Software Requirements Specification

for

Sun SPOT Universal Monitoring System (SUMS)

Version 1.5
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Revision History

Title	Date	Reason For Changes	Version
First Version	10/20/2008	Initial Version	1.0
Revised Version	12/06/2008	Revised to reflect instructor comments and feedback.	1.5

Approval

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1. Introduction

1.1 Purpose

This software requirements specification (SRS) is intended to outline the requirements necessary to implement the SPOT Universal Mote System (SUMS). The audience of this document includes the sponsor and class instructor, and any other personnel associated with and/or affected by this project.

1.2 Scope

The project is the creation of SUMS. SUMS introduces a new level of testing and monitoring capabilities when developing applications on SPOTS. These capabilities include:

- Reading sensor values from motes
- Displaying sensor values from motes through LAMM and WAMM consoles
- Providing a graphical representation of values through LAMM and WAMM consoles
- Saving sensor values on LAMM consoles
- Monitoring the overall topology of motes connected to SUMS
- Providing sample applications to demonstrate use of SPOTs and SUMS

1.3 Abbreviations, Acronyms, and Definitions

Accelerometer – A sensor built into SPOTs that provides data for acceleration in 3 dimensions.

Base station – A SPOT that does not take sensor readings but rather communicates with other SPOTs within range.

High level data – An interpretation of the raw data from a sensor. Example: a Fahrenheit interpretation of an A/D value given off by a thermistor.

LAMM (Local Area Mote Monitor) – This system contains a computer connected to a base station running SUMS which will monitor the high level and low level data from the sensors and SPOTs within range of a base station.

Low level data – The raw data from a sensor. Example: an A/D value obtained from a thermistor.

Mote – A SPOT that has been preprogrammed to interface with SUMS.

Radio Space – A communication space that contains channels through which the Sun SPOTs and base stations communicate.

SPOT (Small Programmable Object Technology) - A wireless sensor network remote produced by Sun Microsystems. The remote complies with the IEEE 802.15.4 standard for wireless communication. It contains a built in accelerometer, thermistor, and light sensor. The remote also allows for outside attachment of sensors and can be programmed with Java Micro Edition because of the built in Squawk Java Virtual Machine.

SUMS (Sun SPOT Universal Monitoring System) – The software system that is being constructed. This software system will allow consoles connected to base stations to function as

LAMMs and the console that wishes to monitor these LAMMs to function as a WAMM.

Thermistor – A sensor built into Sun SPOTs that provides data for temperature of the remote.

WAMM (Wide Area Mote Monitor or Master Console) – This piece of the system architecture is a computer that is running SUMS to monitor the LAMMs and attached base stations. From those base stations, it will be able to see the motes and some high level data being transmitted to the base stations.

Wireless Sensor Network (WSN) – A wireless network of devices using sensors. These devices collect data from their sensors and transmit the data in packets to a base station which is also a part of the WSN.

1.4 References

- Igoe, Tommy, and Dan O'Sullivan. Physical Computing : Sensing and Controlling the Physical World with Computers. Boston: Course Technology, 2004
- Sommerville, Ian. Software Engineering. New York: Addison-Wesley Longman, Incorporated, 2006.
- SunSPOTWorld – Home of Project Sun SPOT. http://www.sunspotworld.com/

1.5 Overview

The SRS will provide a description of the product, the features of the system, the requirements for those features, external interface requirements, other non-functional requirements, and models for analysis of the system. These will be organized into the following sections:

- Overall Description
- System Features
- External Interface Requirements
- Other Non-functional Requirements
- Other Requirements
- Analysis Models

2. Overall Description

2.1 Product Perspective

SUMS is a new, original monitoring system for deployed Sun SPOTs. The motes within the system are meant to run independently and concurrently with other SPOT applications both physically and in code.

The intent is that the motes that are programmed to interact with the system will operate within the SUMS wireless sensor network. These wireless sensor networks will be created by the base stations running SUMS programming. Motes within physical range of the wireless sensor network will connect with the rest of the system.

As the motes run their other application, the motes programmed with code to communicate with SUMS will automatically interact with the SUMS system. SUMS users will need to program the intended SPOTs to use SUMS, but once this task is done the motes will autonomously act during runtime. Connecting to SUMS sending data, and processing commands from SUMS will be done on the mote without any physical input on the mote.

The LAMM and WAMM console subsystems are meant to be as independent and self-contained as possible, however they will externally interact with a SQLite database for logging sensor data. Other than that, the consoles are only intended to interact with SUMS users and other SUMS subsystems.

2.2 Product Features

The SUMS system consists of a master console connected to a network of LAMMs, each of which is connected through a base station to motes within range. The motes will connect and send information to a base station without input from the user at a console or with the mote. The motes are not tied to any one base station, and will be able to move between ranges of base stations.

The information of a mote will be displayed on the master console and connected LAMM console. The information can be displayed in a variety of options chosen by the user at runtime. If the user wishes, the data obtained from a SPOT will be logged for future review.

2.3 User Characteristics

SUMS is intended for specific use by the Texas Christian University (TCU) Computer Science Department. The LAMM portion of the system shall be available to students or faculty who have some experience with or knowledge of SPOTs and Java Micro Edition for programming on the SPOTs. The WAMM portion of the system shall be available to the administrator of the SPOTs. The users are assumed to be using lab computers on the TCU network.

2.4 Operating Environment

The following are the minimum specifications to run the SUMS software on a computer:

- Windows XP Service Pack 3
- Sun Java Runtime Environment (JRE) 1.6.0_07
- Apache Ant 1.6.5
- Microsoft .NET Framework 3.5
- SQLite 3.5

The minimum hardware requirements are as follows:

- 1 GB of RAM
- 3.2 GHz Processor
- 100Mpbs Ethernet connection
- USB port

2.5 Design and Implementation Constraints

2.5.1 Design Constraints

- The combined memory space of the SUMS programming and SPOT application executable shall not exceed 4 MB.

- Motes shall not use more than 512 KB of RAM during runtime.
- Motes shall not use more than 3 analog input pins.
- Motes shall not use more than 4 general purpose input/output pins.
- Motes shall not use more than 3 high current output pins.
- The physical size of the SUMS wireless sensor network shall be constrained by the wireless communication range of SPOT base stations.

2.5.2 Implementation Constraints

- Motes shall be programmed in Java Micro Edition
- Base stations shall be programmed in Java Micro Edition
- LAMMs shall be programmed in C#.NET and must be able to interface with WAMM and connected base station.
- WAMMs shall be programmed in C#.NET and must be able to interface with the LAMMs.

2.6 Assumptions and Dependencies

2.6.1 Assumptions

- The radio signal might be impacted by other objects in a room

2.6.2 Dependencies

- Battery life of the SPOTs

2.7 Apportioning of Requirements

Requirements for applications will be postponed for a future version.

2.8 User Documentation

SUMS will include three primary documentation components once the system is delivered: a user manual, tutorials, and online resources - SUMS online resources may not be available online for a long period of time after May 2009 when the course is over.

The user manual will consist of background information of SUMS, basic installation of the system, definitions of the terms used in SUMS, and also the step-by-step solution of predicted problems of users' implementation. Tables, diagrams and images will be included to provide for understanding. The tutorials will include a number of various media files. All of these files will help users become familiar with SPOTs and our system. There will be sample code for users to evaluate SPOTs and understand how they function. We are keeping all of our project documents and a detail progress report of our project on our website to help our client (Dr. Payne) to keep track of our progress.

Both of the above two documents will be put on a CD and delivered to the project sponsor and instructor (Dr. Donnell Payne) with the system.

All textual documents and presentation slides will be provided in PDF format which can be viewed using Adobe Reader. Images shall be in JPEG format. Video files will be provided in either AVI or MPEG formats for the ease of use.

3. System Features

3.1 WAMM

3.1.1 Monitor the LAMMs

3.1.1.1 Description

Monitor all LAMMs (up to four LAMMs) and display the data being sent from the motes

3.1.1.2 Stimulus/Response Sequences

- WAMM will start in a wait state.
- Once a LAMM initiates connection, WAMM will acknowledge, respond, and connect. WAMM will reject the request if there are four LAMMs already connected to it.
- Then, it will receive the metadata about the connectivity and its motes, including modes, MAC address and sensor types.
- It will display the metadata on the interface in graphical or value form depend on user's option.
- When user selects motes to display, sensors to display and type of display, WAMM will receive data from the LAMMs and display it appropriately.
- If the LAMM disconnects, the WAMM will receive a notification and update the topology.

3.1.1.3 Functional Requirements

- The master WAMM console shall provide overall system topology and allow for more detailed topology and high-level sensor monitoring of LAMMs connected to it.
- WAMM console shall display LAMMs and sensor motes within each LAMM.
- User shall be able to select one or multiple LAMMs from the overall topology display and obtain the detailed LAMM topology(ies) with motes and sensors.
- The user shall be able to select and monitor one or multiple motes from a LAMM for sensor value display as well as viewing sensors on selected mote(s).
- WAMM console shall provide the ability to view a particular sensor type across all motes. (For example, light sensors in all LAMMs)
- Sensor displays shall be configured by the user. This includes display type, min/max values, and labeling information.
- WAMM shall be able to log data from particular sensors.

3.1.1.4 Non-functional Requirements

- On the TCU Lab Subnet, the WAMM console shall reflect topology changes within two seconds.
- On the TCU Lab Subnet, the WAMM console shall provide sensor display updates within one second.

3.2 LAMM

3.2.1 Monitor the Motes

3.2.1.1 Description

Monitor all connected motes (up to four motes per LAMM) and display sensor data sent from them.

3.2.1.2 Stimulus/Response Sequences

- When LAMM get started, it will ask if the user wants to connect to the WAMM. Then it will display a window that allows the user to enter the WAMM's IP address.
- At the same time, the LAMM also checks if a base station is connected to it. If not, it will ask the user to plug a base station in and hit the "Search" button.
- The LAMM will obtain a topology from the base station once a base station connects and sends the topology including motes' sensors' metadata to the WAMM if it connects to a WAMM.
- The LAMM will update the topology and send it to the WAMM if there is a change occurs.
- When the user selects motes to display, sensors to display and type of display, LAMM will receive data from the sensors and display it properly.
- If the user closes the LAMM, it will disconnect from the network. Before that it will send a notification to the WAMM and its base station. The base station will close its connections. The motes will automatically begin searching for a new base station.

3.2.1.3 Functional Requirements

- User shall be able to view the overall LAMM topology with sensor type information.
- The primary LAMM console shall provide the LAMM topology (including base, motes, and sensor types on each mote) and allow for obtaining more detailed sensor information and readings.
- User shall be able to view LAMM topology with detailed sensor information including all motes connected with sensor details.
- Ability to view sensor readings. From the LAMM topology view with detailed sensor information, the user shall be able to select mote(s) and sensor readings for display.
- User shall be able to view one or multiple motes and able to change its sample rate.
- Sensor displays shall be configured by the user. This includes display type, min/max values, and labeling information.

3.2.1.4 Non-functional Requirements

- The LAMM monitor shall respond to topology change within one second.
- LAMM console update frequency shall be up to ten hertz. This is dependent on the sensors being monitored.

3.3 Motes

3.3.1 Dynamically and Automatically Connect to SUMS

3.3.1.1 Description

If the mote is not connected, it will connect to the base station automatically whenever it is in range. Likewise, it should be able to move from base station to base station making connections.

3.3.1.2 Stimulus/Response Sequences

- When it's not connected, if the mote comes into range or is turned on while in range of a base station.
- The mote will send a request to connect to nearby base station(s)
- The mote then waits for an acknowledgement to join sent from the base station. After receive the acknowledgement. The mote will send its metadata to the LAMM and LAMM to WAMM for it to update the topology.
- The mote sends its sensors readings to the base station.
- If multiple base stations wish to connect, take the first base station's request.

3.3.1.3 Functional Requirements

- A mote shall be able to connect to a base station when it is not currently connected and enters that base station's range
- Upon awakening from sleep, a mote shall be able to detect a base station and begin connection protocol.
- A mote shall connect to the first base station that wishes to connect to it.
- Connection shall be terminated when a mote wanders beyond range of the base station.
- Connection shall be terminated when a mote is already connected.

3.3.1.4 Non-functional Requirements

- Connection shall not require any user assistance given the mote is in range and in an awake state.

3.3.2 Send Sensor Data

3.3.2.1 Description

The mote sends sensor readings from its build-in sensors and any other sensors connected through A/D or general I/O pins.

3.3.2.2 Stimulus/Response Sequences

- The mote will make a connection to a base station connected to LAMM
- The mote then waits for an acknowledgement sent from the LAMM through base station.
- Then the mote will send its metadata for the LAMM and WAMM to update the topology.
- The mote will send readings to base station to LAMM and to WAMM.
- The base station will send readings to LAMM.

3.3.2.3 Functional Requirements

- The mote shall be programmed to accept sampling rate from the LAMM console.
- The mote shall be programmed to accept data selected from the LAMM consoles such as sample rate and sensor filters.
- The mote shall be able to read data from internal sensors and send the data to the connected base station.
- The mote shall be able to read data from external or add-on sensors and send the data to the connected base station.

3.3.2.4 Non-functional Requirements

- The mote shall send the data such that the LAMM can update at a frequency of ten hertz.

3.4 Base stations

3.4.1 Connect to Motes in Range

3.4.1.1 Description

The base station connects to motes within range that send a request to connect unless a conflict exists with another base station or there are four motes already on the base station.

3.4.1.2 Stimulus/Response Sequences

- Base station receives connection request from nearby mote
- Base station checks number of motes connected
- If number is four, base station rejects connection else base station will send the request to join to the LAMM and pass an acknowledgement to join from the LAMM to the mote.
- The base station sends the mote's metadata to LAMM and LAMM to WAMM to update the topology.
- If the mote leaves range, the base station disconnects the mote and sends the appropriate topology changes to the LAMM and LAMM to WAMM

3.4.1.3 Functional Requirements

- The base station shall be ready to accept connections whenever there are not four motes connected.
- The base station shall not accept connections when there are four motes connect to that base station.
- The base station shall close all connections if the LAMM shuts down.

3.4.1.4 Non-functional Requirements

- Connection shall not require any user assistance given the mote is in range and in an awake state.

3.4.2 Send data to LAMM

3.4.2.1 Description

The base station will accept data from the motes and transmit the data to the LAMM.

3.4.2.2 Stimulus/Response Sequences

- Mote sends base station data
- Base station sends LAMM data from mote

3.4.2.3 Functional Requirements

- The base station shall be able to obtain data from a connected mote.
- The base station shall be able to pass data to LAMM.

3.4.2.4 Non-functional Requirements

- Base station shall send data such that the LAMM can update at a frequency of ten hertz.

4. External Interface Requirements

4.1 User Interfaces

- SUMS shall allow the user to specify the display format for sensors. Sensors will display text values and may have graphical display options as appropriate for the sensor.
- SUMS shall update the LAMM console within one second of updated data.
- SUMS shall update the WAMM console within two seconds of updated data.
- SUMS shall make available data from all sensors included in the SPOT, battery, signal strength, and any external sensors attached to the SPOT.
- SUMS shall allow the user to select multiple SPOTs (maximum of four) and view sensor data for the selected SPOTs.

4.2 Hardware Interfaces

- Motes and base stations will communicate with each other over CC2420 radio chips which are IEEE 802.15.4 compliant.
- Base stations and a LAMM console shall communicate with each other through a USB connection.
- The LAMM consoles and WAMM console shall communicate with each other over an internal socket.

4.3 Software Interfaces

4.3.1 SQLite

- Mnemonic: SQL
- Version Number: 3.6.4
- Source: http://www.sqlite.org/
- Purpose: To store data from sensors on the LAMM machine

4.3.2 .NET Framework

- Mnemonic: .NET Framework
- Version Number: 2.0
- Source: http://www.microsoft.com/
- Purpose: Necessary to run the LAMM and WAMM consoles, which are planned to be developed in C#.NET

4.3.3 Apache Ant

- Mnemonic: Ant
- Version Number: 1.7.1
- Source: http://ant.apache.org/
- Purpose: Necessary for base station

4.3.4 Java Runtime Environment

- Mnemonic: Java
- Version Number: 1.6.0_07

- Source: http://java.sun.com/
- Purpose: Necessary to run base station

4.4 Communications Interfaces

- The WAMM and LAMMs will communicate to each other using TCP/IP.
- The base stations and motes will communicate through the IEEE 802.15.4 radio standard. The radio protocol is already built into the hardware.
- The LAMMs and base stations will communicate to each other through an internal socket.

5. Other Non-functional Requirements

5.1 Safety Requirements

The SUMS software does not have any safety requirements.

Related hardware safety requirements:

- Do not misuse SPOTs or base stations as personal injury can occur.
- Do not connect sensors to SPOTs without a basic knowledge of hardware.
- Always use caution when connecting sensors to SPOTs.

5.2 Security Requirements

SUMS does not have any security requirements because the data obtained from SUMS is not personal or private data.

5.3 Software Quality Attributes

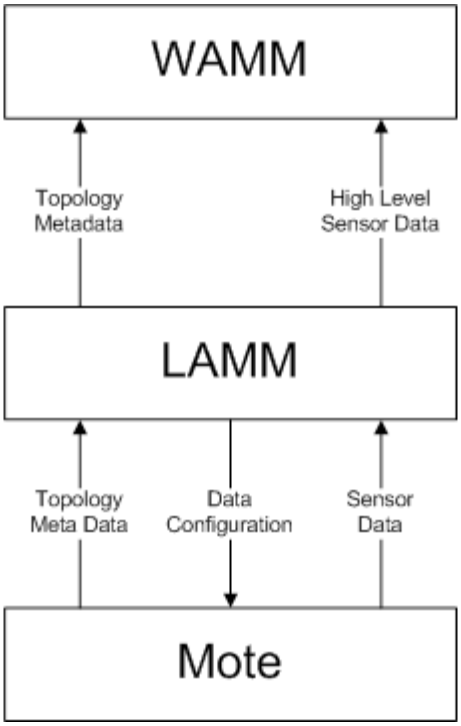
- The software and associated documentation shall be available online at the SUMS website
- The software code shall be well documented for future maintenance and/or development
- A developers guide shall be provided for future maintenance
- A users guide shall be provided to assist users in using the system
- The software shall be properly documented using Visual Studio built-in documentation capabilities.

6. Other Requirements

- Data shall be stored in a SQLite database for easy access and storage.

Appendix A: Analysis Models

Figure A-1: Basic Data Flow Diagram for the SUMS system


WAMM
Topology Metadata
High Level Sensor Data
LAMM
Topology Meta Data
Data Configuration
Sensor Data
Mote