Queue Waiting Time with Several Servers (M/M/c, Erlang C)

Probability of waiting, queue length and waiting time for random arrivals and service at one or more identical servers, by the Erlang C formula.

Method: M/M/c queue with the Erlang C formula and Little's law

Input parameters

Unit system: SI

Parameter	Value	Unit
Arrival rate	12.000	1/h
Service rate of one server	5.0000	1/h
Number of servers	3.0000	

Calculated results

Parameter	Value	Unit
Server utilisation	80.000	%
Probability an arrival waits (Erlang C)	64.719	%
Mean number waiting	2.5888	
Mean waiting time	12.944	min
Mean time in the system	24.944	min
Mean number in the system	4.9888	

Notes for this case

• With random (Poisson) arrivals, exponential service times and c identical servers, the Erlang C formula gives the chance that an arrival must wait; the mean queue is then P_W ρ/(1 − ρ) and Little's law gives the times. Waiting rises steeply as utilisation approaches 100 %: a little spare capacity removes most of the queue. Use it for weighbridges, loading bays, maintenance crews, tool cribs or help desks.

Formula and method

$$P_W = \frac{\frac{a^c}{c!}\frac{1}{1-\rho}}{\sum_{k=0}^{c-1}\frac{a^k}{k!} + \frac{a^c}{c!}\frac{1}{1-\rho}}, \quad a = \frac{\lambda}{\mu}, \quad \rho = \frac{a}{c}, \quad L_q = P_W\frac{\rho}{1-\rho}, \quad W_q = \frac{L_q}{\lambda}$$

Variables

λ	Arrival rate	1/s
μ	Service rate of one server	1/s
c	Number of servers	-
ρ	Server utilisation	-
P_W	Probability an arrival waits (Erlang C)	-
L_q	Mean number waiting	-
W_q	Mean waiting time	s
W	Mean time in the system	s
L	Mean number in the system	-

Method and standards

Erlang C.

Assumptions and limits

- Poisson arrivals; exponential service; infinite queue; first come, first served.

References

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Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/general/economics/mmc-queue-erlang-c

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.