Week\_08

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2025-04-19

# M/M/1 Queuing Model

# Problem 1:  
   
# Model an M/M/1 system with:  
# • Arrival rate (λ=4)  
# • Service rate (μ=6).  
  
library(queueing)  
  
mm1\_input <- NewInput.MM1(lambda = 4, mu = 6)  
mm1\_model <- QueueingModel(mm1\_input)  
  
summary(mm1\_model)

## lambda mu c k m RO P0 Lq Wq X L W Wqq Lqq  
## 1 4 6 1 NA NA 0.6666667 0.3333333 1.333333 0.3333333 4 2 0.5 0.5 3

# Problem 2:  
   
# In a dental clinic, patients arrive randomly at 2 per hour, and the dentist treats them at 5 per hour, fitting an M/M/1 queueing model. Using R's `queueing` package, define the model with `NewInput.MM1()` and solve it with `QueueingModel()`. Retrieve key metrics: utilization (ρ), average number in queue (Lq), in system (Ls), waiting time in queue (Wq), total time in system (Ws), and throughput.  
  
library(queueing)  
  
lambda <- 2  
mu <- 5  
  
mm1\_input <- NewInput.MM1(lambda = lambda, mu = mu)  
mm1\_model <- QueueingModel(mm1\_input)  
  
summary(mm1\_model)

## lambda mu c k m RO P0 Lq Wq X L W Wqq  
## 1 2 5 1 NA NA 0.4 0.6 0.2666667 0.1333333 2 0.6666667 0.3333333 0.3333333  
## Lqq  
## 1 1.666667

cat("Utilization (rho):", RO(mm1\_model), "\n")

## Utilization (rho): 0.4

cat("Average number in queue (Lq):", Lq(mm1\_model), "\n")

## Average number in queue (Lq): 0.2666667

cat("Average time in queue (Wq):", Wq(mm1\_model), "\n")

## Average time in queue (Wq): 0.1333333

cat("Average number in system (Ls):", L(mm1\_model), "\n")

## Average number in system (Ls): 0.6666667

cat("Average time in system (Ws):", W(mm1\_model), "\n")

## Average time in system (Ws): 0.3333333

cat("Throughput:", Throughput(mm1\_model), "\n")

## Throughput: 2

# M/M/c Queuing Model

# Problem 3:  
   
# Model an M/M/c system with:  
# • Arrival rate (λ = 6)  
# • Service rate (μ = 4)  
# • Number of servers (c = 3)  
  
  
library(queueing)  
  
mmc\_input <- NewInput.MMC(lambda = 6, mu = 4, c = 3)  
mmc\_model <- QueueingModel(mmc\_input)  
  
summary(mmc\_model)

## lambda mu c k m RO P0 Lq Wq X L W  
## 1 6 4 3 NA NA 0.5 0.2105263 0.2368421 0.03947368 6 1.736842 0.2894737  
## Wqq Lqq  
## 1 0.1666667 2

# Problem 4:  
   
# A car service center has 2 service bays, with cars arriving at a rate of 7 cars per hour. Each bay services cars at a rate of 5 cars per hour. The manager wants to determine the following metrics for the system: the average number of cars in the system (Ls), the average number of cars in the queue (Lq), the average waiting time in the system (Ws), and the average waiting time in the queue (Wq). These metrics will help assess the efficiency and capacity of the service center.  
  
  
library(queueing)  
  
lambda <- 7   
mu <- 5  
c <- 2   
  
mmc\_input <- NewInput.MMC(lambda = lambda, mu = mu, c = c)  
mmc\_model <- QueueingModel(mmc\_input)  
  
summary(mmc\_model)

## lambda mu c k m RO P0 Lq Wq X L W  
## 1 7 5 2 NA NA 0.7 0.1764706 1.345098 0.1921569 7 2.745098 0.3921569  
## Wqq Lqq  
## 1 0.3333333 3.333333

cat("Utilization (rho):", RO(mmc\_model), "\n")

## Utilization (rho): 0.7

cat("Average number in queue (Lq):", Lq(mmc\_model), "\n")

## Average number in queue (Lq): 1.345098

cat("Average time in queue (Wq):", Wq(mmc\_model), "\n")

## Average time in queue (Wq): 0.1921569

cat("Average number in system (Ls):", L(mmc\_model), "\n")

## Average number in system (Ls): 2.745098

cat("Average time in system (Ws):", W(mmc\_model), "\n")

## Average time in system (Ws): 0.3921569

cat("Throughput:", Throughput(mmc\_model), "\n")

## Throughput: 7