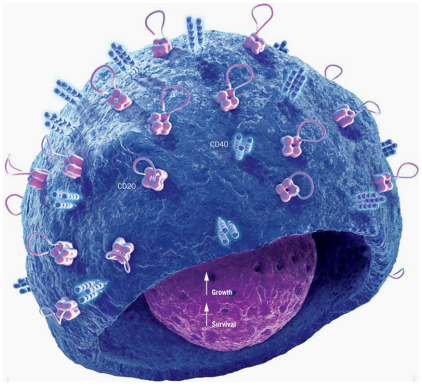
TÉCNICO LISBOA



BLE supported indoor location

Subtitle

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Thesis to obtain the Master of Science Degree in

Elecrical and Computer Engineering

Supervisor(s): Prof./Dr. Lorem Ipsum

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Anyone who has never made a mistake has never tried anything new.

Albert Einstein

Acknowledgments

I would like to thank the Academy,laura, jnos, pais, pais da laura, leal , almeida etc... bla bla bla..

Abstract

The Objective of this Work ... (English)

Keywords

Keywords (English)

Resumo

O objectivo deste trabalho ... (Português)

Palavras Chave

Palavras-Chave (Português)

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Abbreviations

BLE Bluetooth Low Energy

LE Low Energy

IoT Internet of Things

SMP Security Manager Protocol

PHY Physical

QoS Quality of Service

L2CAP Logical Link Control and Adaptation Protocol

HCI Host Controller Interface

P2P Peer-to-Peer

ATT Attribute Protocol The Attribute Protocol

GATT Generic Attribute

GAP Generic Access Profile

List of Symbols

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Introduction

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A Chapter

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Present the chapter content.

2.1 Bluetooth Low Energy

Bluetooth is a wireless technology that was created in 1994 with the objective of replacing cables connecting fixed or portable devices. At this point in time Bluetooth Special Interest Group is in charge of developing and managing this technology characterized by its robustness, low energy consuption and low cost.

The Bluetooth Low Energy (BLE) protocol was introduced with the Bluetooth Core Specification version 4 (also called Bluetooth Smart) circa 2010 alongside two other protocols. Out of the three, BLE standed out for its lower power consuption, lower complexity and lower cost, while allowing for device discovery, connection establishment and connection mechanisms. Due to its characteristics, the BLE protocol was utilized in various Internet of Things (IoT) applications.

2.1.1 BLE's Architecture

Bluetooth's Architecture is everchanging and can become very complex rather quickly with the introduction of different types of protocols. When working with BLE it's important to understand the key components of its architecture because by doing it's possible to better analyze the role of each component and how they operate and depend on each other. There are two main groups of core blocks, the Low Energy (LE) Controller and the LE Host, in 2.1.1.A and 2.1.1.B respectively, and most the most relevant of these components will now be looked at.

2.1.1.A LE Controller Group

Physical (PHY) Layer - Architectural block responsible for all Bluetooths' communication channels on the 2,4GHz radio. Receiving and transmitting packets and supplying information crucial for controlling its timing and frequency through the baseband block.

Link Layer - Architectural block responsible for managing logical links between BLE devices. It can create and release connections, update connection parameters related to PHY links. It's responsible for the discovery and consequently connection procedure and also sending and receiving data.

Device Manager - Architectural block responsible for controlling the general behaviour of the Bluetooth device. This block is responsible for all operations that aren't directly related to data transportation. Some of its operations are: inquiring for the presence of nearby BLE devices; connecting to a BLE device; setting whether or not its local device is discoverable and/or connectable by the others; controlling device behaviour such as managing own's local name or stored keys.

Baseband Resource Manager - Architectural block responsible for all acess to the radio medium, this means acess to the PHY channels. It has two porpuses, first to negotiate contracts with the entities that wish to use the medium and second to act as a scheduler on the same radio medium, granting the entities with said contracts, a time window in which they can utilize the medium. A contract is basically a commitment to deliver a certain Quality of Service (QoS) on the user application.

Link Controller - Architectural block responsible for the encoding and decoding of Bluetooth packets from the data payload and parameters related to the physical channel, logical transport and logical link. It also carries out the Link Layer protocol in conjunction with Baseband manager's scheduling function to communicate flow control and acknowledgement and retransmission request signals.

2.1.1.B LE Host Group

Logical Link Control and Adaptation Protocol (L2CAP) - Architectural block responsible of transmits packets to the Host Controller Interface (HCI) or directly to the Link Layer in hostless systems. It allows for higher-level protocol multiplexing, packet segmentation and reassembly, and the conveying of QoS information to higher layers.

Channel Manager - Architectural block responsible for creating, managing and closing L2CAP channels used in transport of service protocols and application data streams. The local Channel Manager makes use of the L2CAP protocol to communicate with a peer's Channel Manager and together create L2CAP channels and connect their endpoints to the appropriate entities.

Security Manager Protocol (SMP) - Architectural block responsible for implementing the Peer-to-Peer (P2P) protocol that operates over its own dedicated L2CAP channel and generates encryption keys and identity keys. This block is also in charge of storing those same keys and making them available to the controller. These keys are later used in the encryption or pairing procedures.

Attribute Protocol The Attribute Protocol (ATT) Protocol - Architectural block responsible for implementing the P2P protocol between an attribute server and client. This client/server communication happens in a dedicated fixed L2CAP channel. A server can send through this channel responses, notifications and indications, while the client can send requests, commands and confirmations. This block allows the clients to read and write values of attributes on a peer device acting as a ATT server.

Generic Attribute (GATT) Profile - Architectural block responsible for creating a framework for the ATT, in which it is represented the funcionalities of an ATT server. This profile describes the hierarchy of services, characteristics and attributes existent in the server and provides an interface for discovering, reading, writing and indicating of service characteristics and profiles. A more thorough description of profiles can be found in **??**.

Generic Access Profile (GAP) - Architectural block responsible for working in conjunction with GATT to define the base funcionality of BLE devices. The available services in this profile are: BLE device discovery, connection modes, security, authentication, association models and service discovery.

acro! (**acro!**)

acro! (**acro!**)

acro!

acro!

acro!s

As seen in [1]. *Enfatizar*

2.1.2 BLE Profiles

Figure 2.1: Dummy Figure Caption.

Remember you can change the reference style. Another dummy citation [2].

2.2 Section B

2.2.1 Subsection A

The model described can also be represented as

$$\dot{\mathbf{x}}(t) = \mathbf{T}\mathbf{z}(y),\ \mathbf{y}(0) = \mathbf{y}_0,\ z \geq 0 \tag{2.1}$$

where

$$\mathbf{A} = \begin{bmatrix} -(a_{12} + a_{10}) & a_{21} \\ a_{12} & -(a_{21} + a_{20}) \end{bmatrix},\ \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \tag{2.2}$$

2.2.2 Subsection B

Table 2.1: Dummy Table.

Vendor Name	Short Name	Commercial Name	Manufacturer
Text in Multiple Row	ABC	ABC®	ABC SA
	DEF	DEF®	DEF SA
	GHF	GHF®	GHF SA
Text in Single Row	IJK	IJK®	IJK SA
Frescos SA	LMN	LMN®	LMN SA
Carros Lda.	Text in Multiple Column		

3

Conclusions and Future Work

Conclusions Chapter

Bibliography

[1] “Wikipedia,” http://www.wikipedia.org, 2011.

[2] R. Dummy, “How to write a Latex Article,” http://www.biopsychiatry.com/misc/genetic-defects.html, August 2011.

Title of AppendixA