Discussion
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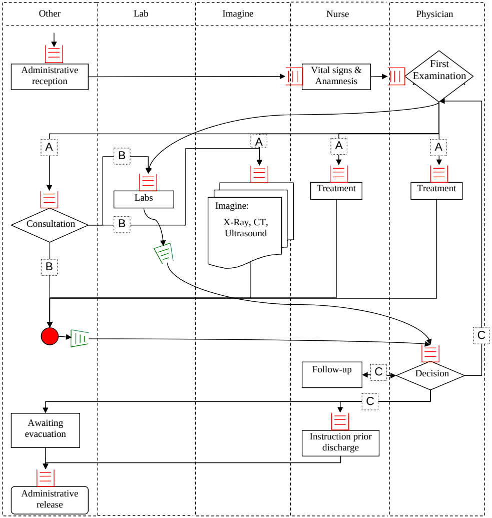
PhD Technion, 2010
With Avishai Mandelbaum

Thesis: “Queues in Hospitals: Queueing Networks with Reentrant Customers in the QED Regime"

A Process Chart of the Emergency Department



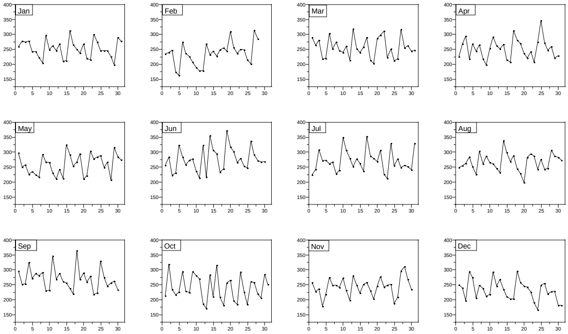
Alternative Operation - C

Recourse Queue - Synchronization Queue –

Ending point of alternative operation -

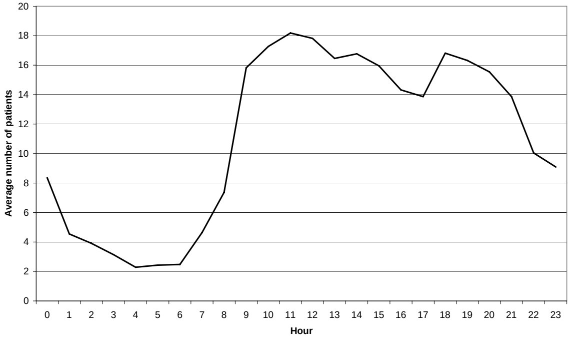
Time-Varying Arrival Rates in ED

Daily arrival rate (by month) to Emergency Department



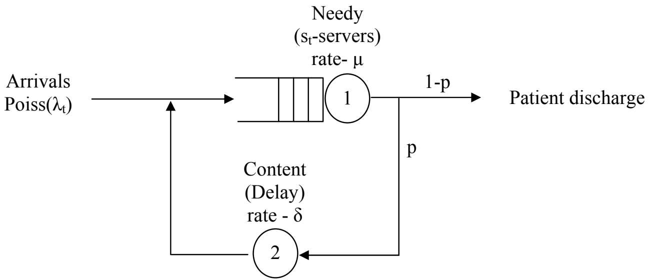
Time-Varying Arrival Rates in ED

Hourly arrival rate to Emergency Department



The Erlang-R Queue:

Time-varying QED Queueing network with Reentrant customers in support of personnel staffing



Operational Performance Measures

Operational performance measures in healthcare:

- Timely service (Waiting): $P(W_t > \tau)$, E[W]
- Left Without Being Seen (Abandonment): $P(A_t)$
- Ambulance diversions percentage (Blocking): $P(B_t)$

Underlying assumption: Operational system performance and quality-of-care are related.

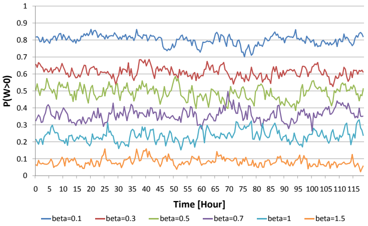
The (time-varying) square-root formula:
$s(t) = m(t) + \beta\sqrt{m(t)}$

The time-varying offered-load function ($m(t)$) is determined by an $M_t/G/\infty$ network

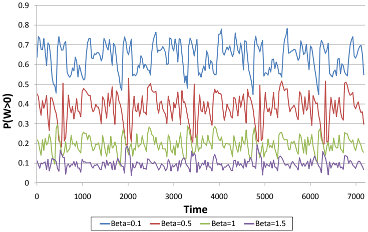
Many server approximations; Are they good for small systems?

P(wait) in ED using time-varying staffing and MOL approximation

Large systems (90 servers)



Small Systems (1-7 servers)



Average of 100 replications.

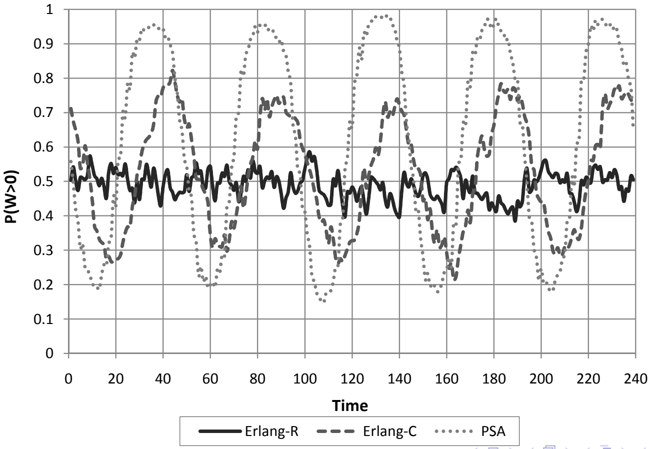
Other Methods

PSA (Pointwise Stationary Approximation), Lag-PSA

OL: $m(t) = E[\lambda(t - S_e)]E[S]$
PSA: $m(t) \approx E[\lambda(t)]E[S]$
Lag-PSA: $m(t) \approx \lambda(t - E[S])E[S]$

When service time is very long and/or has a special structure (like returns or interruptions) PSA could be vary bad; [GKW (2007) survey]

IS vs. PSA when customers re-enter service ("Erlang-R" model)



Conclusion

- **Time-varying queues are real**
- **They are here to stay**
- **They need to be take into account**
- **Proposed methods are effective**

Thank You