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Analysis of queueing theory: Biometric and manual attendance performance measures

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Abstract
In many educational organizations, most universities use manual methods for taking attendance. There is a possibility that Staff give dummy attendance for colleagues who are absent; this work intends to compare the efficiency of biometric based attendance system to that of manual attendance. The study uses single and single server queueing model to analyze service efficiency of biometric and manual attendance. The variables measured include arrival rate (λ) and service rate (μ). They were analyzed for simultaneous efficiency. Primary data were collected through observations from biometric attendance and manual attendance by observation at the attendance system. The result shows that biometric attendance compared with manual attendance was more efficient with the performances measures queueing system.

Keywords: Biometric attendance, queueing analysis, arrival rate, performance measures, service time

1. Introduction

Biometric attendance machine has the capacity to optimize track record of time, productivity and employee absenteeism, lateness, truancy. Attendance monitoring and evaluation have traditionally been approached using time clocks and timesheets (the manual way of taking employee attendance). Monitoring and evaluating attendance, however, ensures effective time management, which increases and inspires employee attendance. It goes beyond simply tracking attendance [1]. Is of the opinion that using employee biometric attendance is the most convenient way to monitor employees' productivity and attendance in businesses, nonprofit organizations, and volunteer organizations. In terms of workforce analysis, daily attendance monitoring, keeping statutory registers, leave records, calculating overtime, and sending data to the payroll system, employee biometric attendance is helpful [2]. The majority of the current manual employee attendance systems mandate that employees manually record their attendance each time they enter the office and each time they leave [3]. Because it is not an electronic system, such a system typically lacks automation and may result in a number of issues, including the time workers must spend looking for and signing their names on the attendance sheet and the possibility that the attendance sheet may be misplaced or kept away from employees due to suspected improper activities. Organizations are now able to systematically manage the attendance of their personnel thanks to the invention and implementation of the biometric attendance system. The system has a database with information about the employees, and it will assist the administrator in updating and manipulating the database [3, 4]. Customers are always expected to authenticate themselves for services supplied to them in today's commercial transactions via control mechanisms like identity cards, ATM cards, driver's licenses, health cards, and so on. For both individuals and corporations, carrying several cards and remembering passwords for various services is a challenging issue [5]. Therefore, the successful implementation of an employee clocking system depends on a safe and efficient identity and access control system.

The Employee Clocking Systems must use biometric data as an additional element in order to make the identification and access control mechanism secure and trustworthy for authentication. Globally, the transition to the digital age is accelerating every hour to keep up with the growth of smart systems and digitization. Biometrics technologies use features including fingerprints, faces, iris, retinal patterns, palm prints, voices, handwritten signatures, and more to confirm identity. The most frequent and widely used biometric for automatic personal identification in this biometric authentication is the fingerprint [6, 7].

Statement of the Problem

Most educational organizations use the manual methods for taking attendance in the University. There is a possibility that Staff give dummy attendance for colleagues who are absent or sometimes the faculty will not be able to hear the response from the staff. This work wish to compare manual and biometric attendance performance measures with data from Admiralty University of Nigeria (ADUN).

2. Literature Review

[8] Make the claim that the technology of fingerprint recognition is widely used to identify people. The authors used a Raspberry Pi, an embedded computer running Linux, with Postgre SQL for database management, a PHP web application, and a U. are. U 4500 fingerprint reader. The database was used to store the fingerprint image binary, and the FLANN INDEX KDTREE open CV method was used to compare the features of two fingerprint images [1]. In their study, they proposed using biometric employee clocking to reduce the high truancy rates in organizations. The experiment's findings showed that the system had a high degree of accuracy, with a TAR value of 99.7%. This accuracy rate is a lot higher than the findings of previous researchers. The high accuracy suggests that employees may find it challenging to check in or out for their absent coworkers. The high accuracy findings will contribute to increased employee performance, improved security of attendance, fast and simple data retrieval, simple staff supervision, and prevention of impersonation in the attendance records [9]. Utilized a Raspberry Pi for an attendance system that uses facial detection and identification. Each student's particular face image was kept in the database. Using the camera, the entire class is photographed during class, and each student's face image is detected and identified by comparison with a saved image in the database [10]. Proposed the use of a Node MCU (ESP8266, fingerprint scanner)-based IoT-based attendance system [11]. Implemented and constructed a portable device containing an R-305 fingerprint reader, an ESP8266 with Wi-Fi, an Arduino for attendance, and a MySQL database to store the data. The established solution has a limitation in that the teacher must start the attendance-taking procedure over again if the internet connection is lost [12]. Developed and installed the fingerprint scanner and ESP8266 biometric attendance system. Using the Pushing Box API service, the Roll no/ID of the recognized finger is uploaded to a Google Spreadsheet [13]. The smart attendance system made use of RFID technology [14]. Proposed an RFID-based student attendance system that would be integrated with systems for ubiquitous computing. The RFID readers would be placed close to the classrooms, according to the authors. The instructor only needs to click once to activate the reader during class. Following that, the antenna reader would scan each card that was connected to the student's identity card and transmit the data it had collected to the main server [15]. It was suggested that an RFID-based Smart Classroom Roll Caller System (SCRCS) be installed in each classroom. At the start of each class, the reader will read the IDs and display the total number of the actual attendance on the SCRCS LED display. The academic office then gathers all of the students' attendance records [16]. A smart attendance system combining the Raspberry Pi and ultrasonic sensors was proposed and put into use. The suggested system consists of four modules: a smart projector module, an ultrasonic sensor module connected to a Raspberry Pi for hand gesture control of PPTs, and a smart attendance module with a fingerprint sensor integrated inside the Raspberry Pi. The faculty can look for information using the fourth module. To identify pupils and record their attendance in an excel spreadsheet, the fingerprint biometric capability is used [17]. A fingerprint-based attendance system was implemented. The writers employed Minutia's fingerprint recognition feature extortion. For the teacher to log in and take attendance, they created a user interface. The system will look up the stored fingerprints in order to recognize the captured fingerprint [18]. The attendance system's biometric fingerprint feature. They made use of a fingerprint scanner and a Raspberry Pi. Using the open cv programming tool with a python script, the database finger and captured finger are compared, and attendance is logged in an excel file that is uploaded to the cloud [19]. A fingerprint attendance system was put in place. The hardware for this system included a micro-controller, a fingerprint reader, an LCD, a real-time clock, and serial connection, which was utilized for sending attendance data to the database and verifying fingerprints. The software component, which accepts attendance records from the hardware side, was implemented using Visual Basic. Excel was used to track and store the attendance [20]. Implemented a system in which each student receives an IP-specific smart card with an ESP8266 module with Wi-Fi connectivity. The central server held the name, roll number, and IP address (connected to the ESP8266). The IP address of each esp8266 connected to the current students is relayed from the Raspberry pi to the main server for attendance tracking [21]. Implemented a passive RFID and ZK fingerprint reader-based attendance system. The SQL Database contains the registered fingerprints. For taking student attendance, RFID and fingerprint scanners were employed. The attendance is recorded if the RFID and fingerprint ID match. This will deter students from using their own RFID tags or those of their friends to take attendance using an RFID-based attendance system. The GUI of the implemented system is efficient [22]. IoT-based portable attendance gadget implemented. To make it portable and send attendance to the server, they used an ATMega16 GPS module. Rapid application development (RAB) for GUI creation is made possible by software programs written in C++.

3. Methodology

Nomenclature

To consider special form of queue organization (limited or unlimited space, limited or unlimited population, etc.), a nomenclature of six positions describing the traits of the model is usually used [25]. Its structure is A/B/C/K/M/Z, where:

A describes the inter-arrival time probability distribution,

B describes the service time probability distribution,

C is the number of servers or channels,

K is the space limit of the service facility in the sense that no more than K customers can be in the system (C in service and K - C waiting in queue),

M is the size of the customer population,

Z is the queue discipline, i.e how the next customer is chosen from the queue when the server completes a service.

When Z is FCFS, $M = \infty$, and $K = \infty$, the last three positions are omitted.

Thus, $M/M/1/\infty/\infty/FCFS$, abbreviated to M/M/1, describes a model in which the inter-arrival and service times are both exponential (M is obtained from the Markovian property of the exponential distribution). there is a single server in a facility that does not impose any restriction on the number of customers; customers arrive from a population that is considered infinite in the sense that the arrival of an individual does not modify the probability of the next arrival and FCFS (First Come, First Served) is the most frequent way in which the next customer to be served is chosen from the queue [25].

Structure of Queueing Package

The S3 special class of functions in R were taken into consideration when [26] built the queueing package. With the help of this kind of function, several queueing models may be constructed in the same way, giving the user a standardized and simple method to generate the models. The following stages are used to generate the model:

1. Create the inputs for the model with the New-Input function;
2. Optionally check the inputs with the Check-Input function.
3. Create the model by calling Queueing Model.
4. Print a summary of the model using print, or a specific model performance measure such as W.

Although step 2 is optional (as it is applied when the Queueing Model function is called), it is recommended that the inputs should always be checked, as this makes it easier to understand the data and, thus to correctly build the model [26].

This situation is modelled in queueing using a single node in which the customer inter-arrival time and service time both follow an exponential distribution, at the rates λ = 2 and μ = 3 respectively, as shown in Figure.

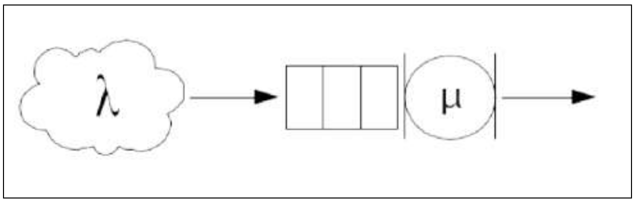

Fig 1: M/M/1 Infinite population, single server

Load the package library (queueing)
Create the inputs for the model. i_mm1 <- New Input. MM1 (lambda=λ, mu=μ)
#Optionally check the inputs of the model Check-Input (i_mm1)
Create the model o_mm1 <- Queueing model (i_mm1)
Print on the screen a summary of the model print (summary (o_mm1), digits=3)
#> lambda mu c k m RO P0 Lq Wq X L W Wqq Lqq

The output of the model also includes components, such as the functions FWq (t) and FW(t), which can be used to view the cumulative probability distribution of the random variables wq (time waiting) and w (time in the system: time in queue + time being served), assuming FIFO(Fist In, First Out) or FCFS(Fist Come, First Served) as the queue discipline. Accordingly, FWq (t) is the probability of a customer waiting for a time less than or equal to t for service [27].

4. Data Analysis and Results

The summary of number of staff's arrival and number of staff's singing in per hour and number of servers. The table1 below shows how Staff entered the system, number of Staff clocked and the number of Biometric Attendance within the data collection time.

Table 1: Primary Data Summary for the Randomly Selected Hours and Days via Biometric and Manual Attendance in the Year 2022.

Date	Time range (Hour)	Total Time (hour)	No. of Staff (Arrival Rate)	No. of Servers	Biometric Attendance (Service Rate)	Manual Attendance (Service Rate)
12th April	8am – 9am	1:00	165	1	720	240
15th April	5pm – 6pm	1:00	168	1	720	240
18th April	5pm – 6pm	1:00	170	1	720	240
20th April	8am – 9am	1:00	166	1	720	240
21th April	8am – 9am	1:00	165	1	720	240
2nd May	8am – 9am	1:00	159	1	720	240
5th May	8am – 9am	1:00	168	1	720	240
11th May	5pm – 6pm	1:00	167	1	720	240

The number of staff clocked-in (Arrival rate) = 166

The number of staff served within 0800hr – 0900hr (service rate) = 178

The number of staff (c) = 1

Total time spent in hours = 1 hr.

Mean arrival rate (λ) = $\frac{arrival\ rate}{total\ time\ in\ hour} = \frac{166}{1}$ = 166

Biometric Mean Service rate (μ) = $\frac{service\ rate}{total\ time\ in\ hour} = \frac{720}{1}$ = 720

Manual Mean Service rate (μ) = $\frac{service\ rate}{total\ time\ in\ hour} = \frac{240}{1}$ = 240

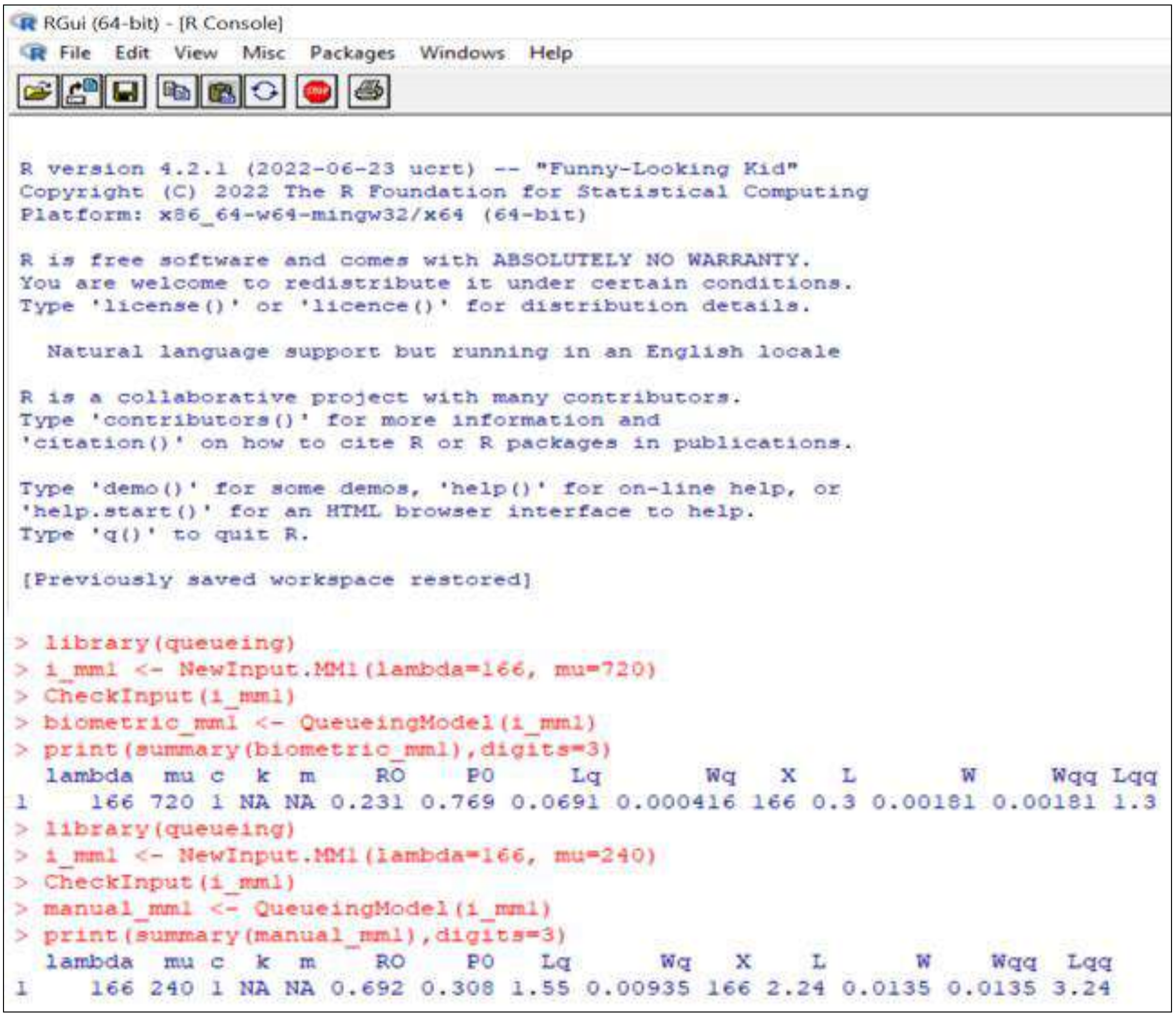

Fig 2: Screenshot of R Programming Coding

5. Results for average attendance

Table 2: Average Data Calculation Result

Inputs	Biometric	Manual
Total Time Involved (t)	1 hour	1 hour
Number of Staff Arrived (λ)	166	166
Number of Staff signed in/out (μ)	720	240
Number of attendance system	1	1
Model Type	m/m/1	m/m/1
Intermediate Calculation		
Performance Measures		
Rho(average server utilization),ρ	0.231	0.692
Probability of System empty, ρ_o	0.769	0.308
Average Staff in the system, L	0.300	2.240
Average Staff waiting in a queue, Lq	0.0691	1.550
Average time in the system, W	0.00181	0.0135
Average time in the queue, Wq	0.000416	0.00935

6. Conclusion

The Queue analyses was done with r programming software, using observational data obtained from Admiralty University of Nigeria, Delta State, Nigeria. The results of the single-server-single channel queuing Models for both biometric attendance and manual attendance revealed a traffic intensity of 23% and 69% respectively. Traffic intensity (utilization) of biometric shows that it will take 3 times of current population without the system being exploded while manual attendance needs urgent attention since it has passed 50% which strikes the balance between server and the staff. This tends to put staff under pressure and hence could force them to skip attendance if another server is not made available.

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