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Vehicular Identification and Authentication System using Zigbee

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Abstract: **This system is used for campus security. For campus security requires identification of vehicle entering in a campus and authentication of person seating in the vehicle. This system uses the Zigbee technology for communication. The Zigbee technology recently developed for wireless sensor network (WSN). Zigbee is low cost, low data rate, low power solution for sensor networking. To achieve above goal require manual system or automated system. The manual system requires more time and man power for the same. So it is possible to implement system with the help of automation. This automated system needs wireless technology. To achieve this system require low cost, low power wireless technique. The Zigbee provides solution for this system. Zigbee is low cost, low power solution and low data rate require for communication. Zigbee is based on IEEE 802.15.4 standard for wireless personal area network (WPAN). Zigbee used in commercial and research applications. This system consists three Zigbee RF module for communication. First RF module placed on gate side to access vehicle information from the vehicle module. This module connects with central data base RF module for verification. The second RF module placed inside the vehicle. This module consist unique serial number and keypad for entering password for person authentication. The third module placed at central computing device. This device consist total data base of authorized vehicle with personal password for person. The central database used for verification and it send result to gate side module for necessary action. This paper gives design of prototype model of the hardware and firmware of the system. The vehicle identification profile developed and design by using Zigbee protocol stack. The hardware implementation of system consist of Xbee RF transceivers module, AVR microcontrollers. The RF module uses frequency band of 2.4Ghz in physical layer [1].**

Keyword: Authentication, RF module, wireless, Zigbee.

1. INTRODUATION

Zigbee is a wireless technology used for many commercial and research applications. It based on IEEE 802.15.4 specifications and become a very attractive wireless connectivity solution due to its open standard, low cost and low power characteristics [2]. Zigbee is suitable for low data-rate and low power consumption applications in comparison with other wireless technologies such as Bluetooth and Wi-Fi. The other technology used for high data rate but Zigbee provide large distance communication with low power, so for low data rate application or wireless sensor applications it is useful then other technology[3]. Zigbee applications include home automation industrial control, building management, environmental monitoring, agriculture management, building automation etc. Many companies use intelligent vehicle management system for high security zone in the company. It provides restricted access to vehicles with identification and authentication. To provide automation require low cost wireless solution for the same. It is proposed a system using Zigbee wireless RF modules to identify and authenticate vehicles entering into such a premise. Design consist of vehicle RF module for each vehicle, Gate side RF module for accessing information of vehicle and central database of all vehicle with RF connectivity with gate side module. Vehicular module consist vehicle information with unique serial number and keypad to enter password. Gate side module used as RF module reader and provide verification result to person seating in watchmen room. It also works like communicator between vehicle module and central database. The central database consist information of all vehicles. Prototype of the system was demonstrated under real conditions and results conclude that the proposed system is useful for campus security [1].

Energy consumption is among the biggest challenges in wireless sensor network (WSN). Zigbee is a protocol that supports low power, low cost, low data-rate operation of its network devices. Major players in the electronics industry, such as Motorola, Samsung and TI are members of the Zigbee Alliance. The Zigbee alliance develops the Zigbee specifications. Zigbee's single chip solution like Xbee, which constitutes a microcontroller and RF communication capability, makes it a protocol with great potential for use in resource-constrained monitoring and sensing applications. The Zigbee network consist three types of devices that are coordinator, router and end-device. The end devices can work in sleep mode and it save energy. Routers continuously listen for end devices. Routers are in ON state for end device listening [3].

2. SYSTEM MODEL

This section presents an overview of the system and introduces the functionality of each of the individual components.

A. Overview

Figure 1 depicts the system model. Vehicular RF modules are installed securely in vehicles needed to be identified, authenticated and managed. Each vehicular RF module is programmed to have a unique serial number for identifying it and keypad connects for password to authenticate the driver. An RF reader module is installed near the entrance. When a vehicle stops at the gate the reader detects the vehicular RF module and retrieves authentication information from it. This information is transferred to a

central database through zigbee interface to verify whether access is granted for a particular vehicle to the premises. Furthermore, the driver of the vehicle is authenticated by means of a password entered using a numerical keypad in the vehicular RF module. Using the information received from vehicular module the gate side module send information to the central database and send back verification result to human security personnel at the entrance or automated security system can take action to allow or deny the vehicle [4].

B. Vehicular RF module

Each vehicle would be equipped with a vehicular RF module having a unique serial number stored in memory of controller. The vehicular RF module would consist of a 2.4 GHz Xbee RF transceiver, microcontroller circuitry, LED indicators, power control circuitry and a numerical keypad used to enter password for driver authentication. In this prototype AVR microcontrollers used to perform software execution.

C. Gate side RF module

The vehicular RF reader is implemented for gate side PC interface and central database connectivity. It provides 2.4 GHz wireless transceiver, micro-controller, power control circuitry and communication interface. This module is connected to a personal computing device (laptop or desktop) through a RS232 interface which is used by the security person at the entrance. Communication from there onwards to central database server is done through zigbee interface. Depending on the verification sent by the database server, positive or negative, the user at the entrance is presented with the simple decision of whether to allow or deny entrance to a vehicle or to check the identification of vehicle and authentication of a driver manually. Although the human agent in the system between the central database and the RF module reader can be removed and the system can be fully automated, it is resorted to implement it with human involvement since most organizations employ security persons [4].

D. Central Database

The central database stores all information of vehicles with unique serial number. This data stored in central computer which connect with the gate side module through wireless connectivity. The module present on central database is work like coordinator. The central database may store entrance time and exit time of vehicle. This database stored in MS access, so it is very simple for admin to modify database as per requirement.

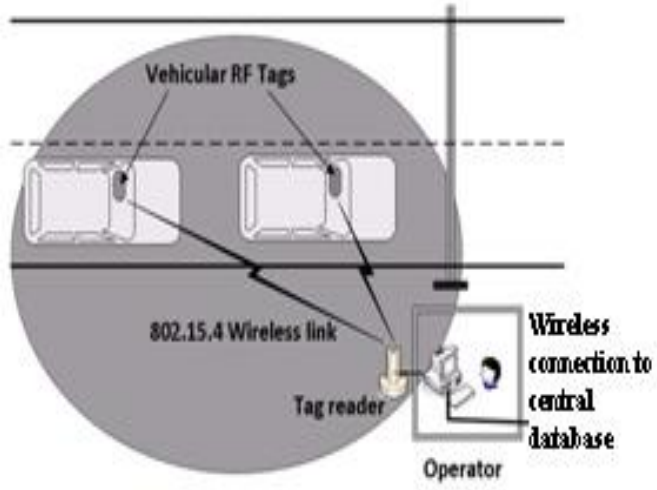

Fig. 1. System Model

3. SYSTEM OPERATION

Here an overview of the Zigbee wireless protocol for operation details, followed by the communication in the system.

A. Zigbee Protocol Overview

Zigbee wireless protocol provides means to network, it provides autonomous devices, each equipped with an IEEE 802.15.4 standard RF transceiver to perform some networked task. The IEEE 802.15.4 wireless standard provides the Physical layer (PHY) and Medium Access Control Layer (MAC) for the wireless communication. On top of this layer there is Zigbee protocol working for Network layer and Application Layer. The PHY, MAC and NWK layers would handle wireless data transmission and organization network of RF transceiver. While the application layer would handle the tasks associated with each autonomous device. After power up, a set of Zigbee devices would involve in network formation.

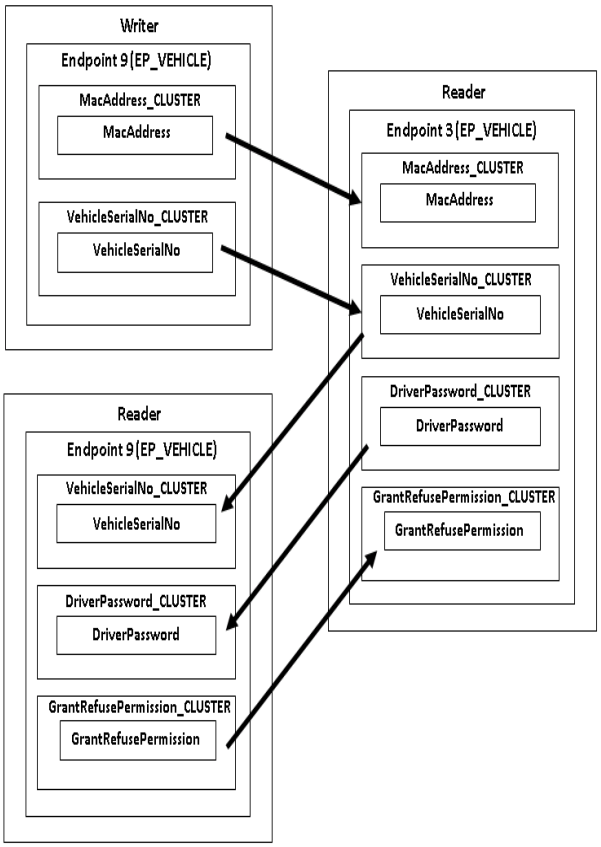

Fig. 2. Vehicle Identification Device Profile

A device defined as a Zigbee coordinator would perform energy scans on the available wireless channels and select an interference free channel for communication. Devices that wish to join the network would send out beacon requests in order to join the network of the coordinator. The newly joined devices to the network can either work as end devices or routers. Here the coordinator is the parent. *Routers* can permit devices to join it and these all end devices are leaf nodes so it cannot provide connectivity to other devices.

In the proposed system a vehicular RF module work like Zigbee end device while the RF reader module work like Zigbee routers. The central database module work as Zigbee coordinator. Different Zigbee devices implement different device profiles defined in the Zigbee protocol stack to suit the application in which they are being used. The Zigbee alliance has defined several device profiles for deferent applications intended for Zigbee devices [2]. The specifications have also provided flexibility to include customized device profiles to suit customizes applications [3]. The system defined the vehicle identification device profile for communication between vehicular module and gate side module *to* suit application as shown in Figure 2. This figure shows the communication sequence in the gate side module and vehicular RF module.

B. Tag-Reader Communication

Figure 3 shows the sequence of steps involved in the communication between vehicular RF module and gate side RF module. Once a vehicle arrives into the area of the gate side RF module the vehicular RF module would issue beacon requests to the gate side RF module. RF reader on gate side would respond with beacon response and join the RF vehicular module into its network as a leaf node or end device. Once this device connected to the Personal Area Network (PAN) of the gate side RF module, gate side module would request the vehicle serial number from the vehicle. After reception of the serial number from the vehicle the password for driver authentication is requested by the reader which is validated with the central database once received from the vehicle. After both serial number and password are successfully exchanged the vehicle would leave the RF module readers PAN. A maximum of 10 RF vehicular modules can be connected in the PAN at a time to the reader. Since devices joining the PAN would leave once they are validated or denied access, this PAN size of 10 is sufficient for the efficient operation of the system. Instead of requesting for information from the module after it joins the PAN of the coordinator, the vehicle serial number and password would be written into it and an acknowledgment would be sent back to the gate side module. These results send to vehicular modules also.

4. SYSTEM IMPLEMENTATION

This section provides the implementation details of the prototype developed. The basic structure of the Zigbee device consists of a 2.4 GHz transceiver and antenna, microcontroller and power control circuitry.

A. 2.4 GHz RF Transceiver

The system uses a low cost, low power IEEE 802.15.4 Xbee RF transceiver developed by Digi electronics to design the RF module in each Zigbee devices. It operates in the frequency spectrum 2.4 - 2.4835 GHz and its data rate is 250 kbp. Direct Sequence Spread Spectrum is used as the modulation technique in the transceiver[5].

Antenna design: An Integrated Whip antenna was used with the transceiver. This is a wire monopole where the top section is folded down to be parallel with the ground plane which reduces the antenna height and maintains a resonant wire length.

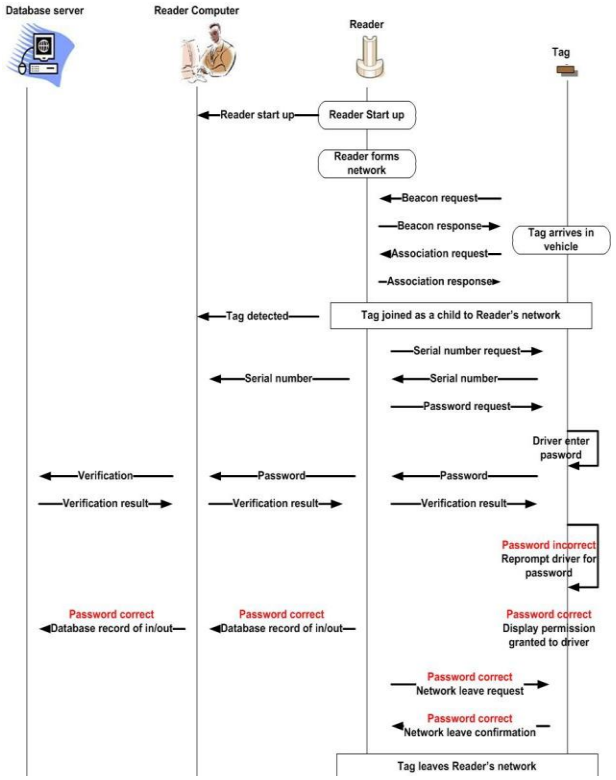

Fig. 3. Communication between Tag and Tag Reader

B. Microcontroller Circuit

In this system microcontrollers used for deferent purposes. There are three microcontroller used in the system. The microcontroller circuit interfaces with the RF transceiver and controls the operation of the Zigbee devices. Atmel microcontroller AVR series was used in the design and it provide firmware required to communicate with RF transceiver and perform other housekeeping routines of the device, such as taking inputs from numerical key pad, communicating with RS232 interface. The Zigbee protocol stack is implemented in the firmware of the microcontroller [6], for their 8 bit microcontrollers to implement the Zigbee protocol with the vehicle identification device profile. Since the application requires securing communication over wireless channels, the application layer provide security encryption. In this system there are two microcontrollers. ATmega128 used for gate side communication and ATmega16 used for vehicular module. ATmega128 provide interface to transceiver, Gate motor, Personal computing device. ATmega16 provide interface to transceiver, Keypad, LCD display. Figure 4 and 5 shows connections of microcontroller with other devices. It may possible to use another microcontroller for automated gate entry to control gate motors.

C. Voltage Regulating Circuit

Both reader/writer and vehicular RF module each require 100 mA under 3.3 V for their operation. Tag was designed to be powered by car battery or 9 volt battery and the reader was designed to be powered by mains electric supply. Fixed positive voltage regulator MC7805 can be used to convert DC voltage 12 V into 5 V. This voltage and current are sufficient for the system.

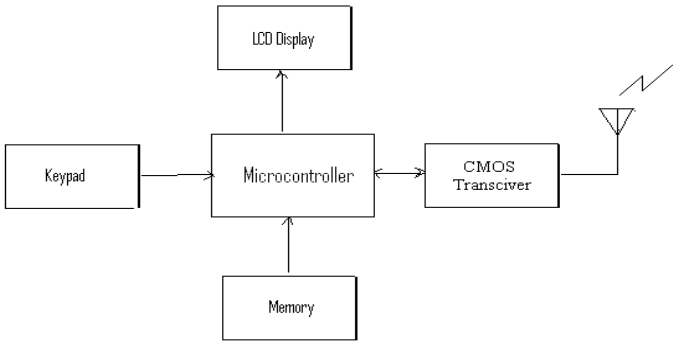

Fig. 4. Block Diagram of RF Vehicular Tag

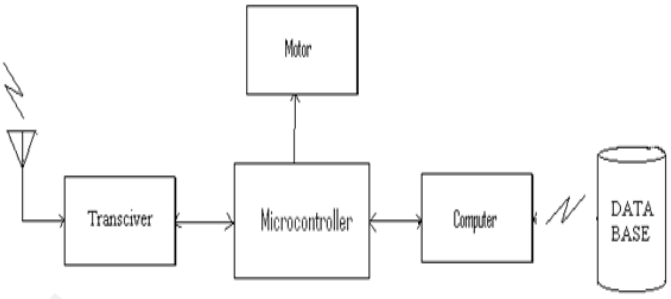

Fig. 5. Block Diagram of RF Tag Reader

5. CONCLUSIONS

In the paper it is presented a novel Zigbee based Vehicular Identification and Authentication system. It is provided with a detailed description of the system referring to the prototype one. This prototype uses wireless database access from central data so it is very flexible system.

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