2. INTRODUCTION TO DISTRIBUTED SYSTEMS

Network Distributed Systems

ROAD MAP

- Fundamentals of DSs
- Basic Communication Protocols
  - ARQs
  - Medium Access Control

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WHAT IS A DISTRIBUTED SYSTEM?

A collection of independent computers that appear to the users of the system as a single computer.

Tanenbaum

EXAMPLES OF DSS

Cluster: “A type of parallel or distributed processing system, which consists of a collection of interconnected stand-alone computers cooperatively working together as a single, integrated computing resource” [Buyya].

Grid: “A type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed autonomous resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements” [Buyya].

NETWORKS VS DS

Networks: A media for interconnecting local and wide area computers and exchange messages based on protocols. Network entities are visible and they are explicitly addressed (IP address).

Distributed System: existence of multiple autonomous computers is transparent

However,many problems (e.g., openness, reliability) in common, but at different levels.

> Networks focuses on packets, routing, etc., whereas distributed systems focus on applications.
>
> Every distributed system relies on services provided by a computer network.

WHY DO WE NEED DS?

Functional Separation:

- Existence of computers with different capabilities and purposes:
  - Clients and Servers
  - Data collection and data processing

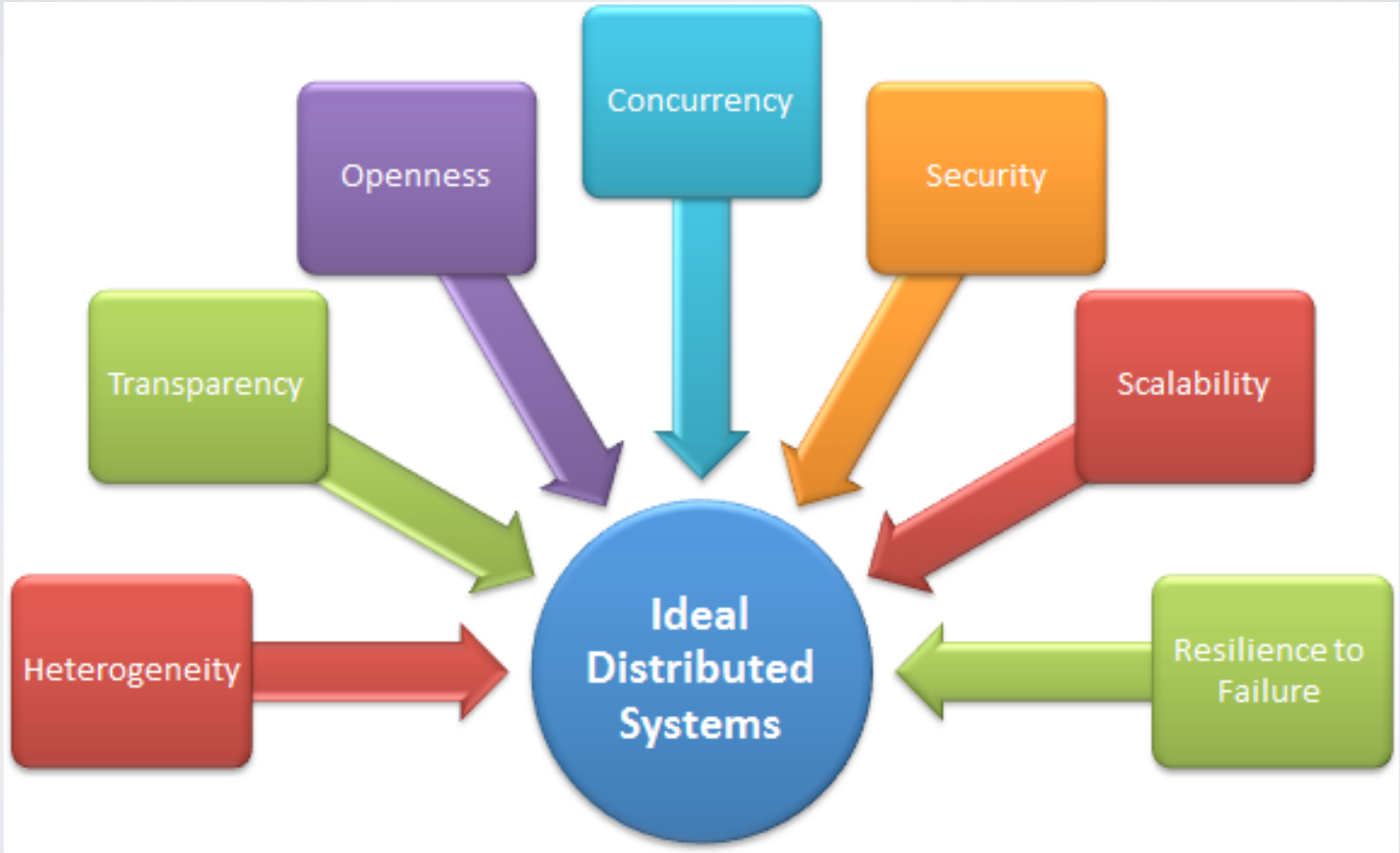
Inherent distribution:

- Information:
  - Different information is created and maintained by different people (e.g., Web pages)
- People
  - Computer supported collaborative work (virtual teams, engineering, virtual surgery)
- Retail store and inventory systems for supermarket chains (e.g., tesco, dunnes)

WHY DO WE NEED DS?

- **Power imbalance and load variation**:
  Distribute computational load among different computers.
- **Reliability**:
  Long term preservation and data backup (replication) at different locations.
- **Economies:**
  Sharing a printer by many users and reduce the cost of ownership.
  Building a supercomputer out of a network of computers.

CHARACTERISTICS OF DS



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RELIABLE TRANSMISSION

Why?

- Frame can be corrupted and lost
- CRCs are not enough - CRCs don't correct errors

Two fundamental mechanisms

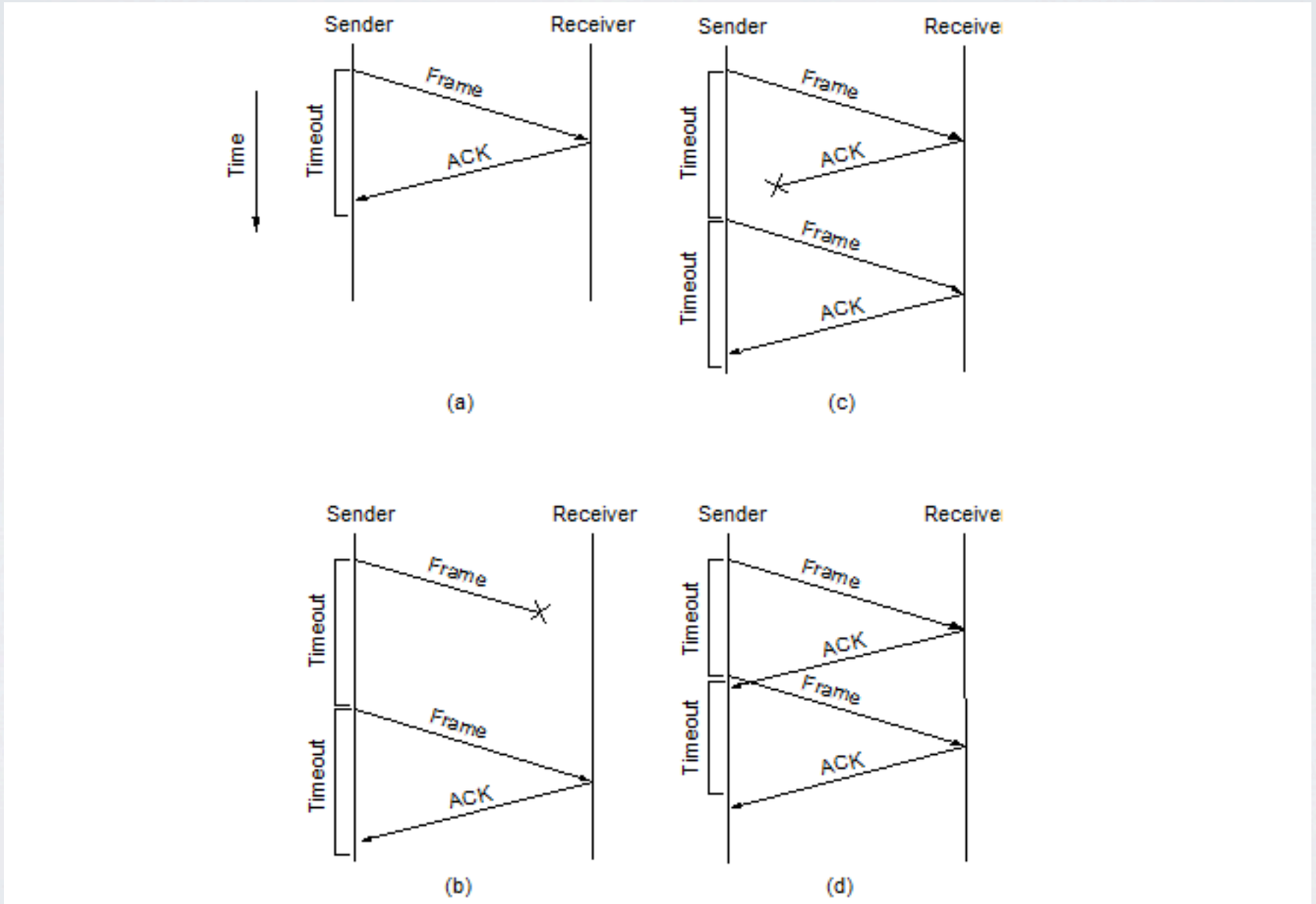
- Acknowledgment
- Timeout

General idea is called ARQ (Automatic Repeat Request)

AUTOMATIC REPEAT REQUEST PROTOCOLS

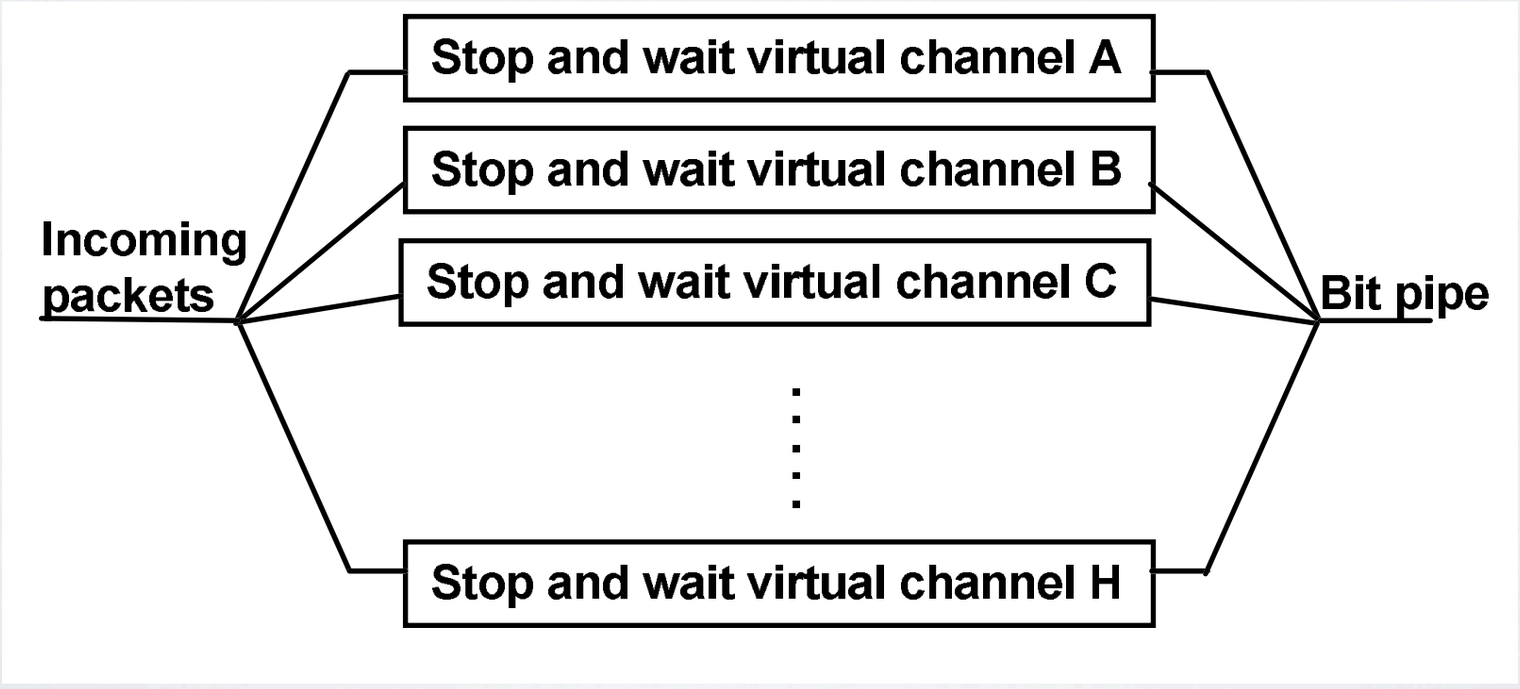
- Causes of message loss
  - Buffer overflow
  - Error detection in a pkt
- ARQ Protocols
  - Stop & Wait
  - Arpanet
  - Go back *n*
  - Selective Repeat

STOP & WAIT ARQ

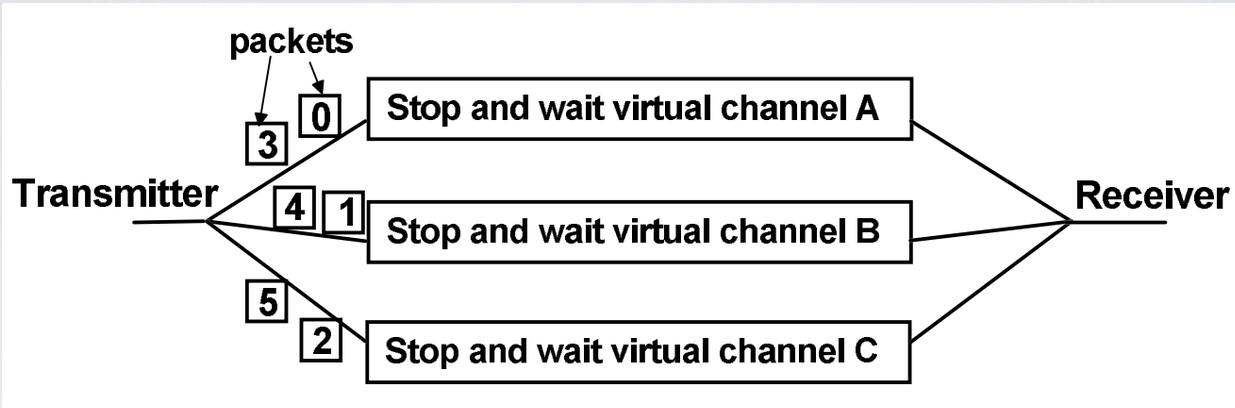


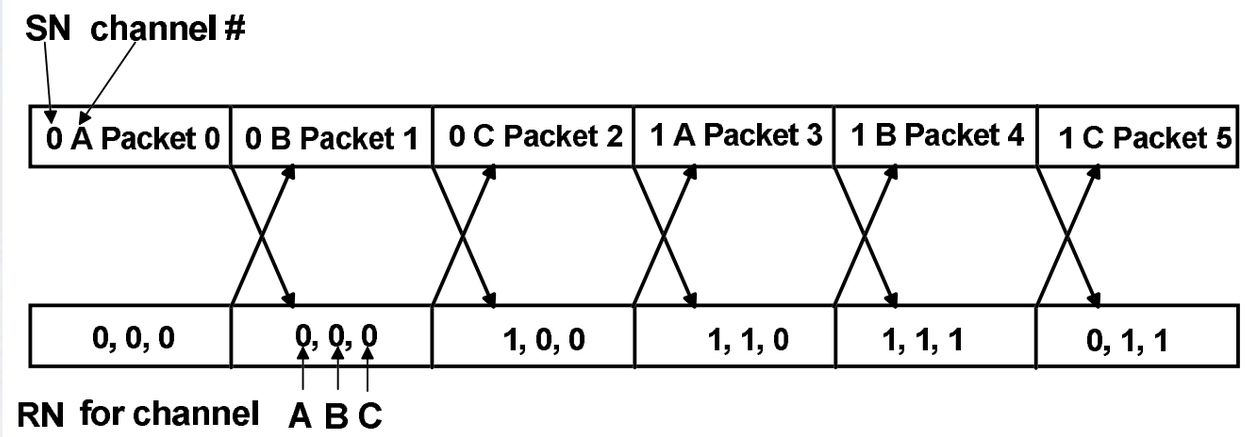
ARPANET ARQ

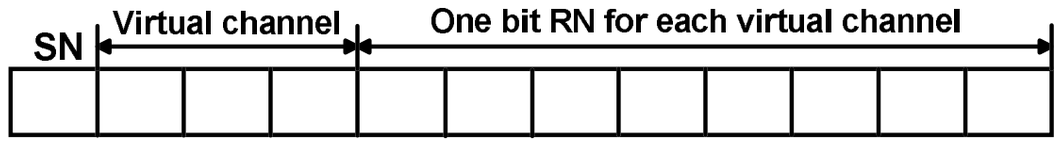
- Better line utilisation
- Unlimited memory required in theory
- Packets are assigned to one of 8 virtual channels which are served in a round robin order
- If the virtual channel's turn comes before an ACK for the virtual channel is received, the packet is retransmitted

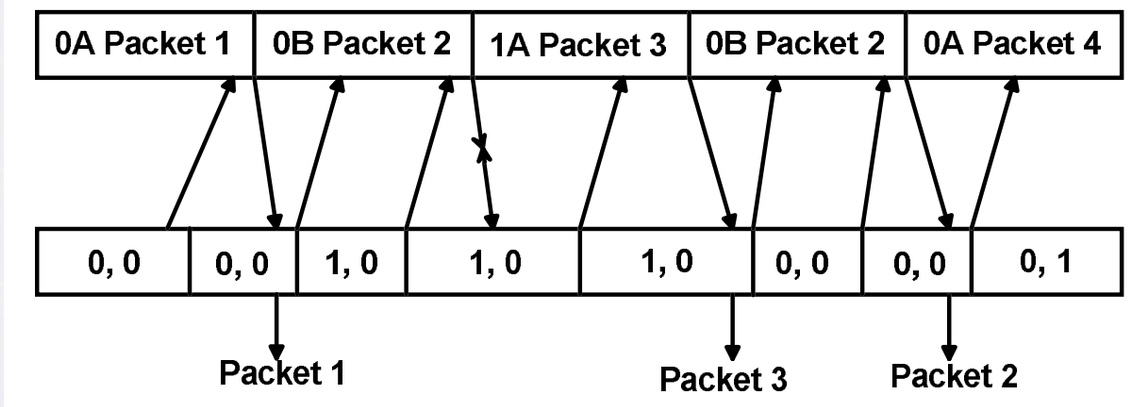


ARPANET

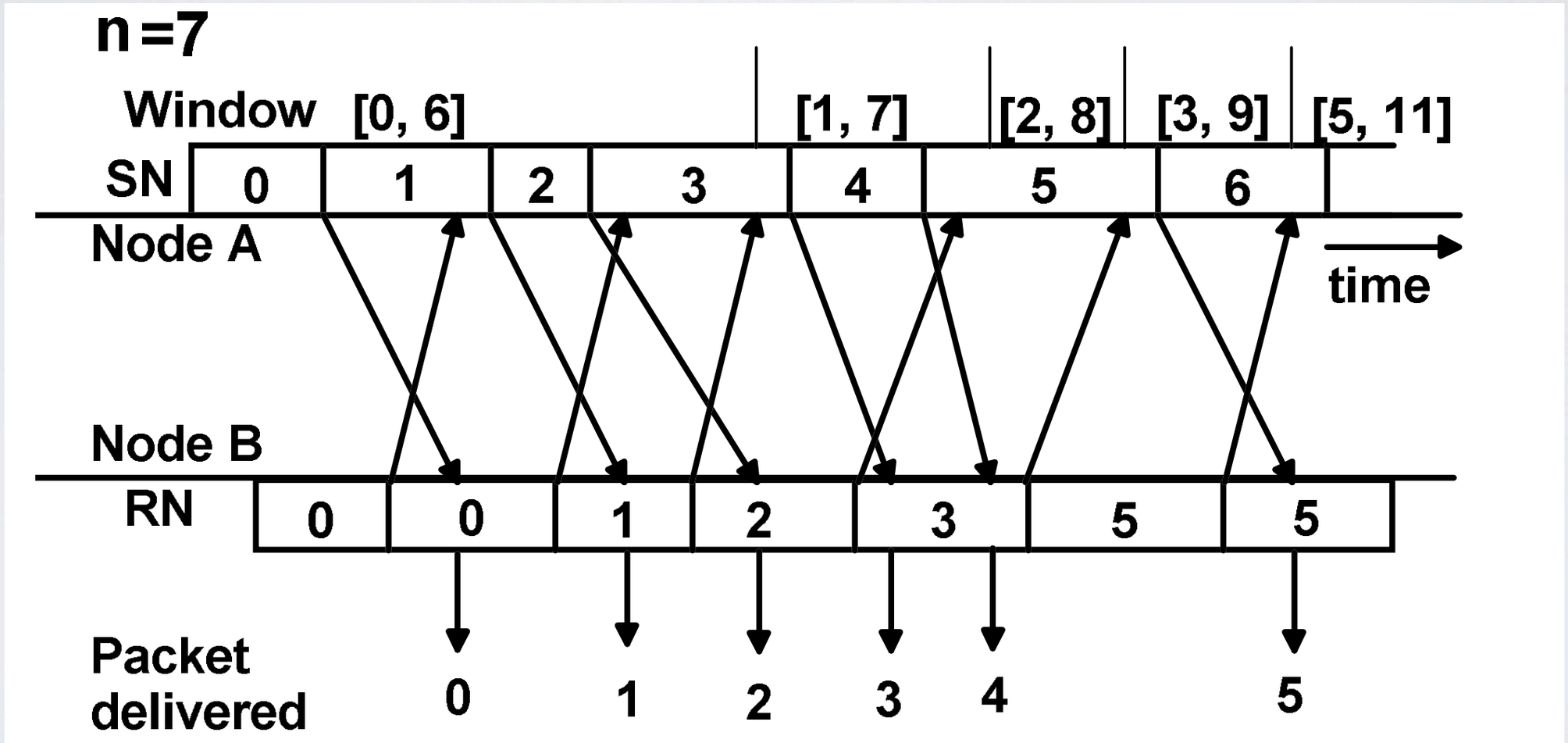

packets
3
0
4
1
5
2
Transmitter
Stop and wait virtual channel A
Stop and wait virtual channel B
Stop and wait virtual channel C
Receiver


SN
channel #
0 A Packet 0
0 B Packet 1
0 C Packet 2
1 A Packet 3
1 B Packet 4
1 C Packet 5
0, 0, 0
0, 0, 0
1, 0, 0
1, 1, 0
1, 1, 1
0, 1, 1
RN for channel A B C


SN
Virtual channel
One bit RN for each virtual channel

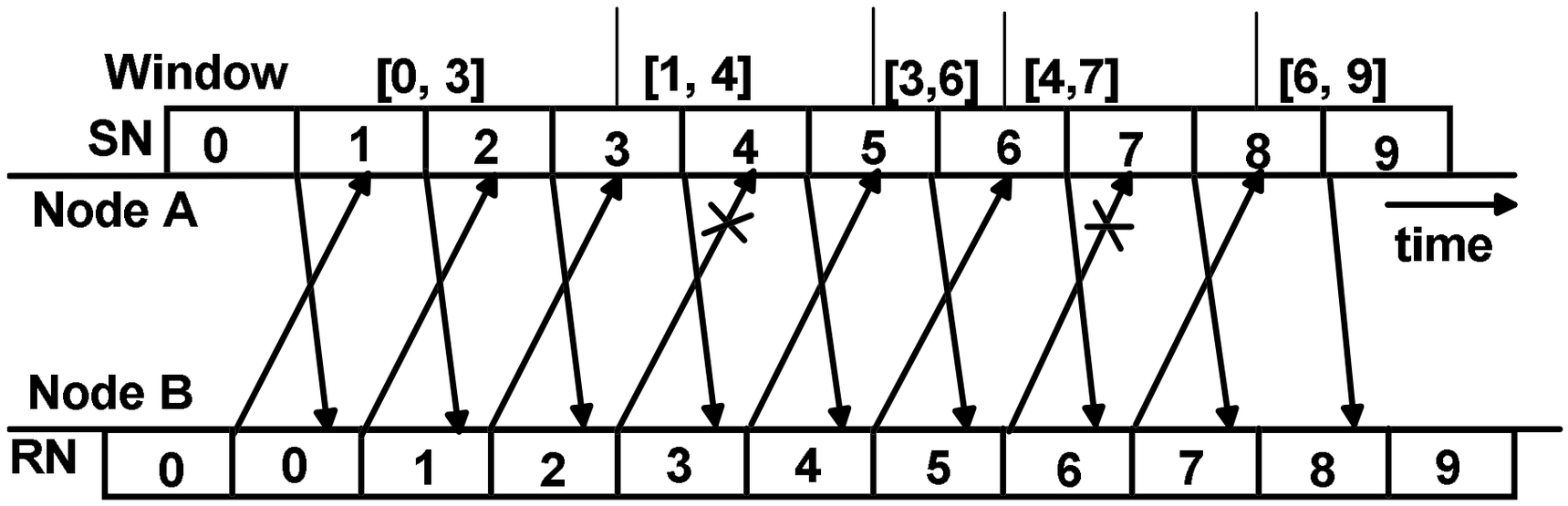

0A Packet 1
0B Packet 2
1A Packet 3
0B Packet 2
0A Packet 4
0, 0
0, 0
1, 0
1, 0
1, 0
0, 0
0, 0
0, 1
Packet 1
Packet 3
Packet 2

GO BACK N


n=7
Window
[0, 6]
[1, 7]
[2, 8]
[3, 9]
[5, 11]
SN
0
1
2
3
4
5
6
Node A
time
Node B
RN
0
0
1
2
3
5
5
Packet delivered
0
1
2
3
4
5

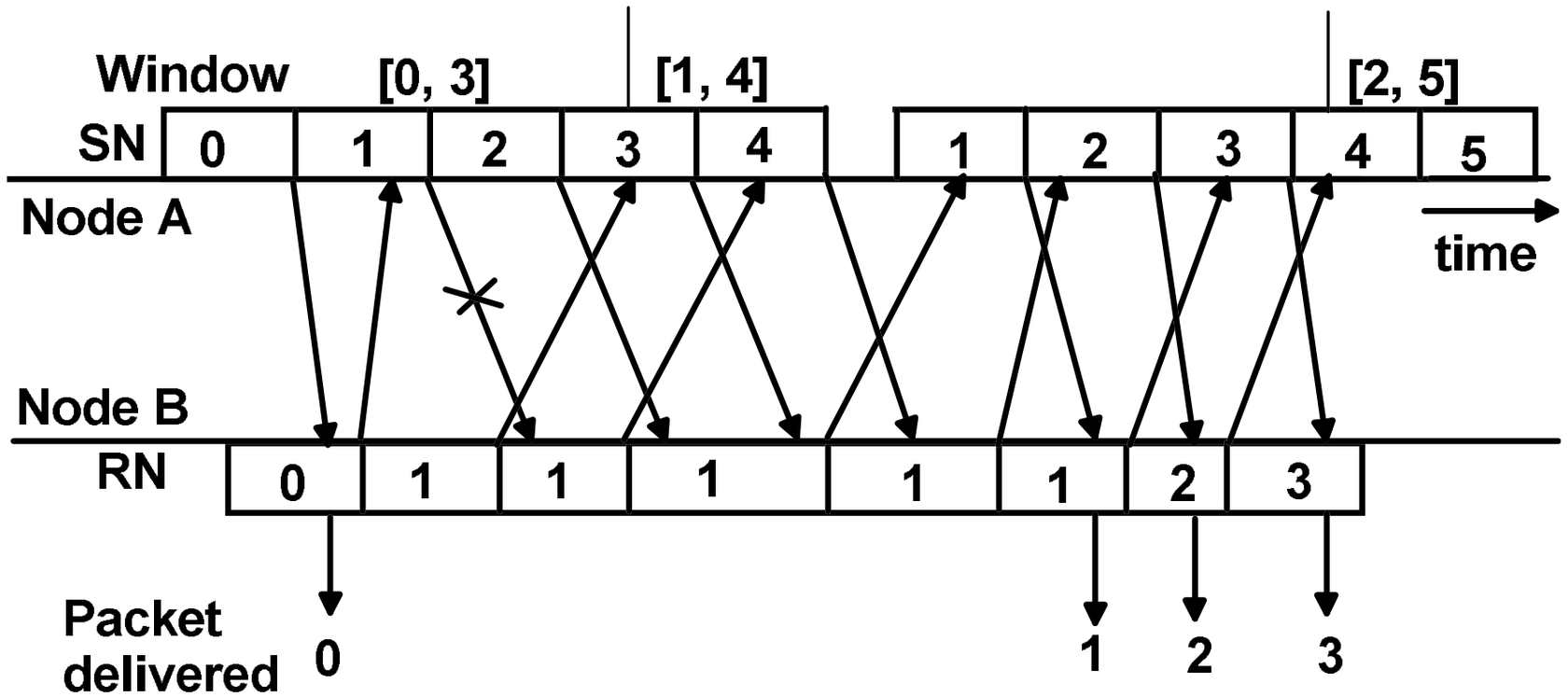
GO BACK N

<u>Example 1</u>: (no retransmissions required due to feedback errors)



GO BACK N

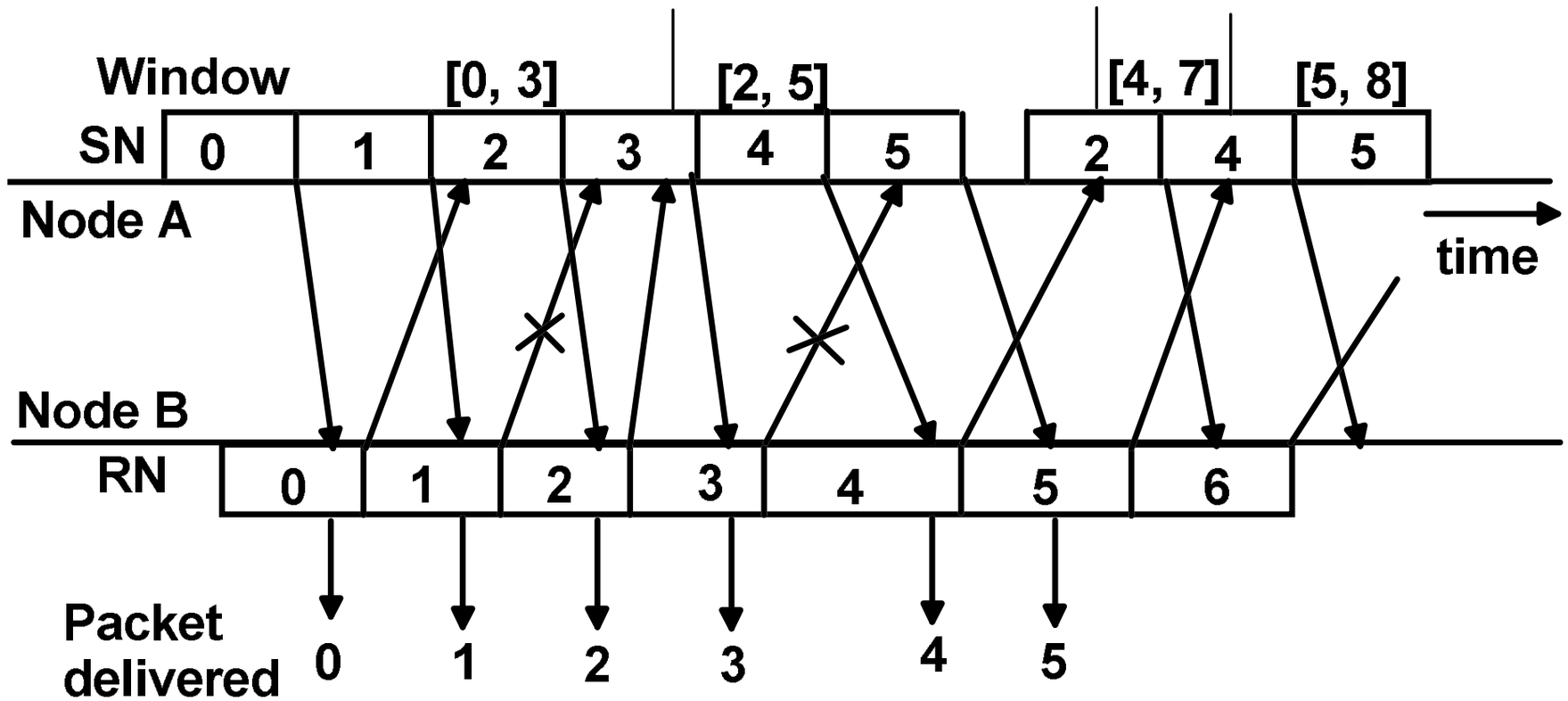
Example 2: (retransmissions because of errors for go back 4)



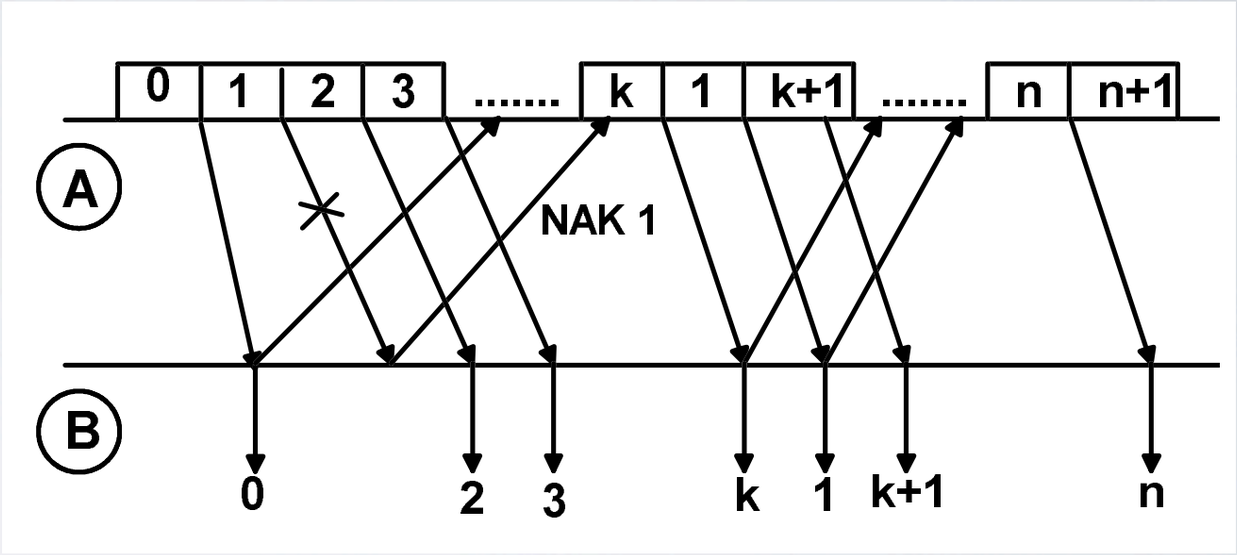
- Good utilisation
- limited memory required (one pkt)
- Full window is retransmitted in case of one error

GO BACK N

<u>Example 3</u>: (retransmissions due to feedback errors for go back n)



SELECTIVE REPEAT ARQ



Sliding window technique (as Go back *n*).

Specifically indicating which packet is missing.

Combines nacks and cumulative acks.

Acks acknowledge all messages with index of up to and including the ack value.

Nacks (negative acknowledgements) specifically request the messages with the indices in the nacks' values.

Limited memory required (a full window).

- http://www.ccs-labs.org/teaching/rn/animations/gbn_sr/

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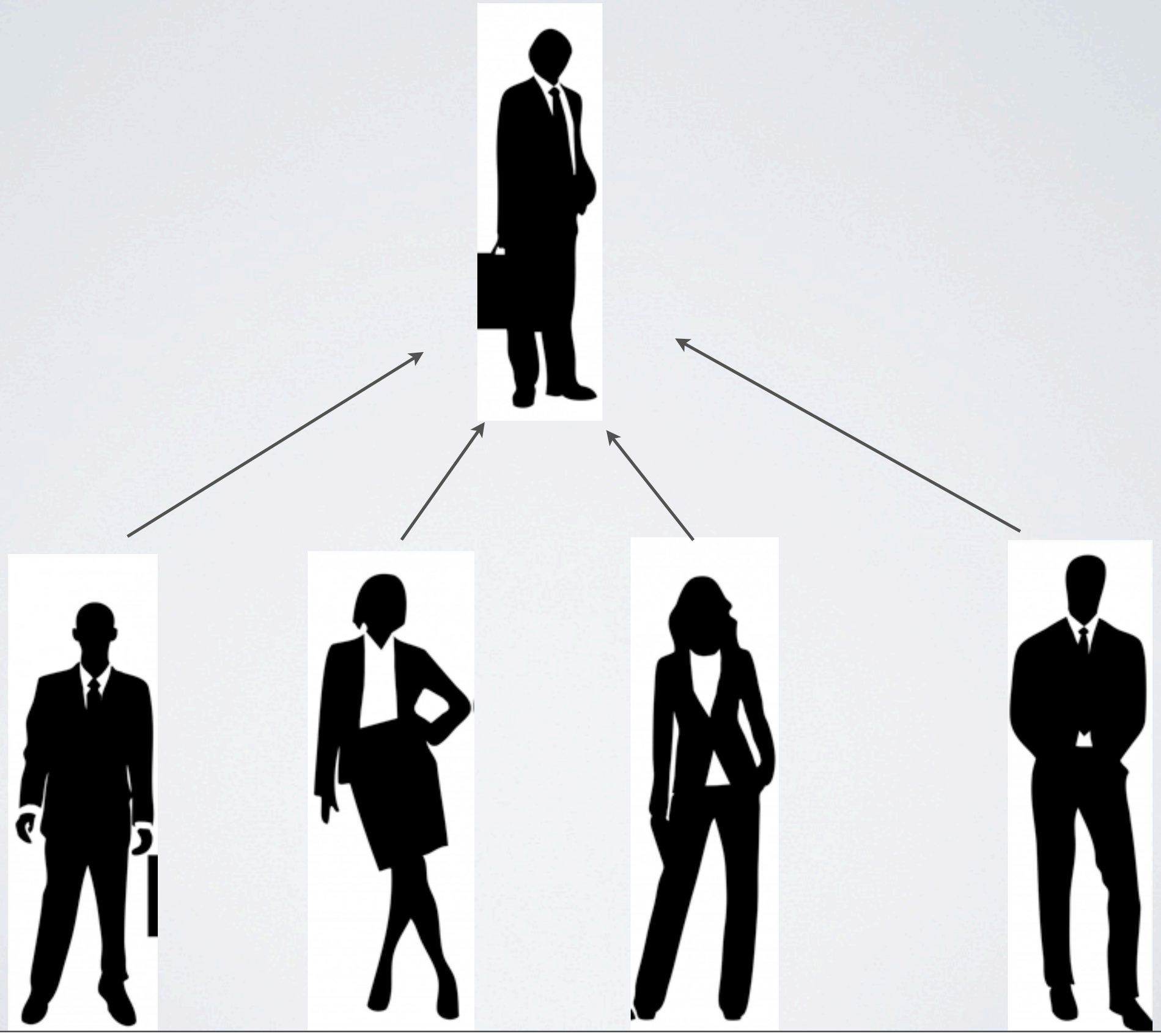
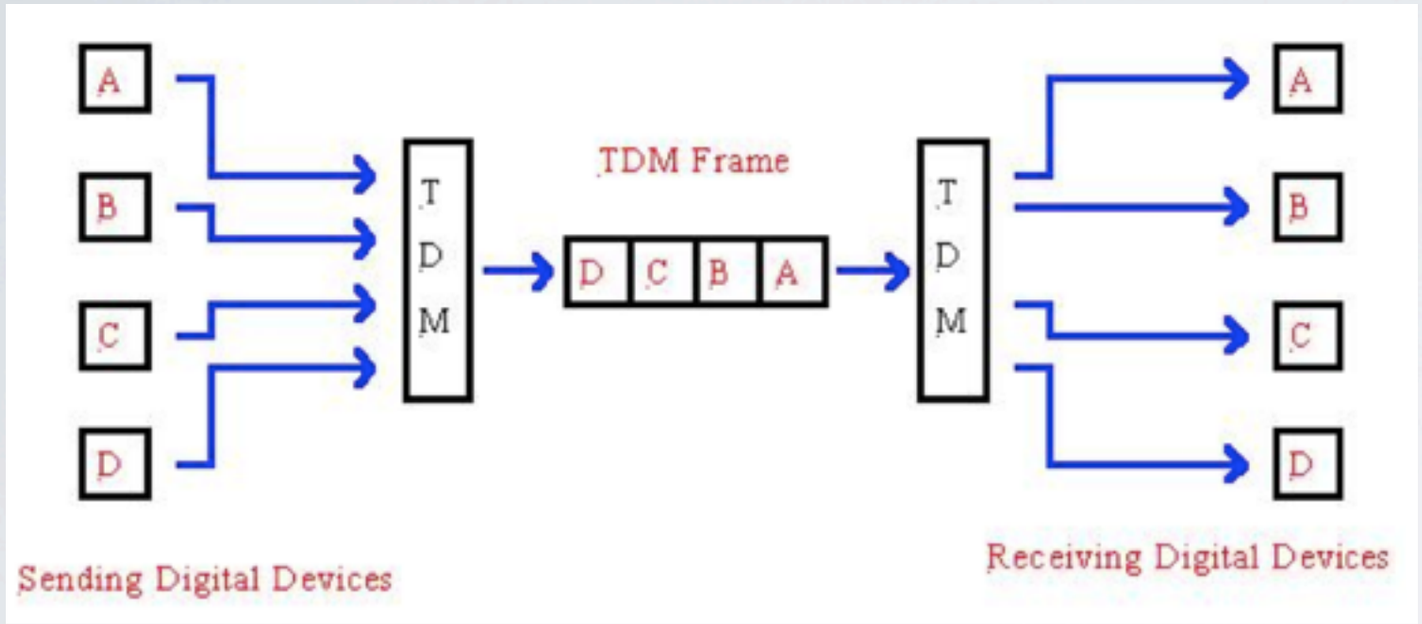
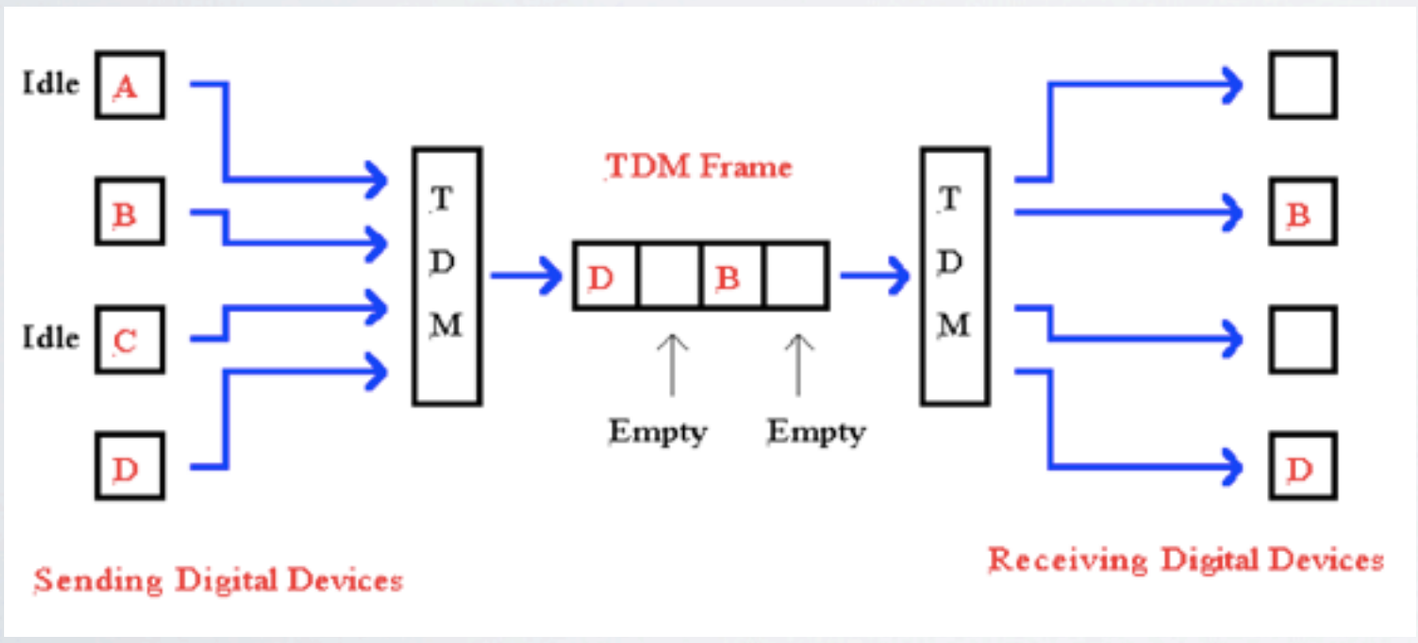
MAC FOR MULTI ACCESS



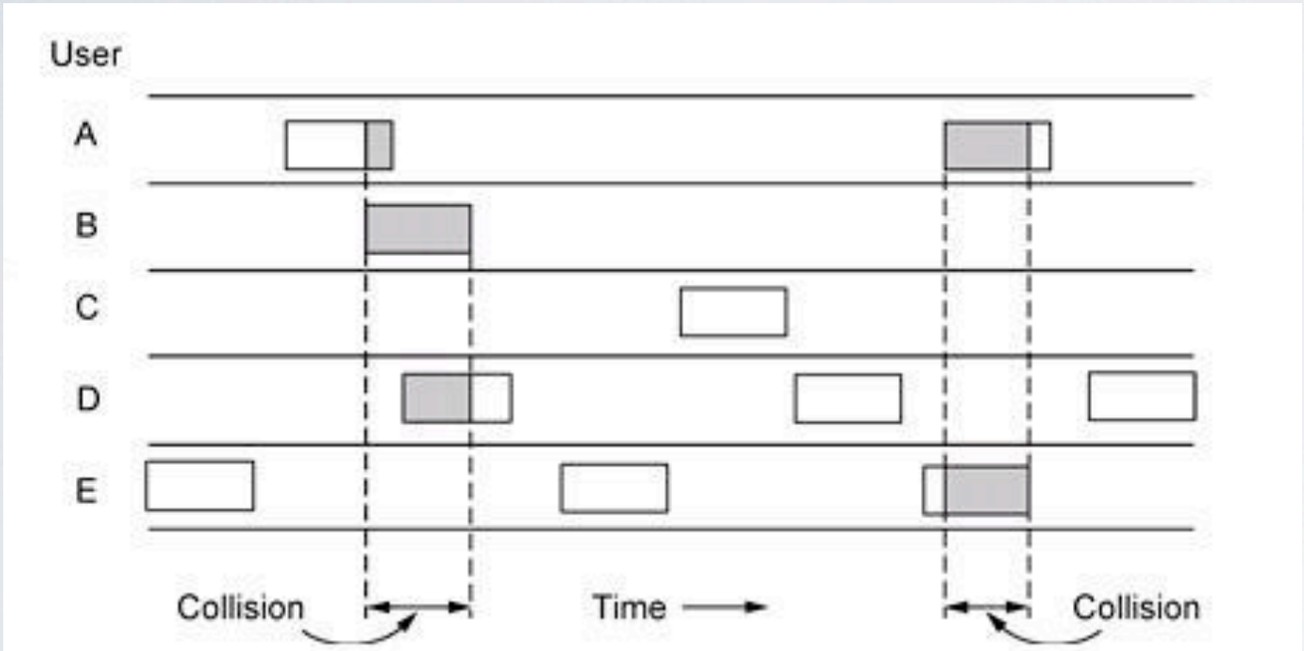
TIME DIVISION MULTIPLEXING





- The best utilisation if everyone always has something to send
- Wastes time otherwise
- Slots can be unevenly assigned to improve efficiency

ALOHA

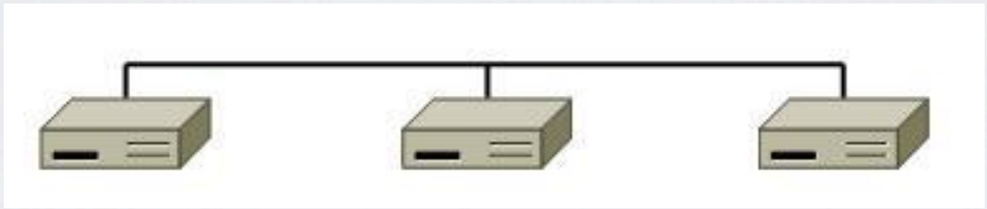


- Send packet immediately
- If collision occurs, back off for a random time, try again
- Simple, works well in load load.
- Improvement: slotted aloha

CSMA

- Improve ALOHA by listening to the medium before we send
  - Easier with wired medium
  - **Does this completely eliminate collisions?**

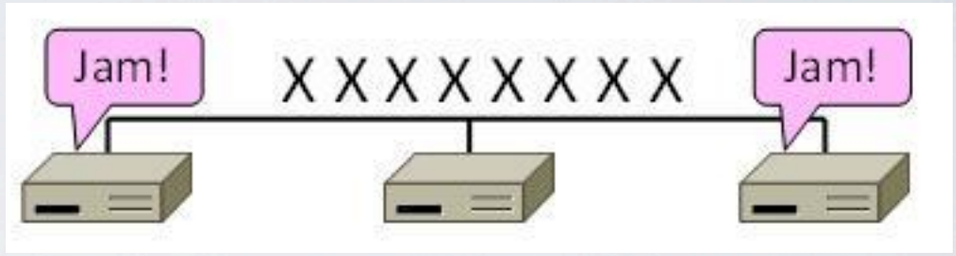
CSMA

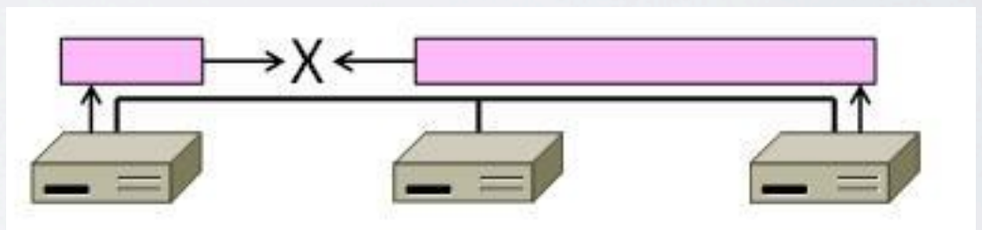


- Propagation delay and simultaneous transmissions can still cause collisions
- Is quite effective when delay and contention is small

CSMA CD

- CSMA with Collision Detection
- Reduces the cost of a collision by detecting it an aborting the frame transmission
- Sends jamming signal to inform everyone that a collision occurred
- Uses minimum frame length (64 bytes) and persistence





CSMA CD BINARY EXPONENTIAL BACKOFF

- Estimates the probability
  - 1st collision - wait 0 or 1 frame time
  - 2nd collision - wait from 0 to 3 times
  - 3rd collision - wait from 0 to 7 times
  - and so on
- BEB doubles interval for each successive collision
  - quickly gets large enough to work
  - very efficient in practice

HTTPS://
WWW.YOUTUBE.COM/
WATCH?V=_AIJV5AQR68