# The MacDonald Simulation

(Not McDonald's due to copyright issues)

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# The Current MacDonald

<u>Arrivals:</u>

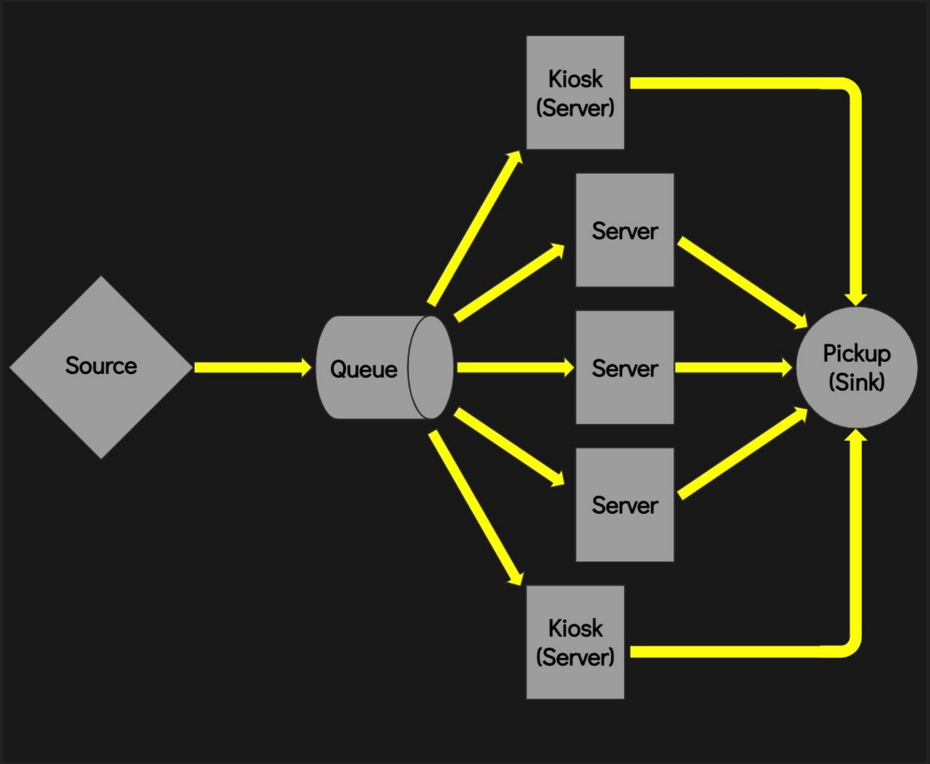
Customers arrive at random time intervals throughout the day[1]

<u>Service:</u>

3 servers and 2 kiosk ordering systems are available, with one order pickup station (sink)

<u>Queue Type:</u>

With these parameters, an **M/M/5** queue is formed



# The Issues

Popular But Old:

Unfortunately, while our MacDonald has become a popular fast food restaurant, its design has become outdated and inefficient.

Our MacDonald hosts 5 servers that normally work fine, but during rush hour, the layout renders it to a very congested state.

Tiny Parking Lot:

Along with the occasional congestion, the parking lot tends to fill up quickly throughout the day, which sometimes causes potential customers to dine elsewhere.

# The Objective

Reduce Congestion:

Our goal is to find a way to reduce congestion and increase the amount of customers we can serve, while also decreasing service time and waiting time as a result.

We hope to do this without having to expand the parking lot or the restaurant, as that would require purchasing more land on top of any other renovation expenses.

# Performance metrics

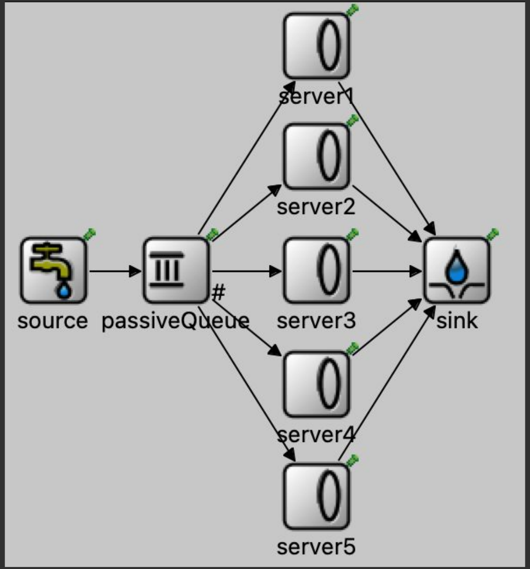
Sink statistics will indicate how well the queue performs, specifically:

- Mean Queueing Time
- Max and Average Total Service Time

## M/M/5 Parameters Initialized

| | |
|---|---|
| **Service Times**[1] | exponential(*60s*) |
| **Number of Jobs** | 10,000 |

## Running the Simulation [Omnet++][3]



# Current Statistics

| | |
|---|---|
| Mean Queueing Time (s) | 14.45 |
| Max Total Service Time (m) | 10.72 |
| Max Queue  Length | 3 |
| Average Queue  Length | 0.000796 ≈ 0 |
| Average Service Time (s) | 59.45 |

# Alternative Design(s)

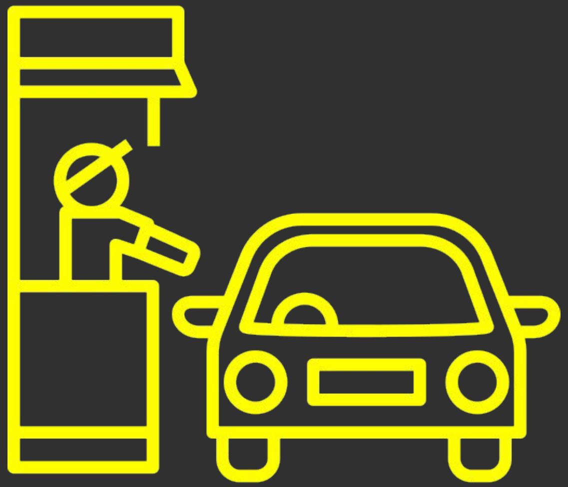
<u>Deterministic Service Time:</u> ✖

It would not make sense to incorporate a deterministic service time, as not all customers will be ordering the same thing, and instead will have random order times, unless given a time limit, which would be unethical.

<u>Additional Queue (Drive Thru):</u> ✔

In order to cater to a large amount of customers more efficiently, another queue can be implemented. This additional queue would be exclusive to customers on-the-go who do not wish to leave their vehicles, with a dedicated server and pickup area.

# Introducing:
# MacDriveThru



# DriveThru Overview

Methodology:

Unlike the original design, the DriveThru implementation involves prioritizing DriveThru customers, as they will be in and out faster since they do not leave their cars.

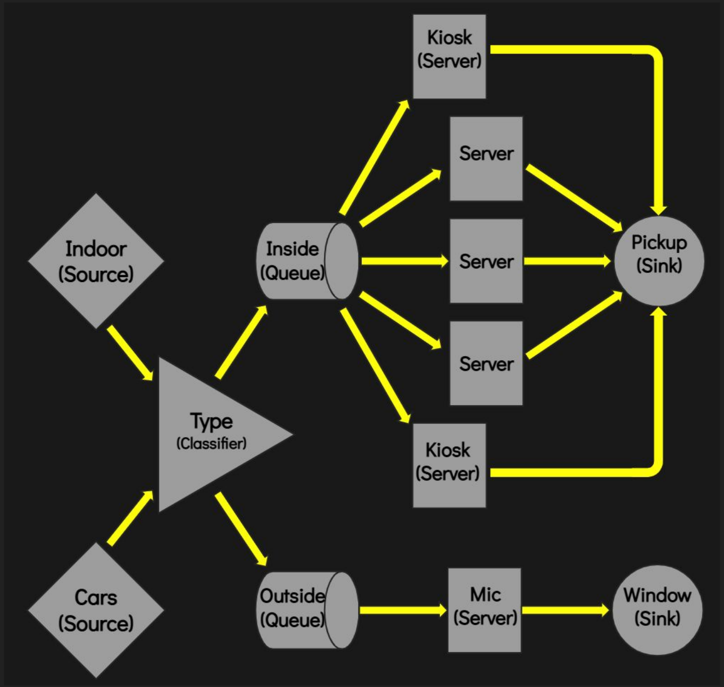
Service:

3 servers and 2 kiosk ordering systems are available with one order pickup station (sink) inside, and one separate DriveThru queue for cars that is given priority since it can be handled quicker.

Queue Type:

With these parameters, an **M/M/5 + M/M/1** priority queue is formed[2]

# Power in Numbers

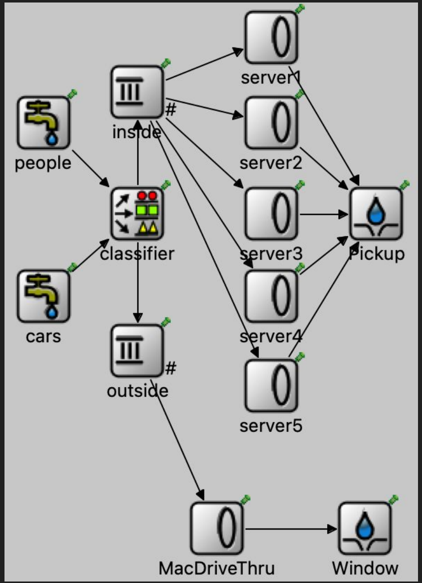



By adding a DriveThru section to our restaurant, we will be benefiting the ordering process in **two** ways:

- Increasing number of servers will allow more orders to be handled at once, effectively speeding up the queue.

- Prioritizing the outdoor traffic will help keep the parking lot less congested, and increase potential customer engagement.

# Updated Simulation Process




## M/M/5 Parameters Initialized

| | |
|---|---|
| Service Times[1] | exponential(*60s*) |
| Number of Jobs | 10,000 |

## M/M/1 Parameters Initialized

| | |
|---|---|
| Service Times[1] | exponential(*30s*) |
| Number of Jobs | 10,000 |

# Queue Results

## Original

| MM5 Queue with Service Time **exponential(60s)** | |
|---|---|
| **Mean Queueing Time (s)** | **14.45** |
| **Max Total Service Time (m)** | **10.72** |
| **Max Queue Length** | **3** |
| **Average Queue Length** | **0.000796** |

## DriveThru

<table>
<tr><th colspan="4">MM5 + MM1 Priority Queue with Inside Service Time exponential(60s) and Outside Service Time exponential(30s)</th></tr>
<tr><td rowspan="2">Mean Queueing Time (s)</td><td>Avg. Pickup</td><td>Avg. Window</td><td rowspan="2">5.6555</td></tr>
<tr><td>0.071</td><td>11.24</td></tr>
<tr><td>Max Total Service Time (m)</td><td colspan="3">10.44 (Inside) | 4.03 (Outside)</td></tr>
<tr><td>Max Queue Length</td><td colspan="3">8 (Outside) | 2 (Inside)</td></tr>
<tr><td rowspan="2">Average Queue Length</td><td>Avg. Inside</td><td>Avg. Outside</td><td rowspan="2">0.0951</td></tr>
<tr><td>0.0012</td><td>0.189</td></tr>
</table>

**Queue Statistics show how well the queue handles incoming customers:**

We see a decrease in average queueing time both outside and inside, as well as a 16.41 second decrease in the max total service time. The average line length is still close to 0, but increases slightly.

# Server Results

## Original

| Server Statistics (Time Average) | |
|---|---|
| Average Service Time (s) | 59.45 |

**Queue Statistics show how long the customer has to wait for their order.**

In comparison to the original design, the DriveThru model provides a similar average service time for the customers inside; however, the average service time in the DriveThru is only 11.24 seconds, bringing the total average service time of the new model down to 31.5 seconds.

## DriveThru

| Server Statistics (Time Average) | |
|---|---|
| Pickup (s) | 59.056 |
| Window (s) | 11.24 |
| Average Service Time (s) | 35.148 |

# DriveThru Queueing Time Accuracy

| Queue Time (Sample Mean of 5 Trials) | | | | | | Variance | 95% Confidence Interval | | |
|---|---|---|---|---|---|---|---|---|---|
| 5.656 | 5.794 | 5.986 | 6.005 | 5.925 | = | 0.017 | 5.765 | , | 5.981 |

## Calculations[4]

Average = (5.656+5.794+5.986+6.005+5.925)/5 = **5.873**

Variance = $[(5.656 - 5.873)^2 + (5.794 - 5.873)^2 + (5.986 - 5.873)^2 + (6.005 - 5.873)^2 + (5.925 - 5.873)^2]/5$ = **0.017**

95% Confidence = CONFIDENCE($\alpha$, Standard Deviation, Number of Trials) = CONFIDENCE(0.1, 0.147, 5) = **0.108**

95% Confidence Interval = ([5.873 - 0.108], [5.873 + 0.108]) = **(5.765, 5.981)**

# DriveThru Service Time Accuracy

| Average Total Service Time (Sample Mean of 5 Trials) | | | | | = | Variance | 95% Confidence Interval | | |
|---|---|---|---|---|---|---|---|---|---|
| 35.148 | 35.268 | 35.813 | 36.011 | 35.385 | | 0.109 | 35.253 | , | 35.797 |

## Calculations[4]

Average = (35.148+35.268+35.813+36.011+35.385)/5 = **35.525**

Variance = [(35.148 - 35.525)$^2$ + (35.268 - 35.525)$^2$ + (35.812 - 35.525)$^2$ + (36.011 - 35.525)$^2$ + (35.385 - 35.525)$^2$]/5 = **0.109**

95% Confidence = CONFIDENCE($\alpha$, Standard Deviation, Number of Trials) = CONFIDENCE(0.1, 0.369, 5) = **0.272**

95% Confidence Interval = ([35.525 - 0.272], [35.525 + 0.272]) = **(35.253, 35.797)**

# Face Validity Assessment

We see an improvement from the results in multiple areas, including waiting time and service time. At face value[4], it is evident that congestion can be handled better, as the amount of jobs handled had doubled while still maintaining an improvement in service time.

Furthermore, money was saved in the process, and all of this was accomplished by adding only one extra **dedicated** server.

# Conclusion

From our results, it can be concluded that the DriveThru model is worth the investment based on our objective. We wanted to improve customer service times, and decrease waiting time – both of which were improved.

In some aspects, the differences were minimal. However, let's consider the fact that the number of jobs were double that of the original model. Thus, the model has shown itself to be much more efficient for dealing with congestion, while only adding **ONE** extra server.

# Thanks for learning about The MacDonald Simulation

# Questions?

# Reference(s)

[1] R. D. Reid and N. R. Sanders, “Waiting Line Models,” *Reid SUPPC 001-020hr - California State University, Sacramento*, 2010. [Online]. Available: https://www.csus.edu/indiv/b/blakeh/mgmt/documents/opm101supplc.pdf. [Accessed: 05-May-2022].

[2] “Priority queue: Set 1 (introduction),” *GeeksforGeeks*, 25-Jan-2022. [Online]. Available: https://www.geeksforgeeks.org/priority-queue-set-1-introduction/. [Accessed: 05-May-2022].

[3] A. Varga, “Simulation Manual,” *OMNeT++ - Simulation Manual*. [Online]. Available: https://doc.omnetpp.org/omnetpp/manual/. [Accessed: 05-May-2022].

[4] C. Comaniciu, “Lecture 14 Slides,” *Canvas*, Apr-2022. [Online]. Available: https://sit.instructure.com/courses/58283/files/9240820?module_item_id=1434405. [Accessed: 05-May-2022].