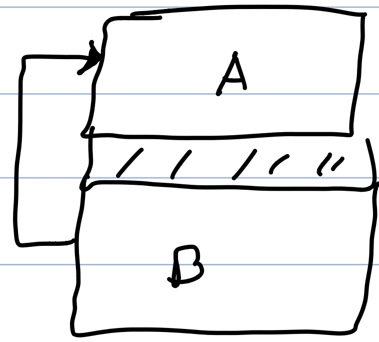
1. Shared memory
2. Message Passing



Direct Comm — Indirect comm

send (P_1 msg) — ↓

recieve (q_1 msg) — mailbox

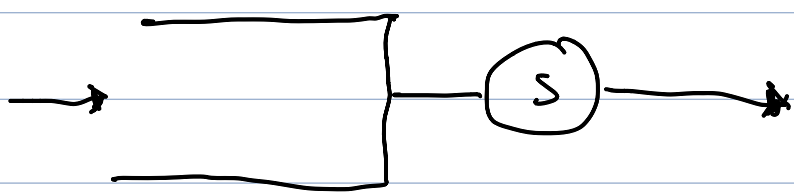
	Shared Memory	Message Passing
Small Data to be shared		✓
Faster	✓	
Easier to implement		✓

Queing Analysis

-> Customers : individuals who want services (process)

servers : satisfy request from customer

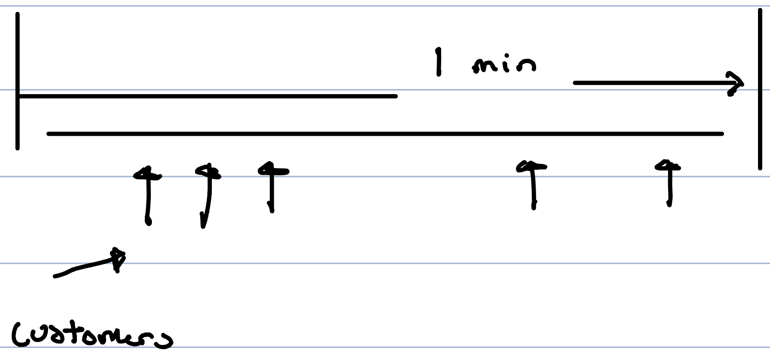
Queues : Waiting areas.



Arival Process : How customers arrive

λ : average arrival rate

λ : 5 customers per 1 min.



Poisson Distribution

es// Gives the probability of a given number of events (i.e. arrivals) over a fixed period of time, if the average rate (λ) is known

PDF : $f(x) = \dfrac{\lambda^x}{x!} e^{-\lambda}$

Pr [No arrivals happen] = $Pr(x=0) = \dfrac{5^0}{5^0!} e^{-5} = e^{-5} = .00674$

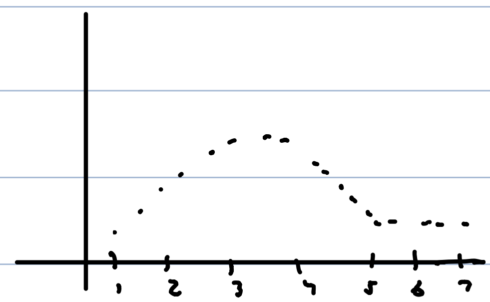
Pr [1 arrivals happen] = $Pr(x=1) = \dfrac{5^1}{1!} e^{-5} = e^{-5} = .033$

[2] = .084

[3] = 0.14

[4] = 0.175

[5] = 0.175



Memoryless Distribution

- Does not depend on other factors or what you've seen before
    - ∞ population

Departure Process

T_s : Average time to get service

Exponential Distribution

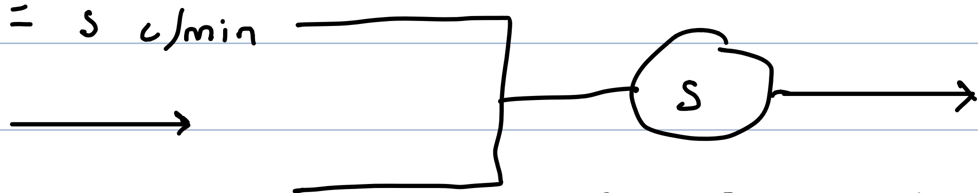
$\therefore$ therefore

C : customers

Average service rate $(\mu) = \frac{1}{T_s}$

ex//

$\lambda = 5$ c/min



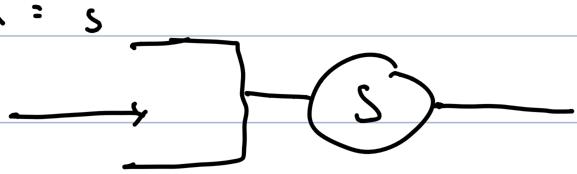
$T_s = 30$ seconds

$\mu = 2$ c/min

Problem

Unstable System $(\lambda > \mu)$

$\lambda = 5$



$T_s = 5s$

$\rho = \frac{5}{12}$ = Avg server Utilization

"rho"

ρ

$\mu = 12$ c/min $\longrightarrow$ This is stable b/c

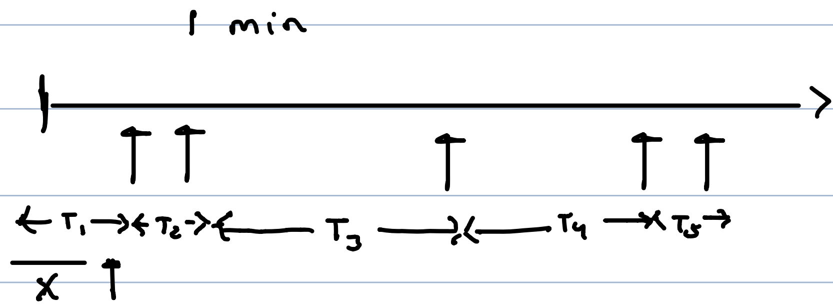
$(\lambda < \mu)$ $\quad 5 < 12$

$\therefore$ Everything checks out

$\rho = \lambda * T_s = \frac{\lambda}{\mu}$

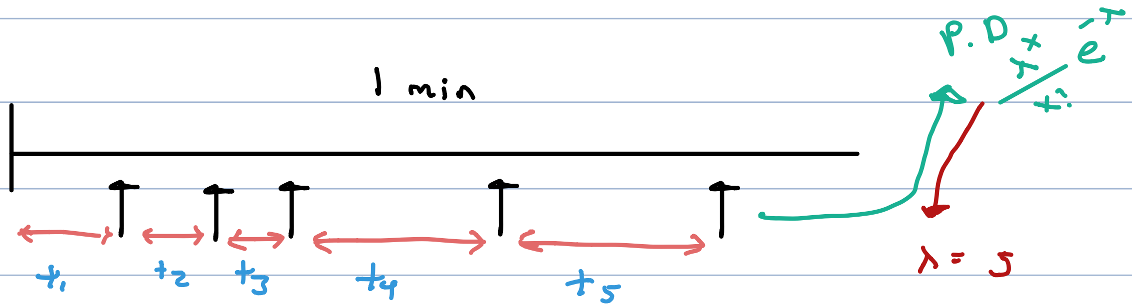
Exponential Dist

gives prob. distribution of times between events



If the arrivals follow a poisson distribution, the interarrival times follow an Exp. Distribution

$$CDF = 1 - e^{-\lambda x}$$



5 customers / min

T_s = 12 seconds

Probability [we observe the first arrival after 60 seconds]

Probability [no arrivals happen in the first 60 seconds]

5 customers per min $\lambda = 5$

$$\frac{\lambda^0}{0!} e^{-5} = e^{-5} = .00674$$

Prob[we observe the first arrival after 30 seconds]

$\equiv$ [no arrivals in the first 30 seconds]

$$\frac{(2.5)^0}{0!} = e^{-2.5} = 0.082$$

Prob [we observe .... 12 seconds]

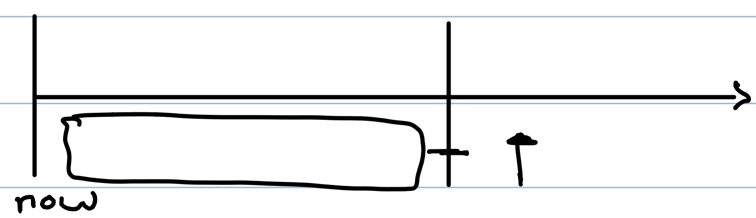
$\equiv$ [No arrivals in the first 12 seconds]

$$\frac{(1)^0}{0!} e^{-1} = 0.3678$$

Prob we observe ..... 6 seconds

$\equiv$ [No arrivals in the first 6 seconds]

$$= e^{-0.5} = 0.605$$



Recap

- Population is infinite (Markov property)
  - → Queue size is infinite

M / M / 1

Arrival Markov

Departure Markov

\# of servers

M / D / 1

Deterministic