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Integrating Cloud Computing, BI, and GIS to Build Smart Business

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Abstract: ***This study presents an integrated framework combining Business Intelligence (BI), Geographic Information Systems (GIS), and Cloud Computing to enable real-time tracking of organizational vehicles. The proposed system employs an Android-based application embedded with GPS and GSM functionalities to monitor vehicular movement and relay location data to a centralized server. By leveraging cloud infrastructure, the system ensures scalability, real-time data communication, and improved decision-making capabilities. The results demonstrate the feasibility of using enhanced GIS tools and BI integration to support the development of smart communities through efficient transport monitoring and data-driven strategies.***

Keywords: Business Intelligence, Geographic Information Systems, Cloud Computing, Real-time Tracking, Android Application

1. Introduction

Basically, the key role in Information Systems (IS) is innovation, which is the process of making a change in something and creating value for the company [1]. The development and improvement of technology attract many people, as technological innovation is the boundary of information systems. IS and technology complement each other to fit business innovation. However, technology innovation and IS work together to enhance the workplace.

For instance, Information Systems can be used to develop police databases. IS helps increase the efficiency of police work, provides a secure and safe environment, and maintains control of local security services. According to [2], Information Communication Technology (ICT) is an IS that provides a new version of the police database. This database connects all police officers together in all counties and contains all information about the offender.

The purpose of this study is to design and implement a cloud-integrated real-time vehicle tracking system using GIS, BI tools, and Android-based GPS technology to enhance service delivery in organizational transport operations.

1.1 Technology Innovation

Generally, integrating technology innovation and IS into a seamless process can enhance the workflow. The success of a particular company or organization is largely dependent on three key elements: strategy, competitiveness, and technological innovation. Strategic management is one tool of an organizational management activity that is used to analyze strategic goals, internal and external environment of the organization [3].

Technology innovation creates market leadership among competitors. Smart companies define internal and external capabilities and synthesize what organizations have with market technology.

1.2 Geographic Information System (GIS)

GIS or Spatial Information is a part of the IS innovation tools that are used to describe and characterize the Earth and other geographies. Spatial data is collected, processed, organized, and structured to become a map. In other words, the GIS is a digitized system that is designed to visualize, analyze, manage, and present all types of spatial data [4].

Essentially, GIS has several functions that enable users to digitize data and analyze relationships between various geographic features. GIS is designed to answer basic and complicated user questions. Likewise, the Internet search engine is like GIS, and both systems have designed query systems. The importance of GIS is overemphasized in the academic and professional arena. In this era, academics and professionals are using GIS more than ever in solving organizational and business problems, population characteristics, economic activity, and political jurisdictions. In management and business sectors, GIS plays a critical role as a success factor because it can analyze large quantities of data, such as market statistics across a geographic area.

1.3 Business Intelligence (BI)

All organizations are created and maintained to fulfill their intended objectives and goals. Whether the organization is made for financial, psychological, or economic reasons, the truth is that all organizations follow a certain criterion. Digital technology allows enterprises to deliver the best service levels for employees and customers.

Digital technology aims to build strong relationships among suppliers, employees, and customers. Digital technology can support management functions using BI technology. Managing an enterprise through BI tools will provide maximum return on investment and enhance performance.

1.4 Cloud Computing

This era is marked by rapid technological advancement, with innovation driving market leadership. Leadership, technology, and competitiveness are the critical success factors for sustaining existing business and continuing to grow. Innovation makes a significant change to key parts of the dominant business, which provides the opportunity to redirect the competitive vectors of an entire industry.

Cloud computing is a strategy used to improve organizational quality by focusing on core competencies and activities. When the organization outsources a job, the job will be concentrated on another part.

The third party will provide excellent service that can guarantee high-quality production as well as increase profit. The company can focus on a thing that it does well and leaves out the tasks to complete the weak part of the job. Another characteristic that Cloud computing provides is disaster recovery services. Cloud process data is moved into the cloud data center, run on virtual computing resources in the form of a virtual machine [5].

One of the key benefits of using cloud computing is increased collaboration. Collaboration is a technique that integrates people, processes, and technology to support businesses and achieve goals. The collaborative approach leads to innovation and creativity in the workplace, which leads to gaining a competitive advantage and creativity in problem-solving.

In general, BI and GIS are techniques and tools that are used in identifying, extracting, and analyzing business data. These techniques keep organizations comfortable and confident about their decisions and create a competitive advantage.

Through Cloud computing, BI and GIS can deliver the right information to the right people at the right time. Cloud is considered the main component for the integration of BI and GIS. This feature makes the organizational structure stronger. Another benefit is that Cloud computing provides opportunities for organizations to become more flexible, cost-effective, and productive. As a result, organizations can deliver new capabilities and increase business value through BI, Cloud, and GIS.

On the other hand, GPS (Global Positioning System) and GSM (Global System for Mobile Communications) based vehicle location and tracking systems will provide effective, real-time vehicle location, mapping, and reporting this information back to the monitoring device, and improving the level of service provided [6]. A GPS-based vehicle tracking system informs the user where the vehicle is and where it has been, and how long it has been. The system uses geographic position and time information from the Global Positioning Satellites.

Currently, mostly the existing tracking systems use techniques of virtual fence known as Geofence, which compare the entity's position with a predetermined zone or a point of interest, checking if the entity is inside or outside an area. Those techniques do not allow full coverage of the course, making it difficult to determine if a truck or another delivery vehicle is traveling on a planned path [7]. Therefore, we need to use an alternative technique that allows continuous monitoring of travel, obtaining information on probable deviations or even emergencies.

This system consists of a fitted mobile, which contains a GSM and GPS modem along with the processor that fits the vehicle permanently. This device is called a tracking device, which continuously accesses its current location and sends updates to the server. A monitoring device, which is an Android application, is providing the user with the exact location of the vehicles of his interest.

2. Literature Survey

According to Gartner, basically, 75% of information technology is allocated to integrate and analyze data [8]. In other words, IT uses tools to identify, discover, and analyze business data such as sales revenue, products, costs, and income to meet organizational goals.

BI, Cloud, and GIS play a significant role in the failure or success of work. BI is defined as "an umbrella term that includes the applications, infrastructure, and tools, and uses the best practices that enable access to analysis of information to improve and optimize decisions and performance [9]."

2.1 Business Intelligence Applications

BI applications had their own databases that supported organizational functions. In fact, 75% of organizations are focused only on structured data to make business decisions [8].

Currently, BI applications are considered a critical success factor of an organization. Organizations and businesses need the ability to quickly analyze their data to identify issues, causes, and opportunities for improvement. There has always been a need for a tool that allows users to monitor automated reporting, distribute results, and make strategic decisions based on short-term and long-term data and trend analysis.

The current BI can link spatial data (GIS) with other data sources to aid in report interpretations. Once these analyses are identified, the business now looks for intelligent answers to certain questions through business graphics information [10].

2.2 Need for Business Intelligence and Integrating Information

How to grasp the latest technology to process this information is a challenge for organizations and is the question that most companies need to answer.

An evolutionary business approach shows sound planning to deliver solutions that meet the long-term goals of the organization. This doesn't mean that the enterprise will have all the latest and greatest technology, but it does mean that an evolutionary business approach delivers information to begin with and sustain enterprise strategic vision and goals. It achieves tactical and strategic goals through information used

to create a sustainable competitive advantage. This can be done through simple or complex solutions [11].
Table 2.1 Shows data requirements and the solution. By and large, enhancing BI applications in organizations can provide a competitive advantage in the marketplace. The concept of competitive advantage began with technological innovations and the types of innovations.

Table 2.1: Organization Technology Solutions and Data Requirements

Data Requirement	Solution
Data Integration	Data Transformation, Query, and Information Integration Services
Data Mean	Data Mapping According Schema and User Requirement
Data Mart,	Aggregation of Queries,
Data Warehousing	Consolidation
Business Rules	Rules Attachment to Measure Data
Track Records, General Ledger, Entity Data	Metadata Storage
Information Management	Discovery Service and Information Management, Analysis Repository

2.3 The Various IT Trends Shape Business Intelligence

Figure 2.1 below demonstrates and predicts BI applications in the global market from 2013 to 2018. In 2013, the BI market launched and earned $2.2 billion; however, the predictor expected the BI market to grow and reach $3.14 billion in 2018 [12].

Over the decade, Cloud BI has developed and been introduced in the market. In 2013, Cloud Business Intelligence was officially launched and earned $0.75 billion, where the analyses forecast grew to $2.94 billion in 2018 [13].

In brief, the chart shows how the economic and market growth of BI and Cloud Business Intelligence increases each year and creates value for businesses.

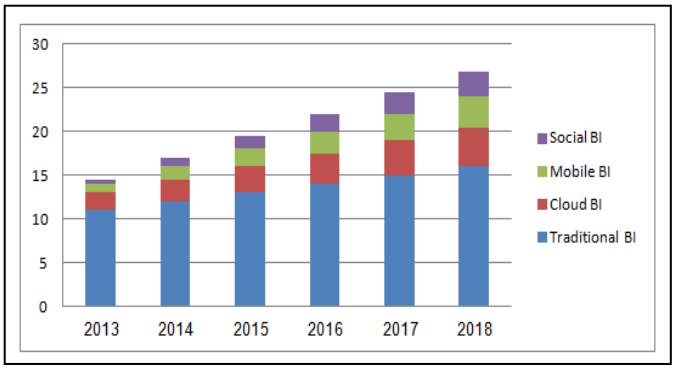

Figure 2.1: The Global Business Intelligence Growth from 2013 to 2018 [12].

The methodology used to determine where you are in the life cycle of the maturity of a product is shown in Gartner Hype Cycle Figure 2.2. As shown in the figure below, any technology that starts with the Technology Trigger phase has great expectations around it.

2.4 Current Business Intelligence Applications

Today, business decisions are based on complete data, in which BI offers tools and techniques to make correct decisions, keep the organization feeling comfortable, and believe in their decisions.

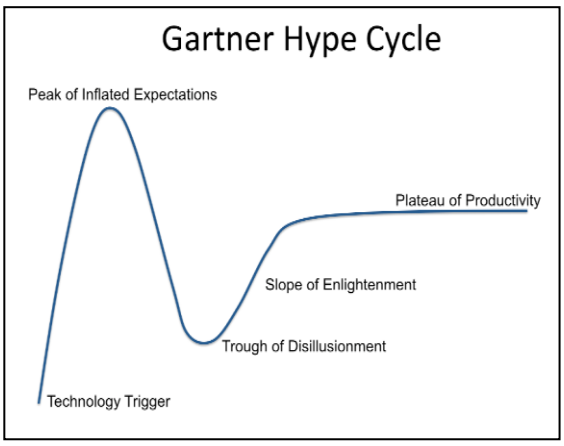

Figure 2.2: Gartner Chart [14].

BI is unique because it can combine data, multimedia, and transactions all in one application to address people's needs and wants. Figure 2.3 below illustrates one BI application as a Dashboard or Web Dashboard that is produced by the BI and GIS team today, which consists of graphs, some charts, and several lists of drill-down capabilities [15].

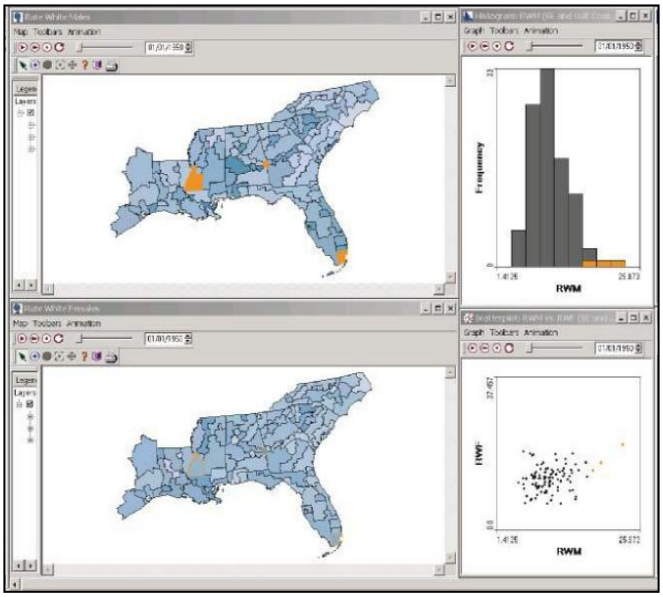

Figure 2.3: Integrate BI and GIS Application [16].

2.5 In-Memory Technology

In general, focusing on the performance of the Random-Access Memory (RAM) is an effective approach for increasing BI systems' performance. Increasing the capacity of the RAM platform significantly enhances the system and will replace the traditional disk-based systems. However, the speed difference between In-Memory RAM systems versus traditional disk-based systems is 1000x times faster than traditional disk-based systems [17]. That means RAM can be processed 1000x times per second.

When In-Memory combines with multiple parallel the result is In-Memory performance. This will improve the BI system in seconds to run a Dashboard application.

2.6 Cloud Business Intelligence

BI is about delivering the right information to the right people at the right time, and cloud computing provides a lightweight, agile way to access BI applications. Cloud BI applications are "hosted on a virtual network, such as the internet [18]." This application has the authority to access multiple devices and web browsers. Integration of the BI system and data warehouse on the web has led to a new BI capability. Figure 2.4 illustrates this.

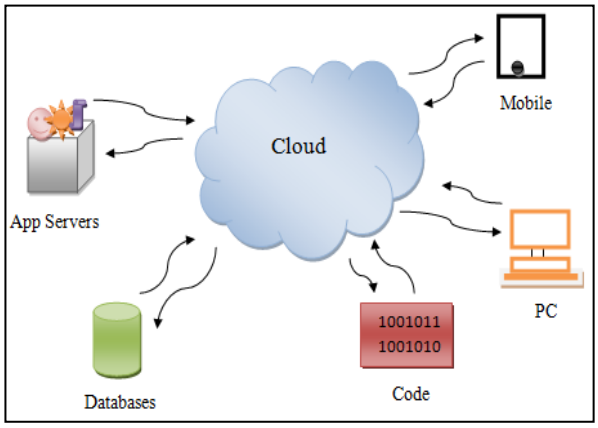

Figure 2.4: Cloud Computing

BI on the cloud has several functions that make the application more critical, including accuracy, implementation speed, deployment efficiency, redundancy elimination, and system flexibility., User-Friendliness, Lower Costs, a Focus on Core Strengths, and Availability [19] [20].

GSM and GPS technologies help to track the vehicle's exact location. The SMS system provides real-time control. You can monitor the location from anywhere using this system [1]. The device used for tracking the location of a vehicle is named SWTRACK. It also provides a mechanism to monitor the detours coming in the planned route and sends an alarm message through the device [7]. The accuracy and precision are provided by the CORS service network and Mobile, which has also verified the feasibility of integrating CORS and Mobile GIS for mobile location services [1].

Satellite navigation now days what every country desires to have to become a great power, as most importantly, it serves military applications and rescue operations. The next generation of satellite navigation is giving services to civil users and hence a very good market from a commercial point of view [21].

To determine the approximate distance between the user and the locations of the desired place, a system was developed. This system is flexible and extendible to easily get the location of the user's interest. The main purpose of departure from existing similar systems is that it is a GPS-based rather than a mobile-based service provider to allow for a more accurate location calculation [22].

To assess the positioning accuracy and convergence time improvement of the combined GPS and GLONASS data processing, a 2-hour and four 3-hour sessions of datasets have been used in the data analysis [23].
The GNSS consists of three main satellite navigation systems. They are GPS (Global Positioning System), GLONASS, and Galileo. The comparative study of these three navigation systems is mentioned in the following table:

Table 2.2: Comparison of GNSS

Parameters	GPS	GLONASS	Galileo
Satellites per complete constellation	32 Block III	24	27+3 spares
Orbital Planes	6	3	3
Plane Inclination	55 deg	64.8 deg	56 deg
Radius of Orbit	26650 km	14100 km	23222 km
Period required for the complete cycle	12 hrs	11 hrs 15 min	11 hrs 15 min
Civil Data Rate of Satellite	50 bps, up to 100 sps	50 bps	50 bps, up to 100 sps
Accuracy	5-20 m	50-70 m	Claimed 1 m
Operation Bands of Satellite	L1, L2, L5	L1, L2, L3, L5	E1, E5, E6

As far as the system is concerned, GPS is the best technology considering its availability and receiver cost. Because today every Android phone comes with an inbuilt GPS receiver installed in it. Therefore, there is no need to purchase a separate GPS receiver for each client. In this system author decided to use an Android mobile, which consists of an inbuilt GPS and GSM modems.

3. Proposed Methodology

This study is significant as it proposes a cost-effective, scalable, and user-friendly tracking system that can improve operational control, reduce inefficiencies, and contribute to the broader goal of building smart communities through digital infrastructure.

The following approach will support organizations to improve the quality of service and production. There are several methods for creating a successful strategy to support smart communities.

3.1 Business Intelligence Cloud

Cloud computing provides a simple way to access servers, storage, databases, and a broad set of application services on the Internet. However, there are certain categories of Cloud Computing services [24], and here is a rough breakdown of what Cloud computing is all about:

1) *Software as a Service (SaaS):* Figure 3.1 shows that SaaS application is designed for end-users and is delivered over the web [25]. SaaS can extend the stack and incorporate the application layer in the Cloud. In addition, users can access data from any connected computer.
2) *Platform as a Service (PaaS):* Figure 3.2 explains how this category can deploy a new web application to the Cloud in minutes and reduce complexity with middleware as a service [25]. However, PaaS is another type of Cloud Computing service that provides a computing platform and a solution stack as a service.

3) *Infrastructure as a service (IaaS):* Figure 3.3 shows how IaaS can manage networking, the operating system environment, stores, servers, and platform virtualization without investment in hardware [25].

Figure 3.1: Software as a Service (SaaS).

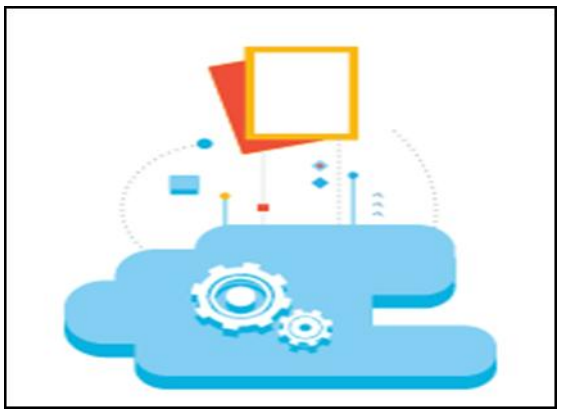

Figure 3.2: Platform as a Service (PaaS).

Figure 3.3: Infrastructure as a Service (IaaS).

Figure 3.4 illustrates the category of a Cloud Computing services stack [26]. Basically, BI has become an essential key for managing businesses. Organizations know the importance of data warehouses to BI, and Cloud computing to integrate and incorporate with an organization's BI application. Thus, integrating Cloud computing with BI can enable business intelligence systems and analytical tools to communicate freely among themselves and with data warehouses.

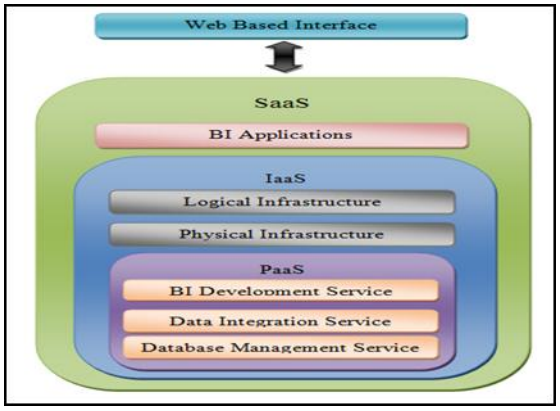

Figure 3.4: Cloud Computing Services

3.2 GIS and GPS Cloud

GIS and GPS are a part of IS innovation tools. These are used to describe and characterize the Earth and other geographies. GPS is a technology used to track movement and cannot possibly be used to its full potential without GIS. It stores and manipulates information about common location components, such as postal zip codes, road names, and longitudes that GPS accumulates. The information is stored in multiple layers in one database, and these layers are linked together to create common location components in maps.

Recently, GIS and BI have been considered as powerful tools when they are integrated into a single application. The application can analyze aerial photographs and satellite images, then create statistical models or draft maps. GIS and GPS rely upon real-time data, communicate with satellites and a database network via the Cloud. Figures 3.5 and 3.6 show the communication process of application [27].

Most of the GPS and GIS vehicle tracking systems provide accurate speed information about each vehicle tracked. Drivers who speed, run red lights or stop signs, accelerate hard, or make sudden stops will be recorded and notified immediately when a vehicle exceeds a set speed threshold, or accelerates hard. Figures 3.7 through 3.11 show the GIS and GPS workflow process.

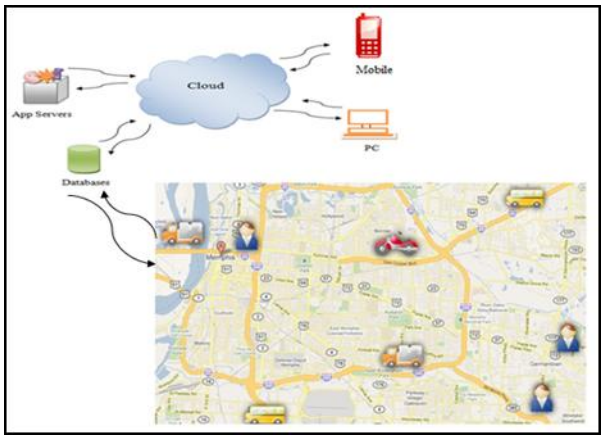

Figure 3.5: GIS and GPS Connected with Cloud.

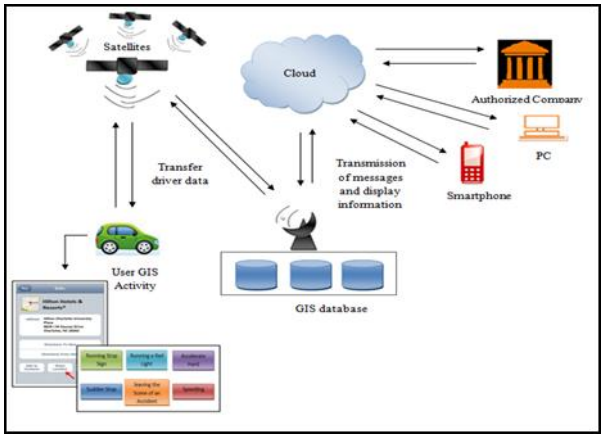

Figure 3.6: GIS and GPS Communication

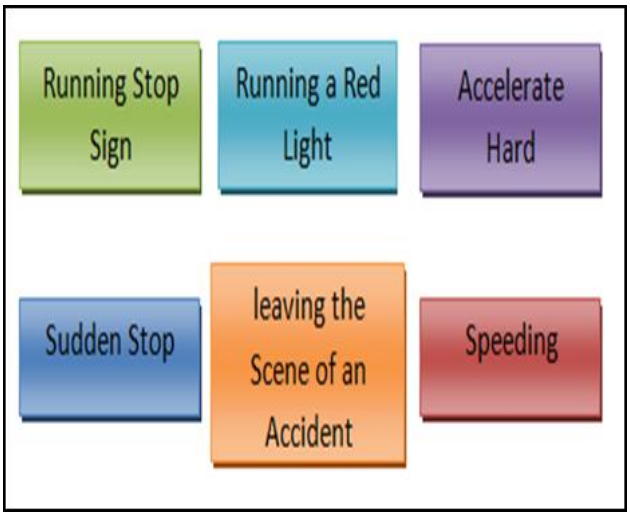

Figure 3.7: Traffic Violations

3.3 Project to Illustrate the Concept of Tracking

In general, a GPS-based vehicle tracking system uses GPS technology, GSM service, and an Android mobile. As shown in Fig.3.12, this system has three main modules transmitting unit, the monitoring unit, and the server. The transmitting side performs tracking functionality. It tracks the vehicle through GPS and transmits its current location to the server. The main function of the monitoring side is to provide a login interface to the user and to show the Google map with vehicle locations.

The server works as a central connector for the transmitting unit and monitoring unit. As both the transmitting side and monitoring side communicate with each other through the Server only. As shown in Fig. 3.12 mobile application communicates with the server and accesses the remote database. At the transmitting side Tracker application obtains its current location through GPS technology and updates it to the server.

1) Project Components:

It consists of two units Transmitting Unit and the Monitoring Unit. The transmitting unit contains an Android mobile which has inbuilt GPS, GSM modem, and GPRS (General Packet Radio Service) functionality. Therefore, the mobile will be used as a transmitting unit. GPS is a main module in this Vehicle tracking system. As vehicles are tracked using GPS technology. GPS is used to determine the exact location of vehicles. But to get the exact location of any vehicle, it needs to be in the focus of four satellites. In the Vehicle tracking system, GSM is used for communication between all three modules.

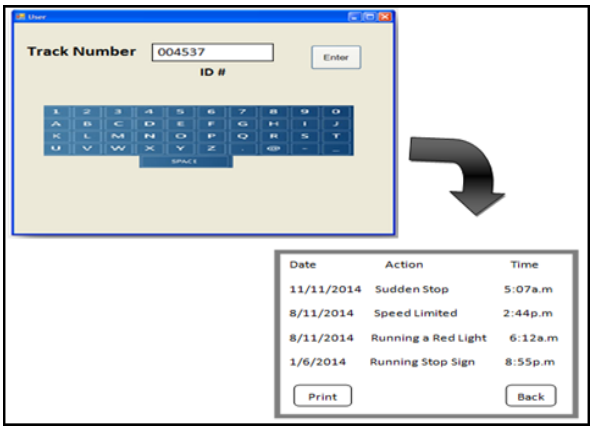

Figure 3.8: Authorization Company's Tracking

Figure 3.9: GPS Speed Alerting Features

Figure 3.10: GPS Sudden Stop Alerting Features

The monitoring unit is an Android Application through which users will get to know the actual position of proposed vehicles.

Figure 3.11: Driver Report

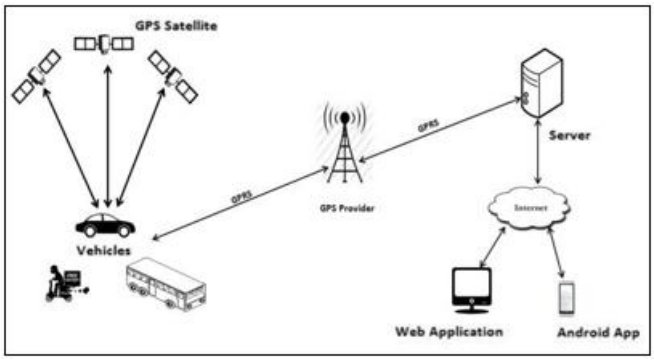

Figure 3.12: System Architecture

This Android provides the user interface through which users communicate with the system. It provides login to the system. After logging in to the system user will get a Google map with the exact location of vehicles.

2) Workflow

The workflow of the GPS-based Vehicle Tracking System is as per the given Fig.3.12. Users can use this system by performing the actions mentioned in the flowchart.

3) Tracking Device:

- The tracking device will continuously request the GPS satellite for its location information.
- At the same time GPS satellite will provide the location information to the tracking device installed in the vehicle.
- The tracking device will send the location information back to the server through GPRS and continuously update the database.

4) Monitoring Device:

- The monitoring device will continuously access the database from the server.
- From that database, the location information will be plotted on Google Maps.

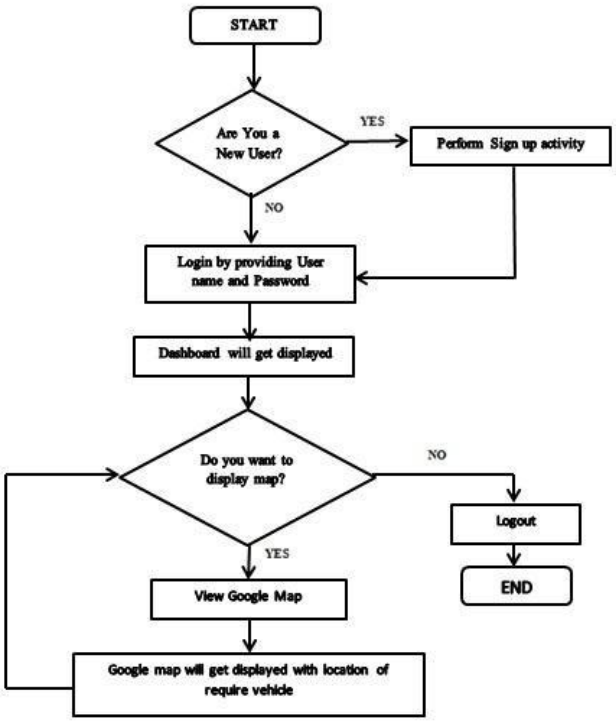

Figure 3.13: Workflow

4. Conclusion

The proposed Android-based vehicle tracking system successfully integrates GIS, BI, and Cloud Computing to deliver real-time monitoring capabilities. The system enhances organizational transparency and supports smart community initiatives by enabling location-based service optimization. Future developments may incorporate anti-theft features and extend the platform for broader urban mobility applications.

5. Future Work

In the proposed system, we can add features like Car locking and thief photo capturing. This will help the user have an anti-theft feature. Upgrading this system is very easy, which makes it open to future requirements without the need to rebuild everything.

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