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GIS Enabled Internet of Things (IoT) Applications: An Overview

R. Vishnu Priya*, S. Sivaranjani, S. Sivakumari

Department of CSE, Faculty of Engineering, Avinashilingam University, Coimbatore, India

*E-mail address: vishnupriya.ruthrasekar@gmail.com

ABSTRACT

Internet of Things (IOT) is a recent trend in communication field that makes internet as a universal thing. It makes all the objects in the world to interconnect with one another and with other devices to attain certain objective. Each object will be equipped with sensors, micro-controllers and receivers for digital communication. Geographic Information System (GIS) is a computer system that deals with geographical data. GIS has an ability to gather, store, examine and manage spatial data and allow users to manage data in maps. IoT and GIS are coupled together to provide a better understanding of geographical data and patterns. This tie-up helps in mapping IoT in an interactive way. This article describes the overview of the integration of GIS enabled IOT applications.

***Keywords*:** Internet of Things, Geographic Information System, Sensor, Mapping

1. INTRODUCTION

Internet had become a part of our life that makes our day-to-day activities simple and easier. Internet is a large database in which data can be accessed anywhere and at anytime. It is also a large network that connects people together. But now-a-days, a new protocol named IoT connects people even to devices, software and our surrounding things. Internet of Things is a paradigm that connects all the objects in the world that are equipped with sensors into a network to gain useful information about these objects [1]. The objects communicate with each other

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and with devices to attain a common goal. IoT is an encouraging research area due to its vast application. It is a new model that utilizes wireless communication technologies for interaction between the objects. The elements in IoT are specified as a thing that should have an exclusive address [2].

1. 1. Techniques enabling IoT

IoT can be enabled using various techniques. Fig. 1 shows the techniques that enables IoT. The techniques are Near Field Communication (NFC), Machine-to-Machine Communication (M2M), Radio-Frequency Identification (RFID) and Vehicle-to-Vehicle communication (V2V) [3].

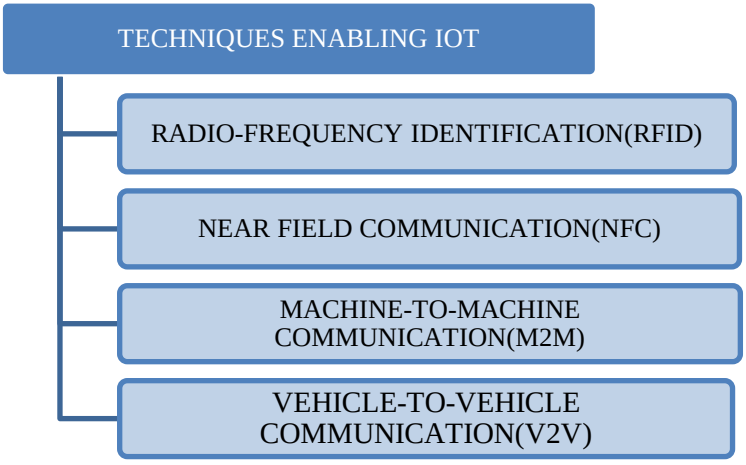

Fig. 1. Technologies that enable IoT

Radio-Frequency identification (RFID) monitors objects in real-time. It consists of a reader and tag. Tags are applied to objects to obtain information using radio-frequency electromagnetic field. The readers are used to read the electronic information in the tag. Tags are microchips with antennas. Near field communication (NFC) is similar to RFID i.e. NFC integrates RFID reader into smart phones. NFC is the most trending technology that communicates with other NFC enabled mobiles by getting them touched or bringing them close. Machine-to-machine communication (M2M) is a process of communicating between microcontrollers, sensors, computers and smart phones. M2M communication is used for sensing, providing access control between different devices and processing the information. Vehicle-to-Vehicle communication (V2V) is a new technology that uses vehicle as a node.

The vehicles communicate with each other through an ad-hoc network. V2V communication does not have a static topology so it is bit complex.

1. 2. Components of IoT

There are three components of IoT. Fig. 2 shows the components of IoT. They are hardware, middleware, presentation [4]. Hardware is used to collect information from the real world objects using sensors, micro-controllers and embedded communication hardware. Middleware is an intermediate component that connects the hardware component with the

presentation component to visualize it. It is used for on-demand storage and also provides tools for data analysis. Presentation component creates application to visualize and interpret the information collected from the hardware component. This application can be accessed anywhere at any platform.

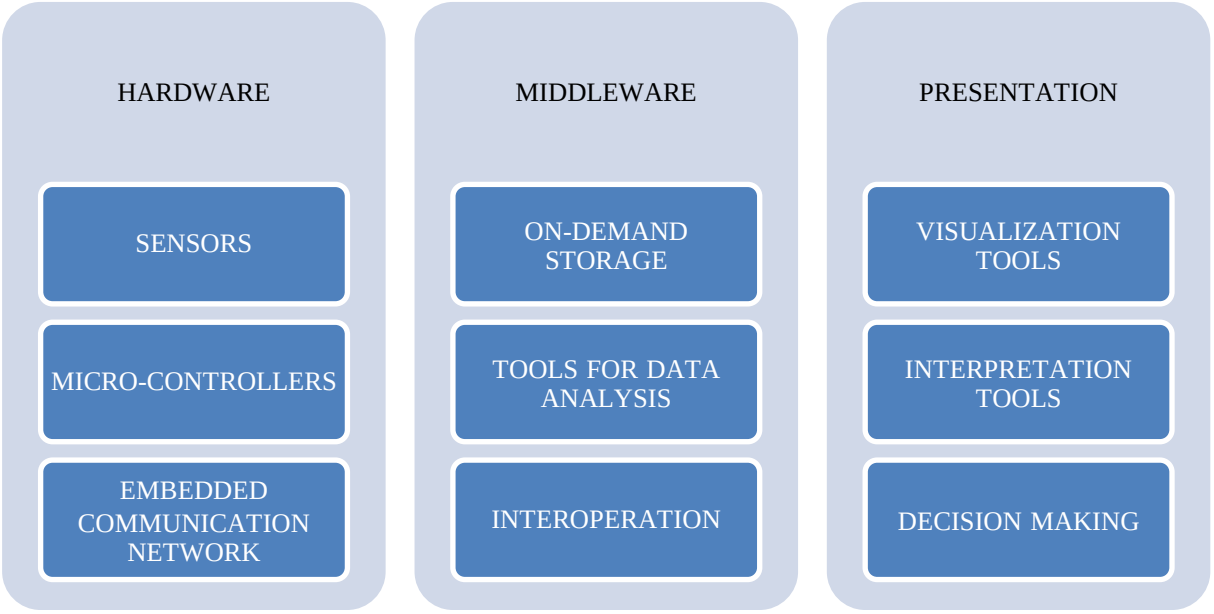

Fig. 2. Components of IoT

2. GEOGRAPHIC INFORMATION SYSTEM (GIS)

Geographic Information System (GIS) is a processing system that has an ability to combine all types of data based on locational component of data. GIS is an application that deals with digital geographical data. It allows users to create maps, visualize information and integrate data of varying types.

2. 1. GIS Dimensions

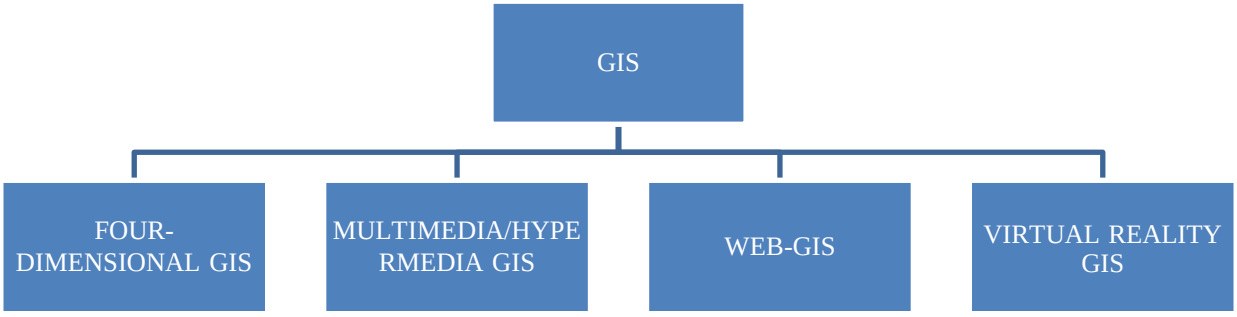

Fig. 3. Types of GIS

There are four different types of GIS. Fig. 3 shows the types of GIS. They are Four-dimensional GIS, Multimedia/hypermedia GIS, Web GIS, Virtual reality GIS [5].

Four-dimensional GIS can handle three dimensions for space and one dimension for time. So that it has a capability to handle more spatial data. Multimedia\hypermedia GIS works with geographically referenced multimedia data like sounds and videos that are selected from a geographically referenced image map. The data are stored in an extended relational database. Web-GIS provides an internet based application that uses geographical data. Now-a-days many geomantic applications are web based. Virtual reality GIS create, manipulate and explore geographically referenced environments.

2. 2. Views in GIS and GIS tools

The idea of GIS is presented in three different views. The views of GIS are shown in Fig. 4. They are map view, database view and spatial analysis view. In map view, GIS performs map processing where each data will be represented as a map. The database view manages the data. The data can be a geographical data, images, reports and sounds. The spatial analysis view analyze and visualize spatial data [6].

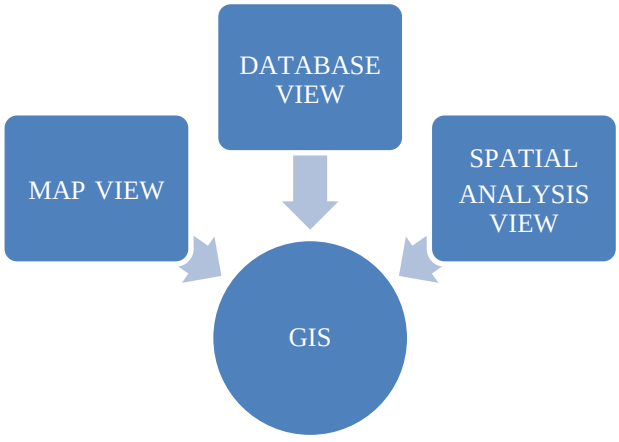

Fig. 4. Views of GIS

Table 1. Open source GIS software

CATEGORY	SOFTWARE
Desktop GIS	QGIS, GRASS GIS, gvSIG, SAGE GIS, uDIG
Web map servers	GeoServer, Mapnik, MapServer, MapGuide Open Source
Spatial database management systems	PostGIS, SpatialLite, TerraLib

There are various open source GIS software are available [7]. The open source software and their purposes are listed below in Table 1.

3. BACKGROUND STUDIES ON GIS ENABLED IOT APPLICATIONS

Peng du et al., [8] designed an emergency management system for public road transport networks using IoT and GIS. IoT is used for observing traffic and serious transport infrastructure in road networks. GIS is used for situational alertness and emergency actions. The authors had presented this work to take safety measures in road transport networks.

Shu-jinliu, Guo-qingzhu [9] proposed an evacuation system by using IoT and GIS technologies to obtain information about the building. IoT and GIS technologies had been used to analyze the impact of smoke on evacuation. The authors concluded that the proposed system have improved evacuation efficiency and also promotes the intellectualization of fire protection.

Isikdag [10] had integrated Internet of Things (IoT) and Building Information Modelling (BMD) to build a new GIS system. Building Information Modelling enables interoperability i.e. exchanging information between different software. IoTenables communication between all devices. The author presented a GIS system that combines information in building "models" and information obtained from city objects. The author concludes that this fusion can be used in system emergency response, urban surveillance, urban monitoring and smart buildings for a smart system.

Wang li-qun, Jiaji-wei [11] had used IoT as a supplementary to GIS. The author combined GPS positioning module with Radio frequency Identification (RFID) for fast data gathering and spatial locating. The experiment results shows that it provide anenhanced decision support for environmental quality management by having both the wireless identification of IoT and robust spatial data expression and analysis capacity of GIS.

Dustin Demuth, Arne Broring, Albert Remke [12] proposed an approach for providing direct and live access to citizen science sensor platform. For this purpose the author had used OGC Geo services REST API on the sensor platform. The authors made the sensor platform to be the head class node on the internet of things, so that it directly provide interfaces that are made reliable by the Open Geospatial Consortium (OGC). The experimental results shows that GIS user can directly have a measured data access to the citizen science sensor platform.

Liu Zengxian and Gao [13] Jun had used Internet of Things and GIS to make the Shanghai city of China to be a smart city. The proposed GIS concentrates more on spatial information management capabilities of Internet of Things. The authors used Internet of things to rapidly identify the features and benefits of GIS spatial analysis. The authors concludes that "Smart Shanghai" builds the city intelligent network and greatly effective multi-party collaboration.

Yongzhi Liu et al., [14] proposed a digital management platform of urban sewage pipe network service. Urban sewage pipe network service is a new methodology to collect and handle spatial data that is combined with the attribute data of sewage pipe network. The authors used IoT and GIS that contains GIS Spatial management and analysis module, sewage information control center module, sewage pipe network grid management module and drainage pipe network dynamic simulation module. The author concludes that the proposed method has been used as a safeguard for water environment and has been applied to Sanya city of Hainan.

Tan Ji-ming et al., [15] demonstrated the correlation between Internet of Things and 3D GIS. The authors had improved the spatial and temporal resolutions in the equipment and facilities of the oilfield network by combining the information sensed and collected automatically from the facilities with the spatial sense and bearings provided by the 3D virtual scene. The experiment result shows that application of IoT and 3D GIS in oilfield had a great advantage in managing the equipment and facilities based on space and time.

He Yu-Cai Wang Dan, Chen Long-hua [16] incorporated Internet of Things and GIS for information management based on space. The author had used wireless sensor network of Internet of Things for information collection, GPS had been used to find the exact location of information collection node and GIS mapping tools had been used for spatial analysis. The author concludes that the proposed monitoring system had rapidly and exactly located the position of fire and generates the fire emergency command.

Qiao Yan-you et al., [17] designed an infrastructure management system that utilized GIS to accomplish management and analysis activities by gathering and storing spatial data. Internet of Things had been used to correctly identify individual objects, so that data can be gathered and updated quickly in the database. The author concludes that usage of GIS Spatial data analysis and Radio Frequency Identification (RFID) in the infrastructure management system had improved its working efficiency.

4. CONCLUSION

Internet of Things is anemergingfield that makes the world digitize and GIS is a powerful tool that deals with geographical data. So utilizing IoT techniques in GIS systems will make the world smarter. This article summarizes the literatures on integration of IoT and GIS technologies and its real time application in various areas which helps the researchers to get an overview of GIS enabled IoT applications.

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