SLIDING WINDOW DATA LINK PROTOCOLS

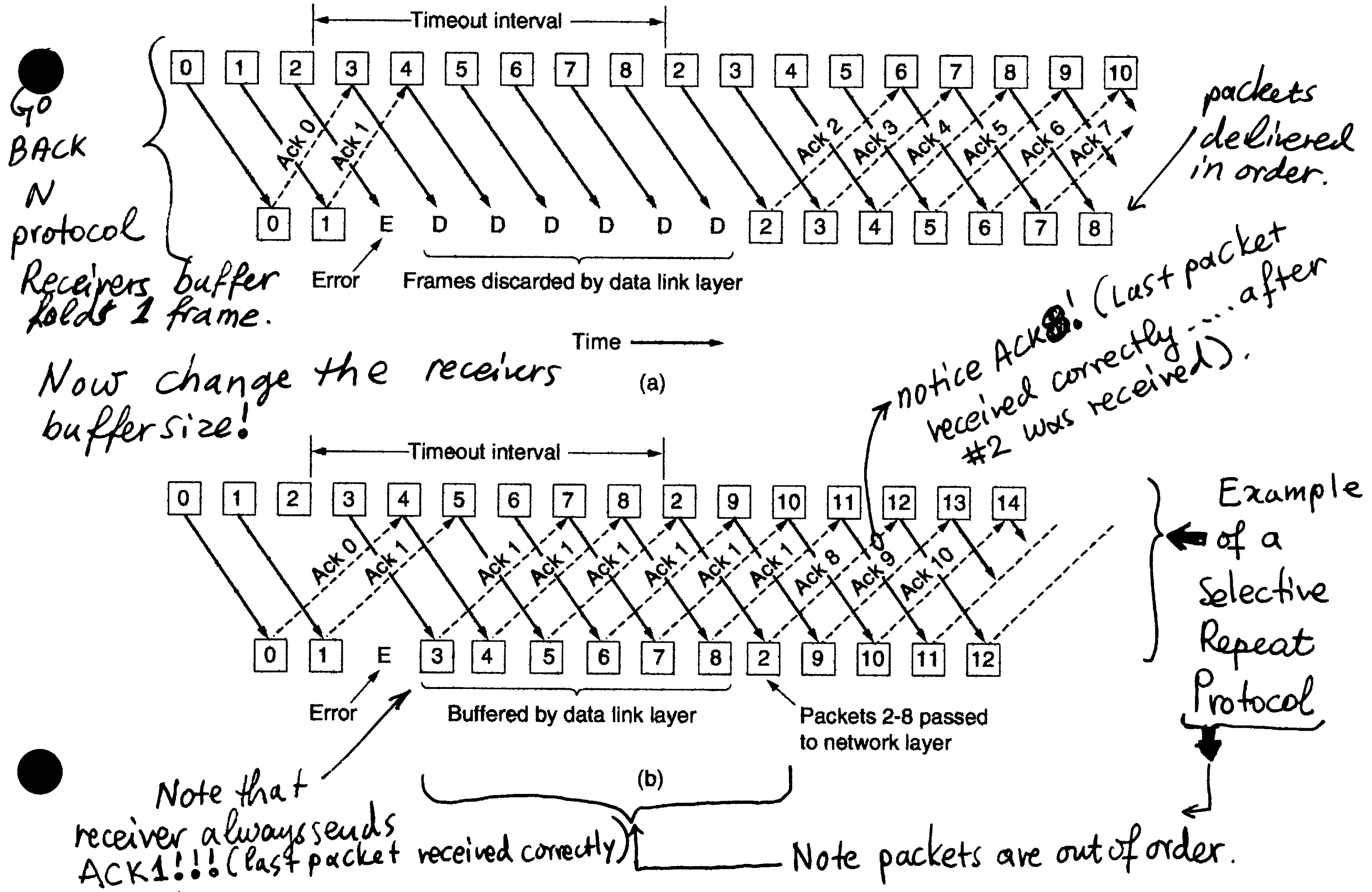


Fig. 3-15. (a) Effect of an error when the receiver window size is 1. (b) Effect of an error when the receiver window size is large.

- Protocol above (b) uses pipelining ⇒ more than 1 packets are unAcked and in transit! It is also SRP!

- Do computation on p. 209 in book! I.e.
  - Channel capacity is b bits/sec
  - Frame size is ℓ bits

  } TRANSP = $\frac{\ell}{b}$ sec

  - Round trip prop. delay is R secs

As we saw $\eta \cong \dfrac{\ell/b}{R + \frac{\ell}{b}} = \dfrac{\ell}{\ell + bR}$

If $bR > \ell$ pipelining can be used to fill the extra space!

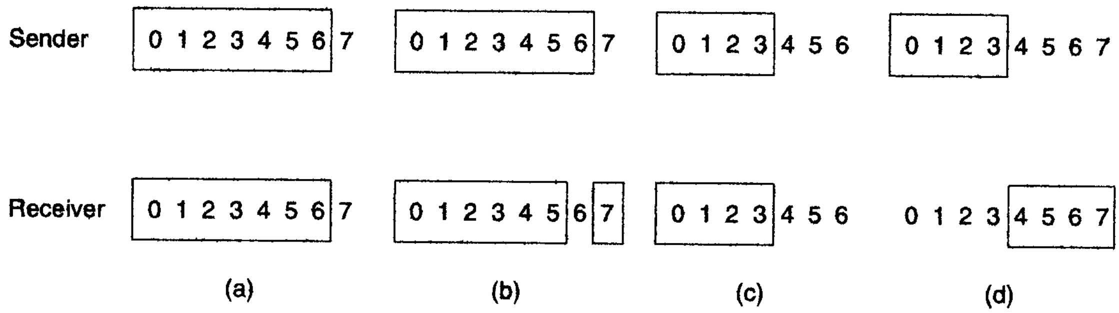


Fig. 3-19. (a) Initial situation with a window of size seven. (b) After seven frames have been sent and received but not acknowledged. (c) Initial situation with a window size of four. (d) After four frames have been sent and received but not acknowledged.

- How about numbering packets? (or ACK's)
- For Stop and Wait ⇒ 0, 1, 0, 1, ... (Simple!).
- In a window protocol, with window size 7 and using Selective Repeat:

① Packets 0-6 are sent first.
② Receiver's buffer allows reception of packets 0-6. All frames are correctly acknowledged.
③ For some reason all ACK's are lost (due to a malfunction).
④ Sender times-out for packet 0 and sends packets 0-6 again!
⑤ Receiver see's packet 0, but expects packet 7! It sends ACK for last succesful packet received! i.e packet 6.
⑥ Transmitter sends packets 7, 0, 1, 2, ..., 5! since he knows that 0, 1, 2, 3, .. 6 were succesfully received.

(7) Packet 7 makes it succesfully but what about packet 0 that has been received previously and is from the first batch?

Problem: The range of packet indices of the most recent window overlapped with the indices of the packet prierious window.

Solution: See figure 3.19 (c) and (d)

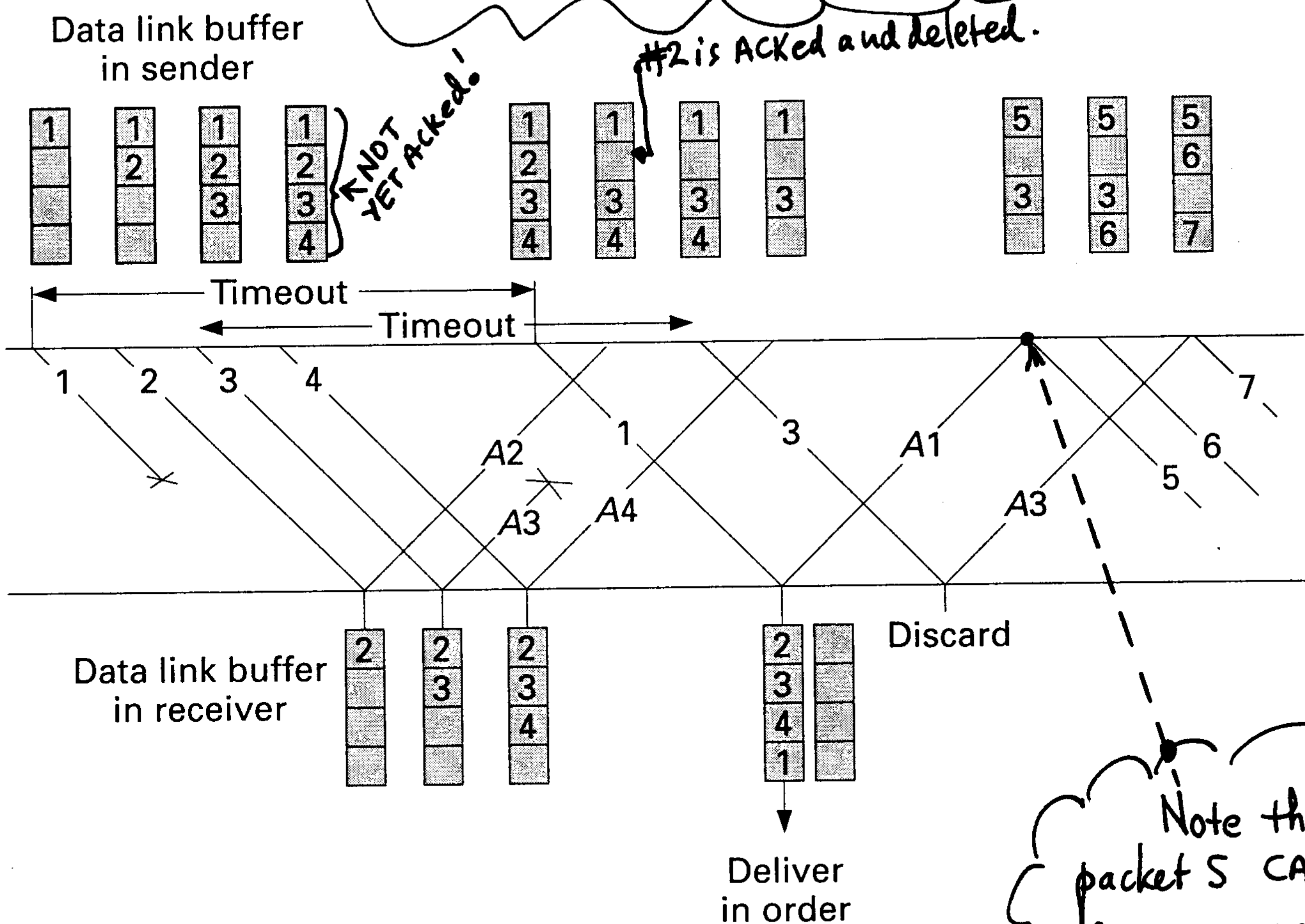
Conclusion: If the transmitter wants to have a window of 4 packets it needs indices 0, 1, 2, ..., 7.
For a window of 7 packets the indices are 0, 1, ..., 13

For a window of W packets the indices are $0, 1, \ldots 2W-1$

SRP Protocols: More details and Variants

(From J. Walrand's book).

• Assumed Window is 4: i.e. Transmitter sends a packet if LESS than 4 packets are UNacknowledged!!



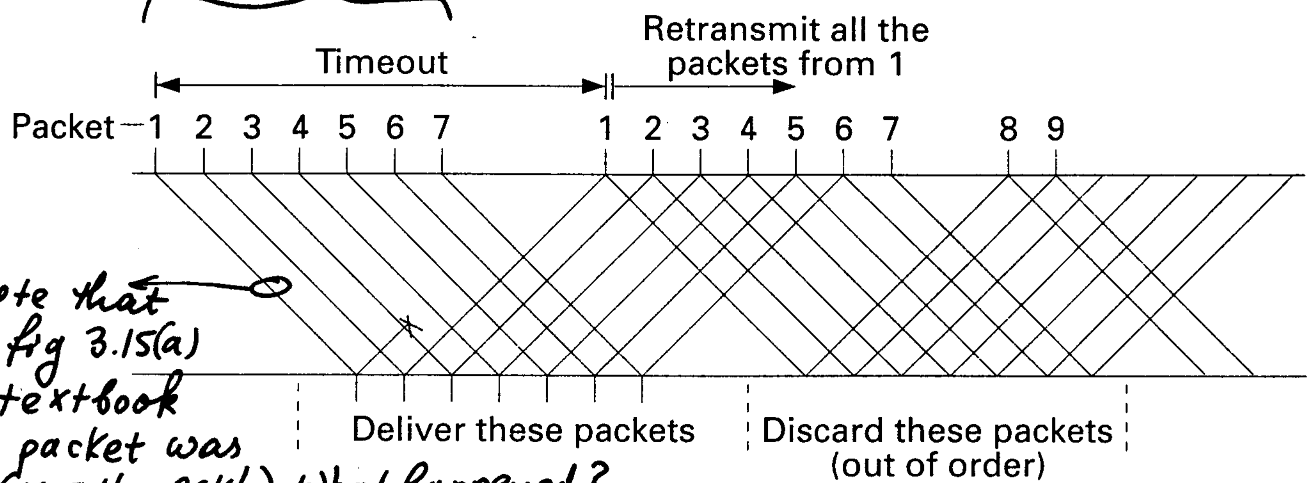
4.14

Note that packet 5 CAN'T be sent till Ack for packet #1 is received

Sender transmits packets 1,2,3,4. Packet 1 is corrupted. Receiver sends ACK2, ACK3 and ACK4 and ACK3 is corrupted. The Sender retransmits packets 1 and 3 after a timeout and the sender receives ACK1 and ACK3. The sender then transmits packets 5,6,7.

GO BACK N: More Details and Variants (From J. Walrand Book).

Window W=7



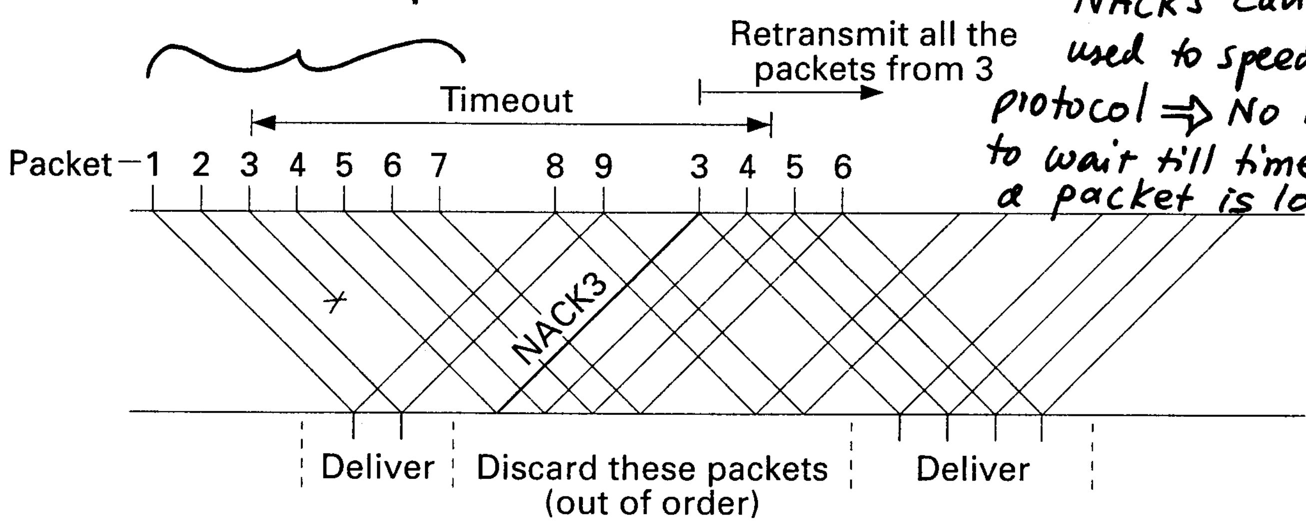
Note that in fig 3.15(a) in textbook the packet was lost (NOT the ACK!). What happened?

4.21

Sequence of Events with GO BACK N protocol.

Window W=7

NACK's can be used to speed up protocol ⇒ NO NEED to wait till timeout if a packet is lost!!



4.22

GO BACK N protocol with NACK's (Negative ACK's).

SRP and Go BACK N performance issues

We will study (outline) the following cases:

- Cases

For SRP:
- Error Free Operation
- Errors and large W ($w \to \infty$).
- Errors and finite W (← complex!).

⇒ Check next slide (i.e. 59)

For Go BACK N:
- General case with errors and finite w.

⇒ Check slide 60.

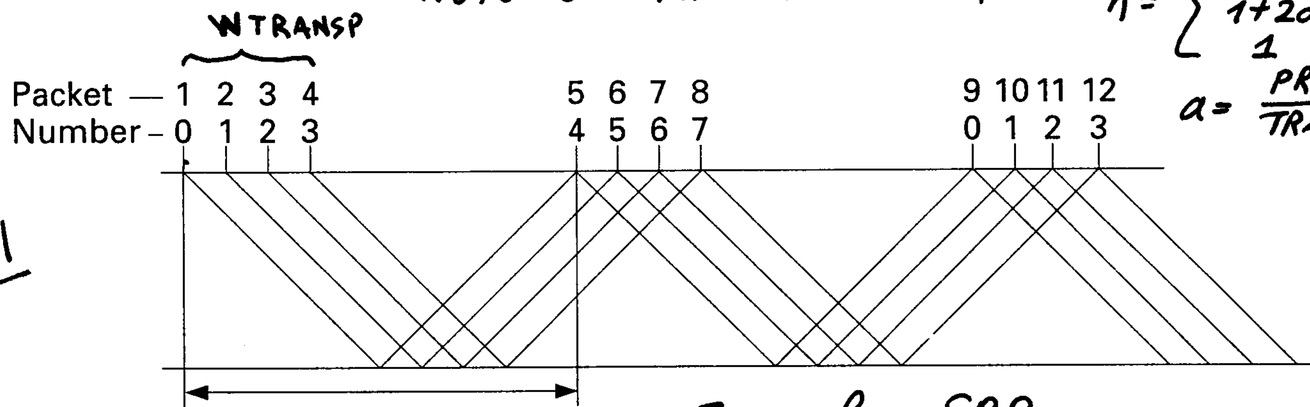
(59c) Error free SRP: If $W \cdot TRANSP < S \Rightarrow \eta = \frac{W\,TRANSP}{S}$

If $W\,TRANSP \geq S \Rightarrow \eta = 1$ (why?).

Note: $S \cong 2PROP + TRANSP$ hence $\eta = \begin{cases} \frac{W}{1+2a} \\ 1 \end{cases}$

$a = \frac{PROP}{TRANSP}$.

Case 1



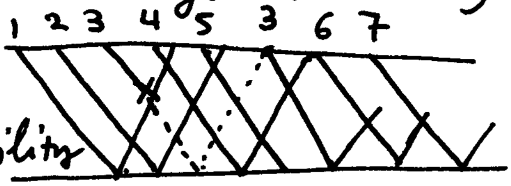
S = time to send packet and receive ACK

Error free SRP. ($W \cdot TRANSP < S$).

4.19

Case 2 Errors and large w ($w \to \infty$)

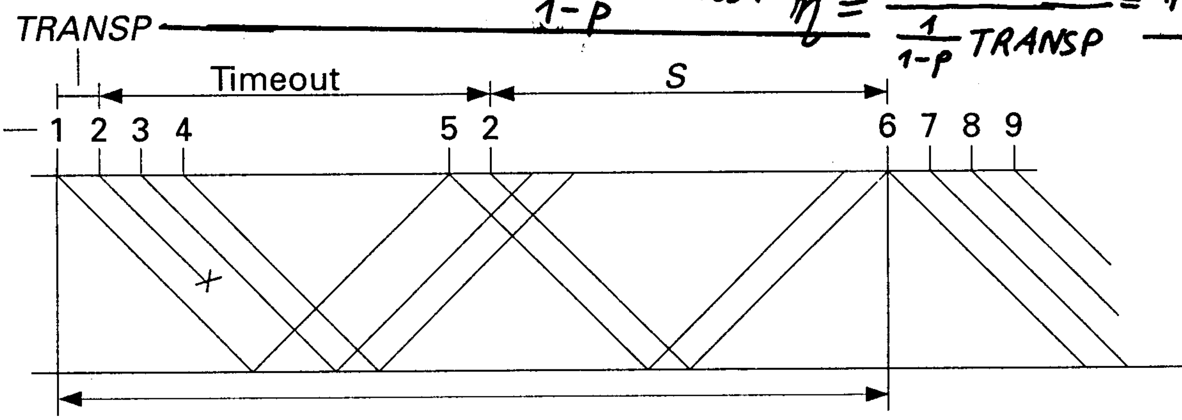
packet loss probability is p.



There is continous operation (no idling!) in this case

Packet is transmitted on average $\frac{1}{1-p}$ times. $\eta = \frac{TRANSP}{\frac{1}{1-p} TRANSP} = 1-p$.

Case 3 (Complex).



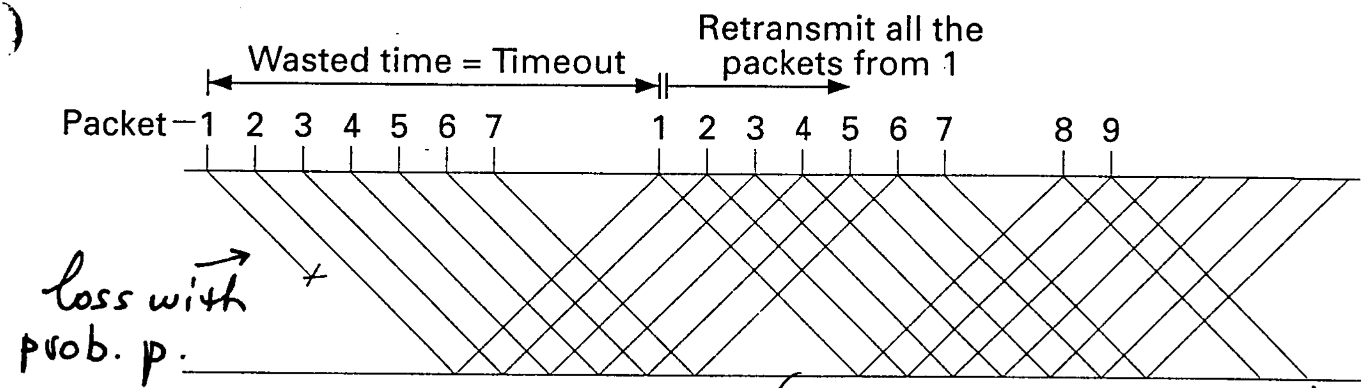
5 packets transmitted in (*S* + *TRANSP* + timeout) seconds

Proof is difficult (Check book by J. Walrand or Saadawi). 4.20

There are random idling periods!

Result: $\eta = \frac{W(1-p)}{1+2a}$

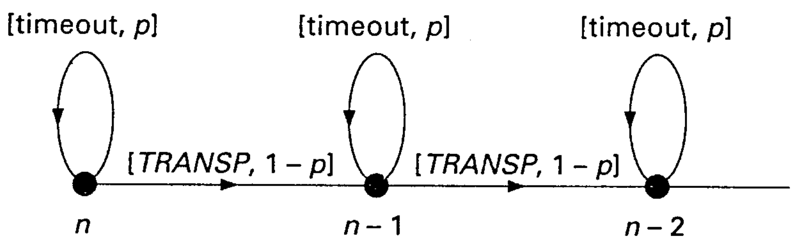
$a = \frac{PROP}{TRANSP}$.



(From J. Walrand book)

4.23

Go BACK N performance Analysis:



You may consult the book by Walrand or Saadawi. Proof is relatively complex but easier than SRP!

$$\eta = \frac{1-p}{1-p+p^W} \quad \left(\rightarrow 1 \text{ for } W \rightarrow 1 \text{ since } p<1\right).$$

If $Wp \ll 1$ $\qquad \eta \simeq \dfrac{1-p}{1-p+Wp}$

⇑ (what is intuition here?)

A PRACTICAL EXAMPLE:

- Assume packets 10,000 bits each
  " ACK's with 100 bits each
  " 100 Km link with PROP= $2.3 \cdot 10^8$ m/s.
  " transmission rate of 100 Mb/s
  " PROC = 0.2 ms.

- Calculate TRANSP, S, etc at home:

If we assume $p=0$ and SRP we can show

$$\eta = \begin{cases} W/13.7 & W\,TRANSP < S. \\ 1 & W\,TRANSP \geq S \end{cases}$$

For $W=1 \Rightarrow \eta = 7.3\%$ (This is ABP!).
" $W=4 \Rightarrow \eta = 29\%$.
" $W=14 \Rightarrow \eta \cong 100\%$!