**PART 1.1**

**Flowchart**

diyagram içeren bir resim

Açıklama otomatik olarak oluşturuldu

**Pseudo Code**

**BEGIN**

**//** Event object has properties as time, type, owner id

nurses **=** 4

beds **=** 6

p\_1 **=** 0.25

termination\_limit // maximum number of healed people that stops simulation

**//** generating arrival times

arrivals[1] = 0

**FOR** i=2 **TO** arrivals.size

arrivals[i] = arrivals[i-1] + exp(1)

**END FOR**

**FOR** starting\_condition **IN** (empty, half, full)

futureEventList // sorts events according to their times in ascending order

waitingQueue // objects in waiting queue has properties entrance time and id

simulation\_time **=** 0

event\_type **=** 'A'

pid **=** 1

healed\_patients **=** 0

**IF** starting\_condition == empty

busy\_nurses = initially\_busy\_nurses **=** 0

occupied\_beds = initially\_occupied\_beds = 0

already\_in\_hospital **=** 0

**ELSEIF** starting\_condition == half

busy\_nurses = initially\_busy\_nurses **=** nurses/2

occupied\_beds = initially\_occupied\_beds = beds/2

already\_in\_hospital **=** nurses/2 + beds/2

**ELSEIF** starting\_condition == full

busy\_nurse = initially\_busy\_nurses **=** nurses

occupied\_beds = initially\_occupied\_beds = beds

already\_in\_hospital **=** nurses + beds

**FOR** i=0 **TO** busy\_nurses

futureEventList.push(Event(exp(1**/**0.3125), 'DN', pid))

pid **++**

**END FOR**

**FOR** i=0 **TO** occupied\_beds

futureEventList.push(Event(exp(1**/**0.1666666667), 'DB', pid))

pid **++**

**END FOR**

**WHILE** healed\_patients **<** termination\_limit

**IF** event\_type **==** 'A'

futureEventList**.**push(Event(arrivals[pid**-**already\_in\_hospital**+**1], 'A', pid**+**1))

**IF** busy\_nurses **<** nurses

futureEventList**.**push(Event(simulation\_time **+** exp(1**/**0.3125), 'DN', pid))

busy\_nurses **++**

**ELSE**

waitingQueue**.**put((simulation\_time, pid))

**ELSEIF** event\_type **==** 'DN'

**IF** Uniform(0, 1) <= p\_1 //stable

futureEventList**.**push(Event(simulation\_time **+** exp(1**/**0.16), 'H', pid))

**ELSE** // critical

**IF** occupied\_beds **<** beds

futureEventList**.**push(Event(simulation\_time **+** exp(1**/**0.1666666667),'DB', pid))

occupied\_beds **++**

**ELSE**

futureEventList**.**push(Event(simulation\_time **+** exp(Uniform(1.25, 1.75)**/** 0.1666666667),'H', pid))

**IF** waitingQueue**.**empty()

busy\_nurses **--**

**ELSE**

waitingPatient = waitingQueue**.**pop()

futureEventList**.**push(Event(simulation\_time **+** exp(1**/**0.3125), 'DN', waitingPatient.id))

**ELSEIF** event\_type **==** 'DB'

occupied\_beds **--**

healed\_patients **++**

**ELSEIF** event\_type **==** 'H'

healed\_patients **++**

simulation\_time, event\_type, pid **=** futureEventList**.**pop()

**ENF FOR**

**END**

**PART 2.1**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ID | interarrival times | arrival time | nurse service time | condition  (s : stable, c: critical) | home healing time | hospital healing time |
| 1 |  | 0,000000000 | 0,000567125 | 0,964519167674982 -> c |  | 1,280412770 |
| 2 | 0,241070487 | 0,241070487 | 0,248228441 | 0,101183859095605 -> s | 7,657424040 |  |
| 3 | 0,647407769 | 0,888478256 | 0,544135251 | 0,314313178869379 -> c |  | 6,291278600 |
| 4 | 4,504118940 | 5,392597196 | 4,386731990 | 0,540291489147209 -> c |  | 8,032148110 |
| 5 | 1,074342570 | 6,466939766 | 8,558291140 |  |  |  |
| 6 | 2,533750560 | 9,000690326 | 2,222955040 | 0,580858365407692 -> c |  | 1,995603210 |
| 7 | 0,319182038 | 9,319872364 | 0,252801625 | 0,139571055815548 -> s | 0,041612336 |  |
| 8 | 1,101845720 | 10,421718084 | 0,540929031 | 0,559317570686995 -> c |  | 4,151340170 |
| 9 | 0,585289474 | 11,007007558 | 0,898865242 | 0,417490498901413 -> c |  | 6,517125070 |
| 10 | 0,228080274 | 11,235087832 | 9,008274120 |  |  |  |
| 11 | 0,082646203 | 11,317734035 | 1,265495060 | 0,51145555488414 -> c |  | 4,764165800 |
| 12 | 0,752756332 | 12,070490367 | 0,562989420 | 0,178068518205268 -> s | 0,015818572 |  |
| 13 | 0,382814961 | 12,453305328 | 1,717808650 |  |  |  |
| 14 | 0,808808754 | 13,262114082 | 4,920111180 |  |  |  |

* Condition is calculated according to the uniformly generated number between 0 and 1. If it is less than 0,25 (p1), condition is stable. If it is more than 0,25 , it is critical.
* Data are generated by 50 iterations.

|  |  |
| --- | --- |
| A(t, id) | : Arrival of patient with id at time t |
| DN(t, id) | : Departure triage of patient with id at time t |
| DB(t, id) | : Departure of patient with id from hospital at time t |
| H(t, id) | : Healing of patient with id at home at time t |

total number of busy nurses : Current number of busy nurses. It can be maximum 4 that is the total number of nurses in the system

total number of occupied beds : Current number of occupied beds. It can be maximum 6 that is the total number of beds in the system

number of healed patients : If there is healed patient at time t, it will be 1. Otherwise, empty.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| simulation time | future event list | next event | total number of busy nurses  (max4 ) | number of patients in queue | waiting time in queue | total number of occupied beds  (max 6) | home healing time | hospital healing time | number of healed patients |
| 0,000000000 | A(0,241070487,2) DN(0,000567125,1) | DN(0,000567125,1) | 1 |  |  |  |  |  |  |
| 0,000567125 | A(0,241070487,2) DB(1,280979895, 1) | A(0,241070487,2) | 0 |  |  | 1 |  | 1,280412770 |  |
| 0,241070487 | A(0,888478256,3) DN(0,489298928,2) DB(1,280979895, 1) | DN(0,489298928,2) | 1 |  |  | 1 |  |  |  |
| 0,489298928 | A(0,888478256,3) H(8,146722968,2) DB(1,280979895, 1) | A(0,888478256,3) | 0 |  |  | 1 | 7,657424040 |  |  |
| 0,888478256 | DN(1,432613507,3) H(8,146722968,2) DB(1,280979895, 1) A(5,392597196, 4) | DB(1,280979895, 1) | 1 |  |  | 1 |  |  |  |
| 1,280979895 | DN(1,432613507,3) H(8,146722968,2) A(5,392597196, 4) | DN(1,432613507,3) | 1 |  |  | 0 |  |  | 1 |
| 1,432613507 | H(8,146722968,2) A(5,392597196, 4) DB(7,723892107,3) | A(5,392597196, 4) | 0 |  |  | 1 |  | 6,291278600 |  |
| 5,392597196 | H(8,146722968,2) DB(7,723892107,3) A(6,466939766, 5) DN(9,779329186,4) | A(6,466939766, 5) | 1 |  |  | 1 |  |  |  |
| 6,466939766 | H(8,146722968,2) DB(7,723892107,3) DN(9,779329186,4) DN(15,025230906,5) A(9,000690326,6) | DB(7,723892107,3) | 2 |  |  | 1 |  |  |  |
| 7,723892107 | H(8,146722968,2) DN(9,779329186,4) DN(15,025230906,5) A(9,000690326,6) | H(8,146722968,2) | 2 |  |  | 0 |  |  | 1 |
| 8,146722968 | DN(9,779329186,4) DN(15,025230906,5) A(9,000690326,6) | A(9,000690326,6) | 2 |  |  | 0 |  |  | 1 |
| 9,000690326 | DN(9,779329186,4) DN(15,025230906,5) A(9,319872364,7) DN(11,223645366,6) | A(9,319872364,7) | 3 |  |  | 0 |  |  |  |
| 9,319872364 | DN(9,779329186,4) DN(15,025230906,5) DN(11,223645366,6) A(10,421718084,8) DN(9,572673989,7) | DN(9,572673989,7) | 4 |  |  | 0 |  |  |  |
| 9,572673989 | DN(9,779329186,4) DN(15,025230906,5) DN(11,223645366,6) A(10,421718084,8) H(9,614286325,7) | H(9,614286325,7) | 3 |  |  | 0 | 0,041612336 |  |  |
| 9,614286325 | DN(9,779329186,4) DN(15,025230906,5) DN(11,223645366,6) A(10,421718084,8) | DN(9,779329186,4) | 3 |  |  | 0 |  |  | 1 |
| 9,779329186 | DN(15,025230906,5) DN(11,223645366,6) A(10,421718084,8) DB(17,811477296,4) | A(10,421718084,8) | 2 |  |  | 1 |  | 8,032148110 |  |
| 10,421718084 | DN(15,025230906,5) DN(11,223645366,6) DB(17,811477296,4) A(11,007007558, 9) DN(10,962647115,8) | DN(10,962647115,8) | 3 |  |  | 1 |  |  |  |
| 10,962647115 | DN(15,025230906,5) DN(11,223645366,6) DB(17,811477296,4) A(11,007007558, 9) DB(15,113987285,8) | A(11,007007558, 9) | 2 |  |  | 2 |  | 4,151340170 |  |
| 11,007007558 | DN(15,025230906,5) DN(11,223645366,6) DB(17,811477296,4) DB(15,113987285,8) A(11,235087832,10) DN(11,905872800,9) | DN(11,223645366,6) | 3 |  |  | 2 |  |  |  |
| 11,223645366 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) A(11,235087832,10) DN(11,905872800,9) DB(13,219248576,6) | A(11,235087832,10) | 2 |  |  | 3 |  | 1,995603210 |  |
| 11,235087832 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DN(11,905872800,9) DB(13,219248576,6) A(11,317734035,11) DN(20,243361952,10) | A(11,317734035,11) | 3 |  |  | 3 |  |  |  |
| 11,317734035 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DN(11,905872800,9) DB(13,219248576,6) DN(20,243361952,10) A(12,070490367,12) DN(12,583229095,11) | DN(11,905872800,9) | 4 |  |  | 3 |  |  |  |
| 11,905872800 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) A(12,070490367,12) DN(12,583229095,11) DB(18,422997870,9) | A(12,070490367,12) | 3 |  |  | 4 |  | 6,517125070 |  |
| 12,070490367 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) DN(12,583229095,11) DB(18,422997870,9) A(12,453305328,13) DN(12,633479787,12) | A(12,453305328,13) | 4 |  |  | 4 |  |  |  |
| 12,453305328 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) DN(12,583229095,11) DB(18,422997870,9) DN(12,633479787,12) A(13,262114082,14) | DN(12,583229095,11) | 4 | 1(id=13) |  | 4 |  |  |  |
| 12,583229095 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) DB(18,422997870,9) DN(12,633479787,12) A(13,262114082,14) DB(17,347394895,11) DN(14,301037745,13) | DN(12,633479787,12) | 4 | 0 | 0,129923767 | 5 |  | 4,764165800 |  |
| 12,633479787 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) DB(18,422997870,9) A(13,262114082,14) DB(17,347394895,11) DN(14,301037745,13) H(12,649298359,12) | H(12,649298359,12) | 3 |  |  | 5 | 0,015818572 |  |  |
| 12,649298359 | DN(15,025230906,5) DB(17,811477296,4) DB(15,113987285,8) DB(13,219248576,6) DN(20,243361952,10) DB(18,422997870,9) A(13,262114082,14) DB(17,347394895,11) DN(14,301037745,13) | DB(13,219248576,6) | 3 |  |  | 5 |  |  | 1 |

* At simulation time 12,649298359, fifth patient is healed and next event will be departure of the patient with id 6 from the hospital.
* Until the first 5 patients are healed, 14 patients enter the system.
* There is just one patient entered the waiting queue that takes 0,129923767 because all the nurses are busy at that time.
* Decision of triage is determined according to the conditions generated from random numbers. Future event list is formed according to that decision. If the patient goes to home for healing, H event will be generated. If the patient occupies a bed for healing at the hospital, DB (Departure from bed) event will be generated at the future event list.
* Next event is determined by taking the event having the closest time to the simulation time in the future event list.
* When A event comes true, total number of busy nurses is increased while coming true of DN event decreases it. Also, coming true of DN event triggers the coming of H event or DB event according to the condition of patient. DB event affects the total number of occupied beds. The coming true of both DB and H events increases the total number of healed patients.

**PART 2.2 - Model responses**

**Number of healed patients=20**

* Empty system

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,865408522188604 | 0,5043569730605689 | 0,16666666666666666 | 0,7597038162410228 | 4,2784810126582276 | 0,2 | 4,932192702415073 |

* Half of the nurses and half of the beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,9479639061477668 | 0,5300141367284166 | 0,20689655172413793 | 0,7228770990361053 | 4,298507462686567 | 0,20689655172413793 | 5,718208767669718 |

* All nurses and beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,9161301612671764 | 0,0809831914631936 | 0,23333333333333334 | 0,8525000325142478 | 4,967213114754099 | 0,20689655172413793 | 5,839655416845072 |

**Number of healed patients =200**

* Empty system

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,9285912984615564 | 0,27102263195489507 | 0,08450704225352113 | 0,8232749860898935 | 3,9551282051282053 | 0,323943661971831 | 5,839000558137688 |

* Half of the nurses and half of the beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,9173162948730008 | 0,3112214240618227 | 0,09004739336492891 | 0,8182484342316042 | 3,9541734860883797 | 0,33175355450236965 | 5,828091888116171 |

* All nurses and beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,9253864103720658 | 0,25896007442566027 | 0,09905660377358491 | 0,8185699086718599 | 3,927392739273927 | 0,32547169811320753 | 5,820481613810681 |

**Number of healed patients =1000**

* Empty system

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,8992400792143742 | 0,3119867037453868 | 0,1256133464180569 | 0,8147485409183625 | 3,956076618229855 | 0,36113837095191365 | 6,391893947468907 |

* Half of the nurses and half of the beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,8954900539901616 | 0,3118243824224693 | 0,11655239960822723 | 0,814711776985856 | 3,988418266048974 | 0,34965719882468166 | 6,302485539618888 |

* All nurses and beds full

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long run marginal probability of being empty for triage or for the beds | The joint probability of both being empty | Average number of people rejected by bed area | Average utilization of each triage nurse | Average number of occupied beds in the hospital | Average number of patients that are treated at home | Average time a sick person gets better |
| 0,8871510925039995 | 0,2941879082680601 | 0,11655239960822723 | 0,8155448034700776 | 4,00132625994695 | 0,3476983349657199 | 6,29272946881923 |

**Comments**