Concordia Institute for Information System Engineering (CIISE)

Concordia University

INSE 691 – TOPICS IN INFORMATION SYSTEMS

Assignment -1:

Submitted to:

Professor Anjali Awasthi

Submitted By:

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Faculty of Engineering and Computer Science
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2. Direct quotations must not exceed 5% of the content of a report, must be enclosed in quotation marks, and must be attributed to the source by a numerical reference citation[1]. Note that engineering reports rarely contain direct quotations.
3. Material paraphrased or taken from a source must be attributed to the source by a numerical reference citation.
4. Text that is inserted from a web site must be enclosed in quotation marks and attributed to the web site by numerical reference citation.
5. Drawings, diagrams, photos, maps or other visual material taken from a source must be attributed to that source by a numerical reference citation.
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8. Your submissions must consist entirely of your own or your group's ideas, observations, calculations, information and conclusions, except for statements attributed to sources by numerical citation.
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I certify that I have read the requirements set out on this form, and that I am aware of these requirements. I certify that all the work I will submit for this course will comply with these requirements and with additional requirements stated in the course outline.

Course Number:	Inse 691	Instructor:	Dr Anjali Awasthi
Name:		I.D. #	
Signature:		Date:	

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.
Approved by the ENCS Faculty Council February 10, 2012

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(Question 1)

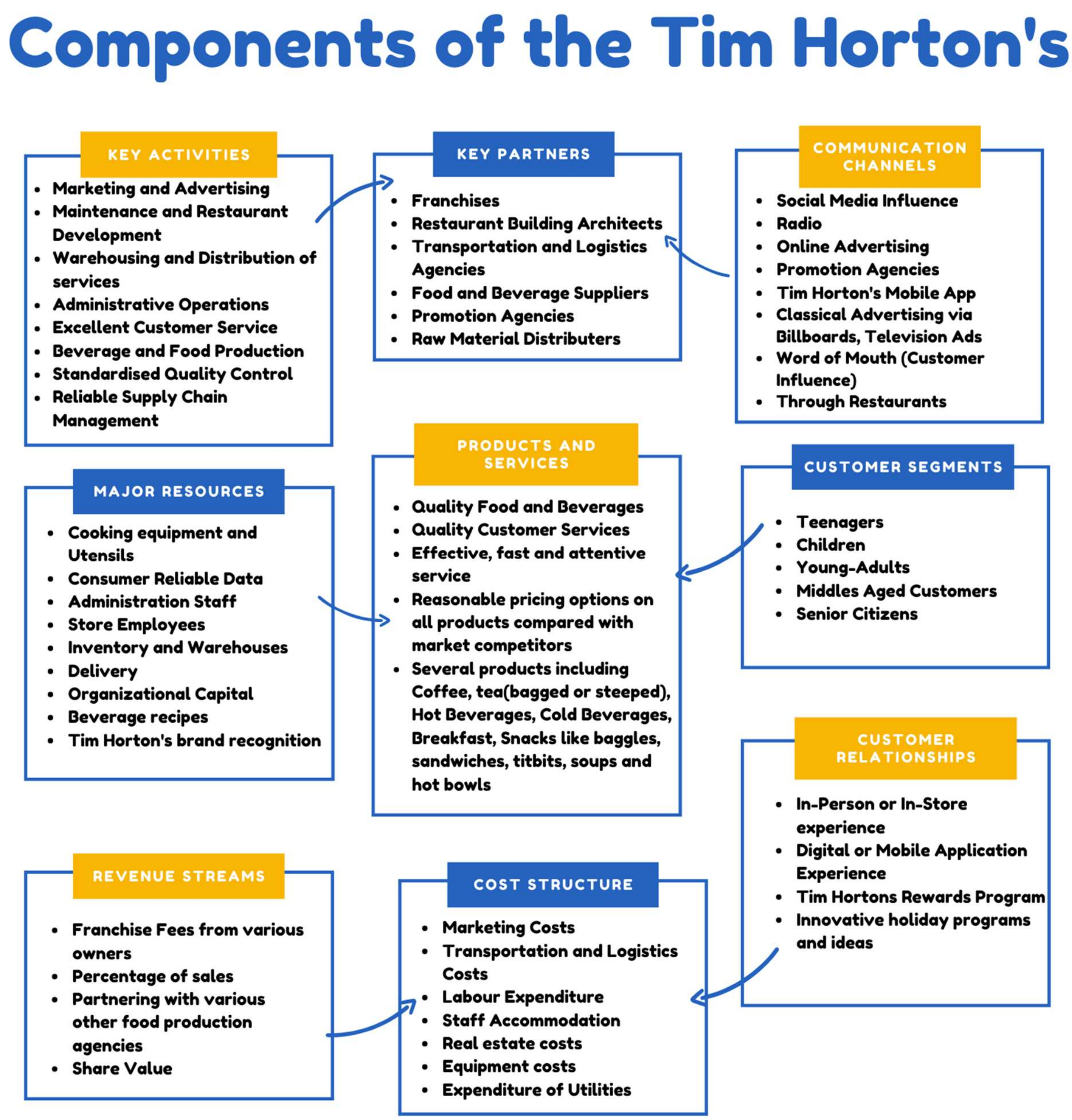
System: Tim Horton's Restaurant

The Tim Hortons chain was founded in 1964 in Hamilton, Ontario. The chain's focus on top quality, always fresh product, value, great service and community leadership has allowed it to grow into the largest quick service restaurant chain in Canada specializing in always fresh coffee, baked goods and homestyle lunches. The chain's biggest draw remains its legendary Tim Hortons coffee.

Components of Tim Horton's:

80% of the behaviour can be explained by the action of 20% of the components (Pareto's rule).

We have divided the Tim Horton's components in such a way that it covers all of its operational and sustainable business plan.



<u>Classifying the Tim Horton's system into:</u>

- **Deterministic vs Stochastic**:
  Deterministic: Those are the systems without random variables.
  Stochastic: These are the systems with random variables.
  So, based on the above definition when determining our Tim Horton's system with these models, it falls under Stochastic system as we are in with the alignment of randomness in our system. To be precise, Tim Horton's deals with irregular intervals as it entirely depends on random customer nature, and it will vary from time to time in the wait time.

- **Discrete vs Continuous**:
  Discrete: As per this system, the variables or state variables change only at a discrete set of points in time.
  Continuous: A continuous system is the one where the state variables change continuously over the time.
  So, based on the above definitions, our Tim Horton's system falls under Discrete Systems because of the fixed set of state changes in our model. Restaurant operational hours are at fixed at certain variables where it will be followed through the franchise chains. When it come to continuous, our system does not abide with those continuous state variable changes.

- **Discrete vs Continuous**:
  Static: This is a specific system where the state of the system remains static or constant over the time.
  Dynamic: This system evolves over the time and it not constant. It entirely depends on the user inputs and parameters.
  So, based on the above definitions, our Tim Horton's system falls under Dynamic Systems as we face dynamic requirements and it's not constant as the predictability of the customers, the wait time and delivery time is not constant, and it changes with the input parameters.

<u>Suitability of different types of simulation models for Tim Horton's:</u>

Based on the above explanation while determining the classification of our system in different systems available. We can use different simulation models as per its classification.

For Example, when we consider the **Dynamic System Classification** of Tim Horton's we know that this system has dynamic state changes which means it is not constant or fixed. In this case, we can opt for System Dynamics Simulation which has high abstraction level (minimum number of details, macro level and strategic level). This will allow modelling of system elements and their interactions including feedbacks. Stock flow or Casual Loop diagrams will give us a better understanding and working of this model.

Now, when you look at **Discrete System Classification** of our system, its state changes occur in fixed set of stages because of the operational hours. In this case, we can opt for Discrete Event Simulation which has the low to medium abstraction level (maximum details, micro levels, operational levels).

Now, when we focus on **Stochastic System Classification,** here because of the randomness in customer's wait time Monte Carlo Simulation suits best for this mode. This simulation model allows the modelling of the Tim Horton system's uncertainty.

<u>**Different Steps to build a Simulation Model for Tim Horton's**</u>:

- **Problem Definition**: Improving the Tim Horton's brand value and cast of the competitors by improving the overall services of the system and reducing the wait time of the customer.
- **Project Planning** – Improving and adapting to the technological advancements to make it more customer friendly (personnel, management support, hardware, software etc) are available to do improve the state variables.
- **System Definition** – We are bounded with randomness as the system is stochastic based. We know that the system input is customer in-time and output is customer out-time. So, it is obvious that change in input or irregular values will lead to irregular or random output as customer out-time. We can design a whole different system with online orders or digital model of the system. But, for now we are not considering any other values.
- **Conceptual Model Formulation** – We will create a model that all the variables and various components with system level indications are designed with charts or stock flows.
- **Preliminary Experimental Design** – We will use the present case scenario of existing parameters and information such as customer in-time(input), out-time(output) and customer wait time. Then, we can use the developed data sets to train and model the required simulation based on our target expectations.
- **Input Data preparation** – Input data is crucial for any kind of model building. So, outmost importance will be allotted into this fixture. We can Collect the data on daily-basis reports, system logs and other ways of logging and then model the system to reach the target expectation
- **Verification and Validation** – With out the verification and validation, no built model reaches the target expectations as we need to train the model and make it perform up to the target expectations.
- **Final Experimental Design and Experimentation** – Main task is to run the model perform various tasks and test cases to determine the performance and metrics to the expected model.
- **Analysis and Interpretation** – Focus on the output data achieved from the model and make a comparison on achieved and expected data from the simulated model. This will help us in achieving the desired expectations.
- **Implementation and Documentation** – Implementation is the key as all the built-in models after successful test cases and detailed validation, we need to implement the model and record the output and expected parameters for future reference. With the implementation, we need a proper flow of documentation such that it can be archived in the future further improvements and extensions.

(Question 2)

Let us consider the given conditions.

Average rate of arrival of patients(λ) = 12 patients/hour

Average rate that a doctor can server(μ) = 15 patients/hour (Average rate is given in minutes, we converted into hours)

Average number of customers in the waiting line(L_q):

$$L_q = \frac{\lambda^2}{\mu(u-\lambda)}$$

$$L_q = \frac{(12)^2}{15(15-12)}$$

$$L_q = \frac{144}{45}$$

$$\boxed{L_q = 3.2}$$

Average number of patients in clinic(L_S):

$$L_S = \frac{\lambda}{\mu-\lambda}$$

$$L_s = \frac{12}{3}$$

$$\boxed{L_s = 4}$$

Average waiting time in the waiting line(W_q):

$$W_q = \frac{L_q}{\lambda}$$

$$W_q = \frac{3.2}{12}$$

$$W_q = 0.266\ Hours$$

$$\boxed{w_q = 16\ minutes}$$

Average waiting time in the clinic(W_S):

$$W_s = \frac{L_s}{\lambda}$$

$$W_s = \frac{4}{12}$$

$$W_s = \frac{1}{3} hours$$

$$\boxed{W_s = 20\ minutes}$$

(Question 3)

As per the given information, the poison distribution with mean rate of arrival (λ) = 10 per hour

Serving rate is μ= 1 and customer in every 5 minutes = 12 per hour

(a) Probability that an customer will arrive one of three spaces in front of the window

$P(N<3) = P(N=0) + P(N=1) + P(N=2)$

we know $P(N=n) = \rho^{n} * (1-\rho)$,

where ρ is utilization rate = λ / μ

$\rho = 10/12$

$\rho = 0.83$

Finally, the probability that an customer will arrive one of the three spaces in front of the window is

$P(N<3) = \{\rho^0 * (1-\rho)\} + \{\rho^1 * (1-\rho)\} + \{\rho^2 * (1-\rho)\}$

$$\boxed{P(N<3) = 0.42}$$

(b) Probability that an arriving customer will wait outside the three spaces is

$P(N>= 3) = \rho^n = (0.833)^3$

$$\boxed{P(N>=3) = 0.57}$$

(c) probability that the arriving customer must wait is equal to utilization rate(ρ)

$$\boxed{\rho = 0.83}$$

(d) Expected waiting time for arrival customer before starting service(W_q)

$$W_q = \frac{\lambda}{\mu\,(\mu - \lambda)}$$

$$W_q = \frac{10}{12(12-10)}$$

$$\boxed{W_q = 24.9 \text{ min.}}$$

(e) It is known that $P(N=n) = \rho^n * (1-\rho)$

From the above one we can write the following

$$P(N>=3) = \rho^n$$

Hence, the number of car spaces is provided in front of window so that an arriving customer has chance to 40% of being able to in one of the provided spaces is given by $P(N>=n) = 40\% = \rho^n$

$$\rho^n = 0.40$$

$$\boxed{n = 5 \text{ spaces}}$$

(Question 4)

Given values are:

20% local

80% international

The Chi-square test statistic is given by:

$$\boxed{X^2 = \sum_{i=1}^{k} \frac{(o_i - E_i)^2}{E_i}}$$

Where, O_i is the observed value and, E_i is the expected value

$E_1 = 100 \times 0.20 = 20$

$E_2 = 100 \times 0.80 = 80$

$O_1 = 16$

$O_2 = 84$

$$X^2 = \left[\frac{(o_1 - E_1)^2}{E_1} + \frac{(o_2 - E_2)^2}{E_2}\right]$$

$$= \left[\frac{(16-20)^2}{20} + \frac{(84-80)^2}{80}\right]$$

$$= \frac{(-4)^2}{20} + \frac{(4)^2}{80}$$

$$= \frac{16}{20} + \frac{16}{80}$$

$$= 0.8 + 0.2$$

$X^2 = 1$

Using the chi-square table,

$P(X^2>1) = 0.317$

Since, P(0.371) > significant level α(0.05)

The null hypothesis is accepted.

(Question 5)

Consider the following Data

15, 10, 12, 12, 10, 8, 10, 11, 15

Apply for the following two techniques to determine if the data is normally distributed.

-K-S test

-Q-Q plot

Sol: -

Given: 15, 10, 12, 12, 10, 8, 10, 11, 15

N=10

I	1	2	3	4	5	6	7	8	9	10
F(Yi)	8	10	10	10	11	12	12	12	15	15
i/N	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
I/N – f(Yi)	-7.9	-9.8	-9.7	-9.6	- 10.5	- 11.4	- 11.3	- 11.2	- 14.1	-14
(i-1)/N	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
F(Yi)- [(i-1)/N]	8	9.9	9.8	9.7	10.6	11.5	11.4	11.3	14.2	14.1

$$D = \underset{1 \le X \le N}{Max}\left(F(Y_i) - \frac{i-1}{N}, \frac{i}{N} - F(Y_i)\right)$$

$$D = \underset{1 \le X \le N}{Max}(-7.9\,, 14.1)$$

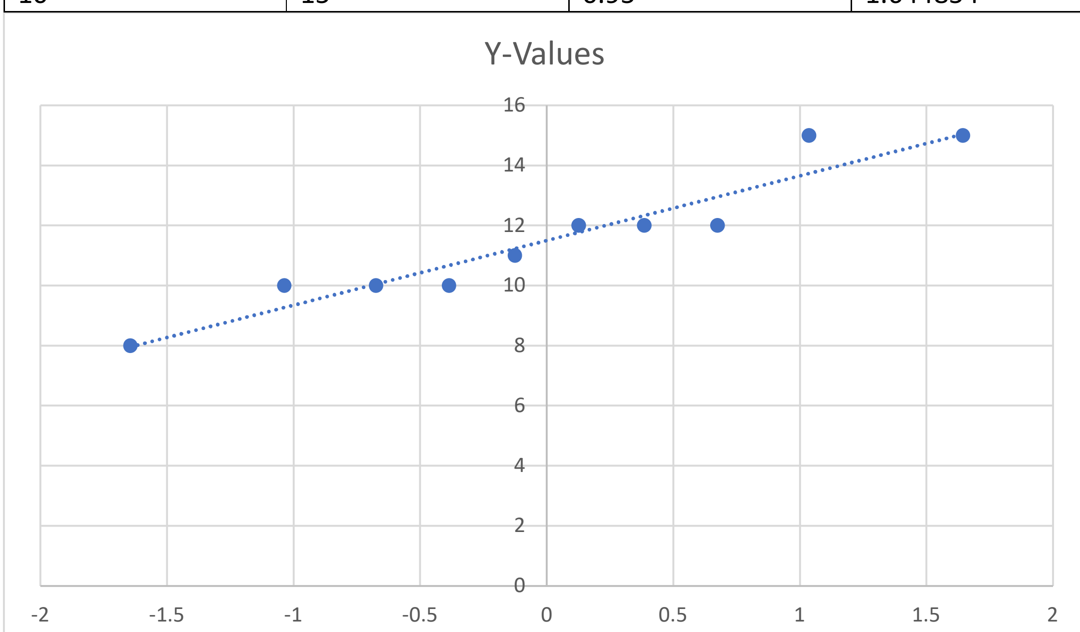
D =14.1

Default value of D(alpha) =0.565

D>D(alpha), Reject null hypothesis

Q-Q Plot

I	X	P_i= (i-0.5)/N	Z score
1	8	0.05	-1.64485
2	10	0.15	-1.03643
3	10	0.25	-0.67449
4	10	0.35	-0.38532
5	11	0.45	-0.12566
6	12	0.55	0.125661
7	12	0.65	0.38532
8	12	0.75	0.67449
9	15	0.85	1.036433
10	15	0.95	1.644854



(Question 6)

(a) Additive Congruential Generator

57, 34, 89, 92, 16

Let X_1=57, X_2=34, X_3=89, X_4=92, X_5=16

Formula: $X_i = (X_{i-1} + X_{i-n}) \bmod m$

calculating mod value:

Modulo Method

First need to divide the Dividend by the Divisor:

73/100 = 0.73

Next, we take the Whole part of the Quotient (0) and multiply that by the Divisor (100):

0 x 100 = 0

And finally, we take the answer in the second step and subtract it from the Dividend to get the answer to 73 mod 100:

73 - 0 = 73

As you can see, the answer to 73 mod 100 is 73.

$X_6 = (X_5 + X_1) \bmod 100 = 73 \bmod 100 = 73$

$X_7 = (X_6 + X_2) \bmod 100 = 107 \bmod 100 = 7$

$X_8 = (X_7 + X_3) \bmod 100 = 96 \bmod 100 = 96$

$X_9 = (X_8 + X_4) \bmod 100 = 88 \bmod 100 = 88$

$X_{10} = (X_9 + X_5) \bmod 100 = 104 \bmod 100 = 4$

$X_{11} = (X_{10} + X_6) \bmod 100 = 77 \bmod 100 = 77$

$X_{12} = (X_{11} + X_7) \bmod 100 = 84 \bmod 100 = 84$

$X_{13} = (X_{12} + X_8) \bmod 100 = 180 \bmod 100 = 80$

$X_{14} = (X_{13} + X_9) \bmod 100 = 168 \bmod 100 = 68$

$X_{15} = (X_{14} + X_{10}) \bmod 100 = 72 \bmod 100 = 72$

(b)Linear congruential Generator

$m=8$, $a=5$, $c=1$, $R_0=5$

Formula: $\mathbf{R_{I+1} = (aR_i + c) \bmod m}$

$\mathbf{V_i = R_I/m}$

$R_1 = (5R_0 + 1) \bmod 8 = 26 \bmod 8 = 2$

$V_1 = R_1/m = 2/8 = 0.25$

$R_2 = (5R_1 + 1) \bmod 8 = 11 \bmod 8 = 3$

$V_2 = R_2/m = 3/8 = 0.375$

$R_3 = (5R_2 + 1) \bmod 8 = 16 \bmod 8 = 0$

$V_3 = R_3/m = 0/8 = 0$

$R_4 = (5R_3 + 1) \bmod 8 = 1 \bmod 8 = 1$

$V_4 = R_4/m = 1/8 = 0.125$

$R_5 = (5R_4 + 1) \bmod 8 = 6 \bmod 8 = 6$

$V_5 = R_5/m = 6/8 = 0.75$

$R_6 = (5R_5 + 1) \bmod 8 = 31 \bmod 8 = 7$

$V_6 = R_6/m = 7/8 = 0.875$

$R_7 = (5R_6 + 1) \bmod 8 = 36 \bmod 8 = 4$

$V_7 = R_7/m = 4/8 = 0.5$

$R_8 = (5R_7 + 1) \bmod 8 = 21 \bmod 8 = 5$

$V_8 = R_8/m = 5/8 = 0.625$

$R_9 = (5R_8 + 1) \bmod 8 = 26 \bmod 8 = 2$

$V_9 = R_9/m = 2/8 = 0.25$

$R_{10} = (5R_9 + 1) \bmod 8 = 11 \bmod 8 = 3$

$V_{10} = R_{10}/m = 3/8 = 0.375$

$R_{11} = (5R_{10} + 1) \bmod 8 = 16 \bmod 8 = 0$

$V_{11} = R_{11}/m = 0/8 = 0$

$R_{12} = (5R_{11} + 1) \bmod 8 = 1 \bmod 8 = 1$

$V_{12} = R_{12}/m = 1/8 = 0.125$

$R_{13} = (5R_{12} + 1) \bmod 8 = 6 \bmod 8 = 6$

$V_{13} = R_{13}/m = 6/8 = 0.75$

$R_{14} = (5R_{13} + 1) \bmod 8 = 31 \bmod 8 = 7$

$V_{14} = R_{14}/m = 7/8 = 0.875$

$R_{15} = (5R_{14} + 1) \bmod 8 = 36 \bmod 8 = 4$

$V_{15} = R_{15}/m = 4/8 = 0.5$