0.1 Communication Link

- Bit pipe with a given capacity C (bit/s)
- Link capacity -> rate at which bits are transmitted to the link
- Link may transport multiplexed traffic streams

Important Variables and Expressions

C
: channel capacity (total capacity)

0.2 Multiplexing Strategies

- Statistical Multiplexing
- Frequency Division Multiplexing
- Time Division Multiplexing

0.3 Statistical Multiplexing

- Packets of all traffic streams merged in a single quele (first-come, first-served)

Important Variables and Expressions

L
: Length of packet

T_{frame}
: time of transmition

$$T_{frame} = \frac{L}{C} \tag{1}$$

0.4 Frequency Division Multiplexing

- Link capacity C subdivided into m portions
- Channel bandwidth W subdivided into m channels of W/m Hz
- Capacity of each channel = C/m

Important Variables and Expressions

L
: Length of packet

T_{frame}
: time of transmition

m
: number of divisions

W
: channel bandwidth

$$T_{frame} = \frac{Lm}{C} \tag{2}$$

0.5 Time Division Multiplexing

- Time axis divided into m slots of fixed length
- Communication -> m channels with capacity C/m

Important Variables and Expressions

L
: Length of packet

T_{frame}
: time of transmition

m
: number of divisions

$$T_{frame} = \frac{Lm}{C} \tag{3}$$

0.6 Queue Models

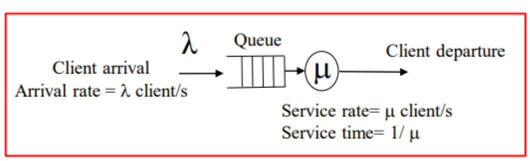

Figura 1: Depiction of a queue model

- Characterization of Delay - Important performance parameter in computer networks
- Customers (packet to be transmitted through a link) arrive at random times to obtain service (transmit a packet)

Important Variables and Expressions

λ
: arrival rate

μ
: service rate

N
: Average number of customers/packets in the network

T
: Average delay per packet -> waiting plus service times

ρ
: traffic intensity (occupation of the server)

$T_{pac(frame)}$
: Service time = packet transmission time

$$T_{pac(frame)} = \frac{L}{C} = \frac{1}{\mu} \tag{4}$$

$$\rho = \frac{\lambda}{\mu} \tag{5}$$

0.6.1 M/M/1 Queue

Important Variables and Expressions

T_W
: average waiting time

N_W
: average number of clients waiting

$$N = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu - \lambda} \tag{6}$$

$$T = \frac{1}{\mu - \lambda} \tag{7}$$

$$T_W = T - T_S = \frac{1}{\mu - \lambda} - \frac{1}{\mu} = \frac{\rho}{\mu(1-\rho)} \tag{8}$$

$$N_W = T_w \lambda = \frac{\lambda}{\mu - \lambda} - \frac{\lambda}{\mu} = N - \rho \tag{9}$$

0.6.2 M/G/1 Queue

$$T_W = \frac{\rho}{\mu(1-\rho)} \tag{10}$$

0.6.3 M/D/1 Queue

$$T_W = \frac{\lambda E(T^2_{pac(frame)})}{2(1-\rho)} \tag{11}$$