CEng 491

FINAL PROJECT

ANALYSIS REPORT

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1. INTRODUCTION

1.1 Purpose of this document

In this document we are going to try to designate our goals and expectations about our software project, bluetooth controller hardware and library. We are going to try to shed light upon our tentative agenda, our future undertakings and details of our intended project. Although it seems at first that the project is about controlling some system with bluetooth, i.e. only proof of concept, the big portion stays on the library and hardware design for controlling purposes. We will try to concentrate on our controller and its workings in this document. At the end of this document we aim to achieve the requirements basis for our project and basic plans and specifications that will help us to achieve some important goals for the project in the future.

1.2 Scope of this document

In this document we defined our functional requirements, interface requirements, performance requirements and our preliminary design and constraints on these. This document also includes our tentative agenda and proposed development methods and environments.

In addition to these although our software requirements elictation team consists of our members, many different people, such as some users, the professionals in this bluetooth area and some colleagues of us helped for the requirements elictation process. On the other hand in this requirement analysis process we did not concentrate on cost and effort estimation since these sources are limited. Effort estimation can not change anything since this project must be done in a limited time and also cost estimation is unnecessary since most of the hardware is supplied by the university and the workers (us) do not want any financial resource to be taken in this project.

1.3 Overview

Our project is to design and implement a general-purpose controller device which will allow any suitably configured bluetooth device to control the intended device which contains our controller module. Thus our controller will be modular, easily installed, compliant with the current standards in the area. We will design and implement developer libraries to use the controller and thus the end product will depend on the specific implementation. We are going to produce a detailed and easily understandable API and a broad spectrum of library functions.

The main speciality of the product will be its generic modules and compliance with other hardware units. By this way blutooth won't be a close-packed technology for other developers since by this product they can easily integrate bluetooth property to their products with ease and a very little background.

1.4 Business Context

Since we won't be producing an end-product in this project, since the product is only for users involved in technology development and hardware production, our project's business context depends on its usability in various applications. Many projects can be realized with our controller, from a 'smart' house to specific 'smart' equipments. As our product will be compliant with the current standards,the Bluetooth 1.0 specifications which were released on July 26, 1999 by the Bluetooth SIG (Appendix 12.1), and will be using bluetooth technology it has virtually endless possibilities. It may be used to simply be used to replace old RF and IR controllers, to introduce flexibility and diversity or it can be used to move the computation away from the end device to a central device which will introduce much more diversity and allow much complex operations on end devices with considerable saving on both the money spent and the controller devices installed.

2. General Description

2.1 Product Functions

Our product will be a controlling circuit which will receive the incoming signals via bluetooth, will apply signals accordingly on its analog and digital outputs, and return feedback on the controlling system again via bluetooth. Our product will also include an API and complementing libraries for the usage of our product.

In addition to these features, we will implement all the hardware that will be built on the serial bluetooth device to make it our controlling circuit. This will include analog to digital and digital to analog converter, an intermediate buffer and necessary pins and intermediate circuit. We will implement the controlling functions, which are the firmware, and document the functions as an API.

The main aim in this product is to make it a generic component with its libraries and provided functions. The controller circuit will have 10 digital and 2 analog input/output pins. By this way it will be easy and comfortable for the users to integrate the product in their designs.

2.2 Similar System Information

In this section we would like to inform about the relationship of our product with any other products. First of all our product is not intended to be a stand-alone product since it should be used as a component of a larger hardware which it will control and also an equipment in which our software is used to control the hardware. The equipment must have bluetooth connection hence.

To start with, our product will need a controlling device, which must be capable of computation or containing pre-computed commands to be sent to our device, using our functions. Thus cell phones and computers will be of our interest. Also a specific control circuit may also be built in this equipment. Since this is a very broad scope we opt to use JAVA as our developing environment which both many cell phones and all computer platforms support. In addition to these JAVA is consistent with our purposes which are to be generic, easy to use and platform independent.

As a second relationship our controller must be built in some controllable hardware. By the word "controllable" we try to insist that outputs and inputs of this controlled device should be reduced as pin-usage. Our controlled device can be used in any areas such as security, smart systems etc.

2.3 User Characteristics

Bluetooth is spread throughout our community and of great interest to many people in Turkey. Our users want both clarity, ease of use, and flexibility on the public side, and modularity and easy installation on the producer side.

Considering almost %95 of people (Appendix 12.2-(1)) using cell phones know whether their cell phone has bluetooth or not, and also widespread integration of bluetooth in cellular phones as %83 and cellular phone usage (Appendix 12.2-(2)) there exists a great market for our product. Also we should note that community is eager to use bluetooth in all aspects, from using it as a remote control for their computer, to “toothing” at night clubs and public places which is not restricted to Turkey. In addition to all these facts "Bluetooth" is a friendly name and technology for the people since cellular phones have an big importance and necessity in their life.

2.4 User Problem Statement

The alternatives of bluetooth controllers are IR and cable controllers, which both have significant drawback compared to bluetooth.

With cable controllers, there is the cable which is a great problem for mobility and flexibility of use. It eliminates interference and security issues, but severely cripples mobility and ease of use. Also if right security and verification techniques are used as 128-bit public/private key authentication combined with a streaming cipher (up to 64-bit) based on A5 security (Appendix 12.2 (3)), security is not a problem. Also bluetooth technology posseses very powerful correction techniques and algorithms, which solve the interference problem, even in the vicinity of microwave ovens which are the biggest interference for the 2.4 GHz bluetooth signal.

With IR controllers, you have to have a line of sight to the device you need to control, and also you don't have any means to verify that your command has been received by the device to be controlled without any external means. With bluetooth, since it broadcasts a radio wave you don't need line of sight. Also two way communication is possible for situations requiring feedback from the controlled device. Also one other advantage is the diversity of the signals that could be sent using bluetooth with each package sent.

So, our project could be the best option available for the means of controlling remote devices, and the ultimate answer for both the producers and end-users seeking diversity and complexity in their devices.

2.5 User Objectives

Our system would need to be:

- Easily installed,
- Easily understood,
- Easy to use,
- Easily expandable
- Secure,
- Precise and
- Diverse (Appendix 12.2 (4)

Both as the software and the hardware, it should be noted that these also depend on the specific application our project would be used in.

2.6 General Constraints

Our system would need to be:

- Real-time,
- Compliant with Bluetooth protocols,
- Compliant with IEEE protocols,
- Independent from the controlling device platform(from the software perspective)as in the form of Java libraries,
- Secure and trusted

3. Team Organization

The team organization selected for the project is controlled decentralized with Orhan Tuncer being the project leader. The reason for selecting this type of an organization is Bluetooth is a very big area and partially new to us so there are so many things to search and learn. The project leader assigns specific search areas to the members and communications which are made are both horizontal and vertical. All decisions are taken with the opinions of group members and since the team consists of five members all decisions can be taken without ambiguity. In addition to these all members have the same rights for a decision to agree or disagree.

4. Research

4.1 Technology Research

At the start of our project our knowledge about Bluetooth technology is not very much and deep. Because of this fact we started to search articles about this technology. We investigate some links over web which are defined in the progressive report. Then we had an opportunity to have a talk with the father of our member Şebnem Sönmezler. He is mastered in the area of pic programming (about the finish his new book) and working in this business area.

From this conversation we concluded that Bluetooth is a new and highly popular technology for wireless networks. Pic programming is a hard issue and we should be interested in this concept after the hardware comes to our department.

There is not much link about the bluetooth controller in the internet so a part of the work and research we should do is postphoned until the arrival of Blue Radio hardware.

4.2 Customer Research

We have taken out two surveys for the reliable information from customers. In the first survey we have researched that whether people know their cellular phone has integrated Bluetooth hardware. The results are as those;

Yes	%95
No	%5

The mopst striking conclusion that can be arrived from these results is noone asks us what the Bluetooth means. The survey is taken out in three different places as METU, Kızılay, 100.Yıl . The involved people are chosen randomly as they are walking in the street and we take care of choosing equal number of people in every age group. The total number of people are 125.

Secondly we contacted with some Computer Engineers to see that what they will wait from such a product. The answers are centralized to easy usage , easy integration and reliability. The full answer set can be seen in section 2.5.

5. Functional Requirements

5.1 Library Functions

Since our project is designing a bluetooth controller library, the major functional requirement is that the library includes every high level function that could possibly be necessary to develop a specific device controller.

This requirement is the most essential part of the project since it provides an interface to the developer which does not require him/her to know the internal structure and mechanism of a bluetooth controller.

There are a number of risks such as the library functions are not enough for developing a device controller, they are error prone or not reliable. We are planning to overcome these risks by a careful specification of the functions needed and by designing an example device controller using our library functions during the proof of concept phase, so that we can make the necessary changes.

5.2 Board Design

We have to design the hardware of the controller which will take place between the computer and the device to be controlled.

This is the one of the bottlenecks of our project since it is required for the proof of concept and testing phase. The board design is highly essential to the overall system and it will determine the form of the final product.

A bad design would block the development of the project in any phase, therefore we are planning to concentrate on the board design for a considerable amount of time, before we go into the details of other development parts, in order to reduce the probability of a design mistake.

In addition to all of these with the design of controller board we must be interested in PIC programming for the controller to be compatible with the serial hardware.

5.3 Portability

Since we are designing a general purpose bluetooth controller, the product has to be portable for a variety of devices.

If this functional requirement would not be satisfied, it will contradict with the main idea of a “general” purpose bluetooth controller. In order to reduce the probability of the occurrence of this type of contradiction, we will consider a wide variety of devices that can be controlled by our product and try to meet their standards during the design phase.

5.4 Data Flow Logging

This function will provide a list of data flows between the computer and the device being controlled, so that the user will be able to keep track of the commands given by the computer and the feedback from the device.

Data flow logging is another critical functional requirement of the overall system, since it will serve as a debugger to the user in the developing phase in addition to keeping the logs once the specific controller is developed and the device is being controlled.

This functional requirement is one of the first requirements to be satisfied, because we are planning to use this facility during the development phase of our project as a debugger.

5.5 Security

Although there would be some applications for the bluetooth controller which does not require security, we assume that our controller system should provide a level of security which can be defined by four fundamental elements: Availability, access, integrity, and confidentiality. If we assure that the connection between the controller and the device is secure under these conditions, no other third party device can interfere with the connection or interrupt, while the device and the controller is communicating without losing integrity and confidentiality.

As it is known by most of the cellular phone users interested in Bluetooth, any Bluetooth device can be realized by a phone when searched for devices. Since Bluetooth technology can communicate out of sight, this can be a critical problem in security issues. In today's cellular phones there is an authentication protocol for giving permission to connect to a Bluetooth device. This must be implemented in our product since the proof of concept can be used in critical places for security.

Also we want to add portability and generic issues to our system. As a result we must implement all the same protocols for the Bluetooth connection about security and in our libraries there must be additional security issues for the hardwares which are wanted to be kept more private that a cellular phone.

6. Interface Requirements

6.1 User Interfaces

The GUI will have to be designed for the specific purpose hardware which our product will control. At the end of this product it is valid that we will design a proof of concept to show the product's usage nevertheless GUI for this is not the main point now.

The most important point in the interfaces is our API for our device and libraries. We will use JABWT and OBEX (Both in Appendix 12.1) for the API design. Here is an overview of our main API design.

Client API

bcnt blu_Connect (char* serverID, char* ClientID)	Opens connection to Blucon server. Returns Blucon connection object which defines the path of server application which is decided by the server.
int blu_Disconnect (bcnt* con)	Closes connection to Blucon server.
int blu_sendLayout (bcnt* cnt)	Sends the pin layout to the server in Blucon pins object format.
bpin blu_readLayout (void)	Reads the values of the pins and returns Blucon pins object.
int blu_writeLayout (bpin pin)	Sets the values of the pins.
void blu_onLayout (bfn* fnc)	The function to be called when new layout arrives. The function must be in bfn format.
void blu_clientLoop (bmain* main)	Client side main processing loop. The function must be in bmain format.

Server API

int blu_sendLayout (bcnt* cnt, bpin pin)	Sends the pin layout to the client.
void blu_onConnect (bcon* con)	The function to be called when a new connection is requested. The function must be in bcon format.
void blu_onDisconnect (bcon* con)	The function to be called when a connection is closed. The function must be in bcon format.
void blu_onLayoutServe (bfun* fun)	The function to be called when new layout arrives. The function must be in bfn format.
void blu_serverLoop (bmain* main)	Server side main processing loop. The function must be in bmain format.

Defined Function Formats

void bfun (bcnt* cnt, bpin pin)
int bmain (void)
void bcon (bcnt* cnt)

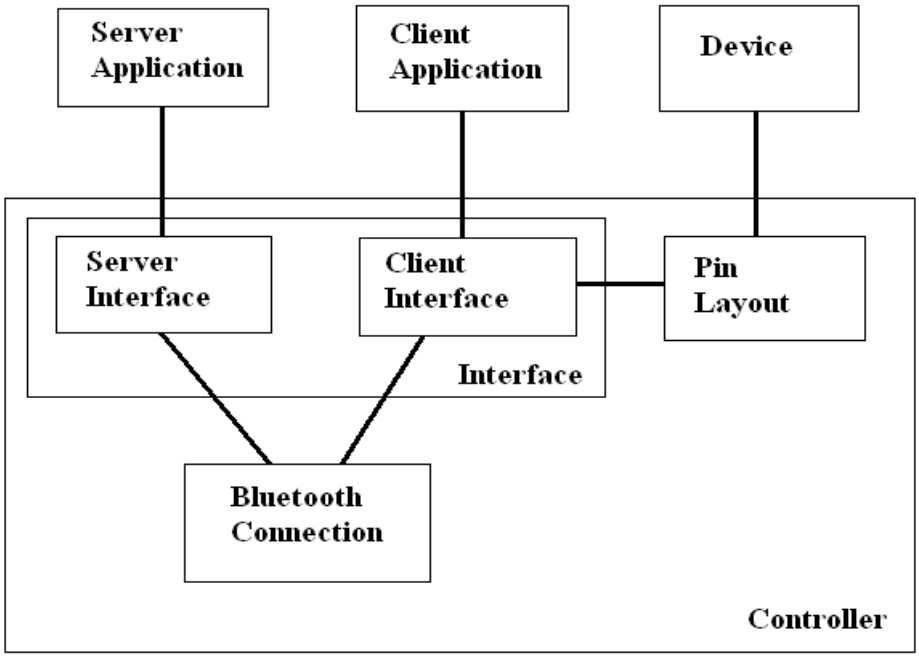

Figure 1 - Controller Architecture

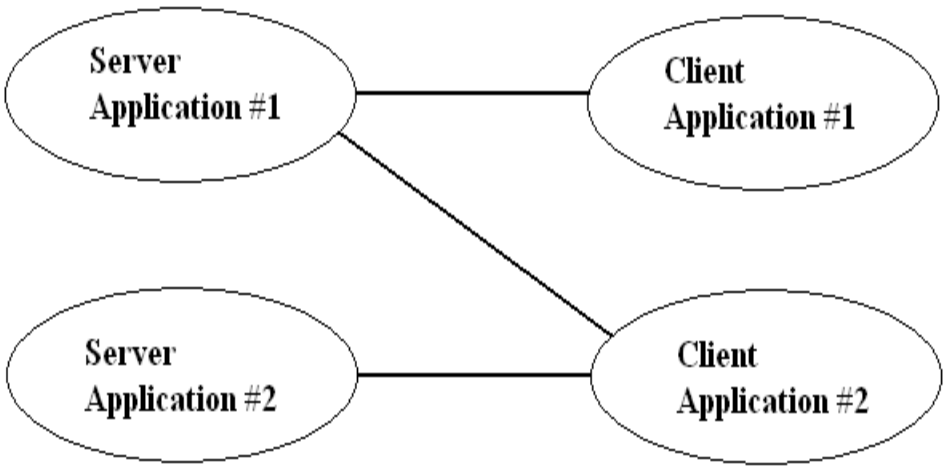

Figure 2 – Many to Many connections of the Client and Server

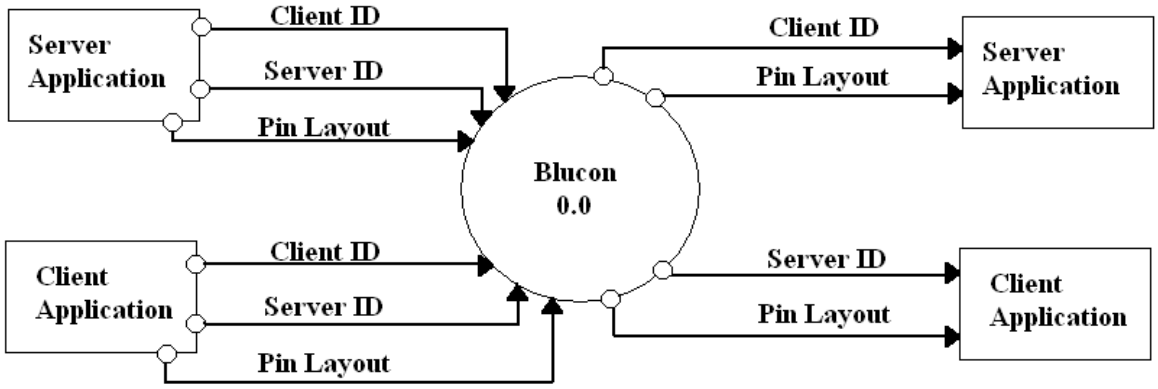

Figure 3 – Level-0 DFD

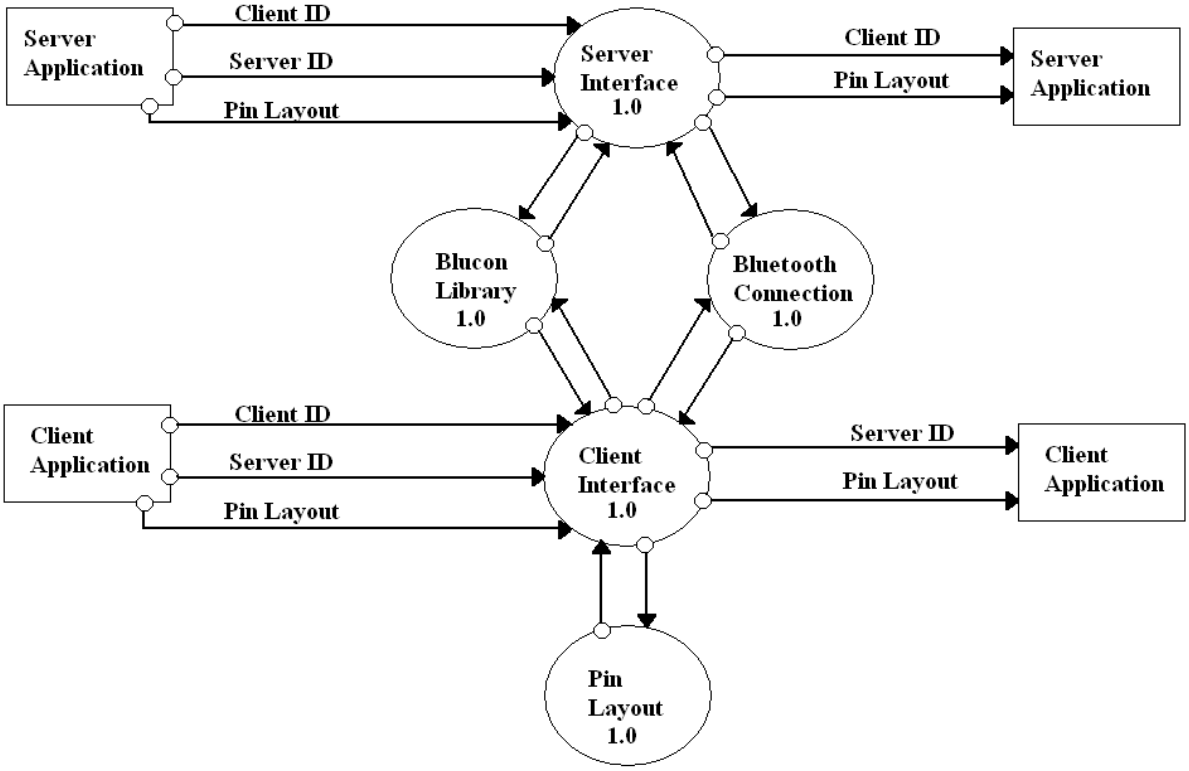

Figure 4 – Level-1 DFD

6.2 Hardware Interfaces

Hardware interface of our product will consist of the digital and analog pins and the generic usage of these pins. After designing the controller circuit, the user will be informed via technical information about the pin usage.

6.3 Communication Interfaces

Here the important issue for our product is to be involved in a piconet(Appendix 12.1) or not. The master role for our product sounds not so clear, because of this fact it is usual to give permission to our controller for being a part of a piconet as a slave role since many devices can be connected via Bluetooth in this range.

7. Performance Reqiurements

7.1 Speed

Since many products need real-time manipulations or feedback, speed becomes an important issue in our design. Different from the delay introduced by radio waves, our manipulation and library should implemented in a way to do its work in a nearly constant time. For this operation minimizing the amount of data which will be transmitted among

piconet comes into mind firstly. For this operation a packing algorithm can be found in the library for users who wants to transmit a big data. Apart from these the library functions will provide basic operations and by this way real time control can be achieved.

7.2 Memory

Only memory requirement in this design is a buffer which must be located at the controller side since data transmission is continiguos and should be handled in a reliable way. In addition to these the buffer will increase the functionality of the library functions since they can take data as a whole.

8.Design Constraints

8.1 Standards Compliance

Since our aim is have a generic product for nearly all purposes, we must obey the standards imposed by the Bluetooth SIG. In addition to these another standards were imposed by the IEEE named IEEE 802.15.1 (Appendix 12.2 (6)) and we try to obey these standards which are in compliance with Bluetooth SIG.

8.2 Hardware Limitations

The serial controller hardware which will be used in our product is ***Blue*Radios Kit.** (Appendix 12.2 (8)). The board outputs in serial port so our remaining circuit must be compatible with serial port.

9. Other non-functional attributes

9.1 Reliability

Since the controlling idea is based on an automation, where the orders from the computer are given according to the feedback from the device and no human interaction during the process, the controller system has to reliable such that the orders and feedback are transmitted consistently under a variety of conditions. To achieve this goal, both the library and the hardware design of the controller should be done accurately. In addition, we are planning to provide an efficient but reliable error checking and correcting mechanism.

9.2 Extensibility

The major idea of the bluetooth controller design is the extensibility of the product. For every device that will be controlled using the controller, a list of high level functions has to be written for specialization. We will give an example to this idea by the proof of concept phase, as a part of our project. In addition to the extensibility property due to the specialization, a list of functions can also be added to the library when needed.

9.3 Reusability

The controller has to be reusable for different devices of the same type in a program designed a specific purpose, furthermore, our controller itself should be reusable in a different project, since the library within the controller is a general purpose library and it does not deteriorate or change by being used in different projects.

9.4 Serviceability

Since we will supply a library with the controller, which will be used for further programming, we should provide a tutorial for the users, including how to integrate the controller into a system, how to use the data flow log, the possible application areas, security constraints and standard issues.

10. Appendices

10.1 Definitions, Acronyms, Abbreviations

API	:	Application Programming Interface
Bluetooth SIG	:	The Bluetooth "Special Interest Group" which was founded in early 1998 by the companies Ericsson, IBM, Intel, Nokia, and Toshiba. Then other members were involved in this group and the group has an very big and important place in the Bluetooth technology area.
GUI	:	Graphical User Interface
IEEE	:	Institute of Electrical and Electronics Engineers
JABWT	:	Java APIs for Bluetooth wireless technology (JABWT) (Appendix 12.2 (6))
OBEX	:	Object Exchange Protocol, mostly used for Bluetooth profiles in Java (Appendix 12.2 (5))
Piconet	:	When one Bluetooth device senses another Bluetooth device (within about a 30-foot range), they automatically set up a connection between themselves. This connection is called *piconet*, and is a kind of mini-network—a *personal area network* (PAN), to be specific. In a piconet, one Bluetooth device is assigned the role of master, while the other device and any subsequent devices, up to eight in total—is assigned the

role of slave. The master device controls the communications, including any necessary transfer of data between the devices.(Appendix 12.2 (3))

10.2 References

(1) Customer Survey-1 (Section 4.2)

(2) An article named "Bluetooth'lu telefonlar çoğunlukta" http://bilisim.milliyet.com.tr/detay.asp?id=1843

(3) Mike Miller,"Discovering Bluetooth",Sybex,PaperBack,Published July 2001 ISBN 0782129722

(4) Customer Survey-2 (Section 4.2)

(5) C Bala Kumar & Paul Kline,Bringing the benefits of Java to Bluetooth http://www.embedded.com/story/OEG20020519S0001

(6)C Bala Kumar, Paul Kline, Tim Thompson, BLUETOOTH APPLICATION PROGRAMMING WITH THE JAVA APIS, Book's Home Page http://www.elsevier.com/wps/find/bookdescription.cws_home/680680/description#description

(7) IEEE Home Page, http://standards.ieee.org/announcements/802151app.html

(8) The Controller Hardware Home Page, http://www.blueradios.com/evaluationkit.htm

10.3 Additional Notes

- This document is prepared due to the standards for requirement analysis specification written in the ICS SE Journal, Volume 4.