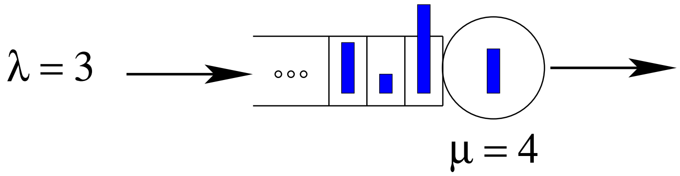
A single-server queue



Average Arrival Rate:

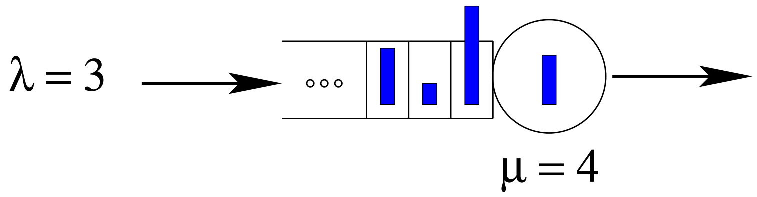
Interarrival Time:

Mean Interarrival Time:

Job Size (Service Requirement):

Mean Job Size:

Average Service Rate:



PEOPLE SPEAK vs. **QUEUEING SPEAK**

Examples from your work:

Common Performance Metrics

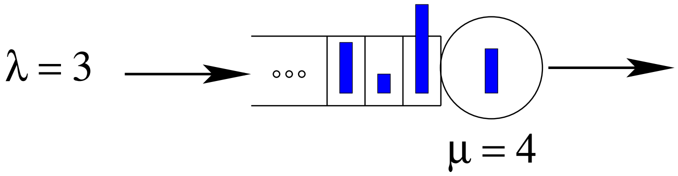
- Response Time, T:

- Waiting Time or Delay, T_Q

- Number of jobs in system, N

- Number of jobs in queue, N_Q

Stability



Question: What happens if $\lambda > \mu$?

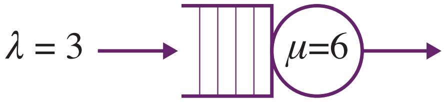
Here's why:
$N(t)$ = Number jobs in system *at* time t
$A(t)$ = Number arrivals *by* time t
$C(t)$ = Number completions(depatures) *by* time t

We will always assume $\lambda < \mu$. (Stability)

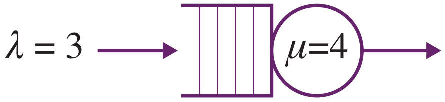
Throughput, X

Question: What is throughput?

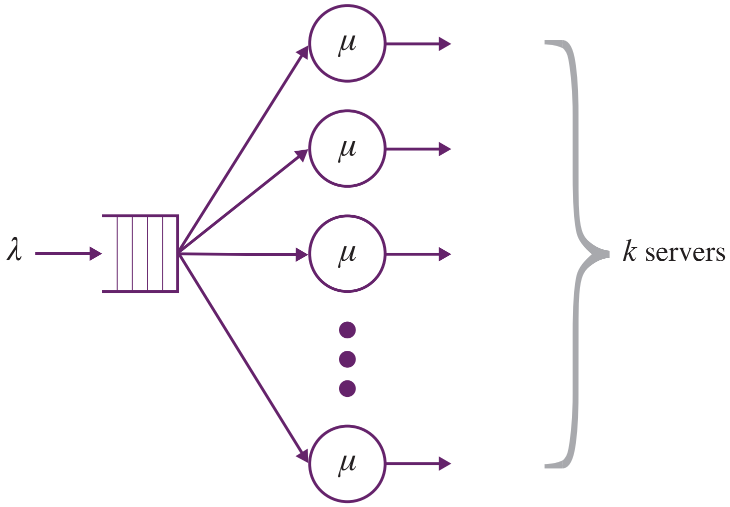
Question: Which has higher throughput?



vs.



Throughput for Server Farm

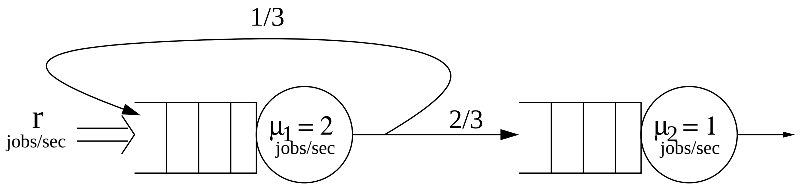


Question: What condition is needed for stability?

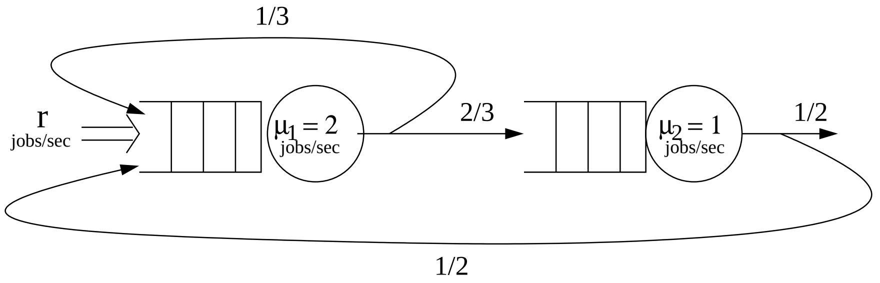
Question: What's the throughput? (assuming stability)

Throughput for Network of Queues

Question: What is the maximum outside arrival rate?

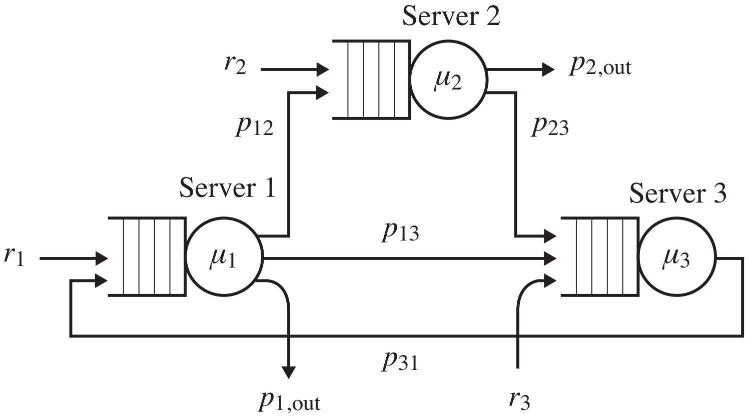


(a)



(b)

Throughput for Network of Queues



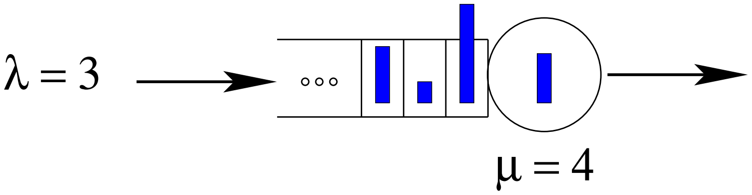
Question: What's the throughput of this system? (assume stability)

Question: What's the throughput of server i?

Question: What do we need for stability of this system?

Device Utilization (Load)

When talking about "utilization," we're thinking of a single device.

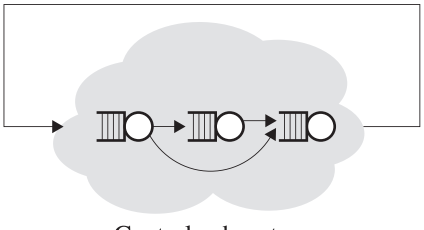


<u>Defn</u>: Device **utilization**, a.k.a. **load**, is the long-run fraction of time that the device is busy.

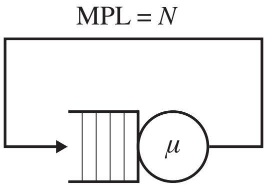
Let $B(t)$ = total time server is busy during $[0, t]$.
Q: What is ρ?

<u>Example</u>:
3 jobs/sec arrive on average.
Each job contributes 1/4 sec of work on average.
Q: What is ρ?

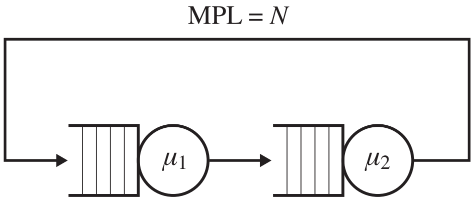
Closed System (Batch)


Central subsystem

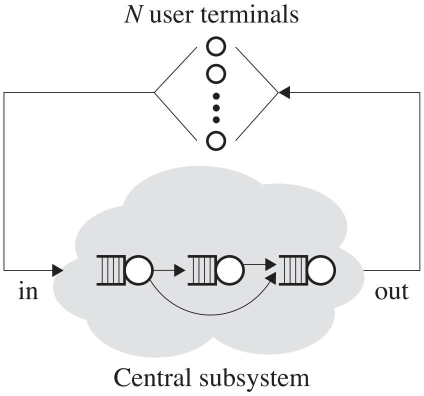
Question: What is throughput below?

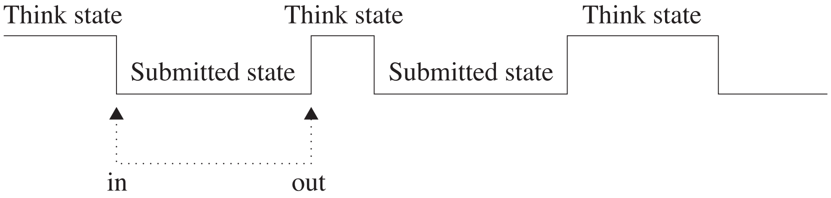


Question: What is throughput below?



Closed System (Interactive)


N user terminals
in
out
Central subsystem


Think state
Think state
Think state
Submitted state
Submitted state
in
out