

***Project: WIMEA-ICT Free and Open Source Radio Sensor (RSS2) node Application for Contiki Embedded Operating System (****WIMEA-ICT RSS2****)***: Requirements Document (version 1.0)

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**1. Introduction**

This document contains the system requirements for the WIMEA-ICTFree and Open Source Radio Sensor (RSS2) node (*WIMEA-ICT RSS2*) Application for Contiki Embedded Operating System. These requirements have been derived from several sources, including WIMEA-ICT project [1], Contiki community[2], and the radio sensor website [3].

1.1 Purpose of Document

This document is intended to guide development of the *WIMEA-ICT RSS2* application. It will go through several stages during the course of the project:

1. **Draft:** The first version, or draft version, is compiled after requirements have been discovered, recorded, classified, and prioritized.
2. **Proposed:** The draft document is then proposed as a potential requirements specification for the project. The proposed document should be reviewed by several parties, who may comment on any requirements and any priorities, either to agree, to disagree, or to identify missing requirements. Readers include end-users, developers, project managers, and any other stakeholders. The document may be amended and reproposed several times before moving to the next stage.
3. **Validated:** Once the various stakeholders have agreed to the requirements in the document, it is considered validated.
4. **Approved:** The validated document is accepted by representatives of each party of stakeholders as an appropriate statement of requirements for the project. The developers then use the requirements document as a guide to implementation and to check the progress of the project as it develops.

1.2 How to Use This Document

We expect that this document will be used by people with different skill sets. This section explains which parts of this document should be reviewed by various types of readers.

**1.2.1 Types of Reader**

* AWS programmers who will use this document to implement the application.
* AWS project managers who will use the document to plan for and schedule resources required for the development of the application.
* AWS maintainers. These AWS stations will be maintained over time therefore the document will be used by these maintainers to know how the weather data is captured, processed, stored and transmitted to the central repository so that they can know how to troubleshoot the AWS.
* Other developers who plan on using the RSS2 motes for other sensing applications so that they can know how to integrate them with the functionalities offered by *WIMEA-ICT RSS2* application.
* Contiki open source development community in order to gain an understanding of the application and possibly make their contributions.
* Meteorologists/ Observers/engineers, who will configure the RSS2 motes during station deployment. The document also helps then to know how the application supports AWS debugging.

**1.2.2 Technical Background Required**

For a general understanding of the document, readers should be computer literate and have basic knowledge of embedded systems, Wireless Sensor Networks (WSNs) and AWSs.

**1.2.3 Overview Sections**

For an overview of the system, all readers need to read section 1, which contains the scope of the project, business case and an overview of the requirements document. In order to understand the application functionalities, the reader must read section 1.5. One must also read section 2, which contains a general description of the application and more specifically the product perspective, product functions and user characteristics if they are to get a general application perspective.

**1.2.4 Reader-Specific Sections**

Section 4, which presents the high level technology architecture is intended for the programmers and maintainers of contiki-RSS2 Mote-based application.

**1.2.5 Section Order Dependencies**

The reader should first read section 1, which provides an introduction of the system. The order in which they read the other sections does not matter.

1.3 Scope of the Product

The *WIMEA-ICT RSS2* application is an open source application intended to be used by AWS engineers, observers and meteorologists to manage AWSs that use RSS2 sensor nodes. Any other sensing application may using RSS2 nodes may use the application. The application shall be based on the ATMEGA128rfr2-based RSS2 node, which was ported to Contiki[2], the embedded operating system. It however may not work for the later versions of the node. The application will be able to capture weather parameters, process them, buffer and transmit them to a remote location, herein referred to as a repository. The application will also provide additional functionalities such as setting the sleep modes, system debugging among others. The free and open source application will be stored in a GitHub repository [4], enabling users to access and modify it where need be.

1.4 Business Case for the Product

In the recent years, WSNs have been used in the implementation of various applications for environmental monitoring. WIMEA-ICT is a project whose aim is to improve weather and Information Management in East Africa using suitable ICTs. In order to achieve one of its objective, that is, designing a robust and affordable AWS based on WSN technology, WIMEA-ICT is proposing to design and implement a free and open source application. Other objectives include improving the weather station network density, better weather information management, better weather information dissemination mechanisms and improving forecast modelling. The project is improving the density of weather stations in Uganda, South Sudan and Tanzania by designing, manufacturing and deploying about 70 AWSs. The AWSs shall automatically transmit the readings to the repository via the Internet.

The RSS2 [3] Wireless Sensor node being a complete and versatile solution, small, flexible and cost-effective, was chosen for the AWS to be designed. The mote has been ported to Contiki operating system, which is free, open source and has a big developer community. The node however runs a proprietary application software, making it hard to customize it for some AWS functions. Additionally, some required functions are completely missing and yet adding them is impossible since the source code is unavailable. More still, using the proprietary software for the mote is likely to increase the cost of the AWS, which is contrary to making the AWS affordable. Given the free and open source platform port, developing a free application shall further lower the cost of producing the AWS.

The aim of the project therefore is to provide an open source RSS2 node application, which will give meteorologists more control by enabling them to modify and reconfigure nodes to suit their requirements whenever they see fit. The application will focus on capturing, processing, buffering weather readings and transmitting them over the network to the repository.

1.5 Overview of the Requirements Document

*WIMEA-ICT RSS2* will carry out the following major functionalities.

1. Capture data: The application will capture environmental data as well as status information of the AWS.
2. Data processing: The environmental data captured by the sensors will be transformed into information that can be understood by the meteorologists, who are the primary users of the application. The application will timestamp the data before transmission.
3. Buffer collected data: After processing, the data shall be temporarily stored on the node until when it is received by the repository.
4. Transmit data through a gateway to a central repository: The application will be used to set data fields to be transmitted, display link quality information and set data transmission intervals.
5. The application will be used for debugging the weather station.

2. General Description

*WIMEA-ICT RSS2* application is a free and open source application for RSS2 nodes used in the implementation of AWS. This application is a cheaper alternative to the proprietary RSS2 node software. It will contribute to the development of AWS in the following ways:

* It will make it easy for AWS programmers and designers to customize these nodes for the AWS functions.
* Lower the costs of producing the AWS.
* Give more control to the meteorologists by making it easy for them to reconfigure the WSN to suit the requirements.

2.1 Product Perspective

*WIMEA-ICT RSS2* is a free and open source application that is intended to substitute the proprietary software currently being used in the RSS2 motes in the AWS. RSS2 motes are responsible for capturing, processing and storing weather data from different sensors before transmitting it to a central repository. Below are the reasons for the need of *WIMEA-ICT RSS2*:-

* The use of the proprietary software for these RSS2 motes is likely to increase the cost of developing the AWS contrary to them being affordable.
* The source code for this proprietary software is hidden, making it hard to customize WSNs that rely of the sensor nodes.

*WIMEA-ICT RSS2* is expected to minimize AWS development costs by eliminating the extra software costs. It will be developed by a team of WIMEA-ICT students. The key stakeholders for the application are the meteorologists services. Other individuals interested in maintaining their own private weather stations shall benefit from the application. Developers who plan on using the RSS2 mote in implementing their applications shall also benefit from the application. WIMEA-ICT will benefit from this free and open source software as it will cut down on the costs of developing the AWS compared to what it would have been with the proprietary software. National Meteorological services shall be able to acquire more affordable AWS. Weather information that shall be obtained from the AWSs will benefit many communities because of its timeliness and accuracy. For example, farmers, fishermen and contractors.

2.2 Product Functions

*WIMEA-ICT RSS2* will perform the following functions:

* Capture weather data for example temperature, pressure and humidity from the different sensors.
* Process captured weather data including sensor signal processing, calculating derived information like dew points, data compression, timestamping and many others.
* Buffer collected data. After processing, the data shall be temporarily stored on the node until when it is received by the repository.
* Transmit timestamped data through a gateway to a central repository
* Provide a configuration menu with which meteorologists and other users can interact.
* In case a new node is added to the AWS, the application shall automatically start communicating with it
* The application shall enable relaying of packets through a given number of hops to the sink
* The application shall enable users to provide aliases for the electrical variables in order to provide meaningful data at the repository

2.3 User Characteristics

* **Meteorologists:** They will use the application to configure and debug the AWS when there is need. They are expected to be computer literate and be able to type simple commands in the terminal. They are also expected to have an understanding of meteorological terms in order to collect, analyze and present information correctly. These users must also know the meteorological terms used by the application.
* **Engineers:** These assist with maintaining and troubleshooting the nodes. They are required to have a background of electricity.

2.4 General Constraints

* The application will be developed based on RSS2 Atmega128rf2 [5] microprocessor-based node. The node has memory of only128KB. The constraint limits the size of the application as it MUST be below 128KB.
* The application will not be compatible with the later versions of this node because of the differences in microprocessors being used.
* For one to configure the node, they must be physically connected to it via a serial USB-TTL cable.
* The application shall run on only Contiki operating system, which runs on a range of low-power wireless devices and provides low-power internet communication.
* Communication between the motes will be wireless. The RSS2 motes communicate using the IEEE802.15.4 [6] protocol and any inter-node communications shall use that standard.

2.5 Assumptions and Dependencies

The following assumptions have been made:

* The application will run on contiki operating system
* The gateway shall be connected to Internet. Other nodes shall not be connected to the Internet
* The version of contiki to be used already has a working driver for RSS2 Mote

3. Specific Requirements

This section of the document lists specific requirements for *WIMEA-ICT RSS2* **application.** Requirements are divided into the following sections:

1. User requirements. These are requirements written from the point of view of end users, usually expressed in narrative form.
2. Reporting requirements.
3. System and Integration requirements. These are detailed specifications describing the functions the system must be capable of doing.
4. Security Requirements
5. User Interface requirements. These are requirements about the user interface, which may be expressed as a list, as a narrative, or as images of screen mock-ups.

3.1 User Requirements

The system shall provide the following user requirements;

* The application shall provide a menu that shall be easy to lean and use
* Consistence shall be maintained when reporting. For example red LEDs shall be used to inform users of unwanted situations in the node

3.2 Reporting Requirements

* The applications shall light the red Light Emitting Diode (LED) to signal possibility of unwanted situations. For example when the node fails to boot
* Green LED shall be used to inform users that everything is okay with the node
* A command line interface shall used to display any debugging information
* Data capture and transmission intervals shall be set by users. A copy of every transmission shall be displayed on a command line interface via serial communication
* All information captured shall be converted to text before being transmitted
* Link status information and sensor data shall be displayed and transmitted to the repository
* Each collected set of data shall be timestamped to establish time it was collected
* Status and specifications of the node shall be provided on request

3.3 System and Integration Requirements

**Capture and format data.**

* The application shall capture data from the different sensors in a WSN. The captured data shall include link quality data or weather data.
* The application shall also format the data, perform sensor signal processing and calculate derived information. For example, dew points.

**Transmit data.**

* The application shall enable sensor nodes to transmit the processed data to a sink node, which shall later transmit it to a central repository.
* The application shall enable transmission of broadcast and multicast messages to the network. The messages shall include network queries and commands from the terminal.
* Nodes shall attach timestamps to the data before transmitting it to other nodes.
* The application shall use serial communication to transmit data.
* The application shall generate and display radio statistics for each transmission.
* The users shall also be able to set the data fields to be transmitted to the central repository based on the requirements of the AWS.

**System debugging:** The application shall make support node debugging at the terminal.

**Data buffering:** The nodes shall buffer collected data before it is transmitted to the sink node, which shall be connected to a gateway device.

3.4 Security Requirements

Since weather information is not confidential information and more so, getting sense out of it requires one to collect over time, we shall no consider any application security measures. Data shall be transmitted without any form of encryption.

Malicious nodes shall not be allowed to join the network. For that reason, any node that attempts to join the network shall be required to be registered with the sink first. Otherwise, it shall neither relay nor transmit to the network nodes.

3.5 User Interface Requirements

Figure 1 WIMEA-ICT RSS2 ApplicationConsole interface showing minutely data captured

Figure 2 Configuring Transmission rate

Figure 3 Menu Items

4. High-Level Technology Architecture

The application is installed on RSS2 sensor nodes that run contiki operating system. They transmit their collected data using IEEE 802.15.4 protocol through a series of relay nodes to the sink node, which transmits it to the repository through a gateway. The sink node is connected to a gateway device, a Raspberry Pi, which is connected to the Internet.

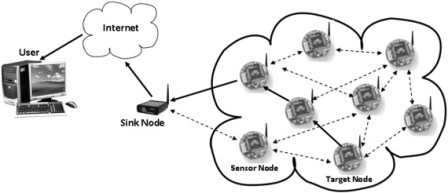
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Figure 4.Wireless sensor network.

5. Customer Support

We shall provide a manual for using the application.

6. Appendices

**6.1 Use Case for Node Configuration**

7. Glossary

Acronyms

*WIMEA-ICT RSS2*WIMEA-ICTFree and Open Source Radio Sensor (RSS2)

**AWS** Automated Weather Station(s)

**WSN** Wireless Sensor Network(s)

**Contiki OS** Contiki Operating system

**References**

[1] “WIMEA-ICT Project.”

[2] “No Title.”

[3] “Radio sensors.”

[4] “WIMEA-ICT Github repository.”

[5] Atmel, “Microcontroller with Low Power Transceiver for ZigBee and ATmega256RFR2 ATmega128RFR2 ATmega64RFR2 1 Pin Configurations,” vol. 3, pp. 1–14, 2011.

[6] LAN/MAN Standards Comitee, *IEEE Standard for Information technology- Telecommunications and information exchange between systems- Local and metropolitan area networks- Specific requirements--Part 15.4: Wireless MAC and PHY Specifications for Low-Rate WPANs*, vol. 2006, no. September. 2006.