INDU6311: Simulation
Department of Mechanical, Industrial and Aerospace Engineering
Concordia University

Team Project Description and Template

Submission details

Please include your team number in the name of ALL your files.

Please submit a zip file at the Moodle link "Team Project Submission" with the following:

- Your ARENA files (for each alternative).
- Your presentation.
- Your output analysis file and if any additional file you have.
- Only one person from each group should submit.

Deadline:
April-4th- at 12 PM

Presentation:
You should present your work in around 15 minutes. All the members should participate in presenting. Your presentation should include:
Group number and name of members
Introduction
Your model + screenshots of your ARENA
Your answers to the questions, analysis, conclusion, and recommendation
If there are some extra tables or results, you can add them as an appendix at the end of your presentation.

Only one submission per group

Presentation dates:
April-4th and April-11th

Number of group members:
Maximum 6

Model part 1:

In Model part 1, you will be modelling a primary care clinic called MTL_Clinic and assume that MTL_Clinic is a walk-in only clinic. "Walk-in Only" means that patients cannot make an appointment in advance – if they have a health concern, they should arrive at the clinic and wait until their turn to see a doctor. Patients arrive at the clinic according to an exponential distribution with mean 7 minutes.

The clinic is open from 8 am to 5 pm, 7 days a week. Any patient who has entered the system at closing time still has to be served on the same day (this will result in overtime, particularly for nurses and doctors).

Upon arrival at the clinic, a patient is first required to obtain a mask and sanitize their hands. Doing so takes between 15 and 30 seconds, uniformly distributed. The patient then sees a receptionist. The receptionist registers the patient by taking their information, such as their medical card number, and asks the patient to wait until they can be seen by a nurse. The time it takes a receptionist to register a patient is distributed according to a triangular distribution with minimum value of 1 minute, a most likely value of 2 minutes, and a maximum of 3 minutes.

A nurse sees registered patients on first-come, first-served order. The nurse has several triage tasks: a) measure the patient's weight and blood pressure, b) record their symptoms on the computer, and c) the nurse assesses the symptoms of the patient and assigns priority to the patient for being seen by the doctor. The time the patient spends with the nurse is variable. The distribution of time at the nurse therefore can be approximately modelled by a triangular distribution with parameters 2 minutes, 5 minutes and 25 minutes.

As part of the assessment, the nurse asks the patient if they are experiencing any pain (approximately 50% of patients say yes); if yes, the patient is asked to assess their pain on a scale of 1 to 10, with 10 being the most severe. If the patient reports a pain of 8 to 10, the nurse calls an ambulance to send the patient to the emergency room; this happens in about 1% of clinic visits. If the patient reports a pain level of 6 or 7, the nurse assigns the patient priority 1 (approximately 25% of the time), while if the patient reports a pain of level 5 or less, priority 2 is assigned which happens in around 74% of clinic visits. Patients with no pain are assigned priority 3 (lowest priority). After seeing the nurse, the patient goes back to the waiting room of the clinic (for patients who have not been sent to the emergency room).

Patients are seen by the doctor according to their priority (and according to FCFS within each priority group). The time it takes the doctor to diagnose a patient's condition and/or prescribe next steps is exponentially distributed with mean 15 minutes. After seeing the doctor, three outcomes are possible: 1) the doctor prescribes the patient some medication (30% of patients), the doctor refers the patient to a specialist (20%) or 3) the doctor refers the patient for ablood test (50%).

If the patient is assigned a blood test, they go back to the waiting area and wait for a nurse to call them to do the test. The nurses doing blood tests are the same nurses that do the triage (but the patient does *not* have to see exactly the same nurse as triaged them). Blood test patients are treated in FCFS order together with new arrivals (they do not have any priority). The time required for a blood test is distributed according to a continuous uniform distribution with minimum of 7 minutes and maximum of 10 minutes. If no blood test is required, the patient leaves the clinic immediately; if a blood test is required, the patient

leaves the clinic after the blood test. The clinic currently has two receptionists, five nurses and three doctors.The clinic is interested in estimating the following metrics:

a) waiting time until a patient sees a nurse for triage (from the time of arrival) [note: this is not the time until patient joins the nurse's queue, it is the time until the patient actually starts speaking with the nurse] Note: triage here means the whole process of triage (all three tasks the nurse performs initially when a patient arrives). Triage does not include a blood test.

b) waiting time until a patient sees a doctor (from the time of arrival) by patient type [note: thisis not the time until patient joins the doctor's queue, it is the time until the patient actually starts speaking with the doctor]

c) total time in the system per visit (from arrival until leaving the clinic) by patient priority type [hint: using the "record into set" option in the record module will make your model more compact. You do not have use the hint if you do not know how to; there are many ways to correctly model the same concept in Arena.]

d) latest time a patient leaves the clinic (over a week) [hint: you can use a combination of "output" module and built-in functions in Arena in the "build expression" menu. You do not have use the hint if you do not know how to; there are many ways to correctly model the same concept in Arena.]

You need to simulate this system for a week, with 20 replications.

Model part 2

Recently, MTL_Clinic has experienced a surge of arrivals, and the inter-arrival distribution for requests to see a doctor is now exponential with mean 5 minutes (whereas before it had a mean of 7 minutes). As a result of this increase, MTL_Clinic has also started receiving a lot of complaints about long wait times to see a doctor.

The board of MTL_Clinic would like you to determine the best way to improve the operations of the clinic under this new arrival rate, specifically with regards to various waiting time performance metrics. Currently, MTL_Clinic is considering one potential alternative: switching **one** doctor to an appointment-based system; this alternative is described below. You need to evaluate this alternative as well as propose at least one alternative of your own. You need to develop and present a comparison of the three alternatives (current walk-in system, proposed appointment-based system and your own proposed alternative) and recommend an alternative for MTL_Clinic to implement.[1] Your comparison should be based on the performance metrics you defined in part 1 and/or combined metrics (e.g., weighted combinations of metrics) and/or alternative (well-justified) metrics.[2] Your ultimate goal is to propose a way to manage MTL_Clinic better without any monetary investments; if you are not able to achieve this goal, you need to provide an estimate of the investments required (e.g., if you want to hire an extra nurse, you need to provide a cost estimate and justify why this investment is warranted). Solutions with 0 or almost 0 cost will receive better grades than those requiring investments.[3]

[1] You can try more than three alternatives. If you have difficulty implementing the appointment-based system, you can provide a different alternative instead (for partial marks).
[2] Hint: you may want to look at maximum waiting times, not just average ones, since the longer a person waits, the more likely they are to complain about their wait time.
[3] Note that in healthcare, it is indeed possible to get a request of this type. I worked on a project with a hospital that asked for "a no-cost or low-cost solution". Of course, achieving such a goal is not always possible.

For the current walk-in system, you should use the model part 1 (but have to adjust the arrival rate).
Appointment-based system alternative:
MTL_Clinic is considering switching one particular doctor to an appointment-based system. We assume that this means that 1/3 of all patients call the clinic to make an appointment and then arrive at their clinic shortly before their appointment time (1/3 of the initial expo(5) arrival stream make an appointment before arriving at the clinic).

The clinic is open from 8 am to 5 pm, 7 days a week (as before).

Modify your model part 1 to represent MTL_Clinic with one doctor having appointment-based patients only and the other two doctors operating on a walk-in basis as before.

The board of MTL_Clinic suggests having 15-minute appointment slots, given on a "first-**call**, first-appointment" basis (so the time slots are 8:00 am, 8:15 am, 8:30 am, etc. up until 4:45 pm for a particular day). If a particular day gets filled up with appointments, then appointments for subsequent days will be given (again according to the same order). We assume that each patient can arrive at the clinic within 30 minutes of their phone call. For example, suppose the patient calls at 8:05 am. In this case, they will be available for an appointment at 8:35 am. But, since appointments are given only every 15 minutes (see above), this person will be assigned the 8:45 am time slot, if that time slot is available. If 8:45 is not available, then the patient will be assigned 9 am, if that's available, etc.

When a patient with an appointment arrives at the clinic, they follow the same processes and distributions as for walk-in patients (but all appointment patients are seen by one particular doctor). Both the receptionists and the nurses see all arrived patients in FCFS order, regardless of whether they have an appointment or not, but the appointment order is respected for the appointment-based doctor. The 15-minute appointment time slots refer to the amount of time allocated to the patient for seeing the doctor only. However, since the time spent talking to the doctor is stochastic, the patient might actually take up more than 15 minutes of a doctor's time, and the patient assigned to the doctor next might have to wait.

Note that although priority is still assigned by the nurses, the appointment-based patients that stay in the clinic (pain <=7) are processed in order of their appointment, not pain level/priority. Thus, you can still calculate waiting times, etc. by priority type but priority is not explicitly used to determine the order in which the patients are served by the appointment-based doctor. For all of the above analysis, assume that you are running a **terminating simulation.**

Output Analysis

1. **State and explain the run parameters by answering the following.**
    a. **State how many replications you ran:**

    b. **Provide an explanation of how you calculated the above number of replications:**

    c. **Insert a screenshot of your run parameters (should match your model!):**

Present a table of 95% confidence intervals for all major performance metrics in table format, corresponding to the setting above. (Note I am not listing all performance metrics, you can add all the ones you used in your analysis.)

Performance Metric	**95% Confidence Interval (note, this is an interval, so it should be stated in the format [X, Y])**
Waiting time until nurse	
Waiting time until doctor	
Total system time	
Latest time a patient leaves the clinic	

Comparison of Alternatives

3. Describe any missing information about your alternatives below. Add as many alternative labels as needed. For each alternative, specify the changes you have made in the model. Please add a reference to the file name corresponding to each alternative (.doe file).

Alternative 1 : current state (as in part 1)

Alternative 2 : appointment-based system for one doctor with a walk-in system for the other two doctors

Alternative 3: ***Description:*** *Explain your alternative 3.*

Implementation: *Please provide an explanation of your implementation. Please include the file name of the file that contains your implementation.*

4. Results of comparison of alternatives (Add all the relevant metrics you have considered.)

Alternative 1 vs Alternative 2

Metric	**Confidence Interval for Difference of Means**	**Significant Difference? Explain.**	**Conclusion (e.g., is one better than the other or there is no statistical difference?)**
Waiting time until nurse			
Waiting time until doctor			
Total system time			
Latest time a patient leaves the clinic			

Include screenshots of relevant graphs from Process Analyzer or Output Analyzer.

Alternative 1 vs Alternative 3

Metric	**Confidence Interval for Difference of Means**	**Significant Difference? Explain.**	**Conclusion (e.g., is one better than the other or there is no statistical difference?)**
Waiting time until nurse			
Waiting time until doctor			
Total system time			
Latest time a patient leaves the clinic			

Include screenshots of relevant graphs from Process Analyzer or Output Analyzer.

Alternative 2 vs Alternative 3

Metric	**Confidence Interval for Difference of Means**	**Significant Difference? Explain.**	**Conclusion (e.g., is one better than the other or there is no statistical difference?)**
Waiting time until nurse			
Waiting time until doctor			
Total system time			
Latest time a patient leaves the clinic			

Include screenshots of relevant graphs from Process Analyzer or Output Analyzer.

(Include as many tables as needed. Alternative formats accepted as long as you make it clear where there is a significant difference between alternatives and where there is not, and clearly state the conclusion that is being made.)

<u>Recommendations</u>

5. What recommendations would you like to make to MTL_Clinic? Please justify your suggestions based on the above analysis.

Hint: the goal is to provide recommendations that are a result of your analysis, i.e., based on what you tested. Providing recommendations that are not substantiated by your analysis will result in a grade of 0 on this question. For example, if your recommendation is "hire one more nurse" but none of your alternatives evaluated this situation, you would get a grade of 0 on this question.