# Kendall's notation

From Wikipedia, the free encyclopedia

In queueing theory, **Kendall's notation** (or sometimes **Kendall notation**) is the standard system used to describe and classify a queueing node. D. G. Kendall proposed describing queueing models using three factors written A/S/c in 1953[1] where A denotes the time between arrivals to the queue, S the size of jobs and c the number of servers at the node. It has since been extended to A/S/*c*/*K*/*N*/D where *K* and D the capacity of the queue and queueing discipline[2] and *N* the size of the population of jobs to be served.[3][4]

An M/M/1 queueing node
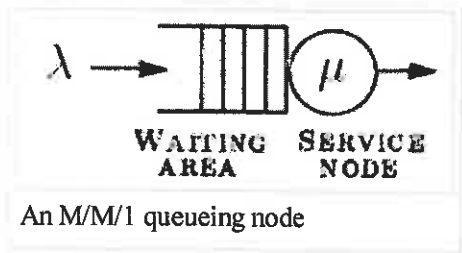
When the final three parameters are not specified (e.g. M/M/1 queue), it is assumed $K = \infty$, $N = \infty$ and D = FIFO.

Contents

- 1 A: The arrival process
- 2 S: The service time distribution
- 3 *c*: The number of servers
- 4 K: The number of places in the system
- 5 N: The calling population
- 6 D: The queue's discipline
- 7 References

A: The arrival process

A code describing the arrival process. The codes used are:

Symbol	Name	Description	Examples
M	Markovian	Poisson process (or random) arrival process.	M/M/1 queue
M^X	batch Markov	Poisson process with a random variable X for the number of arrivals at one time.	$M^X/M^Y/1$ queue
MAP	Markovian arrival process	Generalisation of the Poisson process.	
BMAP	Batch Markovian arrival process	Generalisation of the *MAP* with multiple arrivals	
MMPP	Markov modulated poisson process	Poisson process where arrivals are in "clusters".	
D	Degenerate distribution	A deterministic or fixed inter-arrival time.	D/M/1 queue
E_k	Erlang distribution	An Erlang distribution with k as the shape parameter.	
G	General distribution	Although G usually refers to independent arrivals, some authors prefer to use *GI* to be explicit.	
PH	Phase-type distribution	Some of the above distributions are special cases of the phase-type, often used in place of a general distribution.	

S: The service time distribution

This gives the distribution of time of the service of a customer. Some common notations are:

Symbol	Name	Description	Examples
M	Markovian	Exponential service time.	M/M/1 queue
M^Y	bulk Markov	Exponential service time with a random variable Y for the number of arrivals at one time.	$M^X/M^Y/1$ queue
D	Degenerate distribution	A deterministic or fixed service time.	M/D/1 queue
E_k	Erlang distribution	An Erlang distribution with k as the shape parameter.	
G	General distribution	Although G usually refers to independent service time, some authors prefer to use *GI* to be explicit.	M/G/1 queue
PH	Phase-type distribution	Some of the above distributions are special cases of the phase-type, often used in place of a general distribution.	
MMPP	Markov modulated poisson process	Exponential service time distributions, where the rate parameter is controlled by a Markov chain.[5]	

c: The number of servers

The number of service channels (or servers). The M/M/1 queue has a single server and the M/M/c queue c

servers.

K: The number of places in the system

The capacity of the system, or the maximum number of customers allowed in the system including those in service. When the number is at this maximum, further arrivals are turned away. If this number is omitted, the capacity is assumed to be unlimited, or infinite.

Note: This is sometimes denoted $C + k$ where k is the buffer size, the number of places in the queue above the number of servers C.

N: The calling population

The size of calling source. The size of the population from which the customers come. A small population will significantly affect the effective arrival rate, because, as more jobs queue up, there are fewer left available to arrive into the system. If this number is omitted, the population is assumed to be unlimited, or infinite.

D: The queue's discipline

The Service Discipline or Priority order that jobs in the queue, or waiting line, are served:

Symbol	Name	Description
FIFO/FCFS	First In First Out/First Come First Served	The customers are served in the order they arrived in.
LIFO/LCFS	Last in First Out/Last Come First Served	The customers are served in the reverse order to the order they arrived in.
SIRO	Service In Random Order	The customers are served in a random order with no regard to arrival order.
PNPN	Priority service	Priority service, including preemptive and non-preemptive. (see Priority queue)
PS	Processor Sharing	

Note: An alternative notation practice is to record the queue discipline before the population and system capacity, with or without enclosing parenthesis. This does not normally cause confusion because the notation is different.

References

1. ^ Kendall, D. G. (1953). "Stochastic Processes Occurring in the Theory of Queues and their Analysis by the Method of the Imbedded Markov Chain". *The Annals of Mathematical Statistics* **24** (3): 338. doi:10.1214/aoms /1177728975 (http://dx.doi.org/10.1214%2Faoms%2F1177728975). JSTOR 2236285 (http://www.jstor.org /stable/2236285).
2. ^ Lee, Alec Miller (1966). "A Problem of Standards of Service (Chapter 15)". *Applied Queueing Theory*. New York: MacMillan. ISBN 0-333-04079-1.

3. ^ Taha, Hamdy A. (1968). *Operations research: an introduction* (Preliminary ed.).
4. ^ Sen, Rathindra P. (2010). *Operations Research: Algorithms And Applications*. Prentice-Hall of India. p. 518. ISBN 81-203-3930-4.
5. ^ Zhou, Yong-Ping; Gans, Noah (October 1999). "#99-40-B: A Single-Server Queue with Markov Modulated Service Times" (http://fic.wharton.upenn.edu/fic/papers/99/p9940.html). Financial Institutions Center, Wharton, UPenn. Retrieved 2011-01-11.

Retrieved from "http://en.wikipedia.org/w/index.php?title=Kendall%27s_notation&oldid=549227847"
Categories: Mathematical notation | Single queueing nodes