FUTURE CHALLENGES OF IRSIMPLE PROTOCOL: EFFICIENT FLOW CONTROL SCHEME AND LONG DISTANCE CAPABILITY

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ABSTRACT

IrSimple protocol, recently proposed by the Infrared Data Association (IrDA), promises a simple Infrared protocol for fast, wireless communication between mobile devices and digital home appliances. The existing flow control scheme adopted by IrSimple protocol consumes a considerable amount of energy and resources by retransmitting large sized Information frame in case the receiving secondary station remains busy due to handling other tasks and therefore can not send the acknowledgement of received frames. In our previous work, we proposed an efficient flow control scheme which effectively reduces the redundant data retransmissions by using Receiver Ready (RR) supervisory frames and assumed all the frames are received error free during flow control procedure. In this paper, we examine in detail all possible cases where Information frames or Supervisory frames may be lost at different stages of flow control to investigate the effectiveness of our proposed flow control scheme. Furthermore, we investigate the long distance capability of current IrDA links which is another future challenge to enhance IrSimple protocol applications.

Keywords—IrDA, IrSimple, Efficient Flow Control, Long distance capability

1. INTRODUCTION

The technological advancements in telecommunication is forcing a trend towards unification of network & services, setting up a stage for the emergence of Next Generation Network-NGN. NGN is essentially an IP based network that enables any category of customers to receive wide range of services such as voice, data and video over the same network. The service layer in NGN is independent of underlying network and access is enabled across a wide range of broadband technologies, both wireless such as 3G, Wi-Fi, WiMax and wire line such as Copper DSL, cable, fiber etc. [1] It also focuses on seamlessly integrating the existing wireless technologies including GSM, Wirelss LAN and Bluetooth. IrDA is another emerging short range communications technology which can provide different NGN services from server on backbone network to handheld devices through NW Equipment, an Infrared (Ir) Equipment to relay the contents between Ir connection and other networks.

IrDA has recently adopted IrSimple, a high-speed infrared communications protocol, to provide simple and fast wireless communications between mobile devices and digital home appliances [2]. IrSimple enables mobile devices like camera phones to instantly connect and transmit digital images to similarly enabled televisions, monitors, projectors and photo kiosks. Using IrSimple, users can quickly and very easily ("point and shoot") transmit images from a cell phone, PDA or digital still camera to a color photo printer or a big screen (television) for immediate viewing (Fig. 1). Users can also enjoy fast data transmission between two mobile devices. Furthermore, IrSimple allows business travelers to make slide presentations directly from their PDAs or smart phones to infrared-equipped projectors; eliminating the need for notebook PCs and associated cables.

In the existing IrSimple protocol, the link flow control is managed by Infrared Sequence Management Protocol (IrSMP) [3] layer (higher layer) instead of Infrared Link Access (IrLAP) [4] layer (link layer). However, it wastes a considerable amount of energy and resources by retransmitting large sized Information frame in case IrSMP of secondary station is busy and therefore can not receive the last data. It sends the Unnumbered Information (UI) frame requesting the last data again as there is no data from the upper layer of the secondary station. Receiving the request, primary station resends the last data of the block at IrSMP layer. This process

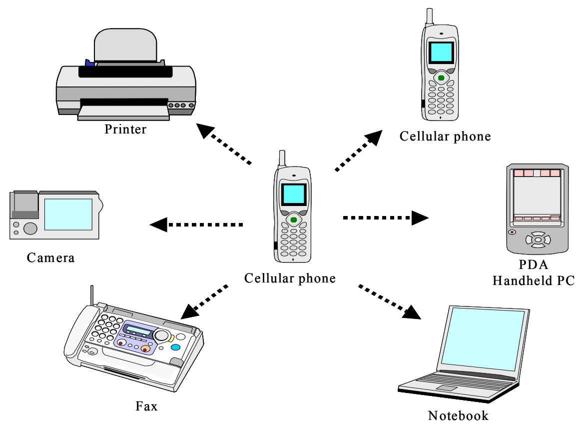

Figure 1. Different IrSimple applications

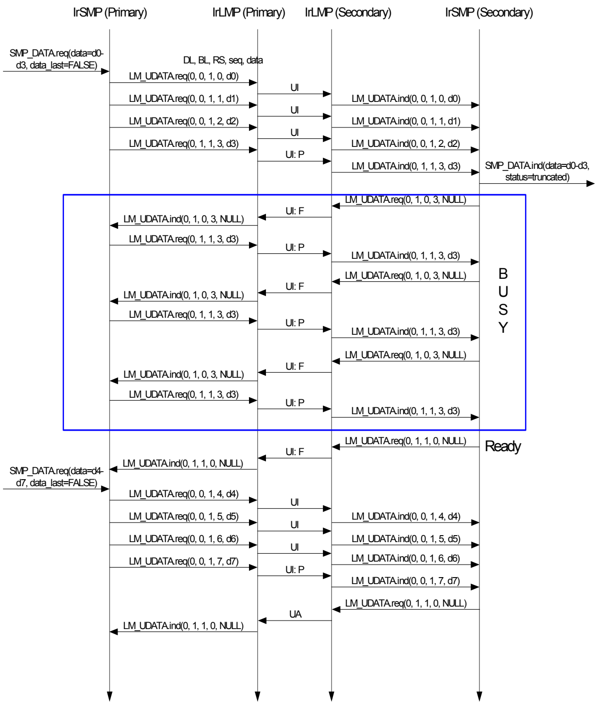

Figure 2. Existing flow control scheme

continues until the busy state is over which results in a significant amount of traffic in the processing systems and waste in data transmission caused by the repetition of last data of the block to maintain the flow control (see Fig. 2).

In our previous work [5], we proposed an efficient flow control scheme (see Fig. 3) in which IrLAP layer can manage the flow control using Receive Ready (RR) supervisory frame (S-frame). As the exchanges of RR S-frame are at the link layer instead of resending the last data at higher layer (IrSMP), the modified flow control reduces redundant data retransmissions in the system significantly. We assumed all the frames are transmitted and received error free during retransmission procedure.

In this paper, we examine all possible cases where Information frames or Supervisory frames may be lost at different stages of retransmission procedure to investigate the effectiveness of our proposed flow control scheme in detail. Another key challenge of IrSimple protocol is the long distance capability of IrDA links. The nature of applications supporting IrSimple requires the current IrDA links to support longer distances. Analytical analysis based on specifications indicates that existing IrDA links can support a wider range of distance by increasing the transmission power.

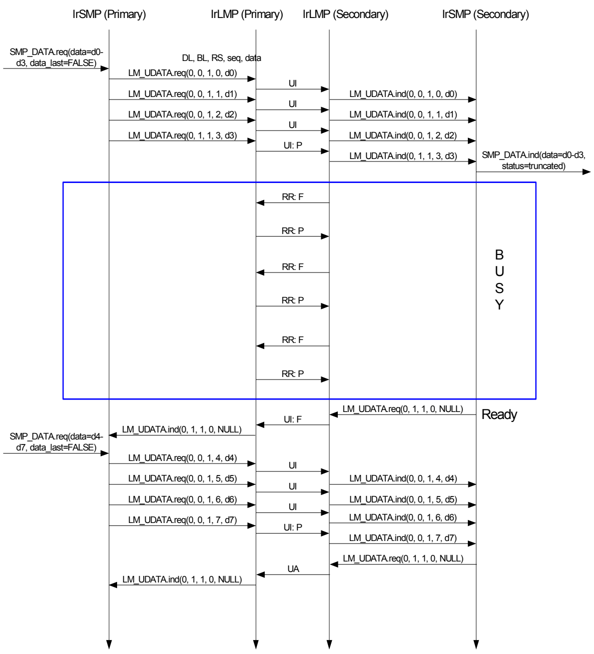

Figure 3. Efficient flow control scheme for IrSimple protocol

2. EFFECTIVENESS OF PROPOSED FLOW CONTROL SCHEME

In this section, the effectiveness of our previously proposed flow control scheme is investigated for all possible cases where a Receive Ready (RR) frame or Unacknowledged Information (UI) frame may be lost due to transmission error. In this case, it is important that the proposed flow control scheme can recover the error without adding any complexity to the system.

2.1. When Receive Ready (RR) frame from secondary station is lost

The IrLAP layer of secondary station sends RR frame with F bit set to 1 (RR-F) when the IrSMP layer is busy and can not acknowledge the last received frame. If the

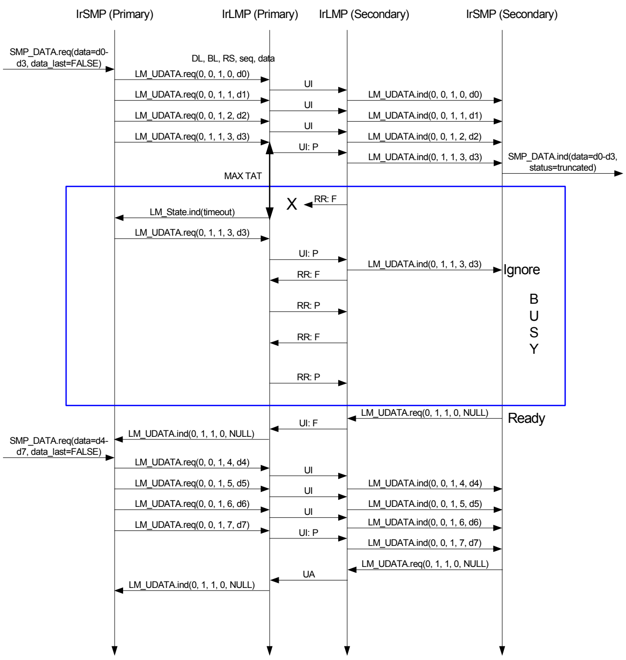

Figure 4. Recovery of Receive Ready (RR-F) frame loss in the proposed flow control scheme of IrSimple protocol

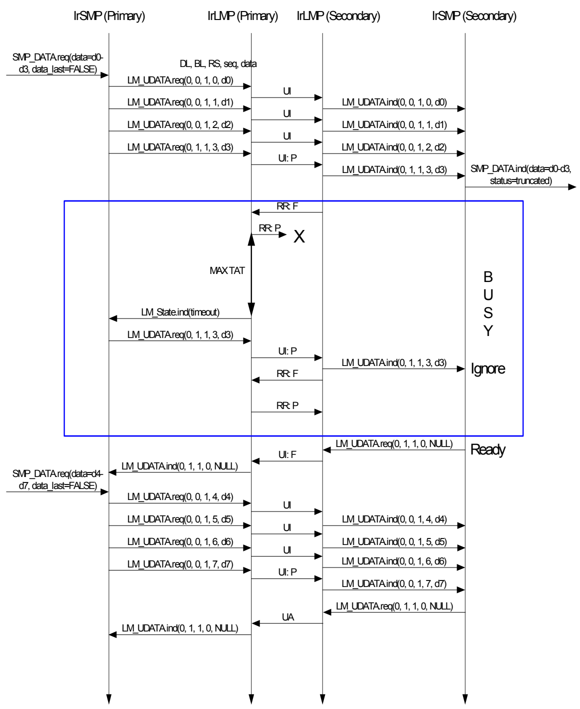

Figure 5. Recovery of Receive Ready (RR-P) frame loss in the proposed flow control scheme

transmitted RR frame is lost due to transmission error, the maximum turnaround time (MAX TAT) at primary station expires. Then the IrLAP layer at primary station resends the last transmitted UI frame with P bit set to 1 (UI-P). Upon receiving this frame, IrLAP at secondary station notifies the higher layer about this duplicate data and sends a RR-F frame to return the control. However, IrSMP layer discards the duplicate data. This way, the proposed flow control scheme can recover the previous RR frame loss. Fig. 4 shows the recovery procedure of

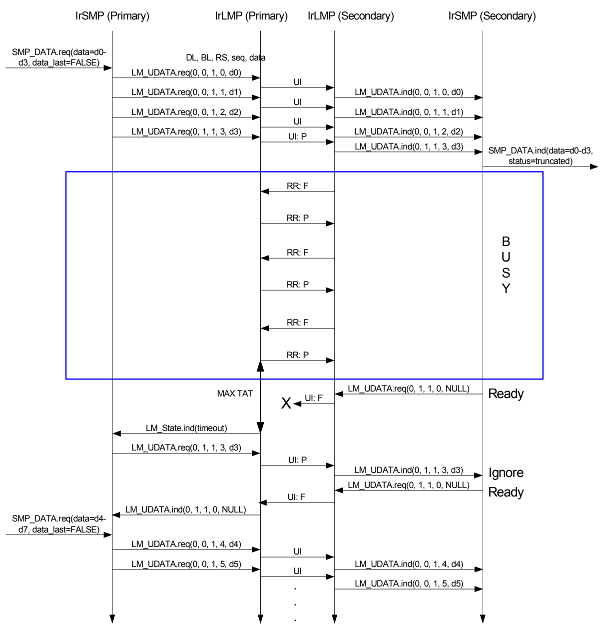

Figure 6. Recovery of Unnumbered Information (UI) frame loss immediately after the release of the flow control

the proposed flow control scheme in case of RR frame from secondary station is lost.

2.2 When Receive Ready (RR) frame from primary station is lost

In this case, the maximum turnaround time (MAX TAT) at primary station expires again as the IrLAP layer at secondary station is unable to detect the control rotation due to the loss of primary station RR-F frame and can not respond. IrLAP layer at primary resends the last data and waits for the response from secondary station. When secondary station IrLAP layer receives this frame, it issues a RR-F frame and the system returns to the usual state of the flow control. The operation of this recovery procedure is briefly explained in Fig. 5.

2.3 When Data (UI) frame is lost immediately after the release of the flow control

Fig. 6 is an example for the loss of the UI frame that the secondary station issues immediately after the release of the flow control. IrLAP layer at primary station notifies a time-out when there is no response from the secondary station as the maximum turnaround time (MAX TAT) is expired. At this point, the system recovers the error the same way explained in previous sections.

3. LONG DISTANCE CAPABILITY OF IRDA LINKS

In this section, we investigate the long distance capability of IrDA links to support IrSimple protocol. Incorporating IrSimple in digital consumer electronics devices and home appliances has led to a significant expansion in applications for this new communications protocol. For example, high-resolution photographs taken with a mobile phone or digital camera can be instantly transferred to a flat-panel TV or printer through a simple operation, similar to that of using a remote control unit. This type of applications requires a long distance capability, typically 1m to 3m, between transmitting devices and receiving appliances. However, IrDA specification recommends only up to 1 meter. So, in case of IrSimple protocol, it is desired to increase link distance beyond the 1 meter guaranteed by IrDA. One possible way to do this is to increase transmitted light intensity.

Infrared is typically used over a distance of approximately one meter, so the linear range of transmitters and receivers is only typically provided in the specification sheets for hardware designed to operate at this distance or less. To find out the range of distance between transmitter and receiver for IrSimple protocol, the link distance has to be modeled based on a direct relationship with the optical power output value of the

TABLE III. SELECTED TRANSMITTER SPECIFICATIONS

SPECIFICATION	Unit	Data Rates	Operating Power Type	Minimum	Maximum
Peak Wavelength, Up	µm	All	Both	0.85	0.9
Maximum Intensity	mW/Sr	All	Standard		500
Maximum Intensity	mW/Sr		Low Power		72
Minimum Intensity	mW/Sr	≤115.2kbps	Standard	40	
Minimum Intensity	mW/Sr	≤115.2kbps	Low Power	3.6	
Minimum Intensity	mW/Sr	>115.2kb/s	Standard	100	
Minimum Intensity	mW/Sr	>115.2kb/s	Low Power	9	

TABLE II. SELECTED RECEIVER SPECIFICATIONS

SPECIFICATION	Unit	Data Rates	Operating Power Type	Minimum	Maximum
Maximum Irradiance	mW/cm^2	All	Both		500
Minimum Irradiance	mW/cm^2	≤115.2kbps	Low power	0.009	
Minimum Irradiance	mW/cm^2	≤115.2kbps	Standard	0.004	
Minimum Irradiance	mW/cm^2	>15.2kb/s	Low power	0.0225	
Minimum Irradiance	mW/cm^2	>15.2kb/s	Standard	0.015	

TABLE I. CALCULATION OF LONG DISTANCE CAPABILITY

Minimum luminance in the vicinity of $1cm^2$	mW/cm^2	0.009						
The maximum attainment distance	cm	20	30	40	50	100	200	300
Gain area	cm^2	400	900	1600	2500	10000	40000	90000
Required minimum luminance	mW/Sr	3.6	8.1	14.4	22.5	90	360	810
Minimum Distance that is required	cm	0.08	0.13	0.17	0.21	0.42	0.85	1.27

transmitter (*Ie*). This value is given in terms of mW/Sr, where Sr stands for a steradian, and normally decreases as the transmission angle increases.

As link distance increases, the same amount of optical power per steradian is still available, however this power is distributed over a greater area; consequently the signal has lower power in the area that is in the range of the receiver. The necessary optical power is also dependant upon the irradiance of the receiver (*Ee*). Irradiance is a measurement unit of received power per unit area incident on a surface (mW/cm^2). This parameter is inversely related to the link distance and also available on most specification sheets. Finally, the relationship between link distance (*d*), optical power output (*Ie*) and irradiance (*Ee*) are quantified from [6]:

$$d = \sqrt{I_e / E_e} \tag{1}$$

In case of minimum receiver sensitivity, the transmitter has to enhance its intensity by increasing its power level. From Table 1 defined by IrDA specification, the maximum transmitter intensity operating at standard power level can be found to be 500 mW/Sr. The minimum receiver irradiance E_{min} (sensitivity) defined by IrDA specification can also be found from Table 2 which is 0.009 mW/cm^2.

The total gain area (g_a) at a distance of d between receiver and transmitter is,

$$g_a = (d)^2 \tag{2}$$

In order to calculate the required minimum luminance (l_{min}), the total gain area is multiplied with minimum receiver irradiance,

$$l\min = ga * E\min \tag{3}$$

Finally, Table 3 compares the required minimum luminance for different values of d and maximum allowable luminance using (1), (2) and (3). It can be seen from Table 3 that IrDA transmitters can achieve up to 3m distance by increasing its intensity. However, this imposes a minimum distance between transmitter and receiver which is approximately 1.27cm for 3m operating range. As the operating distance increases, the minimum distance required between transmitter and receiver also increases. Usually IrSimple applications do not require less than 2cm distance between transmitter and receiver which signifies the suitability of IrDA links to support IrSimple protocol with a long distance capability.

4. CONCLUSIONS

This paper examines the effectiveness of our proposed flow control scheme for IrSimple protocol. We carried out a complete examination for all possible cases where frame losses can occur due to transmission error. It shows that the proposed flow control scheme recovers from any possible frame losses without adding any complexity to the system as well as reduces the redundant data retransmissions. We also examine the long distance capability of current IrDA links which is required to enhance IrSimple applications. Results are presented which reveal that IrDA links can support up to 3m distances by increasing the transmitted light intensity.

REFERENCES

[1] Dharwadkar, S. N. Masood, Nabegha;, “Next Generation Network”, IEEE International Symposium on Consumer Electronics, June 20-23, 2007.
[2] IrSimple, Infrared Simple Profile, Version 1.00, October 14, 2005.
[3] IrDA, Infrared Sequence Management Protocol (IrSMP) for IrSimple, version 1.00, October 14, 2005.
[4] IrDA Infrared Serial Link Access Protocol (IrLAP) for IrSimple Addition, IrLAP errata for IrSimple version 1.00, October 14, 2005.
[5] Alam Mohammad Shah, Shawkat Shamim Ara, Gontaro Kitazumi and Mitsuji Matsumoto, “IrSimple Modeling and Performance Evaluation for High Speed Infrared Communications”, published in the proceedings of IEEE Global Telecommunication Conference 2006 (GLOBECOM 2006), San Francisco, USA, November, 2006.
[6]] Barma, P. and Schlanger, S., “Fundamentals of the Infrared PhysicalLayer,”http://www.eetasia.com/ARTICLES/2004MAY/A/2004MAY25_MSD_AN.PDF