EnginuiTech

Simon Fraser University
Burnaby, BC
V5A 1S9
Enginui-Tech@sfu.ca

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Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S9

The attached document, *RAVS Functional Specification*, specifies the operation and requirements of the system. The **Remote Automated Vending Statistics (RAVS) System** is designed to automatically monitor the status of a vending machine and periodically inform the servicer of its status.

The RAVS functional specification outlines the operation of the system as a whole and then discusses the system as two separate functional blocks – the Monitoring Unit and the Host. This document also describes the communications between each of these systems and how the system will react to the given stimuli.

EnginuiTech was founded by Bill Moats, Shane Schneider, Nestor Siu, and Brad Oldham – four creative and dedicated third year engineering students. We would be happy to answer any questions or concerns you may have regarding our functional specification. I can be contacted via e-mail at wmoats@sfu.ca or by phone at (604) 534-1584.

Sincerely,

Bill Moats, Team Manager
EnginuiTech

Enclosure: *RAVS Functional Specification*

EnginuiTech

RAVS Functional Specification

Submitted by EnginuiTech

Contact Bill Moats
School of Engineering Science
Simon Fraser University
wmoats@sfu.ca

Submitted to Andrew Rawicz
School of Engineering Science
Simon Fraser University

Steve Whitmore
School of Engineering Science
Simon Fraser University

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Executive Summary

It seems as though everywhere you look there is a vending machine selling everything from drinks to sandwiches. These vending machines require constant filling and maintenance and are routinely empty of product for a substantial amount of time causing the machines to be abused. For example, think how many times you have seen someone hammering on a pop machine because it ate their quarter or does not have the drink they want. Valuable time and money is also wasted by suppliers having to routinely check vending machines although they are not empty.

To remedy this problem, EnginuiTech is developing the Remote Automated Vending Statistics (RAVS) System. This system will monitor the status of a single or a group of pop vending machines and report necessary information to the service personnel. The system will also generate sales statistics, which can be used to determine peak usage times and product approval.

This document introduces and defines the various functions of the RAVS System and its sub-components.

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1. Introduction

How many times have you reached to put your money in a vending machine and noticed the sold-out light is on for the product you want? Public areas are becoming filled with vending machines of all descriptions, which require a considerably large amount of time to constantly monitor and fill.

This document specifies the functional operation of the Remote Automated Vending Statistics (RAVS) System, which will automatically monitor the status of the vending machine and report this information to the service personnel.

The primary purpose of this project is to prove the concept is feasible by developing a prototype system on one pop machine and one host computer. It is the intention of EnginuiTech to develop a potentially marketable prototype system that is flexible enough to be implemented with multiple vending machines of all types in the future (with minor modifiactions).

2. System Overview

The RAVS system will monitor desired characteristics of a pop vending machine. The information on the characteristics will be then transmitted to the host where it will be manipulated, stored, and reported.

The system has two functional blocks, the Monitoring Unit (MU) and the Host (see Figure 1). The monitoring unit is defined as the portion of the system that exists inside the pop machine and the Host resides outside of the machine. There is a data connection between the MU and the Host that will be used to communicate the information to and from the pop machine.

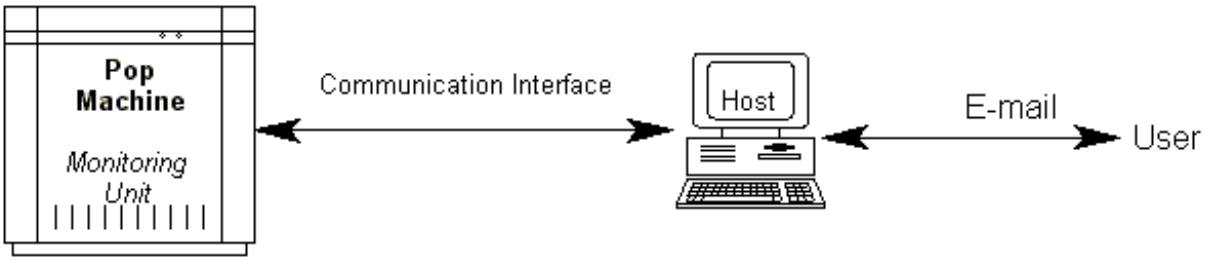

Figure 1: RAVS System Overview

The MU is responsible for monitoring the pop machine's parameters of interest and communicating this information at predefined times to the host system. The host system is responsible for receiving and storing the information from the MUs and generating e-mails to communicate the most important information to the user. The functional details of these systems are discussed in the following sections.

3. The RAVS System Functional Specification

The Remote Automated Vending Statistics (RAVS) System monitors the status and records statistical information of a pop machine. It consists of two functional blocks: a Monitoring Unit (MU), and a Host. The RAVS System will be able to report the following information to the user:

- the quantity of pop in the vending machine (qualitative measure)
- the temperature of the interior of the pop machine where the product is stored
- the selections made by customers and time the selections were made
- if the machine has been vandalized (tipped)

The system will report statistical information at discrete time intervals or on request of the user. The system will immediately alert the user to problems (alarms) such as the interior temperature of the pop machine exceeding the allowable range, any bin of the machine falling below a programmed level, or if it senses that the machine has been tipped. The reporting scheme is specified in Section 3.1.3. The host system will generate e-mail messages to report the information collected by the RAVS system under conditions described in Section 3.2.3.

3.1 Monitoring Unit

The Monitoring Unit (MU) is defined as the portion of the RAVS system contained within the vending machine. The MU is responsible for acquiring the data from the vending machine, temporarily storing this data, and communicating this information to the host for transmittal to the user. Figure 2 shows a high level overview of the monitoring unit subsystems – which are described in later sections.

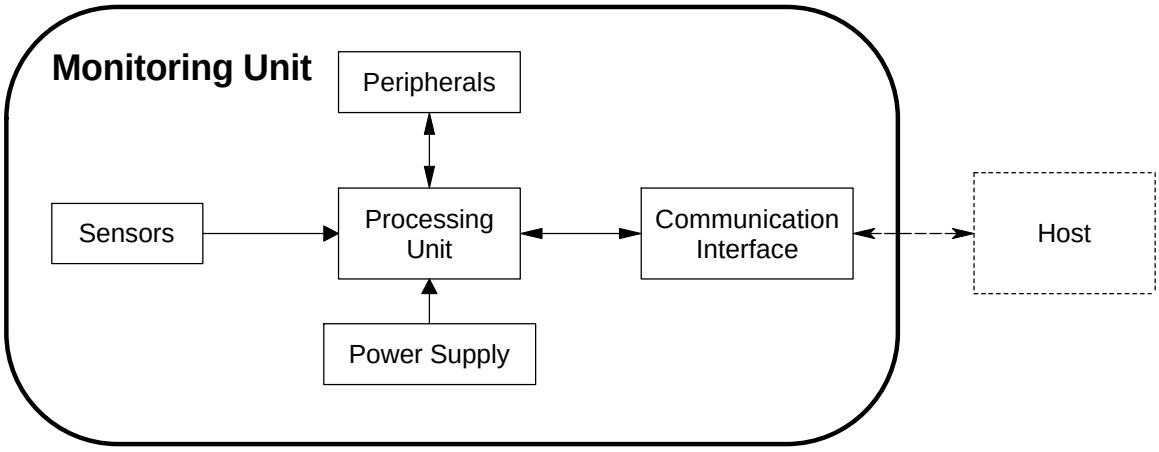

Figure 2: Monitoring Unit Overview

The monitoring system will have a power switch located on the casing and an LED indicator indicating that the unit is powered.

One or more LEDs will be used to indicate the following:

- an alarm condition has occurred
- door is open (sensors are deactivated)
- communications with host established

Aside from the power switch on the MU, all other configurations can only be modified by the Host.

3.1.1 Sensors

The MU will be equipped with sensors to acquire the following information:

- the quantity of pop in each bin of the vending machine
- the temperature of the interior of the pop machine where the product is stored
- if the pop machine has been tipped
- the selections made by customers
- if the door of the pop machine is open

These sensors are shown graphically in Figure 3.

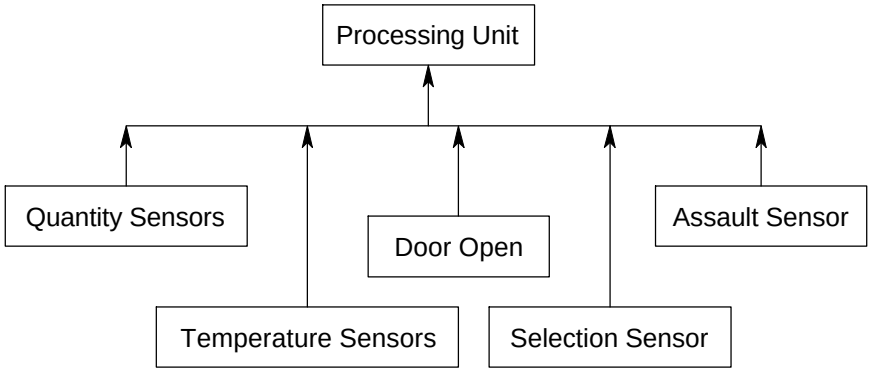

Figure 3: Sensor Array Overview

The quantity of pop in each bin will be measured qualitatively (discretely) indicating the approximate percentage of product in each bin. The MU will only monitor a maximum of 16 bins, with each bin having a minimum of two sensors (which would indicate empty and half full).

The temperature of the interior of the pop machine will be able to measure from –10°C to 50°C with an accuracy of ±5°C.

A sensor will be incorporated into the design to determine if the pop machine is displaced by more than 30° from vertical, which will be used to indicate that vandals have tipped the vending machine.

All sensors will be implemented in a non-destructive manner such that no existing systems on the vending machine need permanent modifications to install the MU. Such modifications include (but are not limited to) drilling holes, cutting wires, and any alteration of the internal structures or operating conditions of the vending machine.

3.1.2 Processing Unit

The processing unit is a micro-controller based system responsible for retrieving and processing the sensor signals (Section 3.1.1), temporarily storing sensor data and event times, generating alarm conditions, and communicating with the host.

The processing unit will have access to a data storage system and a real time clock.

3.1.2.1 Data Storage

The processing unit will maintain a log of customer selections (which bin the product was vended from and the time the purchase occurred). After the information is transmitted to the host the entire log is cleared. The processing unit will also store (and periodically update) the current interior temperature of the pop machine, if the pop machine is tipped, and the current quantity of pop in each bin.

The processing unit will be capable of storing a minimum of 200 customer selections and times.

If the storage capabilities of the processing unit are exceeded before a scheduled communication or request from the host, the processing unit will immediately transmit the data to the host.

The processing unit will also store configuration parameters in a non-volatile data storage system such that they will not be lost in event of a power failure. These configuration parameters are defined in Section 3.1.2.2.

3.1.2.2 System Configuration

The monitoring system stores the following configuration parameters:

- level of pop at which alarm is triggered
- time interval and offset between reports to the host
- maximum allowable interior temperature
- minimum allowable interior temperature
- which alarms on/off
- Monitoring Unit ID

Each of these parameters can be modified remotely by the host.

3.1.3 Communications with the Host

The MU will report information to the host under the following possible situations:

- a programmable time interval has expired
- an alarm condition has occurred
- the host has requested data

Table 1 lists the conditions and information reported by the MU to the host.

Table 1: Monitoring Unit to Host Communications

Condition	Information Reported to Host
Internal temperature is out of acceptable range	Current Temperature Current time
Pop level is below specified limit	Bin number Current quantity of pop in that bin Current time
Pop machine is tipped	Pop machine tipped Current time
Time Interval Expired	Selection and time data log Current Temperature Current Time
Host Request	Configuration Settings Current Time Current temperature Selection and time data log

More detailed description of the communication commands is described in Section 3.2.1. The MU will respond to a request by the host within 10 seconds of the receipt of the request.

3.1.4 Physical Requirements

The MU will be enclosed in a rigid casing able to be mounted on the interior of a pop machine. The case will be made of a conductive material such that it will provide some magnetic shielding for the internal circuitry. The casing will be able to prevent moisture or frost from damaging the internal circuitry. The casing will conform to the physical specifications listed in
Table 2.

Table 2: Monitoring Unit Physical Requirements

Length	40cm Maximum
Width	30cm Maximum
Height	10cm Maximum
Weight	1.5Kg Maximum

3.1.5 Environmental Requirements

The MU will function under the environmental conditions listed in Table 3.

Table 3: Monitoring Unit Environmental Requirements

Operating Temperature Range	-10°C to 50°C
Shipping Temperature Range	-10°C to 50°C
Humidity	Full range of atmospherically humidity
Heat Dissipation	Minimal

3.1.6 Electrical Requirements

The MU will require an input voltage supply of 115V AC at 60Hz line frequency and will not dissipate more than 10 watts of power.

3.2 Host

The host will be primarily responsible for receiving and processing data from the MU, generating e-mail communications with the user, and implementing the user interface to the RAVS System.

The host will meet the following requirements:

- be a 386 PC or better with minimum 4Mb of RAM
- communicate with the user autonomously via e-mail
- remotely configure the MU
- provide GUI based interface for the user
- access the Internet or LAN (using TCP/IP)
- communicate to the MU via serial link at a minimum of 9600 bps

The future concept of the RAVS System is to consists of one host managing many MUs. However, for the purposes of this project, the system will be implemented using only one host and one MU.

3.2.1 Communications with Monitoring Unit

The host will be responsible for handling all MU communications described in Section 3.1.3. The host will also be responsible for generating data requests to the MU when asked by the user.

Communications will be implemented by means of a handshake method through the use of string delimited commands. Each command sent by one device, will be implemented and acknowledged by the other before the next command is sent. Table 4 gives a summary of the commands and responses available to the host and the MU.

Table 4: Available commands and responses for the Host and MU

Commands sent by Host to MU	Replies sent by MU to Host
report / set current time	reply with current time
report / set reporting interval/offset	reply current reporting interval/offset
report current sensor value	reply with sensor value
report data log	reply with data log
report / set configuration field	reply current config. field
report ID	reply with ID
start communication with MU	communication established
end communication	communication ended
do software reset	—-
Commands sent by MU to Host	**Replies sent by Host to MU**
start data log report session	ready to receive data log
send alarm condition	--
system rebooted	--
start communication from MU *ID*	communication with *ID* established
end communication	communication ended
Common Commands and Responses	
acknowledged last message	
last message bad, please resend	
general error message	

3.2.2 Data storage and manipulation

The host will be responsible for:

- handling the communications scheme described in sections 3.1.3 and 3.2.1
- storing all data received from monitoring units
- generating a delimited text log file easily importable to an analysis package (ie. Excel) on a local storage device
- e-mailing the log file at the users request
- e-mailing alarm triggered reports

It is up to the user to interpret and graph the data from the log file as desired.

3.2.3 User Interface

The user interfaces with the host in two different ways: terminal and remote.

Terminal mode involves the user interfacing with the host directly using GUI based software. From the terminal, the user can manually send any of the commands given in section 3.2.1 to configure the MU, or locally configure the host with any of the following options:

- specify the e-mail address to send the reports
- configure the types of reports to be generated (end of the day, assault in progress, low stock, MU rebooted, temperature out of range, general error codes).
- settings for the delimited text log file

Remote mode involves the automatic generation of e-mail reports by the host and sent to the user at a specified e-mail address. These e-mail messages can then be used to automatically generate a page to the distributor.

4. Cost

The cost of manufacturing a MU for a vendor will remain below 5% of the price of a new pop machine. On average the 5% limit places us with a manufacturing cost below $150 which will appeal to a vendor. The host's computer and network setup will be the responsibility of the owner to supply, but the host's software will be included in the price of the MU.

5. Test Method

The purpose of the test method is to verify the system meets the specifications listed in this document. The MU and the Host will be modular in design and allow for separate testing procedures. Once both the MU and the host have been fully verified, the two will be tested as a complete system. The tests for each unit and the completed system are listed below.

5.1 MU Testing

The MU will be tested to verify the functionality of the following:

- Sensors – quantitative, temperature, selection, assault, and door
- Brownout Recovery – test MU response, verify MU can restart its software
- Blackout Recovery – test MU response, verify MU can restart its software
- Data Manipulation – passing information into MU and validation correct storage of data
- Serial Communications – verify appropriate responses to each transmitted command

5.2 Host Testing

The Host will be tested to verify the functionality of the following:

- Serial Communications – dummy terminal talking with host transmitting appropriate commands and responses to requests
- GUI Interface – verify clarity and usability
- File Creation – verify creation of delimited file from data received
- Reporting – verify e-mail reports are generated

5.3 RAVS System Testing

A complete RAVS system will be connected (verified MU and Host) and the following tests will be implemented:

- Communication Establishment – verify that Host and MU can establish communications and exchange commands and responses
- Reporting – verify each of the three reporting conditions establish a connection and exchange the data
- Field Testing (Pilot Site) – place system in an existing pop machine and allow it to collect the information

6. Upgradablity and Future Implementation

The RAVS System can be eventually used for wide spread monitoring of several different vending machines. However, for proof of concept for this project, the system will be implemented on one MU and pop machine communicating with one host. This communication interface will be carried out via a permanent serial cable connecting the MU with the host. For the future wide spread networking, the serial characteristic of the communications can be implemented via any serial medium, including Satellite, modem, router, and Ethernet based networks. The language the MU and host will use to communicate would be as if they were connected directly. The MU and the Host will remain communicating as if they were still connected via the serial cable despite the change in medium.

7. Conclusion

This document has discussed the functional operation of the RAVS System designed to monitor the status of a pop vending machine. A working prototype will be built based on the functional specifications described in this document. This prototype will prove the concept is feasible and serve as a demonstration tool for marketing. By building a RAVS system, service providers will be allowed to monitor the status of their pop machines and collect valuable statistics which can be used to determine product approval and ultimately save time and money.