IoT based Shuttle Cab Monitoring System

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Abstract
With globalization there has been an unprecedented increase in the number of vehicles and it has become hard to track them, even more so because of still using the same old fashioned technique of monitoring, by having the number of trips and the number of passengers being carried in each trip to be physically counted by individual(s). Even with significant advancement in the technological field there has been no to little change in how the monitoring is perceived. Although even with some small changes the monitoring system can be automated and made into self operating one, none have been implemented so far to achieve it. In this paper we propose a model for a smart monitoring system and some feasible methods for implementing it, in both small and large scales. We make use of the Internet of Things with the Cloud Computing to build a smart cab monitoring system. This will not just be helpful for monitoring purpose but will also help to make the system more intelligent through analyzing the pattern and data.

Keywords
IoT, Automated Cab, Monitoring, RFID, IR, People Counter, Cloud Storage

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Introduction

With the ever increase in the number of vehicles there has however not been an efficient way to track and monitor them. The need for Intelligent Transportation System (ITS) has become more and more yet there has been no huge development in the sector. The tracking that is most commonly employed involves the monitoring of vehicles manually by counting the number of trips and the number of passengers. The monitoring of surveillance footage is of course not feasible because of the cost for implementation as it requires the image processing in an advanced level and uses the concept of Machine Learning, and so cannot be implemented by the small scale organization. So to provide for effective way of tracking but at the same time being feasible in terms of both implementation and cost is needed. In this paper we shall discuss one such way of implementing through the use of RFID and IR sensors.

To deal with the problem, we first need to understand the problem and the above mentioned problem can be divided into two sub-problems, first is to count the number of trips made and track the time taken by the cab to travel from one stop to another while the second sub-problem is to calculate the number of passengers in each trip. As mentioned earlier we approach to implement the tracking system through the use of RFID and IR sensors. Additionally we send the data to the cloud, ThingSpeak for further analysis. We first take a closer look at these technologies and describe what exactly makes them the perfect choice for us over other technologies.

RFID

RFID which can be expanded to Radio Frequency Identification, is an Automatic Identification and Data Capture (AIDC) method that uses electromagnetic fields like radio frequency to automatically

identify and track the objects that have already been tagged or equipped with the RFID tag.

RFID tag are equipped with an unique identity which cannot be replicated and are only known to the manufacturer. These tags are stored in a database and linked to an unique key that is private to the organization so as to reference the tag to point to the object. The RFID tags are read by the readers and produces the unique code in hexadecimal which is then cross-referenced with the database and can show all the information regarding the it, that has been stored.

The use of RFID is preferred over other such Identification mechanisms such as Barcode, because it can automatically identify and track tags that are attached to objects from a distance without even requiring line of sight or physical contact [1] as the tag just need to be in the radius of the reader.

IR Sensors

Infrared Sensors are used to sense objects near it by either emitting or detecting infrared radiations. The IR sensor has a transmitter and a receiver placed side by side and the transmitter emits infrared radiations, if there is no obstacle the radiations does not get reflected back and so the receiver detects no radiations and so deduces that there is no obstacle present. However, if an object was present, the emitted radiations would strike the object and get reflected back to and can be detected by the receiver which now deduces that there is an obstacle present. This is the basic working model of the IR sensor [4].

IR sensors are preferred over other object detecting and sensing techniques, like Thermal Sensors, which senses the temperature of the body to detect the presence of an obstacle because the IR sensor is easily available and implemented and is cost efficient unlike thermal sensor.

Related Work

HERO

Hierarchical Exponential Region Organization or simply HERO is a Real-Time Vehicle Tracking system introduced in Shanghai, by Shanghai Grid (SG) and is an Intelligent Transportation System to improve the traffic condition and is based on the Trace-Driven methodology [3]. Shanghai is one of the most densely populated city in the world and so the number of vehicles in the city are also sky rocketing. To improve the traffic management system this concept was proposed that would cover the entire city range. The existing technology that was being used like GPS (Global Positioning System) or GSM (Global System for Mobile communication) are all satellite based [3], and are meant to cover the whole of earth, so the time to answer a query may take minutes in which time the positioning of the cars would have changed drastically.

The Shanghai Grid project exploits the RFID and local-area wireless communication technologies in order to make the system real time. The location information of each and every individual vehicles is actively logged in overlay network of local nodes that are distributed throughout the city but updates the location information only in the nearby nodes [3]. The prototype of the Shanghai Grid works on the model that a vehicle is equipped with an active RFID tag which can emit its ID at a fixed interval and has an efficient communication range of about 2-80 meters[2] which is heavily utilized. The battery can sustain the operation of an active tag for about 6 years [1]. So when a moving vehicle which is equipped with an active RFID tag emits signals and it reaches some reader, the information like status information and vacancy status is updated which can be analyzed and informed to other vehicles requesting for status update information, all in real time.

In **Automatic Toll Collection** the vehicles are equipped with a RFID tag while the reader is placed in the roadside unit. The roadside RFID readers reads the tag and identifies the passing vehicles and then it charges the fare [15].

Proposed Work

As discussed earlier the scenario can be divided into two sub-problems, first is to count the number of trips made and track the time taken by the cab to travel from one stop to another while the second

sub-problem is to calculate the number of passengers in each trip. For counting the number of cabs RFID will be used while people are counted by the infrared sensors.

The cabs will be equipped with unique RFID (radio-frequency identity card) tags and all have unique values that cannot be altered or tampered while the all the cab stops will be having a RFID scanner. Since RFID uses wireless radio frequency to identify objects from a distance without even requiring line of sight or physical contact makes it a perfect for the use. The shuttle cab stops or at an appropriate distances as required, the scanners will be placed strategically so that they will be capable and efficient enough to scan and record the unique Id of the cab through reading the tag and storing it either locally or in the cloud[11]. Each reader has its own read range and they scan all the tags in that range so the number of tags in the read range should not be more than required. A time metric that is the random tag pause time, is one critical factor influencing the RFID read performance. A long pause time helps prevent RFID tags from collision but at the same time it degrades the RFID performance in applications that are time-sensitive and require very less time latency. This will be efficient as it can track the drivers who deviate from their paths or take longer time to cross from one stop to another.

While for counting the number of passengers, People Counter can be implemented using the Infrared Beams counter that works on the Principle of Reflection Light Scanner [5] and is implemented by having the infrared beams attached to side of the door to form an infrared radiation link and when this link is broken when someone passes, it registers the interrupt when a person entering or leaving and thus increases or decreases the counter. All this information can be stored locally or in the cloud and the server keeps record of all the information collected on daily basis in a database and then this data is sent to ThingSpeak, which analyses the information and visualizes it to form graphs which can be further used to improve the Quality of Service in the future.

Figure 1 depicts the architectural design of the proposed work. Here the RFID having the component device name as RC522 is attached to Arduino Uno R3 through number of pins and so is the Infrared Sensor. Both the sensors work separately without being effected by each other as seen in the diagram because both are independent of each other and communicates with Arduino board only.

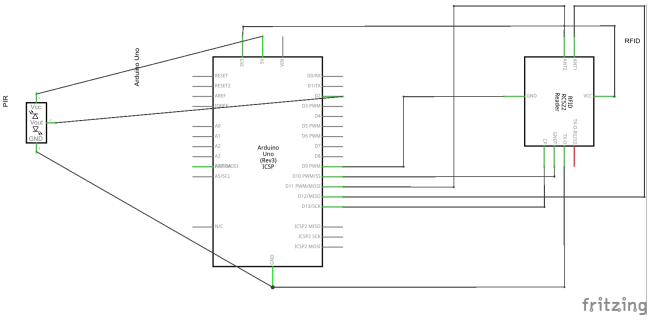

Figure 1. Architectural Design

Results

The scanner was able to scan the tag and store the data in the cloud and the IR sensor which upon getting interrupted records the number of people. These data were then sent to ThingSpeak which then visualizes them to form graphs like the number of rfid scanned vs date graph (figure 2), the ir interrupts vs date graph (figure 3) and the number of people vs date graph (figure 4). From these graphs the peak time of usage and all can easily be found which can be used for future work and to improve the customer service as the availability of cabs at the peak times can be increased and at the non-rush hours only the required number of them need to operate instead of all them thereby conserving the energy and also being cost efficient.

The Figure 2, the depicts the number of RFID tags scanned over a period of time the increase in the graph is the number of tags scanned. From this graph we can determine that at which time cab is moving more frequently.

From the figure 3, which depicts the graph of ir interrupts in the time period and is used to determine the people entering or leaving the cab, the increase in interrupt determines the rush hour where the facilities are required and so the more and more cabs can be made available by analyzing the pattern.

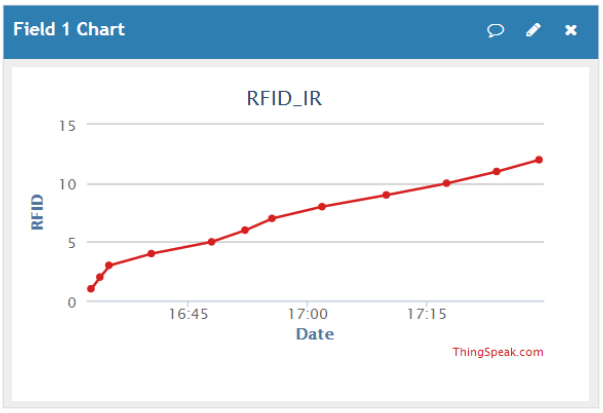

Figure 2. RFID scanned vs Date graph

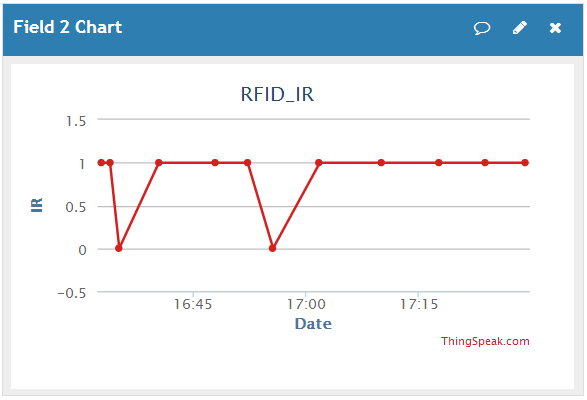

Figure 3. IR interrupts vs Date graph

While the figure 4, shows the graph of number of people inside the cab vs the date. This graph is of most importance as it determines when the cab is being used the most which in turn make the cabs to operate more frequently or more numbers are employed. This trend of usage can be analyzed for future studies and to make the user experience better. From such analysis we can prepare the system so that it handle such kind of traffic.

Conclusion

Using the RFID and IR to record the number of trips and passengers, respectively is an efficient way to automate the monitoring of vehicles. The need for physical staff can be reduced and the time delay can also be lowered. As explained before and evident from the figure 4, the increase in the number of users can be handled efficiently as the pattern can

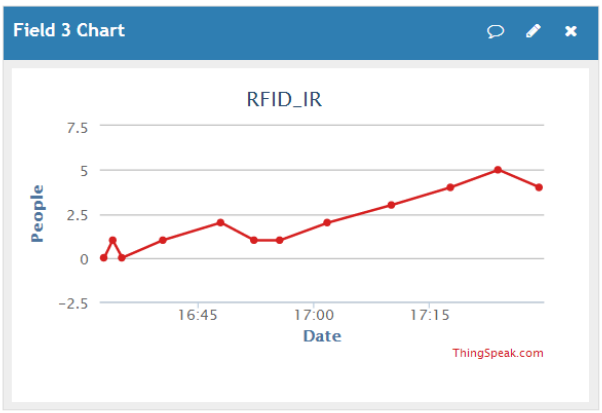

Figure 4. People vs Date graph

be analyzed beforehand and it can be prepared for such scenarios. However, to make the IR more effective the time for the interrupt to be considered for calculations should be more than 2.5 seconds so as to remove any insensitive interrupts. While using Passive RFID tag the cabs were required to slow down so that the scanner can read it, but when using the active tag, which emits its unique value at regular intervals can be designed so that the tags can emit when they are about to reach the scanner and so they can emit its value which can be recorded removing any time delay for scanning.

Future Work

The concept of such monitoring system using the IoT technology is comparatively new and so the scope of future works are huge. As the monitoring system can be made intelligent by Machine Learning so that the system will itself be able handle the rush hours by distributing the vehicles and the system can become self-operating.

This can also be used to regulate the traffic controls in the manner that all the vehicles will be having both the tag and the scanner and a local computing node can be introduced that can store all the information about the traffic by reading all the datas around it and then analyzing them to make smart decisions as where the cars must head in order to face least traffic and so on. The cabs can also be equipped with the GSM module, to facilitate the inter-communication between all the cabs directly

without the local nodes to enrich the user experience and to further reduce the latency.

The payment for the cab ride can also be introduced by issuing all the customers with a tag which needs to be recharged, for paying the cab fare the the system will itself deduct the stipulated money from the tag and thus the users might not always need to carry the exact change for the ride, which also promotes cashless transaction.

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