Algı Kanar - 2016400123
Aslı Aykan - 2016400222

IE 306 Assignment 1 Report

1. Introduction

1.1 Description

The system simulation for assignment 1 works for a system where each of N independent individuals can get sick following a given exponential rate. A sick person can either choose to go to hospital or stay at home for her healing process. There exists a limited number of beds at the hospital and if there is no bed left for the next sick person, she is rejected from the hospital and has to heal at home, which takes longer than it would in the hospital. A sick person is healed following an independent exponential time and one of three types of healing rates. There exists healing rates for hospital cases, at home cases, and at home with rejected cases. The times of healing are still independent. A person who gets well can get sick later again following the same process, and the times of healing are still independent.

1.2 Numerical Formulas & Constants

In the assignment, there exists some given numerical formulas that need to be calculated and some constants that are widely used in the assignment:

Hospital probability: The probability of the sick individual going to the hospital is denoted with p1 = 0.2
Home probability: The probability of the sick individual going to the hospital is denoted with p2 = 1 - p1 = 0.8
Number of Individuals: The number of individuals is calculated as follows:
S = 222 + 123 + 120 + 10000, so 10<S and N = S + 1000 = 1465
Number of Beds: The number of beds in hospital is calculated as follows:
K = least upper bound of N/24 = 62
Inter-arrival rate: The inter-arrival rate for each individual patient is N-NUM_OF_SICK/300 (the machine repair type case we learned in class, it is updated every time the number sick people changes)
Healing at hospital service rate: The healing rate for at hospital service case is 1/6

Healing at home service rate: The healing rate for at home service case is 1/10

Healing at home rejected service rate: The healing rate for at home rejected service case is (⅙)* r in which r~ U[1, 2]

2. Implementation of the Simulation on the SimPy

As denoted as a necessity in the project description, we based our code on the SimPy pseudocode provided in the Jupyter notebook, which was a process-based simulation. So, our code also works as a process-based simulation.

Here are the explanations of the variables that are used on our code:

N = the total number of individual people in the simulation
K = the total number of beds in the hospital
heal_duration_times = a list of duration of healing process for each sick person
NUM_OF_SICK = global variable that holds the number of sick people at any time of the simulation, is incremented with each new patient and decremented with each patient recovering
NUM_OF_SICK_IN_HOSPITAL = global variable that holds the number of sick people at hospital at any time of the simulation, is incremented with each new patient healing at hospital and decremented with each patient leaving the hospital after being healed
DAY_NUM = global variable that holds the total number of sick people in a day, is incremented with each new patient, and reset at each day
DAY_OPTION = global variable that holds the day condition selection (1000, 10000 or 100000 as denoted in the project description)
RANDOM_SEED = random seed value for the simulation
num_of_sick_values = a list of the different values of the *NUM_OF_SICK* variable, each time *NUM_OF_SICK* is updated, new value of it is added to list
num_of_sick_in_hospital_values = a list of the different values of the *NUM_OF_SICK_IN_HOSPITAL* variable, each time *NUM_OF_SICK_IN_HOSPITAL* is updated, new value of it is added to list
num_of_sick_times = a list of time values for the update times of the *NUM_OF_SICK* variable, each time *NUM_OF_SICK* is updated, the current time value is added to list
num_of_sick_in_hospital_times = a list of time values for the update times of the *NUM_OF_SICK_IN_HOSPITAL* variable, each time *NUM_OF_SICK_IN_HOSPITAL* is updated, the current time value is added to list

option = hospital options for starting the simulation as being empty, half full and full (“Empty” if empty, “Half” if half full, and “Full” is full)
isSick = list of boolean lists for each individual in the simulation, each has two boolean values to denote whether the individual is sick and whether she got sick before, the values are initially [False, False] for each individual, and updated when the user initially gets sick (updated to [True, True] now), when the user heals (updated to [False, True]), and when the user gets sick again (updated to [True, True]) now)
PATIENTS = list of patients with all necessary information about the simulation at the time of departure for each patient

Our code starts with the initialization of the SimPy environment, empty time/value lists that are explained above to use while calculating average values, random seed, option for hospital conditions, and the service and inter-arrival rates that are explained in the introduction part. According to the conditions for hospital, it adds that number of sick people to the values of *NUM_OF_SICK* and *NUM_OF_SICK_IN_HOSPITAL,* and also adds the first elements of the *num_of_sick_in_hospital_values* and *num_of_sick_values*, which denotes the number of sick people before the simulation starts. (0 if Empty, math.ceil(K/2) if Half Full, math.ceil(K) if Full)
When the SimPy environment process calls the patient_generator function, it creates patients according to some features. For that number of patients, it directly creates the Patient objects without any inter-arrival time.
After the adding operation, it enters a while loop that exits if the total number of days that is given in *DAY_OPTION* is completed. Since a person who gets well can get sick later again following the same process, it needs to randomly select which person coming to hospital next. To achieve it, we decided to get a random number in range 1 to the number of individuals that are entered in the system until that time. We used this number as an index for the *isSick* list. We created an if block that checks whether the individual of that index is not sick at that time but got sick before and healed. If so, the system chooses a patient as a new patient from the ones who can get sick again. If not, the system checks whether the system is not full. If so, it means the system can create a new individual. If not, the while loop goes to the next iteration and makes these checks with a new index. So, there will be a time in the system in which it is at full capacity(1465 patients), and from that time only old patients will be able to get sick. It is also worth to note that all the patients except the ones that are already in the hospital before the simulation starts, are created with an interarrival rate.

In the Patient class, there exists a constructor with the following fields:
env = environment of the simulation

name = name of the patient (Ex: “Patient 25”)
id = index of the customer (Ex: 25 for Patient 25)
arrival_t = arrival time of the customer
action = initial action of the Patient
goesHospital = boolean value to check whether the patient goes to hospital (an updated value in the Patient class after the probability(0.2) check)
rejected = boolean value to check whether the patient is rejected from the hospital because there’s no bed left for her
fullHospital = boolean value to check whether the Patient should directly go to hospital without any probability calculation (for the hospital being half full and full cases, at time 0 some patients directly go to hospital with 0 interarrival time)

If the simulation starts with an empty hospital, the number of sick people should be incremented by one at each initialization, so there exists an if block for that case in the constructor. As explained before, after each update of *NUM_OF_SICK* value, one element must be added to *num_of_sick_values* and num_of_sick_times (updated *NUM_OF_SICK* value, and current time value)
After the initialization, the action *call* is called. In this function, it firstly makes a calculation for the patient whether she goes to hospital with probability 0.2 by taking a uniform random number between 0-1 and checks whether it’s below 0.2.
After the calculation, it checks whether the patient directly goes to hospital before starting the simulation (half & full hospital cases). If so, it directly moves to the process of healing at hospital.
If not, it checks whether the patient goes to hospital and there exists an empty bed for her. If so, *NUM_OF_SICK_IN_HOSPITAL* value is incremented by 1 and as explained before, after each update of *NUM_OF_SICK_IN_HOSPITAL* value, one element must be added to *num_of_sick_in_hospital_values* and *num_of_sick_in_hospital_time*s (updated *NUM_OF_SICK_IN_HOSPITAL* value, and current time value).
After these operations, it moves to the process of healing at the hospital.
If the patient goes to hospital but there is no empty bed for her, its rejected value is updated to True (it was initially False), and it moves to the process of healing at home.
If the patient does not go to the hospital, it again moves to the process of healing at home.

In the healing at hospital process, the healing duration is calculated with the rate *GOES_HOSPITAL_HEALS_RATE,* then *NUM_OF_SICK* and *NUM_OF_SICK_IN_HOSPITAL* values are decremented by 1, by also adding new elements to the related time and value lists, as explained before.

The process is done with the help of timeout operation. From the *isSick* list, the sickness value of the patient is updated with the value False, because she is healed at the end of this process.

In the healing at home process, it should check whether the patient is rejected from the hospital or not. If so, the duration rate should be (⅙)* r in which r~ U[1, 2]. If not, then the rate is 1/10, which is equal to the *AT_HOME_RATE.* After deciding on the rate of duration, the process is done with the help of timeout operation, and *NUM_OF_SICK* and *isSick* values should be updated. As explained before, after each update of *NUM_OF_SICK* value, one element must be added to *num_of_sick_values* and num_of_sick_times (updated *NUM_OF_SICK* value, and current time value)

3. Model Outputs

For our model output we calculated the average heal duration time, total average sickness time, average number of sick people, average number of occupied beds, long run probability of the hospital being empty, average proportion of sick people in population, and the variances of the sick people values occupied bed values.

In order to calculate these values, we saved the number of sick people values to the *num_sick_values* list and the number of sick people values at hospital to the *num_sick_in_hospital* at each update, and created two time lists for these lists to save the current time at each update. We used these values to calculate necessary average values. We also saved the heal durations in the *heal_duration_times* list.

To calculate the long run probability, we calculated the total time at which the hospital is empty, and divided this value by the total time of the simulation.

(a/b/x means random seed is a, runs for b units of time, x is “Full”, “Half”, or “Empty” according to the initial condition of the hospital)

3.1 10/1000/Empty Case

Average Heal Duration Time: 6.2088341831692775

Total Avg Sickness Time: 20.60570088639524

Average Number of Sick People: 30.282719742154683

Average Number of Occupied Beds: 25.41369763430283

Long Run Probability of Hospital Being Empty: 0.00011471094638014064

Avg. Proportion of Sick people in Population: 0.020670798458808756

Variance of Number Of Sick Values: 6.588087349860691

Variance of Number of Occupied Bed Values: 5.531941459148964

3.2 10/1000/Half Case

Average Heal Duration Time: 6.223032223636081

Total Avg Sickness Time: 20.279014222278942

Average Number of Sick People: 30.899560374248956

Average Number of Occupied Beds: 26.559008400155243

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.021091850084811625

Variance of Number Of Sick Values: 5.943457843129602

Variance of Number of Occupied Bed Values: 5.447096690444778

3.3 10/1000/Full Case

Average Heal Duration Time: 6.076522385722634

Total Avg Sickness Time: 19.619079102025978

Average Number of Sick People: 29.98518386303433

Average Number of Occupied Beds: 26.13369784961813

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.02046770229558658

Variance of Number Of Sick Values: 6.667056803907818

Variance of Number of Occupied Bed Values: 5.537571890251463

3.4 10/10000/Empty Case

Average Heal Duration Time: 6.089750738043542

Total Avg Sickness Time: 203.21893111363323

Average Number of Sick People: 29.78936851728714

Average Number of Occupied Beds: 28.603352429860394

Long Run Probability of Hospital Being Empty: 1.1471094638014064e-05

Avg. Proportion of Sick people in Population: 0.02033403994354077

Variance of Number Of Sick Values: 5.682342432401564

Variance of Number of Occupied Bed Values: 5.541859396237753

3.5 10/10000/Half Case

Average Heal Duration Time: 6.093744475798636

Total Avg Sickness Time: 199.1011420331587

Average Number of Sick People: 30.17985663674059

Average Number of Occupied Beds: 29.08231772194227

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.020600584734976425

Variance of Num Of Sick Values: 5.527057596195159

Variance of Number of Occupied Bed Values: 5.45089534318708

3.6 10/10000/Full Case

Average Heal Duration Time: 6.078243603112393

Total Avg Sickness Time: 194.27560185374594

Average Number of Sick People: 29.480003601876465

Average Number of Occupied Beds: 28.45453502002685

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.020122869352816826

Variance of Number Of Sick Values: 5.5408962880031085

Variance of Number of Occupied Bed Values: 5.35889200952398

3.7 10/100000/Empty Case

Average Heal Duration Time: 6.0025377602609575

Total Avg Sickness Time: 2004.8926821765544

Average Number of Sick People: 29.373433378487608

Average Number of Occupied Beds: 29.254831769745067

Long Run Probability of Hospital Being Empty: 1.1471094638014064e-06

Avg. Proportion of Sick people in Population: 0.020050125173029412

Variance of Number Of Sick Values: 5.485956947795787

Variance of Number of Occupied Bed Values: 5.473974917468777

3.7 10/100000/Half Case

Average Heal Duration Time: 6.00560415880357

Total Avg Sickness Time: 1963.488211294406

Average Number of Sick People: 29.76736865766643

Average Number of Occupied Beds: 29.65761476618676

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.02031902297451774

Variance of Number Of Sick Values: 5.418632566184911

Variance of Number of Occupied Bed Values: 5.412802843370133

3.8 10/100000/Full Case

Average Heal Duration Time: 6.0040643203370525

Total Avg Sickness Time: 1920.1858347296097

Average Number of Sick People: 29.132726912077406

Average Number of Occupied Beds: 29.030180053892312

Long Run Probability of Hospital Being Empty: 0

Avg. Proportion of Sick people in Population: 0.01988582041780058

Variance of Number Of Sick Values: 5.370751357961291

Variance of Number of Occupied Bed Values: 5.354710313990252

3.9 978/1000/Empty Case

Average Heal Duration Time: 6.297382702241209

Total Average Sickness Time: 20.79210930425988

Average Number Of Sick People: 30.626342312486297

Average Number of Occupied Beds in Hospital: 26.081747058065478

Long Run Probability of the Hospital Being Empty: 0.0002904047136884414

Average Proportion of Sick People in Population: 0.02090535311432515

Variance of Sick People Values: 6.74984904705137

Variance of Occupied Beds in Hospital Values: 5.633627257552232

3.10 978/1000/Half Case

Average Heal Duration Time: 6.301797312889998

Total Average Sickness Time: 20.432448625411258

Average Number Of Sick People: 31.07666590406449

Average Number of Occupied Beds in Hospital: 26.905567726652116

Long Run Probability of the Hospital Being Empty: 0.0

Average Proportion of Sick People in Population: 0.021212741231443306

Variance of Sick People Values: 6.340843160134273

Variance of Occupied Beds in Hospital Values: 5.382039637297759

3.11 978/1000/Full Case

Average Heal Duration Time: 6.333559292840497

Total Average Sickness Time: 20.280359483081753

Average Number Of Sick People: 30.830307572007467

Average Number of Occupied Beds in Hospital: 27.017178232439786

Long Run Probability of the Hospital Being Empty: 0.0

Average Proportion of Sick People in Population: 0.02104457854744539

Variance of Sick People Values: 6.036388117737194

Variance of Occupied Beds in Hospital Values: 5.103242580154835

3.12 978/10000/Empty Case

Average Heal Duration Time: 6.070493641381321

Total Average Sickness Time: 203.91471848874826

Average Number Of Sick People: 29.905653097548022

Average Number of Occupied Beds in Hospital: 28.72264040755201

Long Run Probability of the Hospital Being Empty: 2.904047136884414e-05

Average Proportion of Sick People in Population: 0.02041341508365054

Variance of Sick People Values: 5.620004072817669

Variance of Occupied Beds in Hospital Values: 5.439779374919939

3.13 978/10000/Half Case

Average Heal Duration Time: 6.0669677627446035

Total Average Sickness Time: 199.53904963298513

Average Number Of Sick People: 30.24827922310902

Average Number of Occupied Beds in Hospital: 29.096971419892956

Long Run Probability of the Hospital Being Empty: 0.0

Average Proportion of Sick People in Population: 0.02064728957208875

Variance of Sick People Values: 5.562211725698912

Variance of Occupied Beds in Hospital Values: 5.374912091808968

3.14 978/10000/Full Case

Average Heal Duration Time: 6.077836886782755

Total Average Sickness Time: 195.39104700123374

Average Number Of Sick People: 29.647343282562158

Average Number of Occupied Beds in Hospital: 28.533952128194507

Long Run Probability of the Hospital Being Empty: 0.0

Average Proportion of Sick People in Population: 0.020237094390827635

Variance of Sick People Values: 5.439862290059691

Variance of Occupied Beds in Hospital Values: 5.254994158047092

3.15 978/100000/Empty Case

Average Heal Duration Time: 5.997523673474368

Total Average Sickness Time: 1999.205944183035

Average Number Of Sick People: 29.291213806527665

Average Number of Occupied Beds in Hospital: 29.172912537528017

Long Run Probability of the Hospital Being Empty: 2.904047136884414e-06

Average Proportion of Sick People in Population: 0.019994002598312882

Variance of Sick People Values: 5.473463692377561

Variance of Occupied Beds in Hospital Values: 5.453225618915764

3.16 978/100000/Half Case

Average Heal Duration Time: 5.9990421642373235

Total Average Sickness Time: 1957.3338990908715

Average Number Of Sick People: 29.67592645771104

Average Number of Occupied Beds in Hospital: 29.56079567738954

Long Run Probability of the Hospital Being Empty: 0

Average Proportion of Sick People in Population: 0.02025660509058753

Variance of Sick People Values: 5.427337694748247

Variance of Occupied Beds in Hospital Values: 5.407118977194912

3.17 978/100000/Full Case

Average Heal Duration Time: 5.997855563484915

Total Average Sickness Time: 1914.9863172908701

Average Number Of Sick People: 29.056362453523818

Average Number of Occupied Beds in Hospital: 28.945023338086987

Long Run Probability of the Hospital Being Empty: 0.0

Average Proportion of Sick People in Population: 0.019833694507525045

Variance of Sick People Values: 5.362102274586176

Variance of Occupied Beds in Hospital Values: 5.342143910497031

Algı Kanar - 2016400123
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4. Table Examples

	ID	Place	Sick #	Hospital #	InterArrival	Arrival	Duration	Departure
1	1	Home	0	0	0.11471094638014064	0.11471094638014064	17.349380565228014	17.464091511608153
2	2	Hospital	1	0	0.04726188603041726	0.1619728324105579	4.041074249917277	4.203047082327835
3	3	Home	2	1	0.3407494826499615	0.5027223150605195	56.7140992775478 24	57.21682159260834
4	4	Hospital	3	1	0.058910097210265924	0.5616324122707854	2.6317897071071314	3.193422119377917
5	5	Home	4	2	0.11168815961332221	0.6733205718841077	6.103350516911751	6.776671088795858
6	6	Home	5	2	0.0683021240101279	0.7416226958942356	6.105141497012523	6.846764192906759
7	7	Home	6	2	0.07394962891621516	0.8155723248104507	0.45270031620124374	1.2682726410116945
8	8	Hospital	6	2	0.7139321017032338	1.5295044265136846	14.420285744818322	15.949790171332006
9	9	Home	7	3	0.05503098055474895	1.5845354070684334	3.7740811985469858	5.358616605615419
10	10	Home	8	3	0.09336573512674705	1.6779011421951804	10.58366327344416	12.26156441563934
11	11	Hospital	9	3	0.12265604900594027	1.8005571912011207	1.523928611756217	3.3244858029573376
12	12	Hospital	10	4	0.3805463360887556	2.1811035272898764	2.1500372847939784	4.331140812083855
13	7	Hospital	11	5	0.055761022686188405	2.236864549976065	11.591334543159997	13.828199093136062
14	13	Home	12	6	0.21965031404185362	2.4565148640179184	24.41417169075833	26.87068655477625
15	14	Home	13	6	0.09935601117865646	2.555870875196575	1.0159631270560598	3.5718340022526345
16	15	Hospital	14	6	0.024535548914385065	2.58040642411096	2.572535328247487	5.152941752358448
17	16	Home	13	5	0.8219824847069175	3.4023889088178776	1.5491639007803564	4.951552809598234
18	17	Hospital	14	5	0.12079493711944167	3.5231838459373193	3.64991255239629	7.173096398333609
19	18	Home	15	6	0.04025429717656215	3.5634381431138813	1.9153342969296487	5.47877244004353
20	19	Home	15	6	0.22117079048579183	3.784608933599673	5.704173763531869	9.488782697131542
21	20	Hospital	16	6	0.13396239316907854	3.9185713267687516	13.633870477953762	17.552441804722513
22	21	Home	17	7	0.16118692124015926	4.079758248008911	8.743069340302476	12.822827588311387
23	22	Home	18	7	0.01705804623053786	4.096816294239449	22.39393954712307	26.49075584136252
24	23	Home	17	5	0.5188073676488473	4.615623661888296	7.341977310333993	11.95760097222229
25	24	Hospital	18	5	0.15259775376660414	4.7682214156549	6.730569760826779	11.49879117648168
26	25	Home	19	6	0.14189226493217527	4.9101136805870755	4.29599796239505	9.206111642982126
27	26	Hospital	20	6	0.029878245444019298	4.9399919260310945	3.4933585389176445	8.433350464948738
28	27	Home	20	7	0.1378444053833253	5.07783633141442	5.772830229410986	10.850666560825406
29	14	Hospital	19	6	0.36173668662872444	5.439573018043144	0.690825014237338	6.130398032280482
30	28	Home	20	7	0.010627284568941298	5.450200302612085	1.50008868683419	6.950288989446276
31	15	Hospital	20	7	0.3670591122583075	5.817259414870393	3.5553327735366933	9.372592188407086
32	29	Home	21	8	0.1174622124392383	5.9347216273096315	6.1294319237670445	12.064153551076675
33	30	Home	22	8	0.061416801523547775	5.996138428833179	1.6679552172689178	7.6640936461020965
34	11	Hospital	22	7	0.21470532127823394	6.210843750111413	1.305789900617577	7.5166336507289895
35	31	Hospital	23	8	0.07989940226635046	6.290743152377763	2.1082528844641133	8.398996036841876
36	32	Home	24	9	0.005164119597073733	6.295907271974836	0.4733889827083283	6.769296254683164
37	16	Hospital	25	9	0.2593941457330561	6.555301417707892	6.651999686207976	13.207301103915867
38	33	Home	21	9	0.8150718503162798	7.3703732680241725	15.457583987587538	22.82795725561171
39	34	Home	22	9	0.09170508536085295	7.462078353385025	5.564270768591887	13.026349121976912
40	35	Home	23	9	0.0412747525055148	7.50335310589054	32.75541891757781	40.25877202346835
41	36	Home	22	8	0.2361513099619684	7.739504415852508	13.604114214071238	21.343618629923746
42	37	Home	23	8	0.26249332786411	8.001997743716618	9.868922975685871	17.87092071940249
43	14	Hospital	24	8	0.06329614267309355	8.065293886389712	12.473230723002123	20.538524609391835
44	38	Home	25	9	0.04816550975255132	8.113459396142265	0.9323684406763705	9.045827836818635
45	39	Home	26	9	0.014898917455857938	8.128358313598122	5.51944807214462	13.647806385742742
46	4	Hospital	27	9	0.08758722321564481	8.215945536813766	7.126019763235313	15.341965300049079
47	40	Home	27	9	0.20296099479126783	8.418906531605034	5.184534046878384	13.603440578483418
48	41	Home	27	8	0.14169219541166733	8.560598727016702	6.589323042080843	15.149921769097546
49	42	Home	28	8	0.08556246657394295	8.646161193590645	0.8768372409061055	9.52299843449675
50	43	Home	29	8	0.3930111949942915	9.039172388584937	5.196257005190567	14.235429393775505

Patient Table of 10/100000/Empty Case

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

	Time	ID	Event	Sick #	Hospital #	Home #
1	0.11471094638014064	1	Arrival	0	0	0
2	0.1619728324105579	2	Arrival	1	0	1
3	0.5027223150605195	3	Arrival	2	1	1
4	0.5616324122707854	4	Arrival	3	1	2
5	0.6733205718841077	5	Arrival	4	2	2
6	0.7416226958942356	6	Arrival	5	2	3
7	0.8155723248104507	7	Arrival	6	2	4
8	1.2682726410116945	7	Departure	7	2	5
9	1.5295044265136846	8	Arrival	6	2	4
10	1.5845354070684334	9	Arrival	7	3	4
11	1.6779011421951804	10	Arrival	8	3	5
12	1.8005571912011207	11	Arrival	9	3	6
13	2.1811035272898764	12	Arrival	10	4	6
14	2.236864549976065	7	Arrival	11	5	6
15	2.4565148640179184	13	Arrival	12	6	6
16	2.555870875196575	14	Arrival	13	6	7
17	2.58040642411096	15	Arrival	14	6	8
18	3.193422119377917	4	Departure	15	7	8
19	3.3244858029573376	11	Departure	14	6	8
20	3.4023889088178776	16	Arrival	13	5	8
21	3.5231838459373193	17	Arrival	14	5	9
22	3.5634381431138813	18	Arrival	15	6	9
23	3.5718340022526345	14	Departure	16	6	10
24	3.784608933599673	19	Arrival	15	6	9
25	3.9185713267687516	20	Arrival	16	6	10
26	4.079758248008911	21	Arrival	17	7	10
27	4.096816294239449	22	Arrival	18	7	11
28	4.203047082327835	2	Departure	19	7	12
29	4.331140812083855	12	Departure	18	6	12
30	4.615623661888296	23	Arrival	17	5	12
31	4.7682214156549	24	Arrival	18	5	13
32	4.9101136805870755	25	Arrival	19	6	13
33	4.9399919260310945	26	Arrival	20	6	14
34	4.951552809598234	16	Departure	21	7	14
35	5.07783633141442	27	Arrival	20	7	13
36	5.152941752358448	15	Departure	21	7	14
37	5.358616605615419	9	Departure	20	6	14
38	5.439573018043144	14	Arrival	19	6	13
39	5.450200302612085	28	Arrival	20	7	13
40	5.47877244004353	18	Departure	21	7	14
41	5.817259414870393	15	Arrival	20	7	13
42	5.9347216273096315	29	Arrival	21	8	13
43	5.996138428833179	30	Arrival	22	8	14
44	6.130398032280482	14	Departure	23	8	15
45	6.210843750111413	11	Arrival	22	7	15
46	6.290743152377763	31	Arrival	23	8	15
47	6.295907271974836	32	Arrival	24	9	15
48	6.555301417707892	16	Arrival	25	9	16
49	6.769296254683164	32	Departure	26	10	16
50	6.776671088795858	5	Departure	25	10	15

Event Table of 10/100000/Empty Case

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

	ID	Place	Sick #	Hospital #	InterArrival	Arrival	Duration	Departure
1	13	Hospital	31	31	0	0	0.19356924740007758	0.19356924740007758
2	16	Hospital	31	31	0	0	0.4485661051053305	0.4485661051053305
3	18	Hospital	31	31	0	0	0.5064856889904504	0.5064856889904504
4	22	Hospital	31	31	0	0	0.9727257245683921	0.9727257245683921
5	27	Hospital	31	31	0	0	1.2711902003592668	1.2711902003592668
6	12	Hospital	31	31	0	0	1.6337979647053205	1.6337979647053205
7	3	Hospital	31	31	0	0	1.648060263371256	1.648060263371256
8	14	Hospital	31	31	0	0	2.1500372847939784	2.1500372847939784
9	8	Hospital	31	31	0	0	2.3554853631513333	2.3554853631513333
10	28	Hospital	31	31	0	0	2.572535328247487	2.572535328247487
11	19	Hospital	31	31	0	0	2.911131127534635	2.911131127534635
12	25	Hospital	31	31	0	0	3.4955499748470653	3.4955499748470653
13	30	Hospital	31	31	0	0	3.5392916575996414	3.5392916575996414
14	5	Hospital	31	31	0	0	3.59382223587405	3.59382223587405
15	6	Hospital	31	31	0	0	3.8089749282333534	3.8089749282333534
16	9	Hospital	31	31	0	0	4.181931543844859	4.181931543844859
17	1	Hospital	31	31	0	0	4.611689351972295	4.611689351972295
18	15	Hospital	31	31	0	0	5.598748036360422	5.598748036360422
19	7	Hospital	31	31	0	0	6.350197964066496	6.350197964066496
20	4	Hospital	31	31	0	0	6.59209287072743	6.59209287072743
21	2	Hospital	31	31	0	0	8.871917976367284	8.871917976367284
22	24	Hospital	31	31	0	0	8.900483468430938	8.900483468430938
23	10	Hospital	31	31	0	0	11.077615018405139	11.077615018405139
24	21	Hospital	31	31	0	0	14.648503014455	14.648503014455
25	17	Hospital	31	31	0	0	15.48330143818489	15.48330143818489
26	20	Hospital	31	31	0	0	17.464495415669624	17.464495415669624
27	23	Hospital	31	31	0	0	19.911603411888798	19.911603411888798
28	11	Hospital	31	31	0	0	20.996231564959945	20.996231564959945
29	29	Hospital	31	31	0	0	21.137471207734382	21.137471207734382
30	26	Hospital	31	31	0	0	24.084086801912683	24.084086801912683
31	31	Home	31	31	0.006930498057695224	0.006930498057695224	20.01611169460381	20.023042192661507
32	32	Hospital	32	31	0.03240928662720411	0.039339784684899334	6.2771124360051	6.31645222069
33	33	Home	33	32	0.1272633386470115	0.16660312333191085	4.270533506846997	4.437136630178908
34	34	Home	32	30	0.31440990939122276	0.4810130327231336	0.4465531575054094	0.927566190228543
35	35	Home	32	29	0.05296485636732079	0.5339778890904544	5.1884520627003905	5.722429951790845
36	36	Home	33	29	0.05813675953273227	0.5921146486231866	11.18875865435625	11.780873302979435
37	37	Home	34	29	0.10361066626956976	0.6957253148927564	3.1703210842649923	3.8660463991577485
38	16	Hospital	33	28	0.27887494868645885	0.9746002635792153	4.032849504161453	5.007449767740668
39	38	Hospital	34	29	0.1927964011947583	1.1673966647739735	4.676055069303716	5.84345173407769
40	39	Home	33	28	0.47754568012934573	1.6449423449033191	1.8127783030464535	3.4577206479497726
41	40	Home	33	27	0.1618483805397045	1.8067907254430235	17.664808197036045	19.471598922479068
42	41	Hospital	34	27	0.021728672356483264	1.828519397799507	2.5813565521364596	4.409875949935967
43	42	Home	35	28	0.12077050689144324	1.9492899046909502	49.182474388195565	51.131764292886515
44	43	Home	36	28	0.02408734359265474	1.973377248283605	14.898851360759782	16.872228609043386
45	44	Home	37	28	0.031382608511175525	2.0047598567947804	15.546173584910063	17.550933441704842
46	45	Home	38	28	0.08795406073512593	2.0927139175299065	24.028541203452413	26.12125512098232
47	46	Home	38	27	0.1151572099573403	2.207871127487247	0.334529481904436	2.5424060093916827
48	47	Home	38	26	0.2815261137223002	2.489397241209547	17.685696077121793	20.175093318331342
49	13	Hospital	37	25	0.2152511086613644	2.704648349870911	2.1082528844641133	4.812901234335024
50	48	Home	38	26	0.005275756771069051	2.70992410664198	0.4733889827083283	3.1833130893503085

Patient Table of 10/1000/Half Case

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

	Time	ID	Event	Sick #	Hospital #	Home #
1	0	1	Arrival	31	31	0
2	0	2	Arrival	31	31	0
3	0	3	Arrival	31	31	0
4	0	4	Arrival	31	31	0
5	0	5	Arrival	31	31	0
6	0	6	Arrival	31	31	0
7	0	7	Arrival	31	31	0
8	0	8	Arrival	31	31	0
9	0	9	Arrival	31	31	0
10	0	10	Arrival	31	31	0
11	0	11	Arrival	31	31	0
12	0	12	Arrival	31	31	0
13	0	13	Arrival	31	31	0
14	0	14	Arrival	31	31	0
15	0	15	Arrival	31	31	0
16	0	16	Arrival	31	31	0
17	0	17	Arrival	31	31	0
18	0	18	Arrival	31	31	0
19	0	19	Arrival	31	31	0
20	0	20	Arrival	31	31	0
21	0	21	Arrival	31	31	0
22	0	22	Arrival	31	31	0
23	0	23	Arrival	31	31	0
24	0	24	Arrival	31	31	0
25	0	25	Arrival	31	31	0
26	0	26	Arrival	31	31	0
27	0	27	Arrival	31	31	0
28	0	28	Arrival	31	31	0
29	0	29	Arrival	31	31	0
30	0	30	Arrival	31	31	0
31	0.006930498057695224	31	Arrival	31	31	0
32	0.03933784684899334	32	Arrival	32	31	1
33	0.16660312333191085	33	Arrival	33	32	1
34	0.19356924740007758	13	Departure	34	32	2
35	0.4485661051053305	16	Departure	33	31	2
36	0.4810130327231336	34	Arrival	32	30	2
37	0.5064856889904504	18	Departure	33	30	3
38	0.5339778890904544	35	Arrival	32	29	3
39	0.5921146486231866	36	Arrival	33	29	4
40	0.6957253148927564	37	Arrival	34	29	5
41	0.927566190228543	34	Departure	35	29	6
42	0.9727257245683921	22	Departure	34	29	5
43	0.9746002635792153	16	Arrival	33	28	5
44	1.1673966647739735	38	Arrival	34	29	5
45	1.2711902003592668	27	Departure	35	30	5
46	1.6337979647053205	12	Departure	34	29	5
47	1.6449423449033191	39	Arrival	33	28	5
48	1.648060263371256	3	Departure	34	28	6
49	1.8067907254430235	40	Arrival	33	27	6
50	1.828519397799507	41	Arrival	34	27	7

Event Table of 10/1000/Half Case

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

	ID	Place	Sick # Hospital	#In	Arrival	Arrival	Duration	Departure
1	45	Hospital	62	62	0	0	0.03586171964128584	0.03586171964128584
2	22	Hospital	62	62	0	0	0.14747233052036693	0.14747233052036693
3	55	Hospital	62	62	0	0	0.3398495874489467	0.3398495874489467
4	37	Hospital	62	62	0	0	0.4542767778207623	0.4542767778207623
5	43	Hospital	62	62	0	0	0.5395018342564907	0.5395018342564907
6	24	Hospital	62	62	0	0	0.844219749588772	0.844219749588772
7	12	Hospital	62	62	0	0	1.0270828582059006	1.0270828582059006
8	10	Hospital	62	62	0	0	1.0409603515677301	1.0409603515677301
9	61	Hospital	62	62	0	0	1.1292282626788435	1.1292282626788435
10	8	Hospital	62	62	0	0	1.308338551165066	1.308338551165066
11	36	Hospital	62	62	0	0	1.3594007096705705	1.3594007096705705
12	40	Hospital	62	62	0	0	1.3867138781909596	1.3867138781909596
13	16	Hospital	62	62	0	0	1.4157199440352886	1.4157199440352886
14	47	Hospital	62	62	0	0	1.4527597235052887	1.4527597235052887
15	1	Hospital	62	62	0	0	1.915749036818645	1.915749036818645
16	52	Hospital	62	62	0	0	2.05964603786293	2.05964603786293
17	31	Hospital	62	62	0	0	2.233128072592993	2.233128072592993
18	19	Hospital	62	62	0	0	2.235684504711231	2.235684504711231
19	21	Hospital	62	62	0	0	2.5045440740582423	2.5045440740582423
20	27	Hospital	62	62	0	0	2.5357802111726504	2.5357802111726504
21	5	Hospital	62	62	0	0	2.6400465926162595	2.6400465926162595
22	44	Hospital	62	62	0	0	2.6992163505332676	2.6992163505332676
23	6	Hospital	62	62	0	0	2.709791799488466	2.709791799488466
24	38	Hospital	62	62	0	0	2.766868106860285	2.766868106860285
25	29	Hospital	62	62	0	0	2.8455719866444107	2.8455719866444107
26	51	Hospital	62	62	0	0	2.8477896730697156	2.8477896730697156
27	18	Hospital	62	62	0	0	2.9922091173321017	2.9922091173321017
28	34	Hospital	62	62	0	0	3.532523090225564	3.532523090225564
29	17	Hospital	62	62	0	0	3.87504027122049	3.87504027122049
30	3	Hospital	62	62	0	0	3.988555798949945	3.988555798949945
31	14	Hospital	62	62	0	0	3.9901580335142506	3.9901580335142506
32	50	Hospital	62	62	0	0	4.184937738585388	4.184937738585388
33	7	Hospital	62	62	0	0	4.385147906115849	4.385147906115849
34	56	Hospital	62	62	0	0	5.691241325963501	5.691241325963501
35	53	Hospital	62	62	0	0	6.027710240285528	6.027710240285528
36	41	Hospital	62	62	0	0	6.170517578662417	6.170517578662417
37	54	Hospital	62	62	0	0	6.517036843077011	6.517036843077011
38	15	Hospital	62	62	0	0	6.632814722752768	6.632814722752768
39	35	Hospital	62	62	0	0	6.7410500822070585	6.7410500822070585
40	57	Hospital	62	62	0	0	7.062507071160261	7.062507071160261
41	33	Hospital	62	62	0	0	7.43003926266267	7.43003926266267
42	60	Hospital	62	62	0	0	7.775656061720132	7.775656061720132
43	11	Hospital	62	62	0	0	7.776439502486757	7.776439502486757
44	58	Hospital	62	62	0	0	8.031060539224875	8.031060539224875
45	13	Hospital	62	62	0	0	8.435351300288314	8.435351300288314
46	25	Hospital	62	62	0	0	8.799424844051009	8.799424844051009
47	42	Hospital	62	62	0	0	10.577973476609827	10.577973476609827
48	23	Hospital	62	62	0	0	11.646375142703876	11.646375142703876
49	48	Hospital	62	62	0	0	12.494430183794007	12.494430183794007
50	49	Hospital	62	62	0	0	12.543359022623306	12.543359022623306

Patient Table of 978/10000/Full Case

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

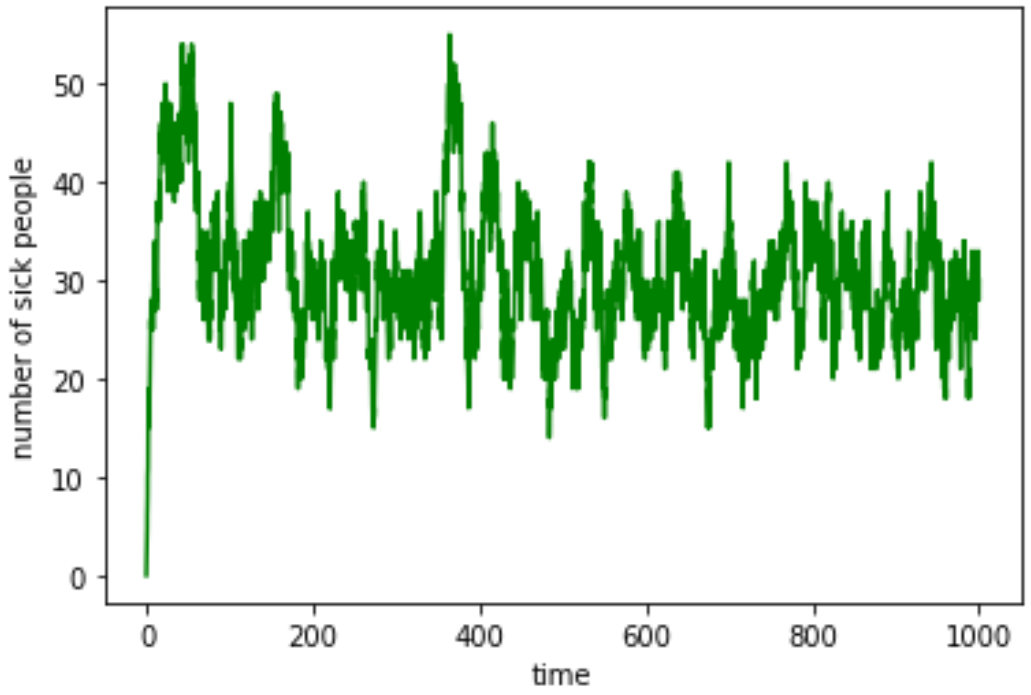
	Time	ID	Event	Sick #	Hospital #	Home #
1	0	1	Arrival	62	62	0
2	0	2	Arrival	62	62	0
3	0	3	Arrival	62	62	0
4	0	4	Arrival	62	62	0
5	0	5	Arrival	62	62	0
6	0	6	Arrival	62	62	0
7	0	7	Arrival	62	62	0
8	0	8	Arrival	62	62	0
9	0	9	Arrival	62	62	0
10	0	10	Arrival	62	62	0
11	0	11	Arrival	62	62	0
12	0	12	Arrival	62	62	0
13	0	13	Arrival	62	62	0
14	0	14	Arrival	62	62	0
15	0	15	Arrival	62	62	0
16	0	16	Arrival	62	62	0
17	0	17	Arrival	62	62	0
18	0	18	Arrival	62	62	0
19	0	19	Arrival	62	62	0
20	0	20	Arrival	62	62	0
21	0	21	Arrival	62	62	0
22	0	22	Arrival	62	62	0
23	0	23	Arrival	62	62	0
24	0	24	Arrival	62	62	0
25	0	25	Arrival	62	62	0
26	0	26	Arrival	62	62	0
27	0	27	Arrival	62	62	0
28	0	28	Arrival	62	62	0
29	0	29	Arrival	62	62	0
30	0	30	Arrival	62	62	0
31	0	31	Arrival	62	62	0
32	0	32	Arrival	62	62	0
33	0	33	Arrival	62	62	0
34	0	34	Arrival	62	62	0
35	0	35	Arrival	62	62	0
36	0	36	Arrival	62	62	0
37	0	37	Arrival	62	62	0
38	0	38	Arrival	62	62	0
39	0	39	Arrival	62	62	0
40	0	40	Arrival	62	62	0
41	0	41	Arrival	62	62	0
42	0	42	Arrival	62	62	0
43	0	43	Arrival	62	62	0
44	0	44	Arrival	62	62	0
45	0	45	Arrival	62	62	0
46	0	46	Arrival	62	62	0
47	0	47	Arrival	62	62	0
48	0	48	Arrival	62	62	0
49	0	49	Arrival	62	62	0
50	0	50	Arrival	62	62	0

Event Table of 978/10000/Full Case

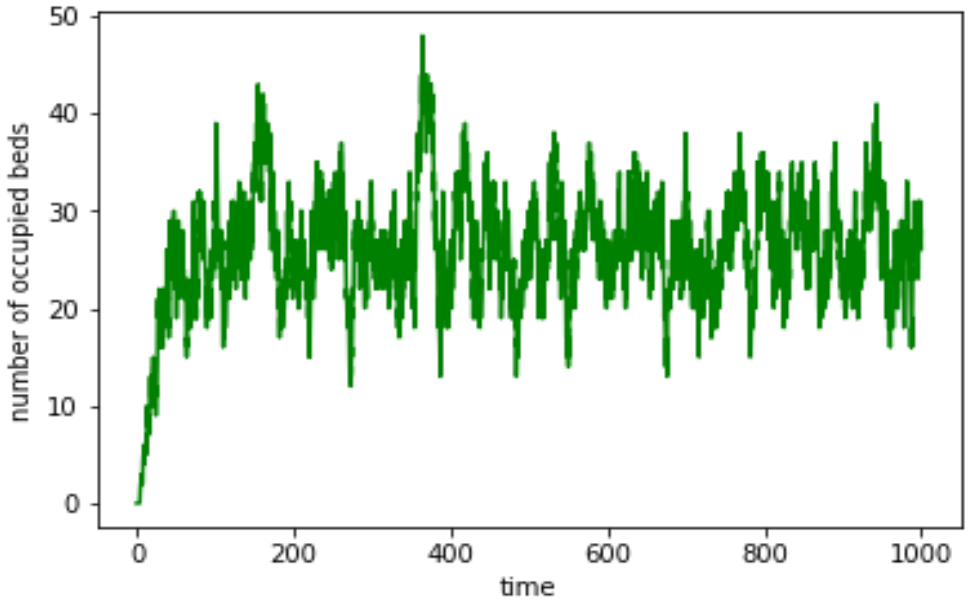
Algı Kanar - 2016400123
Aslı Aykan - 2016400222

5. Plot Examples

(For the case 978/1000/Empty)



Plot Of The Number Of Sick People Values



Plot Of The Number Of Occupied Bed Values

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

6. Conclusion

We observed our model responses to derive some conclusions.

Firstly, we realized that the average heal duration time values between different cases yields similar results, the reason of it is that different values of the duration of simulation and number of the people that are initially at hospital before simulation didn't affect the "rejected case" very much, so the places that the people are healed in didn't change according to the number of unit times or people initially at hospital. In other words, since the "rejected case" is a very rare case in this simulation, it didn't change the average values of healing.

Secondly, we also realized that the average sickness time increases as the duration of the simulation increases. Since people may get sick again after they heal, it's a very natural result that their sickness time will increase as the duration of the simulation increases.

Additionally, we also realized that the long run probability of the hospital being empty is 0 for the half and full hospital cases we tried for our simulation. This probability is equal to the total time in which the hospital is empty divided by the total time. However, in half and full cases, there is no time that the hospital is empty, so this probability in these cases is 0.

Another thing that should be taken into consideration is that the average number of occupied beds does not necessarily increase as the number of sick people initially at hospital before simulation increases. In other words, although we thought that the full hospital cases should give a higher average number of occupied beds, since it is a randomized simulation with different rates, it is not always the case.

Moreover, we also realized that the average number of sick people yields similar values for different cases. The reason for this is that although we implemented a machine-repair simulation, the interarrival rate does not change very significantly, so the values are very similar to each other.

Algı Kanar - 2016400123
Aslı Aykan - 2016400222

7. About Process-Based vs. Event Based Models

Process-based model and event-based model are the two main models that have been used in simulation logic. Process-based simulation puts emphasis on the lifecycle of entities as they go through the simulation. On the other hand, event-based simulation sees processes as a sequence of events. After an event routine, further events can be scheduled for the future. The main difference is that the process-based model deals with each process individually without knowing about the other process in a multi thread-based way. However, for event-based, when it schedules the events, it goes through a one main thread while being aware what the future events hold. We can put this main difference in a real-life analogy. Let us think that there is a restaurant that has enough waiters to serve each table individually. This will indicate a process-based model. Each waiter will go to the kitchen and tell the specific order. Scheduling will be made in a first come first serve manner without waiters knowing about the other events. For event-based modelling, the restaurant in the example would only have one waiter for all the tables. The waiter will tell the kitchen the orders but, now, knowing all the future event list. In this project, we used a process-based model with multiple threats which allocates, serves, and suspends time periods for each thread while using time outs.