McDonalds Simulation Report

Brett Athaide

300177291

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Introduction

1. Problem description

The problem I have noticed at McDonalds is the long lines during “lunch hours” which are peak times for them.

The goal of this simulation is to reduce the long lunch-hour waits at McDonalds across locations by simulating the front-of-house system and testing operational changes. And to find any bottlenecks or points of inefficiency with their system.

This is a discrete-event simulation, where I will analyze the queue, and give possible suggestions for optimizing it.

2. Scope of the study

The scope of this study is the in-store counter ordering, kiosks, kitchen service times of orders at McDonalds. More specifically, as we see later in the report, a McDonalds with a staff of 5 employees (4 in kitchen, 1 at counter), with 3 self-serving kiosks.

The time range will be between 11am – 2pm (3 hours) which are the busy hours of the day.

There will be many replications for a complete analysis. I will model the base-case simulation, followed by multiple “what-ifs” scenarios based on the observations made.

The performance measures are: waiting time, time in system, queue length, throughput, staff utilization, % of customers leaving without orders.

There are other processes and resources that McDonalds is associated with but are outside the scope of this project. Such as time to consume meal, drive-thru, resource allocation, staff schedule changes, environmental effects, and holiday periods.

3. Understand the system

Due to the nature of McDonalds, it is very easy to walk into the store and personally analyze and observe the process and map the waiting times per customer. In addition, because of the scale and reputation of McDonalds, it is very easy to find online datasets for a more complete and larger analyses of locations.

The specific system I will be simulating is a multi-queue, multi-server system. Where a customer walks-in, waits in a multi-queue (either cashier or kiosk), then orders at the cashier (possible multiple, depending of staffing schedule) or kiosk (multiple), payment, order sent to kitchen, food prepared, pickup, and the customer leaves (to-go).

The most important metrics to understand to properly analyze the system is the customer arrival rate, number of cashiers and number of cooks (for a specific time of day).

In the next section (Model description), included is an image of the Arena model which showcases the process flow/mapping.

Model Description

4. Data collection

Using a mixture of personal observations and internet sources, I gathered the following information.

The inter-arrival rates under peak hours is between 0.5 to 1 customer per minute. One thing I have observed is rarely will a single customer enter a McDonalds, generally when customers arrive, it will be groups, meaning more than one person (couples, families).

The order times for customers ordering from the cashiers on average one minute, even shorter. This was observed over a period of 15 minutes during "peak-hours". The order times for customers ordering from kiosks was between 1-4 minutes (also observed over 15 minutes during "peak-hours"). And about 30% of customers prefer to order from kiosks if the lines are of comparable length. There are approximately an average of 3 kiosks per McDonalds. "most customers order food from the cashier as their priority, even the young cluster supposed to engage in high technology. This reflects that the age group and technical knowledge are not the significant factors affecting the kiosks usage. Moreover, the order time of the cashier is faster than the kiosk. In consequently, "Time" is the key issue obviously. "(Ng, Y. (2021, July 9))

The arrival rate and order time for drive-thru is outside the scope of the project.

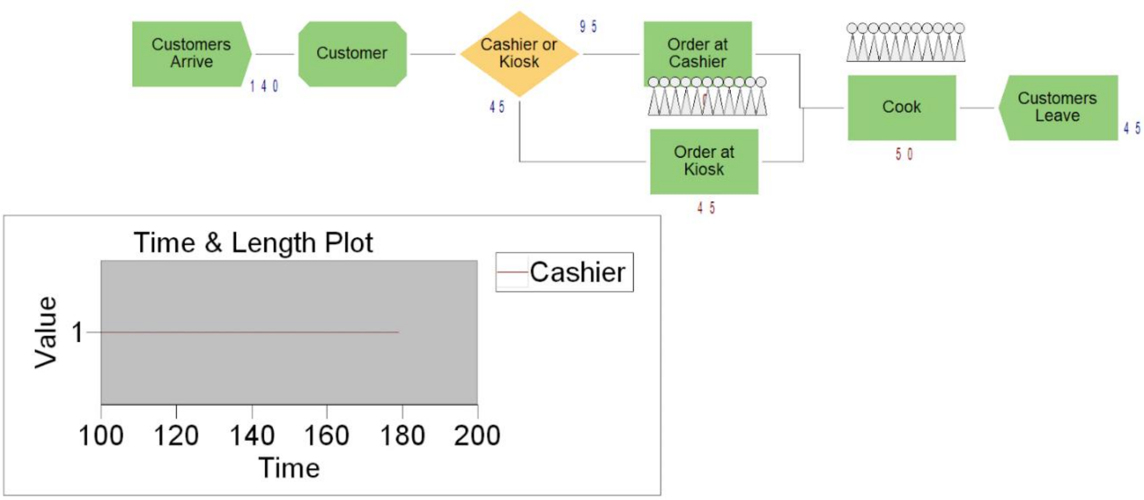
Within the back-house system, cook and meal preparation time. This is dependent on staff scheduling and availability, and was the hardest data to collect. But what I found is that it typically takes 3-5 minutes to prepare an order, once placed. Of course this is the average, and depending on the order, and number of customers that order is for (people who come together will place their orders under a single order).

And lastly, with the modern "face-paced" society it is pretty commonplace to have the fast-food to-go. But there are still customer who prefer to dine-in, and while this does not affect the queue, it does affect the restaurant capacity. Unless this becomes relevant, I will leave this out of the system, it is also a hard statistic to find. And for the purposes of measuring the queue, and not restaurant capacity, the patterns of customers dining-in or eating-out are outside the scope for this project.

That is information about the process and times at each process. But one more very important data needed is number of staff. The scheduling of staff varies across McDonalds, and also varies depending on the time ,and the day. This was a very difficult detail to obtain. But from what I collected, there are about 1 cashier (especially with the presence of kiosks), and 3-4 staff in the kitchen (various tasks).

5. Build model with software

Using Arena, and the data collected above, we are able to put together a simulation of the system.



Here is the Arena system model. As we can see, customers arrive at the system, then they split between ordering at the cashier, or ordering at a kiosk, then both proceed to the cook which represents the kitchen, and all activities associated with that, then customers leave. As mentioned, customers dining-in is outside the scope of this system.

Discussion of Validation & Verification

6. Verify the model

First, verifying the model. From the simulation the logic checks. The process flow matches what the actual McDonalds would appreciate. Now there are some things that we are making assumptions on. First it is possible that staff schedule could change mid-shift, and there might be an increase/decrease or same number but different people that change mid-simulation. In addition, the simulation is assuming that the employees are working for the entire duration of the period. But in the real-world staff might have little breaks or need to use the washroom, etc… which would alter the simulation.

Of course, the simulation is only true if it represents the real-world scenario, and requires the real-world data. As mentioned before, there are some data points that are using averages, and estimates that either I found (but may be less then accurate) or found datasets/datapoints on the internet, which may be not accurate, or represents a different McDonalds with different time averages.

7. Validate the model

After analyzing the report, and simulation, it does represent the real-world observations. It is difficult to completely validate the model. Because the simulation represents a 3 hour period ("peak") lunch-hour. But in my observations and information gathering, I did not observe the real system for this amount of time. Due to this, it is difficult to compare with real data.

But using a reasonability check, there are no negative times, no infinite queues, and the resource utilization are all plausible.

Based on a simulation of 30 replications, all set to 180 minutes (3 hours), here is the data collected.

ARENA Simulation Results
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Output Summary for 30 Replications

Project: ADM 3305 Project 1_V1 Run execution date :10/29/2025
Analyst: Windows User Model revision date:10/29/2025

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Customer.NumberIn	136.76	3.8273	114.00	157.00	30
Customer.NumberOut	132.23	3.8448	113.00	153.00	30
Kiosk.NumberSeized	40.700	2.2935	25.000	53.000	30
Kiosk.ScheduledUtilization	.18873	.01086	.10445	.24768	30
Cooks.NumberSeized	135.00	3.8924	113.00	156.00	30
Cooks.ScheduledUtilization	.74205	.02078	.63476	.85740	30
Cashier.NumberSeized	95.800	3.5153	77.000	112.00	30
Cashier.ScheduledUtilization	.53187	.02029	.43081	.62811	30
System.NumberOut	132.23	3.8448	113.00	153.00	30

Simulation run time: 2.37 minutes.
Simulation run complete.

This is the report summary of 30 replications of the system.

Before analyzing the report. This is not the first simulation. I ran a simulation prior to this, but noticed something was wrong:

ARENA Simulation Results
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Output Summary for 30 Replications

Project: ADM 3305 Project 1_V1 Run execution date :10/29/2025
Analyst: Windows User Model revision date:10/29/2025

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Entity 1.NumberIn	137.60	4.4530	114.00	167.00	30
Entity 1.NumberOut	43.966	.33226	42.000	45.000	30
Kiosk.NumberSeized	.00000	.00000	.00000	.00000	30
Kiosk.ScheduledUtilization	.00000	.00000	.00000	.00000	30
Cooks.NumberSeized	44.966	.33226	43.000	46.000	30
Cooks.ScheduledUtilization	.98956	.00395	.95036	.99625	30
Cashier.NumberSeized	96.700	3.7569	79.000	119.00	30
Cashier.ScheduledUtilization	.53555	.02065	.43049	.63828	30
System.NumberOut	43.966	.33226	42.000	45.000	30

Simulation run time: 2.22 minutes.
Simulation run complete.

This is the fist report summary that I received after the first simulation. One thing I noticed is the lack of kiosks used. This was due to the fact that I set the number of kiosk (resource) available, but in the process it wasn't set up to be used. This was quickly fixed. But one more observation, and harder to notice, but the number of customers who entered the system was around 140 per replication, yet the number of leave the system was around 45. This is due to the fact that I set he number of cooks to one (instead of 4 later on). Even though this was a input mistake, it does show in the simulation how this impact the system. About 2/3 of customers who entered the system in the simulation period did not leave before the simulation ends, shows how long the queue is when only one cook is available.

This was also a tool used to verify the model. Analyzing the report and see if the summary makes sense, and if not to double check the processes, and resources.

We can now observe the actual simulation results. And we can analyze that compared to the "incorrect" model (or one that simulated a busy period, with a lack of kitchen staff), that the number of customer in are around 136, and the number of customer out is about 132, showing that most of the customers are being served (been through the entire system) are relatively the same, with only a few customers still in a queue by the end. This means the system has good throughput, which makes sense as this is a priority for a fast-food restaurant.

Observing the results for the processes, starting with kiosks. The average number of kiosks seized/used was 41. This is 41/137 = 0.299, which is 30%. This does make sense as we stated in the data collection, that about 30% of customers used kiosks. But the utilization for kiosks is 0.188. This is very low, especially compared to the cashier. This means that the kiosk is being used 19% of the time. This can mean multiple things. The first conclusion from this means that either customers are not choosing to use the kiosks more than they can. So even if the kiosks are free, they are not being utilized. The second conclusion is that this particular McDonalds overinvested in the number of kiosks to operate. This is very interesting as in the future "what-if" we can test if we reduce the number of kiosks available, if it will significantly slow the system.

Observing the results for cashier, we can see the number seized is 95 (average), this is the other 70% of customers. Unlike the kiosks, the utilization for the cashier is 0.53, or 53%. This is a lot better, and is probably due to the time to order. Because the average time to order from a cashier is 2 minutes shorter than that of kiosks, customers probably prefer to use this method, even if the queue is slightly longer.

Lastly, observing the results for the cooks (kitchen), we can see the utilization is 74%. This process is probably the most important as all customer order go through this one. One thing I was surprised by is that the utilization for cooks in not closer to 100%, because the lower the utilization, generally means that there is a fewer queue, or the process/resource is not being used. Due to the circumstances of the simulation, where a customer arrives 1 per minute, I find it difficult to believe that there is a period where the kitchen is not cooking an order. Because of this I believe that the kitchen is always busy, but out of the 4 cooks, not all of the are simultaneously working at once.

Discussion and analysis of two "what-if" scenarios

8. Design and run experiments

Based on the data and results from the previous simulation, we made some observations about the utilization of certain processes. One main observation is that the utilization of the self-ordering kiosks was very low. One what-if scenario I will simulate is to decrease the number of kiosks available, to see if McDonalds can save money without affecting throughput.

<u>The following is the summary report for 2 kiosks (everything else the same):</u>

ARENA Simulation Results
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Output Summary for 30 Replications

Project: ADM 3305 Project 1_What-If_2Kiosk — Run execution date :10/30/2025
Analyst: Windows User — Model revision date:10/30/2025

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Customer.NumberIn	136.66	3.8117	113.00	158.00	30
Customer.NumberOut	131.03	3.4561	108.00	147.00	30
Kiosk.NumberSeized	40.366	2.3826	25.000	52.000	30
Kiosk.ScheduledUtilization	.27834	.01666	.15667	.34885	30
Cooks.NumberSeized	134.46	3.5103	112.00	151.00	30
Cooks.ScheduledUtilization	.73770	.01937	.61664	.82977	30
Cashier.NumberSeized	95.966	3.0355	76.000	111.00	30
Cashier.ScheduledUtilization	.53142	.01704	.42230	.61881	30
System.NumberOut	131.03	3.4561	108.00	147.00	30

Simulation run time: 2.52 minutes.
Simulation run complete.

As we can observe reducing the number of kiosks to 2 (compared to 3 last time), the utilization went up by 10% even though the number seized remained the same. Another thing to note is that the throughput remained the same. So in this scenario, with the same inputs and processing time, they can save money by reducing the amount of kiosks operating without affecting efficiency. But can we go further?

<u>The following is the summary report for 1 kiosks (everything else the same):</u>

ARENA Simulation Results
Windows User - License: STUDENT

Output Summary for 30 Replications

Project: ADM 3305 Project 1_What-If_1Kiosk Run execution date :10/30/2025
Analyst: Windows User Model revision date:10/30/2025

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Customer.NumberIn	134.43	4.3944	108.00	156.00	30
Customer.NumberOut	129.23	4.3105	104.00	150.00	30
Kiosk.NumberSeized	40.700	2.6494	27.000	52.000	30
Kiosk.ScheduledUtilization	.56525	.03552	.37938	.73646	30
Cooks.NumberSeized	132.36	4.2710	107.00	152.00	30
Cooks.ScheduledUtilization	.72498	.02348	.58590	.83524	30
Cashier.NumberSeized	93.333	3.4656	77.000	110.00	30
Cashier.ScheduledUtilization	.51451	.01900	.42445	.60737	30
System.NumberOut	129.23	4.3105	104.00	150.00	30

Simulation run time: 2.52 minutes.
Simulation run complete.

Once again the number of kiosks seized has remained the same because the same percentage of customers use the kiosk. But the utilization rate was gone up 37% from the original 3 kiosks, and 27% from 2 kiosks. That being said, with only one kiosk, the utilization matches the utilization of the cashier. So if you want equivalent use out of the kiosks as with the cashier, 1 kiosk is the optimal number for this McDonalds.

One other thing about the simulation is that the customers are split 70% to cashier and 30% to kiosks. In the previous what-if, we analyzed what would happen if we decrease the number of kiosks, but for this what-if we will alter the percentage that go to the kiosk, and another in which there is no cashier.

<u>The following is the summary report for a 50/50% split between ordering at the cashier or kiosk:</u>

ARENA Simulation Results
Windows User - License: STUDENT

Output Summary for 30 Replications

Project: ADM 3305 Project 1_What-If_50_50_percent   Run execution date :10/30/2025
Analyst: Windows User   Model revision date:10/30/2025

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Customer.NumberIn	136.60	2.9862	122.00	155.00	30
Customer.NumberOut	130.56	2.6138	119.00	149.00	30
Kiosk.NumberSeized	68.433	2.8981	56.000	87.000	30
Kiosk.ScheduledUtilization	.31515	.01434	.25513	.42491	30
Cooks.NumberSeized	134.06	2.6653	121.00	153.00	30
Cooks.ScheduledUtilization	.73436	.01568	.65346	.85235	30
Cashier.NumberSeized	67.900	2.5272	53.000	83.000	30
Cashier.ScheduledUtilization	.37513	.01407	.29222	.45371	30
System.NumberOut	130.56	2.6138	119.00	149.00	30

Simulation run time: 2.63 minutes.
Simulation run complete.

We can see from this report, that when we evenly split customers to the cashier and kiosks, the throughput actually did not change. And of course the kiosk utilization increased by just over 10%. This does make sense, because the kiosks were heavily underutilized in the main simulation, allocating more customers to the kiosks would increase their utilization, and would not affect overall efficiency.

<u>The following is the summary report when there is no cashier:</u>

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ARENA Simulation Results
Windows User - License: STUDENT

Output Summary for 30 Replications

Project: ADM 3305 Project 1_What-If_No_Cashier              Run execution date :10/30/2025
Analyst: Windows User                                        Model revision date:10/30/2025

OUTPUTS

Identifier                          Average    Half-width Minimum    Maximum # Replications
___________________________________________________________________________________________

Customer.NumberIn                    137.13     4.0590     114.00     159.00     30
Customer.NumberOut                   132.13     3.6446     113.00     150.00     30
Kiosk.NumberSeized                   136.90     4.0998     114.00     159.00     30
Kiosk.ScheduledUtilization           .63231     .01818     .53313     .74628     30
Cooks.NumberSeized                   134.73     3.9863     113.00     154.00     30
Cooks.ScheduledUtilization           .74158     .02103     .62849     .85206     30
Cashier.NumberSeized                 .00000     .00000     .00000     .00000     30
Cashier.ScheduledUtilization         .00000     .00000     .00000     .00000     30
System.NumberOut                     132.13     3.6446     113.00     150.00     30

Simulation run time: 2.90 minutes.
Simulation run complete.
```

Here when there are no cashiers, and all customer have to use the kiosks, the system throughput actually is very good. It is slightly better than the previous simulations. This is actually surprising to me, because while we are utilizing the kiosks to the maximum potential the order time is almost triple than the cashier, which would counteract the effect of having 3 kiosks, in addition I removed an entire process that offloads the queue.

Conclusions

9. Analyze outputs and make recommendations

In Conclusion, based on the results from the simulation and all the what-if scenarios, we can conclude that the system is optimized, but maybe not cost efficient.

We established that McDonalds has majorly underutilized their kiosks, and can get the same throughput with 2 or even 1 kiosk. Based on this one of my recommendations, is if they do decide to keep the cashier, to decrease the number of kiosks operating.

Or on the contrary, they can go the opposite direction. And instead they can choose to remove the cashier, and only use kiosks. Even though the order time for a kiosk is more than that of a cashier, due to the increased number of kiosks available, it offsets the difference. In fact we can see that multiple McDonalds and other fast-food restaurant are already implementing this system (kiosk ordering only) (Ng, Y. (2021, July 9)).

That being said, there are multiple assumptions that were made, and these decisions to implement what McDonalds has could reflect that. For example, the customer arrival during specific holiday periods could be drastically higher, which would explain having the number of kiosks and cashiers that they do (even if they are not completely utilized during "standard" periods). In addition, the simulation assumed all components and process are operating normally. But in the real-world technological devices such as kiosks can break or have software issues. So having multiple kiosks, while not totally utilized, acts as a redundancy-buffer.

McDonalds is a multi-billion dollar organization, with millions of locations across the globe. It is safe to conclude that they analyzed their system for efficiency and cost optimization. And based on the simulation, it appears to be true. While I have made recommendations for cost optimization, due to the assumptions made, and the processes outside the scope of this project. I can conclude that McDonalds system is both efficient and optimized.

Appendix

References

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