The Pennsylvania State University
University Park Campus

AT&T: Our Connected Lives
The Internet-of-Things (IoT)

Intelligent Global Positioning System (IGPS)
Design Team 7
Freeloaders Corporations
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SECTION 1 EXECUTIVE SUMMARY

As the technological era expands, new and emerging technologies are invented to collect information and data to be used for products and systems that will benefit our lives. Using the Internet of Things concept, machine to machine communications are made possible. Under the concept of connected cars, the Freeloader Corporations came out with an idea called the Intelligent Global Positioning System (IGPS). This concept centralizes in applying and integrating V2V communications systems and traffic coordination.

The main goal of IGPS is to increase the productivity and efficiency of the daily travel activities and routines done by road users. This can be made possible by integrating and processing real time traffic data and providing effective suggestion for road users. Optimally, IGPS is expected to be the solution towards reducing traffic congestions especially in major cities. Besides that, IGPS also has several extra features including real time crowd data, upcoming traffic light warnings and gas station suggestions.

The functions of IGPS centralizes at the Intelligence system that collects, store and process traffic data obtained from user inputs through smartphones, V2V communications by vehicles on the road, authorities and the Department of Transportation. These data is then processed and integrated by the IGPS system. Based on the data collected, suggestions and recommendations are made by IGPS to road users.

IGPS utilizes GPS, cellular networks and Zigbee to function. The data update system in the smartphone requires cellular network to function. The smartphone is also connected to the GPS system through the cloud information system where all the data input made on the smartphone is synchronized with the GPS system. The V2V communications process is made through Zigbee. Zigbee’s capability in functioning under low power demand and long range made it an ideal wireless protocol. Zigbee is long range because it allows the relay of data by passing it off to nearby devices to reach distant objects. The user interfaces used by IGPS are smartphones, built-in GPS and the cloud information system. The use of smartphones allows IGPS to be more mobile and easily accessed. All customers subscribed with IGPS are covered under the security and privacy policy of AT&T.

Further development and innovation of IGPS will bring us a step further towards the invention of autopilot and self-driven cars.
SECTION 2 INTRODUCTION

2.1 PROJECT OBJECTIVES.
Identify opportunities that leverage real-time connectivity and new and emerging technologies to collect information that can be used for products and systems that benefit our lives.

2.2 PROJECT BACKGROUND.
The Internet of Things (IoT) is a scenario in which objects, animals, or people are provided with unique identifiers and the ability to automatically transfer data over a network without human-to-human or human-to-computer interaction.

Machine-to-machine (M2M) solutions wirelessly connect millions of diverse devices to a network, enabling two-way communication. From trucks and turbines to heart monitors and vending machines, M2M allows network-ready devices to connect and share reliable real-time data via radio signals. Monitored and managed remotely, M2M automates processes in industries from transportation to healthcare.

2.3 SPONSOR BACKGROUND.
AT&T is a premier communications holding company and one of the most honored companies in the world. Its subsidiaries and affiliates (AT&T operating companies) are the providers of AT&T services in the United States and internationally. With a powerful array of network resources that includes the nations fastest and most reliable 4G LTE network, AT&T also offers the best wireless coverage worldwide of any U.S. carrier, offering the most wireless phones that work in the most countries. It also offers advanced TV service with the AT&T Universe® brand. The company’s suite of IP-based business communications services is one of the most advanced in the world.

2.4 PROJECT DESCRIPTION.
Connected Car:
The automobile has evolved beyond its original use case of traditional transport. The future of the automobile is dependent on the following four factors: Smart, Clean, Connected and Efficient.

Entries in this category will focus on solutions that consumers can use while in the car. The entries will address problems that improve Driver Safety, Productivity and Infotainment. Students should think about the various problems and enhancements they would like to see addressed in their daily lives as the spend time in the car. Usability will the key in this category as the focus must be on limiting Driver Distraction while maximizing the Driving Experience.
3.1 IoT SYSTEM AND GOALS.

Intelligent Global Positioning System (IGPS) is a vehicle monitoring system that uses Vehicle-to-vehicle (V2V) communications domain of IoT. The system collects V2V communications and traffic data and uses intelligence to make suggestions that will assist road users in planning their daily travel activities efficiently.

Part of the IoT system, several goals have been made to ensure that IGPS serves its purpose. The goals are:

- IGPS will have basic Global Positioning System (GPS) functions such as providing multiple routes to a destination, real time traffic and routes that avoids tolls.
- IGPS will use intelligence to process real time traffic and road user routines and schedules data to make suggestions to users to produce a smooth flow of traffic.
- IGPS will have the ability to suggest suitable routes, departures times and re-route using the data processed from traffic patterns and real time traffic data.
- IGPS will have traffic light data to provide warnings and speed suggestions in approaching an upcoming traffic light.
- IGPS will have the ability to provide real-time crowds in drive-thru, parking lots, gas stations and other road side facilities using V2V communications obtained by vehicles in the particular facilities.
- IGPS will use intelligence to make gas station suggestions with the highest cost efficiency based on mile per gallon.
- After further development and increment of number of users, IGPS will have the ability to coordinate traffic efficiently and bring down traffic congestion down to 0%.

All these goals are made possible by using artificial intelligence to integrate V2V communications data, traffic patterns and real time traffic data.
3.2 SYSTEM MODEL.

3.3 BASIC CONCEPTS.

IGPS will utilize both GPS and cellular networks to function. Any input (e.g. a destination), will trigger IGPS to collect your location data via GPS and subsequent data such as traffic patterns from other devices and stop light times via cellular networks. The IGPS system will then calculate the best route and display a suggested route and departure time for maximum efficiency. Although the use of cellular networks does create a cost, the availability of smartphones which contain both cellular network and GPS capabilities would virtually diminish this cost. Benefits of integrating every vehicle on the road would allow for cars to travel more efficiently, saving money and gas as users would stop less or even not stop at all. The system would also help to lessen bumper to bumper traffic with the recommended departure time.
In order to execute the IoT V2V communications domain, Zigbee is used. After evaluating different wireless protocols, we chose Zigbee wireless technology because it has low power demand and powerful local networking capable of V2V communications. Unlike Bluetooth, Zigbee allows device to relay data by passing it off to nearby devices to reach more distant ones. Furthermore, Zigbee’s alliance with AT&T is not a new thing as AT&T is a proud participant in the development of Zigbee.

3.4 SYSTEM CONTROL.

Users have the ability to control the system using three basic user interfaces which is their smartphone, built-in GPS in their vehicle and the information cloud system. On the other hand, IGPS is controlled externally by AT&T using servers dedicated to the functionality of IGPS. Authorized employees will supervise IGPS 24/7 to ensure that it functions effectively. Users are able to control the systems using their smartphone by downloading the IGPS mobile app provided by AT&T. The use of smartphones as one of the user interface enables the user to control IGPS wherever they are and whenever they want. The built-in GPS systems function as a normal GPS with added features including real time traffic updates, re-route suggestions and also an interface system that collects traffic data from V2V communications and user daily travel routines. For safety reasons, the built-in GPS has the voice action commands function to avoid distracting the driver. The information cloud system enables users to synchronize their daily schedule with the system that enables IGPS to give suggestions that will make their daily travel activities more efficient. However, the cloud system is optional; therefore, the user’s approval is needed before the function is enabled.

Security and user’s privacy are at most important in IGPS. Customers who are subscribed under IGPS are entitled to the security and privacy policy under AT&T. It has been a well-known AT&T policy that all customers account information is kept safe and encrypted to reduce the vulnerability of hacking activities. Customers have the ability to dictate whether their information is available for marketing purposes or not. The AT&T privacy policy strictly state that all the data collected is kept private unless instructed otherwise by the customer. However, there are several examples that enable AT&T to share customer’s personal information, which is:

- Across AT&T companies to ensure that AT&T are able to provide customers with the best experience.
- Other companies that perform services on behalf of AT&T and all this companies are required to protect the information under the same privacy policy.
- Other authorities and entities in respond to 911 requests of emergencies, court orders and legal process, assisting identity verification to prevent fraud and identity theft and also transfer or sale of delinquent accounts of third parties for collection.
The IoT data are collected, stored and monitored by AT&T in the IGPS server rooms. These rooms are classified as authorized personals only basis and are equipped with high level security details.

3.5 DAY-IN-THE-LIFE.

Imagine a year from now; you plan to go on a holiday in Miami, Florida during the winter. Before you begin your 18 hour journey, you access your IGPS mobile app and key in your travel itineraries. As soon as you enter your vehicle, the IGPS cloud information system will transfers all the information keyed in the smartphone. The built-in GPS in the vehicle will suggest the fastest route to Florida in accordance with the speed limit throughout the journey, real time traffic patterns and also routes that avoids tolls. On top of that, IGPS will suggest gas stations for you to fill up gas based on the highest efficiency for miles per gallon per dollar. While you were on the I-95 heading south, an accident happened 10 miles from your location. The accident has caused cars on the road to be bumper to bumper. Luckily, your IGPS suggested a re-route and asks you to take the nearest exit. After taking the re-route, you have avoided the traffic jam and you are able to continue your journey smoothly. Half-way through your journey south, you decided that you want make a quick stop to buy some food. Using the voice action command function, you searched for the nearest drive-thru. IGPS suggested that you make the next exit and headed straight to McDonalds as they have the shortest waiting time. As you make the exit, IGPS warns you that there is a traffic light stop ahead and if you maintain at 20 mph, you pass through the light without stopping. After buying your meal, you continued driving south and arrive in Miami, Florida safe and sound.

Imagine that five years later; you decided to go on a summer vacation in Portland, Maine. Before you begin your 9 hour journey, you access your IGPS mobile app and key in your travel itineraries. Once you have done keying in, suggested suitable departure times to start your journey. As soon as you enter your vehicle, the IGPS cloud information system transfers all the information keyed in the smartphone. The built-in GPS will suggest the best route to use at that point of time based on the speed limit of the route used and real time traffic patterns. While you were on the I-84E heading east, an accident happened 10 miles from your location. As majority of the road users subscribes to IGPS, most traffic has been successfully diverted from the accident; therefore, traffic congestions have been avoided. Three-quarters through your journey east, you decided that you want make a quick stop to buy some food. Using the voice action command function, you searched for the nearest drive-thru. IGPS suggested that you make the next exit and headed straight to Hardees as they have the shortest waiting time. As you make the exit, IGPS warns you that there is a traffic light stop ahead and if you maintain at 15 mph, you pass through the light without stopping. After buying your meal, you continued driving east and arrive in Portland, Maine safe and sound.
3.6 DEVELOPMENT AND MARKETING.

Garmin is a formerly American company that develops consumer, aviation and marine technologies for the Global Positioning System (GPS). In 2010, Garmin became a Swiss owned company making hundreds of millions in revenue per year. As they are well established and leading contributors in the GPS market, it is undeniable that Garmin has the capacity of building and marketing IGPS successfully in the market. Apart from that, Garmin has been a leading innovator in building GPS devices and systems for the future.

Google has been a part of the human life since the beginning of the technological revolution in the 90’s. With a net income of $12 billion for the year 2013, Google has definitely become one of the biggest multinational corporation specialized in internet-related services and products. In the GPS market, Google has become a contributor in the navigation industry with the introduction of Google Maps. Google Maps has been a popular mapping service application especially for smartphone users. With its latest 3D mapping function and also vast amount of spending power, Google definitely has the capacity to build and market IGPS. On top of that, Google’s recent takeover of Waze, a GPS-based geographical navigation application program smartphones shows their interest in the GPS and navigation industry.

Apple is known as Google’s main competitor in producing mapping service application. Being a pre-installed app in the Apple iOS system, Apple maps are popular among iPhone and iPad users all over the world. Being behind Google Maps all this while, Apple is keen to overtake their main competitors Google with new innovations in the mapping service application. Knowing the amount of iPhone and iPad users in the market, Apple has the capacity to build and market IGPS both technologically and financially.
The increase in demand of motor vehicles caused the increase in population has resulted in an increase in the amount of cars on the road. Even though this has affected positively to the country’s economy and the automobile industry, the increase in cars on the road has caused major traffic congestions in major cities especially during the holidays. The figure below shows the US vehicle ownership growth for the past century.

The key to counteracting traffic congestions and reducing traffic accidents is the coordination of vehicles on the road. Therefore, Freeloaders Corporation introduces the Intelligent Global Positioning System (IGPS).

IGPS is a Global Positioning System (GPS) equipped with an artificial intelligence system that is capable of suggesting routes, departure times, gas stations and re-routes based on live feed of real time traffic patterns, traffic light coordination and also real time crowd data at a particular place. IGPS functions under the V2V communications system in the Internet of Things (IoT) domain. The long term goals set on IGPS is to produce a traffic jam free environment and also to allow road users to have a more efficient journey in terms of gas mileage and time. One of IGPS’s key features is that it is capable to divert traffic out from a congested route caused by accidents. This feature can not only reduce traffic congestions but also allow emergency vehicles to function effectively in dealing with the accident.
The function ability of IGPS centralizes at the main intelligence system that collects, store and utilizes traffic data from road users, authorities and the Department of Transportation. Road users provide data inputs through their smartphones, built in GPS in their vehicles and the cloud information system. They provide their journey details and itineraries for the system to process under the traffic data. Authorities provide real time traffic data such as traffic accidents and road constructions. The Department of Transportation provides traffic lights data and real time traffic data. All the data collected will be processed to find the real time traffic pattern. With the traffic pattern produced as the output of the processed data, the intelligence system is able to make effective suggestions to road users that will effect positively in their daily travel activities.

The basic concepts used by IGPS are the GPS, cellular network data and Zigbee. Any user input made will be collected via GPS. Subsequent updates on real time data will be channeled through both the GPS system for the built-in GPS and also the cellular network data for the smartphone. These will be updated frequently to ensure that IGPS is able to provide the best route suggestions and recommendations at a particular point of time. AT&T’s ability to provide wide data coverage across the United State enhances IGPS’s capability of serving its purposes. On top of that, Zigbee plays a major role in executing the V2V communications activity. The table below shows the comparison between Zigbee and other relevant wireless protocols.

### Comparison of relevant wireless protocols

<table>
<thead>
<tr>
<th></th>
<th>WiFi</th>
<th>Bluetooth</th>
<th>Ultra Wideband</th>
<th>ZigBee</th>
<th>ISA100.11a</th>
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<tbody>
<tr>
<td>Built on</td>
<td>IEEE 802.11</td>
<td>IEEE 802.15.1</td>
<td>IEEE 802.15.3</td>
<td>IEEE 802.15.4</td>
<td></td>
</tr>
<tr>
<td>Frequency Bands</td>
<td>2.4 GHz</td>
<td>2.4 GHz</td>
<td>Variable</td>
<td>2.4GHz, 915MHz, 868MHz</td>
<td></td>
</tr>
<tr>
<td>Primary Application</td>
<td>Wireless LAN</td>
<td>Cable Replacement</td>
<td>Indoor Short-Range</td>
<td>Home and Office</td>
<td>Industrial Process Control</td>
</tr>
<tr>
<td>Data Rate</td>
<td>150 Mbps</td>
<td>1 Mbps</td>
<td>1.6 Gbps</td>
<td>250 kbps</td>
<td>&lt; 250 kbps</td>
</tr>
<tr>
<td>Nodes per Network</td>
<td>30</td>
<td>7</td>
<td>200+</td>
<td>65,000</td>
<td>65,000</td>
</tr>
<tr>
<td>Range</td>
<td>100 m</td>
<td>10 m</td>
<td>5 m</td>
<td>100 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Topologies</td>
<td>Star, Tree</td>
<td>Star, Tree</td>
<td>Star, Tree, Mesh</td>
<td>Star, Tree, Mesh</td>
<td>Star, Tree, Mesh</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>High</td>
<td>Medium</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
<tr>
<td>Complexity</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Very High</td>
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Zigbee is chosen as the most suitable wireless protocol because it requires low power demands and powerful local networking capable of V2V communications. Zigbee’s ability to relay data by passing it off to nearby devices enables it to reach more distant objects.
Smartphone has grown from an accessory to a necessity. Therefore, Smartphone is an ideal user interface as it can be accessed easily. Using the IGPS mobile application, IGPS can be accessed wherever the users are and whenever they want. On top of that, in order to increase user’s ability to access IGPS in their cars, a built-in GPS is required. The IGPS mobile app can be connected to the built-in GPS system through the Information Cloud System. This enables users to key in their travel plans before entering their cars. On the other end of the system, IGPS is controlled externally by AT&T authorized employees through servers dedicated to IGPS. The server will be monitored 24/7 to ensure that IGPS functions effectively.

Security and user’s privacy is a key aspect in IGPS system control requirements. Fundamentally, all customers subscribed under AT&T are entitled to the company’s security and privacy policy. It has been an AT&T policy that all customer related information is kept safe and private from the general public. However, according to AT&T’s privacy policy, there exceptions made where customer information is released to selected parties. These parties are across AT&T, other companies that perform services on behalf of AT&T and authorities with the presence of court orders and legal process. These exceptions are made to ensure that AT&T is capable of providing customers with the best service available and also based on request made in respond to emergencies. The selected parties are required to protect the information acquired under the same privacy policy.

After conducting thorough research, there are three large companies classified as capable of building and marketing IGPS. The three companies are Garmin, Google and Apple. Garmin is a Swiss company that develops the Global Positioning System (GPS) for consumer, aviation and marine purposes. Garmin has been a leading innovator and contributor to the innovation of GPS; therefore, they have the technological advantage in building IGPS. Besides Garmin, Google also has the capability of building and marketing IGPS. After their recent takeover on Waze, it is clear that Google has developed interest in the navigation industry. As one of the biggest multinational corporation specialized in internet-related services, Google has the marketing edge in developing and selling IGPS to the public. Their latest 3D mapping function has shown that Google is keen on being a lead contributor to the industry. Apple maps application is a pre-installed application available for iPhone and iPad users. Knowing Apple’s research capability and popularity among smartphone users, Apple definitely has capability of building and marketing IGPS to the public. Being a close competitor towards Google maps, developing IGPS will give them the extra edge needed to compete with Google.

The long term goal towards the implementation of IGPS is to be able to coordinate traffic so that the traffic congestions happening in most major cities can be reduced. The ability of suggesting departure times and providing real time re-routes enables road users to increase the efficiency of their everyday travel activities. Besides that, the ability to divert traffic from an accident site will reduce the respond time required by emergency vehicles to arrive at the scene.
Inspired by the flight coordination system used in Air Traffic Control (ATC) towers, Intelligent Global Positioning System (IGPS) functions under the main goal of improving the efficiency of road users in undergoing their daily travel routines. Here are the benefits of implementing IGPS:

- Road users are capable of traveling efficiently daily to work.
- Road users are capable of planning their journey ahead of a business or holiday trips.
- Road users are capable of receiving real time traffic news and data to help them plan a perfect departure time.
- Road users are able to receive warnings regarding an upcoming traffic light.
- Road users are able to determine the amount of crowd at a particular road side facility.
- Road users are able to obtain their best gas mileage per gallon per dollar.
- Traffic can be coordinated based on the travel patterns made by road users daily (e.g. route taken to work, daily departure from their house to work).
- In case of an accident, traffic can be diverted away from the accident area to avoid traffic congestions.
- In case of an accident, the response time made by emergency vehicles can be reduced and this could save lives.

Based on the research made on the basic concepts and system models of IGPS, we identified several strengths and weaknesses of the IGPS concept design. The strengths of IGPS are as follows:

- IGPS can be accessed wherever we are and whenever we want.
- IGPS uses a voice action command system for built-in GPS to avoid road user being distracted from focusing on the road.
- IGPS uses cellular network data; therefore it works well with other AT&T services.
- IGPS uses Zigbee to conduct V2V communications which uses low power demand, long range and low level of complexity.
- IGPS connects real time traffic data from road users, authorities and the Department of Transportation.
- IGPS users are covered under the AT&T high security encryption systems and customer information privacy policies.
The weaknesses of IGPS are as follows:

- The accuracy of the suggestions and recommendations made by IGPS is as accurate as the data obtained from road users, authorities and the Department of Transportation.
- IGPS will only function effectively if road users follow the suggestions made by IGPS.
- Zigbee has low complexity, slow in speed and high cost.
- The long term goal for IGPS can only be implemented if most vehicles on the road subscribes to the IGPS service.
- The AT&T privacy policy can be over ruled by court orders and legal documentations.

The way we see IGPS is that it is a step further in developing an auto pilot system for cars. In other words, IGPS is the fundamental aspect of developing a self driven car. The benefit of having a self-driven car is to reduce road accidents. Imagine in the future, road users are able to read newspapers at the driver seat of their car and a non-stop journey to San Francisco by car is made practical and safe.

We recommend AT&T to market IGPS side by side with their other current services. The best way to market IGPS to the public is through bundle services where customer can receive multiple AT&T services under one plan. These customers can be bound under annual contracts to ensure that AT&T receives continuous subscription of the plan for at least a year. We also recommend AT&T to conduct mutual agreements and contracts with car manufacturers and work side by side with them to further develop and innovate the IGPS application.
SECTION 6

REFERENCES


