# Assessment of Wireless Technologies for deployment in Intelligent Transportation System based on Internet of Things

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***Abstract*—**Use of Internet of Things (IoT) with modern wireless network is a trend of the emerging technologiesfor different systems which can be deployed in various kinds of environment to monitor, communicate withor control the associated elements in the system. The activities e.g., monitoring and communication by IoT can play an important role to designanIntelligent Transportation System (ITS). In this paper, we assess the suitability ofIoT enabled wireless technology to be used forITS. We performed some comparative study to find the best wireless technology that provides reliability, low cost, less power consumption and less data latency for next generation ITS.This technology will reduce energy consumption of the deployed IoT devices as well as ensure safety, efficiency and convenient for transportation systems.

*Keywords—Wireless Sensor Network (WSN);Intelligent Transportation System (ITS);IoT;ZigBee; MAC protocol; Energy efficiency*

## 1. INTRODUCTION

Internet of Things (IoT) connects physical objects by a communication system (e.g., wireless sensor network (WSN)) that facilitates to acquire and share information; monitor, track and control the Things (some objects e.g., actuators, motors);[1, 2]. IoTcan be divided into a sense layer, a service layer, a network layer, and an application layer. The sense layer can sense, collect information, and the network layer permits the interaction among the different items using Internet technology, whereas the service layer provides solutions to the application or to the other end users for further intelligent processing[3]. IoT can add a new area to Intelligent Transportation Systems (ITS)due to a growing demand of efficient, low-power consumption and low cost. There are various challenges and issues in implementing this emerging solution toward ITS, e.g., real-time traffic management system, smooth and seamless connectivity, exact vehicle location forecast, security and privacy, interoperability, proper communications, associated with IoT that need to be addressed[4, 5].Fig. 1 shows the general architecture of IoT enabled Intelligent Transportation System paradigm.

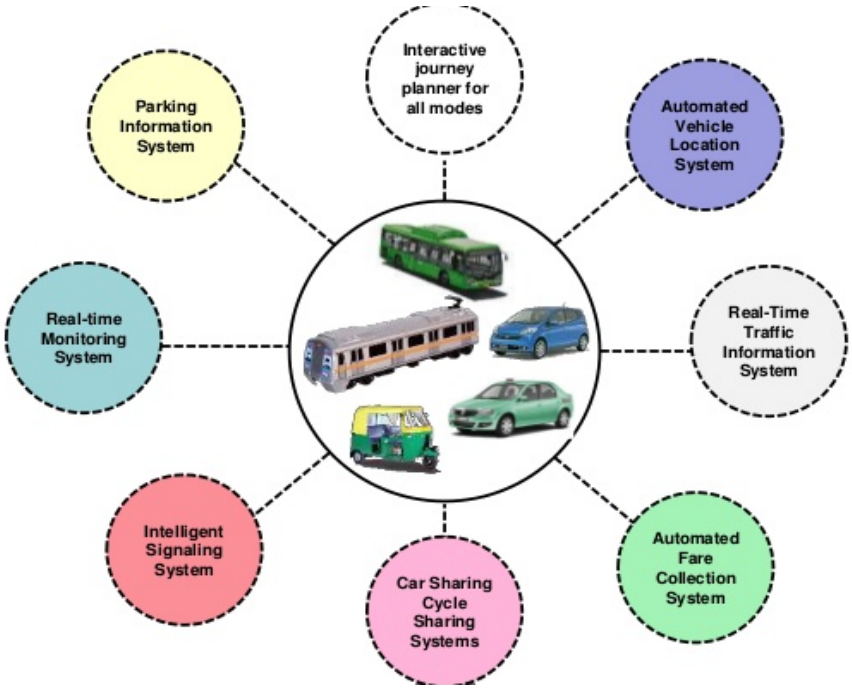


Fig. 1: IoT enabled Intelligent Transportation System General Architecture

Advanced citytransportation has a lot of importance because of large holding ability, high delivery effectiveness, low energy usage and low transport costs[6]. In the developing world,many families and individuals buy their own motorcars. But infrastructures of road do not acquire proportional development. As a result it produces considerable air pollution, safety risk, excessive traffic jam and exacerbate feelings of inequities in the society. For resolving this problem many countries are choosingITS. Smart transportation system is comprised of information technology, electronic sensor technology, data transmission technology.IoT based ITS requires an efficient integration of computer technology placed on the entire area traffic system created in a huge range, all-round role, real-time, accurate and efficient integrated transport management system [7, 8].

WSN in ITS have made great progress. The fundamental sensor node system contains sensors with little size, inexpensive, data processing, wireless communications along with a high level of collaboration [9, 10]. The users can quickly and rapidly put up WSN where itis inconvenient to wire cables. The WSN is made of nodes from the few a number of hundreds and even thousands, where each node is attached to a single sensor. WSNs consists of a lot of low-cost micro-sensor nodes implemented into the monitoring area; therefore, the multi-hop system of self-organizing system formed through wireless communication. IEEE802.15.4 based zigbee requirements provide a milestone of WSN [11]. ITS have been benefited from the appearance of the new standard in Vehicles and Vehicles-road Communication based on WSNs. The solution of intelligent transport system of WSN based on zigbee technology will be better than other work.

The rest of the paper as follow, in section 2, we will discuss the related work. Section 3 presents the overview of suitableIoT based wireless technologies. The comparative study of existing protocol is discussed in section 4 and finally we conclude the paper in section 5.

## 2. RELATED WORKS

There are numerous works that deal with the system design issues and challenges with WSN for ITS. In [12], the authors addressed a kind of smart transportation system emerging

solution of WSNs based on ZigBee technology. Using the comprehensive investigation of three aspects of network topology, energy efficient, as well as being reliable and stable, their work brings forth advanced component design of sensor nodes and suitable network protocols for urban public transport system. In [13], the authors proposed an architecture based on WSN technology for ITS of a transportation network. With the help of WSN technology, the traffic info of the network can be accurately measured in real time. Based on this architecture, an optimization algorithm was proposed to minimize the average travel time for the vehicles in the network. The authors in [14]addressed a real-time traffic lights status reminder system based on WSN technology for ITS. In [15],the authors developed a road condition monitoring system using multiple sensor data basedon Software Defined Network (SDN) for ITS. The road conditions on both normal and disaster cases were monitored and storedto the cloud server to provide the data to the public through the web page. Moreover data can also be exchanged between the vehicles running on the same road in realtime. Intelligent transportation technology of node-localization in WSNwas proposed by the authors in [16]and a framework of ITS was designed and realized that provides a system for the application of ITS. The authors proposed a novel two-tiered ITS architecture predicated on WSN and peer-to-peer (P2P) Network in[17]that provides significant traffic details about the road which therefore, helps the people to take best choices of driving. In[18],the authors remarked that safety of road travel may be increased if automobiles can be built to form teams for interacting data among themselves.They presented a unique approach to improve the security of road travel utilizing the ideas of WSN with Bluetooth protocol. In [14], they discussed how to develop mobile ad-hoc system network for a vehicular system and transmit data sensed by the on-board sensors.The authors proposed the effective smart transport system that depends on the abundance of prompt road information. They provided the part of road information by taking dynamic route guidance system. They also illustrated the concept of utilizing magnetic sensors to identify automobiles and exactly how the street info is attained by network aggregation. In [19], the authorsdescribed the concept to construct an ITS under the IoT platform. Their design has three elements: the sensor system, monitoring system and the display system.
Although there have been many worksonITS with WSN, our work will pave the way to design realible next generation ITS.

## 3. OVERVIEW OF SUITABLE WIRELESS SENSOR TECHNOLOGY

There aremany wireless sensing technologies introduced in the past years, such as, Bluetooth, Wi-Fi, UWB, Zigbee and RFID. Each technology has specific criteria for operation in an area.For example, Bluetooth is a short-range wireless technology with IEEE 802.15.1 standard. It can communicate up to a speed of 3Mb/s. The transmission needs a relatively high power level so that it is not appropriate for battery enabled sensor in vehicle. Moreover, it allows only eight active devices. Ultra-Wideband (UWB) is a radio technology that operates on 3.1-10.6 frequency band and supports short range communication data rate up to 110 Mb/s. RFID PHY layer waveform and simple MAC protocol design (coupled with high cost of RFID readers) makes it unsuitable for WSNreliability and latency requirements [20].

Zigbee is a short range communication technology and IEEE 802.15.4 standard. It operates on ISM radio spectrum (868 MHz, 915 MHz, and 2.4 GHz). Zigbee is a low cost, high data rate, low power consumption, and supports star, mesh, and hybrid topology. It has long battery life and provides more security by its encryption technique. ZigBee transmission power is –25–0 dBm, which is significantly lower than others. Moreover, it needs only 15ms to wake up. This emerging feature allows the transmission device to remain sleeping most of the time, which preserves the device’s battery power. It allows to connect up to 65000 sensor nodes. In [21],

they have evaluated the performance for intra-car WSN . This study showed that the Zigbee is a viable and promising technology for intra-car WSN . Zigbee is designed to six months to two years on just two AA batteries [3]. Hence, the Zigbee is expected to play an important role to design ITS for future generation.

## 4. COMPARATIVE STUDY OF EXISTING PROTOCOLS

Table1 summarizes the main difference of existing IEEE protocols for wireless devices. Zigbee supports different types of network topology and its MAC protocol is designed with CSMA/CA feature that provides extra facilities to ensure data transfer robustly. The main advantage of zigbee protocol is to allow more than 65000 sensor nodes in a single network. The number of sensor nodes for ITSis increasing day by day. This huge number of sensor nodes can be maintained through this protocol.

Table 1: Main comparison of existing protocols

| **Standard** | **Bluetooth** | **Wi-Fi** | **UWB** | **ZigBee** |
|---|---|---|---|---|
| IEEE specification | 802.15.1 | 802.11a/b/g | 802.15.3a | 802.15.4 |
| Frequency band | 2.4 GHz | 2.4 GHz; 5 GHz | 3.1-10.6 GHz | 868/915 GHz; 2.4 GHz |
| Max signal rate | 1 Mb/s | 54 Mb/s | 110 Mb/s | 250 Kb/s |
| Nominal range | 10 m | 100 m | 10 m | 10-100 m |
| Max number of cell nodes | 8 | 2007 | 8 | > 65000 |
| Chip price | $5 | $20-25 | $1 | $2 |
| Data Protection | 16-bit CRC | 32-bit CRC | 32-bit CRC | 16-bit CRC |
| Topology | Star | ESS,BSS | Peer-to-peer | Tree, star, mesh, and hybrid. |

Zigbeeis intended for portable device, short range, and limited battery power. Although, it offers very low power consumption and lead long battery life. As shown in Table2 and Fig.2, Zigbee chipset consumes less power compared to others chipsets.

Table 2: Power Consumption of Each Protocol

| Standard | Zigbee | Bluetooth | Wi-Fi | UWB |
|---|---|---|---|---|
| Chipset | CC2430 | BlueCore2 | CX53111 | XS110 |
| VDD(Volt) | 3.0 | 1.8 | 3.3 | 3.3 |
| TX(mA) | 24.7 | 57 | 219 | ~227.3 |
| RX(mA) | 27 | 47 | 215 | ~227.3 |
| Bit Rate (Mb/s) | 0.25 | 0.72 | 54 | 114 |

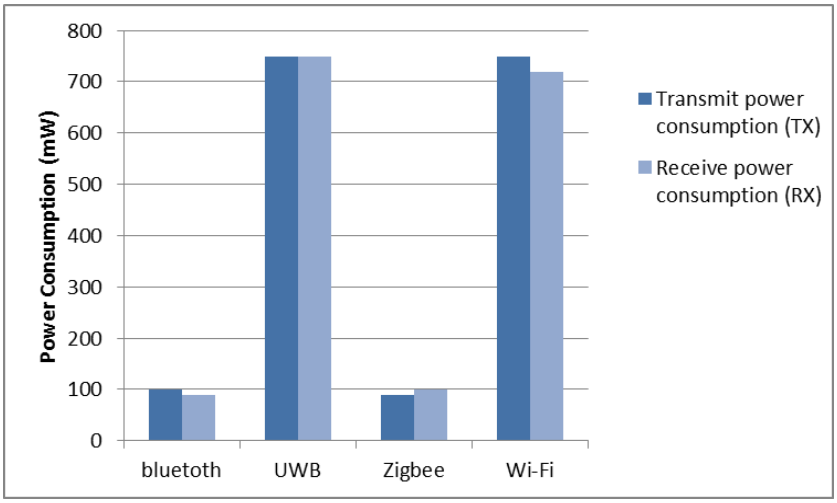


Fig.2: Comparison of power consumption for each protocol

As shown in Table 3 and Fig.3, Bluetooth is the most complicated protocol compared with others. The total number of primitives is more than zigbee, as well as others too. However, Zigbee has only 48 primitives that reduce the network complexity. Compared to other technology, Zigbee is a simple and suitable for ITS.

Table 3: Number of Primitives for Each Protocol

| Standard | Zigbee | Bluetooth | Wi-Fi | UWB |
|---|---|---|---|---|
| MAC Primitives | 35 | 151 | 32 | 77 |
| PHY Primitives | 13 | 37 | 43 | 29 |

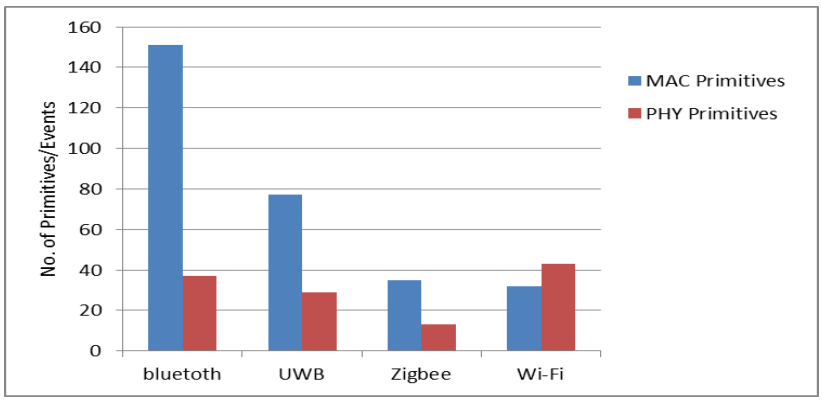


Fig.3: Comparison of the complexity of each protocol

## 5. CONCLUSION

Zigbee with IEEE 802.15.4 standard is a standard device developed to deal with the communications for a number of vehicles, at-home, and commercial applications by allowing pervasive WSNs for IoT paradigm. The key features of this protocol is always to retain the community convenience, ensuring low cost, short range, less data latency, and low power usage implementations. The high-level characteristics of Zigbeeenables it to be an important technology to ITS by providing the low-cost WSNs using the objective of enhancing the

dependability of future wireless control systems in automobiles; therefore, the localization and navigation of automobiles road interaction systems. IEEE 802.15.4 allows low-cost WSNs solution that enables the abilities needed for ITS in-vehicles and vehicles-to-road infrastructure systems, but network architecture problems must be addressed within the top levels for the protocol stack, especially, within the MAC layer.

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