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REVITALIZING UNIVERSITY MOBILITY: A BUSINESS PROCESS REENGINEERING ANALYSIS OF SCOOTY RENTAL SYSTEM

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ABSTRACT

Moving from one place to another in the university was a difficult task as one had to walk and there was no availability of transportation within the university. This took a lot of time and caused fatigue for students, leading to various health issues. Hence, there was a need for a system in the university that could resolve these problems for the students. This paper introduces a rental scooty system so that students can easily move from one place to another. This would save their time and eliminate any health issues they might face. The charges for using this bike system would be based on a per minute basis. This system is inspired by the facilities provided in foreign universities and it will help the students to travel easily without any health problems. A survey was conducted among the students to find the need for this system, and the results showed positive feedback from the students. After a survey the simulation model of the current process was build to investigate the time required by the students then after applying business process engineering model the solution was proposed. This solution is then again modelled in AnyLogic so that the feasibility of the solution can be checked. The simulation findings indicate a significant enhancement in process efficiency, with the average simulation duration decreasing from 1,173.74 seconds in the current process to 398.21 seconds following the implementation of the suggested solution. This signifies an average time reduction of roughly 775.53 seconds, demonstrating a substantial enhancement in system efficiency. Hence, this research acts as a green signal for the implementation of the rental scooty system in the university. In the future, this system can be applied not only in universities but also in housing societies, providing a convenient solution to the people.

Keywords: *Scooty Rental System; QR Code; Business Process Engineering; BPMN; Simulation and modeling; Bike Rental System.*

INTRODUCTION

Universities do not provide adequate transportation systems, and students must travel from one department to another on foot. This is not a big issue if the university is small, but in case of a large university like ours, it becomes difficult for students to travel from one department to another by foot. For example, the distance between gate 1 and gate 2 is substantial, and walking becomes tiring. The heat in the summers becomes unbearable, and the cold in the winters becomes unbearable too. When students must travel from one department to another, it takes a lot of time, causing them to be late for class. Some students

must walk from their homes to the bus stop, and then walk again within the university, causing them headaches, foot pain, and other health problems. These issues pose a significant problem for the students.

Our research is focused on fixing the problems and introducing a Scooty Rental system in the university. Some research has already been done and the system has been applied before. In foreign countries, this system is already in operation, with scooties, bicycles, and motorcycles available in rental systems. The system is also operating in some big city universities in our country, so we are inspired to implement this system in our university.

Our research is different from previous research as there were limitations in previous research, such as the lack of strict rules for students. Students perform stunts on bicycles and over-speed on bikes, leading to many accidents.

Our research aims to address the previous limitations by introducing electric scooties in the university. This has several benefits, such as the inability to perform stunts, a speed limit, and reduced likelihood of accidents. The bikes will be available in a stand managed by the university department. Students will have to register through an application to start their scooty ride. The registration process will be simple, with students only needing to provide personal details and a university email address. When they want to take a bike from the stand, they will need to scan a QR code on their app. The QR code will appear on the stand, and once scanned, the bike will unlock, and the ride will start. A timer will be available on the app, and the student can only end the ride by scanning the QR code on the stand. Each slot will have a unique QR code, and charges will be calculated based on the time the bike was used. The student can make payment through various options available. If they don't pay, they will incur a daily penalty of 20 Rs and won't be able to start the next ride until payment is made.

BACKGROUND

This section briefly discusses the key words from the title: 'BPE', 'BMPN' and 'Simulation', and what they mean when they are put together.

Business Process Engineering (BPE)

Business Process Engineering (BPE) is a systematic and comprehensive approach to examining, analyzing, and improving the processes within an organization. Its aim is to optimize business performance by making processes more efficient, effective, and flexible. The goal of BPE is to increase an organization's ability to respond to changing market conditions, customer demands, and other factors that affect business success.

The BPE process typically involves the following steps:

- *Process mapping:* Creating a visual representation of a process to gain a clear understanding of how it works and identify areas for improvement.
- *Process analysis:* Evaluating the process to identify inefficiencies, bottlenecks, and other areas that can be improved.
- *Process redesign:* Using methodologies for process improvement, like Lean and Six Sigma, to eliminate waste, streamline workflows, and increase overall business performance.
- *Implementation:* Implementing the improved processes and monitoring their performance to ensure they are delivering the desired results.

BPE can be applied to many different procedures within an organization, from customer service and sales processes to supply chain management and operations processes.[1]

2.2 Simulation Modelling

Simulation modeling is a method used to study and analyze complex systems and processes by creating a computer-based model that mimics the behavior of the real-world system. The aim of simulation modeling is to understand how the system operates, identify bottlenecks, improve decision-making, and predict future outcomes.

Simulation modeling includes the steps listed below:

- *Defining the system:* The first thing to do is identify the system that needs to be modeled and define its scope, objectives, and constraints.
- *Developing a model:* A mathematical representation of the system is constructed using the information gathered from the first step. This can be done using various

techniques, such as mathematical modeling, system dynamics modeling, or agent-based modeling.

- *Validating the model:* The model is validated to ensure that it accurately represents the real-world system. This involves comparing the outputs of the model with data from the real system.
- *Running simulations:* The model is run under various conditions, and the results are analyzed to understand the behavior of the system and make predictions about future outcomes.
- *Analysing results:* The results of the simulations are analyzed to identify patterns, trends, and relationships within the system. This information is used to make decisions and improve the system.

Simulation modeling is used in a variety of fields, including engineering, finance, healthcare, and logistics. It allows organizations to test and evaluate new ideas, strategies, and processes without the need for expensive prototypes or real-world experiments.[2]

Role of Simulation Modelling in BPE

Simulation plays a crucial role in Business Process Engineering (BPE) as it allows organizations to model, analyze, and improve their business processes before implementing them in real-life scenarios. By simulating a business process, organizations can evaluate the performance, identify bottlenecks, and make changes to optimize the process. This helps organizations to minimize the danger of implementation failure and ensure the success of the process.

Here are a few examples of how simulation is used in BPE:

- *Supply Chain Management:* Organizations can simulate their supply chain processes to evaluate the impact of changes in demand, production schedules, transportation routes, and inventory levels.
- *Customer Service Processes:* Companies can simulate customer service processes, such as call center operations, to determine the optimal staffing levels, call routing, and response times.
- *Production Planning:* Manufacturing companies can use simulation to evaluate alternative production plans and schedules, considering factors such as equipment utilization, manpower, and inventory levels.
- *Healthcare Processes:* Healthcare organizations can use simulation to analyze and improve patient flow, resource utilization, and treatment times in hospitals and clinics.[3]

Business Process Model and Notation (BPMN)

Business Process Model and Notation (BPMN) is a standardized graphical notation used to represent business processes. It is used to describe how a business process's activities move through it and to clearly communicate the steps involved in a process to all stakeholders.

BPMN is based on flowchart notation and uses a set of standardized symbols to represent the various elements of a business process, such as tasks, events, gateways, and message flows. The use of a standard notation makes it easier for stakeholders from different backgrounds and with different levels of technical expertise to understand and collaborate on the process design.

BPMN consists of the following elements:

- *Flow objects:* These are the fundamental components of a BPMN diagram, and they represent the steps in a process. Examples of flow objects include tasks, events, and gateways.
- *Connecting objects:* These are used to connect flow objects and represent the flow of control within a process. Examples of connecting objects include sequences, message flows, and associations.
- *Swim lanes:* These are used to divide a BPMN diagram into horizontal or vertical lanes, each representing a particular participant or role in the process.
- *Artifacts:* These are used to provide additional information or context to
- BPMN diagram and can include data objects, groups, and annotations.

BPMN is designed to be easily understood by both technical and non-technical stakeholders and can be utilized for numerous business processes, including workflow processes, data-driven processes, and conversational processes.[4]

Role of BPMN in Simulation

Business Process Model and Notation (BPMN) is a graphical representation of a workflow's business processes. A standardized approach to modeling and analyzing business processes is provided by BPMN, making it simpler for various stakeholders to comprehend and communicate process flow and execution.

Simulation using BPMN involves creating a virtual representation of a business process and testing how it performs under different conditions. The purpose of simulation is to identify potential bottlenecks, inefficiencies, or areas for improvement before the process is implemented.

An example of a BPMN simulation could be modeling a loan application process. A BPMN diagram can be created to represent the various tasks involved in the process, such as receiving the loan application, checking the credit history, verifying income, and so on. The simulation would then run through these tasks and calculate the time and resources required to complete each one. This information can then be used to identify areas where the process can be streamlined or optimized to improve efficiency.[4]

Advantages of BPE

Business Process Engineering (BPE) is the systematic analysis, design, and improvement of business processes. It involves rethinking, redesigning, and streamlining processes to improve efficiency, reduce costs, increase customer satisfaction, and support organizational goals.

The following are some of the key advantages of BPE:

- *Improved efficiency:* By rethinking and streamlining processes, BPE can reduce waste, eliminate redundancies, and increase overall efficiency. This can result in faster process times, reduced errors, and lower costs.
- *Increased customer satisfaction:* By focusing on customer needs and creating processes that are more responsive to their needs, BPE can lead to increased customer satisfaction.
- *Better alignment with organizational goals:* BPE can assist in ensuring that processes are in line with the organization's overall goals and objectives, resulting in more effective and efficient use of resources.
- *Improved decision-making:* By gaining a deeper understanding of processes and the data that drives them, BPE can provide valuable insights into the operations of an organization and inform decision-making.
- *Increased agility:* BPE can help organizations respond quickly and effectively to changes in the business environment, making them more agile and better able to compete.
- *Better collaboration:* BPE can improve collaboration between departments and functions, resulting in more effective and efficient processes.

BPE requires a systematic and disciplined approach and can involve a variety of techniques, including process mapping, process simulation, and process reengineering.[5]

List of papers in this special issue:

Sr. No.	Title	Author	Year	Summary
1	A decision support system for rebalancing strategy in electric scooter sharing systems: a case study in Mashhad, Iran	Sima Tafakkornia, Babak Rezaee & Alireza Sherkat Bazazan	2025-09-20	This paper addresses charging, relocation and system rebalancing problems and proposes a discrete event simulation model in order to optimize electric scooter sharing operations. The model is implemented on Iran's Mashhad system and compared with various rebalancing policies using extensive simulations. The findings indicate that an effective strategy leads to significant increase in end user satisfaction, operational efficiency, as well as financial performance.[6]

2	Optimizing Profitability of E-Scooter Sharing System via Battery-aware Recommendation	Jiwon Kim, Taewoong Jung, Yonghun Choi, Daeyong Kim, Hojung Cha	2024-06-03	This paper proposes EcoRide, a recommendation engine for enhancing profitability by precisely estimating battery life, selecting affordable e-scooters, and applying multi-agent reinforcement learning to overcome the problems of poor battery information and high-operational costs [7].
3	Agent-based models for simulating e-scooter sharing services: A review and a qualitative assessment	Panagiotis G. Tzouras, Lambros Mitropoulos, Eirini Stavropoulou, Eleni Antoniou, Katerina Koliou, Christos Karolemeas, Antonis Karaloulis, Konstantinos Mitropoulos, Marilena Tarousi, Eleni I. Vlahogianni, Konstantinos Kepaptsoglou	2023-03	In this paper, we survey and conduct a qualitative analysis of Agent-Based Models (ABMs) to identify their fit for simulating e-scooter sharing services gaining traction in cities worldwide as a first- and last-mile mobility solution.Based on ten evaluation criteria, the study characterizes what is currently good and bad about "standard" ABMs for flexible, multimodal traveler behavior. Results underline an essential trade-off concerning scalability of e-scooter model for informing policy-making (i.e., to aim at estimating models distinguishing between both vehicle link and network level) and suggest the extension or hybrid approach on simulation modelling of pedestrian–vehicle designed to reflect users' dual-mode behavior.[8]
4	Modelling on the Readiness in Implementation of Bike Sharing System at University	Mohd Azizul Ladin, Lee Fui Jun	2022-03-01	The study aimed to analyze the willingness of students at the University of Malaysia Sabah (FSSA) to shift from private vehicles to bike sharing. The results showed that 88.1% of the 160 respondents are ready to accept the implementation of a bike sharing system. The main factor motivating the shift is reduced fuel consumption and congestion, while the main factor discouraging it is the hilly topography of the university. The study also found that a decrease in bicycle rental charging price could increase the shift percentage. Four transportation models were developed to reflect the students' willingness to shift.[9]

5	Agent-based models for simulating e-scooter sharing services: A review and a qualitative assessment	Panagiotis G. Tzouras , Lambros Mitropoulos	2022-02-18	In order to close the gap between ABMs and e-scooter sharing services, this study will analyse current ABMs and perform a qualitative evaluation. The ten requirements are related to each model's ability to adapt to new difficulties, represent shared mobility modes, execute large-scale simulation, characterise spatiotemporal fluctuation of demand, simulate mixed traffic, bicycle, and pedestrian, integrate new choice models, and model multimodal trips. The outcomes highlight each model's benefits and drawbacks when replicating flexible transport modes and services.[10]
6	Understanding and Predicting the Usage of Shared Electric Scooter Services on University Campuses	Seyed Mohammad Hossein Moosavi, Zhenliang Ma	2022-1	With the help of supervised and unsupervised machine learning methods, this study forecasts SFFES usage on a university campus. The presence of green spaces and bodies of water, age, the quality of the road surface, daily travel time and cost around the campus, monthly income, private vehicle ownership, connectivity between roads, modes of transportation to and from campus, and gender were identified as the top 11 attributes. Using the crucial variables that were determined, the random forest method was created to forecast the SFFES usage frequency. To learn more about the characterization and specification of users, simulation-based sensitivity analysis was carried out. Providing all inhabitants with accessible, equitable, safe, cheap, and sustainable transportation options is the responsibility of service providers and authorities. There is a way to ensure sustainable mobility.[11]

7	Determination of Best Public Transport Mode Using Multicriteria Analysis: A Case Study of Peshawar City, Khyber Pakhtunkhwa Pakistan.	Muhammad Shan Khalid & Rawid Khan & Arsalaan Khan & Muhibullah Khan, Zarif Khan, Naqeebullah Khattak	2021-10-08	The rapid population growth in cities is putting pressure on their transportation systems, causing the need for sustainable transportation solutions. These solutions come with high social, environmental, and financial costs. To solve these transportation problems, cities are using Traffic Management plans and MCDM techniques to find the best solution.[12]
8	An exploratory study of the bike rental system	Hana Ayedi, Nadia Hamani	2019-06-15	This study aimed to guide the city of Sfax towards sustainable transport by exploring the travel habits and bike usage of its citizens. A survey and LOGIT model were used to identify the factors that influence the choice of bicycle rental. The results showed that artisans, unemployed people, students, and executives were the most favorable towards bike rental, and a short-term rental system was preferred over long-term rental. In future work, a techno-economic feasibility study will be conducted to propose the best formula for the implementation of a bike rental system.[13]
9	Prototyping Design of a Low-Cost Bike Sharing System for Smart City Application	Irfan Gani Purwanda, Trio Adiono	9-2017	Using digital signs, an NFC reader, a GUI, an automatic lock and unlock system, and Wi-Fi, the suggested BSS can offer a low-cost implementation in comparison to the global market. It can be used as an additional tool and for public services in a smart city setting. The LCD monitors can be used as more interactive digital signage and as a promotional tool to draw in more customers. It also has the ability to connect the local server to a cloud database system.[14]
10	Design, Build, and Installation of an Automated Bike Rental System as a	Dr. Tristan M. Ericson, Dr. Kala Meah, Dr. James Moscola	2016-06-26	In a capstone design project, students from mechanical, electrical, and computer engineering designed and built two automated bike rental systems. The project provided interdisciplinary design

	Part of Capstone Design			experiences, allowed students to demonstrate individual and team skills, and taught them to incorporate customer input and societal impacts in their designs. The project was evaluated using design reports, presentations, comments from proprietors of nearby businesses, and observations. It was an effective technique to involve students in engineering design while meeting community needs.[15]

Table 1. List of papers in this special issue

METHODOLOGY

This study's methodological approach is based on different steps including modulations and simulations. First, we identified the problem as students we were facing this problem, so we thought if we are facing this problem, then other students in the university will also be facing this issue. So, we identified the problem. Then, we confirmed it with other students in the university by preparing a questionnaire and getting it filled out by students from different departments. When the survey's findings came out, it revealed that 98% of the students wanted a transport system within the university. Now that our objective was clear, we created models and simulations to show the problem in a better picture. Models meant creating a model that was basically showing the problem. The model created was called a BPMN model. The model was showing that there was a problem. Then, to show the problem in a real environment, we created a simulation. The problem was now visible in the simulation.

After a thorough analysis of the problem, we decided to implement an automated system within the university and chose a rental scooty system. Scooties were a better option than bicycles as students could overspeed or engage in reckless behavior and cause accidents. Scooties were a safer option as they have a limited speed. To examine the working of the scooty rental system, we created a BPMN diagram and conducted a simulation. Upon comparison, the problem we faced has now been resolved. To explain the working of the application, we also designed the interfaces and detailed its proper functioning in this study.

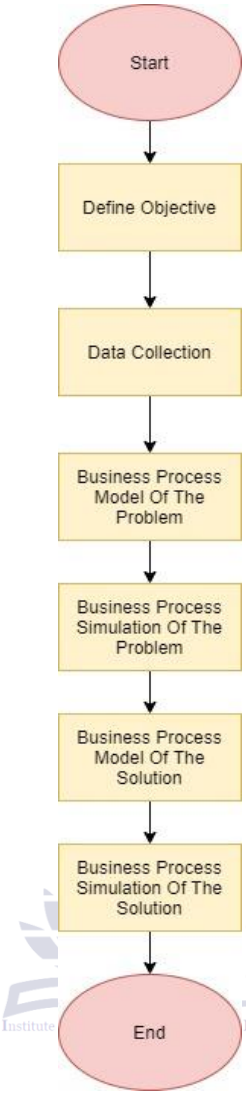


Figure 1. Flowchart of complete process

A survey was conducted among 100 university students to research a certain purpose. The survey consisted of 9 different questions, each with 5 options for the students to select. The responses for each question were analyzed and the percentage was calculated and saved in an excel file. A BPMN (Business Process Model and Notation) design was created using Lucid chart tool. This design showed the real problem and the different components of BPMN were used to create Is-A process. The purpose of creating the BPMN was to use it for simulating the Is-A process. Once the Is-A process was ready, the simulation was created using Any logic software. Different blocks were used to create the logic of the problem, and the simulation was ready. The simulation showed the real problem.

After identifying the problem and having a clear objective, the To-be process was created to fix the main problem. The old system was converted into the new system, and the To-be design was created in the BPMN. Using this BPMN, the simulation for the solution was created. The To-be process was created based on the BPMN solution. The logic was set, and the simulation was created accordingly. The new system can now be seen in the simulation, and the problem has also been solved.

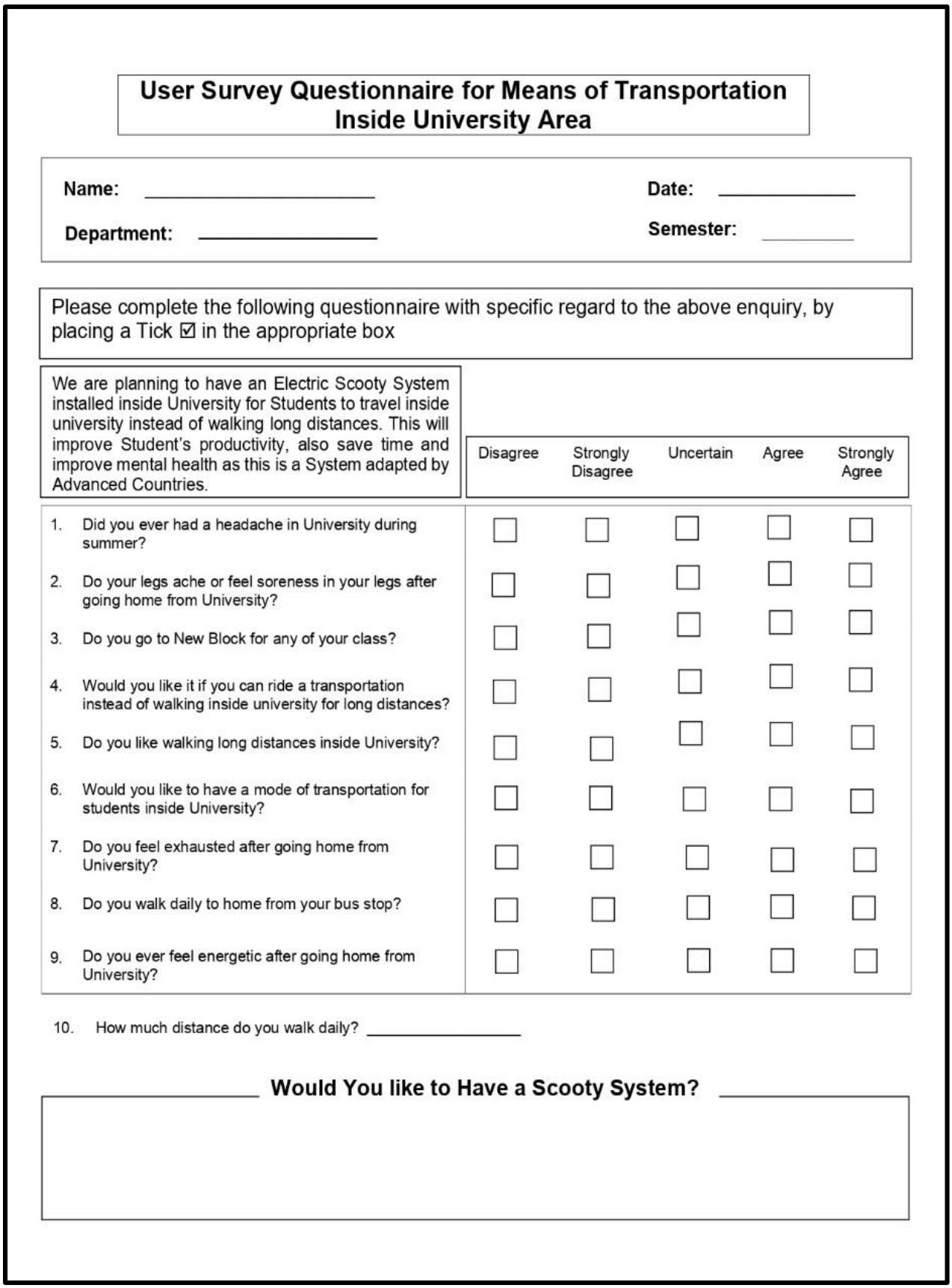
EXPERIMENTS & RESULTS

To go from home to university, there are buses available but as soon as we reach the university, we are told to walk as there is no transport facility available inside the university. The university is very big, and it takes 10 minutes to

walk from gate 2 to our own departments. Due to this, we often arrive late to class and the exhaustion starts in the morning itself. If there is a class in another department, we must walk to that department as well. Similarly, if we must go to the mosque, bank, or gate 1, it becomes a problem as there is no convenient transportation in the university. The students' entire energy is wasted just by walking in the university, and they only go home to sleep because of the daily exhaustion. There are other issues faced as well, such as headaches, foot pain, etc. Both in winter and summer, there are many difficulties due to walking. In summer, walking becomes unbearable and in winter, it can cause fever, etc. This is a big problem, and it is necessary to fix it. That is why in this research paper, a proper solution to this problem has been discussed.

Questionnaire

It is a survey for 100 students to see whether they want this service or not and if they have any problem with the walking long distances inside the university.



User Survey Questionnaire for Means of Transportation Inside University Area

Name: _____ **Date:** _____

Department: _____ **Semester:** _____

Please complete the following questionnaire with specific regard to the above enquiry, by placing a Tick ☑ in the appropriate box

We are planning to have an Electric Scooty System installed inside University for Students to travel inside university instead of walking long distances. This will improve Student's productivity, also save time and improve mental health as this is a System adapted by Advanced Countries.

	Disagree	Strongly Disagree	Uncertain	Agree	Strongly Agree
1. Did you ever had a headache in University during summer?	☐	☐	☐	☐	☐
2. Do your legs ache or feel soreness in your legs after going home from University?	☐	☐	☐	☐	☐
3. Do you go to New Block for any of your class?	☐	☐	☐	☐	☐
4. Would you like it if you can ride a transportation instead of walking inside university for long distances?	☐	☐	☐	☐	☐
5. Do you like walking long distances inside University?	☐	☐	☐	☐	☐
6. Would you like to have a mode of transportation for students inside University?	☐	☐	☐	☐	☐
7. Do you feel exhausted after going home from University?	☐	☐	☐	☐	☐
8. Do you walk daily to home from your bus stop?	☐	☐	☐	☐	☐
9. Do you ever feel energetic after going home from University?	☐	☐	☐	☐	☐

10. How much distance do you walk daily? _____

Would You like to Have a Scooty System?

Figure 2. Questionnaire for data collection

Data Collection

We are planning to have an Electric Scooty System installed inside University for Students to travel inside university instead of walking long distances. This will improve Student's productivity, also save time and improve mental health as this is a System adapted by Advanced Countries.	Disagree	Strongly Disagree	Uncertain	Agree	Strongly Agree
1. Did you ever had a headache in University during summer?	7%	1%	9%	45%	38%
2. Do your legs ache or feel soreness in your legs after going home from University?	8%	5%	12%	27%	48%
3. Do you go to New Block for any of your class?	24%	11%	9%	25%	31%
4. Would you like it if you can ride a transportation instead of walking inside university for long distances?	15%	7%	9%	33%	36%
5. Do you like walking long distances inside University?	20%	16%	16%	31%	17%
6. Would you like to have a mode of transportation for students inside University?	12%	9%	10%	40%	29%
7. Do you feel exhausted after going home from University?	4%	7%	14%	34%	41%
8. Do you walk daily to home from your bus stop?	22%	14%	7%	32%	25%
9. Do you ever feel energetic after going home from University?	39%	35%	10%	7%	9%

Conclusion of Questionnaire Data

According to above data, majority of student body inside university suffer from headaches and Foot pain and extreme tiredness at the end of the day. Some also feel so sick that they must visit health center for restoration. Through this Questionnaire, our problem is already identified and shown. To solve this, we also conducted the questionnaire on the solution and most of the student body strongly agrees to have rental scooty system. We talked to the student body and most of them not only agreed but they also urged us to have this system implemented. This shows that how much this system is needed for the students. It is necessary. 57% claims that they walk home from their bus stop. This means that they do not only have to walk inside university all day but also, they must walk outside going towards their home too. This doubles down troubles and thus University should have a proper system.

Is-A Process

BPMN

First, students enter the university. Then their next step is to decide where they want to go. According to their decisions, they visit the places in the university i.e., block, cafe, hostel, ground, mosque, etc. Whatever place the student decides he/she must cover a long distance so obviously it will take much of their precious time and too much walking will impact their body due to covering the long distances. Walking is generally considered a healthy and low-impact form of exercise, but excessive walking can lead to several problems. They may feel headache, foot pain, muscle fatigue and soreness, knee pain, back pain, dehydration, etc. It's important to listen to your body and take rest breaks if you're feeling any discomfort or pain but it will also take the time of the student and much more.

It's very difficult for a student to manage his/her time for these purposes due to their busy academic schedule. It's also a good idea to stretch before and after walking but it will also take time for the student and students don't have much time to do such things. Maybe due to these reasons, he/she may go for a checkup

so obviously, it's also a waste of time and money. As a student, it's a tedious job to go for checkups, etc. because these things distract them to devote their time to studying, and being a student it's also a matter of money and students didn't have much money. If a student wants to go to the block so, he/she must cover 200 meters which will take almost 5 minutes to cover. Similarly, for a cafe, hostel, ground, and mosque he/she must cover 400 meters, 700 meters, 1.2-kilometers, and 600 meters respectively and it will take approximately 5-8 minutes, 10-15 minutes, 15-20 minutes and 10-15 minutes respectively. If a student wants to visit the other places in the university so that place will obviously have a distance, and time will take to cover this. Walking from one place to another place and the existence of a long distance between them cause a loss of time and energy.

Every day a student visits many places, visits a department for lectures, visits a library for books, visits a cafe for a launch, and visits a mosque for prayers., and many other places like the ground, etc. There is a lot of distance, and it takes time and energy which makes a student feel tired and not able to devote more time to study. A student cannot make his time productive. Finally, his grades are not so good, and he starts doubting his own ability.

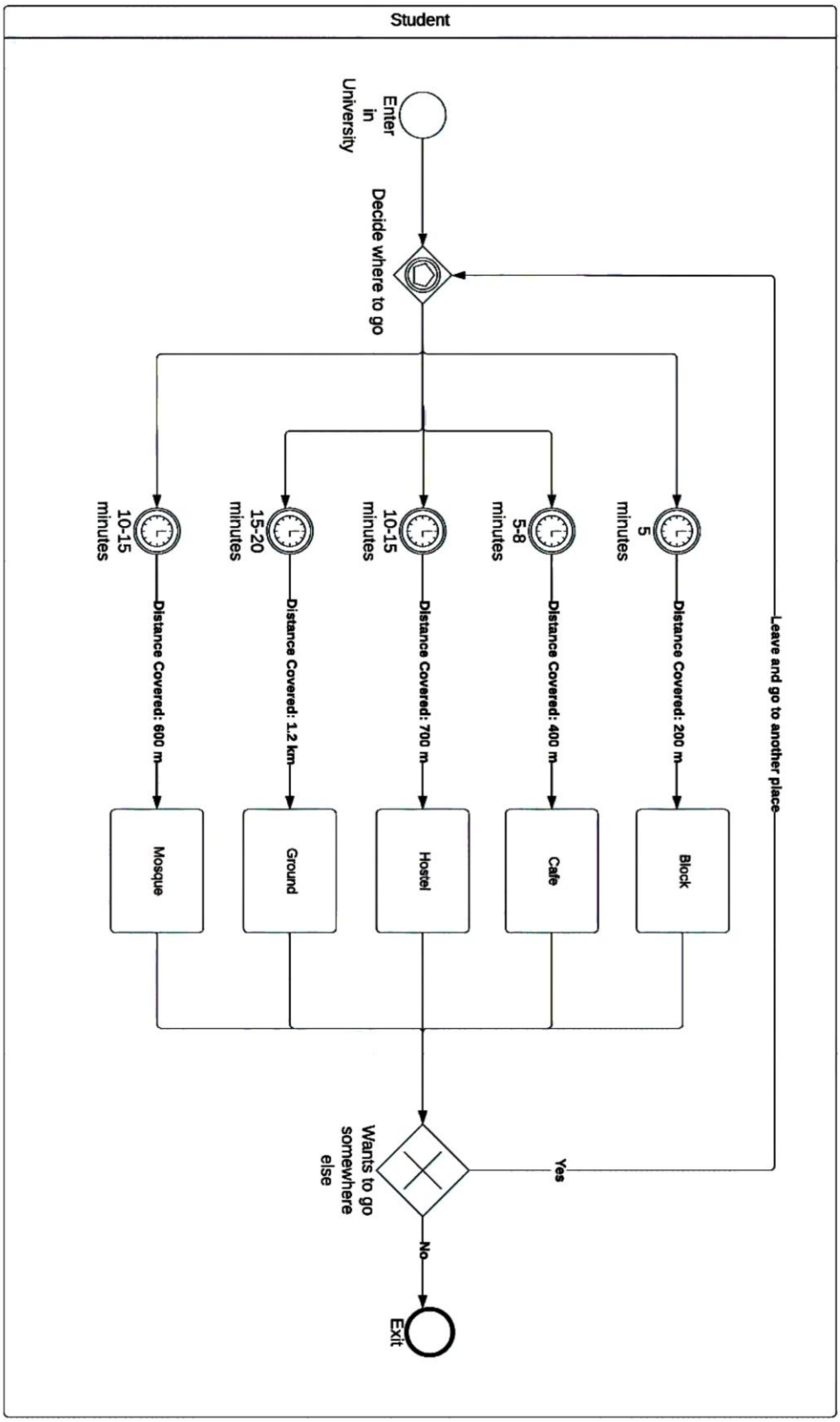


Figure 3. Is-A Process BPMN

Simulation Model

We made a simulation in which 100 students come through Gate 2 and go to Arfa Kareem Block, New Block, From Arfa Kareem to Bank and Mosque. The data is gathered on time it took them to walk towards their destinations. Also, their physical conditions also change according to time and probability data gathered by the Questionnaire. The Green color represents a normal state while the red state represents headache and blue state represents foot pain. The result of this simulation clearly shows the problems students must face daily which is being late and having physical and medical issues which results in poor performance of studies.

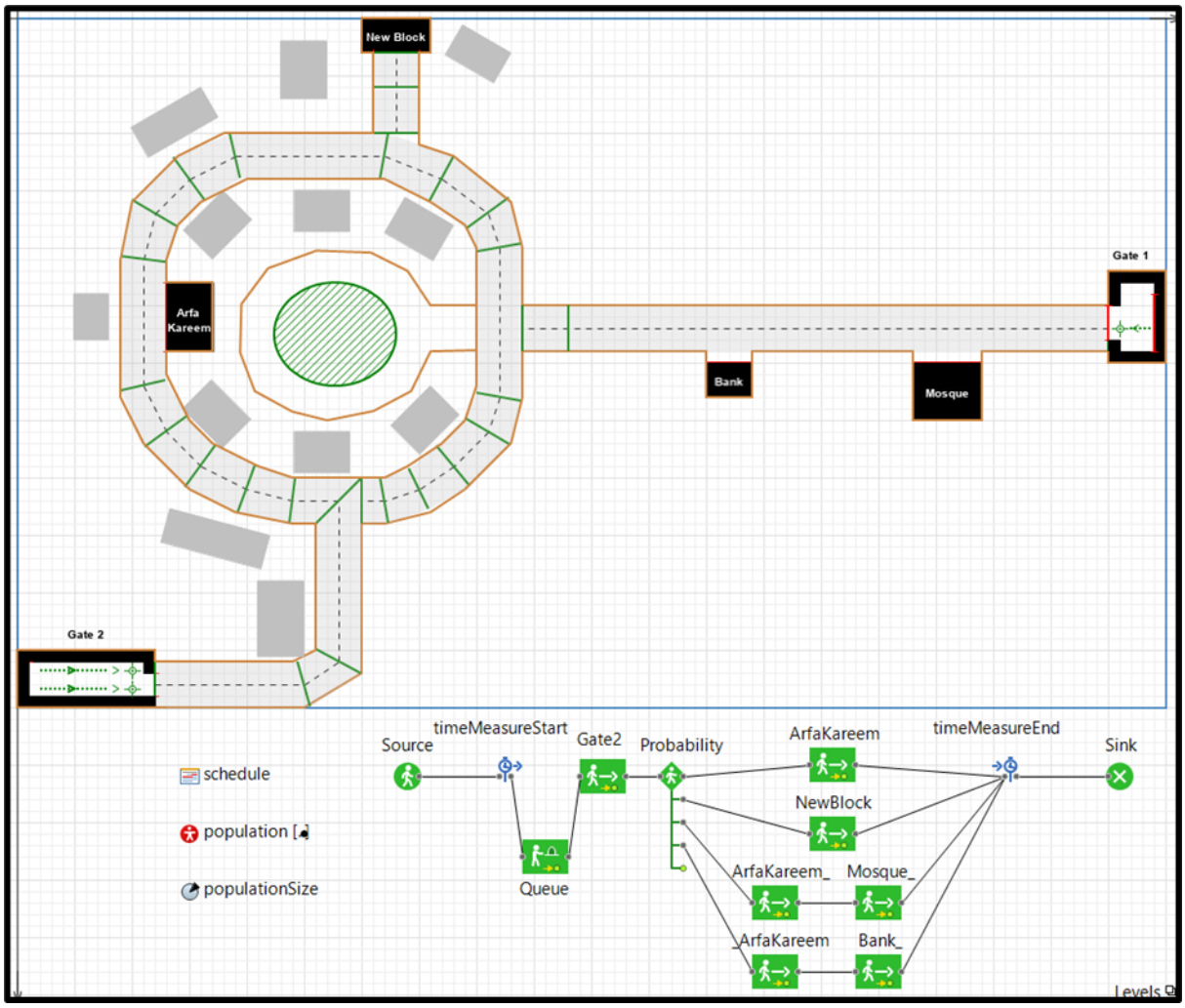


Figure 4. Is-A Simulation Model

State Chart

The state chart uses an event and a variable to check when to shift and use another variable to change the color representing medical conditions. The event controls when the state chart should start by using a Boolean type of variable. The state chart itself uses wait and rate transitions. When the state chart shifts using event, it uses rate transition to turn a specific number of agents slowly and precisely to specific color which will represent its change of state and medical condition. Then it also recovers from that state using a time transition in a day.

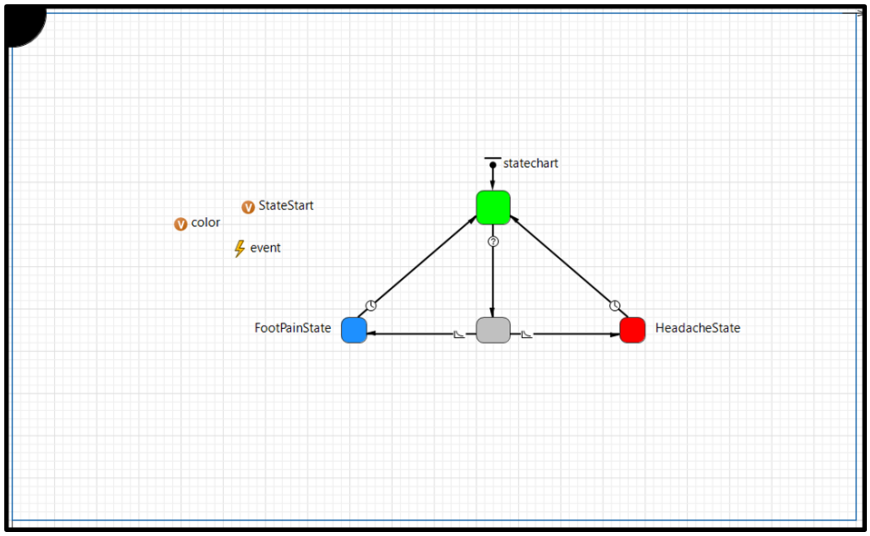


Figure 5. Is-A Process State Chart

The time at which event of the state chart occurs is same as schedule time. Which means when the agents start spawning according to schedule, the event occurs and through a Boolean type of variable cause the start chart to start too. Thus, during the whole travel of spawned agents, some of them randomly change colors due to state chart to show the problems. The agents spawned go to 4 destinations Mosque, Bank, Arfa Kareem and New Block but how many should go to which destinations is proposed by the data of questionnaire. According to precise probability, they went their own ways. This whole scenario shows that students on top of being late and consuming a lot of time, also suffer through physical and medical problems. Also walking such long distances is also poor for your health if you can't maintain your diet. In Summer it's become extremely problematic for students.

Is-A Process Simulation Data

This data is the combined average data collected by 100 Agents. Overall, you can see it takes around 11 minutes to reach Arfa Kareem, 16 minutes to New Block, 23 minutes to walk from Gate 2 to Arfa Kareem to Bank and 30 minutes for Mosque. You can see how much time is spent on walking daily which results in poor performance of students and causes foot pain, tiredness, headaches, or risks of heat stroke in summer.

Destination	Distance (m)	Time (s)	Speed (m/s)
Gate 2 – Arfa Kareem	829.8987793	682.95335	1.172834209
Gate 2 – New Block	1139.57959	972.59392	1.173421346
Gate 2 – Arfa Kareem – Bank	1640.840408	1407.95528	1.166981963
Gate 2 – Arfa Kareem – Mosque	1903.132356	1629.46259	1.169681685

Table 2. Data for the simulation of the problem

To-be Process

BPMN

First, students enter the university. The students who want to use scooty instead of walking will go to the scooty stand and the others will walk as usual they did. When students reached the scooty stand first to check if there is any scooty available then they'll proceed otherwise they'll be leaving the stand and walk because there is no scooty available for them, so they must walk instead of driving. If a student wants to drive the scooty and it's available, then he'll scan the QR Code. It's necessary to scan the QR Code because the scooties are locked at the stand and he must unlock the scooty first so he can use it. For scanning the QR Code the student must open the respective application which is specially designed for this scooty system. If a student already installed the application, then it's good but if he/she didn't install it already then, he/she must download and install it first to be entertained by this system. If he/she installed it already then, it's good for him/her because he/she wouldn't spend time installing it and maybe he/she doesn't have an internet connection.

The student will open the application. If a student already has an account, then he/she will log in with his username and password otherwise he/she must create the account first by entering his/her credentials like name, roll no, etc. The student will log in to the application with a username and password which he/she specified during the creation of the account. Now if the student logs in, then the student is eligible to scan the QR code of the scooty. When a student scans the QR Code of the scooty, then the scooty will unlock. When it's unlocked the time counter starts from zero. The time counter runs till the QR code is not scanned at the scooty stand. Now the student can use this rental service. Now he/she will drive the scooty and visits the places where he/she wants to go like mosque and cafe etc. This system will charge a student according to the time elapsed. The fare price is already defined in the system. The student can use this service just within the area of the university. It's against the rules of the system to go outside of the university so a student can't go outside the university by driving the scooty. Price will be calculated over time. When a student finished the journey and wants to return the scooty to the scooty stand then he/she will go for the scooty stand and park it.

Now he/she must pay the fare of the ride. Now again he will open the application and then scan the QR code of the scooty. Then the time counter which started when the scooty is unlocked will stop. Now the time counter of the scooty will show the total distance covered by the scooty, the time elapsed from the scooty unlocking to again locking state, and the fare of the scooty according to the time elapsed. Now it's time to pay the fare so the student will pay the fare by several methods like Easypaisa, Jazz Cash, and debit card but they can't pay by cash because this system is fully automated. It's very easy for them to pay the fare by using a card or any other banking application. Once the QR code is scanned and payment is done then scooty will be locked. Now the purpose of the student fulfilled and now he/she can go so he/she will leave the scooty stand.

Now, whenever a student comes to the scooty stand and wants to take the scooty then again, this whole process repeats, and he/she will be getting benefits from the system. By using this system, a student can travel a long distance by spending the minimum time. So, a student can save his/her precious time. Now, they will not feel headaches, foot pain, muscle fatigue and soreness, knee pain, back pain, dehydration, etc. because their energy is conserved. Now students' energy and time are conserved, and they may invest them in their studies and productive things. Finally, their grades will be good, and they will not doubt their own ability.

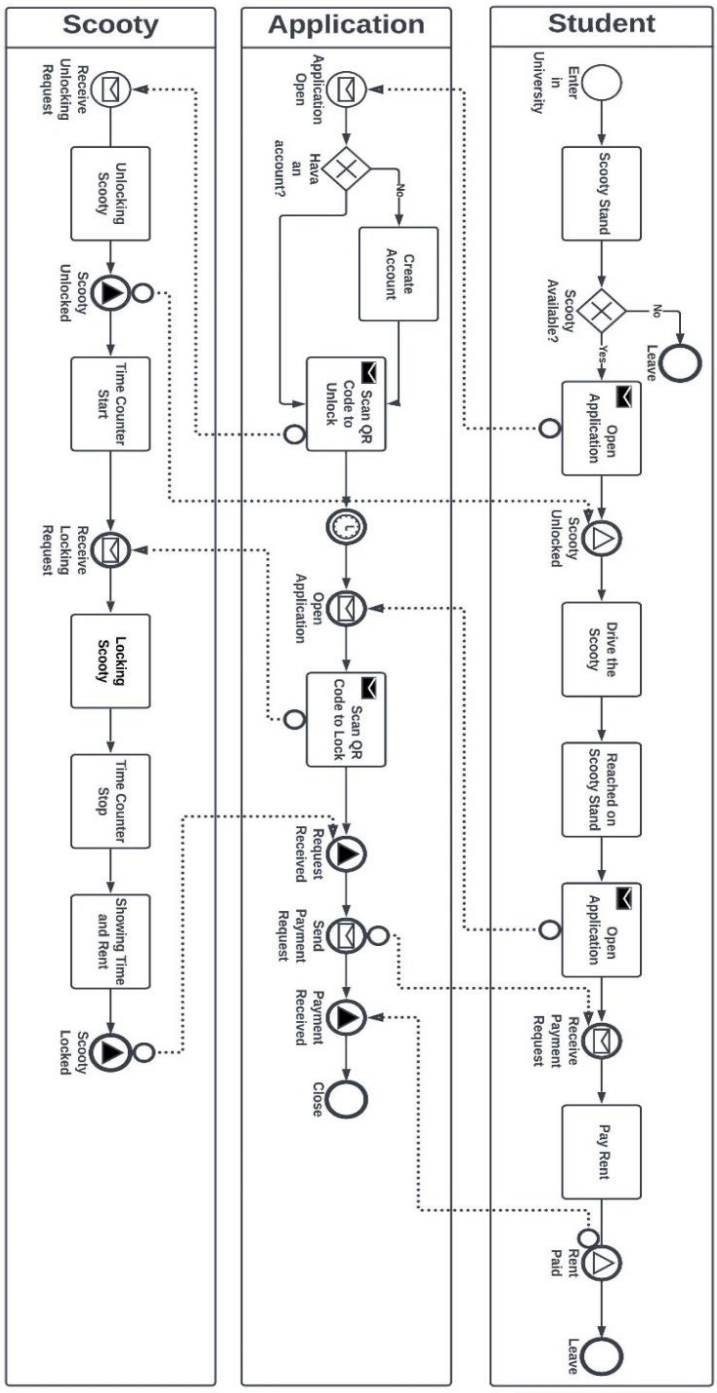


Figure 6. To-be Process BPMN

Simulation Model

For our Solution simulation, 100 Students first have a choice to go to the scooty stands first. This results in less time consumption, also students don't get tired that much and foot pain probability decreases to nearly 0%. Cases of headaches also decreases.

When student reaches a stand, there is a small simulation run of the mobile app in which through several states, Phone first scans the QR code, then check the balance and if available then starts the counter of money which is 5 rupees per minutes. When the students reach the destination stand, the counter stops and the money is deducted from the total amount.

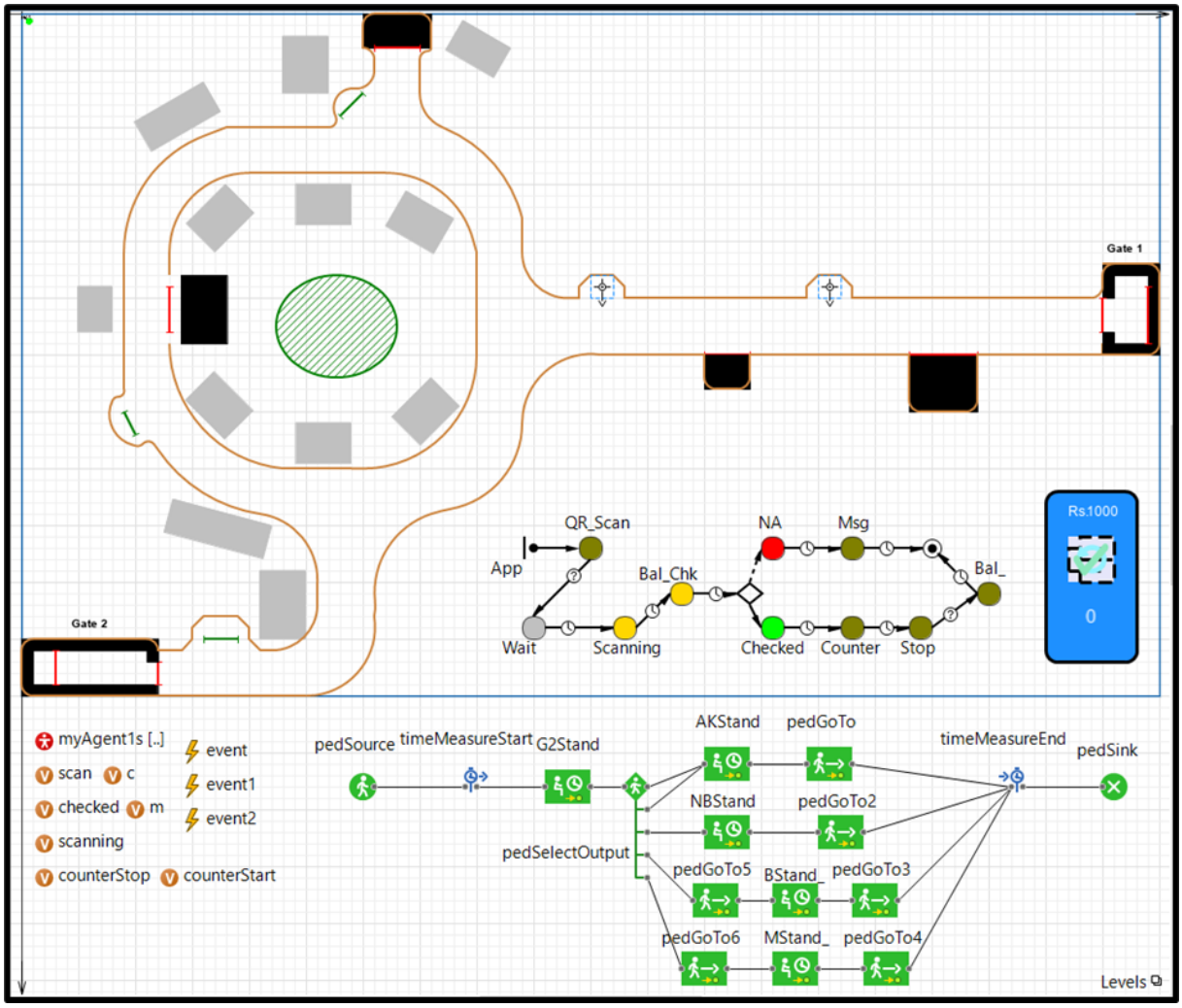


Figure 7. To-be Simulation Model

The simulation starts with interface at blank and state chart at pause. When the first agent reaches a stand. Then The state chart shifts from pause to showing barcode then scanning barcode, check the balance and then starts the counter for money. These states consecutively change the interface of mobile by using several variables, events, and conditions.

To-be Process Simulation Data

According to average data collected by 100 Agents, it takes 4 mins to reach Arfa Kareem, 5.5 minutes to reach New Block, 7.9 minutes to reach from Gate 2 to Arfa Kareem then to Bank, 9.1 minutes for Mosque. You can see how much less time it took for students to reach their destination if they use the scooties. Also, when the elderly people come with students, they are also required to walk inside university as bringing your transport inside is not allowed. With this Rental Bike system, it will be less troubling for the elderly people also as they can use this facility and don't have to walk long distances which is poor for their health.

Destination	Distance (m)	Time (s)	Speed (m/s)
Gate 2 – Arfa Kareem	847.9309	241.50323	3.565958014
Gate 2 – New Block	1189.10853	330.262	3.664444198
Gate 2 – Arfa Kareem – Bank	1694.698503	476.48225	3.630700597
Gate 2 – Arfa Kareem – Mosque	1916.727428	546.58526	3.580022766

Table 3. Date for the simulation of the solution

Difference between Is-A and To-be Process Simulation Data

On Average 774 seconds are saved by using Scooties instead of walking. Not only this difference shows the time saved, but it also means that the possibility of extreme tiredness or other problems due to walking will completely be reduced to 0 percent.

Problem Simulation Time(s)	Solution Simulation Time(s)	Time Saved(s)
682.95335	241.50323	441.45012
972.59392	330.262	642.33192
1407.95528	476.48225	931.47303
1629.46259	546.58526	1082.87733

Table 4. Difference between problem and solution simulation time

Difference between Is-A and To-be Process

Sr. No.	Is-A Process	To-be Process
1	Students have only one choice to reach the destination which is walking.	Students have choice whether they want to prefer walking or use our scooty system.
2	Students are forced to walk, no matter what's the condition.	Students are not bound to walk because they have a choice.
3	Students waste much of their time in walking.	Students conserve their time by using scooties.
4	Students spend a lot of their energy on walking.	Students can conserve their energy by using scooties.
5	Students cover less distance in more time.	Students cover more distance in less time.
6	Due to the students cannot spend more time in studies due to fatigue of walking etc.	They can give much of their time to studies.
7	It causes headaches, foot pain, muscle fatigue and soreness, knee pain, back pain, dehydration, etc.	No or fewer chances of headaches, foot pain, muscle fatigue and soreness, knee pain, back pain, dehydration, etc.

Table 5. Difference between problem and solution BPMN

In our Is-A BPMN, the process starts in which the participant just must walk towards the destination no matter what the situation there one choice and its walking is only. This process costs a lot of time and forces the participant to walk while ignoring the participant's condition. Meanwhile, in our To-Be BPMN, the process where the participant must walk is not a must and is given as a choice to the participant. In this choice, two processes get involved which validates the participant to ride a scooty. This does not force the participant to walk and thus this process takes in the consideration of the participant's condition. As a result, this process is more favorable and is wanted by the student body.

4.7 Working of Application

The first interface of the app will show related to the user's account and will have two options, "Create Account" and "Sign-In." If the user is using the app for the first time and has never created an account, they can click on "Create Account" to create their account.

Figure 13. User Interface of the Application

Create Account

To create an account, the user will have to provide their personal details such as Name, Roll Number, Department, Semester, Phone Number, Email, Address, and select a password. Then, they will receive an OTP in their email, and their account will be successfully created. Once the user has created their account, they can sign-in to their account.

Sign-In

To sign-in, the user must have an account. To sign-in, the user will have to enter their email and password, and then they will receive an OTP in their email which they will need to enter in the app. If the user enters their email or password incorrectly, they will receive an error message asking them to re-enter the information correctly or create an account.

Scan QR

The next interface will show the user the scooters available on the stand. The user can check the power of the scooters. Each scooter will be locked in its parking slot. To unlock the lock, the user will need to scan a QR code from their app. This QR code will be available on the stand. As soon as the user scans the QR code, the bike will unlock from its slot, and the ride will start in the app, and a timer will show the ride time.

Payment

If the user has reached their destination, they will return the bike to the stand near their destination. If there is a free slot, the user can park the scooter there and end the ride by scanning the slot's QR code from their app. As soon as the QR code is scanned, the bike will lock in the slot, and the ride will end, and the app will show the charges based on per minute basis. For payment, the user can use the Easypaisa app, jazz cash, or Debit Card.

If the user does not make the payment within the given time, they will be charged 20 Rs daily, and this will be shown as a penalty in the app. The user will not be able to start the next ride until the payment is made.

CONCLUSION

Scooty Rental System, tailored to specific University Campuses, highlights the ingenuity behind efficient, sustainable, and hassle-free on-campus transportation. Designed to meet the needs of students and staff, the system allows users to find, hire, and return scooters via an intuitive mobile app. The effectiveness of the redesigned processes is validated by simulation results which show a significant reduction in operational time and an increase in the reliability of service provided. The system is also aligned with environmental objectives because it mitigates the negative impact of carbon emissions and alleviates traffic congestion on the campus. All in all, the project encapsulates the positive impact of smart mobility solutions on accessibility, efficiency, and university transportation system sustainability. This study evaluates the necessity of the scooter rental system in universities. The data from the survey directly shows that students do not like walking,

and they desire a transportation system within the university. The study used the survey data to model the problem and then simulated the problem. Then, it modeled the solution and simulated the solution, creating a complete process to change the system. Previously, there was no transportation in the university, but now, according to this study, the scooter rental system can be easily introduced in the university. The models and simulations also show that this system is 100% working and any problems that were occurring have now been fixed. Students will not face any health issues and they will not be late for their classes anymore. The design of the application has also been created in this study. The working of the application and its complete flow have been validated. The system has been completely changed to an online rental scooty system. Students can now rent a scooty from one stand and leave it at another stand and pay through the app. This solves the problem of students taking a long time to travel from one place to another and being late for class. With this system, they can now attend lectures on time and won't face any additional health issues due to walking long distances daily.

REFERENCES

[1] J. vom Brocke and M. Rosemann, Eds., *Handbook on Business Process Management 2*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010. doi: 10.1007/978-3-642-01982-1.

[2] A. M. Law, *Simulation modeling and analysis*, Fifth edition. in McGraw-Hill series in industrial engineering and management science. Dubuque: McGraw-Hill Education, 2013.

[3] W. M. P. van der Aalst, M. La Rosa, and F. M. Santoro, "Business Process Management," *Bus. Inf. Syst. Eng.*, vol. 58, no. 1, pp. 1–6, Feb. 2016, doi: 10.1007/s12599-015-0409-x.

[4] "Business Process Model and Notation (BPMN), Version 2.0".

[5] "BUSINESS PROCESS MANAGEMENT. Practical Guidelines to Successful. Implementations. Fourth edition JOHN JESTON - PDF Free Download." Accessed: Feb. 12, 2023. [Online]. Available: https://docplayer.net/129359579-Business-process-management-practical-guidelines-to-successful-implementations-fourth-edition-john-jeston.html

[6] S. Tafakkornia, B. Rezaee, and A. Sherkat Bazazan, "A decision support system for rebalancing strategy in electric scooter sharing systems: a case study in Mashhad, Iran," *J. Simul.*, vol. 0, no. 0, pp. 1–26, doi: 10.1080/17477778.2025.2558698.

[7] "Optimizing Profitability of E-Scooter Sharing System via Battery-aware Recommendation," SciSpace - Paper. Accessed: Oct. 24, 2025. [Online]. Available: https://scispace.com/papers/optimizing-profitability-of-e-scooter-sharing-system-via-1v2gh2kmib

[8] P. G. Tzouras *et al.*, "Agent-based models for simulating e-scooter sharing services: A review and a qualitative assessment," *Int. J. Transp. Sci. Technol.*, vol. 12, no. 1, pp. 71–85, Mar. 2023, doi: 10.1016/j.ijtst.2022.02.001.

[9] M. A. Ladin, L. F. Jun, A. S. Darawati, M. R. M. Yazid, A. Abbil, and H. A. M. Yahia, "Modelling on the Readiness in Implementation of Bike Sharing System at University," *Int. J. Adv. Res. Educ. Soc.*, vol. 4, no. 1, Art. no. 1, Mar. 2022.

[10] "Agent-based models for simulating e-scooter sharing services: A review and a qualitative assessment | Elsevier Enhanced Reader." Accessed: Feb. 12, 2023. [Online]. Available: https://reader.elsevier.com/reader/sd/pii/S2046043022000016?token=F8A3112A7B6F073035DCF4BC8F3C4C56171F905DC4A252A6E9FDCE5BBEC2326630AB1EF2A433A637F41DFFC8BDE88BB3&originRegion=eu-west-1&originCreation=20230211203309

[11] S. M. H. Moosavi *et al.*, "Understanding and Predicting the Usage of Shared Electric Scooter Services on University Campuses," *Appl. Sci.*, vol. 12, no. 18, Art. no. 18, Jan. 2022, doi: 10.3390/app12189392.

[12] M. shan khalid, R. Khan, A. Khan, M. Khan, and A. Lah, "Determination of best public transport mode using Multicriteria Analysis: A case study of Peshawar city, Khyber Pakhtunkhwa, Pakistan," Oct. 2021.

[13] H. Ayadi, A. Zouari, and N. Hamani, "An exploratory study of the bike rental system," June 2019.

[14] I. G. Purwanda, T. Adiono, S. Situmorang, F. Dawani, H. A. Samhany, and S. Fuada, "Prototyping design of a low-cost bike sharing system for smart city application," in *2017 International Conference on ICT For Smart Society (ICISS)*, Sept. 2017, pp. 1–6. doi: 10.1109/ICTSS.2017.8288882.

[15] S. F. Kiefer, T. M. Ericson, K. Meah, and J. Moscola, "Design, Build, and Installation of an Automated Bike Rental System as a Part of Capstone Design," presented at the 2016 ASEE Annual Conference & Exposition, June 2016. Accessed: Jan. 30, 2023. [Online]. Available: https://peer.asee.org/design-build-and-installation-of-an-automated-bike-rental-system-as-a-part-of-capstone-design