MARMARA UNIVERSITY
FACULTY OF ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

IE3081 MODELING AND DISCRETE SIMULATION
PROJECT

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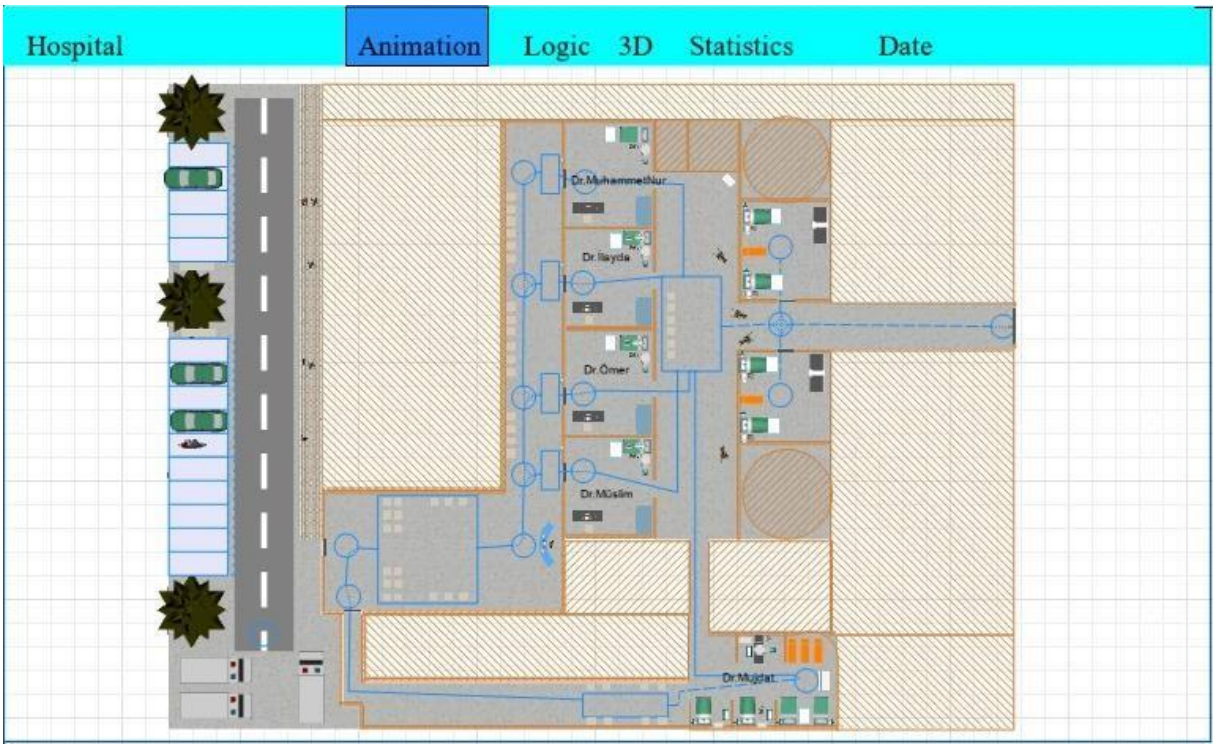
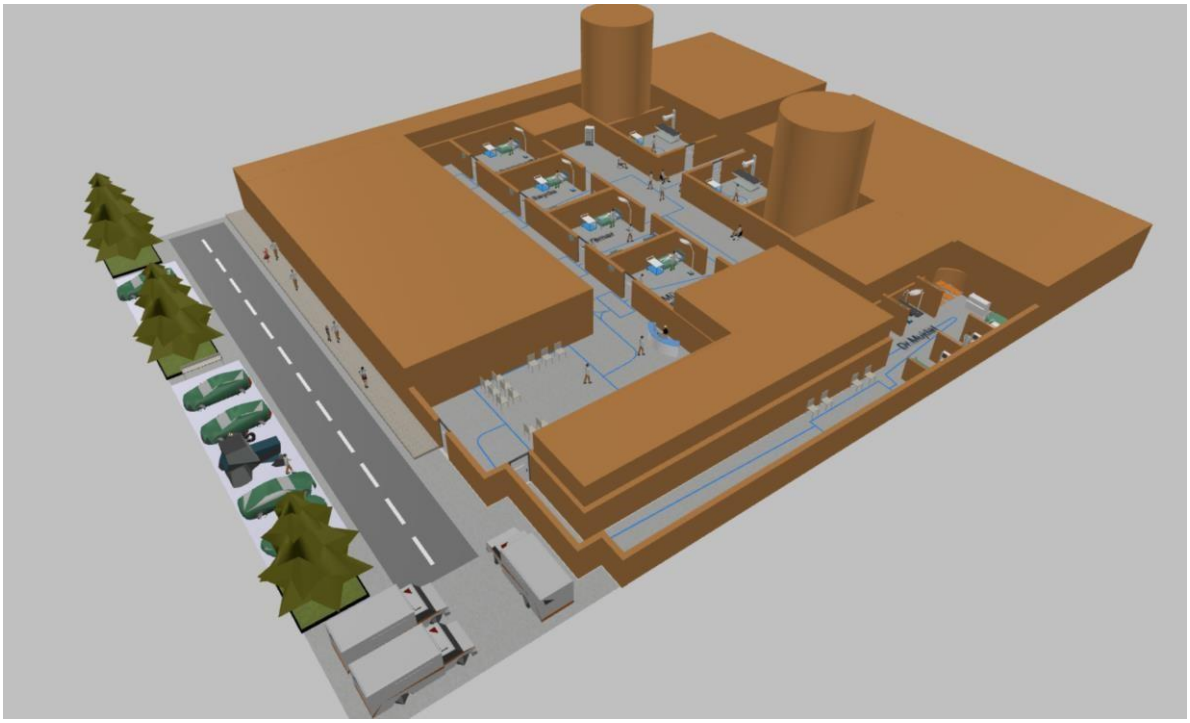
System Definition

We built a simulation to simulate a small hospital. In the hospital there are doctors, and each doctor has its own branch. Also, there are nurses who are responsible for some operations like injection, measuring blood pressure etc. Patients will arrive to the system and according to their disease they will be directed to convenient doctor. Doctors will inspect the patient. Doctors may direct patients to the nurses for some operations like injection. Patients will go the nurses if they are required to. Then patients will leave the system. Also, in the simulation there will be emergency patients and they will immediately direct to emergency doctor. Emergency patients will have priority when they are waiting in the nurse queue.

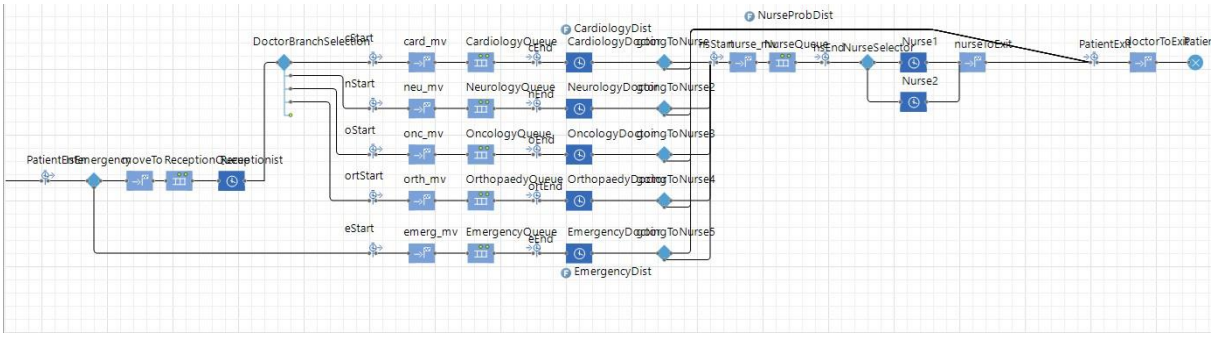
2D View of the Model



3D View of the Model



Logic



System Components

PatientIn: It is a source where patients arrive to the hospital.

IsEmergency: It is a selector component. Some proportion of the incoming patients will be emergency patient.

Receptionist: A delay component to simulate patient registration procedures. Patients may need to wait in the queue.

DoctorBranchSelection : It is a selector component. Patients will go to the different branches according to their disease.

CardiologyDoctor: A delay component to simulate cardiology doctor inspection.

NeurologyDoctor: A delay component to simulate neurology doctor inspection.

OncologyDoctor: A delay component to simulate oncology doctor inspection.

OrthopaedyDoctor: A delay component to simulate orthopaedy doctor inspection.

EmergencyDoctor: A delay component to simulate emergency doctor inspection.

g**oingToNurse components:** It is a selector component. Doctors will direct some of patients to the nurse.

Nurse : Delay components to simulate service of the nurses.

PatientOut: It is a sink where patients leave the hospital.

MoveTo components : It is direct to the patient according to the arrival location.

Generation of Random Variates

In the simulation all random numbers are generated by Anylogic's default random number generator and java.util.Random class of java. These random number generators are trusted to have uniform distribution and no correlation among the generated random numbers.

Input Variables

- **Number of patients arriving to the hospital**: We will run the model for 250 patients.

- **Proportion of emergency patients**: 20% of the patients will be emergency patients.

- **Doctor branch selection**: 24% of the patients will go the cardiology doctor. 23% of the patients will go the neurology doctor. 25% of the patients will go the oncology doctor. 28% of the patients will go the orthopedic doctor.

- **Rate of Going Nurse**: 50% of patients of cardiology doctor will go the nurse. 40% of patients of neurology doctor will go the nurse. 30% of patients of oncology and orthopedic doctor will go the nurse. 20% of patients of emergency doctor will go the nurse.

- **Interarrival times of patients**: Patients interarrival times are uniformly distributed between 1 and 2 minutes.

Service Times

- **Receptionist Service Time:** Uniformly distributed between 1 and 2 minutes.

- **Cardiology doctor's inspection time probability distribution**:

Service Time (Minutes)	Probability	Cumulative Probability
4	0.40	0.40
5	0.40	0.80
6	0.20	1.00

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- **Emergency doctor's inspection time probability distribution**:

Service Time (Minutes)	Probability	Cumulative Probability
5	0.60	0.60
6	0.20	0.80
8	0.20	1.00

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- **Neurology doctor's inspection time** is uniformly distributed between 2 and 5 minutes.

- **Oncology doctor's inspection time** is uniformly distributed between 4 and 6 minutes.

- **Orthopaedical doctor's inspection** time is uniformly distributed between 3 and 6 minutes.

- **Service time of nurses**:

Service Time (Minutes)	Probability	Cumulative Probability

4	0.30	0.30
5	0.10	0.40
6	0.25	0.65
7	0.35	1.00

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Output Variables

- Average time spent by a patient in the hospital
- Average queue waiting times for each doctor
- Utilization of each doctor
- Utilization of nurses
- Utilization of receptionist

Output Values and Responses

We have collected these data from database after model run.

- **Queue Waiting Times for Each Doctor:**

Doctor Type	Average Queue Waiting Time (minutes)
Cardiology Doctor	3.4
Neurology Doctor	2.3
Oncology Doctor	17.6
Orthopaedical Doctor	13.8
Emergency Doctor	9.3

- **Utilization of Doctors:**

Doctor Type	Utilization %
Cardiology Doctor	63.5
Neurology Doctor	47.7
Oncology Doctor	91.0
Orthopedic Doctor	70.6
Emergency Doctor	58.8

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Queue Waiting Time for Nurses:

Nurses	Average Queue Waiting Time (minutes)
Nurse 1 – Nurse 2	5.5

Utilization of Nurses:

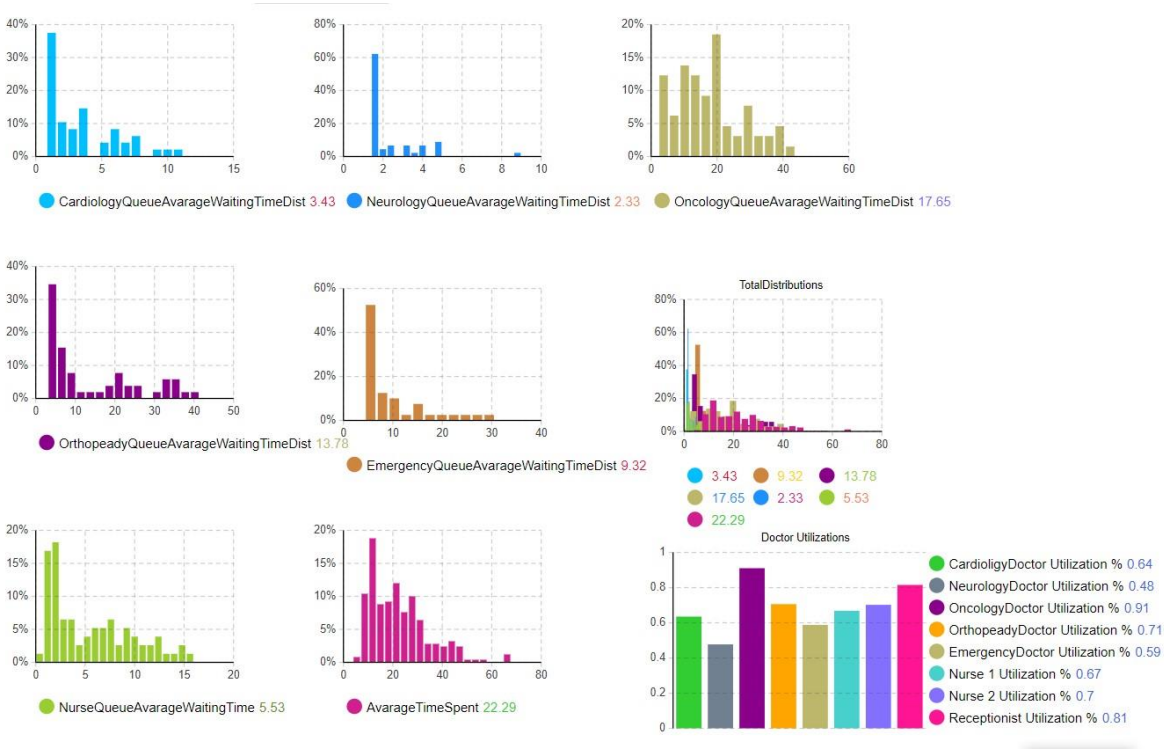
Nurse	Utilization %
Nurse 1	66.8
Nurse 2	70.2

Utilization of Receptionist:

Receptionist	Utilization %
Receptionist	81.5

- **Average Time Spent by a Patient:** It is measured as **22.3** minutes.

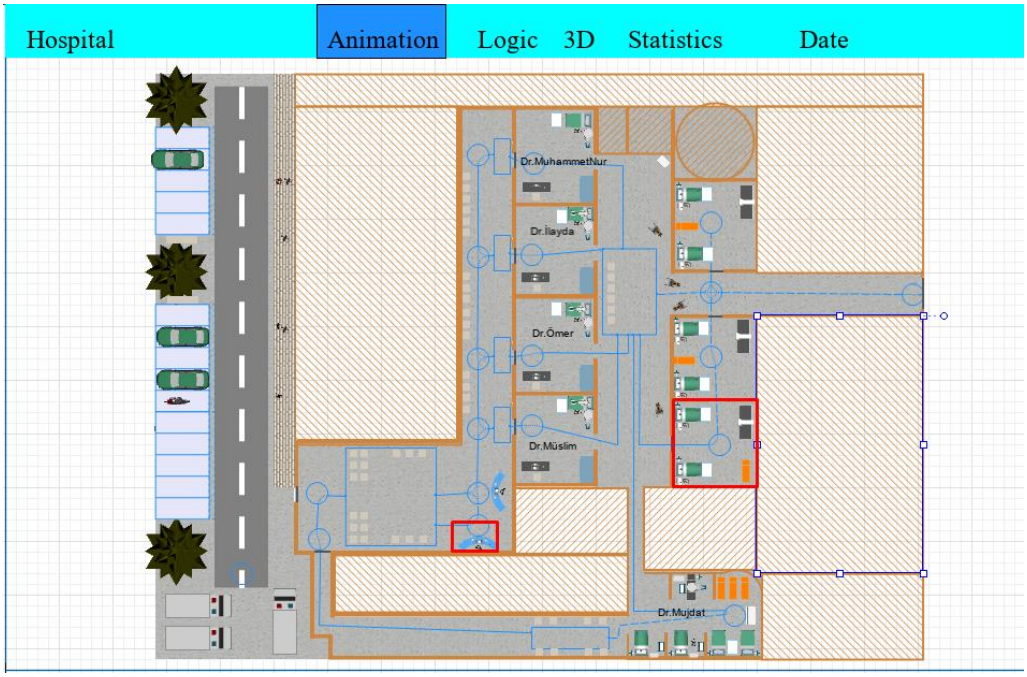
Graphics of Statistics:



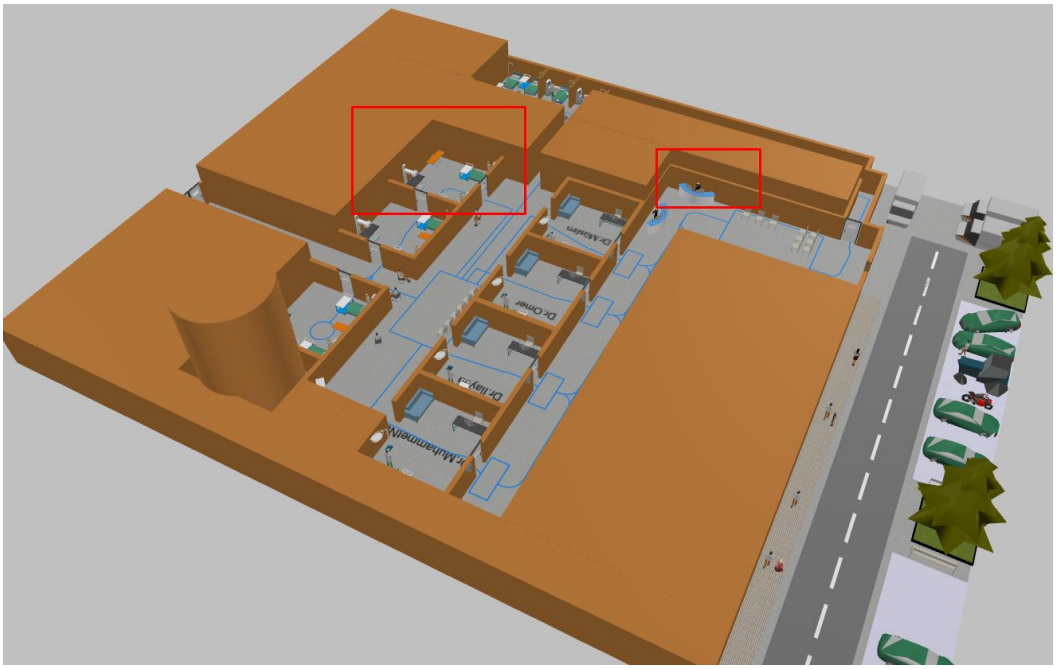
ALTERNATIVE DESIGN PART II

The nurse and reception departments have been updated. Since a lot of queues occurred in the first simulation and in order to assign patients to doctors more regularly, we organized **the nurse and reception.**

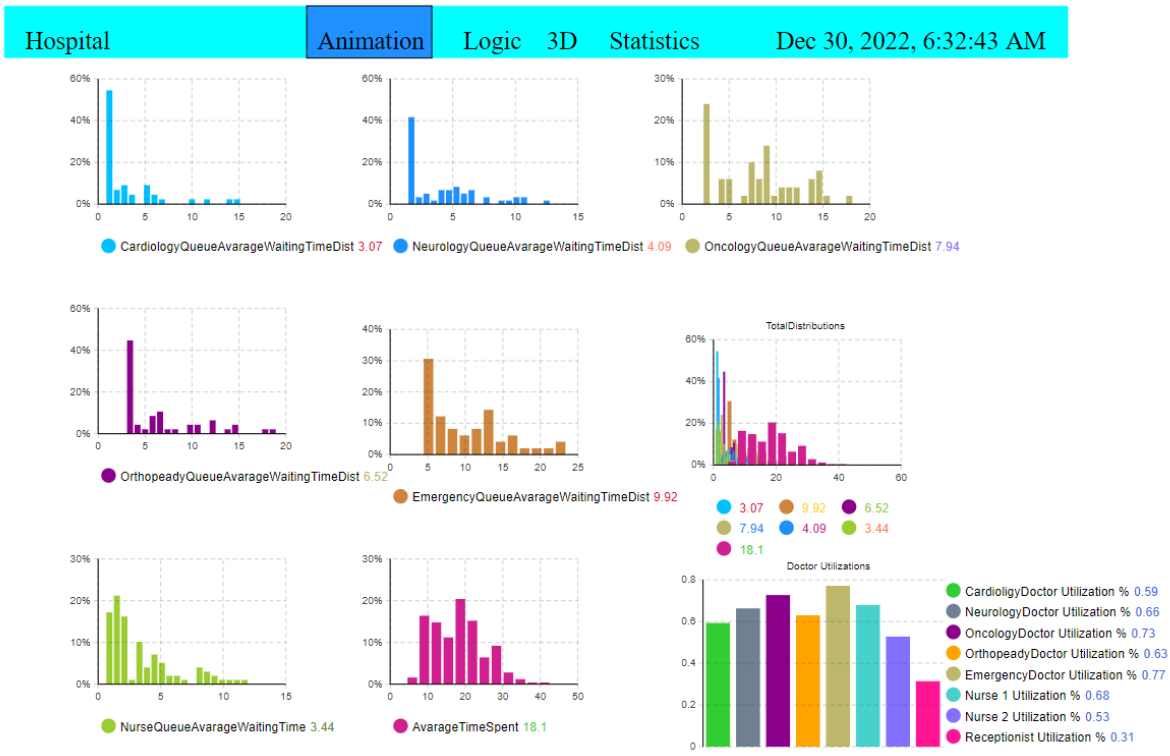
ALTERNATIVE DESIGN 2-D VIEW



ALTERNATIVE DESIGN 3-D VIEW



Graphs of statistics that change according to the updated departments



Outputs and the values of First System

Seeds	Avarage Time Spent By Patient	Avarage Nurse Waiting Time
100	20,083	3,547
200	20,073	5,955
300	20,126	5,817
400	21,584	8,23
500	18,635	6,175
600	20,434	4,332
700	19,998	4,962
800	19,201	4,561
900	20,147	6,085
1000	20,315	7,13
1100	16,354	4,048
1200	22,093	3,934
1300	23,779	12,175
1400	18,424	6,076
1500	20,935	9,334
1600	19,562	4,435
1700	17,048	3,318
1800	18,318	3,074
1900	18,959	3,844
2000	20,97	4,395
Mean	**19,851**	**5,571**
Variance	**2,699**	**4,868**

Outputs and the values of Alternative System

Seeds	Avarage Time Spent By Patient	Avarage Nurse Waiting Time
100	17.559	2,031
200	19.614	2,136
300	17.711	2,197
400	17.135	1,992
500	19.072	2,253
600	21.386	2,142
700	20.001	2,428
800	16.183	2,507
900	17.472	2,787
1000	17.621	2,035
1100	19.034	2,089
1200	15.877	1,913
1300	19.148	2,549
1400	18.498	2,285
1500	17.717	3,012
1600	16.394	1,949
1700	17.659	2,489
1800	17.457	2,346
1900	17.110	2,101
2000	15.429	2,025
Mean	**17,904**	**2,263**
Variance	**2,070**	**0,080**

Avarage Patient Exit Time Comparison

Replication	First System	Alternative System	Observed Difference
1	20,083	17,559	2,524
2	20,073	19,614	0,459
3	20,126	17,711	2,415
4	21,584	17,135	4,449
5	18,635	19,072	-0,437
6	20,434	21,386	-0,952
7	19,998	20,001	-0,003
8	19,201	16,183	3,018
9	20,147	17,472	2,675
10	20,315	17,621	2,694
11	16,354	19,034	-2,68
12	22,093	15,877	6,216
13	23,779	19,148	4,631
14	18,424	18,498	-0,074
15	20,935	17,717	3,218
16	19,562	16,394	3,168
17	17,048	17,659	-0,611
18	18,318	17,457	0,861
19	18,959	17,11	1,849
20	20,97	15,429	5,541
Sample Mean	19,851	17,903	1,948
Sample Variance	2,699	2,070	5,191

Confidence Interval Calculation For 95% Confidence Level (Unequal Variances)

Estimator : **1.948** from the table

$$s.e.\left(\bar{Y}_{.1}-\bar{Y}_{.2}\right)=\sqrt{\frac{S_1^2}{R_1}+\frac{S_2^2}{R_2}}$$

Standard Error is calculated as **0.488** using formula above.

$$\upsilon=\frac{\left(S_1^2/R_1+S_2^2/R_2\right)^2}{\left[\left(S_1^2/R_1\right)^2/(R_1-1)\right]+\left[\left(S_2^2/R_2\right)^2/(R_2-1)\right]},$$

Degrees of Freedom is calculates as **36** using formula above

For a = 0.05

$t_{a/2,36}$ = 2.028 is found using T-table

$$\bar{Y}_{.1}-\bar{Y}_{.2}\pm t_{\alpha/2,\upsilon}s.e.(\bar{Y}_{.1}-\bar{Y}_{.2})$$

C.I found as **(-0.958,2.937)** using formula above.

Inference

Confidence interval includes 0 so there is no strong statistical evidence that alternative system is better than first system.

Average Nurse Waiting Time Comparison

Replication	System 1	System 2	Observed Difference
1	3.547	2.031	1.516
2	5.955	2.136	3.819
3	5.817	2.197	3.62
4	8.23	1.992	6.238
5	6.175	2.253	3.922
6	4.332	2.142	2.19
7	4.962	2.428	2.534
8	4.561	2.507	2.054
9	6.085	2.787	3.298
10	7.13	2.035	5.095
11	4.048	2.089	1.959
12	3.934	1.913	2.021
13	12.175	2.549	9.626
14	6.076	2.285	3.791
15	9.334	3.012	6.322
16	4.435	1.949	2.486
17	3.318	2.489	0.829
18	3.074	2.346	0.728
19	3.844	2.101	1.743
20	4.395	2.025	2.37
Sample Mean	5.57135	2.2633	3.30805
Sample Variance	4.867737	0.080566	4.433199148

Confidence Interval Calculation For 95% Confidence Level (Unequal Variances)

Estimator : 3.308

Standard Error is calculated as **1.089**

Degrees of Freedom is **19**

$t_{a/2,19}$ 2.093 is found using T-table

C.I found as **(-1.029,5.587)** using formula above.

Inference

Confidence interval includes 0 so there is no strong statistical evidence that alternative system is better than first system.