

0.1 Communication Link

- Bit pipe with a given capacity C (bit/s)
- Link capacity \rightarrow 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 queue (first-come, first-served)

Important Variables and Expressions

L
Length of packet

T_{frame}
time of transmission

$$T_{frame} = \frac{L}{C} \quad (1)$$

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 transmission

m
number of divisions

W
channel bandwidth

$$T_{frame} = \frac{Lm}{C} \quad (2)$$

0.5 Time Division Multiplexing

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

Important Variables and Expressions

L
Length of packet

T_{frame}
time of transmission

m
number of divisions

$$T_{frame} = \frac{Lm}{C} \quad (3)$$

0.6 Queue Models

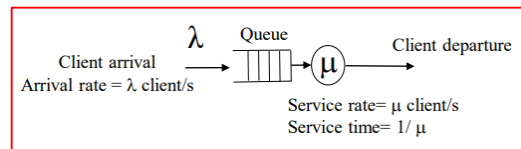


Figura 1: Depiction of a queue model

- 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

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

$$\rho = \frac{\lambda}{\mu} \quad (5)$$

0.6.1 M/M/1 Queue

- Poisson arrival
- Exponential service time
- Time Division Multiplexing

Important Variables and Expressions

T_W	average waiting time
N_W	average number of clients waiting

$$N = \frac{\rho}{1 - \rho} = \frac{\lambda}{\mu - \lambda} \quad (6)$$

$$T = \frac{1}{\mu - \lambda} \quad (7)$$

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

$$N_W = T_w \lambda = \frac{\lambda}{\mu - \lambda} - \frac{\lambda}{\mu} = N - \rho \quad (9)$$

0.6.2 M/D/1 Queue

$$T_W = \frac{\rho}{2\mu(1-\rho)} \quad (10)$$

0.6.3 M/G/1 Queue

$$T_W = \frac{\lambda E(T_{pac(frame)}^2)}{2(1-\rho)} \quad (11)$$