Design and Analysis of a Real-Time Bus Queuing and Monitoring System

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Abstract

A significant portion of the student's time is wasted daily waiting for a bus and contending for a seat upon the bus arrival. In this paper we propose a real-time bus Queuing and monitoring system, which aims at increasing the productivity of the students by engaging them in an active waiting; and at the same time enhancing the picture of our universities and the society overall. The system is proposed for Yarmouk University as a case study, although it is general and can be used anywhere.

Keywords: Queue; Congestion; Service Time; Actual Waiting Time; Perceived Waiting Time; ER Diagram.

Introduction

Many students suffer every day from the long periods they spend waiting for public buses. Upon the bus arrival, students struggle for getting a seat in those buses. If the student misses a bus, he or she is involved in a similar contention when the next bus arrives hoping a better luck, and the cycle is repeated. Unfortunately, this ugly scene occurs every day and carries many catastrophic consequences. Firstly, a great amount of every student's time is wasted, which has a very bad impact on the student's academic achievements. Secondly, the waiting and contention on buses under bad weather conditions result in an unpleasant effects on the student's health and psychology. Thirdly, the scene of tens of students running after the bus and contending at the bus door presents to the observer a bad picture about the society, since these students represent the educated sector. Of course, there are many other bad consequences.

In an attempt to offer a practical solution to the aforementioned problem, we propose a real-time bus Queuing and monitoring system. The use of the proposed system comes with several benefits. Among many others, the list below outlines some of these benefits:
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- Achieving a controlled and balanced waiting time for all students.
- Using the available tools to monitor student waiting in real time.
- Minimizing the actual waiting time by choosing appropriate Queuing disciplines.
- Minimizing the perceived waiting time by engaging students in active waiting. This can be made possible by filling the waiting time with activities that reduce the perceived waiting time and consequently enhance the waiting experience.
- Helping stakeholders to decide when to add additional service buses especially at severely congested instances.
- Keeping statistics for later use: if data is gathered and stored, then stakeholder can at any point in time use that data for evaluation purposes.
- Generating reports on student waiting times, where operational inefficiencies can be identified and addressed through training and/or process changes.

One of the most important components of our proposed system, which we will talk about in detail later, is the use of display panels at each of the university faculties and in the library. The display panel is usually a plasma display panel (PDP) [1], or a liquid crystal display (LCD) [2], which are lightweight flat screen display technologies. One possible view that the student expect to see on the display panel is shown in Figure 1. The existence of such display panels at different locations inside the university enables students to plan ahead of time when is the right moment to book tickets according to their situations. Furthermore, if the student finds out that he or she has to wait for, say an hour, then that student can fill the waiting time with useful activities like studying at the library, doing a homework, or surfing the Internet. When it is time to go, the student leaves, where he or she finds the bus waiting.

![Figure 1: An example display panel, where at each instant of time and for any of the desired destinations, the student will be able to know the number of available buses, the number of students ahead of him, and how long he has to wait if he books at the moment](image-url)
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This paper is organized as follows: the following section talks about the problem statement. A literature review is given in Section 3. Next, we give a short background about the subject and illustrate some notations and examples. The proposed real-time bus queuing and monitoring system is introduced in Section 5 and Section 6 talks about the system database. Some practical considerations are given in Section 7, and finally Section 8 concludes the paper.

Problem Statement

The need for an efficient system to process such overwhelming numbers of students leaving the university after finishing their classes is not just a luxury but a necessity. Before getting into the details of the proposed queuing and monitoring system, let us have a look at an example (adapted from [3]) that will give some feel of the topic. Consider a group of buses having the same destination and capable of serving 200 students every 50 minutes. Now suppose that the average arrival rate of students is 170 student per hour, throughout the day in average, with some variability.

During any time of the day, there may be no students, or one, or multiple students. For example, it is anticipated that the nature of student arrivals to be bursty especially at the end of lecture times, when lots of students bunch up. At that case arriving students enter a queue waiting to be served. During quiet times, there is a greater opportunity to catch up and clear the queue. Table 1 gives an example of the behavior of such a system. The entries in the table show the number of students who arrive at five-minute periods, the number of students served during that time, and the number of outstanding requests waiting in the line. Here, we focus on the segment of the day 2:00 P.M. - 4:45 P.M., which is the peak service period that we are the most concerned with since it is the most congested time of the day. It should be pointed out that if the buses are idle (the number of arriving students is less than the maximum bus capacity), the students must wait until the bus is full and this case is not of interest to us.

Table (1): An example queue behavior for the period of the day 2:00 P.M. - 4:45 P.M. assuming a service rate of 200 students per 50 minutes.

<table>
<thead>
<tr>
<th>Time</th>
<th>No. of Arriving Students</th>
<th>No. of Served Students</th>
<th>Backlog</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:00P.M.</td>
<td>100</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>2:05P.M.</td>
<td>100</td>
<td>20</td>
<td>160</td>
</tr>
<tr>
<td>2:10P.M.</td>
<td>70</td>
<td>20</td>
<td>210</td>
</tr>
<tr>
<td>2:15P.M.</td>
<td>0</td>
<td>20</td>
<td>190</td>
</tr>
<tr>
<td>2:20P.M.</td>
<td>0</td>
<td>20</td>
<td>170</td>
</tr>
<tr>
<td>2:25P.M.</td>
<td>0</td>
<td>20</td>
<td>150</td>
</tr>
<tr>
<td>2:30P.M.</td>
<td>0</td>
<td>20</td>
<td>130</td>
</tr>
<tr>
<td>2:35P.M.</td>
<td>0</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>2:40P.M.</td>
<td>0</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>2:45P.M.</td>
<td>0</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>2:50P.M.</td>
<td>0</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>2:55P.M.</td>
<td>0</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>
In this example, we consider a number of practical (or close to practical) assumptions. The total number of buses going to a particular direction is assumed to be 10. The round trip time for one bus is approximately 50 minutes. The arrival of buses is of stochastic nature, that is, two or three buses may arrive at the same time, or the students may wait for 10 minutes before a bus comes. But we are pretty sure that during the 50 minutes period all the ten buses arrive, so for simplicity we assume that one bus arrives every 5 minutes. The capacity of all the buses is assumed to be the same, that is 20 passengers. The filling time (the time for all the passengers to get into the bus) is assumed to be 4 minutes, which is short enough before the arrival of the next bus. The service rate is thus 200 students/50 minutes, or 240 students/hour, or 1 student/15 seconds.

As this example illustrates, with increasing student arrival rate, the utilization of the system (the fraction of time the buses are busy serving students) increases and with it the congestion becomes more severe, the queue becomes longer and the waiting time increases. At full utilization, the system becomes saturated when all the buses are working 100% of the time. In this case the departure rate remains constant (20 students/5 minutes), no matter how greater the arrival rate becomes.
Many students wish that getting into the bus is accomplished in a civilized and organized fashion and that not much of their valuable time is wasted in vain. Thus, improving student satisfaction and alleviating congestion is the ultimate goal of our work, where in this paper we propose a system that is capable of placing students in appropriate queues, reducing the time spent waiting by the student, and producing a positive impact on the service experience.

**Literature Review**

Queuing theory is a branch of applied mathematics utilizing concepts from the field of stochastic processes to study the waiting line phenomena [4]. Customer (or client), server, service time, and waiting time are some basic terms used in Queuing analysis. Figure 2 depicts a simple Queuing system. In our work, customers are students (or passengers), buses are the servers, service time is the bus roundtrip time, and waiting time is the time spent by students waiting in the line to be served. The importance of Queuing analysis in our daily life has led to a continually growing literature. [5] covers Queuing theory and many applications in computers and communications. [6] is an introductory textbook to Queuing theory with a number of worked-out examples. [7] has a good treatment of Queuing networks, which are several interconnected queues.

![Figure (2): Queuing system structure](image)

In his paper [8], Maister talked about some psychological considerations involved in managing customers' acceptance of waiting time. He presented eight propositions about the psychology of queues. In summary, Maister says that unoccupied time feels longer than occupied time, pre-process waits feel longer than in-process waits, anxiety makes waits seem longer, uncertain waits are longer than known, finite waits, unexplained waits are longer than explained waits, unfair waits are longer than equitable waits, the more valuable the service, the longer I will wait, and that solo waiting feels longer than group waiting. Each of Maister's propositions was considered in our work to influence the students' satisfaction about bus waiting experience.

In his paper [9] Delbrouck proposed a procedure to approximate the main congestion functions associated with peaky and smooth teletraffic utilizing the parametric similarities between the predictive value of Pascal and Bernoulli distributions, and busy-idle state probabilities in lost-call cleared systems, to Poisson and Gaussian distributions.
Whitt [10] investigated the possibility of predicting each customer's waiting time in queue before starting service in a multiserver service system with the first-come first-served service discipline by exploiting information about system state, including the number of customers in the system ahead of the current customer, and by classifying customers and the service agents to which they are assigned. He used a predicted waiting-time distribution in addition to a summary statistic such as the mean or the 90th percentile to the customer upon arrival and possibly thereafter in order to improve customer satisfaction.

In the other paper of Whitt [11], he studied the effect upon performance in a service system, such as a telephone call center, of giving waiting customers state information. He distinguished two phenomena experienced by customers: balking, which is the abandonment immediately upon arrival, and reneging that is to abandon after waiting some time. He studied two M/M/s/r queuing models and showed that customers are more likely to balk when all servers are busy than reneging if the service provider announces anticipated delays to customers.

Jouini et al. [12] studied the problem of announcing delays to customers upon their arrival to multi-class call center. Two classes of customers with different priorities were considered. They developed a method based on Markov chains in order to estimate expected delays of new arrivals. The estimated delay was given firstly to a model without reneging. Then, they took into account the change in customer behavior when delay information is communicated to him. In that case they replaced customer reneging by balking that depends on the state of the system. In [13], Acharya and Ravindran discussed the application of queuing theory to library and information fields with examples related to counter service and circulation of books.

Many commercial products have come to the market recently for the purpose of queuing management [18], [19]. These products are usually seen in banks and post offices to enhance queuing experience. Such products have had good impact on both customers and business managers by alleviating the effect of long waiting times, managing the available serving agents effectively, and increasing the overall customer satisfaction.

**Background, Notation, and Examples**

A standard notation, called Kendall's notation [14], has been devised for describing and summarizing the properties of a queuing system. The notation is A/B/C, where A specifies the distribution of interarrival times, B refers to the distribution of service times, and C specifies the number of servers. The following abbreviations denote the most common distributions:

- **M**: exponential distribution, M comes from memoryless (independent and identically distributed)
- **D**: deterministic arrivals (fixed-length service)
- **G**: general distribution
Thus the model M/D/1 could be used to describe our queuing model, where we have Poisson arrival rate, fixed service time (e.g. 200 students per 50 minutes), and one server (assuming that the same destination buses are working as one server). Many useful formulas have been developed in the literature [3]-[7] for describing different queuing systems. Among many others, the following equations are of the most interest to us, where the M/D/1 queue is assumed. The notations used in the analysis are summarized in Table 2. The average number of students waiting for service is:

$$w = \frac{\rho^2}{2(1-\rho)},$$  \hspace{1cm} (1)

where,

$$\rho = \frac{\lambda}{\mu},$$  \hspace{1cm} (2)

and

$$T_s = \frac{1}{\mu}.$$  \hspace{1cm} (3)

The mean waiting time is:

$$T_w = \frac{\rho T_s}{2(1-\rho)},$$  \hspace{1cm} (4)

and the $y$th percentile is:

$$m_{T_w}(y) = \frac{T_w}{\rho} \times \ln \left( \frac{100\rho}{100 - y} \right).$$  \hspace{1cm} (5)

Table 2: Summary of notations used in the analysis of the proposed system.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>Arrival rate; mean number of arrivals per second</td>
</tr>
<tr>
<td>$T_s$</td>
<td>Mean service time</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Mean number of students served per second</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Utilization; fraction of time server is busy</td>
</tr>
<tr>
<td>$w$</td>
<td>Mean number of students waiting to be served</td>
</tr>
<tr>
<td>$T_w$</td>
<td>Mean waiting time</td>
</tr>
<tr>
<td>$m_x(y)$</td>
<td>$y$th percentile; that value of $y$ below which $x$ occurs $y$ percent of time</td>
</tr>
<tr>
<td>$T_{iw}$</td>
<td>Expected waiting time for an individual student</td>
</tr>
<tr>
<td>$N$</td>
<td>Number of students ahead of me</td>
</tr>
<tr>
<td>$M$</td>
<td>Maximum bus capacity</td>
</tr>
<tr>
<td>$BIAT$</td>
<td>Bus interarrival time</td>
</tr>
<tr>
<td>$RTT$</td>
<td>Individual bus roundtrip time</td>
</tr>
<tr>
<td>$B$</td>
<td>Total number of buses going to the same direction</td>
</tr>
</tbody>
</table>
**Example 1**

Returning back to the example given in Table 1, we said that $\mu = 240$ students/hour = 1 student/15 seconds. During the period 2:00 P.M. to 5:00 P.M., we see that the server (buses) is full almost all of the time. If $\lambda = 239$ students/hour, then

$$\rho = \frac{\lambda}{\mu} = \frac{239}{240} = 0.99583,$$

$$T_s = \frac{1}{\mu} = \frac{1}{240} \text{ hour} = \frac{1}{4} \text{ minutes} = 15 \text{ seconds}.$$

$$w = \frac{\rho^2}{2(1-\rho)} = \frac{0.99583^2}{2(1-0.99583)} = 119 \text{ students},$$

$$T_w = \frac{\rho T_s}{2(1-\rho)} = \frac{(0.99583)(0.25 \text{ min.})}{2(1-0.99583)} = 29.875 \text{ minutes},$$

and

$$m_{T_w}(90) = \frac{T_w}{\rho} \times \ln(10\rho) = \frac{29.875}{0.99583} \times \ln(10(0.99583)) = 68.952 \text{ minutes}.$$

This means that, at any moment between 2:00 P.M. and 5:00 P.M., 119 students in average every day will be waiting for service doing no useful work, a typical student will wait about half an hour (29.875 minutes) every day, and that 10% of the students will wait for more than an hour (68.952 minutes) every day. This example illustrates the urgent need for occupying the actual waiting time of students with a useful work to reduce the perceived waiting time and to increase their productivity.

Although equations (1)-(5) are very useful in summarizing the queue state especially for administrative purposes, students are much concerned about the actual expected waiting time that they will spend in the queue (the fourth column of Figure 1). The work of Whitt [10], [11] and Jouini et al. [12] for anticipating delays at call centers is close to the problem at hand but with some major differences. Although Whitt [10] used the number of customers in the system ahead of the current in the prediction of the customer's expected waiting time, he assumed different classes of customers and service agents, besides his assumption of exponential service time. In our case we assume one class of customers (students) and servers (buses), and that the service time is fixed.

Jouini et al. [12] have used identical service times by assuming a similar content of different types of calls, but the estimated virtual delays they provided with and without reneging considered two classes of calls according to the level of priority of the customer. Again, in our case we assume a single class of clients. Finally, in [11] the author addressed a similar problem for a call center model with a single class of impatient customers. He proposed a model incorporating announcements by assuming that a new customer who finds all servers busy balks with a given probability. In our
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case, the student decides before joining the line weather to wait or not, since a summary of the system is provided to students at different locations inside the campus. Once a student elects to wait in queue, we assume that he would never abandon thereafter since he needs to go home.

The expected waiting time for an individual student can be roughly calculated utilizing the available information as follows:

\[ T_{iw} = \left\lfloor \frac{N}{M} \right\rfloor \times BIAT, \]  

\[ BIAT = \frac{RTT}{B}, \]  \[ \text{and } \left\lfloor X \right\rfloor \text{ is the floor function of } x; \text{ the maximum integer less than } x. \]

\textbf{Example 2}

Suppose that a student wishes to go in a certain direction, where the total number of buses going to that direction is 10, the maximum bus capacity is 20 passengers, and the bus roundtrip time is 50 minutes. How long has that student to wait before she can get in the bus if she finds out that 234 students are ahead of her in the line?

\[ BIAT = \frac{RTT}{B} = \frac{50}{10} = 5 \text{ minutes}, \]

\[ T_{iw} = \left\lfloor \frac{N}{M} \right\rfloor \times BIAT = \left\lfloor \frac{234}{20} \right\rfloor \times 5 = 55 \text{ minutes}. \]

\textbf{The Proposed Queuing and Monitoring System}

To improve student satisfaction and enhance the waiting experience, our proposed system transforms a physical queue into a virtual one [15], which is a fictitious queue that enables waiting customers do useful work other than just waiting in a real line while preserving the right order of waiting customers. Looking at Figure 1, we see that the most challenging problem is knowing the number of students waiting in the line and the number of available buses. To this end, our proposed queuing and monitoring system consists of many components as illustrated in Figure 3. A server is used to store the database (see Section 6) and to process transactions.
A display panel is mounted at an open place in each of the university faculties that enables students to get current information about different directions at any time of the day (Figure 1). In addition to that, ticket printers are also provided. To deal with the problem of knowing the number of students in the queue, we propose using smart card readers/scanners. In this context, the student ID can be used to buy tickets, where it can be charged with different amounts of money (JD 1, JD 2, JD 5, JD 10, JD 20, etc.). If the balance goes down, the student can recharge the card again automatically. When the student checks in, at the time of requesting the service inside the campus, he is added to the tail of the queue. When he checks out, at the time he gets in the bus, he is removed from the head of the queue. The student is charged the exact amount of payment only when he checks out. The use of such smart cards has other merits like releasing the student from having the appropriate change, he is charged the exact amount, it is very convenient. Other means like finger prints or retinal scans can also be employed.

To know the number of available buses, the bus driver may also have a smart card, so that he checks in upon arrival and checks out at departure; or a radio frequency identification (RFID [16]) can be fixed at the bus, where it can be identified upon arrival and departure. The assumptions used in our work are listed in Table 3. These assumptions have been chosen to be as close as possible to reality. In this table, the dispatching discipline is the way students are treated where we use the first in, first out (FIFO), also known as first-come, first-served (FCFS) dispatching discipline.

Table (3): Summary of assumptions used in the proposed system.

<table>
<thead>
<tr>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatching discipline is FIFO.</td>
</tr>
<tr>
<td>After joining the queue, students are infinitely patient; no balking or reneging.</td>
</tr>
<tr>
<td>Service times are fixed.</td>
</tr>
<tr>
<td>Arrivals are Poisson distributed.</td>
</tr>
<tr>
<td>All buses to the same destination have the same capacity.</td>
</tr>
<tr>
<td>All buses to the same destination have the same roundtrip time.</td>
</tr>
<tr>
<td>All passengers are students.</td>
</tr>
</tbody>
</table>
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The server gets as inputs the students who check in and out as well as the buses which check in and out. With this vital information available at the server, it can calculate the number of available buses in addition to the number of students currently booking for a certain direction, and estimate the expected waiting time if the student makes a request at the moment using the equations given in Section 4. This information is fed as output to all the display units, providing students with up-to-date information throughout the day long.

The Database

The database that the server maintains is illustrated by the Entity-Relationship (ER) diagram [17] shown in Figure 4. The main entity in our database is the student who has a name and a unique ID (or university number). Students make reservations (bookings). Every reservation that the student makes is identified by a date and a time. For each reservation, the student expected departure time can be computed. Reservations made by students use buses. A bus is identified by its plate number and has a direction (final destination) and a maximum number of seats. At any given time, a bus may or may not be available (ready for service). The bus is analogous to the server in the queuing terminology, which could be free or already serving customers. A certain reservation is made from one of the university faculties. Each faculty has a name, is identified by a unique code, and is requires a certain amount of time to get walking from there to the gate, where the buses park. In order for the student to make a reservation, he should have a positive amount in his account balance, which has an expiration date.

The ER diagram of Figure 4 could be possibly mapped into the relational database schema [17] shown in Figure 5. Our database consists of five relations (tables): STUDENT, RESERVATION, BALANCE, BUS, and FACULTY. The STUDENT relation has the Name and Number attributes, with the Number being the primary key. The STUDENT relation has no foreign keys. The RESERVATION relation has the attributes Student number, Date, Time, Expected departure time, Faculty code, and Bus plate number, where the primary key is composite and consists of the simple attributes Student number, Date, and Time. Faculty code and Bus plate number are two foreign keys for the RESERVATION relation.

The BALANCE relation has the attributes Student number, Amount, and Expiration date, where the primary key is composite and consists of the simple attributes Student number (which is also a foreign key), and Amount. The BUS relation has the Plate Number, Direction, Number of seats, and Available attributes, with the Plate number being the primary key. There are no foreign keys. Finally, the FACULTY relation has the Name, Code, and Time to gate attributes, with Code being the primary key and no foreign keys.
The extension, or a database state [17] is a populated database, that is a database loaded with actual data. Figure 6 shows one possible database state for the real-time bus queuing and monitoring system. In any valid database state, tuples (rows) are added to the RESERVATION table when the student books (checking in) and deleted when she checks out, the BALANCE amount is then updated automatically. STUDENT tuples are inserted every new semester if there are freshmen, and deleted at the end of the semester when they graduate. Every time a new bus comes to service is added to the BUS table and is deleted when it retires.
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**Figure (5):** The relational database schema of the real-time bus queuing and monitoring database.

**Figure (6):** One possible database state for the real-time bus queuing and monitoring database.
Example 3

Figure 7 shows some of the updates that can be applied to the database schema of Figure 5 using the structured query language (SQL), where U1 is used to add a freshman to the STUDENT table. U2 is used to update the balance of a student, while U3 is used to remove a retired bus from the database.

\begin{verbatim}
U1: INSERT INTO STUDENT
VALUES ('Marwan Mufeed', '20108');

U2: UPDATE BALANCE
SET Amount = 16.77
WHERE Student_no = 20078;

U3: DELETE FROM BUS
WHERE Plate_no = '876';
\end{verbatim}

**Figure (7):** Some of SQL updates that can be applied to the database schema of Figure 5.

Example 4

We can get the values of $RTT$, $B$, $N$, and $M$ of Example 2 using the SQL queries Q1, Q2, Q3, and Q4 given in Figure 8, respectively.

\begin{verbatim}
Q1: SELECT RTT
FROM BUS
WHERE Direction = 'Downtown';

Q2: SELECT COUNT(*)
FROM BUS
WHERE Direction = 'Downtown';

Q3: SELECT COUNT(*)
FROM RESERVATION
WHERE Direction = 'Downtown';

Q4: SELECT No_of_seats
FROM BUS
WHERE Direction = 'Downtown';
\end{verbatim}

**Figure (8):** Some SQL queries on the database schema of Figure 5.

Some Practical Considerations

In this section we talk about some of the practical issues that should be considered to complement the proposed real-time bus queuing and monitoring system. One of the assumptions we made previously was that all the passengers are students. Non-student passengers are also allowed to book using our system, they can be given temporary IDs and placed in the proper queue.
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If the student reserves much earlier, the reservation will be canceled say 15 minutes after time to go, although he will be charged nothing for the reservation. In such a case, the student can be informed of the cancelation.

SMS messages (wireless text messages) can be sent from our proposed system to GSM mobile phones of the student informing him of the number of students waiting ahead of him in the queue of a certain direction if the student requests this service. In a similar way, an email can be sent to the student. The message will be something like: "Expected waiting time is 43 minutes. Please be there at 3:27 P.M. Your reservation will be canceled at 3:42 P.M."

A voice interface can also be used in our system to call students to the bus of the correct direction.

Concluding Remarks

Most of our university students suffer every day from the long periods of time they spend on the public transportations. The need for an efficient system to process such overwhelming numbers of students is not just a luxury, but a necessity. To improve student satisfaction and alleviate congestion, many students wish that getting into the bus is accomplished in a civilized and organized fashion. The main contribution of this paper is the construction of a real-time bus queuing and monitoring system. We propose a model which removes some of the burdens placed upon our students when they use the public transportation network. We have demonstrated how the proposed system is able to minimize the actual waiting time of students by choosing the most queuing principle and using available tools to monitor waiting in real time. It minimizes the perceived waiting time by engaging students in an active waiting like filling the waiting time with activities that reduce the perceived waiting time and hence enhance the waiting experience.
تصميم وتحليل نظام يعمل في الزمن الحقيقي للإشراف على عملية انتظار وركوب الطلاب في الحافلات العمومية

هسين الزعبي و محمود الخصاونة و شادي اللبون

ملخص
يُشيع جزء كبير من وقت الطالب يومياً بانتظار الحافلات العمومية وفي التزاحم مع زمانه للحصول على مقعد عند وصول الحافلة. في هذا المقال نقدم مقترحاً لتصميم وتحليل نظام يعمل في الزمن الحقيقي بهدف زيادة إنتاجية الطلبة وذلك من خلال إشراكم بما يسمى بالانتظار المفرط، ويبنف الوقت تحسين صورة الجامعات والمجتمع ككل. هذا النظام مقترح لجامعة اليرموك كعينة دراسية رغم أن نظام عام ويمكن تطبيقه في أي مكان.

References


