Wireless Technologies on Internet of Things in Partnership with Thought Creator

João Quintas

Activities Report

Abstract—The conducted activity for Portfolio was done in partnership with Thought Creator. The goal is to find a suitable solution for the growing market of Internet of Things (IoT). The activity consisted on a meticulous study on existing low consumption wireless technologies along with a study to determine which chip is most appropriate for the desired technology. This work will have a follow up next semester, where a working prototype and a board design will be made to be used on future projects of Thought Creator.

Index Terms—(Internet of Things, Low Consumption Wireless Technologies, IEEE standard 802.15.4, low-rate WPANs), LaTeX, paper

ACRONYMS MUST be expanded in first usage in the text body. (Even if previously expanded in Abstract)

1 Introduction

THE term IoT [1] recently became popular due to an increase in demand of the global infrastructure of networked physical objects. Although this vision is captivating no consensus exist about how to implement it. IoT is somewhat inspired by the great success shown by Radio-Frequency Identification (RFID) technology, which is widely used for tracking objects. IoT is designated as the interconnection of uniquely identifiable embedded computing devices within the Internet. It goes beyond machine-to-machine (M2M) in the sense that it is expected to offer advanced connectivity of devices, systems and services, covering a wide range of protocols, domains, and applications. The interconnection of the embedded devices, including smart objects, is expected to usher automation to nearly all fields.

The goal of this work was to aid Thought Creator to choose the most appropriate low consumption wireless technology microchip to implement in future projects. The activity consisted of a meticulous study of the available technologies to find out which one is the most adequate for Thought Creator's needs. After deciding on the technology a comparison between available microchips from different brands was conducted to decide on the most profitable.

• *João Quintas, nr. 63538,*
E-mail: jcoquintas@gmail.com,
Instituto Superior Técnico, Universidade de Lisboa.

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2 IoT Technologies

There are three main technologies on low consumption wireless communications.

- ZigBee [2]
- Insteon [3]
- Z-Wave [4]

In this section an introduction to all three technologies will be made. The chosen technology will also be presented along with the motives behind the decision.

2.1 ZigBee

ZigBee is a low-cost and low-power wireless mesh network IEEE 802.15.4 standard for low-rate WPANs. It is mainly used for long battery devices in wireless control and monitoring applications. It supports generic, star and tree networking. Popular usage of this technology include smart homes, connected lighting, and utility industry.

(1.0) Excelent	ACTIVITY					DOCUMENT						
(0.8) Very Good	Objectives x2	Options x1	Execution x4	S+C x1	SCORE	Structure x0.25	Ortogr. x0.25	Gramm. x0,.25	Format x0.25	Title x0.5	Filename x0.5	SCORE
(0.6) Good												
(0.4) Fair	2	1	4	0.8	7.8	0.25	0.25	0.25	0.2	0.5	0.1	1.55
(0.2) Weak												

2.1.1 Usage

ZigBee affordably connects the widest range of devices to improve comfort, security and convenience for consumers. It is a world wide technology of choice by several service providers, installers and retailers who deliver home automation, security, and energy management applications.

Another application of this technology can be found in connected lighting. It is used in residential and commercial lighting applications. A great example is Hue [5] by Philips. It allows users to gain control over LEDs, light bulbs, fixtures, remote controls and switches. Users may change lighting options such as color, luminosity, and dim remotely to reflect ambiance, task, or season, all while managing energy usage and making their homes greener.

ZigBee is also the world's leading standard for interoperable products that monitor, control, inform, and automate the delivery and use of energy and water. It is deployed along millions of smart meters around the world to help create greener homes by giving consumers the information and automation needed to easily reduce power and water consumption.

2.1.2 Security

Security in the ZigBee technology is implemented using 128-bit keys. The key distribution is done by a special device, over a secure network, which other devices trust, designated as the trust center. Devices will have the trust center's address and initial master key preloaded. Typical applications without special security needs will use a network key provided by the trust center (through the initially insecure channel) to communicate. The trust center maintains both the network key and provides point-to-point security.

2.2 Insteon

Insteon enables simple, low-cost devices to be networked together using the power-line, radio or a combination of both. All Insteon devices are capable of transmit, receive, or repeat messages without requiring a master controller (unlike ZigBee presented in Section 2.1) or complex routing software. The Insteon network can easily connect to other, larger networks, such as LANs and Wi-Fi, and can be controlled by different user interfaces such as smartphones, PCs, and other third-party controllers.

2.2.1 Usage

The main usage of Insteon is on home automation. It is mainly used to remotely control lighting, heating, air conditioning, timers, automated doors, appliances, and irrigation. It is also used to monitor water leaks, room occupancy, and humidity. Several alerts defined by the user can also be sent by SMS or/and e-mail. These alerts can range from alerting a break in, a gas leak, or even a reminder that a light was left turned on when the house is empty.

2.2.2 Security

Just like mechanical locks and keys, Insteon's security relies on the same principals: physical possession of devices. An eavesdropper attacker would need the knowledge of Insteon's addresses, which are masked by the low-level Insteon firmware engine. At a higher level, Insteon extended messages allow for encryption using well known global standards such as AES-256. All extra security features have to be implemented separately.

2.3 Z-Wave

Z-Wave is a low-power wireless communication technology designed for remote control applications. Its protocol is optimized for reliable, low-latency communication of small data packets with data rates up to 100 kbit/s. Unlike Wi-Fi or other IEEE 802.11-based (ZigBee mentioned on Section 2.1 uses the IEEE 802.11 standard) wireless LAN systems that target high-bandwidth data flow, Z-Wave targets higher data rates. Z-Wave operates around 900 MHz, a sub-gigahertz frequency range. The only mesh network topology offered by Z-wave is the source-routed.

2.3.1 Usage

From lighting, climate, irrigation and shading controls to intelligent outlets and power strips,

there are hundreds of simple, interoperable Z-Wave products that let you monitor, control and manage your home energy usage. The user is one button click away to automatically lock all the doors, turn off the lights, fans, air conditioners, televisions, computers and just about anything else you may want to switch off before leaving the home. It is also used to monitor people on a house, specially elderly family or friends.

2.3.2 Security

Just like Insteon (mentioned in Section 2.2), Z-Wave does not offer any kind of security. It supports AES encryption standard with 128 bit keys. Any security protocols have to be implemented separately.

2.4 What We Chose

The choice between the three was very straight forward. All three technologies are very popular and used in multiple scenarios, but only one meets all the requirements by Thought Creator. The choice was the ZigBee (see Section 2.1) for three main reasons:

Open Standard
Of the three, ZigBee is the only one to offer an open IEEE standard 802.15.4 for low-rate WPANs. This facilitates the development of products and services.

Security
ZigBee is the only one, out of the presented possibilities, to have security issues into account. This is extremely important for solutions out side of home automation.

Commercial Use
Even though Z-Wave and Insteon can be adapted to other purposes other then home automation, ZigBee is the only one with a greater focus on commercial use. Since Thought Creator is looking for commercial solutions rather then home automation, ZigBee fits the purpose.

3 MICROCHIPS

With the chosen technology a suitable microchip for Thought Creator's needs has to be studied. The market of microchips is vast and very competitive, so a meticulous study was conducted to find out the best possible solution. Aspects such as frequency band, power consumption, and the price were taken into account. There are three types of chips to cover:

- Modules
- Radio
- Micro Computing Unit (MCU) + Radio

3.1 Modules

A module is each component of a set of standardized parts that are mounted together to form a more complex component. In this case the modules come already with a MCU and a radio transmitter plus receiver in a PBC ready to use with no need to weld. In this category several options were taken into account from different brands. The most appropriate modules were Anaren A2530X series, Atmel AT86RF233, Microchip MRF24J40MX series, and the NXP JN5168-001-M0X series. All these modules work on a frequency band of 2.4 GHz, have a receiver sensitivity between -94 dBm up to -104 dBm[1], and have a price range from 14.11 euros up to 28.23 euros. If a module was to be used, the one to go for would be the Microship MRF24J40MD due to its low price (17027 euros), and its antena sensibility being -104 dBm.

3.2 Radio

Radio chips do not come with any computing unit. It is only used as an antenna to receive and transmit data using the IEEE 802.15.4 standard. The prices are much lower when compared with the other two options mentioned in this section and allow the implementation of ZigBee (see Section 2.1) technology on already developed products by Thought Creator. The most appropriate choices included the Texas Instruments CC2520, Atmel AT86RF23X series, Microchip MRF24J40, and the Microchip MRF24XA series. All operate under the 2.4 GHz frequency band, have a receiver sensitivity ranging from -95 dbm to -101, and have

1. The lower the dBm the more sensitive it is, meaning it has a greater reach of signal.

an unitary price ranging from 3.52 euros up to 5.32 euros. The most appropriate choice would be the Microchip MRF24J40 because it is the cheapest, and even though its receiver sensitivity isn't the greatest of the possible choices (-95 dBm), it can easily be integrated with possible solutions using the chosen module due to having the same manufacturer.

3.3 MCU + Radio

MCU plus radio is a chip that comes with a computing unit and a radio transmitter and receiver in the same chip. The prices are lower when compared with the modules, but a little higher then the radio's prices. Although it is not the most economic choice it can be a cheaper solution when compared with a separate MCU with a ZigBee radio. This solution won't have compatibility issues since the MCU is designed to work along with the radio. The possibilities are the Texas Instruments CC253X series, Atmel ATSAMR21E17A, Freescale MKW2XD512VHA5 series, and the NXP JN516X series. They all operate with a 2.4 GHz frequency band, have a receiver sensitivity ranging from -95 dBm to -102 dBm, and prices ranging from 3.94 euros up to 10.59 euros per unit. The most adequate choice would be the NXP JN5168 due to it's price (4.88 euros), its processing power, and a good receiver sensitivity (-97dBm).

4 Future Work

Now that a complete low consumption wireless technology has been chosen the next step is to build a viable solution for future Though Creator's products. Next semester a working prototype using ZigBee technology will be made along with a complete board design.

5 Conclusion

IoT is a growing market with endless applications. Finding the write technology is essential to start building great applications and services. This conducted study was made to find a solution that meets Thought Creator's needs. Among the three presented technologies in Section 2 ZigBee was the chosen one. As for the chips presented in Section 3 the Microship MRF24J40MD, Microchip MRF24J40, and NXP JN5168 are the chosen chips for modules, radio and MCU plus radio respectively.

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