Traffic Light Using Multiple Wireless Technologies

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Abstract— This paper presents the study and experimental tests for the viability analysis of using multiple wireless technologies in urban traffic light controllers in a Smart City environment. Communication drivers, different types of antennas, data acquisition methods and data processing for monitoring the network are presented. The sensors and actuators modules are connected in a local area network through two distinct low power wireless networks using both 868 MHz and 2.4 GHz frequency bands. All data communications using 868 MHz go through a Moteino. Various tests are made to assess the most advantageous features of each communication type. The experimental results show better range for 868 MHz solutions, whereas the 2.4 GHz presents the advantage of self-regenerating the network and mesh. The different pros and cons of both communication methods are presented.

Keywords: **Wireless communications, Zigbee, Moteino, wireless sensors network, cloud computing, traffic light.**

I. INTRODUCTION

Every major city has a large part of the population travelling by car or by public transportation, and traffic jams are a frequent problem [1-3]. Hence, the traffic density keeps increasing at an alarming rate in developing countries which calls for intelligent traffic lights control to replace the conventional manual and time based ones. New traffic systems have been developed to provide answers to these strategies [4]. In many cities, which have a monitoring system implemented, thousands of sensors are deployed in the pavement and connected to a traffic control central [2,3]. Usually, the coverage is limited to central and downtown areas. However, the range of the communication networks that support sensing technologies has expanded rapidly. Intelligent Transport Systems (ITS) are advanced applications which aim to provide innovative services relating to different modes of transport and traffic management. ITS enable users to be better informed and make safer, more coordinated and smarter use of transport networks. In this paper the ITS existing artificial intelligence services are combined with wireless communication technologies (WCT) [2,3]. One of the main goals of the presented work is to create an independent and more secure wireless infrastructure to support ITS and Smart Cities, creating a system with a multi-level architecture using multiple wireless technologies. The overall structure of the traffic control system is based on a set of wireless devices supporting the protocols to gather data from the sensors and control the traffic lights [5]. There are several well-known wireless communications devices and protocols like Bluetooth, ZigBee, RFID, GSM, among others [6]. In the traffic lights scope, classically, data that was acquired in a certain location is used to support a decision making action to know which road to open, decided by any pre-programmed or pre-defined algorithm or local sensors. In wider area scope, the central system processes the data acquired remotely in the various locations with devices able of doing so.

II. MULTI-LEVEL SYSTEM

The whole system composed by sensors, data acquisition, processing, actuation and communications was developed in a multi-level system type, as shown in Figure 1. Figure 1 shows the Zigbee local area network (1,2,3), a gateway (4) connected to a database (5) that communicates with an application server (6) and the business intelligence layer (7). In the end of the network the final user (8) can access all the information in multiple devices. Each one of the eight levels is technologically and structurally independent from each other. The multi-level structure proposed in Figure 1 can be transposed to a Cloud architecture system, taking advantages of the existing internet Cloud Services where the controlling actions can be set from anywhere.

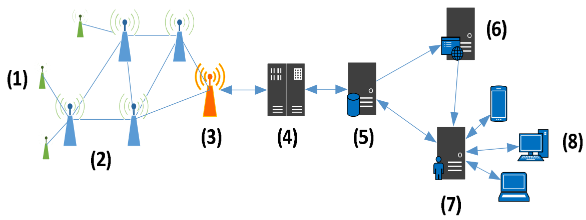

Fig. 1. Multi-level architecture system.

III. COMMUNICATIONS

The system was implemented using two different operating frequencies. The frequencies selected are the 868 MHz and the 2.4 GHz, the last one using the ZigBee standard. This standard is a reliable one, low power, low cost and efficient for information networks.

The ZigBee is a specification of high level communication protocol based on the IEEE 802.15.4, a standard for a Low Power – Wide Area Network (LP-WAN) [5]. The ZigBee modules used in the field tests were built taking in consideration the most desirable features of the ZigBee protocol: the ability to create the data network mesh, the self-healing and security [7-10]. The characteristics of the different communication modules used are shown in Table 1.

TABLE 1

COMMUNICATION MODULES USED

COMMUNICATION MODULES		
Characteristics	Zigbee PRO S2	RFM69HW (Moteino)
Antenna	Chip	External
Tension	3,3 V	3,3 V
Estimated Energy Consumption	295 mA	130 mA
Output Power	50 mW	100 mW
Speed	250 kbps	300 kbps
Estimated Range	1600 m	Unknown
Frequency	2,4 GHz	868 MHz
Encryption	128-bit	AES-128 / CRC-16 / 66-byte FIFO
Network Topology	ZigBee	Star

IV. NETWORK TESTS

To assess the real range of communications established by the two communications drivers, emitter and receiver, prototypes were created. The receivers are composed by a Moteino with a pre-installed RFM69HW chip and a ZigBee module, both connected via FTDI/USB to a computer, as shown in Figure 2 and in Figure 3. The emitters are a Moteino with the same chip pre-installed and a ZigBee connected to an Arduino Uno. Both were connected to a power bank and, after some programming, started sending messages to the receivers, as shown in Figure 4 and in Figure 5. The strength of the connections is assessed using the RSSI value. The range tests were divided as follows: open field tests (line-of-sight) and urban environment (near wireless networks, buildings and trees) and have been made in Instituto Superior Técnico (IST) Alley in Lisbon.

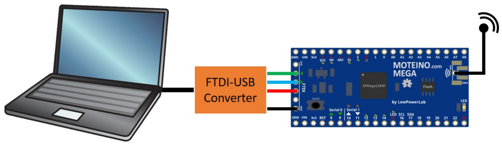

Fig. 2. Moteino receiver diagram with RFM69HW chip.

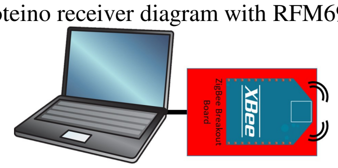

Fig. 3. ZigBee receiver diagram with Breakout Board.

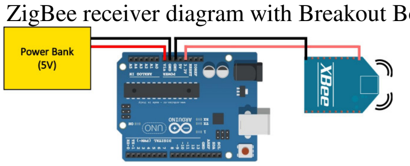

Fig. 4. ZigBee emitter powered by an Arduino Uno diagram.

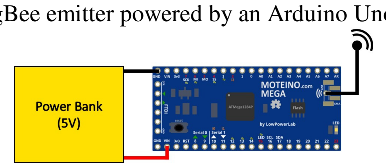

Fig. 5. Moteino emitter diagram.

V. CONCLUSIONS

In the linear tests the communications module with the lower operating frequencies obtained worst RSSI values while in range. However, in the urban test the Moteino showed an improvement of the RSSI values, comparing with the Zigbee. Both modules lose the signal of the emitters in the same spot in all the tests. The ZigBee module with the capabilities of the protocol to self-form the network mesh and auto-healing makes it the best alternative to use locally on traffic control and management systems. Is very common the necessity to implement several sensors in an intersection and traffic lights area. The ZigBee permits that those sensors to be connected and implemented in the existing network with minimal effort. For the long range communications between intersections the Moteino presented the best stabilization. The maximum range obtained with the Moteino is not sufficient for several traffic light spots interconnection, so other wireless communication technologies should be considered.

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