Telecommunication Networks
15B11EC611

PERFORMANCE ISSUES

- **APPENDIX 7A PERFORMANCE ISSUES**
- **Kindly refer page numbers: 216 to 222 of the Book_2_Data-and-Computer-Communications-by-WilliamStallings (8th Edition) for detailed discussion.**

Performance analysis over noisy channel

- Frame transmitted over a noisy channel may get corrupted/lost. Therefore it may require several retransmissions.

Average number of transmissions of a frame

Probability that a bit is in error = p

Probability that a bit is not in error = $1-p$

Probability that all the L bits are not in error = $(1-p)^L$

Probability (P_f) of one/more errors in a frame = $1-(1-p)^L$

Probability that (i-1) frames are received with one/more errors = $P_f^{\,i-1}$

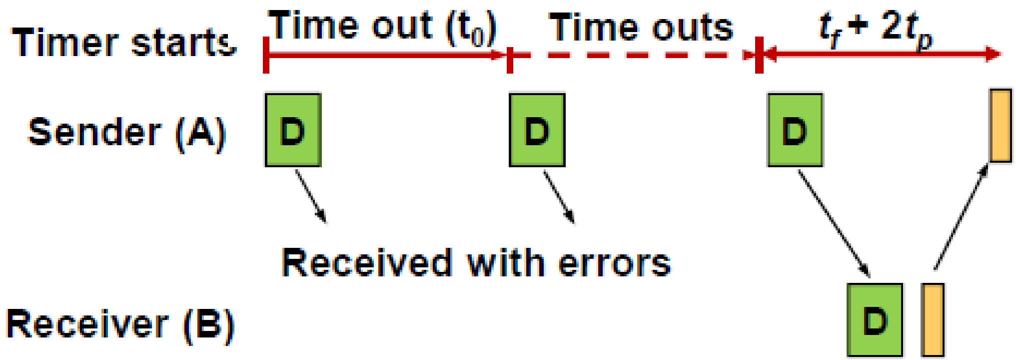
Probability that i^{th} frame is without errors = $P_f^{\,i-1}(1-P_f)$

Average number of transmissions of a frame

$$N_r = \sum_{0}^{\infty} iP_f^{\,i-1}(1-P_f) = \frac{1}{1-P_f} = \frac{1}{(1-p)^L}$$

Note $\sum_{i=1}^{\infty}(iX^{i-1}) = \frac{1}{(1-P)^2}$ where $-1 < X < 1$

Link Utilization in Stop-and-Wait protocol



Number of transmissions required for a frame	$= N_r$
Time out interval	$= t_0$
Time required for sending a frame correctly	$= (N_r - 1)\, t_0 + t_f + 2t_p$
Minimum value of t_0	$= (t_f + 2t_p)$
Min. time for transmission of a frame correctly	$= N_r\, (t_f + 2t_p)$

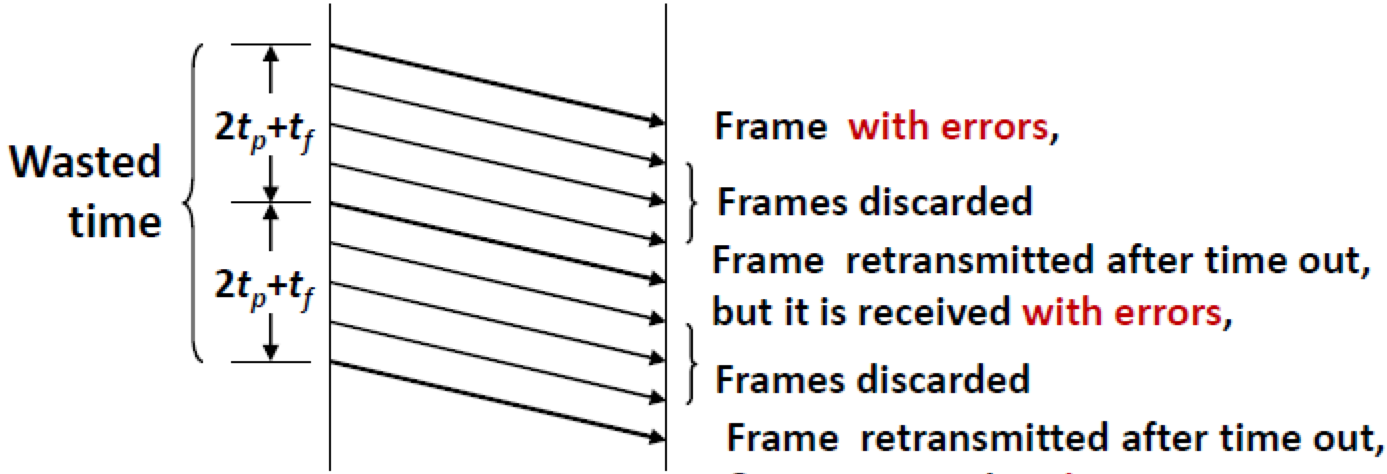
Link utilization

$$U = \frac{t_f}{N_r (t_f + 2t_p)} = \frac{1 - P_f}{1 + 2A}$$

$$N_r = \sum_0^{\infty} i P_f^{\,i-1} (1 - P_f) = \frac{1}{1 - P_f} = \frac{1}{(1-p)^L}$$

Link Utilization in Sliding Window: Go-back-N

Case (1) W ≥ 1+2A



Minimum time out = $2t_p + t_f$

Transmissions required for one frame $= N_r = 1/(1 - P_f)$

Time wasted in retransmissions $= (N_r - 1)\ (t_f + 2t_p)$

Link time effectively utilized $= t_f$

Link utilization efficiency $U = t_f/[t_f + (N_r - 1)(t_f + 2t_p)]$

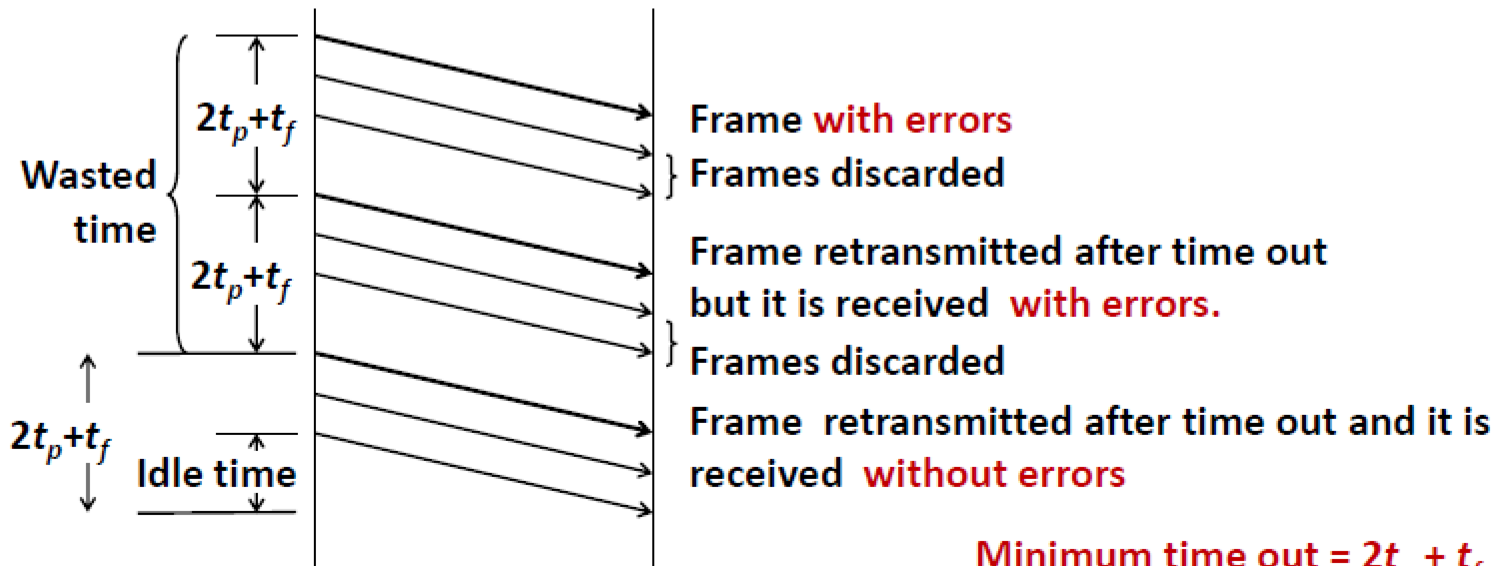
$= 1/[1 + (N_r - 1)(2A+1)]$

$= (1-P_f)/[(1-P_f) + P_f\,(2A+1)]$

$= (1 - P_f)/(1 + 2P_f\,A)$

Link Utilization in Sliding Window: Go-back-N

Case (2) W < 1+2A



Minimum time out = $2t_p + t_f$

When a frame is received correctly, frames sent in $(t_f + 2t_p) = W$

Average link engagement time per frame $= (t_f + 2t_p) / W$

Time wasted in retransmissions $= (N_r - 1)(t_f + 2t_p)$

Link utilization efficiency $= t_f / [(N_r - 1)(t_f + 2t_p) + (t_f + 2t_p)/W\ ]$

$= W/[(2A+1)(1+W(N_r - 1))]$

$= W(1-P_f)/[(2A+1)(1 - P_f + WP_f)]$

Link Utilization in Sliding Window: Selective-reject

Case (1) W ≥ 1+2A

- Sender receives acknowledgement before it exhausts its window i.e. when W≥1+2A.
  - Channel is continuously occupied before arrival of acknowledgement.

Frames transmitted during $(t_f + 2t_p)$ $= (t_f + 2t_p)/t_f$

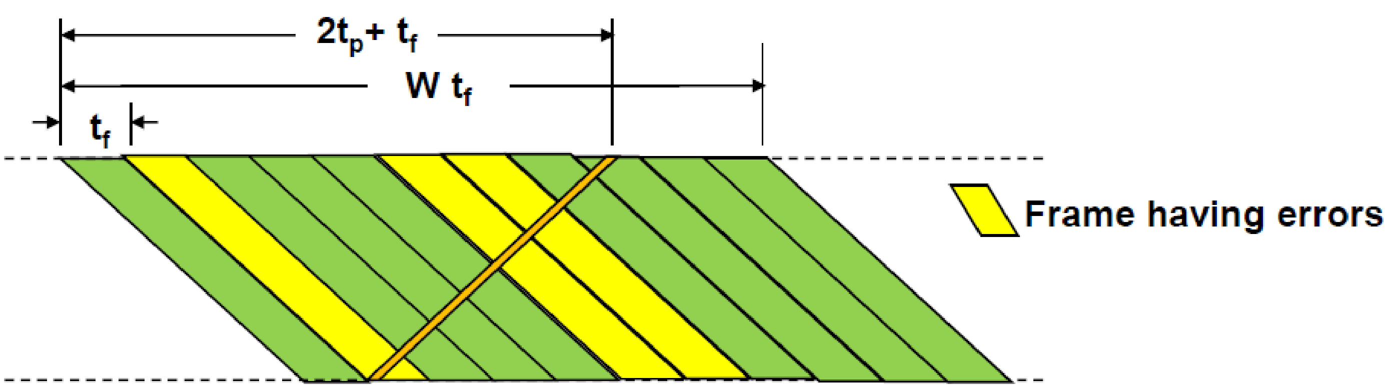
Frames received with errors $= P_f(t_f + 2t_p)/t_f$

Link time wasted $= t_f\, P_f(t_f + 2t_p)/t_f = P_f(t_f + 2t_p)$

Link time effectively utilized $= (t_f + 2t_p) - P_f(t_f + 2t_p)$

Link utilization efficiency U $= (t_f + 2t_p) - P_f(t_f + 2t_p)/(t_f + 2t_p)$

$= 1 - P_f$



Link Utilization in Sliding Window: Selective-reject

Case (2) W < 1+2A

- Sender exhausts its window before it receives an acknowledgement i.e. W<1+2A.
  - Channel is idle after window is exhausted.

Frames transmitted during $(t_f + 2t_p)$ $= W$

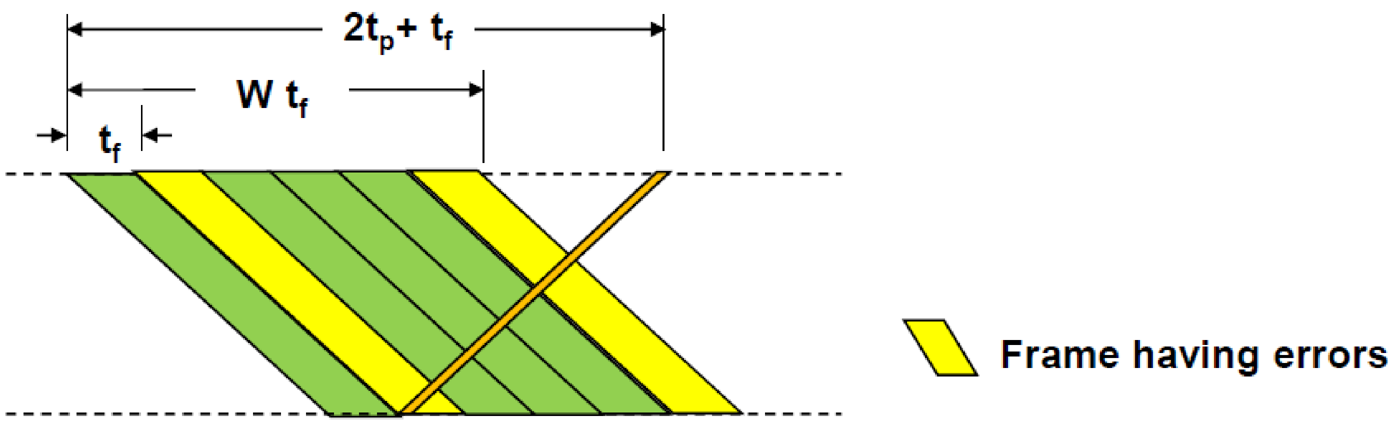
Frames received with errors $= P_f W$

Link time wasted $= t_f P_f W$

Link time effectively utilized $= Wt_f - t_f P_f W$

Link utilization efficiency U $= (Wt_f - t_f P_f W)/(t_f + 2t_p)$

$= W(1 - P_f)/(1 + 2A)$



Link utilization efficiency (U) – No errors / Noiseless channel

Stop-and- Wait, $U = t_f / (t_f + 2t_p) = 1/(1+2A)$ **where $A = t_p / t_f$**

Sliding-window

$$U = \begin{cases} W/2A+1 & W < 2A+1 \\ 1 & W \geq 2A+1 \end{cases}$$

Link utilization efficiency (U) – With errors / Noisy channel

Stop-and- Wait, $U = (1-P)/(1+2A)$

Sliding-window – Selective Reject

$$U = \begin{cases} W(1-P)/2A+1 & W < 2A+1 \\ 1-P & W \geq 2A+1 \end{cases}$$

Sliding-window – Go-back-N

$$U = \begin{cases} W(1-P)/(2A+1)(1-P+WP) & W < 2A+1 \\ (1-P)/(1+2AP) & W \geq 2A+1 \end{cases}$$

THANK YOU