


Modelling Queues

Rotary Science and Technology Forum, 9 - 20 January 2023

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Getting started:

1. Login to the computer using the following details:
Login: «login»
Password:
2. Open **RStudio** and then open the file: H:\data\queue_dashboard.Rmd
3. Run the file by clicking: . The output should appear in a new window. The first time you do this it may take a couple of minutes as new packages install.
4. In the following activities we will change the parameters of the simulation and inspect that output.
To change the parameters for the simulation, edit the numbers in the section that looks like this:

```

```{r, echo = FALSE, results = "hide"}
#####
EDIT NUMBERS IN THIS SECTION
#####

lambda = 1 # number of customers arriving per minute
average_service_time = 0.5 # number of minutes
num_servers = 1 # number of checkout operators
simulation_length = 100 # number of minutes

mu = 1/average_service_time # number of customers served per minute
rho = lambda/(mu*num_servers) # traffic intensity

#####
```

```

Activity 1: Exploring the code

1. Change the code so the simulation runs for a longer time, e.g.
`simulation_length = 10000`
2. Run the simulation using the “knit” button and inspect the output. Repeat this a few times and inspect the output.
3. Change the number of servers
`num_servers = 2`
4. Run the simulation a few times using the “knit” button and inspect the output.

Activity 2: What happens if customers arrive faster than they are served?

1. Change the number of servers back to 1
`num_servers = 1`
2. Change the values of lambda (arrival rate) and/or mu (service rate) e.g.
`lambda = 3`
3. Run the simulation using the “knit” button and inspect the output.
4. What happens to the number of people in the system if $\lambda > \mu$?

Activity 3: Which queueing configuration is best?

Is it better to have 3 servers each with their own queue, or with a combined queue?

1. Change the parameters as follows:
`lambda = 1`
`mu = 2`
`num_servers = 3`
2. Run the simulation using the “knit” button and inspect the output in the two tabs:
 - a. “A single queue with n servers” and
 - b. “n queues with n servers”.
3. Inspect the performance measures, which queueing configuration performs the best?

Activity 4: Design your own checkout

- Two types of customers
 - Express (12 items or less)
 - Arrival rate 4 per minute
 - Service rate 1 per minute (service time = 1 min)
 - Regular (more than 12 items)
 - Arrival rate 1 per minute
 - Service rate 0.2 per minute (service time = 5 min)
- Two types of checkouts
 - Self-checkout (12 items or less) cost = \$10
 - Staffed-checkout (any number of items) cost = \$100

Aim: Find a configuration of self and staffed checkouts which:

- Costs \$700 or less
- Average waiting time in the queue is less than the average service time
 - Express customers – average time in queue less than 1 minute
 - Regular customers – average time in queue less than 5 minutes

1. Open **RStudio** and then open the file H:\data\new_supermarket_dashboard.Rmd
2. Change the number of staffed and self-checkouts in the code below

```
```{r, echo = FALSE, results = "hide"}
#####
EDIT NUMBERS IN THIS SECTION
#####
num_servers_selfcheckout = 0 # number of checkout operators
num_servers_staffed = 7 # number of checkout operators > 0

simulation_length = 1000 # number of minutes
#####
```
```

3. Run the simulation using the “knit” button and inspect the output.
4. Find the checkout configuration which consistently (across multiple simulation runs) meets the aims stated above.

More information:

Resources from today: <https://github.com/sarahemarschall/rotary2023>

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Info about AUT Bsc: <https://www.aut.ac.nz/courses/bachelor-of-science>