

IoT Based Bus Transport System in Bangalore

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Abstract— The Internet is a living entity, always changing and evolving. New applications and businesses are created continuously. In addition to an evolving Internet, technology is also changing the landscape. Broadband connectivity is becoming cheap and ubiquitous; devices are becoming more powerful and smaller with a variety of on-board sensors. The proliferation of more devices becoming connected is leading to a new paradigm: the Internet of Things. The Internet of Things is driven by an expansion of the Internet through the inclusion of physical objects combined with an ability to provide smarter services to public. The IoT can assist in integration of communications, control, and information processing across various transportation systems. Application of the IoT extends to all aspects of transportation systems, i.e. the vehicle, the infrastructure, and the driver or user. The system collects data by vehicle terminal and uploads data to the server through the network and makes data visible to the consumer. One aspect, the consumer may inquire about public transit vehicle information by Web. On another aspect, the consumer can know public transit vehicle information by station terminal. The experiments have tested that the Intelligent transportation system can offer public transit vehicle information to many consumers with convenient way thereby this system can ease the city mass transit problem.

Index Terms—IoT, Communication, mass transit.

I. INTRODUCTION

With the progress of technology, there are more and more objects which are being installed with sensors and are having the ability to communicate with each other. The way in which information is getting transferred is changing as the physical world outside is becoming more of an information system. Internet of things (hereafter referred to as IOT) deals with having physical objects we see around us in a network in one form or the other. It mainly deals with RFID, infrared sensors, global positioning systems and scanners. These have helped the objects to not only sense information but also interact with the physical world.

Why MRT (Mass Rapid Transit) Bus transportation system?

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With rapid population growth, there is always a strain on the transportation facilities. This strain can be reduced by having an intelligent transportation system. The Metro train system in Bangalore is still not functional fully. So we as a team felt that the bus

system in Bangalore has scope for improvement as it is not very advanced in terms of technology and there is a need for the passenger to understand and evaluate different bus options efficiently. There should be some technology that can guide the passenger in doing this. This is where we can try and implement the internet of things infrastructure. One key area we can improve is:-

Bus information system

Bangalore bus stands usually have information related to bus numbers and bus stops. However, searching for relevant information is quite painful in this maze of data. Also, a passenger is unaware of how much time a bus would take in the present traffic conditions to reach his starting stop. Other information that the passenger would like to know is the remaining sitting capacity of the bus in addition to next upcoming buses along with their capacities. He/she would also like to know how much time it would take to reach the destination along with the various options to travel. Internet of things can help in having an interaction between the passenger and the bus through the means of a mobile phone app. Thus, the system can judge how empty the bus is and according to the present traffic, how much time, would the upcoming buses take to reach the bus stop at which the passenger is standing. On entering the destination on the mobile app, the passenger would also know how much time it would take to reach the destination as per the current traffic along that route and also the different routes that he/she can take to reach the destination. This will be tracked by the buses running along that particular route. They will sense the traffic on that route to give real-time estimates. This same technology enables the user to know when the bus would arrive at his stop of origin.

II. LITERATURE REVIEW

Industry Overview

Bangalore Metropolitan Transport Corporation, abbreviated as BMTC, is a government agency that operates the public transport bus service in Bangalore, India. The BMTC was formed in 1997, as the result of a split of the Karnataka State Road Transport Corporation. The bus transportation system is extremely poor in terms of passenger satisfaction. Bus capacity is a major concern as it could not keep pace with the increasing population. Buses play a significant role in the public transportation system of Bangalore with around

12.85 lakh effective Kms per day. It has total fleet size of more than 6500 buses and at about 39 depots. It covers a large portion of the urban city mass transportation.

Bus systems

Advanced systems for buses around the world:

Many advanced bus transport systems have been designed around the world namely Bus Rapid Transport System which has been implemented in various countries such as Brazil, Australia, South America and few other parts of Asia. The success of this system has enabled majority of the commuters to shift from taking their own vehicles to taking public bus transport. These buses operate on dedicated bus lanes and the system has an automated system named “ITS (Intelligent transport system)” imbibed in it to keep track of traffic congestion. It also has GPS enabled route controllers to maintain public transport controlling systems. It also maintains the digital video cameras for processing the video signals digitally to collect the real time information about the road traffic conditions which can be used effectively to control the traffic.

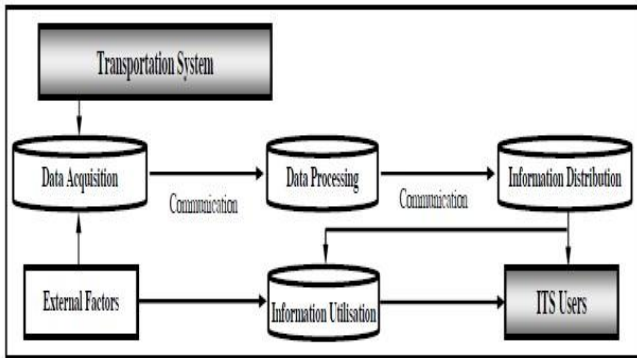


Fig: The Basic Structure of ITS Information chain.

ITS systems work with information and controlled technologies which provide the core ITS functionalities such as loop detectors.



Fig: How ITS Providing Real time Information

Bus route identification in apps and Google Map

What is the most crucial aspect a passenger considers while travelling between two locations in a public bus system.

Most researchers feel that frequency of a particular bus route is on top of the list and this is the reason why Google Maps™ has shifted focus to the frequency of the bus route rather than the shortest bus route. They have partnered with a few transit agencies so as to integrate data in certain U.S and European cities like Boston, Madrid where one can see “live departure times” and service alerts. They are working with other public transit partners to provide live data to more people in more cities. Another application which Google Maps™ has related to this is traffic data. Google offers this information in about 50 American cities, where the user can see a simple red/yellow/green color for a particular road indicating the traffic on that road. It gets this data from municipalities and companies which pays for these sensors and gets them installed.

A particular researcher has come up with an innovative method for providing information regarding the location of a vehicle. It consists of transmitter and receiver sub-systems where the receiver sub-system has receivers distributed along the route of the vehicle. Each of these receivers has a data processing unit associated with it which would have the ability to identify the vehicle and to estimate a time period for the vehicle to arrive at each stop.

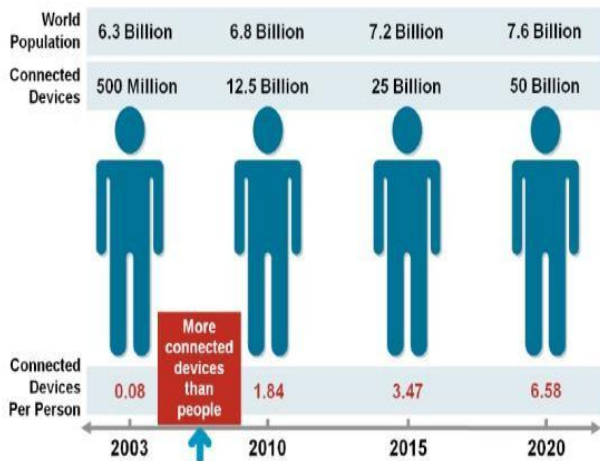
How often has a passenger being confused on a transit network with common lines regarding whether to board a bus which is about to reach the stop or wait for a direct route bus? Researchers believe that if a bus stop provides online information on the estimated arrival time of buses, a passenger can choose the best possible combination of waiting time and expected travel time. They have suggested a general framework to determine the probability of boarding a particular bus when online information is available to the passenger. Their research shows that providing online information at stops changes the way passengers make decisions with more passengers going for the direct and less regular bus when there is information and more passengers going for the indirect and more regular bus when there is no information.

Evolution/Emergence of internet of things

Internet of things is formed by the interconnection between the networks of everyday objects we use. It involves the wireless sensors which are used to send the information to every object and to the people responsible for them. The term internet of things came into existence 10 years ago with the founders of MIT “Auto ID centre”. The Auto id refers to the broad class identification of technologies such as smart cards, sensors, voice recognition and biometrics used in industry to help in automating, reducing error and increasing the efficiency of the technology. Since 2003, RFID tags and EPC played a major role as a standard identification of technologies, in which RFID tags were used in tracking of the objects whereas EPC or electronic product code served as the link to data. Meaning of internet of things has expanded since then. Using sensors and sensor networks, more information about the objects and environment can be noted clearly. In present world of internet we still have to generate our own ideas to make things work such as recording a video. Our ideas and information are not the main reasons for the survival of our

society, hereafter it will be based on the things. Software embedded in the object helps in keeping track of them making the computers analyze and think, feel and sense the information without limitations of human intervention using sensor technology such as RFID to the utmost capabilities rather limiting them to just sensing the barcodes. The future expectations for the Internet of Things would be managing the huge data wherein the users will be connected to more and more users in the coming years. In Europe, many projects are being addressed in connection with the Internet of Things.

Figure 1. The Internet of Things Was "Born" Between 2008 and 2009



Source: Cisco IBSG, April 2011

IOT in various sectors

2012 has been an important year for Intelligent Transportation Systems in USA. The Ann Arbor Safety Pilot can define how effective the public sector participation can be in automotive technology innovation. This pilot project involves both vehicle-to-vehicle and vehicle-to-infrastructure communication along with warning messaging. The concept of connected cars is in an app-based growth stage in the US.

As of 2008, number of things connected to the Internet was greater than the human population and this number is estimated to reach 50 billion within 2020. There has been a lot of research related to Internet of things in different areas. Some of the most prominent sectors are:

Smart home systems:

Components like sensors, actuators and networks are installed in the home network to provide the various functionalities. These researchers have proposed a semantic Web-based methodology called SPIDER as given in the figure below. A lot of research is done to explore the benefits and possibilities of smart homes thus creating an interconnected smart environment with the help of sensors and actuators. For example, the room can be adjusted to a person's preference profile settings once his mobile phone enters the building or the fridge automatically orders milk once the stock in the fridge is over.

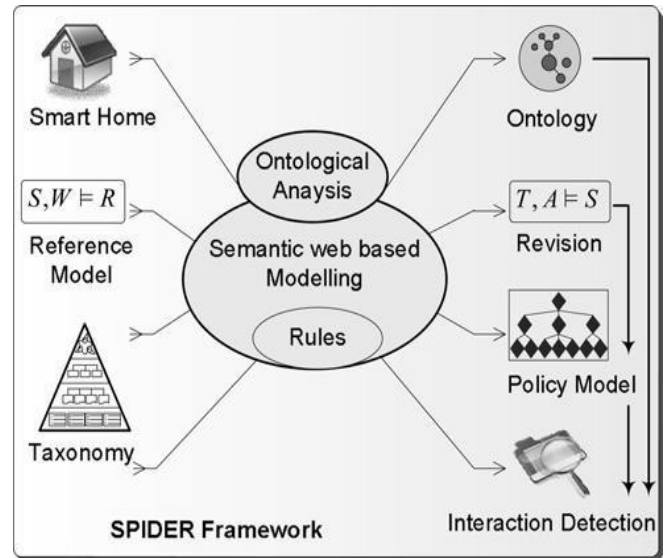


Fig: Framework of proposed model

Retail/Supply Chain Management:

Supply chain management is a set of all activities which integrate the suppliers, manufacturers, transporters and the passengers so that the product is delivered on time and to the right destination in the required quantity. In order to achieve this, every function in the supply chain must operate efficiently with real time collaboration and integration. As majority of the problems in SCM were related to disconnected information system and lack of new technology, research has revealed that effective information sharing can substantially improve the performance.

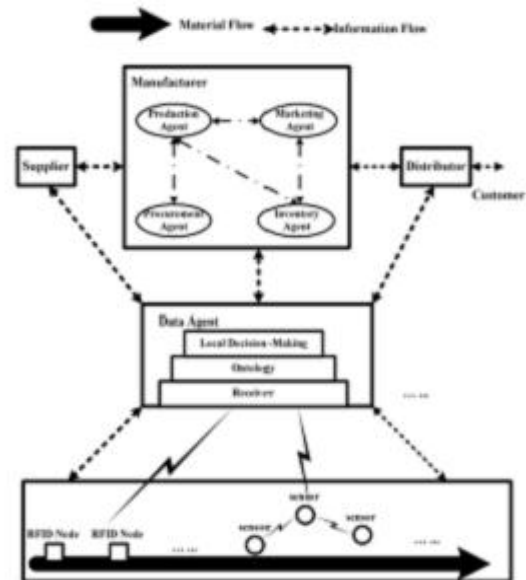


Figure 1 A Distributed Architecture for SCM over the IoT

Source: Lou Ping, Q. L. (2011). Agile Supply Chain Management over Internet of things. International Conference on Management and Service Science (MASS). RFID technology has been used in SCM for real-time traceability which in turn has improved the supply chain integrity. Further, IOT employs to facilitate information flow in global integrated supply chain systems. Retailers can

optimize many applications using IOT and RFID which could enable checking receipts of goods, tracking out of stock and real time monitoring of stocks without any human intervention. Also, IOT offers many applications like fast payment solutions with automatic check outs using biometrics or detection of allergen in a product.

Researchers have proposed the benefit of using IOT in car insurance. If insurance clients are ready to install electronic recorders in their cars which can track and record acceleration, speed and other parameters and this information is communicated to the insurers, they could receive discounts on the premiums. On the other hand, the insurer can save costs by being involved very early when the accident occurs and thus can take quick actions.

Healthcare:

Mobile phones with RFID sensor capabilities, Bluetooth, ZigBee, and WiFi can be used as a platform for monitoring vital medical parameters like temperature, heartbeat rate, blood pressure, cholesterol level etc. Wireless identifiable devices can be implanted to store medical health records of individuals. Having ready access to these records when the patient is unconscious and unable to communicate for themselves can save a patient’s life in emergency situations. This can be useful especially for people suffering from diabetes, cancer, coronary heart disease as well as people with complex medical device implants like pacemakers, joint replacements etc. Also, networks can be formed within the human body that can directly communicate with physicians and emergency services. For example, automated internal Cardioverter-Defibrillator can be built into human heart which can autonomously decide when the shocks should be administered to defibrillate. It would also be fully networked so that the physician can follow up on his patient.

Existing Transportation systems using Internet of things

Internet of things has been currently used in a starting phase in bus transportation systems mainly catering to the scope of traffic management and infrastructure monitoring.

Traffic management using Intelligent Transport systems:

IT’S enabled transport systems gives the leverage for the advanced transport systems that allows buses and trains to report their positions so that the passengers are made aware of the real time availability of their buses and trains. Currently available transport systems for the internet of things are given below.

Present available intelligent transport systems around the world

Ten countries are taking significant steps in the deployment of the Internet of things in starting phase in various nations that includes Australia, France, Germany, The Netherlands, Sweden, Singapore, South Korea and United Kingdom.

ITS Category	Specific ITS Applications
1. Advanced Traveler Information Systems (ATIS)	Real-time Traffic Information Provision Route Guidance/Navigation Systems Parking Information Roadside Weather Information Systems
2. Advanced Transportation Management Systems (ATMS)	Traffic Operations Centers (TOCs) Adaptive Traffic Signal Control Dynamic Message Signs (or “Variable” Message Signs) Ramp Metering
3. ITS-Enabled Transportation Pricing Systems	Electronic Toll Collection (ETC) Congestion Pricing/Electronic Road Pricing (ERP) Fee-Based Express (HOT) Lanes Vehicle-Miles Traveled (VMT) Usage Fees Variable Parking Fees
4. Advanced Public Transportation Systems (APTS)	Real-time Status Information for Public Transit System (e.g. Bus, Subway, Rail) Automatic Vehicle Location (AVL) Electronic Fare Payment (for example, Smart Cards)
5. Vehicle-to-Infrastructure Integration (VII) and Vehicle-to-Vehicle Integration (V2V)	Cooperative Intersection Collision Avoidance System (CICAS) Intelligent Speed Adaptation (ISA)

Source: *Intelligent transportation systems* (Explaining International IT Application Leadership)

Advanced public transport system (APTS) i.e. used in findings of the next bus and next train timings that is common worldwide in USA The advanced systems has the potential of tracking 82 percent of the vehicle crash scenarios., France is deploying the ISA system that slows the fast moving automatic vehicles. This has also been used in as for analyzing the real time traffic congestion information in countries such as Japan, South Korea Congestion pricing in Sweden, Singapore and United Kingdom, vehicles miles travelled system is calculated in Netherlands and Germany. Japan and South Korea have been leading in the usage of intelligent traffic systems. South Koreans has deployed 9300 buses and 300 bus stops for their real time bus timings notifications in addition they also use T- Money an electronic smart card system to make contact less transactions for the daily bus transport systems whereas the same system has been called as the Suica in Japan.

Seoul’s Bus Transport system:

This below diagram gives the overview of the usage of internet of things in different fields in South Korea.



Source: *Intelligent transportation systems* (Explaining International IT Application Leadership)

Research methods used in Iota papers

IoT-I project has run a survey in 2010 to identify the different IoT application scenarios in different domains. This survey was based on 270 responses from 31 countries and it identified smart home and smart city as the most attractive scenarios. Another survey was conducted addressed to top executives representing retailers and manufacturers of European FMCG companies. In addition, a consumer survey was done to get useful input regarding the innovative retails consumer services. A survey was also carried out to examine the possible application layer protocols for sensor networks. In January 2009, a team of researchers in China studied Internet routing data to understand the growth of connected devices to the internet. The recognition of the power of data by business was studied in a recent survey of over 600 global business leaders. To study the impact of strategic applications of IoT, a survey was conducted to determine what impact they would make.

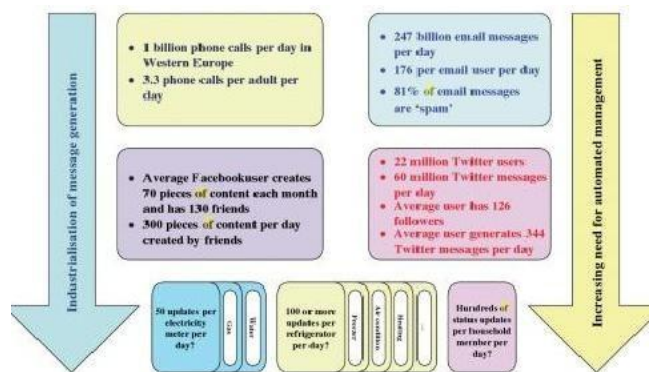
These research papers suggest a need for a public survey to understand the passenger side for a particular IoT implementation. Also there is a need for a qualitative survey to understand the feasibility of implementing IoT in a certain area.

Challenges and drawbacks of internet of things

One of the main challenges for the Internet of Things is in transformation of the connected objects into the real time sensing actors which also involves the societal and ethical considerations. IOT technologies enable or control the capabilities of the people and how this influences people's capabilities to satisfy accountability demands. The multiple dimensions of accountability such as visibility, responsibility, control transparency and predictability should be taken into consideration to be controlled with the capacities of IOT technologies.

Internet of things is spreading widely in the present world which accounts for at least two objects connected per person. It is expected that by 2015 an average person would be accompanied by seven objects. The key challenge that sparks for this innovation is protection of privacy.

Three very important barriers that exist for IoT development are having a single standard, the development and transition to the newer IPv6 and developing energy sources for the huge number of sensors. Another challenge in building IOT is lack of common software fabric and how to combine all the software systems in building the common software platform. The first direct challenge for this is that the generation of huge scale of data may even have digital twin in cloud that could be generating regular updates as a result of which the messaging volume could easily reach between 100 to 10000 per person. below diagram gives the trend of how messaging is carried on for users:



Source: Google images Trend of Messaging

III . TECHNICAL ARCHITECTURE

Existing research on the topic of Internet of Things shows a dearth of research on its implementation in transportation systems. The architecture proposed by our research team would establish a connection between the bus and its information and the passenger through the means of sensors, embedded device, satellite, mobile phone app and a cloud server cum database.

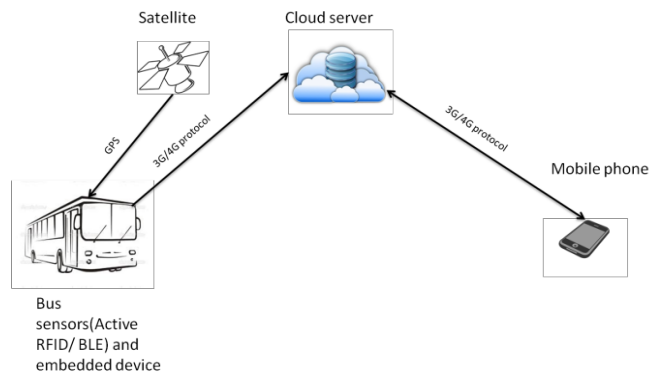


Fig: Technical Architecture

Bus Sensors:

There would be sensors at the entry and exit of each bus to calculate the vacant seating capacity of a particular bus. The sensors would be preferably using short-range wireless technologies like active RFID. Active RFIDs have a read range of 300 feet or more and are battery powered. The most crucial advantage with active RFIDs is that it can automatically broadcast its signal unlike passive RFIDs which transmit a signal upon receiving RF energy from a reader. Another better option is to use BLE sensors. These sensors drastically reduce the cost of buying as well as the power consumption cost. This information goes into the embedded device inside the bus.

Embedded device:

The embedded device in the bus collects the information of the bus related to its location, time and speed. Location details are received through GPS from satellites and this is essential for establishing the "time tags" of each location. These details are also sent to the cloud server after every minute through any standard protocols that 3G/4G telecom support to ensure freshness of data.

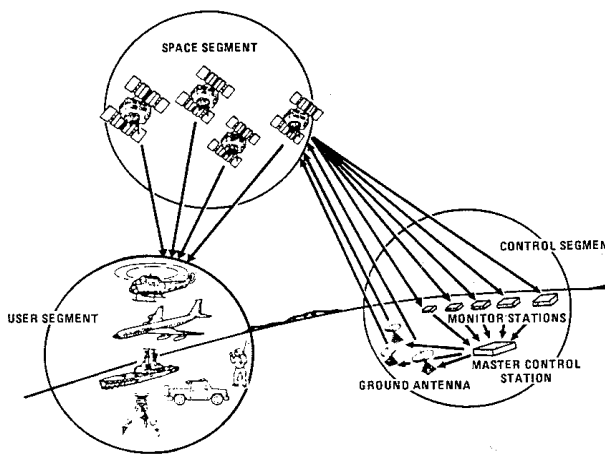
Satellite:

Satellite transmits signals to the bus on ground as well on a very accurate time reference which is provided by atomic blocks. Satellites provide synchronized information so that accurate information is provided at the exact same instant. GPS architecture has three major segments of division.

GPS Space Segment (SS):- The space segment contains the GPS satellites. There are 24 GPS satellites in the GPS design which are distributed into 8 each in three circular orbits. The satellites move around the earth in orbits in such a way that the angular difference between each orbit is 30, 105, 120 and 105 degrees. These 4 satellites create an intersection to give the exact location of the user.

GPS Ground Segment (GS): - This segment is responsible for the proper functioning of all operations of the global positioning system like replacement of a dysfunctional satellite. It also helps keep the GPS system operational and functional within its specification. It is also responsible for the security issues of the system.

GPS User Segment (US): - This segment contains GPS receivers. It receives the GPS signals and solves the navigation equation to determine the accurate co-ordinates and accurate time. There are two types of users, the military users who use the Precise Positioning Service and the civilians who use the Standard Positioning Service.



Source:
<http://allaboutgps101.blogspot.sg/2010/12/what-are-3-segments-of-gps-systems.html>

Mobile Phone App:

When the passenger opens the Iota app on his/her mobile phone, he is greeted with a “from” and “to” text box and a “Go” button. The passenger can enter any source and destination with the app providing help in the form of auto-complete fields of some of the important locations in Bangalore. One can also enter “My location” in “from” location. On clicking on “Go”, passenger is taken to the next

screen. If the passenger is unsure of the name of location, he can use map to select it.



Fig: Screen 1

The 2nd screen consists of 3 tabs which give the buses in ascending order from 3 aspects:

Buses as per Arrival Time:

This will give the buses in ascending order of their arriving at the original stop.

Buses as per Total Arrival Time:

This will give the buses in ascending order of the time taken to complete the journey.

Buses as per shortest Walking Distance:

This tab will give the buses in ascending order of the walking distance needed to complete the journey.

If the journey requires more than one bus to complete the entire journeyman asterisk sign (*) would be displayed next to the bus router.



Fig: Screen2

The 3rd screen would be a pop-up screen which would appear when one clicks on any one bus route. This pop-up screen would have two parts. The upper part would give the details of how to complete the journey for example, walk to original stop, take bus to which stop and then to walk till destination. The lower part would give details of the next buses in the ascending order of their arrival time along with the number of vacant seats information.

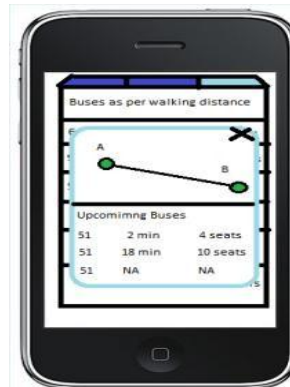


Fig: Screen 3

The 4th screen would appear if the passenger needs to setup an alarm/notification for a particular bus approaching their stop. Thus, if the alarm is set for 5 min, it would notify the passenger 5 minutes before the bus reaches his stop. Thus, if the person resides close to the bus stop, he could accordingly leave his home after he receives the notification. On the other hand, it would also be beneficial for passengers who have some urgent work near the bus stop and desire to complete it until the bus arrives.

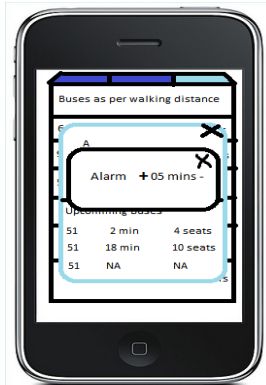


Fig: Screen 4

Cloud Server:

It saves and classifies the multiple bus information. It acts like a safety bridge between the phone and the bus's embedded device and sensors. Plan to use cloud database service like *Simple2Db* or *SmallDb* wherein the database service provider installs and maintains the database. Big data processing and analysis is used here and the database service answers user queries to fetch the appropriate data.

Algorithm for IoT implementation

We are trying to provide real-time information which would be extremely accurate using the concept of internet of things i.e. Interaction between virtual objects and their communication. This basically tries to convert the distance between two buses into time taken by the first bus to travel that distance. For this calculation, we have introduced a concept called as "time tagging". Using this concept, we assign time tags to pre-defined locations on the bus path. The time at which a bus reaches a particular location becomes the time tag for that location. This time tag will be used for the calculation of the time gap with the next bus. So, the time difference between two buses or between a bus and a stop is essentially the difference between the time tags between the locations of these places. Let us understand this example with an illustration.

In the below figure we see Bus a travel across 3 locations. These are marked with the time at which Bus A had reached them. So, if another bus B reaches Location 1 at the time 1.00 p.m., then the distance between the buses can be calculated by the difference of the time tag between the two locations i.e. 2 minutes. Now, the question that arises is that can this data predict the actual timing between two buses.

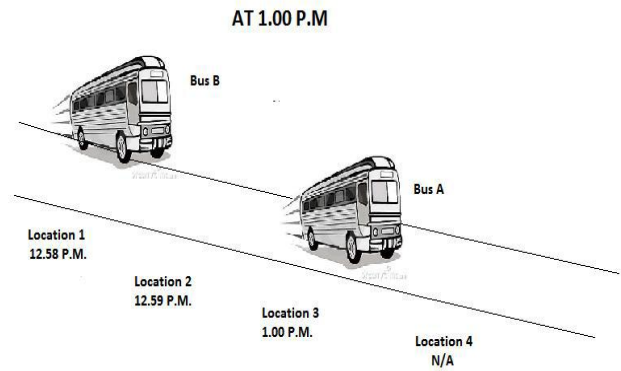


Fig: Location of buses before the scenario takes place. We can test this functioning for a few scenarios.

Scenario 1: Bus B is moving and Bus A is moving. Say bus B which reached location 1 at 1.00 pm. At this point of time, bus A is at location 3. The difference between the time tags of these two locations is thus 2 minutes. Now, in the next two minutes, say Bus B moves to location 3 and Bus moves to a new location 4. The time difference would still remain the time tag difference, 2 minutes.

Scenario 2: Bus B gets stuck in a traffic jam while Bus A keeps moving Say bus B which reached location 1 at 1.00 pm got stuck in traffic at the same place till 1.02 pm. In the meantime, bus moves some distance to a new location say location 4 at 1.02 pm. Thus the time tag of location 4 would be 1.02 pm. Again the comparison of bus B's location to bus A's location would be the time difference between the two, which now would be 4 minutes and would be accurate.

Scenario 3: Bus B keeps moving while Bus A gets stuck in a traffic jam Say bus B moves to a location 2 by 1.01 pm and bus A is stuck at location 3 in traffic in the same time. So the time difference between the two locations is one minute which is precisely the difference in the time tags of the two locations.

Scenario 4: Both buses A and B get stuck in traffic jams. Imagine a scenario where both bus B and an are stuck in traffic at locations 1 and 3 respectively. As there is no physical displacement of the two with respect to each other, the time difference would remain the same which is 2 minutes as there is no apparent movement between the two buses.

Thus we can infer that this algorithm we can estimate of time difference between two locations would be very accurate. How can an application use this information to determine the time taken by a bus to reach a particular bus stop?

Real Time Scenario

The time taken by a bus would be given by the difference in time tags between two buses minus the time elapsed since the first bus trespassed the bus stop. In this diagram, the time taken by bus B to reach the bus stop would be the 2 minutes.

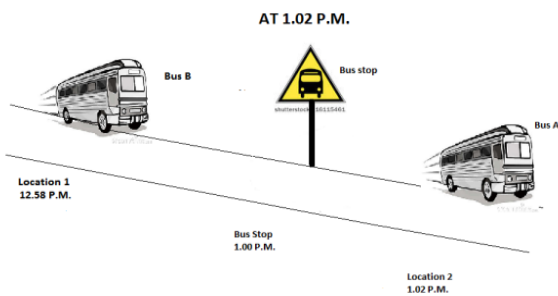


Fig: Real Time Scenario

Scenario	Time tag of bus A	Time tag of bus B	Difference in Time tags	Actual Time Difference
1	1.00 p.m.	1.02 p.m.	2 min	2 min
2	12.58 p.m.	1.02 p.m.	4 min	4 min
3	12.59 p.m.	1.00 p.m.	1 min	1 min
4	12.58 p.m.	1.00 p.m.	2 min	2 min

IV. RESEARCH METHODOLOGY

Problem Statement

The research is aimed at increasing real time information provided to the passengers of Bus transportation system in Bangalore using Internet of Things.

Objectives

To study the features and functionalities of Internet of Things in different industry sectors. To establish a design to implement Internet of Things in order to better the passenger’s experience of bus transportation. To conduct a primary research with technological experts as well as transport management and prove issues and challenges faced while using this technology.

Steps in Methodology

We have segmented our methodology into different stages.

Introduction

As stated earlier our main goal is to improve the bus transportation system in Bangalore by implementing the internet of things. Our main challenges in our research may include the less availability of data, time constraint since the research process is still being carried on and there were no proper signs of implementation in this field as this is considered to be one of the highly innovative ideas in the near future.

Stage 1: secondary Research

In this stage we are confined ourselves in collection of secondary data taken from different sourced articles, materials, journals, online materials. We have divided our literature into nine related areas research in nine related areas

to understand more about the conceptuality in certain fields and to get familiar with different aspects of the research which helped in designing the research frame work and research prototype models of the application. These models in turn were used as a foundation for our future research.

Stage 2: Primary Research

Since the research being carried in new field, we understand that more emphasis should be given in collecting the data through primary research. According to the above given scope we have this stage into divided into two parts.

Expert opinion: It includes meeting the professionals and experts who are well aware of the technical aspects of the internet of things and gain knowledge accordingly.

Industry overview: Understanding the functionalities of the transport industry in Bangalore.

Stage 3: Impact Analysis

In this stage, we try and find out the impact of our app in comparison with a leading app in the current mobile market.

Stage 4: Interpretation of the findings

Acquiring the historical data available from the outcomes of any previous research findings through the secondary research process. This gives us the brief overview about the happenings of the past to analyze our research process by sticking onto our limitations. Analyzing the obtained information from the specialist personnel such as experts and the personal who are already into the industry to gain knowledge about the feasibility of our research in real time scenario. Using the past data we try to analyze and make the Forecast of the future trends that include advantages & disadvantages from the various aspects of our research design.

Stage 5: Recommendations & Conclusions

On the basis of the primary and the secondary research, arriving at the recommendations would be the key objective of this phase.

Limitations of using IoT in the bus transport system in Bangalore

Loss of GPS: Intermittent loss of GPS signals happen from time to time and this may result in bus real time locations not being obtained.

Partial implementation: IoT has been only partially implemented as of now and is expected to be implemented to the fullest by the year 2025.

Maps: Google maps already exist indicating the buses available including the route map. There are also other bus route maps like www.mybmtc.com available on websites helping the passengers.

SMS service: There is a real time SMS bus arrival system that helps users with the bus arrival timings via SMS.

Bus transit guides: There are few existing Bangalore bus transit guides like www.mybmtc.com where in passengers can come online and check the route and timings of the buses.

Seat availability in buses: Seats availability displays already exist in buses with the usage of pressure sensors

placed on its stairs. However, as our app would give the passenger information much before he enters the bus; this would not pose much of a problem.

Data pack costs: We cannot find internet and Wi-Fi connectivity everywhere at the bus stops. In India the data pack costs are high which might give the limitations of usage for this app.

Limitations of our Research:

The design and our research findings are based on the technological assumptions and the present scope of the Internet of Things. Real time testing of the proposed design has not been implemented. Algorithm cannot estimate the time a bus will wait at a specific location and fails to take this into account for time calculations.

Analysis and Interpretation

Qualitative Analysis

There were some key findings from in-depth interviews with the industry experts worldwide in Internet of Things and we had the following Learning.

Learning:

Use of a common protocol for communication is essential when IoT is dealing with different objects and selection of the protocol will decide the fate of any IoT project. The most important part of the bus application infrastructure would be the embedded device and design of the same would be crucial for the project it is essential to build the ecosystem which connects each part of the IoT infrastructure.

Impact Analysis

A quantitative analysis was not possible as the application we have proposed does not exist as of now. As a result, we tried to estimate the future impact of our proposed application on the society. On doing this impact analysis, we discovered six major factors which would create a substantial impact.

Better Time Management:

The alarm feature provided by our bus application would make the life of application users very convenient. It gives flexibility to users as they could now reach the bus stop in exactly the same time that the bus would take to reach. Thus, it would allow them to make maximum utilization of their time thus drastically improving time management.

Savings in Time:

The technology used in this application is based on the direct communication between the buses themselves; it offers the highest possibility of providing the most accurate real time information. This means that the user would benefit in terms of optimizing his use of time.

Bus Efficiency:

This application can provide real time information about the arrival time of buses to the and transit bus operators. Most importantly, it could also provide information about the crowd in the buses. This data can be used by the bus operators to analyze whether there is any significant pattern in the crowd in buses at any particular time or routes. Thus, they would be in a better position to schedule extra service depending upon the crowd density.

Cost:

Mobile application is opensource. So free of cost for the user.

Crowd Management:

Since users would have real time information about the occupancy status of the next and the upcoming buses, they would be able to make better decisions in terms of which bus they should take. This, in turn would help in better crowd management in the buses.

Choice:

The application offers different options to users in terms of the buses and the routes that they can take to reach a particular destination. As already discussed, it gives information depending on the arrival time, total travel time, walking distance and seat capacity. Thus, the user has a wide range of options to choose from depending upon his preference at a particular time. For, example, seat occupancy status can be of immense use for older generation. Shortest arrival time can be of significant importance for office goers and so on. Thus, it caters to different needs of the society as a whole.

Inference and Managerial Implications:

The results clearly show that our IOT application will provide efficient time management, bus efficiency, crowd management, time savings and number of options provided to users.

V. CONCLUSION

Outcome and Managerial Implications

An in depth study on the use of IoT in different sectors revealed that most of the research was concentrated on the future benefits to be derived by using IoT. This research has been done for smart home systems, retail and supply chain management, insurance, healthcare, transport among many others. However, through our study we found that there was a dearth of research in IoT in the transportation sector. We also found that the bus transportation system and the bus application currently used in Bangalore have huge potential of further improvement. Therefore, the research was aimed to find out the feasibility of using of Internet of things in the bus transportation system in Bangalore and to validate whether it improves the consumer experience. The design proposed by us has capitalized on the advantages provided by IoT by giving real time data to the consumers for each bus route. Through the Impact analysis and Competitive analysis it is clearly say that the time management, time saving, bus efficiency management, bus crowd management and in the number of options being offered to users. Also, a robust analysis of the algorithm used for IoT confirmed that the IoT application with the use of direct communication between the buses would give the most accurate arrival time in all circumstances. IOT would thus take care of the real time traffic condition which was one of the prime reasons why the existing applications were not able to give accurate timings. The qualitative research with experts all over the world revealed that there is a challenge in terms of selecting a common protocol that facilitates a secure, efficient and real-time communication between buses, system and the application.

Implications of the Research for business and other stakeholders

Consumer

Our major stakeholders for the project are the consumers who use the bus services in Bangalore for transportation. Consumers would benefit by using an application that not only gives them the most accurate arrival time possible but it also gives them the freedom and luxury of leaving their residence at their own convenience by setting up an alarm for the arrival of the bus at a stop nearest to them. Commuters have always faced difficulties travelling in an overcrowded bus. As a result, many a times, they take up other modes of transport which are not as cost efficient. What further adds to their frustration is the fact that the next upcoming bus was relatively vacant. Our research paper offers an application that would also take into account the seating capacities and would thus display the vacant seats for the next upcoming buses. Thus, the consumer is in a better position to make his journey more convenient. Also, the number of options offered in terms of selecting the parameter for buses as per the situation the consumer is in, make it the most Viable application. For example, he can select the bus capacity criteria if convenience is more crucial to him or the arrival time criteria if time is more important to him in a particular situation.

BMTC

Another major stakeholder is BMTC. Can improve their services by leveraging on the data provided by the IoT application. The data can be analyzed to determine the time of the day when the bus is most crowded and also the bus stops where the crowd density is more. This analysis would help BMTC schedule and manage buses on specific routes in the most optimal way. Thus, if implemented it would have a significant impact on consumers as well as BMTC.

Learning

The learning from this research has been immense. Our team was exposed to the uses of IoT in different sectors. Also, we were enlightened about the limitations of using IoT and how nascent the technology is in various parts of the world. However, the scope of this technology is immense and it can be used almost in each and every field to make our lives' simpler. Also, we could convert the distance between two buses into time using a sturdy algorithm which was fool-proof under all scenarios.

Future Scope

Making the model sturdier by taking the signal waiting time into consideration. This would require all the signals to be included as virtual objects. Usage of other sensors costing less than that of the RFID's can be used in detecting the devices. Details of the traffic congestion can be added if needed to help the passenger in deciding to board the bus. Voice enabler system appended in the app to help the passenger in notifying the details about the bus status. Linking the personal balance account of the delink card with the application wherein the details of the balance amount are can be displayed in the application helping him/her to alert if low balance available in the account.

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