

OUTLINE

NETWORK Basic Definition – Network Elements

QUALITY OF SERVICE Speed – Delay - Error

MECHANISMS

- Multiplexing
- Switching
- Error Control
- Flow Control
- Congestion Control
- Resource Allocation

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NETWORK

BASIC DEFINITION

- Collection of Network Elements organized to support and transfer information from one user of the network to another.

NETWORK ELEMENTS

- Link

Element that transfers a bit stream with specific propagation time **PROP** and at a certain rate **R**.

(Copper Links - Optical Fiber - Wireless Links)

- Switch (Telephone Nets) Router (Computer Nets)

Device that transfers incoming information streams to outgoing information streams.

(Sometimes switches use “buffers” memory elements to store information)

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MECHANISMS

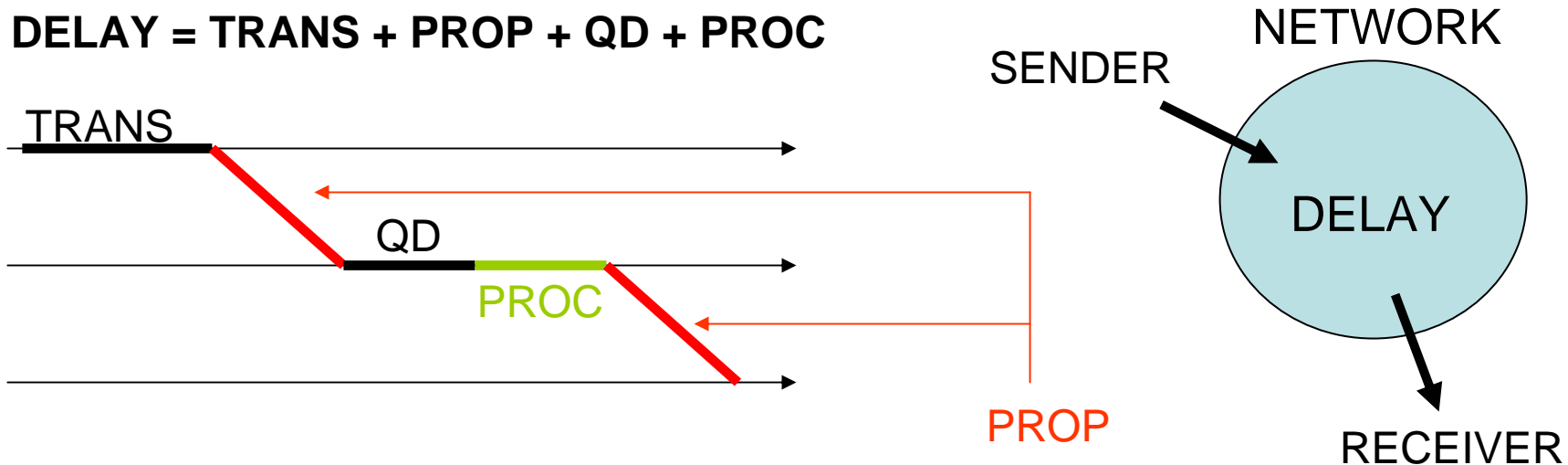
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QUALITY OF SERVICE

TIME DELAY

- The time delay between **sender** and **receiver** inside the network can be calculated by the following sum:

$$\text{DELAY} = \text{TRANS} + \text{PROP} + \text{QD} + \text{PROC}$$



ERRORS

- Errors are any form of distortion in the conveyed information through the network

$$\text{BER} = \text{\#of Erroneous Bits per unit time}$$

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MECHANISMS - MULTIPLEXING

MULTIPLEXING (MUX)

- Merging various bit streams inside the network (**LINKS**) into main stream (**TRUNK**).

Many **LOGICAL** channels are merged to one **PHYSICAL** channel.

DEMULTIPLEXING (DeMUX)

- Separation of a main data stream to many small ones.

Advantages

- Less links less installation cost.
- Less Service costs

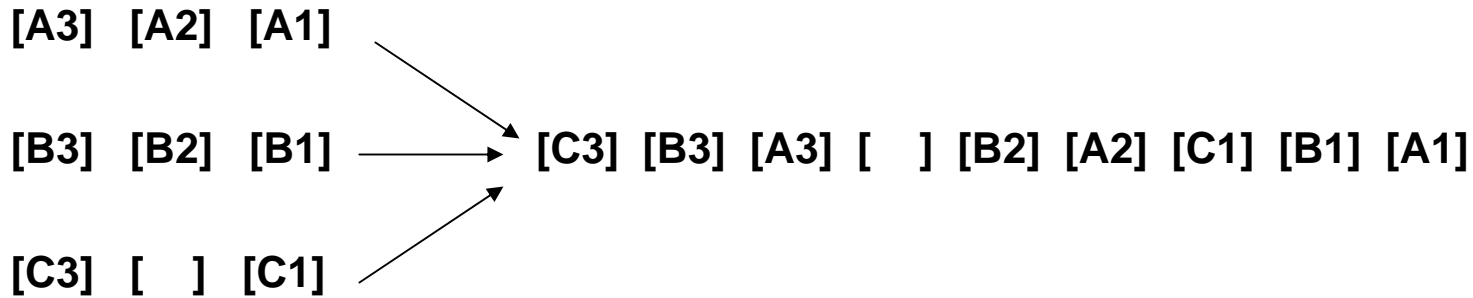
Drawbacks

- More sophisticated hardware (MUX - DeMUX)

MECHANISMS - MULTIPLEXING

TIME DIVISION MULTIPLEXING (TDM)

- Assign to each incoming bit stream **one time slot** per **frame**



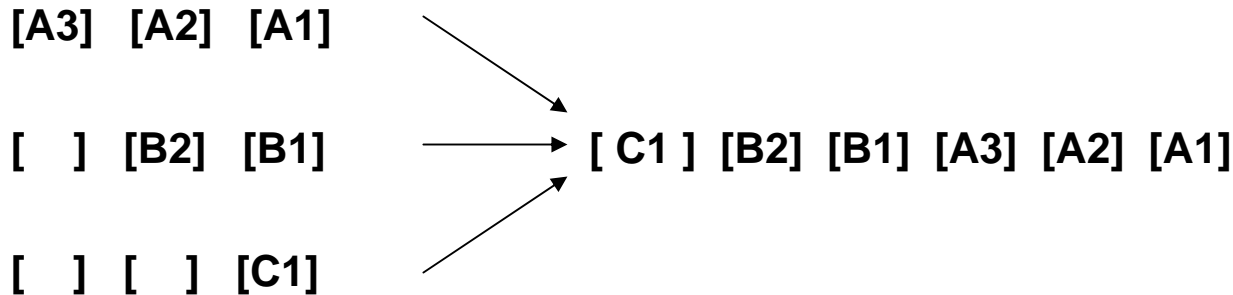
Good for **Constant Bit Rate** incoming traffic **CBR**

Multiplexing Gain = 1

MECHANISMS - MULTIPLEXING

STATISTICAL MULTIPLEXING (SM)

- Assign to each incoming bit stream # **of time slots** per frame **proportional** to the **incoming bit rate**.



Good for Bit Bursts **Variable Bit Rate** incoming traffic **VBR**

Multiplexing Gain > 1

MECHANISMS - MULTIPLEXING

STATISTICAL MUTIPLEXING (SM)

Advantages

- Increased utilization of the trunk.

Disadvantages

- More complex Mux and DeMux devices
- Bigger overheads in the packets than traditional TDM (Identification Purposes)

SERVICES

Traditional TDM

- Telephony
- Real time video Sound (Video Conference)

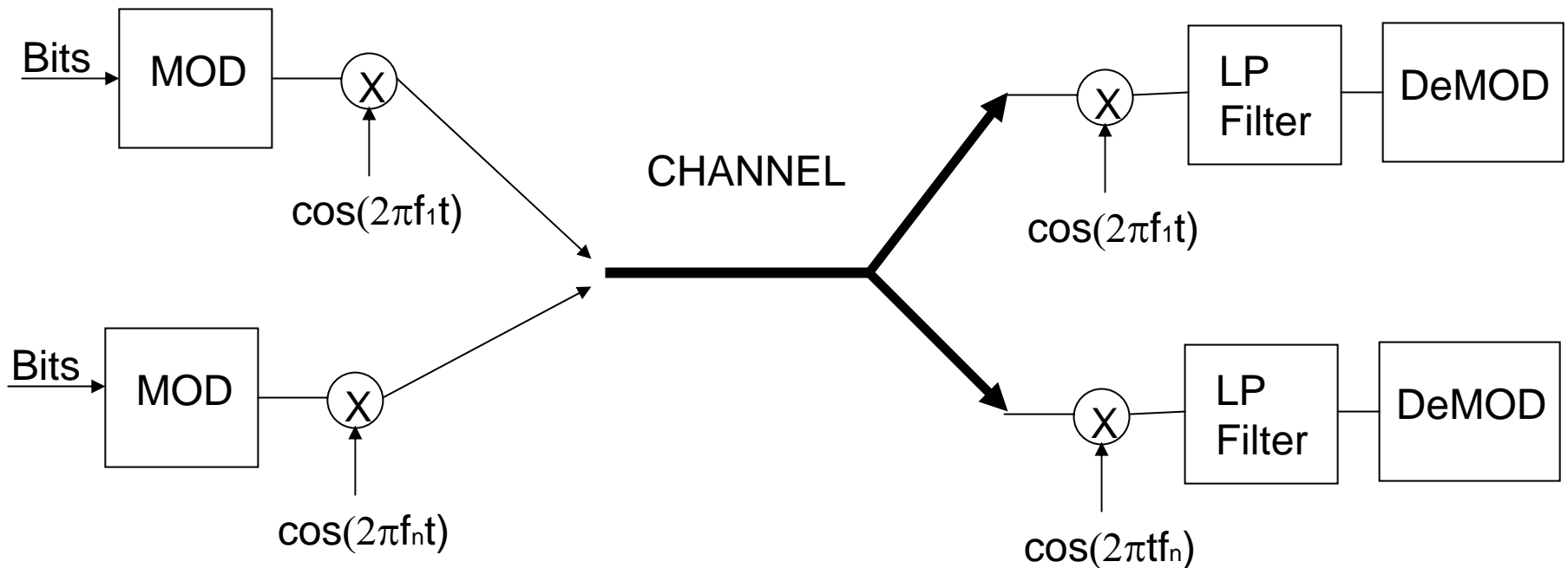
Statistical Multiplexing

- Data transfer
- Not Real time Communication

MECHANISMS - MULTIPLEXING

FREQUENCY DIVISION MULTIPLEXING (FDM)

- Assign to each incoming bit stream one specific **frequency band**



MECHANISMS - MULTIPLEXING

FREQUENCY DIVISION MULTIPLEXING (FDM)

Limitations

- Waste of bandwidth (Guard Bands)
- Interference between neighbor bands (Crosstalk)

Spectral Efficiency

Ratio of the **Rate (R)** divided by the **Bandwidth (B)** used

Normally between 0.5 to 0.8

Good modulation schemes can increase the spectral efficiency.

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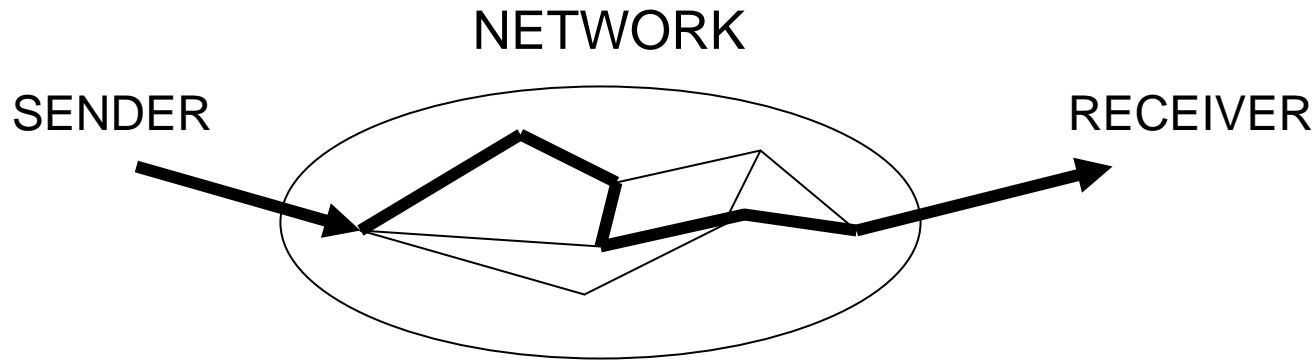
MECHANISMS

- Multiplexing
- **Switching**
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MECHANISMS - SWITCHING

CIRCUIT SWITCHING

The information stream follows a **FIXED ROUTE** inside the network



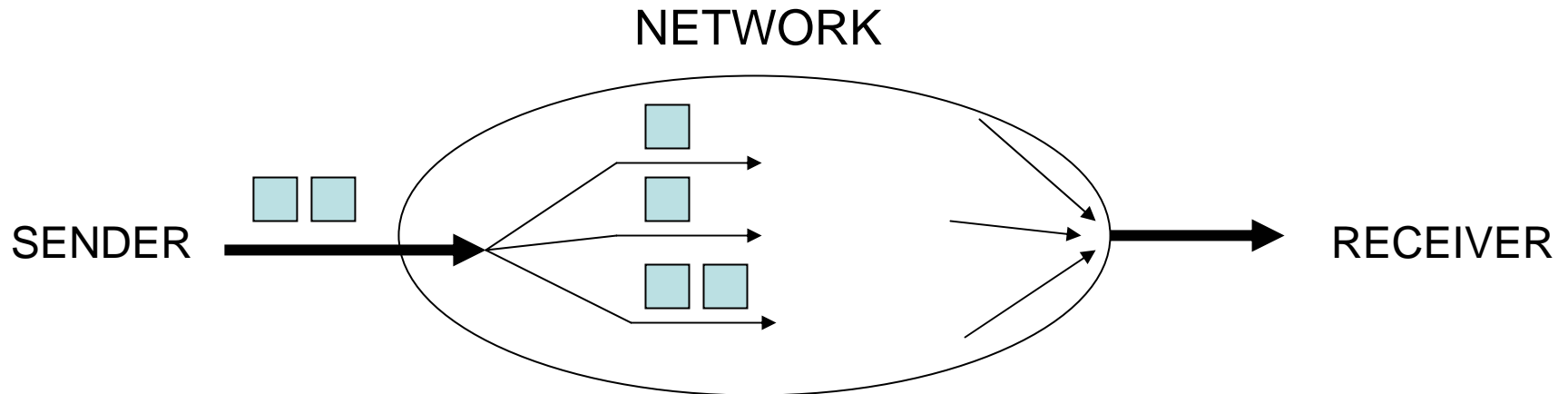
After the call is initiated a predefined route of the information is fixed

After the termination of the call the resources (Predefined Route) is released.

MECHANISMS - SWITCHING

PACKET SWITCHING

The information is divided into information units **PACKETS** which are routed inside the network.



The packets are collected back to the receiver in a coordinated manner and the whole message is reconstructed!

MECHANISMS - SWITCHING

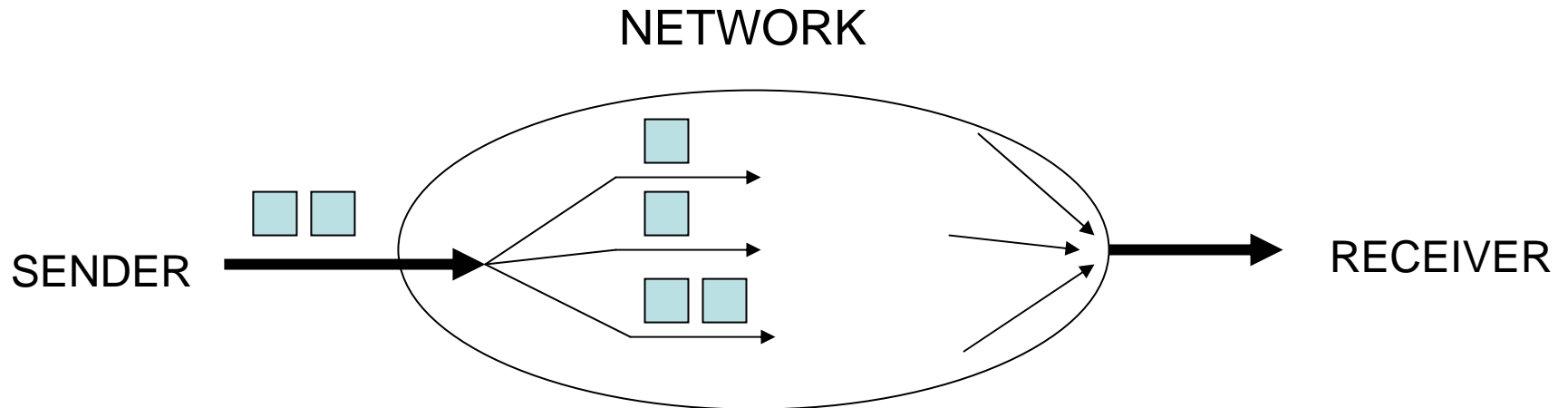
PACKET SWITCHING

Datagram

No predefined route of the packet stream

Virtual Circuit

Predefined route of the packet stream called Virtual circuit

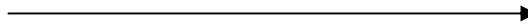


MECHANISMS - SWITCHING

SERVICES

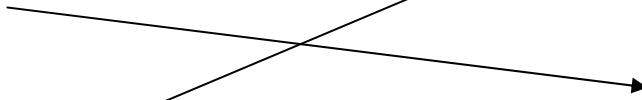
SWITCHING

Video Conference



Circuit Switching

Data Transfer



Packet Switching

Telephony

FIND THE ARROWS !