RFID Solutions: Parking Optimization and Customer Satisfaction

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Abstract

The current method of parking lot allocation has been used in Texas A&M University is not performing at optimal levels of efficiency. The Transportation Services issues parking permits each year to students, staff and faculty, based on the locations requested. We found the problem; there were too many parking spots assigned to individuals, which were not being used, but reserved. The parking spots that are not being used can now be allocated to other individuals to increase the parking lot utilization rate. These parking spots can be sold to individuals at a higher price due to its location depending on the zone and time of day.

This paper presents a capstone project that has designed and implemented a RFID parking pilot project that will involve the creation of a wireless real-time system to collect timely data for statistical analysis. This data will yield statistical results on specific parking lots on Texas A & M campus and will assist in a better understanding of the commuters' behavior. The questions arose are: who parked where, how long did they park there, and what time of day did they park there? The answer to these questions will provide insight on how parking lots are currently being used and possible methods to create higher profit margins and better customer satisfaction. In addition, the answer to these questions will assist the University to utilize parking spaces more effectively and efficiently. To provide the practical and accurate answer by collecting real-time data, the project will implement the system that incorporates both, RFID and GPS technologies. The data collected from the system will be wirelessly transmitted via the Internet into a database to be analyzed. The analysis of the transmitted data in the database will be accomplished using the management software package created by students. The analyzed results will be published on a web page for displaying data in real-time. From these results, a cost-benefit report will be created, showing the profit that could be obtained by the Transportation Services, when full implementation of the campus wide project is completed.

Introduction

Texas A&M University currently has 34,000 parking spaces and five parking garages. In order to monitor the traffic and parking on campus, Texas A & M transportation services currently employs 60 officers. A majority of the parking lots are not gate restricted and

require frequent monitoring to ensure parking rules are being followed. The current monitoring method employed at the non-gated lots is visual inspection performed by the on-duty officers. The restrictions on these lots vary from 30 minute parking, student parking, visitor parking, faculty/staff parking and 24-hour reserved parking. In most situations, the penalty for violating a parking regulation is a ticket issued by the transportation officers. These parking citations can vary from a warning all the way to the vehicle being towed. With 34,000 parking spaces and a limited monitoring staff, some individuals disregard regulations without penalty. This act can cause other individuals to be late to work, class or to also break regulation. There are other situations that occur after business hours. These situations include convenient parking spaces being un-utilized, individuals parking in garages without paying and other parking lots being under utilized. These situations along with parking offenses lead to a large loss of revenue for the transportation services. This capstone project is proposing a pilot project which will gather data to reduce officer monitoring time, increase regulation enforcement, reduce the need for large monitoring staff and reduce the need for large officer monitoring fleet.

Vehicle parking in the Texas A&M University campus has been a debatable and controversial topic for a number of years. The most important issue of all is the underutilization of parking spaces throughout the University campus. This underutilization occurs when individuals who have a reserved parking space choose not to use their assigned spots. Underutilization also occurs when individuals are waiting or searching for a parking spot at night when a majority of the reserved tag holders have gone home for the day. Other issues in parking include failure to follow regulations, large cost of monitoring staff and the large cost of providing monitoring methods for these officers.

In order to solve the given problem, there is a need of a proven method for gathering data (number of cars parked in which lot and at what times) in a systematic manner. The data gathered will provide an analysis of parking lot utilization and will aid in maximizing profit and reduce cost for the transportation services at Texas A&M University campus. This paper explores the use of Radio Frequency Identification (RFID) [1], [2], [3], [4] to solve all the above mentioned problems, especially the underutilization problem, by dynamically allocating the parking spaces in a prioritized fashion to people who want them, not only at Texas A & M University campus but everywhere on the planet.

Background

A team of three undergraduate Electronics and Telecommunication Engineering Technology students implemented the RFID parking pilot project, which involved the creation of a wireless real-time system to gather data for statistical analysis. This data was gathered to show statistical results on parking lot usages and will assist in a better understanding of the commuter behavior. The data gathered includes things like “Who used a spot?”, “When was it used?”, “For how long?” etc. The answer to these questions will provide insight on how parking lots are currently being used and possible methods to create higher profit margins. To provide this data, the team implemented a system that

incorporates both RFID and GPS technologies [5], [6]. The data (ID from RFID, location from GPS and time from the system) collected from these components on a mobile platform was wirelessly transmitted via the Internet into a central database for analysis. The analysis of the data was accomplished using the software package created by students. The analyzed results were presented using a web server for real-time data visibility. Among other results, was a cost-benefit report, showing the profit that could be obtained by the Transportation Services upon a full campus wide implementation of this system.

The RFID Parking Project

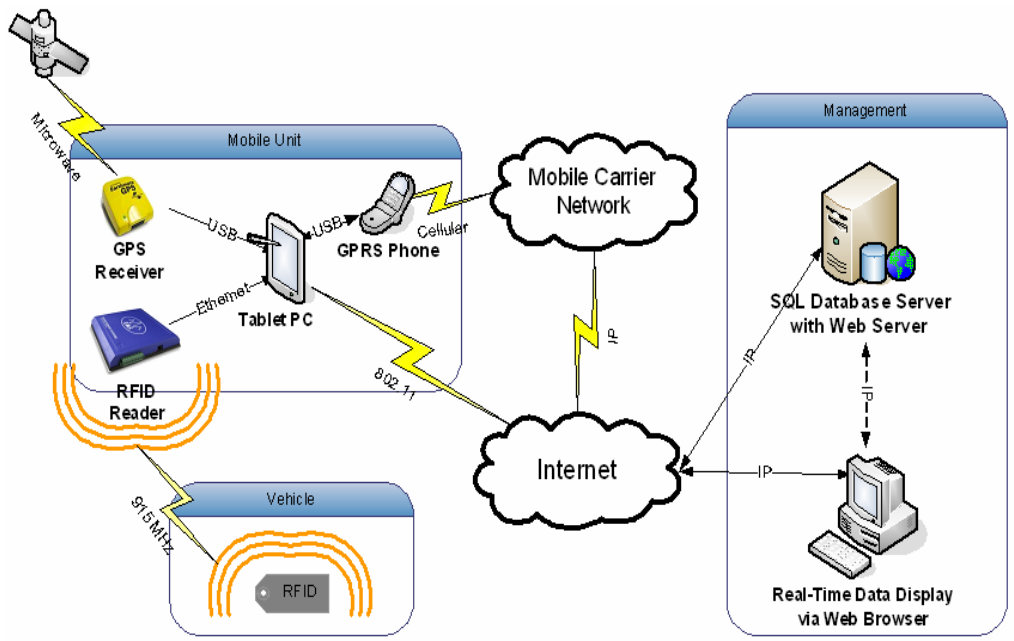

Figure 1: The RFID Parking System Design

The RFID Parking project is an integrated system that utilizes RFID, GPS, wireless connectivity and an advanced web-based system to show current parking utilization. There are three major components that make-up the composition of the project: the vehicle, the mobile unit, and the database and management as shown in Figure 1.

1. The Vehicle component is nothing but a 915 MHz RFID tag placed on a vehicle. This is just to indicate the presence of a vehicle in the spot. A Mobile Unit picks this tag up when it passes by. If no tag is read, the assumption is that the parking spot is empty.
2. The Mobile Unit is a unit that the parking inspector carries with him/her. This unit contains a PC, an RFID reader, a GPS receiver, and a 802.11/GPRS internet connection [7]. The RFID reader identifies the vehicle, the GPS information is required for location of the vehicle, while the wireless connectivity is required to

transmit the data real-time to a database. All the logic on the mobile unit was implemented on National Instrument's LabView [8], [9].

3. The database and management module is the most important part of the project. The mobile unit and the vehicle are simple modules, just to aid in the data collection process, while this module is responsible for storing, analyzing and controlling the parking data. Data coming in from numerous mobile units is stored in the database, reports generated from this data are published automatically using a web-server. These can be reviewed by customers (upon proper authentication), or by the management to better design the parking system.

The user friendly interface of the Mobile Unit Executive Dashboard is shown in Figure 2. This dashboard provides both visual and audio feedback to the operator when the Mobile Unit is in operation. The dashboard provides indicators of the current modes of operation. There is also a list of hot-keys to allow for a faster more efficient user interface. The Mobile Unit software is created to provide easy installation and minimal user interaction.

Figure 2: Mobile Unit Executive Dashboard

Benefits of the Project

The most important benefit the pilot project is a systematic analysis of current parking utilization. This utilization data shows whether or not the parking facilities are being used to their capacity. The management software can provide a method of viewing where parking is currently utilized the least. This provides the user the ability to log onto to the Internet and view the current availability of parking prior to leaving the house or through a wireless mobile device while driving. An example report is shown in Figure 3. Yes, there is still the possibility that upon arriving to the destination that there will no longer be available spots. This can be minimized by providing the user with historical usage data. Based on this the user can make an educated decision.

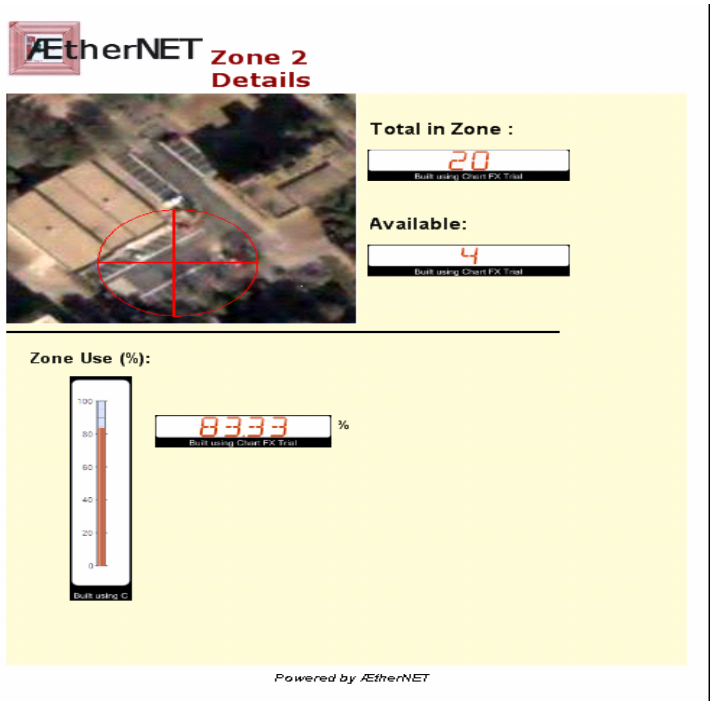

Figure 3: Zone 2 Details

Another benefit of this project is that the parking coordinator will be able to utilize a dynamic pricing structure to utilize the parking facilities at optimal capacity. Consider an example situation with two parking lots, where one of the lots is filling up with vehicles quick while the other is completely empty. The owner could lower the price of the empty parking lot to attract more users to park there. Alternatively, the price of the busy lot can be raised for higher revenues. This is the objective of a dynamic pricing structure.

Design of Experiment

The objective of this section is to design the experiment to gather data for the pilot project and the benefit of implementation. This document will show different analysis of the test period data. The analysis will include maximum utilization, minimum utilization and average utilization.

In order to learn the behavior of the parking lot, owners need to be assigned to a specific parking spot. Once the parking spots were assigned to a certain vehicle the utilization monitoring could start. The parking lot utilization data was gathered for a three week test period. Since the data of focus was for after business hours, the following times were chosen to monitor the parking lot: 3:00PM, 5:00PM, 7:00PM, 9:00PM, 11:00PM Monday through Friday and 9:00AM, 3:00PM, 7:00PM, 11:00PM Saturday through

Sunday. In order to show the expandability of the project, multiple zones were monitored.

The data gathered during the three week test period yielded that for both zone one and zone two the total average utilization was highest Monday thru Wednesday. The average total utilization for zone one on Monday, Tuesday and Wednesday were respectively 25.8%, 29.5% and 30%. Zone two had a total average utilization of 25.8%, 21.6% and 26.6% respectively for Monday, Tuesday and Wednesday as shown in Figure 4. As the week progressed the average total utilization for both zones began to decline. On Thursday, zone one had a total average utilization of 13.8% and zone two had an average utilization of 12.5%. Then on Friday zone one had a total average utilization of 11.4% while zone two was utilized 10.8%, on average. The total average utilization for both zones was below 5% for both Saturday and Sunday. On Saturday the total average utilization of zone one was 3.5% and 6.5% for zone two. Then on Sunday, zone one began to increase with a total average utilization equal to 4.1% and zone two continued to decrease to 4.1%. This total average utilization consisted of both valid and invalidly parked vehicles. Both were included to ensure both legal and illegal utilization were accounted for in the average. Figure 4 shows that for the most part valid parking made up a majority of the total utilization for the three week test period.

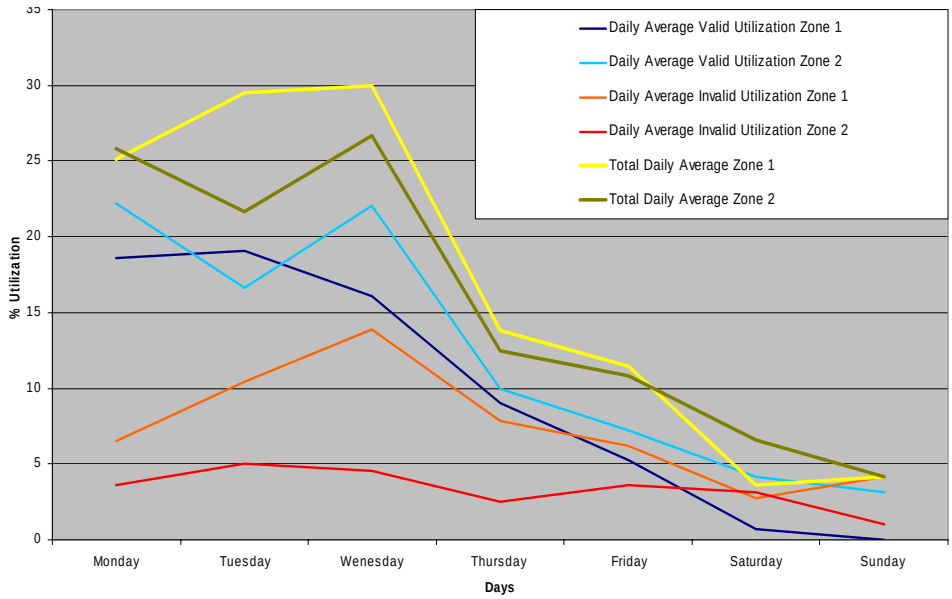

Figure 4: Average Total Utilization

The utilization data was also analyzed to check which test time provided the most utilization. Both zone one and zone two had an average utilization of less than 10% at the 9:00AM samples. The peak utilization for zone two occurred at 3:00PM and was equal to 46%. Zone one also had an average utilization of 46% at 3:00PM, but peaked at 5:00PM with an average utilization of 51.9% as seen in Figure 5. Then as the test times continued

to increase the average utilization began to decrease. Both zone one and zone two were always utilized though the 11:00 PM although the majority of the utilization was invalid.

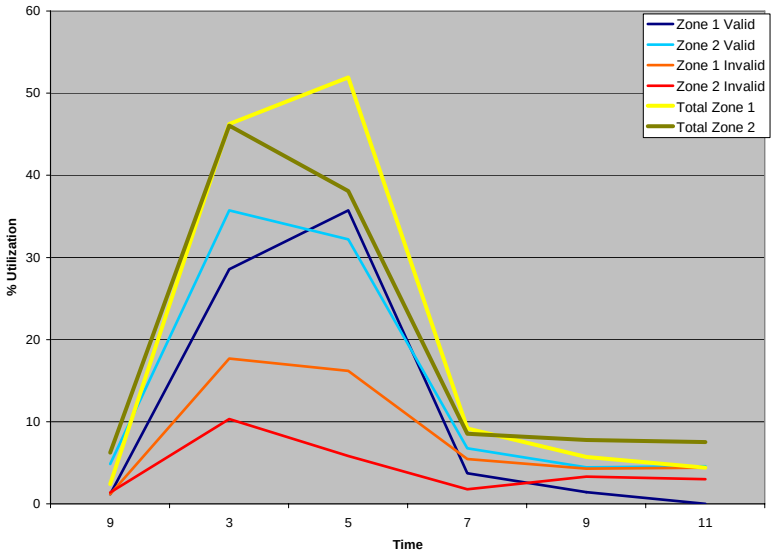

Figure 5: Average Zone Utilization per Test

The average utilization of a day was the next calculation gathered using the parking lot statistical data. From the calculation, zone two had the most usage with more than 50% valid parking. The zone one valid utilization was approximately 11% and 4% invalidly parked vehicles as shown in Figure 6. This data shows that on an average basis the utilization of both zones is limited to less than 20%.

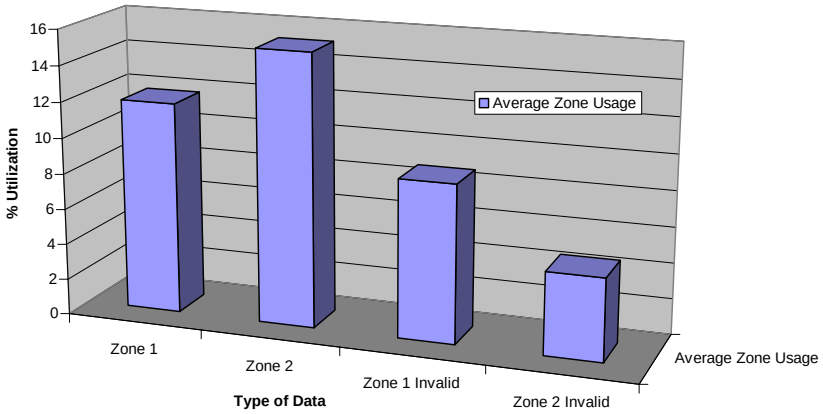

Figure 6: Average Day Utilization

The data gathered from the three week period of zone one and zone two parking utilization yielded that the parking lots are being under utilized. The utilization was made

up of both invalid and validly parked vehicles. The data shows that the utilization of the zones was not even 50%. This under utilization can be viewed as an opportunity cost. These zones could be rented out after business hours or sold on game day weekends. The data shows that the current methodology of zone usage is inefficient. The data reveals that current utilization is inefficient and that the RFID Parking system can help define utilization on a larger scale.

Cost Benefit Analysis

The most obvious benefit from this project comes from the ability to dynamically adjust the parking price. This dynamic pricing will not only balance-out the parking utilization throughput the campus but also bring in higher revenues to the parking authorities. As an example, consider two parking lots of equal size, similar location, next to each other with accessibility being the only difference. Let lot 1 be closer to the main street allowing easier access, while lot 2 be in the middle of the block with the entrance a short distance away. The owner's desire is always to have the parking utilization at a near 100% level, while the user's desire is to park in Lot 1 and save some time. If the owner prices lot 2 lower than lot 1, then most users will park in lot 2. If the owner has statistical usage data of these 2 lots, the prices can be set differently not only for different lots but also for different times. As one can see this is a win-win situation for both the owners and the users. The mobile unit system offers this dynamic pricing flexibility. This system will lower overhead, lower man-power and increase revenue.

The data gathered over the test period showed consistently that one of the parking lots was underutilized after 5 P.M. on weekdays and on weekends. Those who park in this lot during the day pay a substantial amount to reserve their right to park 24 hours a day and 7 days a week. This raises an important question: Why can't students or any other people have the option to park in that lot after the close of business? For instance, the teacher's certification program strictly offers their courses at night from the hours of 6-10 PM. Most of these individuals are women who must park in a distant location & possibly walk quite a distance through a few badly lit areas of campus. One solution would be to offer these individuals an option to purchase a night pass for parking lot 10 rather than paying by the hour usage of the campus parking garages. Another possibility is allowing the girls who live in the dormitory to have access to this parking lot for loading and unloading items at a minimal price. All of these suggestions are simple ideas to utilize the parking spots more effectively and generate more revenue that has been untapped.

Conclusion and Future Work

This paper explores the use of RFID technology to solve the problems faced by the parking authorities at the Texas A & M University, especially the underutilization problem. The project has successfully demonstrated a way to collect usage data using RFID and other automation technologies, and to use this data to dynamically price the parking spaces to balance the utilization. It is easy to show benefits not only at Texas A & M University campus but every parking entity on the planet.

The project is in it beginning phase of implementation. The current testing done with the pilot project was to gather data on parking lot utilization and to show proof of concept. The test result demonstrated that utilization of parking spaces was far from being efficient. Our system showed that RFID coupled with GPS was an effective way to monitor the utilization of parking lots. The division of the lot into two zones proved the future capability of a larger scale expansion of the project. The RFID parking project is in the stages of being demonstrated for both Texas A & M University Transportation Services and other potential markets. The current expectation of the next stage of the project is a campus wide implementation on all uncovered parking lots. The system has the potential of increasing both parking utilization and the most importantly potential revenue. The system has the capabilities of revolutionizing the effective utilization of parking lot.

Acknowledgement

This project was done by three electronics and telecommunications engineering technology students, Joseph Christoferson, Jaime Burgoa, and Derek Rodriguez.

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Biographies

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