Advanced Systems Lab
Understanding Throughput and Response Time

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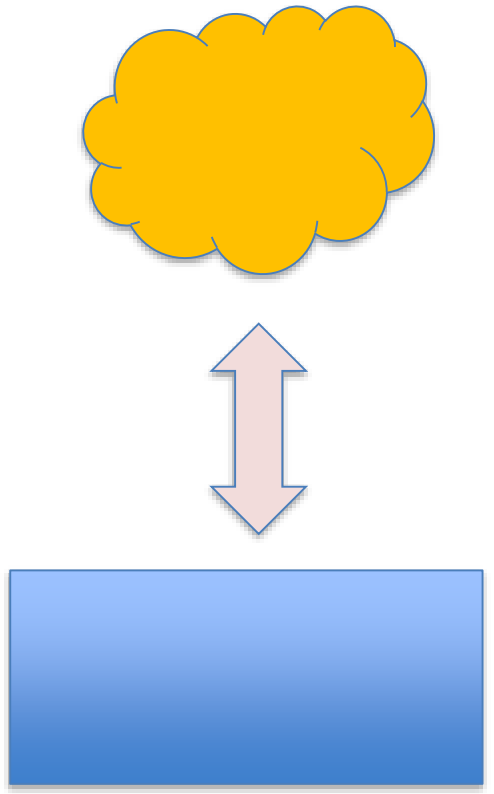
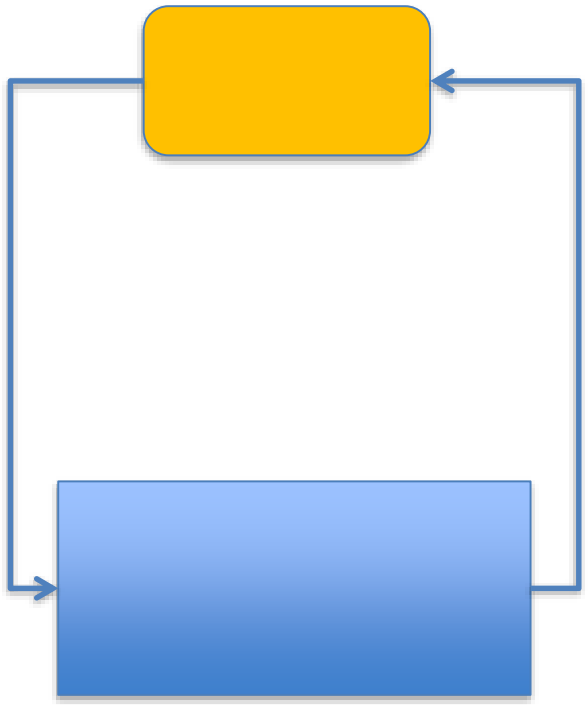
Open system

- Load comes from a potentially unlimited set of clients
- Load is not limited by clients waiting
- Load is not self-adjusting (load keeps coming even if system stops)
- Tests system's stability
- Example: web server



Closed system

- Load comes from a limited set of clients
- Clients wait for response before sending next request
- Load is self-adjusting
- System tends to stability
- Example: database with local clients



Example

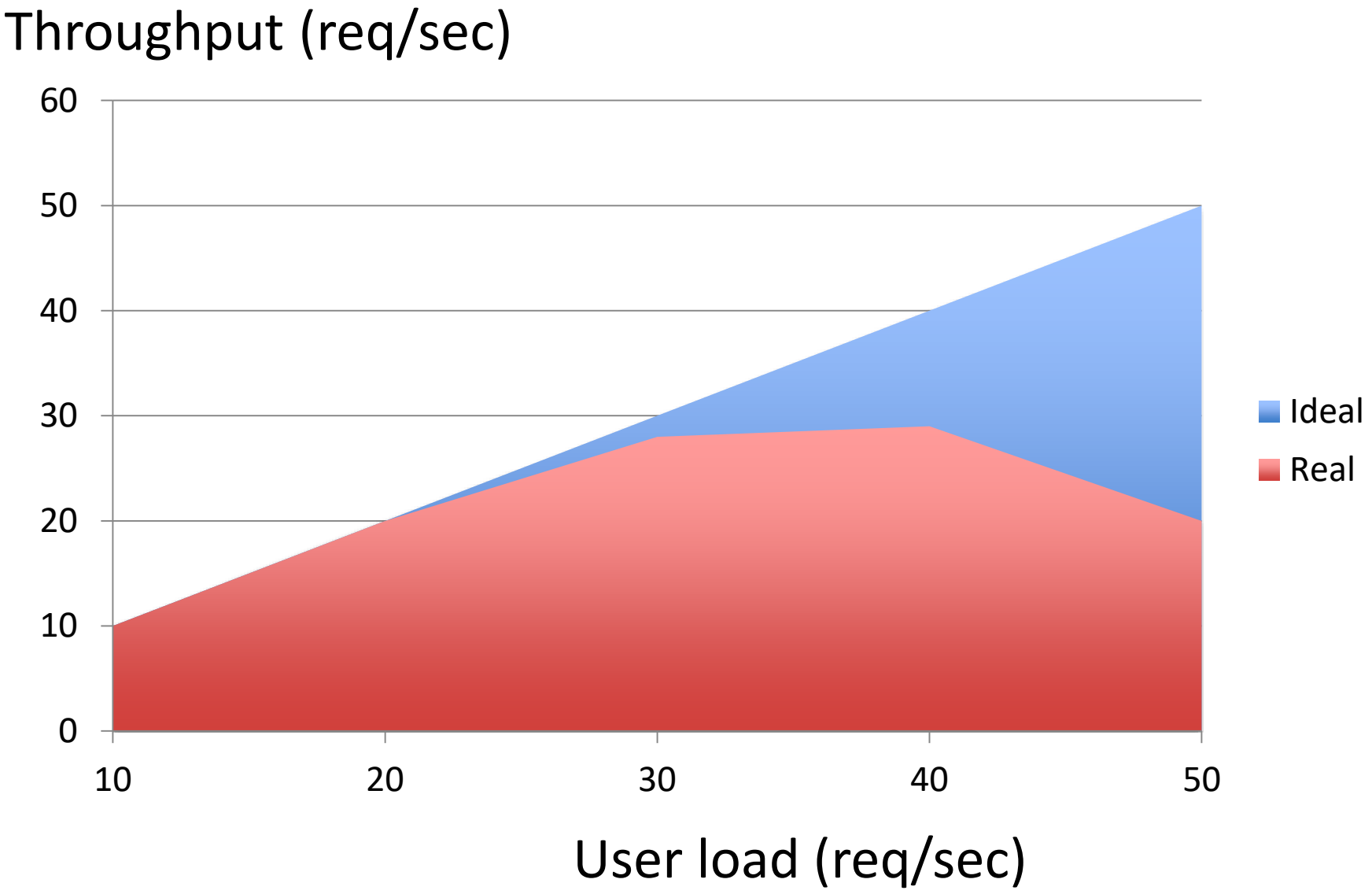
- Throughput: requests completed per unit of time (secs)
  - count only “successful” requests (no error, < timeout)

- Response Time: time to complete a given task when measured from a well defined start and end points
  - max/min/avg time (secs) to complete a request
  - time for “successful” and completed tasks

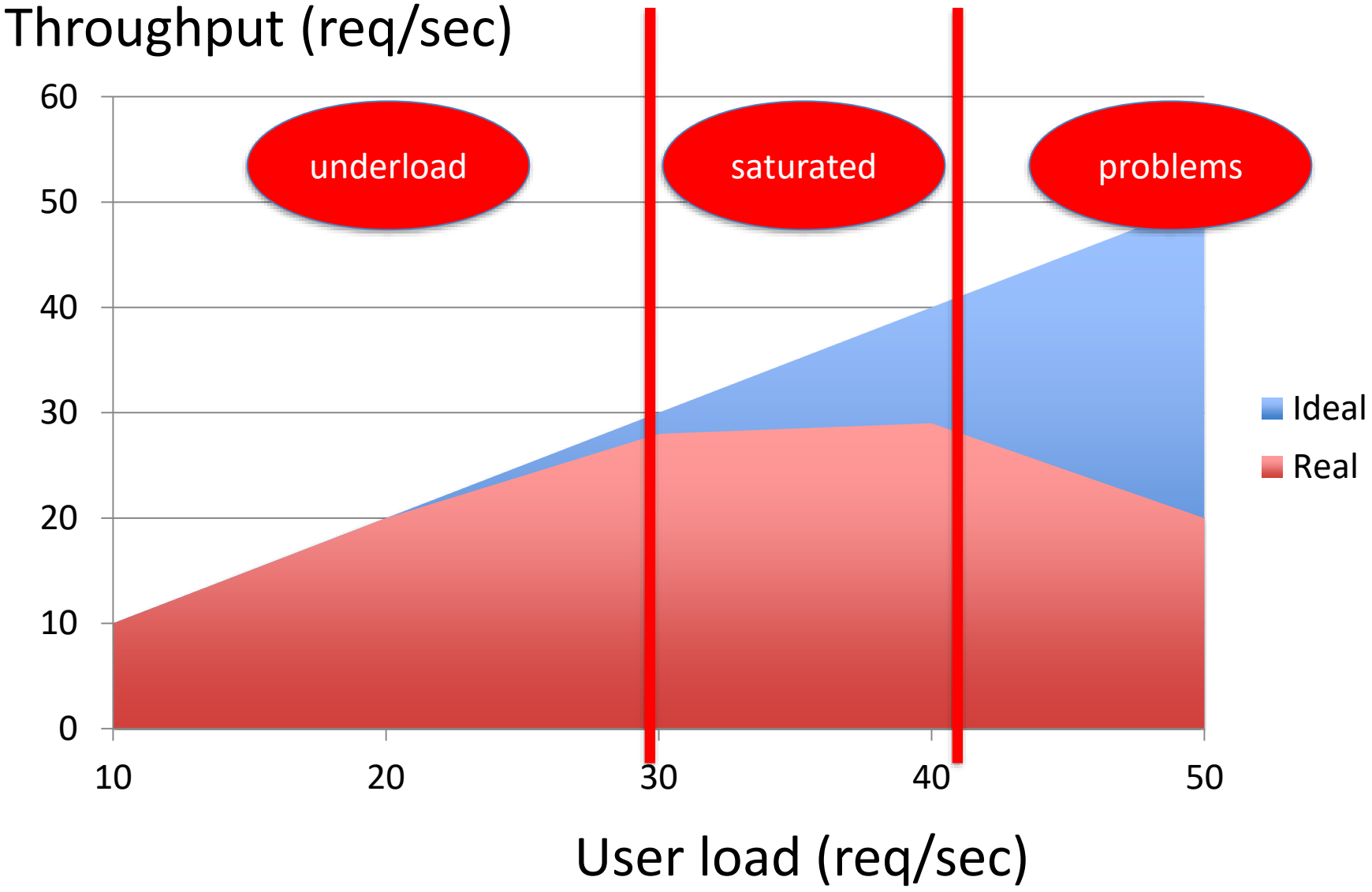
These are not absolute values, they depend on the load on the system:

- User Load: number of requests arriving per unit of time (secs)

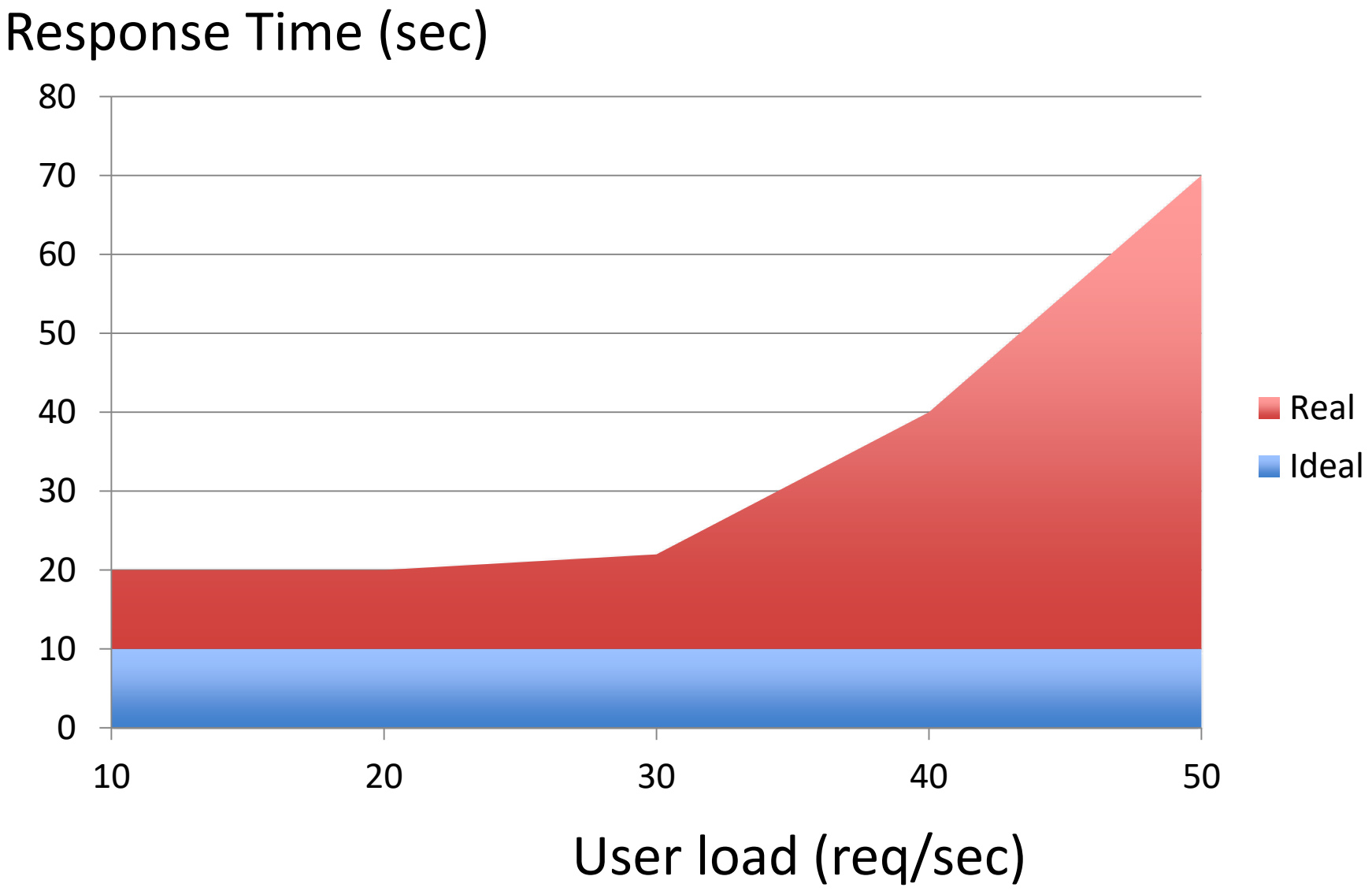
How does throughput look like



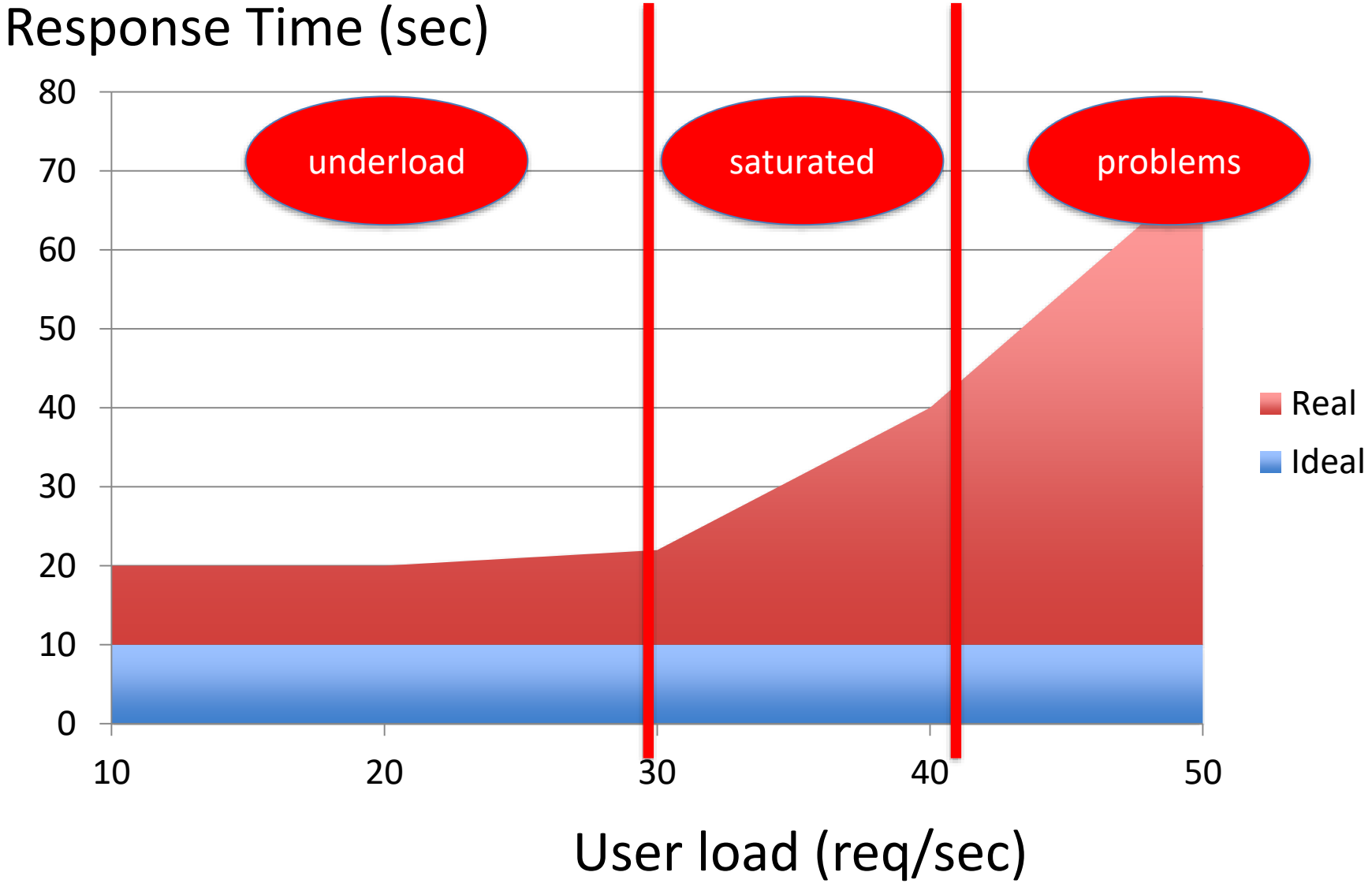
Throughput Analysis



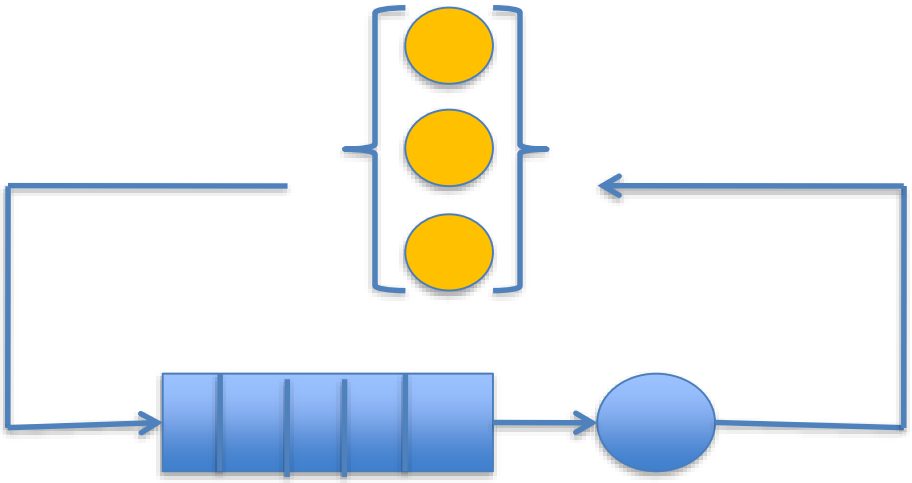
How does Response Time look like



Response Time Analaysis



Interactive Response Time Law



- Users submit a request, when they get a response, they think for a time Z, and submit the next request
- Applies to measurements in any system under a generic set of conditions

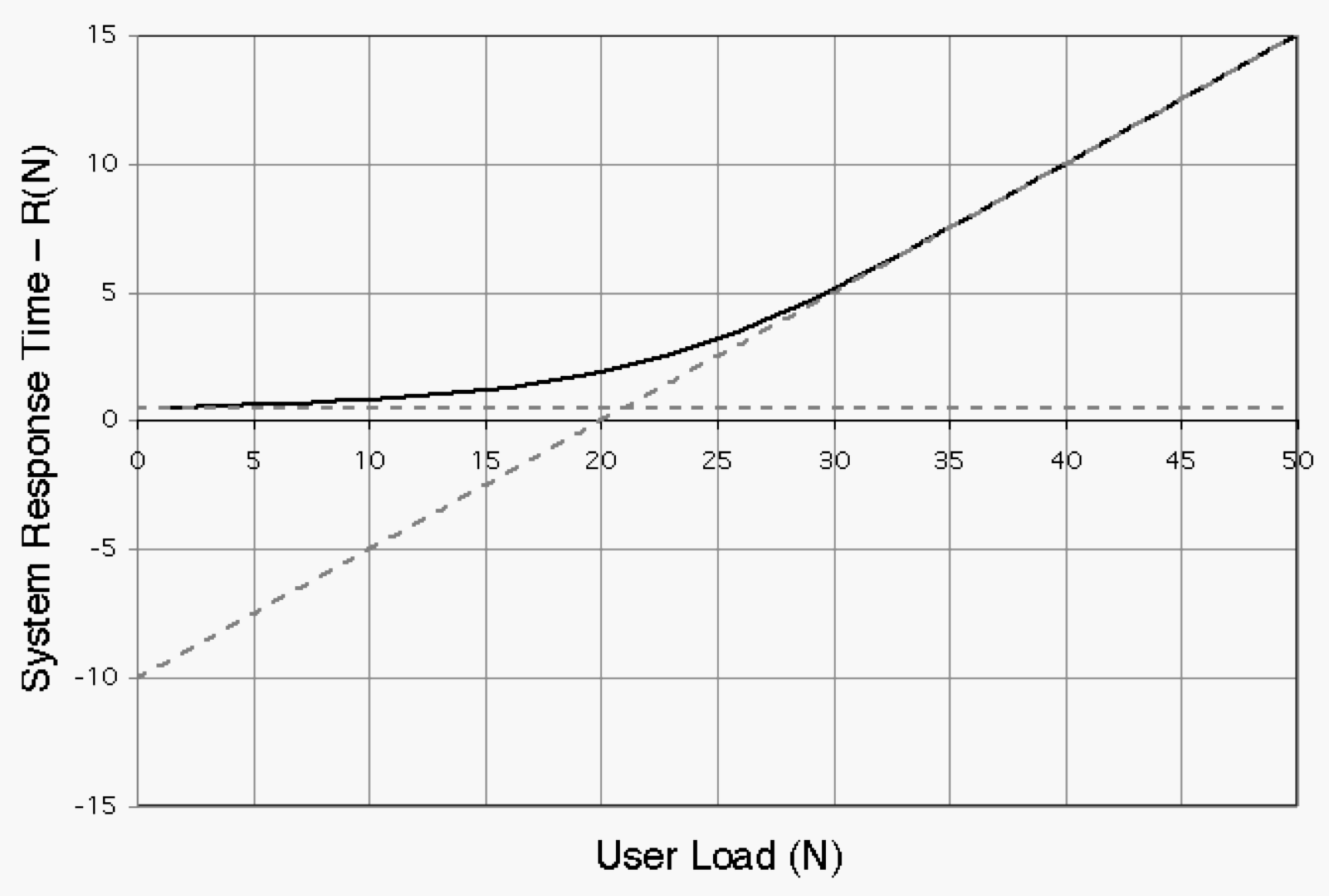
Interactive, closed systems

- Response time R
- Total cycle time R+Z
- Each user generates T/(R+Z) requests in time T
- There are N users

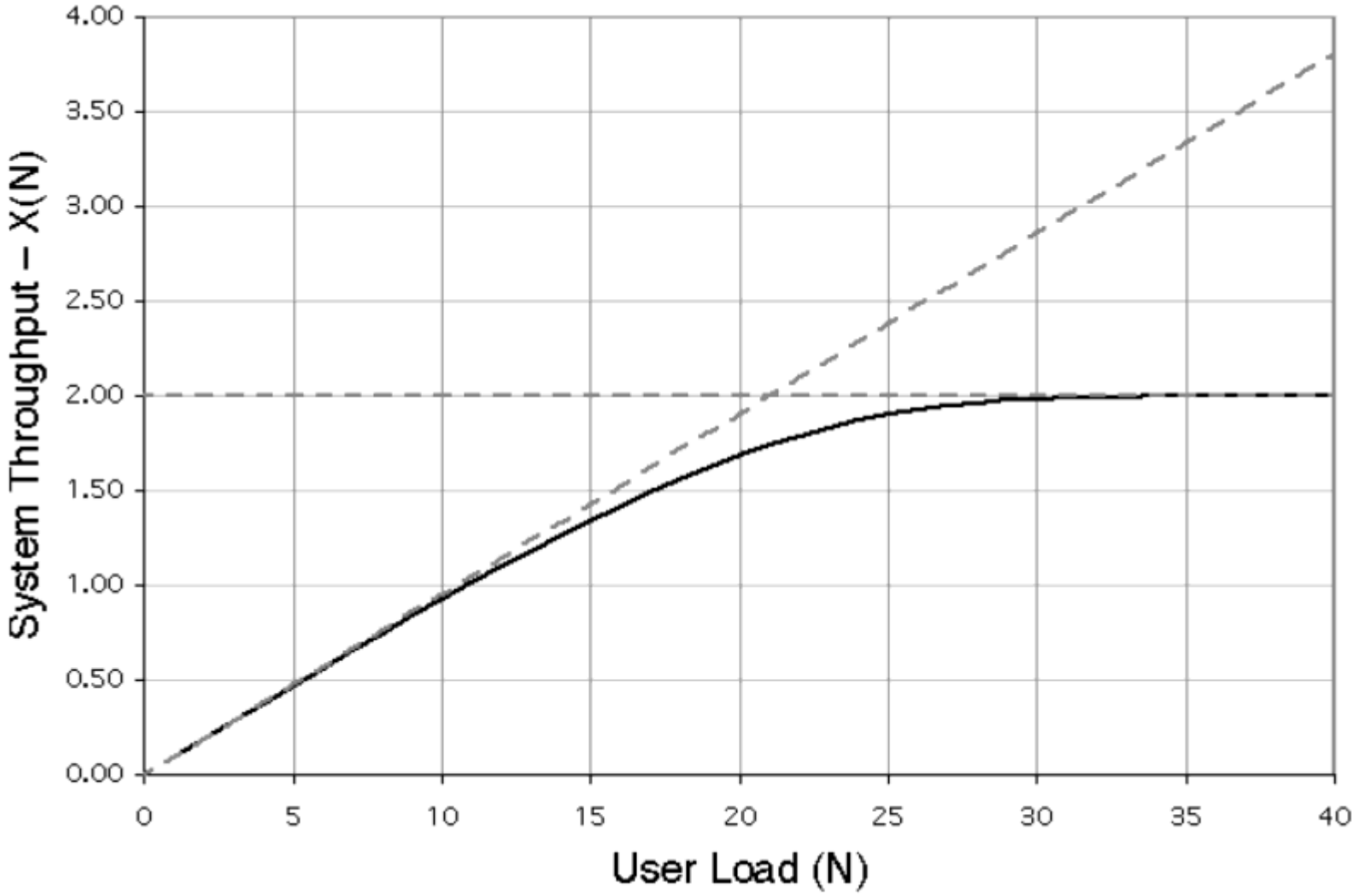
$$X = \frac{Jobs}{Time} = \frac{N\dfrac{T}{R+Z}}{T} = \frac{N}{R+Z}$$

$$R = \frac{N}{X} - Z$$

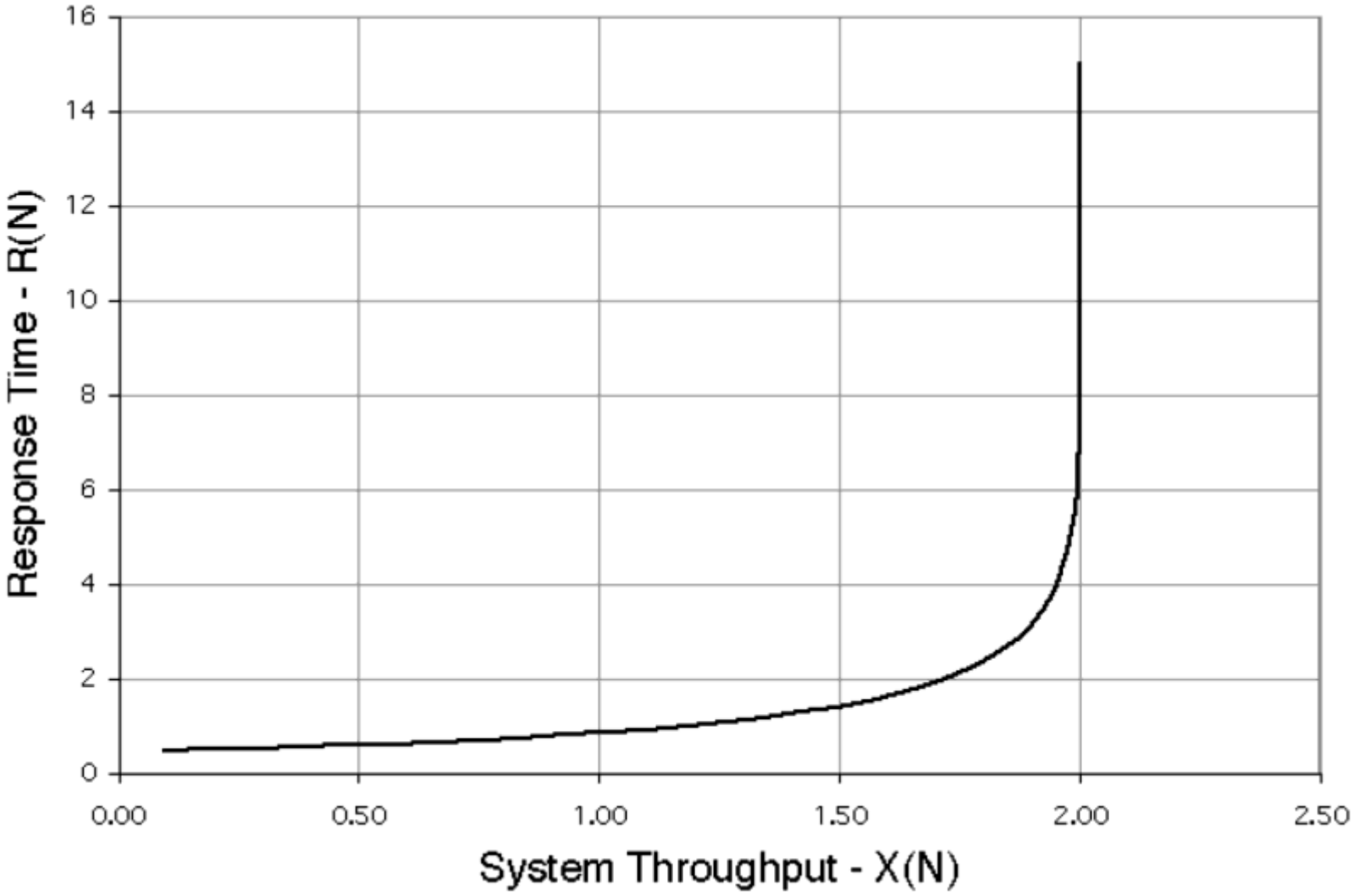
Interactive Law in practice



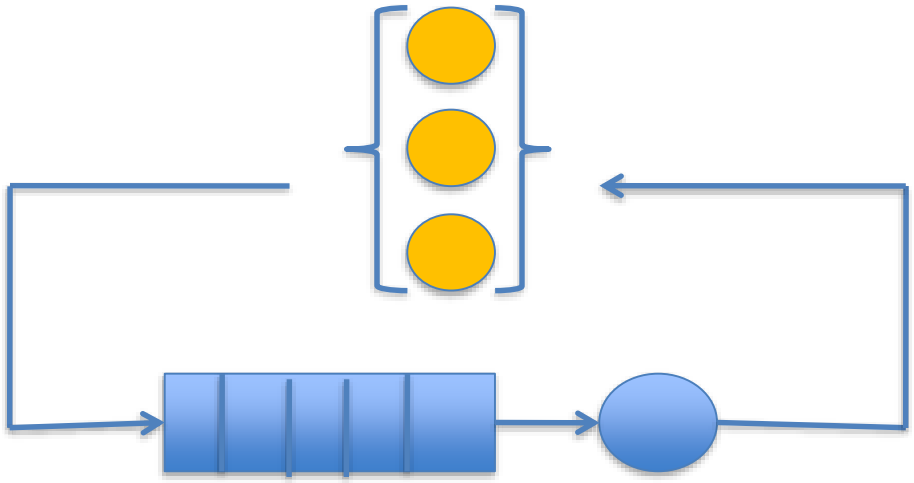
Interactive law in practice



Interactive law in practice

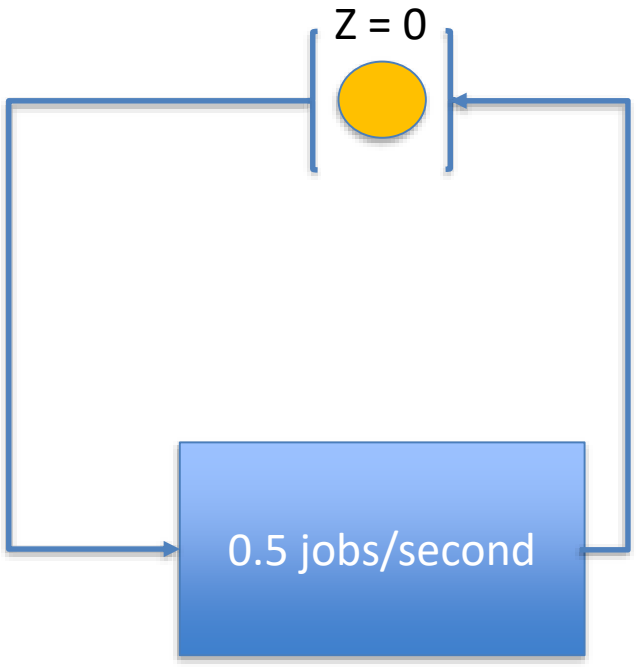


Warning!



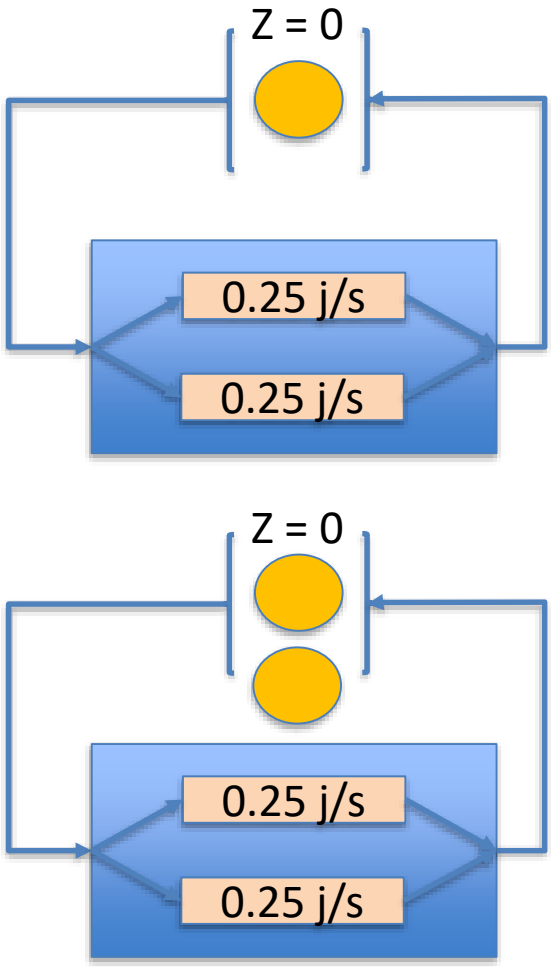
- Real systems are not ideal
  - Not all jobs are equal
  - Not all processing is identical
  - Network effects
  - Processing overhead (not only wait)
  - Exceptions and not “normal” return values

Example



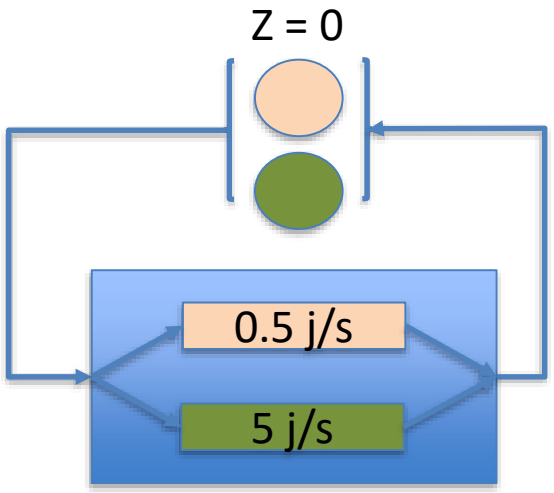
- What is the throughput?
- What is the response time

Example

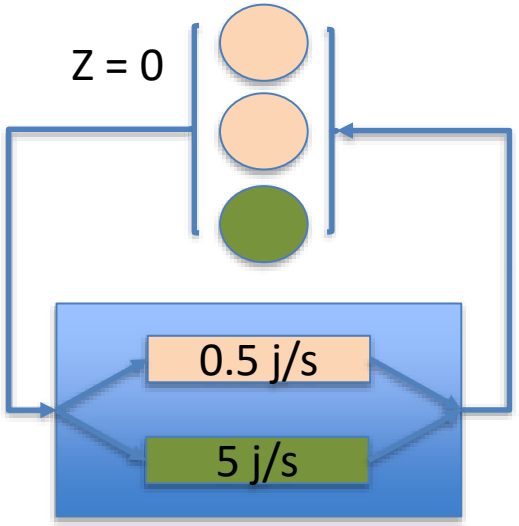


- What is the throughput?
- What is the response time
- Try for 1 clients, 2, 3, 4 …
- Plot the results

Example

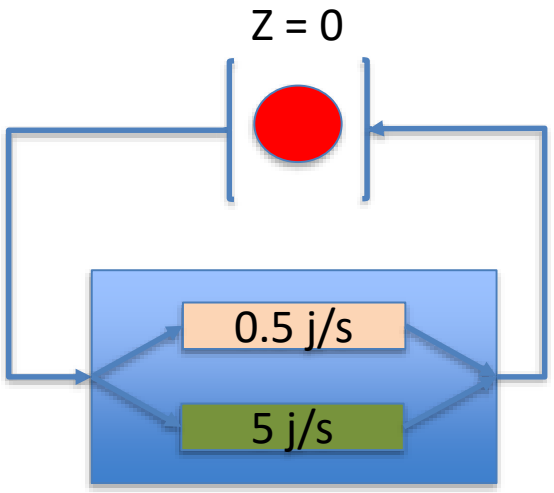


- Throughput is 5.5 j/s
- Response time is (2/5.5) 0.36 seconds
- Actual response times are 2 sec for pink jobs and 0.2 sec for green jobs



- Throughput is 5.5 j/s
- Response time is (3/5.5) 0.54 seconds
- Actual response times are 4 sec for pink jobs and 0.2 sec for green jobs

One more example



- Client submits 1 pink job and 1 green job, alternating:
  - Throughput = 2 jobs/2.2 sec = 0.9 j/s
  - RT => 1.1 seconds
- Client submits 1 pink job and 2 green jobs, and starts over again
  - Throughput = 3 jobs/2.4 sec = 1.25 j/s
  - RT => 0.8 seconds
- Client submits 2 pink jobs and 1 green job, and starts over again
  - Throughput = 3 jobs/4.2 sec = 0.71 j/s
  - RT => 1.4 seconds

Take home message

- What you measure (throughput and/or response time) depends on the workload
- How you submit jobs (and in which order) can make a big difference
- Understanding the performance of your system requires to understand how it works (the inner workings of the system) and the workload you are considering.