Central Library

Group 7

July 7, 2023

1 Problem Statement

The system assigned to Group 7 is the Central Library, IIT Kharagpur. We will be studying the system as a discrete events system, identifying some of the problems in the existing model and suggesting possible solutions to them through discrete events simulation.

1.1 Library as a System

The central library can be viewed as a complex system comprising of many subsystems. Several subsystems that simultaneously work inside the central library are:

- Laptop Entry Register counter - All incoming and outgoing students carrying laptop need to mark their entry and exit respectively in this register
- Personal Book Entry Register counter - All students carrying personal text books need to make entry in this register
- Book Issue counter - Library books can be issued here for borrowing and using it outside library
- OPAC Access Machines - The location of the books on different shelves can be searched using OPAC software
- Xerox and Print Out counter - Photocopies of library books or prints related to academics can be obtained from here
- Digital Library - Those students who don't carry their laptops to the library may access the internet comfortably through the computers installed in the Digital Library
- Student Seating Area - Different sections and halls where students can sit and study or work

The entities in the subsystems identified above are the users of the library, mainly the students.This complex system can be defined through a number of subsystems, each having their own state variables.

1.2 Conceptual Model

For such a large system, conceptual models for different subsystems can be defined separately. Few example models are given below:

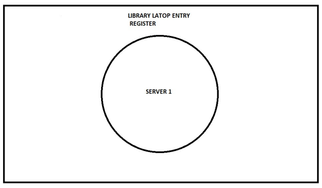


Figure 1: Laptop Entry Counter

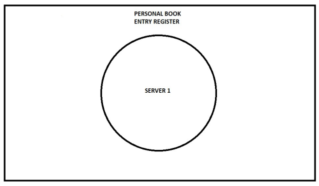


Figure 2: Personal Books Entry Counter

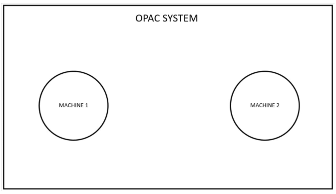


Figure 3: OPAC Access Machines

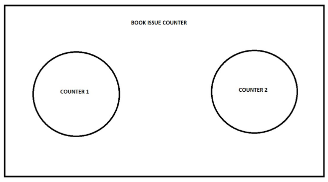


Figure 4: Book Issue Counter

1.3 Problems to solve using Discrete Events Simulation models

Scopes for improvement are identified in various subsystems of the large system of Central Library. Few of the problems that we have identified and aim to solve using discrete events simulation are:

1. Single register at the Laptop Entry and Personal Book Entry counters are inadequate, leading to long queues of students at peak hours.

2. Queue management at the book issue counter.

3. To find a book, people may have to wait due to inadequate number of the OPAC systems installed.

4. The number of computers installed in the Digital Knowledge Access Centre is insufficient compared to the number of students who need access to them simultaneously.

5. The cycle stand is highly inadequate to park huge number of cycles of the students during peak hours or exam days, when library usage is maximum.

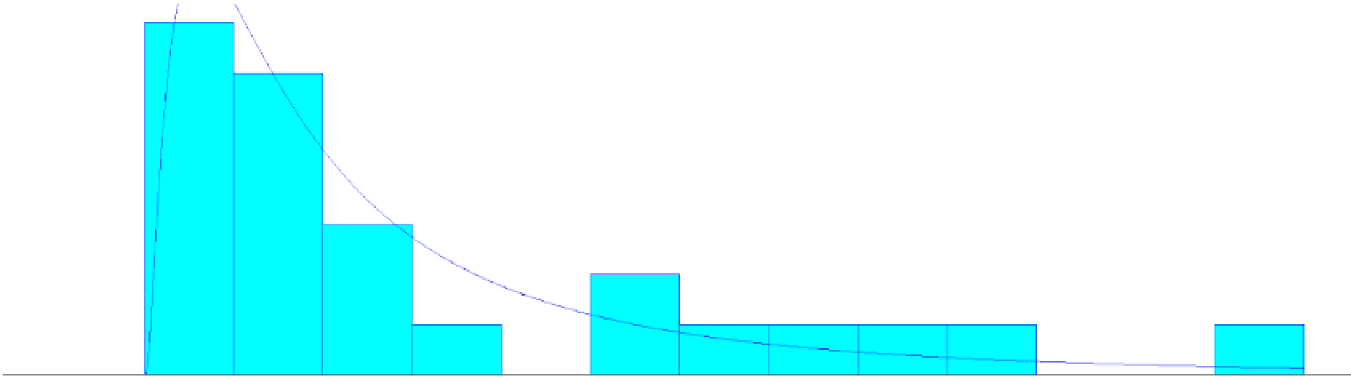
2 Data Collection

The data for inter arrival and service times were obtained through library entry registers and in-person analysis of various counters. The data thus obtained was analysed using

Arena Input Analyzer tool to get the best-fitting distribution expression based on least squared error. It was then tested for presence of auto correlation in the obtained data.

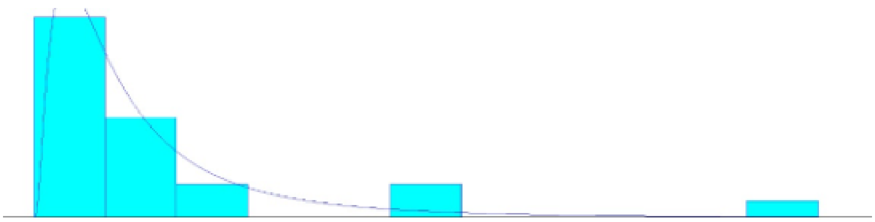
Once uniformity and the independence of data was confirmed through various tests, the distribution thus obtained was used to generate random variates for simulating the system.

2.1 Laptop and Book Entry Counter - Interarrival time (Weekday)



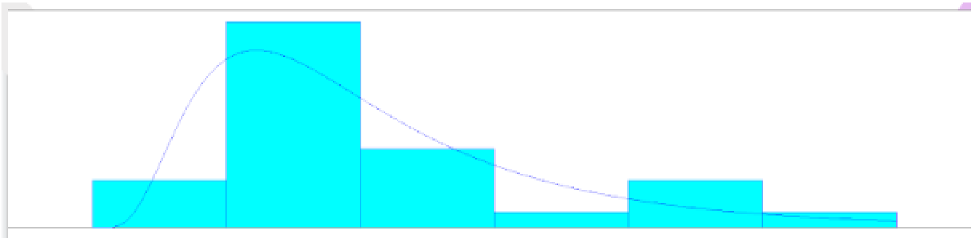
Distribution : Lognormal
Expression : -0.5 + LOGN(3.42,5)
Squared Error : 0.012341

2.2 Laptop and Book Entry Counter - Interarrival time (Weekend)



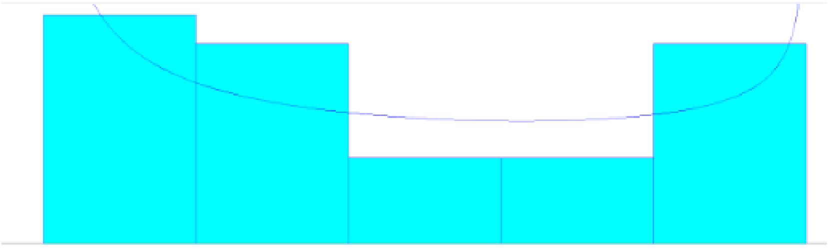
Distribution : Lognormal
Expression : -0.5 + LOGN(1.65,1.92)
Squared Error : 0.015052

2.3 Cycle Stand : Inter arrival Time (Weekday)



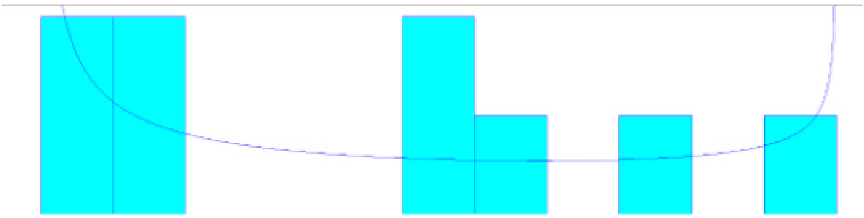
Distribution : Lognormal
Expression : -0.5 + LOGN(2.18,1.5)
Squared Error : 0.024773

2.4 Cycle Stand : Inter arrival Time (Weekend)



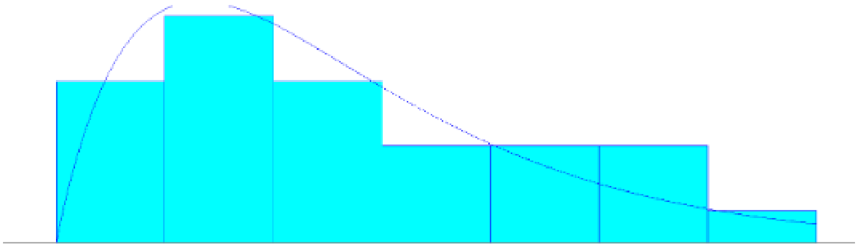
Distribution : Erlang
Expression : -0.5 + ERLA(0.436,3)
Squared Error : 0.001483

2.5 OPAC : Inter arrival Time



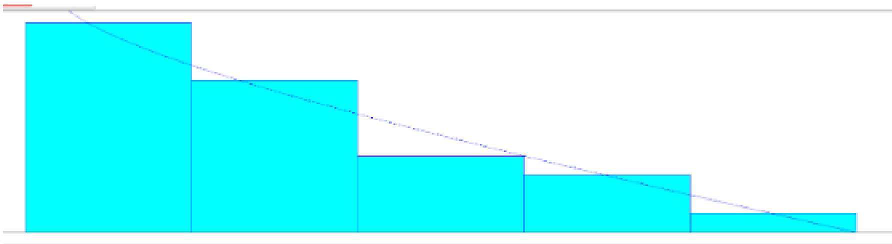
Distribution : Beta
Expression : -0.5 + 11*BETA(0.477,0.689)
Squared Error : 0.073976

2.6 Digital Knowledge Access Center : Inter arrival Time (Weekday)



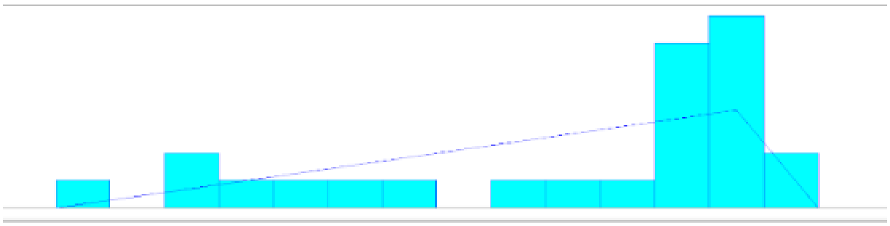
Distribution : Gamma
Expression : -0.5 + GAMM(1.37,1.96)
Squared Error : 0.006212

2.7 Digital Knowledge Access Center : Inter arrival Time (Weekend)



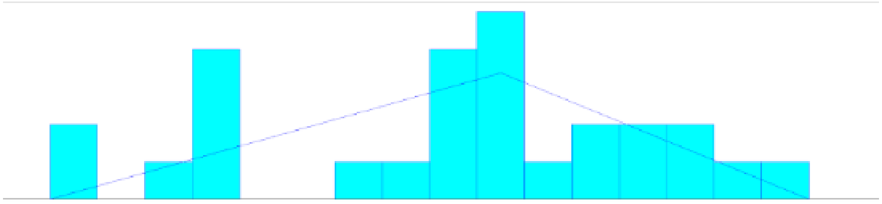
Distribution : Beta
Expression : -0.5 + BETA(0.916,1.99)
Squared Error : 0.002102

2.8 Book Issue Counter : Inter arrival Time (Weekday)



Distribution : Triangular
Expression : TRIA(1.5,14,15.5)
Squared Error : 0.063137

2.9 Book Issue Counter : Inter arrival Time (Weekend)

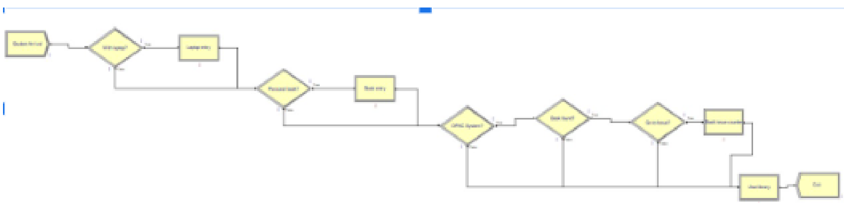


Distribution : Triangular
Expression : TRIA(0,9,15.5)
Squared Error : 0.042145

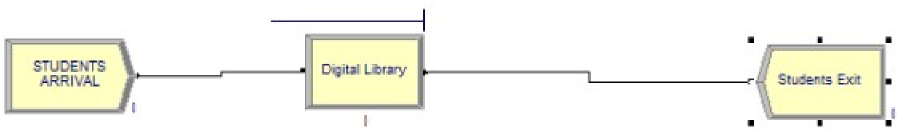
3 Model Conceptualization and Translation

The essential features of the subsystems were identified and used to create the conceptual model, basic assumptions were modified to obtain useful approximation results.
The conceptualised models were fed into computer software, Arena here, the parameters and configurations was added to all the different modules, and proper simulation models were developed.

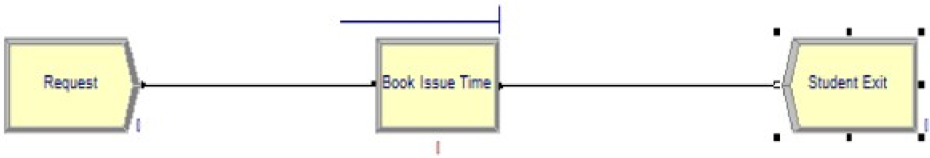
3.1 Library Model



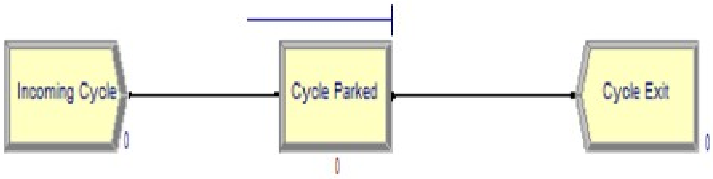
3.2 Digital Knowledge Access Centre Model



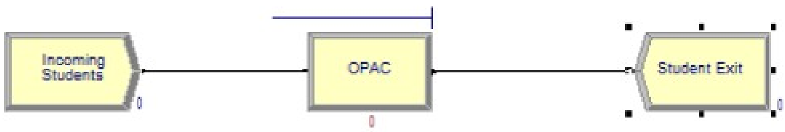
3.3 Book Issue Counter Model



3.4 Cycle Stand Model



3.5 OPAC Machine Model



4 Verification and Validation

The models created were debugged to remove any runtime or definition errors. All the models were run on Arena Simulation Software using different configurations and number of replications, and executed satisfactorily.

The results obtained were matched and compared with the original subsystems in the Central Library. The obtained report showed a high degree of coincidence with the actually observed value, in terms of queue length as well as waiting time. Thus the models are verified and validated.

5 Configuration Analysis

The models created were run with different configurations. Different number of replications were tried and the best and most efficient configuration was reached at.
Different configurations were compared on the basis of average waiting time, average queue length and maximum queue length and average resource utilization, and a trade-off was arrived at between optimal resource utilization and waiting time. The results obtained are hereby reported.

6 Results

6.1 Laptop and Book Entry Counter

Laptop Entry Register (Weekday)	
Configuration	Maximum Waiting time
1 laptop entry, 1 personal book entry	154.05 seconds
2 laptop entry, 1 personal book entry	50.12 seconds

Laptop Entry Register (Weekend)	
1 laptop entry, 1 personal book entry	379.44 seconds
2 laptop entry, 1 personal book entry	239.95 seconds
3 laptop entry, 1 personal book entry	69.51 seconds

6.2 Digital Knowledge Access Center

Digital Library	
No of Systems	Average Wait time
69	2.11 hours
80	1.57 hours
100	0.72 hours

6.3 Book Issue Counter

BOOK ISSUE COUNTER		
No of counters	Average Wait time	utilization
2	3 minutes	0.67

6.4 OPAC Machine

OPAC Machines		
Number of Machines(Hall 1)	Average Wait Time	Utilization
2	4.2 minutes	0.63

6.5 Cycle Stand

Cycle Stand(Weekends		
Configuration	Queue Waiting Time	Average Waiting Time
350(capacity)	64.775	59.269
500(capacity)	20.77	17.46

7 Suggested Changes

1. Add one more register for laptop entry on weekdays, two more on weekends. Number of registers for book entry is sufficient.

2. Install and increase number of computers in Digital Knowledge Access Center to 100 to reduce average wait time, from its present number, 69

3. Construct a new cycle stand with capacity up to 150 to bring down average wait time and queue waiting time significantly, especially during weekends

4. The results obtained for Book Issue Counters and OPAC machines show a sub-optimal utilisation of these resources. The average waiting time is also reasonable. So it is not preferred to make any changes to these subsystems

8 Future Work

We plan to use discrete events simulation to solve few more problems that are commonly faced by the students. Due to unavailability of sufficient data, it was not possible to complete these analyses now, hence some of these are included as our future work.

1. An analysis of number of copies of in-demand books required to serve a significant percentage of needy students

2. Seating Capacity and the optimum number of charging ports in each hall

9 References

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2. https://www.sciencedirect.com/topics/engineering/simulation-example

3. https://repository.lib.ncsu.edu/bitstream/handle/1840.4/5965/19910006.pdf?sequence=1
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