Open system Interconnection (OSI)

DataLink Layer

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Selective Repeat Protocol-

- Selective Repeat protocol or SR protocol is an implementation of a sliding window protocol.
- The features and working of this protocol are explained in the following points-
  - **In SR protocol, sender window size is always same as receiver window size.**
  - **In SR protocol,**
    - Sender window size = Receiver window size
    - The size is of course greater than 1 otherwise the protocol will become Stop and Wait ARQ
    - If n bits are available for sequence numbers, then-
    - Sender window size = Receiver window size = $2^n/2 = 2^{n-1}$

Selective Repeat Protocol-

- SR protocol uses independent acknowledgments only.
  - Receiver acknowledges each frame independently.
  - As receiver receives a new frame from the sender, it sends its acknowledgment.
- SR protocol does not accept the corrupted frames but does not silently discard them.
  - If receiver receives a frame that is corrupted, then it does not silently discard that frame.
  - Receiver handles the situation efficiently by sending a negative acknowledgment (NACK).
  - Negative acknowledgment allows early retransmission of the corrupted frame.
  - It also avoids waiting for the time out timer to expire at the sender side to retransmit the frame.

Selective Repeat Protocol

- SR protocol accepts the out of order frames.
  - Consider receiver receives a frame whose sequence number is not what the receiver expects.
  - Then, it does not discard that frame rather accepts it and keeps it in its window.
- SR protocol requires sorting at the receivers side.
  - Receiver window is implemented as a linked list.
  - When receiver receives a new frame, it places the new frame at the end of the linked list.
  - When the received frames are out of order, receiver performs the sorting.
  - Sorting sorts the frames in the correct order.

Selective Repeat Protocol

- SR protocol requires searching at the senders side.
  - Receiver does not reject the out of order frames.
  - Receiver accepts the out of order frames and sort them later.
  - Thus, only the missing frame has to be sent by the sender.
  - For sending the missing frame, sender performs searching and finds the missing frame.
  - Then, sender selectively repeats that frame.
  - Thus, only the selected frame is repeated and not the entire window.
  - That is why, the protocol has been named as Selective Repeat Protocol.
- SR protocol leads to retransmission of lost frames after expiry of time out timer.
  - Consider a frame being sent to the receiver is lost on the way.
  - Then, it is retransmitted only after time out timer expires for that frame at senders side.

Selective Repeat Protocol

- **Efficiency of SR Protocol**- Efficiency of any flow control protocol is given by-
  Efficiency = Sender Window Size in Protocol / (1 + 2a)
- In selective repeat protocol, if sender window size = N, then-
  Efficiency of SR Protocol = N / (1 + 2a)

PRACTICE PROBLEMS BASED ON SELECTIVE REPEAT PROTOCOL

Q1 The maximum window size for data transmission using the selective repeat protocol with n bit frame sequence numbers is-

- **Solution:** We know-
  - With n bits, total number of sequence numbers possible $= 2^n$.
  - In SR Protocol, **sender window size = receiver window size = W (say)**
  - **Min Available Sequence Numbers = Sender window size + Receiver window size**
  - So we have-
    $2^n = \mathbf{W + W}$
    $2^n = \mathbf{2W}$
  - $\mathbf{W} = 2^{n-1}$
  - Therefore, maximum window size possible of sender and receiver $= 2^{n-1}$

Q2 In SR protocol, suppose frames through 0 to 4 have been transmitted. Now, imagine that 0 times out, 5 (a new frame) is transmitted, 1 times out, 2 times out and 6 (another new frame) is transmitted. At this point, what will be the outstanding packets in senders window?

- **Solution:** In SR Protocol, only the required frame is retransmitted and not the entire window.
  - Step-01: Frames through 0 to 4 have been transmitted- **4 , 3 , 2 , 1 , 0**
  - Step-02: 0 times out. So, sender retransmits it- **0 , 4 , 3 , 2 , 1**
  - Step-03: 5 (a new frame) is transmitted- **5 , 0 , 4 , 3 , 2 , 1**
  - Step-04: 1 times out. So, sender retransmits it- **1 , 5 , 0 , 4 , 3 , 2**
  - Step-05: 2 times out. So, sender retransmits it- **2 , 1 , 5 , 0 , 4 , 3**
  - Step-06: 6 (another new frame) is transmitted- **6 , 2 , 1 , 5 , 0 , 4 , 3**

Q3 The selective repeat protocol is similar to Go back N except in the following way-

1. Frame Formats are similar in both the protocols
2. The sender has a window defining maximum number of outstanding frames in both the protocols
3. Both uses piggybacked acknowledgments where possible and does not acknowledge every frame explicitly.
4. Both uses piggyback approach that acknowledges the most recently received frame

- **Solution:-**
  1. Both the protocols use the same frame formats because both are sliding window protocols.
  1. The variation occurs only in the coding and implementation.
  2. In both the protocols, sender has a window which defines the maximum number of outstanding frames.

- **Solution:-**
  3. Both the protocols use piggybacked acknowledgments wherever possible.
  3. Sending acknowledgments along with the data are called as piggybacked acknowledgments.
  3. But Go back N protocol uses cumulative acknowledgments and does not acknowledge every frame explicitly.
  3. On the other hand, Selective repeat protocol acknowledges each frame independently.
  4. Both the protocols use piggyback approach.
  4. Go back N acknowledges the most recently received frame by sending a cumulative acknowledgement which includes the acknowledgement for previous packets too if any.
  4. On the other hand, Selective Repeat protocol acknowledges all the frames independently and not only the recently received frame.

Q4 Consider a $128x10^3$ bits/sec satellited communication link with one way propagation delay of 150 msec. Selective Retransmission (repeat) protocol is used on this link to send data with a frame size of 1 KB. Neglect the transmission time of acknowledgment. The minimum number of bits required for the sequence number field to achieve 100

- **Solution:** Given- Bandwidth = $128x10^3$ bits/sec Propagation delay (Tp) = 150 msec Frame size = 1 KB
  Now,
  To achieve 100% utilization, efficiency must be 100%. Efficiency is 100% when sender window size is optimal i.e. 1+2a
- **Calculating Transmission Delay**
  Transmission delay (Tt) $= \frac{Frame\ size}{Bandwidth} = \frac{(1x2^{10}x8bits)}{(128x10^3 bitspersec)}$
- **Calculating Value of a-** a = Tp / Tt= 150 msec / 64 msec
- **Calculating Optimal Sender Window Size**
  Optimal sender window size = 1 + 2a

- **Calculating Number Of Sequence Numbers Required**
  In SR Protocol, sender window size and receiver window size are same.
  So, sender window size = receiver window size = 6
- For any sliding window protocol, minimum number of sequence numbers required
  = Sender window size + Receiver window size = 12
- **Calculating Bits Required in Sequence Number Field-**
  Minimum number of bits required in sequence number field= $\lceil log_2(12) \rceil$=4
- Thus:
  - Minimum number of bits required in sequence number field = 4
  - With 4 bits, number of sequence numbers possible = 16
  - We use only 12 sequence numbers and rest 4 remains unused.

Comparison Table

	Stop and Wait ARQ	Go back N	Selective Repeat	Remarks
Efficiency	1 / (1+2a)	N / (1+2a)	N / (1+2a)	Go back N and Selective Repeat gives better efficiency than Stop and Wait ARQ.
Window Size	Sender Window Size = 1 Receiver Window Size = 1	Sender Window Size = N Receiver Window Size = 1	Sender Window Size = N Receiver Window Size = N	Buffer requirement in Selective Repeat is very large. If the system does not have lots of memory, then it is better to choose Go back N.
Minimum number of sequence numbers required	2	N+1	2 x N	Selective Repeat requires large number of bits in sequence number field.
Retransmissions required if a packet is lost	Only the lost packet is retransmitted	The entire window is retransmitted	Only the lost packet is retransmitted	Selective Repeat is far better than Go back N in terms of

Comparison Table

Bandwidth Requirement	Bandwidth requirement is Low	Bandwidth requirement is high because even if a single packet is lost, entire window has to be retransmitted. Thus, if error rate is high, it wastes a lot of bandwidth.	Bandwidth requirement is moderate	Selective Repeat is better than Go back N in terms of bandwidth requirement.
CPU usage	Low	Moderate	High due to searching and sorting required at sender and receiver side	Go back N is better than Selective Repeat in terms of CPU usage.
Level of difficulty in Implementation	Low	Moderate	Complex as it requires extra logic and sorting and searching	Go back N is better than Selective Repeat in terms of implementation difficulty.

Comparison Table

Acknowledgements	Uses independent acknowledgement for each packet	Uses cumulative acknowledgements (but may use independent acknowledgements as well)	Uses independent acknowledgement for each packet	Sending cumulative acknowledgements reduces the traffic in the network but if it is lost, then the ACKs for all the corresponding packets are lost.
Type of Transmission	Half duplex	Full duplex	Full duplex	Go back N and Selective Repeat are better in terms of channel usage.

Conclusions

- Go back N is more often used than other protocols.
- SR protocol is less used because of its complexity.
- Stop and Wait ARQ is less used because of its low efficiency.
- Depending on the context and resources availability, Go back N or Selective Repeat is employed.
- Selective Repeat and Stop and Wait ARQ are similar in terms of retransmissions.
- Go back N and Selective Repeat are similar in terms of efficiency if sender window sizes are same.
- SR protocol may be considered as a combination of advantages of Stop and Wait ARQ and Go back N.
- SR protocol is superior to other protocols but because of its complexity, it is less used.

Important Notes:

- Protocols at data link layer like HDLC (Low level protocols) use Go back N.
- This is because:
  - Bandwidth is high
  - CPU is very busy doing routing job
  - Error rate is low since out of order packets are not possible in wired medium
- Protocols at transport layer like TCP (High level protocols) use selective repeat.

Q1 If the bandwidth between the sender and receiver is sufficient, CPU and buffers are moderate, then which flow control protocol would you suggest to use?

- **Solution:** The suggested protocol would be Go back N.

Important Notes:

Q2 If the bandwidth between the sender and receiver is moderate, CPU and buffers are sufficient, then which flow control protocol would you suggest to use?

- **Solution** The suggested protocol would be Selective Repeat

Thank You