

Digital Communication and Packet-Switched Networks (ECE446 Lecture 09/08/05)

- **Last Time:** Basic Network Elements and Mechanisms
 - links, switches, speed-delay-error, multiplexing, switching
- **This Time:** More on Network Elements and Layered Architecture s
 - error control, retransmissions, flow/congestion control, layers.

Error Control Mechanisms

Link-level Error Detection:

- A simple detection method: add a parity bit
 - Want to transmit 7 bits: 0110100.
 - Add bit so that # of 1s is even: 0110100**1**.
 - If a single error occurs (e.g., 0100100**1**), receiver can detect.
 - If an even number of errors occurs, those go ***undetected***.

Error Control Mechanisms

Link-level Error Detection:

- A simple correction method: add multiple parity bits.

0	1	0	1	1	0	0	1
1	0	1	0	0	1	1	0
0	0	1	0	1	1	0	1
1	0	0	1	0	0	1	1
1	1	0	0	1	1	0	0
0	0	1	0	0	1	0	0
1	1	1	0	1	0	1	1
0	1	0	0	0	0	1	

Error Control Mechanisms

- An error can be CORRECTED

0	1	0	1	1	0	0	1
1	0	1	0	0	1	1	0
0	0	1	0	1	1	0	1
1	0	0	1	1	0	1	1
1	1	0	0	1	1	0	0
0	0	1	0	0	1	0	0
1	1	1	0	1	0	1	1
0	1	0	0	0	0	1	

How many errors can I correct? More efficient design on Code can be chosen.

Error Control Mechanisms

Computer Networks use both: ***Detection & Correction***

- Add parity bits to a packet for error detection
 - No error detected, send ack for packet.
 - Error detected, discard and **retransmission needed.**Useful on noisy channel with feedback
- Add parity bits to a packet for error correction
 - Add enough parity bits to correct largest possible # of errorsUseful with noisy channel with no feedback

- Add parity packet

- Put parity bits in a separate packets

- If packet lost, can be recovered from packets received.

Useful for dealing with loss of packets due to discarding or congestion

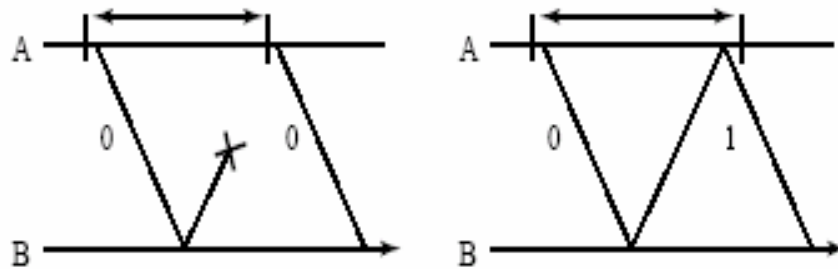
Error Control Mechanisms

- Retransmissions: **the Alternating Bit Protocol**
 - Sender numbers packets with alternating 0s and 1s.
 - Receiver acknowledges each correctly received packet with its bit.
 - Sender waits to get ack to send next packet.
 - If error in packet transmission, no ack sent.
 - If no ack received, or ack received in error, resend after timeout.

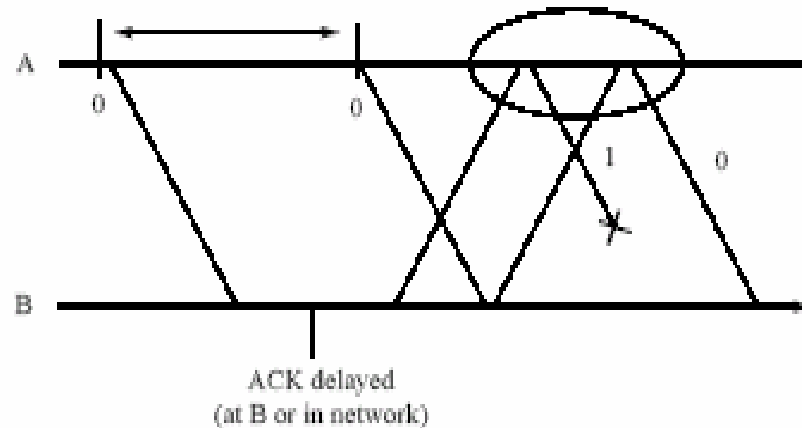
Error Control Mechanisms

What can go wrong in ABP without numbering packets:

- If ack lost, cannot distinguish packet from retransmission.



- If ack delayed, deadlock can result.



Error Control Mechanisms

- Retransmissions: **the Go-Back-N Protocol**

- ABP can be inefficient if propagation times are long (sender waits idle while packet is in flight).

- Choose a window size N , large enough so that “the pipe is full.”

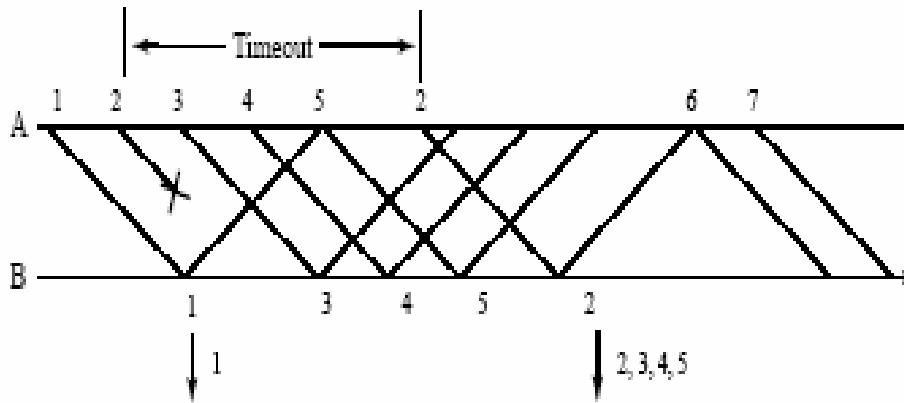
- Sender numbers packets sequentially modulo N (0, 1, ..., $N-1$, 0, ...)

- Receiver acks correctly received packets with last one released:
e.g. : Receive: 1 2 3 6, What are the acks?

More efficient because, when errors are rare, roughly N -fold throughput increase.

Error Control Mechanisms

- Retransmissions: **the Selective Repeat Protocol**
 - Go-Back-N can be inefficient if cost of sending a packet is high
 - Instead of resending the whole window after the ack, only send the next packet.



- Saves number of retransmissions

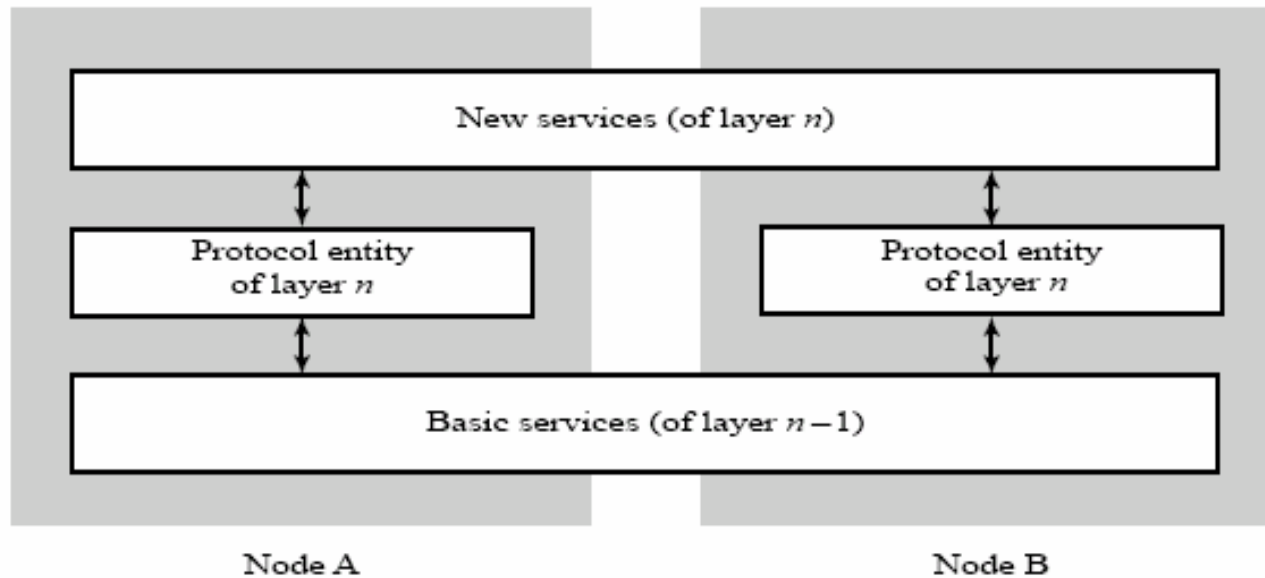
Flow/congestion Control

- Sometimes need to dynamically throttle sources:
 - If receiver's memory is full
 - If routers/switches multiplexing many streams become congested

Can do by dynamically updating the window size. Will spend time on this later.

Layered Architecture

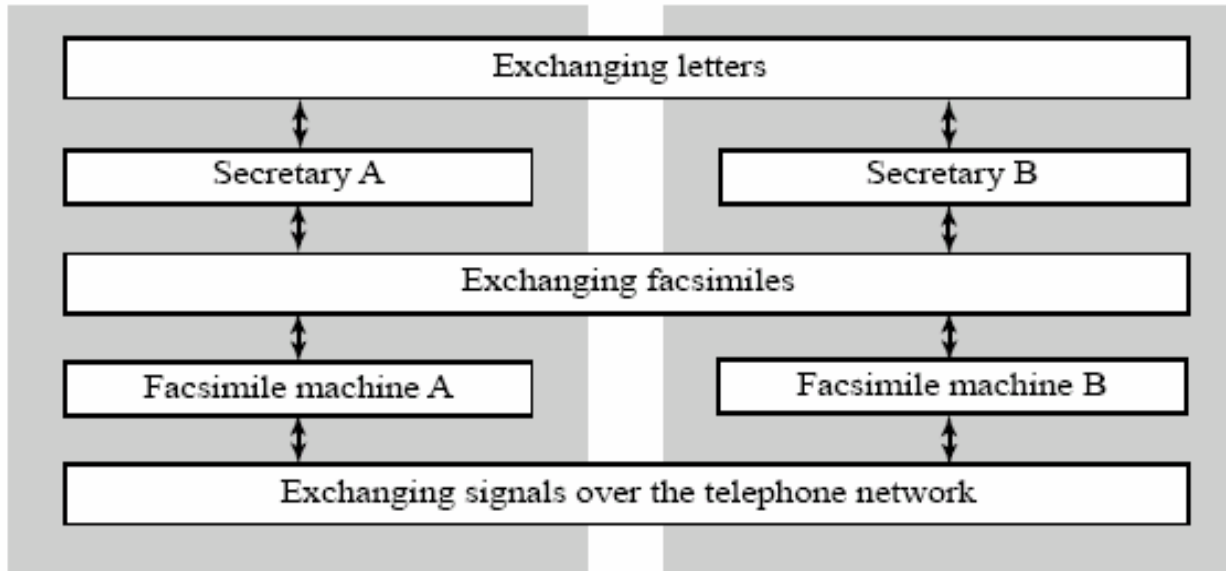
- The idea of creating complex services out of simple ones



- Example: Reliable packet delivery, built on top of error detection/correction codes, and retransmission protocols

Layered Architecture

- A non-technical example: Two managers exchanging letters



- Will spend more time on this later

Reminder

- ECE446-L MAILING LIST
 - Sign up as soon as possible
- ONLINE TEXTBOOK
 - Check email sent by An-swol
- HOMEWORK 1 DUE
 - Office hours 1:00-2:30 Friday Rhodes 362
 - Office hours 1:00-2:30 Monday Rhodes 338 or opposite one