OPTIMUM WINDOW AND FRAME SIZE FOR IrDA LINKS

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Abstract

For the first time we derive a simple formula for the throughput, optimum window and frame sizes of IrDA IrLAP protocol. For 16Mbps links the use of the proposed window size of 127 frames makes the link performance worse at higher line BER. The significance of minimum turnaround time on throughput is being studied.

Introduction

IrDA infrared wireless ports are populating millions of products such as laptops, printers, personal digital assistants and mobile phones every year [1]. The data rate options range from 115.2Kbps, 1.152Mbps, 4Mbps and 16Mbps. The IrDA standard specifies link BER less than 10^{-8} for a link operating from 0 to at least 1m. The hardware is driven by the IrDA link layer protocol IrLAP [2]. This work is concerned with the study of maximising the link throughput by selecting optimum parameters for IrLAP. The parameters for maximum throughput for any BER are of great interest to link designers. Performance analysis of IrLAP protocol using the concept of virtual transmission time was presented in [3] and the significance of window size N and other link parameters was presented in [4]. We use a new analytical model, which allows the derivation of a simple and intuitive equation for the IrLAP throughput. Based on this equation we derive optimum parameters for frame length and window size. The results give us insights for the optimum control of the link for maximum throughput.

Analysis

Table 1 includes a list of symbols used for our analysis.

The symbols for t_S , t_I , t_{ack} , p and D_b are defined by:

$$t_S = \frac{l'}{C} \quad , \quad t_I = \frac{l + l'}{C} \quad , \quad t_{ack} = 2t_{ta} + t_S \quad , \qquad p = 1-(1-p_b)^{l+l'} \quad , \quad D_b = lD_f \qquad (1)$$

In order to calculate the link throughput a mathematical model is developed using the concept of “window transmission time”. It determines the number of correct in sequence frames received in a complete *N* frame window transmission and the time needed for that transmission.

We derive that the frame throughput D_f is given by:

$$\boxed{D_f = \frac{1-p}{p} \frac{(1-(1-p)^N)}{Nt_I + p(t_{Fout} + t_s) + t_{ack}}} \qquad (2)$$

Intuitively, (2) reveals that D_f , is given by the number of correct frames transmitted before an error occurs, (term (1-p)/p), times the probability of an error in a window (term (1-(1-p)^N), divided by the average window transmission time.

Differentiating (2), and to a very good approximation we can derive the following optimum values for window size *N* and frame size *l*.

$$\boxed{N_{opt} = \sqrt{\frac{2t_{ack}C}{l^2 p_b}}} \qquad \boxed{l_{opt} = \sqrt{\frac{2(Nl' + t_{ack}C)}{N^2 p_b}}} \qquad (3)$$

The optimum values (3), reveal that maximum throughput is achieved when the product of the probability of an error in the window, ($\approx Nlp_b$), times the number of bits to be retransmitted due to the error, (which on average is half the window,($Nl/2$)), must be equal to the acknowledgement time in bits, ($t_{ack}C$), plus the number of the overhead bits in the window, (Nl').

Results

Using (2), we plot Fig.1, which shows throughput efficiency against BER for a 16Mbps link for various values of N and t_{ta}. Increasing the window size decreases link turnaround frequency. For low BER, increasing the window size results in significant throughput improvement for large t_{ta} and a smaller improvement for small t_{ta} values. The price we pay for using large window sizes, is that throughput becomes sensitive to increase in BER. This is because following an erroneous frame a large number of frames will be transmitted out of sequence in the same window. By selecting small window size (e.g. window size 7 in fig 1.) the link becomes resistant to increase in BER and still offers a high throughput efficiency of 0.968 at low BER and t_{ta}=0.1ms. Throughput against window size for various BER values and t_{ta} is shown in Fig. 2. Throughput significantly decreases with window size increase for high BER (10^{-6}) and slightly increases for low BER(10^{-10}). The increase or decrease level depends on values of t_{ta}.

Fig.3 shows time allocation of various IrLAP tasks against BER. It is obvious that for a wide range of BER (from 10^{-8} to 10^{-4}), the key factor that reduces throughput is the retransmission of correctly received out of sequence frames. This is a limitation of the IrDA IrLAP protocol when non-optimum window size is used. For high BER although the link is still operational optimum values for N become of key importance if maximum throughput is to be achieved. Only at very high BER, $>10^{-4}$, the main factor causing decrease in throughput is the retransmission of frames with errors. Fig.3 reveals that the effect of t_{Fout} timer is significant for high BER. Fig.3 also shows that if a small t_{ta} value is implemented, in comparison to t_I , throughput is not significantly affected. Fig.4 shows the optimum frame size and optimum window size for any BER resulting to maximum throughput. The corresponding optimum throughput is shown in Fig. 1.

References

[1] Williams S., “IrDA: Past, Present and Future”, IEEE Personal Communications, Vol. 7, No.1, pp. 11-19, Feb 2000.

[2] IrDA: “Serial Infrared Link Access Protocol (IrLAP) – Version 1.1”, (Infrared Data Association, 1996).

[3] Barker P., Boucouvalas A.C. & Vitsas V., “Performance Modelling of the IrDA Infrared Wireless Communications Protocol”, International Journal of Communications, 2000, accepted for publication.

[4] Boucouvalas A.C. and Barker P., “IrLAP protocol performance analysis of IrDA wireless communications”, Electronics Letters, Vol. 34, No. 25, pp.2380-2381, Dec 1998.

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Table and figure captions:

Table 1: Parameters used in modelling IrLAP throughput

Fig. 1 Throughput against BER for 16Mbit/s link, l=16Kbits

△ N=127,t_{ta}=0.1ms ▲ N=127,t_{ta}=10ms
◇ N=50,t_{ta}=0.1ms ◆ N=50,t_{ta}=10ms
□ N=7,t_{ta}=0.1ms ■ N=7,t_{ta}=10ms
x optimum N ○ optimum l

Fig. 2 Throughput against maximum window size for 16Mbit/s link, l=16Kbits

△ BER=10^{-6},t_{ta}=10ms ▲ BER=10^{-10},t_{ta}=10ms
◇ BER=10^{-6},t_{ta}=1ms ◆ BER=10^{-10},t_{ta}=1ms
□ BER=10^{-6},t_{ta}=0.1ms ■ BER=10^{-10},t_{ta}=0.1ms

Fig. 3 Time allocation of various IrLAP tasks against BER
Link rate = 16Mbit/s, Packet size = 16Kbts, t_{ta} = 0.1ms, N = 127 frames

□ useful data transmission (throughput efficiency)
◇ retransmission of correctly received out of sequence frames
x retransmission of error frames
◆ t_{Fout} timer expiration
● reversing link direction (hardware latency)

Fig. 4 Optimum window for l=16Kbits and optimum packet size for N=127 against BER
Link rate = 16Mbit/s, t_{ta} = 0.1ms

□ optimum window size
▲ optimum packet size

Table 1

Symbol	Parameter Description	Unit
C	Link data baud rate	bits /sec
p_b	Link bit error rate	-
p	Frame error probability	-
l	I-frame message data length	bits
l'	S-frame length / I-frame overhead	bits
t_I	Transmission time of an I-frame	sec
t_S	Transmission time of an S-frame	sec
t_{ta}	Minimum turn-around time	sec
t_{ack}	Acknowledgement time	sec
t_{Fout}	F-timer Time-out period	sec
D_f	Frame throughput	frames/sec
D_b	Data throughput	bits/sec

Figure 1

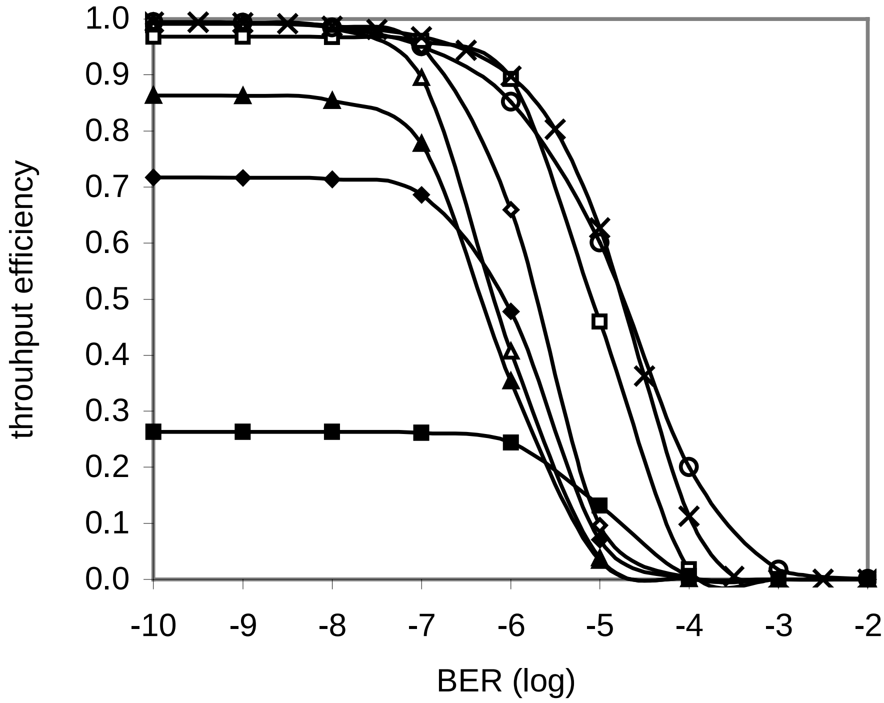
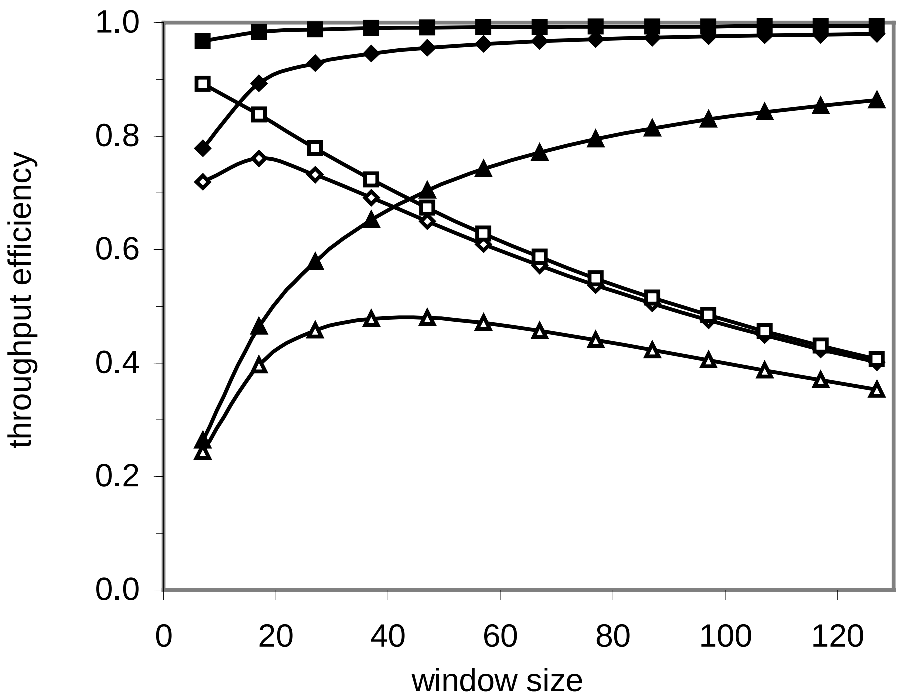

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
throuhput efficiency
-10
-9
-8
-7
-6
-5
-4
-3
-2
BER (log)

Figure 2



1.0
0.8
0.6
0.4
0.2
0.0
throughput efficiency
0
20
40
60
80
100
120
window size

Figure 3

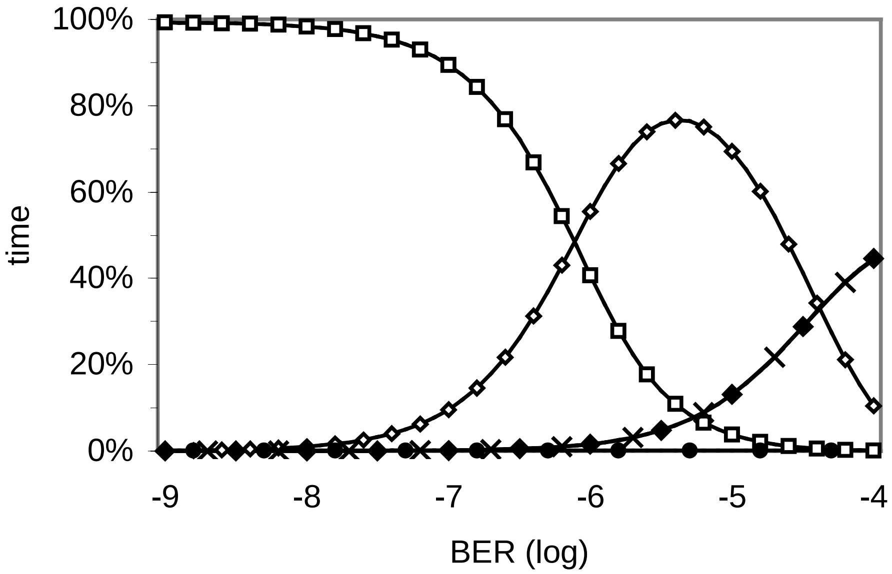
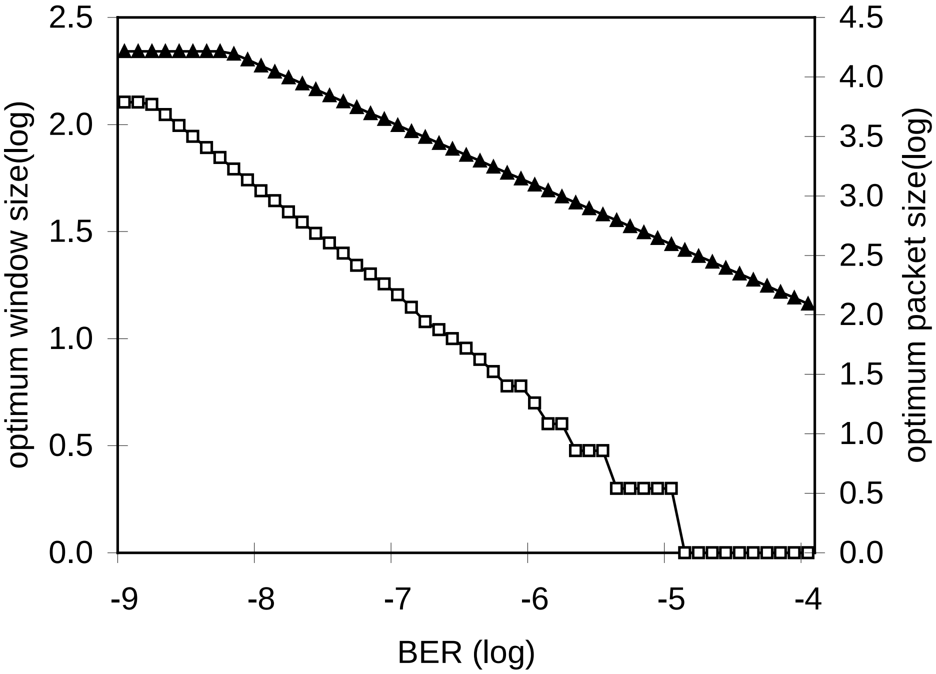


Figure 4



2.5
2.0
1.5
1.0
0.5
0.0
optimum window size(log)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
optimum packet size(log)
-9
-8
-7
-6
-5
-4
BER (log)