Original Research Paper

Volume : 5 | Issue : 12 | December-2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

"MOVING SERVERS: AN APPLICATION OF SERVICE SURRENDER FACILITY"

Statistics

KEYWORDS: Queue, Service Surrender Facility, Moving Server, Bulk Queues
Area of research: Statistics, Operations Research

Ashwini Deshpande Department of Statistics, Ramnarain Ruia College, Matunga, Mumbai

S. P. Kane Vice Chancellor, Rashtrasanta Tukdoji Maharaj Nagpur University, Nagpur

ABSTRACT This paper deals with a unique application of service surrender facility i.e. a Moving server. A system of moving server is a system where the server moves from one queue to another to serve the customers. Local trains/trams/metro-trains (public transport) and elevators are some examples of moving servers that serve queues at multiple queues. The example of elevators is discussed in detail in this paper to depict the working of moving servers.

1.1 Introduction:
The classical literature of queueing theory published so far speaks about a single queue that is governed by one or more servers. In these queueing systems, the customers from the queue move from ahead towards the server, avail the service provide by the server and leave the queueing system.

1.2 Types of Serving Systems
In a queueing system, the service facility may execute as follows:
There is one serving channel which serves one customer at a time. Such a system is called SINGLE SERVER SYSTEM.
For e.g. single ATM.

There may be more than one serving channels, where each channel gives the same quality of service thereby serving more than one customer at a time. Such a system is called PARALLEL SERVER SYSTEM.
For e.g. ticket windows at railway stations.

There may be a series of service channels and each customer has to pass through each channel before completion of the service. Such a system is called SERIES SERVER SYSTEM.

For e.g. check-in procedures at the airports.
The servers generally take up the customers in the First Come First Served fashion. This procedure of taking customers for service is known as Queue Discipline. The properties of the queueing system which are concerned with the waiting times of the customers generally depend upon the queue discipline.

For e.g. the variance of the waiting times of the customers is more with the queue discipline LCFS than, with the queue discipline FCFS, though the mean waiting time remains the same.

1.3 Existing Queue disciplines
FCFS (FIFO):
FIRST COME FIRST SERVED
(FIRST IN FIRST OUT)
{E.g. queues at booking windows}

LCFS (LIFO):
LAST COME FIRST SERVED
(LAST IN FIRST OUT)
{E.g. goods stored in go-downs}

SIRO:
SERVICE IN RANDOM ORDER
{E.g. people entering the train}

GD: GENERAL DISIPLINE
{Independent of any specific discipline}

SHORTEST PROCESSING TIME: {E.g. Computer operators prioritize jobs waiting to be processed according to their expected processing time and run the shortest jobs first.}

PRIORITIES: Some customers are given priorities over the others.

The probability distribution of the number of units in the system remains unchanged. Hence the queue discipline that is generally used is GD.

1.4 Models of Queueing Theory
- Simple Markovian Models
- Self-Service Model
- Machine Serving Model
- Erlangian Model
- Bulk Queues
- Fork Model
- Multi-queue Models etc.

2.1 Service Surrender Facility
In practice it has been observed that there are many situations where the customers not only have to wait in a single queue but they also have to wait in the second queue. The analysis of the second queue differs from the analysis of the first queue.

But it is not always necessary that the customers have to go through two different queues. The existence of second queue is possible only when the system has a characteristic of 'SERVICE SURRENDER FACILITY'.

In certain situations the service availed by the customers is returned by one or more customers due to dissatisfaction (e.g. misfit of the size), lack of requirement (e.g. railway or bus tickets) or at times may be because the availed service does not get exhausted even after utilization (e.g. library books). In such situations the SERVICE is said to be SURRENDERED. These services are very much in demand since the availability of the service with the server is limited.

2.2 Concept of Moving Server
The various examples of queueing systems which compulsorily have a service surrender facility are library books, local trains/trams/metro-trains and elevators, etc. that move from point to point carrying people.

The example of local trains/trams/metro-trains and elevators also depict one more peculiar and important property namely, in these situations the server is moving i.e. the server moves from one point to other carrying the customers who wish to move from one point to another.

The example of an Elevator is the best example to depict the situation. It has been estimated that currently about 54% of the world's population is urban and that by 2050 this number will be about 66% (Populations Division, Department of Economic and Social Affairs, United Nations 2014). The elevator moving between floors is the server and the passengers who want to move from one floor to another form the customers. These systems most commonly include an up- and down-button on each floor so the passenger can inform the operating system in which direction she wishes to travel.

Since elevator traffic kept on increasing the control system "Collective Operation" was introduced. Collective Operation implies collecting and storing all calls in one direction, then reversing the elevator and collecting all the calls in the other direction (Frederick Cedar, Alexandra Nordin).

When the customers board the elevator their service is said to have begun and when they alight at their desired destination their service is said to end. Also they are said to have surrendered their services since unless the previously boarded passengers alight, the new passengers cannot be accommodated in the elevator. Hence this is a classic example of both, SERVICE SURRENDER FACILITY and MOVING SERVER.

2.3 Working of a Moving Server

Consider a queueing system which consists of one server and more than one parallel queues.

The working procedure of this system is that the server moves from one queue to another to serve the customers.

The best example of this is an ELEVATOR carrying passengers from one floor to another.

The elevator is the server making the facility available and the passengers are the customers who are carried from on floor to another.

This is where the service has to be surrendered by the earlier customers so that it can be utilized by the next set of customers.

Also this is an example of finite system capacity since the service is limited to the capacity of the elevator.

Such type of service has to be surrendered i.e. the elevator has to be vacated, since it implies the completion of service.
Also here, since the customers are served in groups, the system is said to serve BULK QUEUES.

The situation can be described as follows:
There are multiple queues at fixed points and there is a moving server who will move from first point to second, second to third and so on... and also from the last point to second last point in the backward direction till it reaches the first point. This procedure continues as long as the customers are waiting to avail the service.

2.4 Multiple Moving Servers (Elevator) Problem

Consider a situation where there are more than one moving servers who serve the queues at multiple points. The problem of queues at 2 points does not require two servers since there would be no queue formed in such a system.

The various cases that can be covered under it are

2.4.1 Three Queues and 2 moving servers

There are two servers (ELEVATORS) who make the same facility available to customers at each of the three queues (floors) with the same service rate. Each server does two different jobs of going UP and going DOWN. The programming of the displacement of the server is such that whenever there is a call for service, the one which is the nearest to the caller will reach that queueing point to serve the customers waiting there. Though there are two servers there is only a single queue at each point.

Thus availability of the server depends on the position of the server.
Hence this will also be an example of PRIORITIES and BULK SERVICES.

The concept of FCFS is not applicable to servers as the only priorities it has are of direction and proximity. This is because if two calls are generated simultaneously, the server will give priority to the nearest one. If one call is generated even a fraction of second before the other, for that server, the second call doesn't exist at all at that moment of time. After the mechanism of the server is activated, it cannot override its priority i.e. direction. This means that the server won't change its direction mid service. Thus first come first serve is applicable to only those queues which have limited resources.

2.4.2 'n' (>2) Queues and 2 moving servers

There are two servers (ELEVATORS) who make the same facility available to customers at each of the n queues (floors) with the same service rate.

Generally the working of elevators is programmed with respect to a direction i.e. upward and downward. The service in both these directions is of opposite types. When the sever (ELEVATOR) is moving in one direction and it receives calls for that direction from intermediate queues, it will attend all those calls on the way proceeding in the same direction (without changing the direction) serving as many customers as possible (i.e. carrying them in the elevator and dropping them at the desired floor) till it reaches the last serving point (the farthest destination) demanded by the customers.
But the programming of the displacement of the server is also such that whenever there is a call for service, the one which is the nearest to the caller and moving in that direction will reach that queueing point to serve the customers waiting there.

Thus availability of the server depends on the position of the server in addition to the direction in which the server is moving.

The programming of each server (ELEVATOR) is such that at each queue, there are two calling switches: DOWN arrow for going down and UP arrow for going up available to the customers.

The switch for calling the two servers (ELEVATORS) is common.
The customer is supposed to select that arrow in the direction in which he/she wishes to go in.

Though there are two servers there is only a single queue at each point.

If a customer selects the DOWN arrow, that one of the two servers (ELEVATORS) which is moving downwards and towards that floor will stop on that floor.

If a customer selects the UP arrow, that one of the two servers (ELEVATORS) which is moving upwards and towards that floor will stop on that floor.

Each server will give service to the one who calls for service from any of the queues but since the movement of the server is direction-prone, it will give priority to those who demand for service in the direction in which the server is proceeding on the way. It will not change the direction in any case till it completes the service that it has begun in one direction i.e. the priority is given to the direction.

The concept of FCFS is not applicable to servers as the only priorities it has are of direction and proximity. This is because if two calls are generated simultaneously, the server will give priority to the nearest one. If one call is generated even a fraction of second before the other, for that server, the second call doesn't exist at all at that moment of time. After the mechanism of the server is activated, it cannot override its priority i.e. direction. This means that the server won't change its direction mid service. Thus first come first serve is applicable to only those queues which have limited resources.

The M/M(1,m)/1 bulk-service queueing model can be fit to this system and all measures of the model are applicable to it.

The average waiting time of any customer will be dependent on from where is a previous call generated and how many floors does the server goes up and down before attending the current call.

2.4.3 'n' Queues and multiple moving servers

'c' servers (ELEVATOR) moving sequentially between 'n' points (floor) Such systems work on the principle called Traffic Management Systems for high-rise elevators

Traffic Management Systems of the elevators transport millions of people comfortably, safely, and fast to the top of the world's tallest buildings.

This is a highly efficient and energy-saving Traffic Management System with state-of-the-art terminals in functional design that also provides enhanced economics and modernizations.

Traffic Management System can do much more than ordinary destination control systems. It incorporates a new method of combining the most efficient use of the building's elevators with an exceptional ride experience for each passenger. We provide a new level of passenger communication that allows a new level of elevator utilization.

It replaces buttons by keypads. It is the creative use of an enormous amount of knowledge about passenger traffic patterns and behaviour located throughout the world. The intelligent Traffic Management System is designed for single as well as multi-deck elevators. Hence the key features of the system are cutting-edge traffic performance, reduced time to destination, greater architectural flexibility, and optimized usable building space. It can also provide individualization of passengers and their needs, multi-level access control, as well as visitor control and guidance all reconfigurable by the customer at any time. Glass pillars and keypads are conveniently located in the lobbies and on each floor. To call an elevator, press the buttons for the desired floor. The screen displays a letter that indicates the elevator.

People no longer look for the elevator. The elevator looks for People. Traffic Management System is a powerful and unique control system based on a simple principle: to bring passengers to their destinations faster, with less crowding and more comfort than any conventional elevator system. The system's advanced software drives a powerful logic program that systematically optimizes the elevator traffic flow. It uses a sophisticated algorithm to manage the complexities of traffic patterns as they change through the day.

Step 1. Choose the destination via the touchscreen.
Step 2. Read the elevator car assignment.
Step 3. Walk to the assigned elevator to avail the service.

Few applications of queues at 'n' points and multiple moving servers can be quoted as:
Fleet taxi services

- Supermarkets delivering commodities at home
- Food joints like McDonalds, Pizza Hut, etc. providing home deliveries

References:

1. Erlang, A.K. (1909); Probability and telephone calls Nyt. Tidsskr. Mat. Ser B Vol. 20
2. Feller, W. (1950); An introduction to probability theory and its applications. John Wiley & Sons, Inc. New York.
3. Kane N. S. (2001); Analytical Study of Queueing Systems with Service Surrender Facility to the Customer; Ph. D. thesis, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
4. Lakhani P. B. (2007); A Study of Some Special Types of Secondary Queues; Ph. D. thesis, Sant Gadge Baba Amravati University, Amravati
5. Medhi J.; Stochastic Processes – New Age International Publishers
6. Medhi J.; Stochastic Models in Queueing Theory – Academic Press
7. Frederick Ceder , Alexandra Nordin (2013); Elevator Control Strategies Simulating different algorithms to find the most efficient strategy