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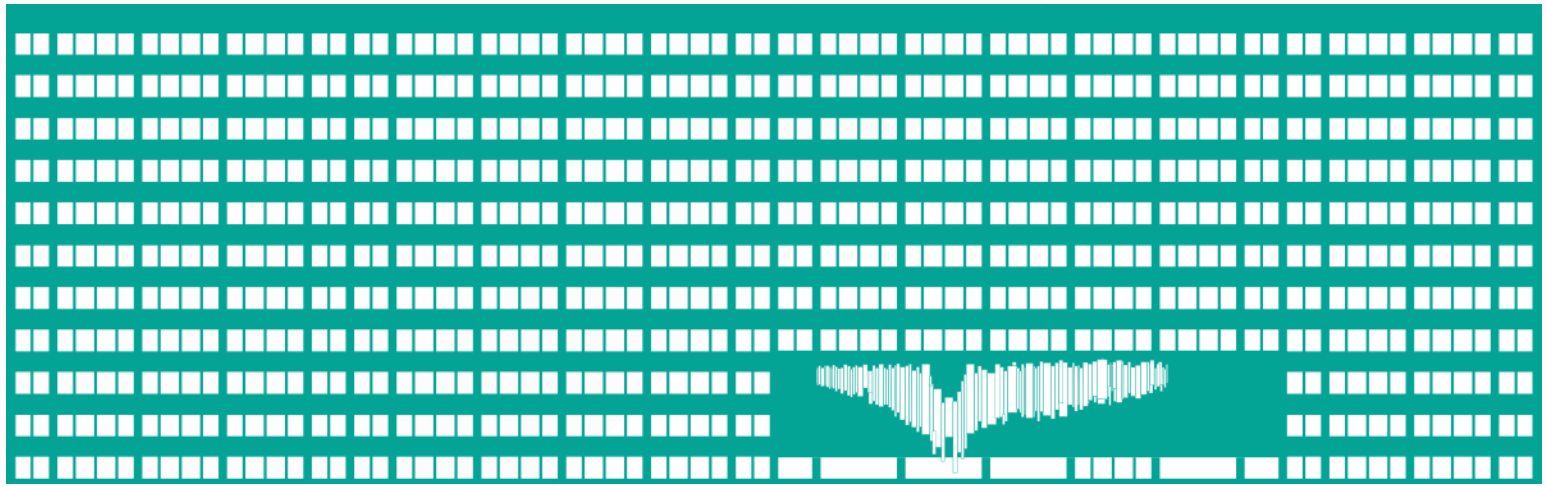

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VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE | DEPARTMENT OF TELECOMMUNICATIONS

Modeling and Dimensioning of Networks

Queuing Theory in the Field of Computer Networks

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Introduction to Queuing Theory

- mathematical study of waiting lines (queues)
- queues are present everywhere
  - computer networks
  - hardware elements
  - service lines
  - ...

Field importance

- network modeling
  - design
  - performance evaluation and estimation
  - cost reduction
  - waiting time elimination
  - predictive analysis
- network dimensioning

Key concepts

- servers - physical servers, routers, cashiers,...
- customers/requests
- arrival rates - λ
- service rates - μ
- Poisson process
  - completely independent events (no memory)
  - average rate

Queue types

- FIFO
- LIFO
- Priority Queues
- SIRO
- ...

Little's law

- Little’s Law is a fundamental formula in queuing theory.
- It relates the number of customers in a system (L), the arrival rate (λ), and the average time a customer spends in the system (W).
- Formula: $L=\lambda W$

Little's law - assumptions, usage

- assumptions
  - the system is stable and in a steady state
  - arrival rate and service rate are consistent
- usage
  - network performance analysis (i.e. packets in the system)
  - resource allocation and capacity planning
  - traffic management

Little's law - scenario

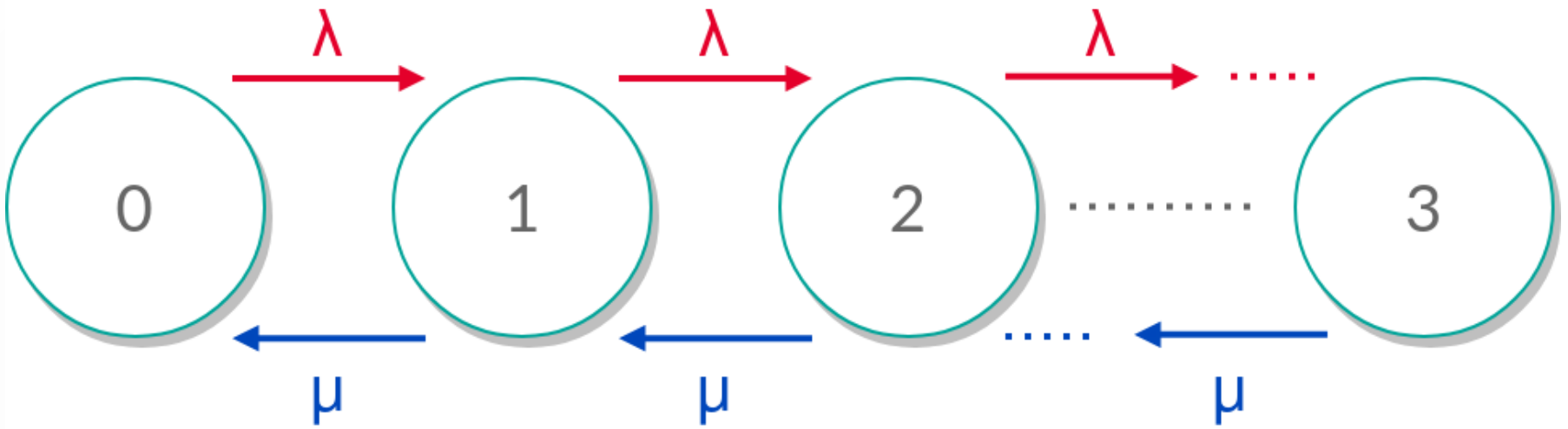
- web server receives an average of 100 requests per minute (λ)
- on average, each request spends 2 seconds in the system (W)

$$L = \lambda W$$

$$L = 100 \cdot \frac{1}{30}$$

$$L \approx 3.33$$

Markov chains



Queue models

- remember Kendall's notation?
- M/M/1 system,
- M/M/c system,
- other?

Key metrics

- utilization $\rho = \frac{\lambda}{\mu}$
- throughput,
- waiting time,
- queue length

What is modeled?

- TCP vs UDP
- server-client vs p2p
- symmetric vs asymmetric traffic
- short-lived vs long connections
- packet sizes

Points of interest

- location in network
  - customer side
  - network side (and where in the network - access, aggregation, backbone)
- used application
  - voice/video
  - data

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