A Dynamic Queuing System: Interactive Spreadsheets and Data Analytics

Jaideep T. Naidu
Thomas Jefferson University

Queuing theory is an important field of Operations Research with wide applications in the service industry as well as in healthcare settings. This paper is motivated by a recent visit to a local DMV (Department of Motor Vehicles) office and upon observing the queuing system they use at that office. In this paper, we create interactive spreadsheets of a smaller and a modified version of such a dynamic queuing system. We discuss how our proposed system has additional features and provide future directions to make our system superior and efficient.

Keywords: spreadsheets, queuing analysis, single channel, multi-channel

INTRODUCTION

Queuing theory is one of the most practical and applied topics found in all standard operations management textbooks (Stevenson, 2017 and Winston, 2019). Queuing concepts are discussed in business programs and in Industrial Engineering coursework. Queues are often called *waiting lines* and can be observed and experienced in our daily lives. Typically, a queue is formed when there are customers ahead of us who are either waiting to be served or currently being served. We wait in lines in banks, post-offices, grocery stores, theme parks, and the list goes on and on. This paper is motivated by a recent visit to a DMV office. The DMV offers services such as: (i) application for a Real ID; (ii) written test for a learner's permit; (iii) driving test to obtain a permanent driver's license; and (iv) renewal of an existing driver's license. Some services may take longer than others. Our local DMV had multiple service windows/counters that were open on the day of our visit. However, we believe that these were dedicated windows catering to specific services. Our visit to the DMV was to obtain a Real ID. We had been asked at the front desk about the purpose of our visit and accordingly issued a ticket. Our ticket had the following information:

A117 *There are 4 customers ahead of you*

While waiting to be served, we noticed that the screen at the top of each service window/counter displayed the ticket number that was currently being served. We saw that only one counter with the A series was serving A113 when we entered. This led us to conclude that the automated ticketing system may have included A113 (in addition to A114, A115 and A116) when it printed "*there are 4 customers ahead of you*" on our ticket. We also noticed that two windows were serving customers with the *C* series, and three other windows were serving customers with the *S* series. Soon, the window that was serving A113 had now called

A114 and that led us to think that this was a dedicated window that catered to Real ID applicants only. Since there were more windows for the C and S series, we assumed there were more requests for those types of services. For example, we saw several youngsters sitting in front of computers on our left and we assumed that the S series may be for these customers taking the written test.

The observations at the DMV Office motivated us to use this to our Data Analytics class and guide our students to create an "interactive" spreadsheet model of a modified version of the DMV queuing system. Excel spreadsheets are an important component of our class since Microsoft Excel is widely used in the industry. Its popularity is attributed to its unparalleled flexibility, versatility, and wide range of data management, analysis and visualization capabilities. It is used by financial analysts, retail and project managers, business analysts, and accountants to name a few. Due to the increasing use of data-driven decision making in the industry, the demand for proficiency in Microsoft Excel has increased significantly in recent times. Teaching spreadsheets is not specifically about helping students learn spreadsheets but to also help them grow to make more informed decisions as managers in the real world. Educational theory, such as Dale Edgar's Cone of Experience, suggests that learners remember 70% - 90% of what they say and do (active learning). Excel exercises or projects are considered as active learning (Braun, 2017). And with more exposure to spreadsheets, students become more confident in analytical work (Leong and Ma, 2024).

Discussing real and practical problems to learn Excel formulas has become very important. Classroom instruction is geared towards this style of teaching (Formby et al. 2017). Excel continues to be one of the primary tools for data analysis (Leong and Cheong, 2008). Due to its pervasive use in industry and management education (Patrick et al. 2019, Higgins et al. 2020), the use of real-life examples in the classroom is necessary and justified. Finally, spreadsheet modeling improves student understanding of queuing theory and concepts (Grossman, 1999).

QUEUING CONCEPTS

Waiting lines occur when there is a temporary imbalance between supply (capacity) and demand. Waiting lines add to the operation's cost and reflect negatively on customer service. Typically, long waiting lines or larger than usual wait times are not viewed favorably by customers and this may result in customer goodwill and lower customer base in the long run (Stevenson, 2017). The following are some simple *Measures of Performance* that most service providers focus on.

(a) L_q = Average number of customers waiting in line;
(b) L_s = Average number of customers in the system i.e., number in line + number being served;
(c) W_q = Average time a customer waits in line;
(d) W_s = Average time a customer is in the system i.e., time in line + time being served;
(e) $\rho = \lambda/M*\mu$ = System Utilization
where ρ is the Greek letter Rho, λ is the Greek letter Lambda, μ is the Greek letter Mu, and M is the number of windows (also commonly referred to as counters, servers, etc.)
(f) P_w = Probability that a customer has to wait for service
(g) P_0 = Probability that there are zero customers in the system (indicating an arrival is served immediately).

Obviously, the smaller the above values are, the better it is for the customer. For the service provider, achieving lower values for these measures may often require adding more capacity, increasing their operating costs. Hence, the service provider always tries to balance maintaining customer satisfaction and optimizing their service costs.

While some queuing formulas are simple and fairly intuitive, others can be complex. For example, the formulas for L_q and P_0 (Probability of zero customers in the system) for a multiple channel queuing system are given below.

Average number in line

$$L_q = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^M}{(M-1)!(M\mu-\lambda)^2} P_0$$

Probability of zero units in the system

$$P_0 = \left[\sum_{n=0}^{M-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \frac{\left(\frac{\lambda}{u}\right)^M}{M!\left(1-\frac{\lambda}{M\mu}\right)}\right]^{-1}$$

Understanding Queuing concepts and its applications in the real-world start with an understanding of fundamental concepts like arrival rate (λ), service rate (μ), and number of service windows (M). There are several anecdotal evidences of how early researchers of queuing theory and even graduate students stood outside banks and post-offices to study arrival patterns of customers. Based on their studies and observations, it is generally assumed that arrivals from infinite population sources are typically random and follow a Poisson distribution. Similarly, service times are assumed to have an exponential distribution in several scenarios and settings.

Our experience has shown that students generally understand arrival and service rates. They also understand that arrivals are typically random in the case of an infinite population source and service times are typically unequal and uncertain in several scenarios. So, we focus primarily on how to interpret the solutions to various problem-solving exercises. However, after our DMV visit, we decided to supplement our teaching with an interactive spreadsheet exercise. Our students appreciate Excel's power and gain a better understanding of the concepts. They also enjoy the process of creating these spreadsheets.

We now explain our Interactive spreadsheets, a modified DMV queuing system version.

OUR PROPOSED VERSION OF THE DMV QUEUING SYSTEM

Dedicated Window 1

We start with a single Dedicated Window to cater to Service Type 1 (customers requesting a Real ID). This scenario is realistic and observed during non-peak times at banks and post-offices. Occasionally, even during non-peak hours, there is a chance of longer than anticipated waiting lines due to randomness of customer arrivals. During such times, the service provider may open more windows/counters to reduce wait times of customers. This is routine practice at banks, grocery stores, and various retail outlets.

We create an interactive spreadsheet dedicated for Service Type 1 (see *Appendix 1*). We assume that each Type 1 customer takes 3 minutes to be served. So, the first customer entering the system will be issued ticket #100 which states "0 ahead; Approx. wait = 0 min". The approximate wait time is an added feature we incorporate into our proposed interactive spreadsheet and is something that DMV did not have during our visit. Assuming the first customer is still being served, the second customer who enters the system is issued ticket #101, stating, "1 ahead; Approx. wait = 3 min". If this second customer enters after the first customer leaves, the ticket would state, "0 ahead; Approx. wait = 0 min" instead. When the 3rd customer enters the system, ticket #102 stating "2 ahead; Approx. wait = 6 min" is issued. The interactive spreadsheet created by us ensures that the manager opens a new window for the customer who enters the system when they are already 4 people ahead. Thus, this 5th customer's ticket will state, "Please wait". The manager is alerted with the message, "Open another Window" and this *heads up* is actually given when the 4th customer enters the system. This provides the manager sufficient time to open another window.

Hybrid Window 2

To make the spreadsheet experience more interesting, we create a second Window that is "Hybrid" in terms of service (see *Appendix 2*). In other words, it is not dedicated to a particular type of service. This implies that the service provider or clerk is trained to handle all types of services that they offer. Our interactive spreadsheet considers four types of services with different service times as stated below.

- *Service Type 1* (application for a Real ID): Approximate service time = *3 minutes*;
- *Service Type 2* (written test for a learner's permit): Approximate service time = *5 minutes*;
- *Service Type 3* (driving test for a permanent driver's license): Approximate service time = *2 minutes*; and
- *Service Type 4* (renewal of an existing driver's license): Approximate service time = *4 minutes*.

Note that Service type 3 is not the actual driving test. This may be a simple case of verifying if the applicant with the Learner's permit has completed a certain number of hours of Instructional or guided driving before assigning an officer to conduct a driving test. Since DMV routinely handles such requests, arriving at such time estimates for each service type may be theoretically possible.

Here, the wait time depends on the number of customers ahead and the service type requested by those ahead. For example, if the first customer is Service Type 1, the ticket issued states, "0 ahead; Wait time = 0 min". If the 2nd customer is Service Type 2, then the ticket states, "1 ahead, Wait time = 3 min". If the 3rd customer is Service Type 3, the ticket issued states, "2 ahead, Wait time = 8 min" since the system adds 3 and 5 (based on customers 1 and 2). The following Tables provide a detailed explanation.

TABLE 1
DEDICATED WINDOW 1

Customer	Ticket #	Service Type	Comments
			At time t = 0, Dedicated Window 1 is open and wait time is zero for the 1st customer
1	100	1	The 1st customer (Service Type 1) goes to the Window with no wait time. The ticket states, "*0 ahead, Approx. Wait = 0 min*".
2	101	1	The 2nd customer (Service Type 1) is issued a ticket which states, "*1 ahead, Approx. Wait = 3 min*". *Assumption*: 2nd customer enters the system when 1st customer is still being served.
3	102	1	The 3rd customer (Service Type 1) is issued a ticket which states, "2 *ahead, Approx. Wait = 6 min*". *Assumption*: 1st customer is still being served.
4	103	1	The 4th customer (Service Type 1) is issued a ticket which states, "3 *ahead, Approx. Wait = 9 min*". *Assumption*: 1st customer is still being served.
5	104	1	The 5th customer (Service Type 1) is issued a ticket which states, "*Please wait*". *Assumption*: 1st customer is still being served.

TABLE 2
HYBRID WINDOW 2

Customer	Ticket #	Service Type	Comments
			At time t = 0, Hybrid Window 1 is open and wait time is zero for the 1st customer
1	110	1	The 1st customer (say, Service Type 1) will go to the Window with no wait time. The ticket issued states, "*0 ahead, Approx. Wait = 0 min*". *Exception*: If the Hybrid window is absorbing the overflow from Dedicated Window 1, it may simply serve the customer who was issued the ticket which states, "*Please wait*".
2	111	4	The 2nd customer (say, Service Type 4) will be issued a ticket which states, "*1 ahead, Approx. Wait = 3 min*". *Assumption*: 1st customer is still being served.
3	112	3	The 3rd customer (say, Service Type 2) is issued a ticket which states, "2 *ahead, Approx. Wait = 7 min*". *Assumption*: 1st customer is still being served.
4	113	2	The 4th customer (if Service Type 3) is issued a ticket which states, "3 *ahead, Approx. Wait = 12 min*". *Assumption*: 1st customer is still being served.
5	114	1	The 5th customer (if Service Type 1) is issued a ticket which states, "*Please wait*". *Assumption*: 1st customer is still being served.

LIMITATIONS

Our proposed spreadsheets do not replicate actual random arrivals at different intervals. Also, as per our proposed model for the Dedicated Window, the 5th customer is considered an overflow and may be served at a newly opened window. This is not fair to the earlier customers who may actually take longer to be served at Window 1 (since there are 3 customers ahead). In a real-life setting, the 2nd customer from Window 1 (who is first in that waiting line) should be called to the new window ahead of the later customers.

We assume that the customer is completely served at a single window. In a real-life setting, a customer may be required to go to more than one window. For example, a customer may first have to go to Window 1 to submit a form and take the written test on a computer. If the test succeeds, that customer may need to go to Window 2 to get a photo taken for a Learner's permit. Our spreadsheet does not consider such scenarios. We also do not consider human behavior such as balking or reneging (Economou et al. 2022) since DMV offers essential services and customers cannot go elsewhere.

CONCLUSIONS AND FUTURE DIRECTIONS

We create interactive spreadsheets of a dynamic queuing system. This paper was motivated by observing the queuing system at a local DMV office. It is a well-known fact that queuing concepts are best understood and interpreted with simulation and by using interactive spreadsheets.

If all clerks/officers are trained for all kinds of services, there will only be hybrid windows that serve any service type and the customer (irrespective of the service type) will be called to the next available window. This would then be equivalent to multi-channel systems found in banks, post-offices, etc. Let us assume there are three windows currently open and that Window 1 is currently serving Service Type 1 (3 minutes), Window 2 is serving Service Type 2 (5 minutes), and Window 3 is serving Service Type 3 (2

minutes). Let us assume that eight customers are currently waiting in line (two are service type 1, two are service type 2, two are service type 3, and two are service type 4) in this multi-channel system. Let us now assume that a new customer walks in at this time. For this scenario, the ticket prints the following:

11 customers ahead
Estimated Wait time is 13 minutes

We now explain how the estimated wait time is computed for the ticket above. It is easy to see that there are indeed 11 customers ahead (including those currently being served). It is also easy to see that there are three customers each of service types 1, 2 and 3 (including those being served). As for service type 4, there are only two customers in line. Thus, the total processing time of all these 11 customers is: 3*3 + 5*3 + 2*3 + 4*2 = 38 minutes. In other words, there is a total of 38 minutes of processing time that must be completed by the 3 Windows combined. Since there are 3 windows, we simply divide 38 by 3 to end up with the estimated wait time of 12.67 minutes, which is then rounded up. Since these are only time estimates, we do not take consider the possibility that the customers currently being served may be almost done at those windows. We simply assume that the service has just started.

We will look into creating an Excel spreadsheet for such a multi-channel system. Of course, this scenario can be easily programmed using Python code.

ENDNOTE

1. The spreadsheet used in this exercise is available and the reader can obtain it from the author.

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APPENDIX 1: CREATING A SPREADSHEET FOR DEDICATED WINDOW 1

Our specific *cell address based instructions* are based on the instructor prepared spreadsheet. So, when a student has a question about a particular cell, it becomes easy to respond and guide the student.

1. Open an Excel spreadsheet and INPUT the following data/text in the following cells of the worksheet for the *Dedicated Window*.
   - C4: Window 1 (Dedicated)
   - D4: Ticket #
   - D5: Customer Type
   - E5, F5, G5, H5: These cells will all have "1" entered indicating that Service Type 1 is performed
   - D6: Status
   - D7: Message
   - L4: Window 1
   - M4: Start (indicating the starting ticket serial number to be issued to the customer)
   - K5: Total
   - L5: 4 (indicating that the system considers *four* as the maximum allowable queue size for this window)
   - M5: 100 (indicating that the ticket serial numbers issued to customers start from 100)
   - K6: In Queue
   - K7: Available

Since the above is essentially data entry, the Professor may email an Excel file to students (with the above already entered) to save time in the classroom.

2. Cells E6, F6, G6, H6 must have the following in their dropdown menu: *In Queue, Available*. To do this in cell E6 for example, put the cursor in that cell, click "Data", click "Data Validation", select "List" and select "K6:K7".
3. The Instructor guides students with Excel formulas in various other cells of this spreadsheet. We also provide a hard copy of Figure 1 (see below) since it has the cell addresses where Excel formulas must be entered. The Excel formulas are explained while creating this spreadsheet.

FIGURE 1
BASIC INITIAL GRID

Window 1 (Dedicated)	Ticket #	E4	F4	G4	H4	I4		Window 1	Start
	Customer Type	1	1	1	1		Total	4	100
	Status	E6	F6	G6	H6		In Queue	L6	
	Message	E7	F7	G7	H7		Available	L7	

The first set of formulas are for cells L6 and L7. Cell L6 must show the number of customers in the system referred to as "*In Queue*". This is based on the cells E6, F6, G6, and H6. And cell L7 must show available capacity in the system. Once the students enter these formulas, they play around with the dropdown menu in cells E6, F6, G6, and H6 so that the formulas in L6 and L7 make sense.

- L6: *=COUNTIF(E6:H6,K6)*
- L7: *=L5-L6*

The next set of formulas are for cells E4, F4, G4, and H4 to generate ticket numbers with the starting value being 100 for Customer 1, 101 for Customer 2 and so on. The formula in cell E4 may require explanation and then the Excel formulas for F4, G4, and H4 become obvious.

- E4: *=IF(E6=$K$6,$M$5*($L$5-3),"")*
- F4: *=IF(F6=$K$6,$M$5*($L$5-3)+1,"")*
- G4: *=IF(G6=$K$6,$M$5*($L$5-3)+2,"")*
- H4: *=IF(H6=$K$6,$M$5*($L$5-3)+3,"")*

The following *nested IF* Excel formula is common for cells E7, F7, G7, and H7. These cells will display the number of customers ahead and the Approximate wait time.

=IF($L$6=0,"0 ahead; Approx. wait = 0 min",IF($L$6=1,"1 ahead; Approx. wait = 3 min",IF($L$6=2,"2 ahead; Approx. wait = 6 min",IF($L$6=3,"3 ahead; Approx. wait = 9 min",IF($L$6=4,"Please wait")))))

This means the first customer will be issued a ticket with the message "0 ahead; Approx. wait = 0 min" since this customer has no wait time. The 2nd customer (if the first customer is still being served) will be issued a ticket with the message "1 ahead; Approx. wait = 3 min". Since the allowable number of customers in the system is 4, the 5th customer will be issued a ticket with the message "Please wait" implying that a new window will open up. Finally, Cell I4 has the following Excel formula to serve as a "heads up" for the manager to consider the likelihood of a 5th customer requesting for this service and to be prepared to open an additional window.

- I4: *=IF(L6=4,"OPEN ANOTHER WINDOW","")*

We provide hard copies of Figures 2, 3, and 4 so students can test their formulas at various stages in the queuing process. With no customers in the system, the Excel screen looks like Figure 2 below.

FIGURE 2
ZERO CUSTOMERS IN THE SYSTEM

Window 1 (Dedicated)	Ticket #							Window 1	Start
	Customer Type	1	1	1	1		Total	4	100
	Status	Available	Available	Available	Available		In Queue	0	
	Message	0 ahead; Approx. wait = 0 min	0 ahead; Approx. wait = 0 min	0 ahead; Approx. wait = 0 min	0 ahead; Approx. wait = 0 min		Available	4	

When there are three customers in the system, the Excel screen looks as shown below in Figure 3.

FIGURE 3
THREE CUSTOMERS IN THE SYSTEM

Window 1 (Dedicated)	Ticket #	100	101	102				Window 1	Start
	Customer Type	1	1	1	1		Total	4	100
	Status	In Queue	In Queue	In Queue	Available		In Queue	3	
	Message	3 ahead; Approx. wait = 9 min	3 ahead; Approx. wait = 9 min	3 ahead; Approx. wait = 9 min	3 ahead; Approx. wait = 9 min		Available	1	

Finally, with four customers in the system, the Excel screen looks as shown below in Figure 4.

FIGURE 4
FOUR CUSTOMERS IN THE SYSTEM

Window 1 (Dedicated)	Ticket #	100	101	102	103	OPEN ANOTHER WINDOW
	Customer Type	1	1	1	1	
	Status	In Queue	In Queue	In Queue	In Queue	
	Message	Please wait	Please wait	Please wait	Please wait	

	Window 1	Start
Total	4	100
In Queue	4	
Available	0	

APPENDIX 2: CREATING A SPREADSHEET FOR HYBRID WINDOW 1

1. Open an Excel spreadsheet and INPUT the following data/text in the following cells of the worksheet for *Hybrid Window 2*.
   - C11: Hybrid (Window 2)
   - D11: Ticket #
   - D12: Customer Type
   - D13: Service Type
   - D14: Status
   - D15: Time Estimate
   - D16: Wait Time (Min)
   - D17: Message
   - L11: Window 2
   - M11: Start (indicating the starting ticket serial # to be issued to the customer)
   - K12: Total
   - L12: 4 (indicating that the system considers 4 as the maximum allowable queue size for this window)
   - M12: 110 indicating that the ticket serial numbers issued to customers start from 110
   - K13: In Queue
   - K14: Available

The Professor may email an Excel file to students (with the above already entered) to save time.

2. Cells E14, F14, G14, H14 must have the following in their dropdown menu: *In Queue, Available*. Creating such a drop-down menu was already explained in Appendix 1.
3. The Instructor guides students with the Excel formulas in various other cells of this spreadsheet. For convenience, we provide a hard copy of Figure 5 (see below) since it has cell address of various cells where Excel formulas must be entered. The students write the Excel formulas in a logical sequence and the formulas are explained during this process.

FIGURE 5
BASIC INITIAL GRID

Window 2 (Hybrid)	Ticket #	E11	F11	G11	H11	I11
	Customer Type	E12	F12	G12	H12	
	Service Type	E13	F13	G13	H13	
	Status	E14	F14	G14	H14	
	Time Estimate	E15	F15	G15	H15	
	Wait Time (Min)	E16	F16	G16	H16	
	Message	E17	F17	G17	H17	

	Window 2	Start
Total	4	110
In Queue	L13	
Available	L14	

The first set of formulas are for cells L13 and L14. Cell L13 must show the number of customers in the system (referred to as "In queue"). This is based on the cells E14, F14, G14, and H14. And cell L14 must show available capacity in the system. This is straightforward and similar to Window 1.

- L13: *=COUNTIF(E14:H14,K13)*
- L14: *=L12-L13*

The next set of formulas are for cells E11, F11, G11, and H11. These generate the Ticket numbers with the starting value being 110. This requires no explanation as it is similar to Window 1.

- E11: *=IF(E14=$K$13,$M$12*($L$12-3),"")*
- F11: *=IF(F14=$K$13,$M$12*($L$12-3)+1,"")*
- G11: *=IF(G14=$K$13,$M$12*($L$12-3)+2,"")*
- H11: *=IF(H14=$K$13,$M$12*($L$12-3)+3,"")*

The next set of formulas are to prompt front desk to enter customer type when the customer enters.

- E12: *=IF(E14=$K$14,"","Service Type?")*
- F12: *=IF(F14=$K$14,"","Service Type?")*
- G12: *=IF(G14=$K$14,"","Service Type?")*
- H12: *=IF(H14=$K$14,"","Service Type?")*

The next set of cells E13, F13, G13, and H13 will be where front desk will enter 1, 2, 3, or 4 depending on the service requested by the customer.

The following formulas are for cells E15, F15, G15, and H15 and these simply print the time estimate depending on the service type requested.

- E15: *=IF(E13=1,3,IF(E13=2,5,IF(E13=3,2,IF(E13=4,4,""))))*
- F15: *=IF(F13=1,3,IF(F13=2,5,IF(F13=3,2,IF(F13=4,4,""))))*
- G15: *=IF(G13=1,3,IF(G13=2,5,IF(G13=3,2,IF(G13=4,4,""))))*
- H15: *=IF(H13=1,3,IF(H13=2,5,IF(H13=3,2,IF(H13=4,4,""))))*

The next Excel formula is common for cells E16, F16, G16, and H16 to display the Wait time depending on the number of customers ahead and the type of service requested by each.

=IF($L$13=0,"0 MIN",SUM($E$15:$H$15))

The next Excel formula is common for cells E17, F17, G17, H17 and is to display the number of customers ahead.

=IF($L$13=0,"0 ahead",IF($L$13=1,"1 ahead",IF($L$13=2,"2 ahead",IF($L$13=3,"3 ahead", IF($L$13=4,"Please wait")))))

This means the first customer will be issued a ticket with the message "0 ahead"; the 2nd customer (if the first customer is still in the system) will be issued a ticket with the message "1 ahead" and so on. Since the maximum allowable number of customers in the system is 4, the 5th customer will be issued a ticket with the message "Please wait" implying a new window opens momentarily. Finally, Cell I11 has the following Excel formula.

- I11: *=IF(COUNTIF(E13:H13,"")=0,"OPEN ANOTHER WINDOW", "")*

We also provide hard copies of Figures 6, 7, and 8 so students can test their formulas at various stages in the queuing process. With no customers in the system, the Excel screen looks like Figure 6.

FIGURE 6
ZERO CUSTOMERS IN THE SYSTEM

Window 2 (Hybrid)	Ticket #					
	Customer Type					
	Service Type					
	Status	Available	Available	Available	Available	
	Time Estimate					
	Wait Time (Min	0 MIN	0 MIN	0 MIN	0 MIN	
	Message	0 ahead	0 ahead	0 ahead	0 ahead	

	Window 2	Start
Total	4	110
In Queue	0	
Available	4	

When there are two customers in the system, the Excel screen looks as shown below in Figure 7. Since the 1st customer requested service type 1 (3 minutes) and the 2nd customer requested service type 4 (4 minutes), the wait time is 3 + 4 = 7 minutes as shown in Figure 7.

FIGURE 7
TWO CUSTOMERS IN THE SYSTEM

Window 2 (Hybrid)	Ticket #	110	111			
	Customer Type	Service Type?	Service Type?			
	Service Type	1	4			
	Status	In Queue	In Queue	Available	Available	
	Time Estimate	3	4			
	Wait Time (Min	7	7	7	7	
	Message	2 ahead	2 ahead	2 ahead	2 ahead	

	Window 2	Start
Total	4	110
In Queue	2	
Available	2	

Finally, with four customers in the system, the screen looks as shown below in Figure 8.

FIGURE 8
FOUR CUSTOMERS IN THE SYSTEM

Window 2 (Hybrid)	Ticket #	110	111	112	113	OPEN ANOTHER WINDOW
	Customer Type	Service Type?	Service Type?	Service Type?	Service Type?	
	Service Type	1	4	3	2	
	Status	In Queue	In Queue	In Queue	In Queue	
	Time Estimate	3	4	2	5	
	Wait Time (Min	14	14	14	14	
	Message	Please wait	Please wait	Please wait	Please wait	

	Window 2	Start
Total	4	110
In Queue	4	
Available	0	