MITx: CTL.SC0x
Supply Chain Analytics

Week 10: Queueing Theory and
Course > Discrete Event Simulation > Practice Problems > PP1 - Windsor's Keren Branch

PP1 - Windsor's Keren Branch

Tip #1: Please notice that this practice problem closely resembles the one solved in Recitation 1. If you are uncertain about how to solve this problem, we recommend that you watch Recitation 1 again.

A note from Roberto: 'While preparing both recitations, I was under the impression that the triangular distribution is defined in terms of its minimum, **mean** and maximum values. This, however, is incorrect: it is defined in terms of its minimum, **mode** and maximum values. I am very sorry about this mistake: I should have known this. Unfortunately, I discovered this error too late to fix it in the videos. So, every time in the recitation videos when I mention the value of a *mean* or *average* delay in a problem that I will then enter as part of a triangular distribution in the software, that value is actually a *mode*, not a *mean*. Apologies. In the problem below, and in the graded assignments, the correct term (mode, not mean) is used.'

The Windsor Bank in Eritrea is opening a new branch in the city of Keren, which will feature both ATMs and tellers to serve the bank's clients. The exact number of ATMs and tellers that will be available at any given time to serve the clients of this branch has not been decided yet, and is the subject of this problem.

Based on historical data from other branches in the city of Asmara, and some general information about the population and economic activity of Keren, experts with Windsor Bank estimates that the rate of arrivals of clients at the Keren branch will be around 40 per hour. (Assume that inter-arrival times follow an exponential distribution.) Among these clients, the bank estimates that:

- a third will only need to use an ATM, and will then leave,

- another third will only need to see a teller, and will then leave, and

- another third will need to first use the ATM and then see a teller, and only then leave.

Based on observations conducted in their Asmara branches (which are considered applicable to the Keren branch, too) over a period of one month, the Windsor Bank estimates that:

- the time it takes a client to use the ATM, once it is available, follows a triangular distribution with a minimum of 2 minutes, a mode of 10 minutes, and a maximum of 20 minutes, and

- the time it takes a client to complete their business with a teller, once in front of the teller, follows a triangular distribution with a minimum of 3 minutes, a mode of 10 minutes, and a maximum of 30 minutes.

The Windsor Bank prides itself in offering a good experience to its clients. To ensure prompt service, the bank wants to have enough ATMs and tellers to provide their clients with prompt service. Ideally, to ensure the clients are satisfied:

- the average time spent waiting in line for an ATM to become available should be around 5 minutes or so, at most, and

- the sum of the time spent waiting in line for an available teller plus the time spent being served by that teller, on average, should be around 15 minutes or so, at most.

While respecting these average times, the bank also wants to maintain costs reasonable: the bank does not want to install an unnecessarily large number of ATMs, which are very expensive, or to hire more tellers than are needed, which are also expensive (although significantly less expensive than the ATMs).

Create a discrete-event simulation of the clients arriving at the bank, using the ATM and teller services as described above, and then leaving the bank. Model the ATMs and tellers as resources, since we will ask about utilization later. Do a simulation run from time 0 to time 72,000 minutes.

Part 1

0 points possible (ungraded)
At the end of the 72,000 minutes, how many clients have entered the bank?
Due to the uncertain nature of simulations, your answer is evaluated with a 5% tolerance.
Be aware that it may be graded as correct even if it is 5% off from our estimated value.

| 48101 | ✔ **Answer:** 48000 |

48101

Explanation
Given that customers arrive at a rate of 40 per hour, after 72 thousand minutes we can expect approximately 40*72/60=48 thousand customers to have entered the bank.

| Submit | You have used 1 of 3 attempts |

ⓘ Answers are displayed within the problem

Part 2

0 points possible (ungraded)
How many of these clients go directly to the tellers?
Due to the uncertain nature of simulations, your answer is evaluated with a 5% tolerance.
Be aware that it may be graded as correct even if it is 5% off from our estimated value.

16015

✓ **Answer:** 16000

16015

Explanation

Given that approximately one third of the customers go directly to the tellers, we can expect approximately 16 thousand customers to do that.

Submit   You have used 2 of 3 attempts

🛈   Answers are displayed within the problem

Part 3

0 points possible (ungraded)
How many of these clients go to the ATMs?
Due to the uncertain nature of simulations, your answer is evaluated with a 5% tolerance.
Be aware that it may be graded as correct even if it is 5% off from our estimated value.

32086

✓ **Answer:** 32000

32086

Explanation

Given that approximately two thirds of the customers go to the ATMs, we can expect approximately 32 thousand customers to do that.

Submit   You have used 1 of 3 attempts

🛈   Answers are displayed within the problem

Part 4

0 points possible (ungraded)
How many of these clients go to the tellers altogether, including both those that go directly from the door and those that go after using the ATMs?
Due to the uncertain nature of simulations, your answer is evaluated with a 5% tolerance.
Be aware that it may be graded as correct even if it is 5% off from our estimated value.

27969

✗ **Answer:** 32000

27969

Explanation

Given that approximately two thirds of the customers use the tellers, we can expect approximately 32 thousand customers to do that.

Submit   You have used 3 of 3 attempts

ℹ️ Answers are displayed within the problem

Tip #2: The four questions above are a basic sanity check that the general rules of the flow of clients around the bank, and the expected arrival rate, are being respected.

Part 5

0 points possible (ungraded)
If the bank installed 11 ATMs, what would be their utilization?
Select the value closest to your answer.

~43% ▼   ✔ **Answer:** ~43%

Explanation

If the bank installed 11 ATMs, their utilization would be approximately 43%.

Submit   You have used 1 of 3 attempts

ℹ️ Answers are displayed within the problem

Part 6

0 points possible (ungraded)
If the bank installed 6 ATMs, what would be the average time, in minutes, spent by clients waiting in line for an ATM to become available?
Due to the uncertain nature of simulations, your answer is evaluated with a 1 minute tolerance.
Be aware that it may be graded as correct even if it is 1 minute off from our estimated value.

0.8   ✖ **Answer:** 2.6

0.8

Explanation

With 6 ATMs, clients would spend approximately 2.6 minutes waiting in line.

Submit	You have used 3 of 3 attempts

ℹ   Answers are displayed within the problem

Part 7

0 points possible (ungraded)
How many ATMs should Windsor Bank have available in its Keren branch at any given time?
Select the value closest to your answer.

6 ▼	✔ **Answer:** 6

Explanation

In order to keep the average waiting time in the ATM queue under 6 minutes or so, the bank should install 6 ATMs.

Submit	You have used 1 of 3 attempts

ℹ   Answers are displayed within the problem

Part 8

0 points possible (ungraded)
If the bank had 6 ATMs and 11 tellers available at any given time, what would be the tellers' utilization?
Select the value closest to your answer.

~58% ▼	✔ **Answer:** ~58%

Explanation

If the bank had 6 ATMs and 11 tellers available, the tellers' utilization would be approximately 58%.

Submit	You have used 1 of 3 attempts

ℹ   Answers are displayed within the problem

Part 9

0 points possible (ungraded)

If the bank had 6 ATMs and 10 tellers available at any given time, what would be the average time, in minutes, spent by teller clients (including both the time they spent waiting in line for the tellers and then being served by the tellers)?

Due to the uncertain nature of simulations, your answer is evaluated with a 2 minutes tolerance. Be aware that it may be graded as correct even if it is 2 minutes off from our estimated value.

> 14.492   ✔ **Answer:** 14.7

14.492

Explanation

If the bank had 6 ATMs and 10 tellers available at a given time, on average teller clients would spend a total of 14.7 minutes waiting in line and being served by the tellers.

Submit   You have used 1 of 3 attempts

ℹ   Answers are displayed within the problem

Part 10

0 points possible (ungraded)
How many tellers should Windsor Bank have available at any given time in its Keren branch?

Select the value closest to your answer.

10 ▼   ✔ **Answer:** 10

Explanation

In order to keep the average service time (the sum of both the time in the teller queue and with the teller themselves) around 15 minutes or so, the bank should have 10 tellers available at any given time. This number of tellers would result in a service time of approximately ~15 minutes.

Submit   You have used 1 of 3 attempts

ℹ   Answers are displayed within the problem

Once you have solved the questions above on your own, or at least tried your best, you can download Roberto's AnyLogic model for these questions here.

Calculating Timeouts

The president of the Keren branch is considering installing only 4 ATMs, and having only 6 tellers available at any given time.

He has been warned that ATM clients will leave if they have to wait 5 minutes or more for in line for the ATM or the tellers.

Part 11

0 points possible (ungraded)
Asume the Keren branch of Windsor Bank has 4 ATMs and 6 tellers available at any given time. Assume also that clients waiting in line for the ATM will leave after waiting 5 minutes.

What fraction of the clients that enter the ATM line are expected to leave the line after waiting 5 minutes?
Enter your answer in decimal form using two decimal places. For example, if your answer is 23.24%, you should enter .23 in the box below. Due to the uncertain nature of simulations, your answer is evaluated with a 0.1 tolerance (10%). Be aware that it may be graded as correct even if it is 0.1 off from our estimated value of the fraction.

| 0.25 | ✔ **Answer:** 0.25 |

0.25

Explanation
If the bank had 4 ATMs and 6 tellers available at a given time, approximately 25% of the clients would leave the ATM line after waiting 5 minutes:
8.0K / 32.1K = ~ 0.25

| Submit | You have used 2 of 3 attempts |

ⓘ   Answers are displayed within the problem

Part 12

0 points possible (ungraded)
Still with 4 ATMs and 6 tellers, assume that clients waiting in line for the tellers will leave after waiting 5 minutes in that line.

What fraction of the clients that enter the tellers line are expected to leave that line after waiting 5 minutes?
Enter your answer in decimal form using two decimal places. For example, if your answer is 23.24%, you should enter .23 in the box below. Due to the uncertain nature of simulations, your answer is evaluated with a 0.05 tolerance (5%). Be aware that it may be graded as correct even if it is 0.05 off from our estimated value of the fraction.

| 0.1076272 | ✔ **Answer:** 0.11 |

0.1076272

Explanation

If the bank had 4 ATMs and 6 tellers available at a given time, approximately 11% of the clients would leave the tellers line after waiting 5 minutes: 3.1K /28.0K = ~.11

| Submit | You have used 1 of 3 attempts |

ℹ️ Answers are displayed within the problem

Once you have solved the questions above on your own, or at least tried your best, you can download Roberto's AnyLogic model for these questions here.

Questions, comments and suggestions about this section

If you have any questions, comments or suggestions about this section, please use the "Add a Post" button in the discussion forum below. Your post will be indexed in the right category and it will be easier for the staff to answer it!

If you have a question, classify your post as a "question" (instead of "discussion"), since we try to review those posts first.

Discussion

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Topic: Week 10 / PP1 - Windsor's Keren Branch

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Simulation issues

discussion posted 8 days ago by **KumarRajneesh**

Hi I have used a time plot the way it was shown in recitation 1 video and that graph shows me ATM resource between 10-15 most optimally around 12 ATM.Time measure end for ATM service with 12 ATM resource which I have created in my simulation shows mean-10.6,min-2.06 ,max-22. My answer of Part 7 with 12 have gone wrong. Can anyone help me understand this. Also How should I upload an image of the simulation for sake of others to help me out.

regards Rajneesh

This post is visible to everyone.

Add a Response

3 responses

gskreft   **+**

7 days ago   **...**

An easy way to insert an image on a PC:

Use the "Snipping Tool" that is built into windows. You can find it from the start button and just start typing snip...

After you take the image, save the file as a jpg on your hard drive.

Go back to your post and select the Image Button or hit CTRL-G. There seems to be a bug and some of the button disappear from time to time and if you cannot see them, the CTRL-G will work.

Click on choose your file and you can click the box "ignore description" or you can put one in.

Your image should now show up in your post.

Add a comment

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agathaclarice (Community TA)   **+**

6 days ago   **...**

Please follow the advise of gskreft and upload you model, so it will be easier to understand your problem.

Add a comment

KumarRajneesh   **+**

5 days ago   **...**

Hi All , Although I solved the problem by simulating the way it was done in Recitation 1, where seize and release was used. However I am not able to figure out what is wrong with the way I worked initially where I didn't used seize, delay and release agent.Here is the screen shot of the earlier approach.
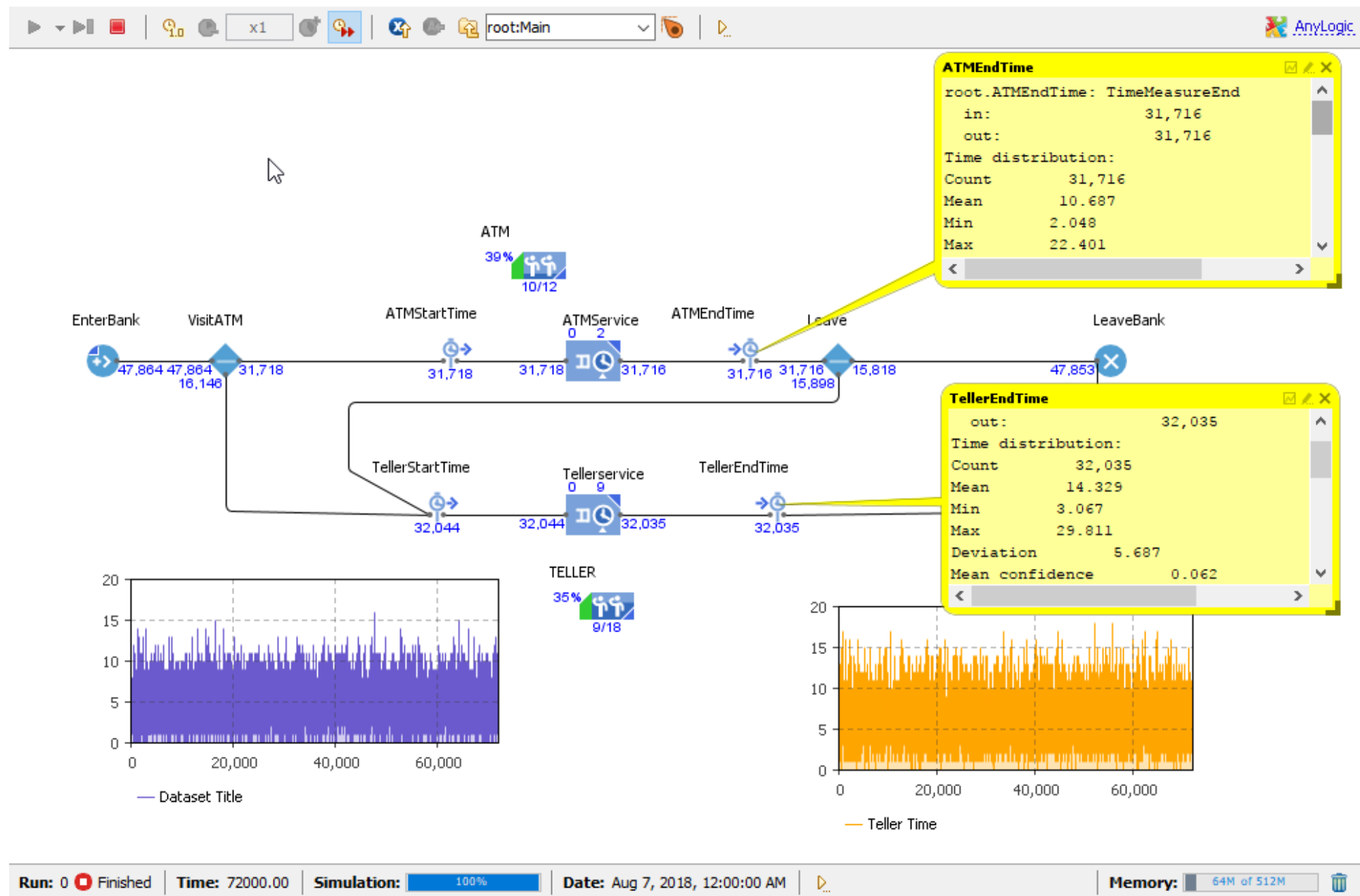
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Add a response:

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