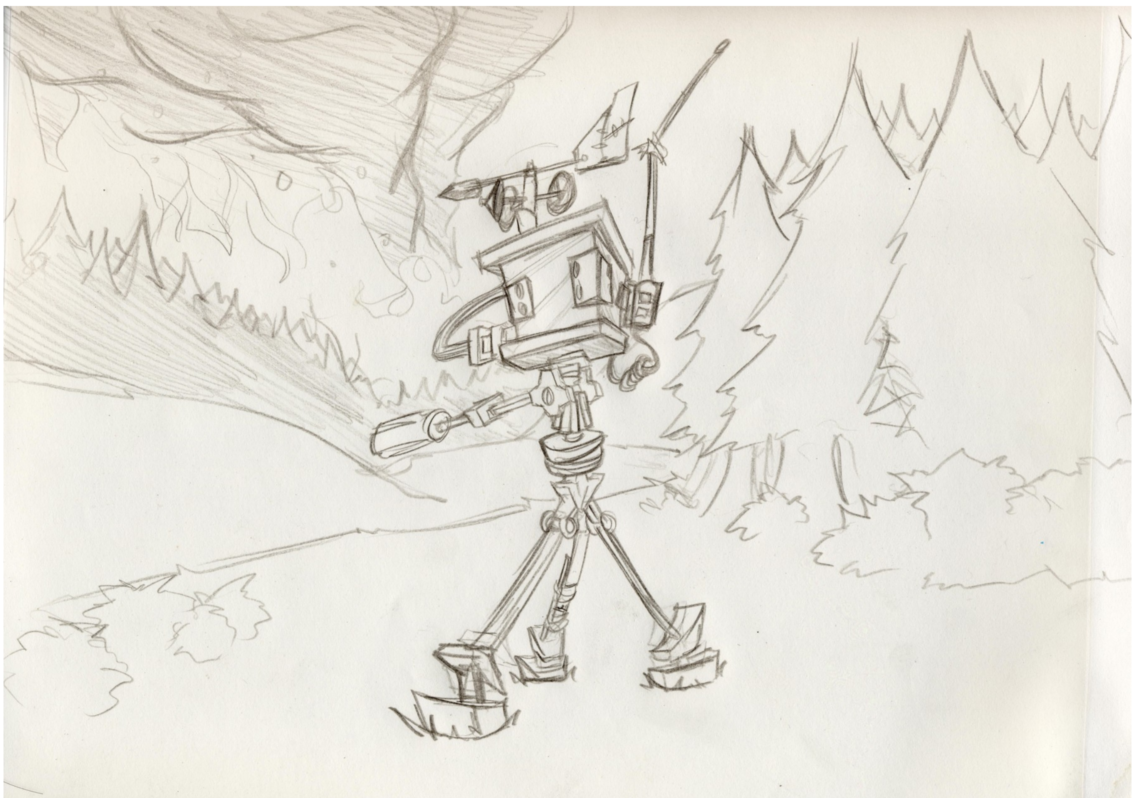
A.M.E.N.

Autonomous Meteorological Embedded Network for Fire Fighters



By

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We, the senior design class for Fall 2008 - Winter 2009, are excited to begin work on a project we call A.M.E.N.
One of our main motivators to take on this project was the ability to build a product that is practical and applicable in the real world.

As it is well-known to our professors and classmates, the project consists of improving the current procedure fire fighters use to measure meteorological conditions around a fire in order to help predict the fire's path. Instead of using archaic methods that require manual labor and a significant amount of time that the fire fighters could be putting to better use, our project will automatically take meteorological condition measurements at a specified interval and relay that data to the fire fighter's computer.

Our minimum requirements project consists of building two devices (nodes). One of these devices, the field node, will be placed near an actual fire, and the other, the laptop node, will be connected to laptop in the fire engine cabin. These two nodes will communicate wirelessly over a 900MHz radio frequency. The field node will data such as temperature, humidity, wind velocity and direction, and GPS coordinates. Once the laptop node obtains this data it will transfer it to the laptop via USB interface, where it will be displayed on a user friendly interface that we will provide.

The field node is likely to be mounted on a tripod that has a built-in level. Leveling out the device is required because the vane of the wind sensor must be parallel to the ground in order to obtain a proper reading. Hence, during physical setup the fire fighters will have to make sure that the device is level. That said it is our goal to make this device as simple-to-use to as possible; requiring minimal human intervention. Thus why, there will be a built-in compass that will be used to calculate which direction the node is facing.

The above mentioned information will be our minimum requirements for the project. Ultimately we would like to upload this information to a web database and from there have it display on a Google Maps interface. If time permits, we would also like to build multiple field nodes that relay information through one another in a mesh network allowing distant field nodes not in range of a laptop node to transmit information through the network to the laptop node. This will enable the firefighting crew to obtain a comprehensive understanding of the fires possible future behavior.

A detailed look inside the field node reveals four separate sensors (Figure 1): wind speed and direction, GPS (Figure 5), compass (Figure 6), and temperature/humidity (Figure 7). These sensors connect to a microcontroller using several different interfaces (analog, UART, and I^2C). Wind speed and direction are both analog outputs; one voltage, the other frequency. The rest of the signals will all be digital. After much research and deliberation we have decided that, for our prototype, only the temperature/humidity sensor will be replaceable as it is the one that has a much shorter life-span than all the other sensors.

Once data is obtained by the sensors, it is sent to the microcontroller. It is the microcontrollers job to convert the data, if need be (analog-to-digital), translate the raw data into correct barometric units and send that data out a UART to the transceiver. The microcontroller will be a Cypress CY8C29x66 (either CY8C29466 or CY8C29566), and it will be programmed using Cypress' PSoC Designer and Programmer. Refer to Figure 2 for the basic electrical specifications.

The last device featured in the field node is the 900MHz wireless transceiver. This device will receive data from the microcontroller, pack it up into packets, and send it wirelessly to an identical transceiver on the laptop node.

Once received on the laptop node, the data is sent to the laptop via USB. On the laptop there will be a program running that captures the data, stores it, and displays it into some sort of user-friendly interface to be written by us in C.

Providing the proper power supply to all components will be one of our main challenges. Most of our components operate at around 3.3 volts, so it is our hope that when we begin to test our sensors, all of them will operate properly at that voltage. For now it appears that none of the signals will have to be amplified, but this is something that we will have to work out through testing, since the Wind sensor lacks a comprehensive datasheet. It is certain though, that a linear voltage regulator will be used because we will be working with low noise signals and also because it will be good on power efficiency.

Our funding is mostly generated through our relative colleges at UCSC. We have received help through to other outside sources, one will be providing cash, and the other will provide acrylic material that will be used to make the enclosure for the field node. As a team we also plan on providing out-of-pocket contributions if necessary.

The delegation of work has been well distributed. Here is a short breakdown for each individual:

Dmitry: Will be in charge of programming the microcontroller to have an interrupt-driven system. He along with Fan, will be responsible for getting all of the sensors to be able to communicate with the microcontroller and will be in charge of the antenna design.

Fan: Will be in charge of the interfaces between the wind sensor, and the humidity/temp sensor with the microcontroller, sensor calibrations, detachable sensor board, and user program on laptop.

Flavio: Will be in charge of most of the data keeping, documentation, and literary tasks. He is also in charge of overseeing proper power distribution to all components and will design the circuit board by use of OrCAD. He will mostly design and build the acrylic device that will encompass the field node.

Brian: He will be responsible for the networking components of the project, both those between nodes and any internet database connections. He will also be responsible for

USB driver implementation to deliver information from network the User Interface on laptop. He is also the nominated leadership for the group and will be insuring that the group meets its deadlines and providing help where needed to all other areas of the project.

Everyone: will have a part in testing devices, design of the enclosure, assembly of the final sensor node. We will all be responsible for keeping good engineering notes.

Figure 1: Sensors

Symbol	Description	Min	Typ	Max	Units	Notes
Vdd	Supply Voltage	3.00	–	5.25	V	See DC POR and LVD specifications, Table 3-15 on page 27.
I_{DD}	Supply Current	–	8	14	mA	Conditions are 5.0V, T_A = 25 °C, CPU = 3 MHz, SYSCLK doubler disabled, VC1 = 1.5 MHz, VC2 = 93.75 kHz, VC3 = 0.366 kHz.
I_{DD3}	Supply Current	–	5	9	mA	Conditions are Vdd = 3.3V, T_A = 25 °C, CPU = 3 MHz, SYSCLK doubler disabled, VC1 = 1.5 MHz, VC2 = 93.75 kHz, VC3 = 0.366 kHz.
V_{OH}	High Output Level	Vdd - 1.0	–	–	V	IOH = 10 mA, Vdd = 4.75 to 5.25V (8 total loads, 4 on even port pins (for example, P0[2], P1[4]), 4 on odd port pins (for example, P0[3], P1[5])). 80 mA maximum combined IOH budget.
V_{OL}	Low Output Level	–	–	0.75	V	IOL = 25 mA, Vdd = 4.75 to 5.25V (8 total loads, 4 on even port pins (for example, P0[2], P1[4]), 4 on odd port pins (for example, P0[3], P1[5])). 150 mA maximum combined IOL budget.
V_{IL}	Input Low Level	–	–	0.8	V	Vdd = 3.0 to 5.25.
V_{IH}	Input High Level	2.1	–		V	Vdd = 3.0 to 5.25.

Figure 2: Microcontroller Electrical Specs

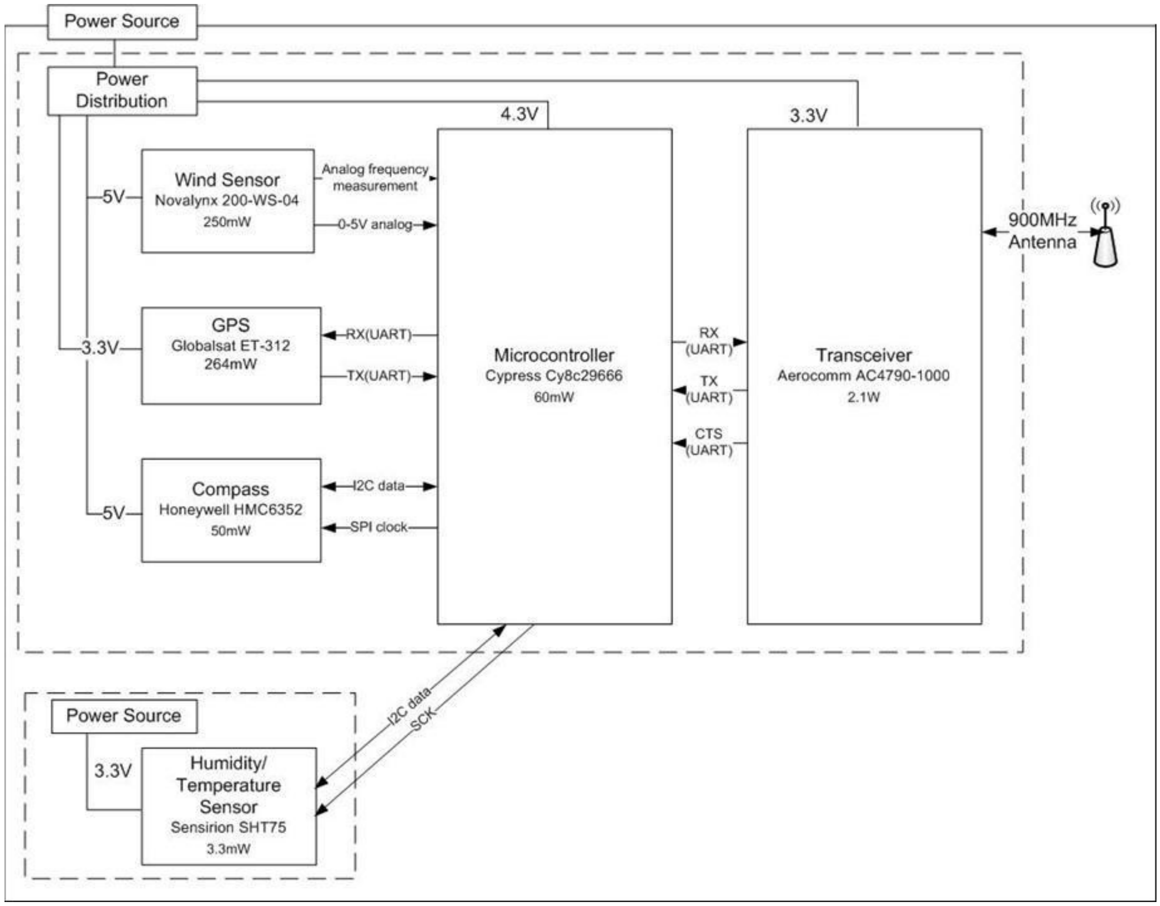

Figure 3: Block Diagram of Sensor Node

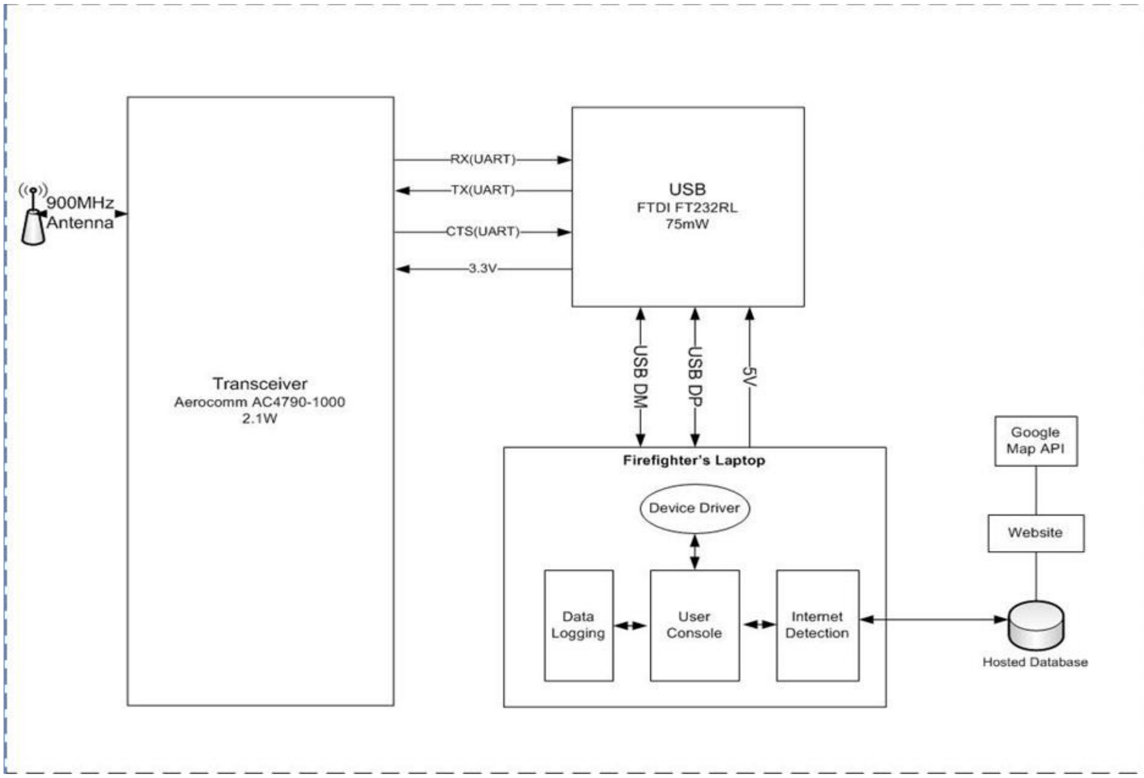

Figure 4: Block Diagram of Laptop Node

General	
Chipset	SiRF Star III
Frequency	L1, 1575.42 MHz
C/A code	1.023 MHz chip rate
Channels	20 channel all-in-view tracking
Sensitivity	-159 dBm
Accuracy	
Position	10 meters, 2D RMS 5 meters, 2D RMS, WAAS enabled
Velocity	0.1 m/s
Time	1us synchronized to GPS time
Acquisition Time	
Reacquisition	0.1 sec., average
Hot start	1 sec., average
Warm start	38 sec., average
Cold start	42 sec., average
Power	
Main power input	3.3V +- 5% DC input
Power consumption	80mA (Continuous mode) 65mA(Trickle power mode)
Interface	
Dimension	27.9mm * 20mm * 2.9mm
Baud rate	4,800 to 57,600 bps adjustable
Output message	SiRF binary or NMEA 0183 GGA, GSA, GSV, RMC,VTG,GLL
Antenna	Active or passive antenna

Figure 5: GPS Specs

Characteristics	Conditions [1]	Min	Typ	Max	Units
Supply Voltage	Vsupply to GND	2.7	3.0	5.2	Volts
Supply Current	Vsupply to GND				
	Sleep Mode (Vsupply = 3.0V)		1		µA
	Steady State (Vsupply = 3.0V)		1		mA
	Steady State (Vsupply = 5.0V)		2	10	mA
	Dynamic Peaks				mA
Heading Accuracy	HMC6352		2.5		degRMS
Heading Resolution			0.5		deg
Heading Repeatability			1.0		deg

Figure 6: Compass Specs

Relative Humidity

Parameter	Condition	min	typ	max	Units
Resolution [1]		0.4	0.05	0.05	%RH
		8	12	12	bit
Accuracy [2] SHT10	typical		±4.5		%RH
	maximal	see Figure 2			
Accuracy [2] SHT11	typical		±3.0		%RH
	maximal	see Figure 2			
Accuracy [2] SHT15	typical		±2.0		%RH
	maximal	see Figure 2			
Repeatability			±0.1		%RH
Replacement		fully interchangeable			
Hysteresis			±1		%RH
Nonlinearity	raw data		±3		%RH
	linearized		<<1		%RH
Response time [3]	τ (63%)		8		s
Operating Range		0		100	%RH
Long term drift [4]	normal		< 0.5		%RH/yr

Electrical and General Items

Parameter	Condition	min	typ	max	Units
Source Voltage		2.4	3.3	5.5	V
Power Consumption [5]	sleep		2	5	μW
	measuring		3		mW
	average		150		μW
Communication	digital 2-wire interface, see Communication				
Storage	10 – 50°C (0 – 125°C peak), 20 – 60%RH				

Temperature

Parameter	Condition	min	typ	max	Units
Resolution [1]		0.04	0.01	0.01	°C
		12	14	14	bit
Accuracy [2] SHT10	typical		±0.5		°C
	maximal	see Figure 3			
Accuracy [2] SHT11	typical		±0.4		°C
	maximal	see Figure 3			
Accuracy [2] SHT15	typical		±0.3		°C
	maximal	see Figure 3			
Repeatability			±0.1		°C
Replacement		fully interchangeable			
Operating Range		-40		123.8	°C
		-40		254.9	°F
Response Time [6]	τ (63%)	5		30	s
Long term drift			< 0.04		°C/yr

Figure 7: Temperature and Humidity Sensor Specs

	Fire Department Current	FD Specs	Our Component
Temperature	Unknown		+/- .3° C
Humidity	Unknown		+/- 2%
Wind Direction	Unknown		+/- 3°
Wind Speed	+/-2 mph < 10mph +/-5 mph > 10 mph		.5 mph or +/- 3%
Transceiver Distance	N/A		Up to 20 miles
GPS Accuracy	If commercial unit 5 – 10m		10 meters

Table 1: Requirements