Data Link Control

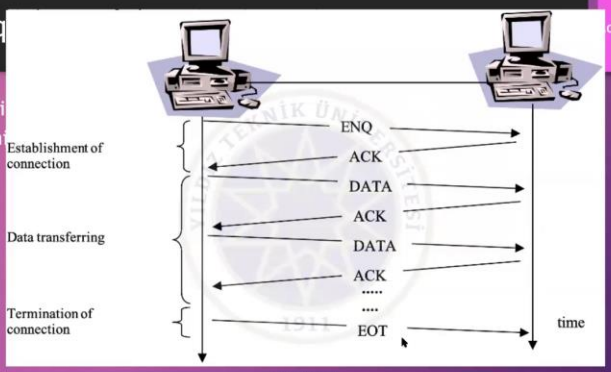
- Basic tasks of the data link layer:
  - Framming and determining of start and end points to ensure synchronization
  - Flow control
  - Error control / Retransmission
  - Addressing
  - Line dicipline / Link management

Enq/Ack (Enquiry/Acknowledgement)

- Point to point (in WANs)
- Units are expected to have equal properties

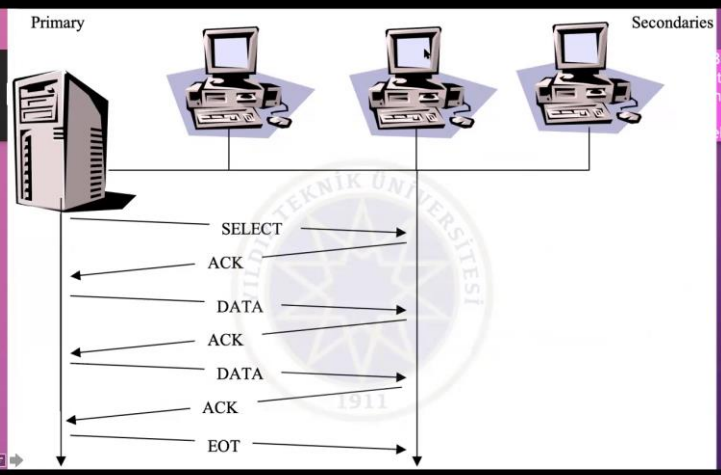
Enq

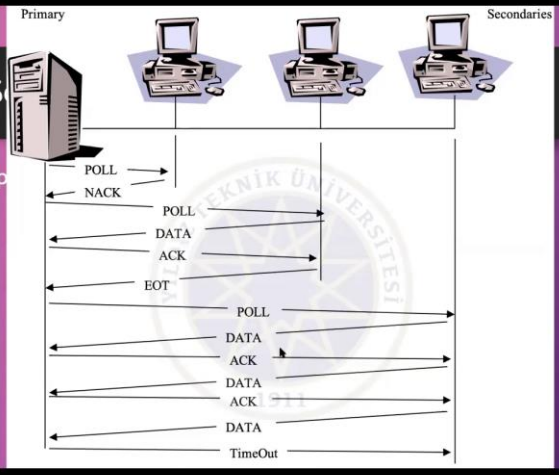
- Poi
- Uni



Poll/Select Connection Management

- Multi-point (in LANs)





Poll/S

- Multi-p

Flow Control

- Overwhelm
- Buffer
- There are two basic techniques:

Stop & Wait

- ACK is required for every transfer.
- Pros:
  - Packages consist of smaller pieces
  - Effective use of buffers
  - Medium is busy for a shorter time
  - Error probability decreases
  - Error control processing times are shortened.
  - Wait time may be shorter for other devices in LANs.

Stop & Wait – Line Utilization (U) Rate

- t_{frame}: Transmission time of a single frame
- t_{prop}: The time it takes from the sender to the receiver
- t_{ack}: The time it takes for all bits of the ACK to exit the receiver
- $T_F = t_{frame} + t_{prop} + t_{ack} + t_{prop}$
- $T_F = t_{frame} + 2t_{prop}$
- $U = \frac{t_{frame}}{t_{frame}+2t_{prop}}$
- $a = \frac{t_{prop}}{t_{frame}} \Longrightarrow U = \frac{1}{1+2a}$
- $t_{prop} = \frac{distance}{velocity} = \frac{d}{v}$ and $t_{frame} = \frac{frameSize}{dataRate} = \frac{L}{R}$

Stop & Wait – Line Utilization (U) Rate – Con't

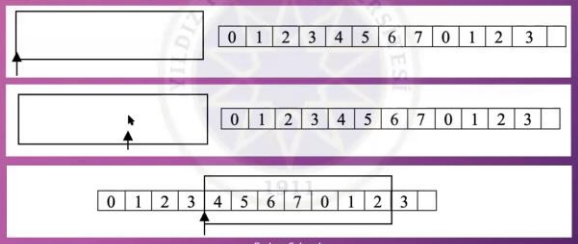
- Example:
  - Data communication is made between two points at a distance of 1000 km (d = 1000 km = 10^6 m) at a speed of 155.52 Mbps (R=155.52 10^6 bit/sec).
  - The transmission speed of the line is 200.000.000 m/sec (V=2 10^8 m/sec).
  - Frame size is 424 bits (L = 424 bit).
  - What is the Line Utilization (U) in Stop & Wait Flow Control mode?
- Answer
  - $a = \frac{t_{prop}}{t_{frame}} \Longrightarrow U = \frac{1}{1+2a}$
  - $t_{prop} = \frac{distance}{velocity} = \frac{d}{v}$ and $t_{frame} = \frac{frameSize}{dataRate} = \frac{L}{R}$

Sliding Window

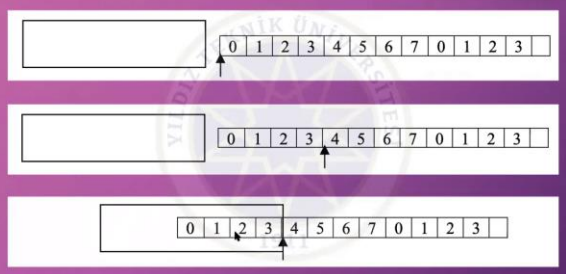
- U rate is low in Stop & Wait
- The sender sends a certain amount of data to the receiver without ACK data.
- Frames are transmitted in convoys.
- The receiver can send ACK data for several frames.
- Frame number is necessary
  - n-bit ⇒ 2^n frame
- Piggy backing

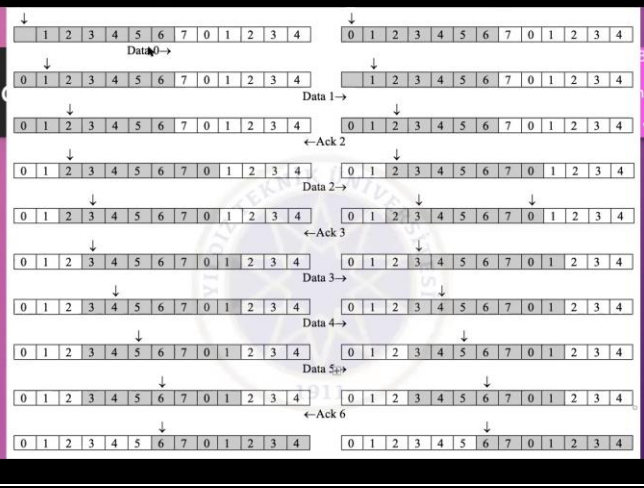
Sliding Window – Sender Side

- Window size: 2^n-1
  - Example: If frame sequence number bit length is n=3, windows size is 2^n-1 = 7

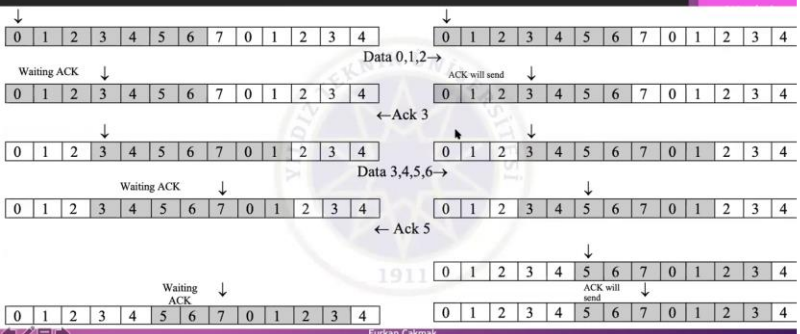


Sliding Window – Receiver Side

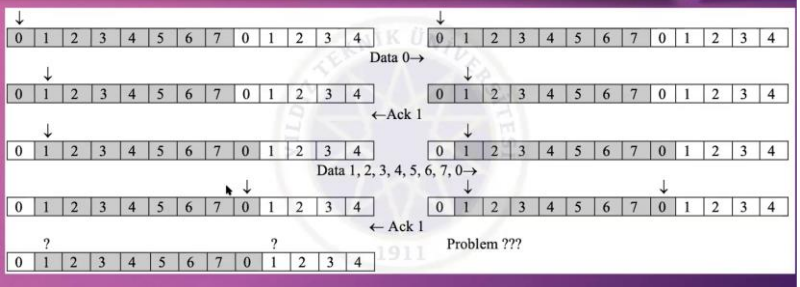




Sliding Window – Both Side Example



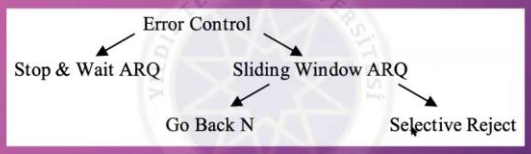
Sliding Window – Window Size 2^n-1



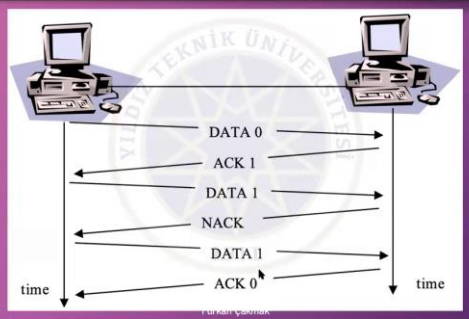
Sliding Window - Line Utilization (U) Rate

- In Stop & Wait $a = \frac{t_{prop}}{t_{frame}}$
- In Sliding Windows $t_{frame} = 1 \Longrightarrow a = t_{prop}$
- If w (window size) ≥ (2a +1)
  - U = %100
- If w < (2a+1)
  - $U = \frac{w}{2a+1}$
- $U = \begin{cases} 1 & w \geq 2a+1 \\ \frac{w}{2a+1} & w < 2a+1 \end{cases}$

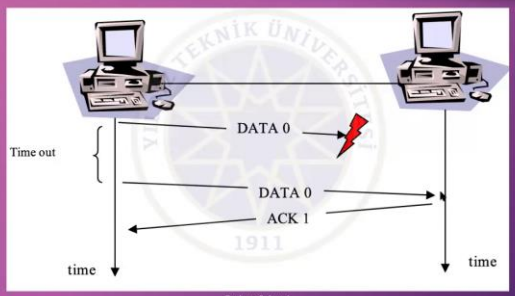
Error Control, Automatic Repeat reQuest (ARQ)



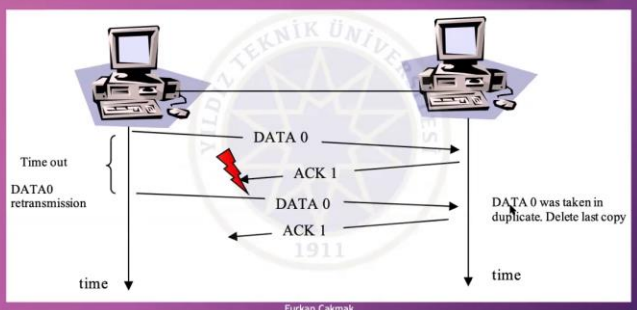
Stop & Wait ARQ



Stop & Wait ARQ



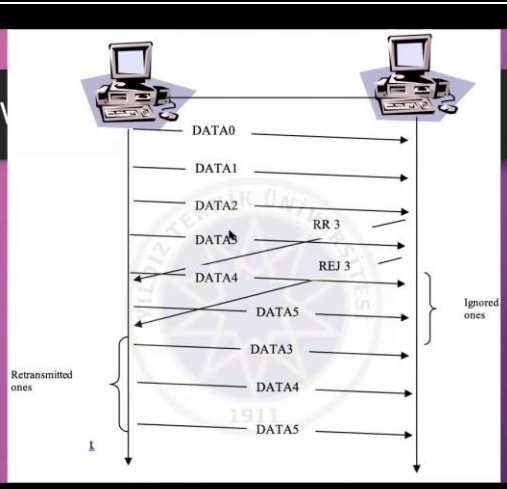
Stop & Wait ARQ

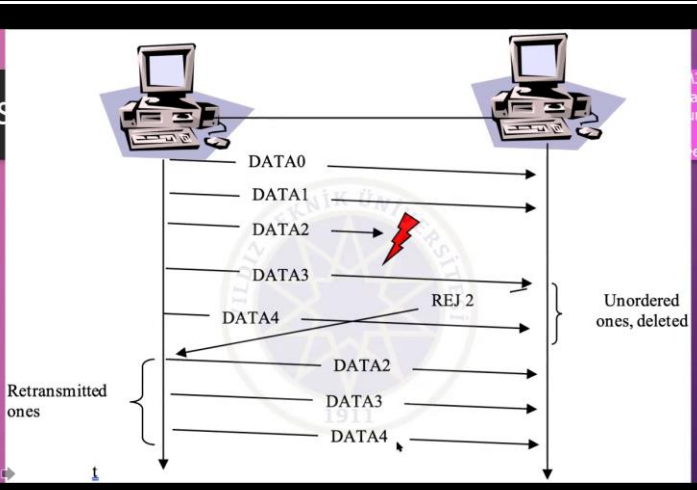


Sliding Window ARQ

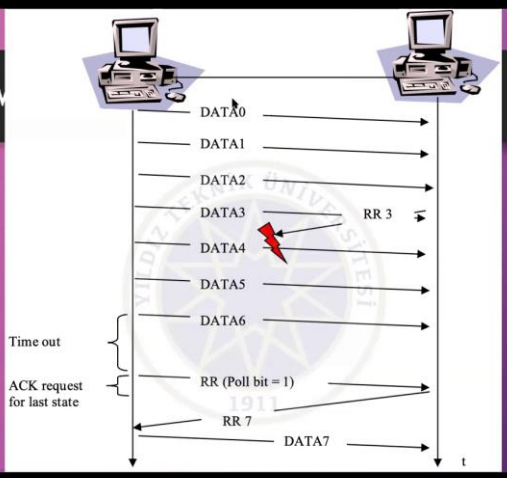
- There are some differences caused by the sliding window technique when the frames inside the window are sent without a receipt.
  - The sender continues to store the frames in the buffer until it receives ACK for the frames.
  - In the ACK / NACK information coming from the receiver, there will be a number field showing which numbered frame it is for.
  - Receive Ready
    - RR 3 and RR 6 means: I have received 3, 4, 5 numbered frames, waiting for frame 6.
  - Each faulty frame is immediately reported by the receiver to the sender.
    - REJ - Reject
    - SREJ - Selective Reject
  - The sender also has a timer in the sliding window approach.
    - Lost data frame
    - Lost acknowledge frame

Sliding W





Sliding W

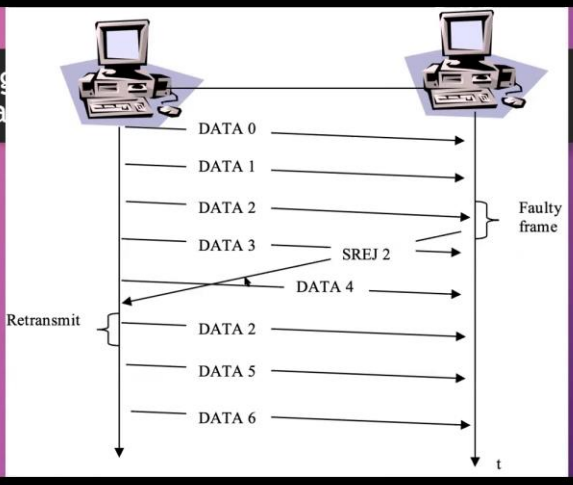


Sliding Window - Selective Reject / Selective Repeat ARQ

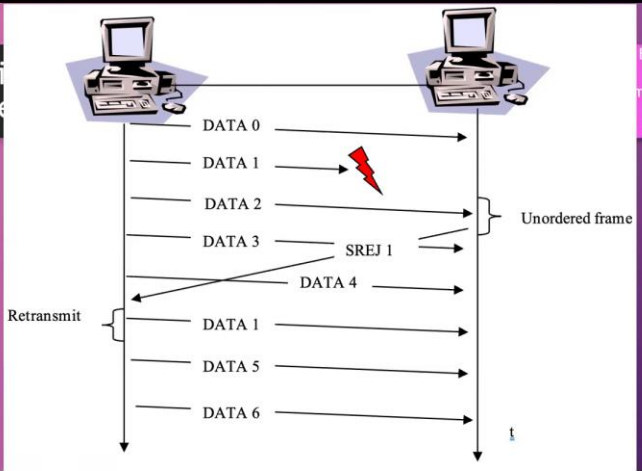
- In this technique, the receiver will receive the frames unordered.
  - Search and Sort Algorithms are necessary.
  - Processing complexity increases
    - In Go Back n: $w = (2^n-1)$
    - In Selective Reject: $w \leq (2^n+1)/2$
  - SREJ
  - The receiver accepts frames without error after faulty frame.
  - Frames will come in different order due to faulty frames.
    - Duplicated ones

Furkan Çakmak

Sliding Repea



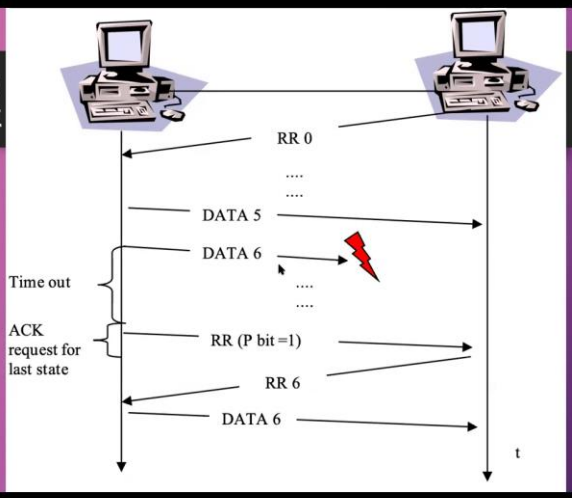
Slidi Repe



Sliding Repeat

BLM3051 Data Communication

Week 6



Sliding Repeat

BLM3051 Data Communication

Week 6