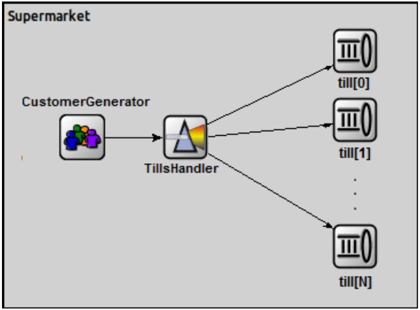
Project 2 - Quick Checkout

Francesco Paolo Culcasi
Alessandro Martinelli
Nicola Messina

M. Sc. in Computer Engineering
Performance Evaluation of Computer System and Network



- Project assumptions
  - Inter-arrival and Service demand
  - Splitting policy
  - Quick checkout tills
  - Service time
- Modeling and Implementation
  - CustomerGenerator
  - Customer
  - TillsHandler
  - Till

Verification and Calibration

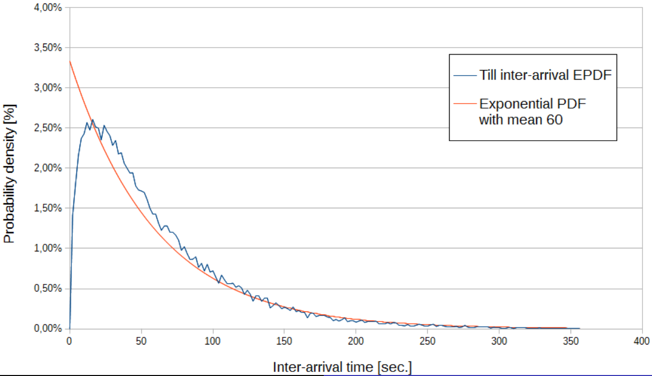
System verification

- Varying P
- Varying SD
- Constant IA

$$SD = \frac{IA \cdot N}{unitServiceTime}$$

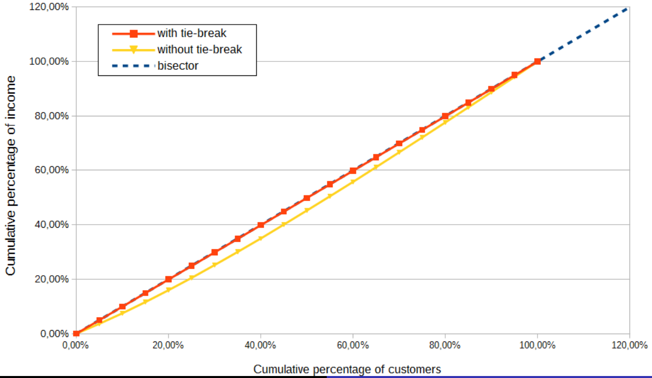
Calibration

- Comparison with M/M/1 system
- Parameters with fixed values, i.e. $N = 20$, $unitServiceTime = 2s$.
- Significant values for K and P



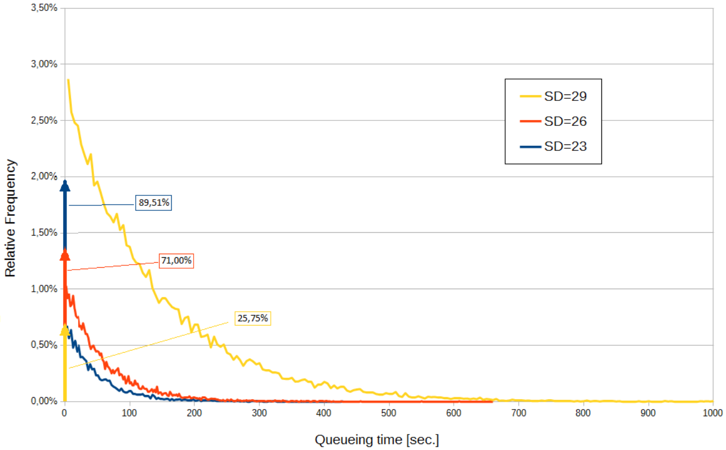
	Exponential SD		Lognormal SD
Undistinguished tills	P=0, exp SD		P=0, logn SD
	⇕		⇕
Normal & Quick checkout tills	P=0.1, exp SD	⇔	P=0.1, logn SD

- Warm-up time analysis
- Load fairly distributed



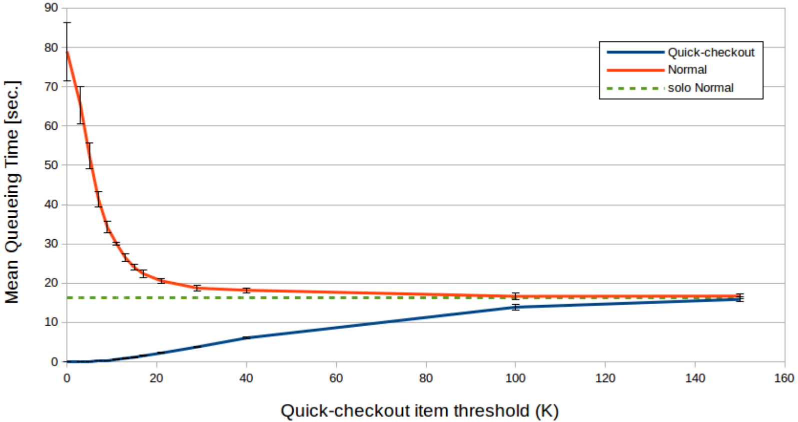
Exponential Service Demand, Undistinguished Tills

- IA at a single queue is not exponential
- QT increasing with SD and has a Delta in 0.
- This is not a PASTA system, since $p_0 \neq r_0$



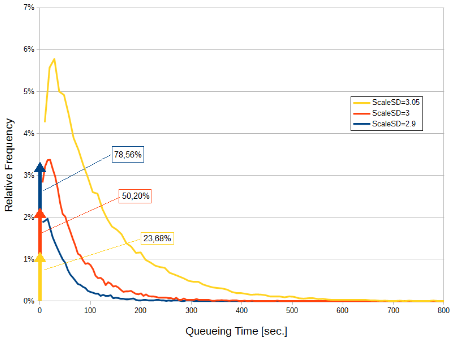
Exponential Service Demand, Normal and Quick checkout tills

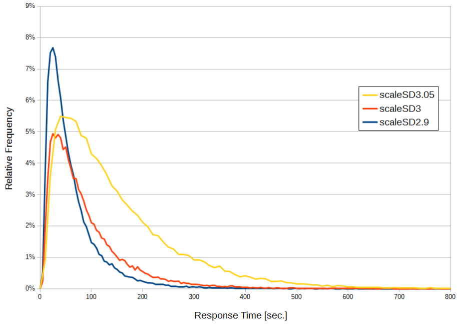
- Quick-Checkout tills behavior varying K
- Normal tills behavior varying K.
- Same trend: Solo Normal queueing time.



Lognormal Service Demand, Undistinguished Tills

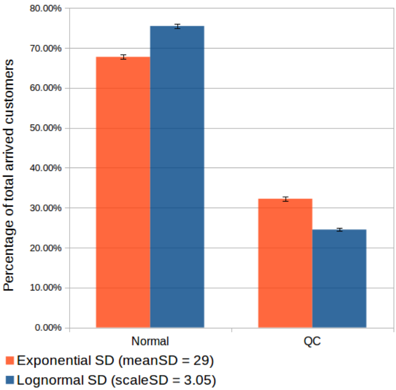
- Comparison with *Exp Undistinguished Tills*
  - ⟹ Similar behaviour
  - ⟹ Lower probability to obtain lower queueing times
- Difference among QT and RT distributions

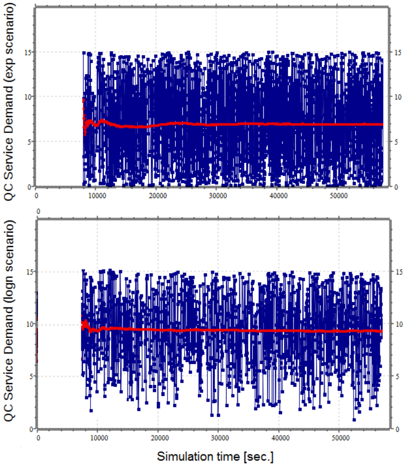




Differences over *Exp Normal+Quick checkout*:

- Higher mean service demand of quick checkout customers
  - $\Longrightarrow$ Lower load (totArrivedCustomers)
  - $\Longrightarrow$ Higher idle time

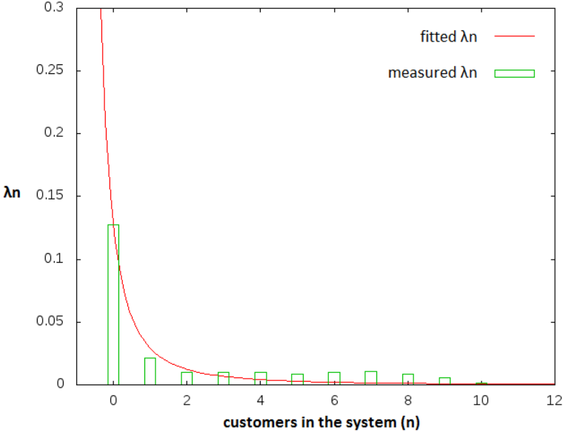




- Customers are sent to tills relying on the # of customers in each of them (NON probabilistic splitting). This brings to state dependent arrival rates.

  $\Longrightarrow$ Tills are non M/M/1 systems
- We can still use M/M/1 as an overestimation of the mean # of customers in the till
- We have a closed form for $E[N]$

- Till arrival rate (λ_n) looks like a hyperbole, leading the analysis to hypothesize it is a standard discouraged model
- Actually a discouraged model variation fits lot better.



$$\lambda_n = \frac{\lambda}{(n+1)^{\alpha}}$$

$$\alpha \simeq 2$$

- Using Chapman-Kolmogorov equations we can exploit $E[N]$ in a closed form
- both M/M/1 system and our system loads can be compared

$$E[n] = \frac{\sum_{n=0}^{\infty} \frac{n \cdot \left(\frac{\lambda}{\mu}\right)^n}{(n!)^2}}{\sum_{k=0}^{\infty} \frac{\left(\frac{\lambda}{\mu}\right)^k}{(k!)^2}} = \frac{\sqrt{\frac{\lambda}{\mu}} I_1\left(2\sqrt{\frac{\lambda}{\mu}}\right)}{I_o\left(2\sqrt{\frac{\lambda}{\mu}}\right)}$$