Traffic Lights through An IoT

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Abstract-*Vehicular traffic is continuously increasing around the world. The existing methods for traffic management and control are not efficient in terms of performance, maintenance and cost. Intelligent Traffic Lights which has the ability to preempt emergency vehicle to drastically reduce the response time is needed. Internet of Things is the next big thing in the Tech World. In fact it"s already here. The revolution is real. In this paper, an alternative to the currently established system of preprogrammed traffic lights which are used in most of the cities across the world is put forth.*

Keywords-Internet of Things, Emergency Vehicle Preemption, Node.js, Global Positioning System.

I. INTRODUCTION

Intelligent Traffic Lights in itself contains wide variety of propositions and ideas, although very rarely implemented successfully. Some to ensure smooth flow of traffic using Image processing or by vehicle density sensors, while others are used to preempt emergency vehicles and this is what our focus is on. Emergency Vehicle Preemption is a must if we want to name our system Intelligent Traffic Lights. It has the potential to save many lives which is invaluable. While most of the system to achieve Emergency Vehicle Preemption (EVP) uses wide range of expensive sensors. Our system uses a different approach. An Internet of Things approach

INTERNET OF THINGS

The Internet of Things (IOT) will change everything including ourselves. It is the future. The potential benefits of IOT are almost limitless and it is opening new opportunities for growth, innovation and knowledge creation. The Internet of Things is defined by ITU and IERC as a dynamic global network infrastructure and self-configuring capabilities based on standard interoperable communication protocols where physical and virtual things have identities, physical attributes and virtual personalities, use intelligent interfaces and are seemingly integrated into the information network. [1] We can see the Internet of Things as a general evolution of Internet "from a network of interconnected computers to a network of interconnected objects". [2] Here the idea is to connect the traffic lights to the internet to communicate with it. Once this is done the applications are limitless. We can easily preempt emergency vehicle using GPS which we have already successfully implemented. It can also be taken further to synchronize the traffic lights by means of communication of traffic lights with each other.

EMERGENCY VEHICLE PREEMPTION

As stated earlier there are many alternatives and different methods in which traffic signals can be made smart but the presence of traffic preemption for emergency vehicles is one of the most important functionality. Simply because it saves lives. Sudden appearance of an emergency vehicle en route to an emergency can extremely disruptive to nearby vehicles as some drivers manoeuvre to get out of the way and some do not. This can cause conflicts, driver confusion and finally results in a road block denying right of way to emergency vehicles. Providing safe and fast driving environment for emergency vehicles to reduce response time is a critical issue in traffic removal. Under effective preemption, ones can reach their destinations at the earliest possible time which is one of most critical factors in saving lives. [3] Most Preemption techniques to date developed operate on a single intersection basis and depend on local detection of emergency vehicle to activate signal. There are many disadvantages to this which are in detail shown in next segment.

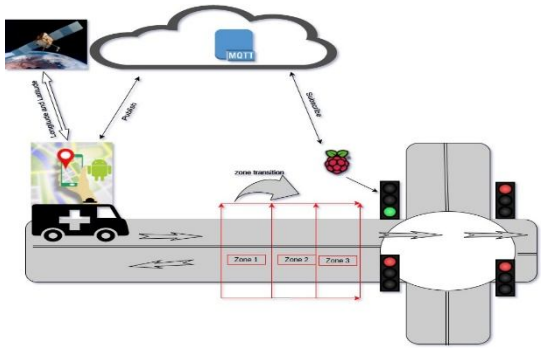
II. SYSTEM ANALYSIS

A. Existing System

Some of the proposed methods of emergency vehicle preemption along with possible disadvantage are shown below: (1) Some systems use an acoustic sensor linked to the preemption system. This can be used alone or in conjunction with other systems. Systems of this type override the traffic signal when a specific pattern of tweets or wails from the siren of an emergency vehicle is detected. One major disadvantage is that sound waves can easily be reflected by buildings or other large vehicles present at or near an intersection, causing the "reflected" wave to trigger a preemption event in the wrong direction. [4][5]

(2) A vehicle that uses a line-of-sight traffic signal preemption system is equipped with an emitter which typically sends a narrowly directed signal forward, towards traffic lights

in front of the vehicle. These line-of-sight systems generally use an invisible infrared signal, or a visible strobe light which serves a dual purpose as an additional warning light. The emitter transmits the waves with specific frequency and the traffic lights must be equipped with a compatible traffic signal preemption receiver to respond. Drawbacks of line-of-sight systems include obstructions, lighting and atmospheric conditions. The major drawback is it is extremely expensive to install. [4][5] (3) Radio-based traffic-preemption systems using a local, short-range radio signal which can usually avoid the weaknesses of line-of-sight systems. A radio-based system still uses a directional signal transmitted from an emitter, but being radio-based, its signal is not blocked by visual obstructions, lighting or weather conditions. The advent of FHSS (Frequency Hopping Spread Spectrum) broadcasting has allowed radio-based systems to overcome limitations of interference. The drawback is similar to that of line-of-sight, the range cannot be predicted and it is much more expensive than an alternative that is suggested next. [4][5] (4) EVP using GPS seems the most logical especially with the advent of widespread GPS (Global Positioning System) applications. Although extreme weather conditions can impact the functionality of GPS receiver it is still by far the most economical system. [4][5]



Proposed System and Implementation

The above figure represents our proposed system design. The basic idea here is that the devices or the "things" in IOT are all the traffic lights. As there are connected to internet it gives us a means of communication remotely. As mentioned earlier we use smartphone in emergency vehicles to send the location coordinates. Smartphone are preferred to a dedicated GPS device because it is most economical (most likely than not an ambulance driver already has one) and the system can be widely adopted with just an application instead of physical installing device in each and every vehicle. Although there is a disadvantage of smartphones losing data connections but as the system is primarily focused on urban or metropolitan areas the chances of network loss is much less. The next part of the system is a centralized server. We have used Node Webserver and implemented socket connection for communication with the devices. Consider all the smartphones with our application which is nothing but the emergency vehicles as our clients so are all the traffic lights. Now in case of emergency the ambulance driver can open the app which has to be authorized. More on that later. The application immediately starts sending the location coordinates to the central node server. It then checks for the nearest traffic signal and grants green until it passes that signal. Sounds simple but it is extremely complicated to implement as there are many barriers to overcome such as, from which side the ambulance is coming. You do not want to trigger the wrong side. Another thing we need to consider is that the nearest traffic signal is not always the right target. It should be the nearest "approaching" traffic signal. Considering all the complexities our system works like this: The location coordinates of the target traffic junctions is stored in our database. This can be done by physically going to that place and noting down the exact coordinates. Also one more important thing to do is to note down the bearing of different roads or paths which are diverged from that junction. We than calculate the location coordinate of a point maybe around 250 meters from the junction for all given bearings. (This is calculated by the server). This is also stored in our database. This is extremely important as you can see later. So the next step is design an app which has to quickly authenticate and send location data to the server. There are couple of things that can be done. One to make sure the app works only on that device once registered this can be done by mapping the IMEI address and the next step is to make sure the app works in an ambulance and not any other vehicle. This can be easily done by sensors which detect if a particular object is in range. It is already widely implemented in smart locks of mid-range to high range cars. So another tricky part is solved. Then coming to the server which already has access to the location of traffic junctions, just needs an emergency signal from one of the vehicles to start its work. Consider there is an emergency and the ambulance has to go to the place of casualty. It then continuously sends the location coordinates every second to the server. The server first checks the distance to every traffic junction and sorts the list based on the distance. This is done by using Haversine formula which calculates the great circle distance between and two location coordinates.

Haversine Formula: $a = \sin^2(\Delta\varphi/2) + \cos\varphi1 \cdot \cos\varphi2 \cdot \sin^2(\Delta\lambda/2)$ $c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{(1-a)})$ $d = R \cdot c$ Where φ is latitude, λ is longitude (difference between 2 longitude), R is earth‟s radius (mean radius = 6,371km), „a‟ is the square of half the chord length and c is the angular distance in radians, d is final distance in kilometres.

Alternatively we could use google maps API. We need to implement to know which works the best. Next thing to do is to see if the nearest junction is less than may be 500-

1000m. This is done because you do not want the traffic signal to be triggered if the ambulance is still 3km away from that junction. It causes more problems than solve any. If it is in range the server then picks the first signal on the list. It then checks if the server is approaching or moving away from the signal. It does this by checking the distance on nth second and then again on n+10th second. If the distance has reduced then it can be considered as approaching. Ok so to recap we have got an emergency vehicle and we have also got a traffic junction towards which it is moving. Now we need to find the exact side from which it is approaching. Now suppose there are four roads converging to that junction, Server calculates the nearest 250m point from the ambulance and it that traffic light is immediately granted green. It will also be monitoring if the ambulance has passed that particular signal using same n and n+10 principle. Once it confirms that it has passed it the checks the nearest signal and the process continues. It might seem complicated but we already implemented all the rules and have successfully simulated the operation gaining positive results. So if there are two ambulances in a same area requesting for emergency, what happens then? These kinds of situations although rare cannot be discarded. So right now the ambulance emergency which can be considered as an event get added onto the queue. So it is first in first out. Suppose if they are in different regions the emergency requests gets processed in parallel. We have used Node.js which is JavaScript runtime built on Chrome‟s V8 JavaScript engine. The entire code except for the android app is written in JavaScript. The communications happen through sockets which are implemented using Socket.io which enables real-time Bi-directional transfer of data. Finally for the database we have used RethinkDB which is a real time database which means the changes need not be polled and get automatically pushed. This is can be very helpful when the system grows. The entire codebase is made available and link can be found below. [7]

III. CONCLUSION

There are about 8 billion IOT devices as of 2017 and the figure is likely to double within 2021. [6] that is something extraordinary and adding traffic lights to the list is not only an option but necessary. We believe it can be easily implemented in wide scale and economical cost. The system is extremely flexible in terms of the functions and additional features can be added easily. The system has been simulated and the results are encouraging. Further improvements are in progress.

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