York University

Faculty of Science and Engineering

ENG 4000

Engineering Project

Specification And Milestones

Report

TABLE OF CONTENTS

WIRELESS DETECTION AND RANGING

(WIDAR)

Team Members and Area of Focus

Members:

Hamdi Roumani
Team Leader
taal@yorku.ca
Focus: *Responsible for comparing and evaluating candidate wireless sensor network kits based on a criterion stated in the "Short Project Description". Once this decision is taken this member will work along side Douglas Stamp on the communication between the wireless sensor nodes. The project leader will act as a liaison between the WIDAR team and the advisor.*

Patrick Tayao
patrick.tayao@percepta-crm.com
Focus: *Researching alternative methods of interfacing a mobile robot with wireless sensor nodes.*

Douglas Stamp
dstamp@yorku.ca
Focus: *Website design and maintenance. Researching communication methods between wireless sensor nodes.*

Tyson J Hamilton
tyson@yorku.ca
Focus: *Website design and maintenance. Researching communication between wireless sensor nodes and the mobile robot (Working along side Patrick Tayao).*

Faculty Advisor

Professor Natalija Vlajic
Department of Computer Science and Engineering
vlajic@cse.yorku.ca
416-736-2100 x 77878

Project Description

Wireless Sensor Networks (WSN) is a fast growing technology for developing systems to monitor a variety of constrained environments. These environments can be vastly different, from a manufacturing plant to a remote location in the rainforest. Wireless sensor networks consist of two major components: nodes and a base station. Nodes are low power consuming devices that are integrated with different data feeds to monitor a situation. These feeds may contain environment sensors or, for example, video feed from different nodes. The information gathered by different nodes is then transmitted from one to another using peer-to-peer protocols. The responsibility of the base station is to provide a powerful communication device to relay information from different nodes to the end user.

A problem arises when a node or group of nodes fail and break the communication within a sub network of the wireless sensor nodes, producing two fully operational groups of nodes that cannot establish a communication link between one another. Since the base station has a connection to only one of the groups, the other will not be able to establish any communication with it, thus hindering any data transfer.

A viable solution to this problem is to introduce into the network a mobile node which will act as a communication bridge between the two independent groups of nodes. A challenging task in the implementation of this solution is the localization of nodes to ensure proper placement of the mobile robot. Since nodes are scattered in different geographical locations the localization process is difficult.

To simulate the aforementioned problem, the project will implement two groups of nodes. A video feed will be recorded by a camera attached to a node in one group and transmit the video feed to the other group where the base station exists, hence allowing communication to an end user application. Without any information on the location of the nodes, the mobile robot will run a positioning algorithm that will search for the communicational gap. It will then find the optimal position within the network to bridge this gap so to resume transmission from one group to the other. To ensure the correctness of the positioning algorithm, different gap scenarios will be implemented.

Implementing the solution to the problem stated above will be the defining goal of this project. There are many possible expansions that will be considered as the project progresses. Although there is an abundant amount of theoretical material available in this research field, there is a lack of experimental / empirical data. Therefore, there will be different testing phases that will provide useful data for analysis in the design of our project. Possible expansions to the project include the implementation of mobile nodes opposed to static ones. To further elaborate, the gap between the groups of nodes will still exist, the nodes themselves, however, will be able to move apart implying an algorithm to bridge the gap will need to dynamically execute.

MILESTONES

Project phases include the Project Definition, Research, Implementation, Testing, Integration, Finalization and Presentation. The organization of these phases is displayed graphically in the Gantt chart on our project website online for easy viewing:

http://www.cse.yorku.ca/~cs232039/eng4000/ToDoList/milestones.htm

Project Definition

- Development of contract proposal

MOBILE ROBOT

Research

- Search for feasibility of acquiring or building mobile robot.
- Determine Hardware Requirements.
- Determine Interfacing Options.
- Determine Algorithm requirements.
- Determine Mobility control.
- Determine Energy Requirements.
- Selection of Mobile Robot

Implementation

- Robot Construction
- Algorithms development:
  - Robot Localization.
  - Movement.
  - Connection Strength Management.
  - Power Management.
  - Signal processing.
- Interface support.

Testing

- Algorithm Testing
- Bug Fixing

Wireless Sensor Network Mote

Research

- Research and selection of WSN kit.
- Acquisition of WSN kit.
- Determination of Communication between nodes.
- Acquire online docs and materials for developing WSN.
- Determination of sensor devices to attach to nodes.
- Determination of sensors to attach to nodes.
- Determination of specifications of sensor devices and sensor nodes.

Implementation

- Develop code for WSN communication.
- Develop code for transfer of information between nodes.

Testing

- Test communication within several WSN.
- Fix any bugs determined.

Integrated System (mobile robot and wireless sensor network mote)

Integration

- Develop code for synchronization between mobile robot and WSN.
- Develop code in the mobile robot to communicate with wireless sensor nodes.
- Develop code in the mobile robot for gap determination.
- Develop code in the mobile robot for localization.

Testing 2

- Test integrated system with different gap scenarios.
- Fix any bugs determined.

Finalization

- Onsite testing and ensure system is implemented in area of presentation.

Presentation

- Produce posters for final presentation.
- Develop a video presentation.

BUDGET

WIRELESS SENSOR NETWORK

Item: ScatterWeb Wireless Sensor Nodes (Starter kit research line)
Price: $1,376.96 (97O EUR)
Link:
Description: The components in this kit include:

- 4 full-featured Embedded Sensor Board (ESB) sensor nodes
- 1 eGate/USB gateway
- 1 JTAG flash adapter
- 2 EYE camera modules

This research kit includes all of the equipment required to test and develop the wireless sensor network.

Although this kit is priced higher then our total budget, our advisor has offered to purchase the kit for us (She will retain rights to the kit after the project has finished)

This kit contains all the equipment we need to test and develop a wireless sensor network. Although we are unlikely to require additional purchases, the following may be considered (They would be used to extend our project, time and budget permitting):

Item: Camera Module (for ESB)
Price: $126.32 (89.00 EUR)
Link: http://www.scatterweb.net/

Item: eGate/Web
Price: $282.40 (199.00 EUR)
Link: http://www.scatterweb.net/
Description: Provides a method of connecting the ScatterWeb to the base station.

We will also require a host computer (base station) so that we can interface with the wireless sensor network. We do not need to allocate any budget for this item as a few group members have laptops that we can use for the base station.

Finally, we will allocate a limited budget for unforeseen items pertaining to the wireless sensor network. This will, if necessary, most likely be used for extra caballing.

Item: unforeseen items (e.g. cabling)
Price: $50.00

MOBILE ROBOT

Item:	HCS12: Dragon12 Development Board
Price:	$139.00 (or possibly rented from York University)
Link:	http://www.evbplus.com/dragon12.html
Description:	The development board will be the main processing component of the mobile robot. It will be responsible for controlling motion, and signal processing.

Item:	Planetary Gear Motor (2)
Price:	$80.00
Link	http://www.lynxmotion.com/Product.aspx?productID=515&CategoryID=71
Description:	These motors will be used to drive the wheels. They operate at 12V(dc) and can do 65RMP providing 28.00Kg-cm torque.

Item:	Mounting Bracket and Chassis
Price:	$50.00
Description:	The mounting bracket will house the Dragon12 and be attached to the chassis to combine the remaining physical components of the robot. A light alloy will be used to create both the brackets and chassis.

Item:	Motor Mount
Price:	$10.00
Link:	http://www.lynxmotion.com/Product.aspx?productID=104&CategoryID=42

Item:	Molded Urethane Tires
Price:	$25.00
Link:	http://www.lynxmotion.com/Product.aspx?productID=372&CategoryID=39

Item:	Wheel Hubs
Price:	$10.00
Link:	*http://www.lynxmotion.com/Product.aspx?productID=114&CategoryID=42*

EXTRA COMPONENTS

Item:	Lab time
Price:	$300 @ $10/hr (estimate)
Description:	This lab time will be used for developing software.

Item:	I2C Cable
Price:	$5.00
Description:	This cable will be required for data transfer between the ESB and Dragon12.

Item: *Host Computer (base station)*
Price: $0.00 – use of team member computer

Item: Extra hardware (cabling, tape, tools, etc.)
Price: $50.00 (estimate)

TOTAL BUDGET

The cumulative hard cost (i.e. the mandatory expenditure)

$350

The remaining budget is preliminary and may not be spent. We will allocate the following cost for the final presentation (This will include the cost of the presentation board that we will require):

$200

Technical Specifications

(***Please refer to diagram at the end of this report for an overview of the system)***

System Operation

A wireless sensor network will be set up with two fully operational groups of nodes that cannot establish a communication link between each other. A mobile robot, with an embedded sensor board integrated to it, will bridge this gap and allow both groups to communicate. To demonstrate this system on a scale suitable for the presentation, the communication range of each ESB will be lowered.

We have divided our project into two separate groups. This way, we can divide our group into two teams and work on both the parts independently. The two groups are the "Wireless Sensor Network" aspect and the "Mobile Robot" aspect.

Wireless Sensor Network Specifications

Introduction

The system will require a fully operational wireless sensor network to function. The WSN will be responsible for transferring all information between the nodes and will also demonstrate the fundamental properties involved in a WSN.

Through extensive research, ScatterWeb's "starter kit research line" has been selected as the solution for our WSN system. The many alternatives provided lots of different advantages however the ScatterWeb was picked for its high-level implementation and ease of use.

Techincal terms / Glossary (ScatterWeb's system)

ESB (Embedded Sensor Board):
These are the nodes of the wireless sensor network system. Usually, they perform some environment specific operation (i.e. light sensor, video recorder)
NOTE: This task does not need to be limited to sensing. For example, a node may start or stop a process depending on some onboard timer.

Base Station:
A computer which may have network accessibility. All information from the WSN system is sent to the base station, it can then proceed to process the information.

Scatter Flasher (eGate):
This item allows a base station to interface with the WSN.

Input / Output

Similar to most WSN the system will perform an environment specific task. A single node in the group will be fastened with a camera to record the surroundings. The input of the system will be the video recorded, transmitting through the WSN to the base station. The output of the system will be the GUI display on the base station of the data recorded. Initially the base station will not receive the data because a gap will be present, however the mobile robot will be used to bridge this gap and allow a flow of data from the input node, to the base station.

User Interface

The user interface will allow monitoring capabilities such as viewing the video data transferred and if time permits the signal strength of the received signal. A module to estimate the location of the mobile robot, and network gap may also be developed.

Testing

The WSN will be initially tested without any gaps in the communication link. This will be accomplished by ensuring connectivity between individual nodes and transferring data from one end of the network, to the other. This will involve sending simple messages, then upon success transferring the data. Running in parallel with these tests, the software GUI will also be tested for completeness and correctness.

Mobile Robot

Introduction

The mobile robot will be required to autonomously locate and bridge a gap between two non-connected wireless sensor networks (WSN). The robot will be in contact with the WSN that is connected to the base station and be expected to locate the optimal position to connect to the remaining WSN group that is collecting information via the sensors.

The mobile robot will be constructed using the HCS12: Dragon12 Development board for movement and signal processing. The HCS12 will control each wheel separately by driving the voltage output to the motors. Information will be transferred from the ESB to the HCS12 through an I2C cable before being processed. The chassis of the robot will be constructed in the machining laboratory at York University with the motor mounts and wheel hubs.

The HCS12 will require several algorithms for processing data and moving the robot. These include signal strength analysis, robot movement based on this data and an algorithm that can determine the location of the gap in the network. The Codewarrior software will be used for the development process.

Testing

Testing will be broken down into robot motion, and signal processing separately. Once these two elements are tested thoroughly and ensured to be correct they will be tested together. Testing the motion of the robot will involve ensuring accurate movement based on the output of the HCS12 to each motor separately. This includes displacement, angles of rotation and error analysis.

Alternating the signal strength of the ESBs and noting the response of the HCS12 debugging software that will be developed to test accuracy will allow a proper analysis of the signal processing.

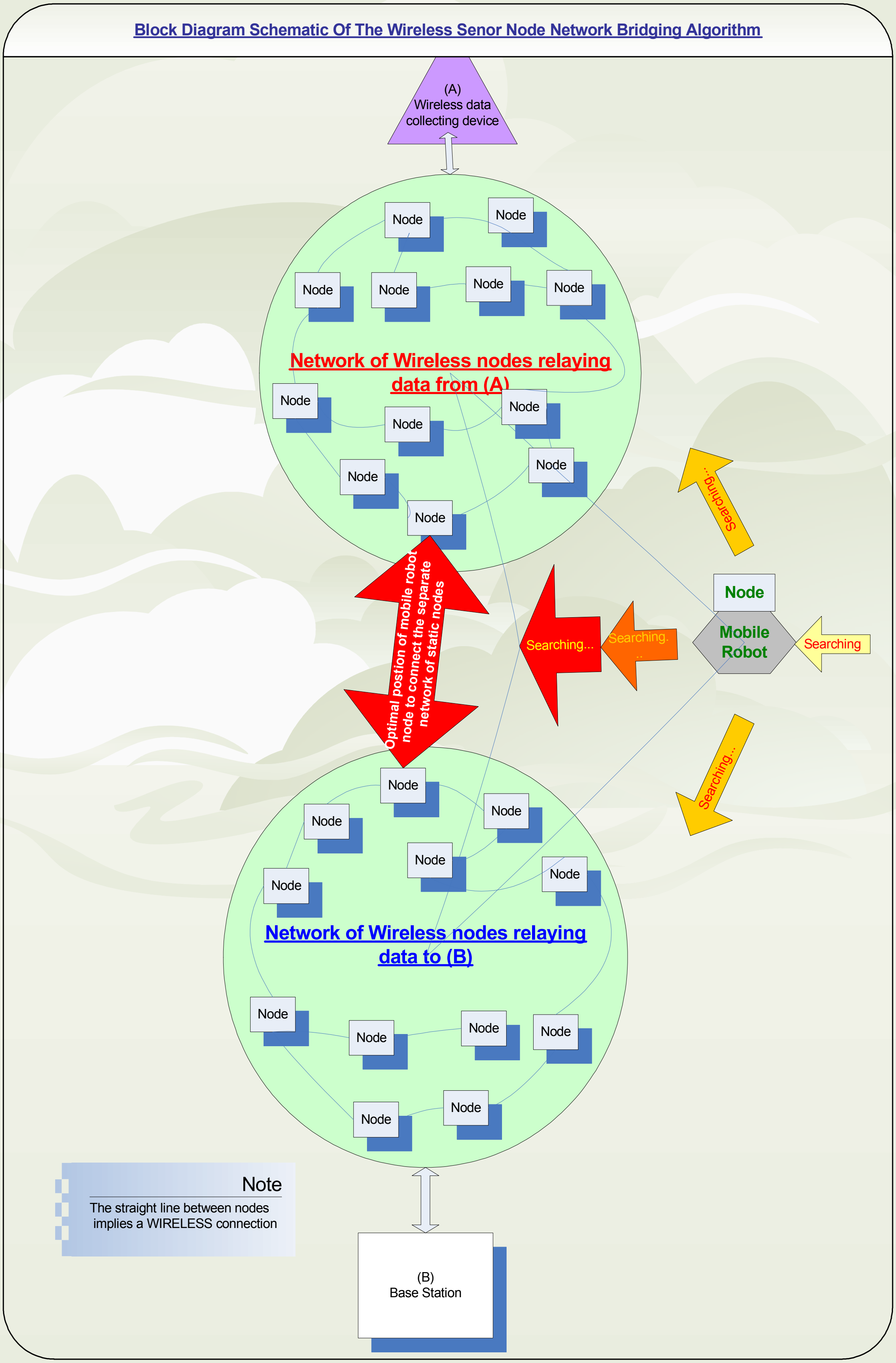
Once these two phases are complete, using the signal processing to analyze the data and autonomously move the robot to the optimal position to bridge the gap will be tested. This will ensure the interfacing between the two software elements, and the hardware is seamless and works correctly.

Input / Output

The robot essentially acts as an intelligent mobile node, thus has many similarities to the input and output of an ESB in the wireless sensor network. The way the robot analyzes and responds to the input received is what differentiates it from a regular ESB. The output of the robot will be almost identical to that of an ESB however, there has been consideration of adding extra data from the mobile robot to inform the base station of the current location of both the robot and the gap in the network.

Deliverables

The project will deliver two systems, a wireless sensor network and a mobile robot. The sensor network will be configured to communicate and transfer information from one end of the network to the other. A mobile robot will be equipped with a wireless sensor communication device to communicate with other sensor nodes and will be configured to determine gaps within the sensor network. When a gap is determined, the mobile robot will be configured to move to an optimal position to bridge this gap and ensure communication between the independent groups of nodes.



Block Diagram Schematic Of The Wireless Senor Node Network Bridging Algorithm
(A)
Wireless data collecting device
Node
Network of Wireless nodes relaying data from (A)
Optimal postion of mobile robot node to connect the separate network of static nodes
Searching...
Searching...
Searching...
Searching
Node
Mobile Robot
Network of Wireless nodes relaying data to (B)
Note
The straight line between nodes implies a WIRELESS connection
(B)
Base Station