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III. Background

The project is broken down into a few main components. Each component has it’s own set of requirements and also has to interface with the other components.

Sensors

Currently many sensors exist on the market. The main factors that will be focused on for this project are cost, ease of use, and temperature dependencies. Since one unit/node will be designed to be placed outside, a subset of the sensors need to be picked for their robustness. Many sensors claim to operate at -40º C but sometimes these extreme temperatures can only be tolerated for a set period of time before sensor ceases to function. Some sensors also experience deviations in the accuracy of the data at extreme temperatures. Others are only specified to operate for short bursts of time, and then enter a sleep mode.If the sensor is pushed to operate longer than it’s specified ‘burst,’ it will become unreliable. The SHT21Humidity sensor by Sensirion[1], for example, claims a normal operating accuracy of 2% with an extreme of 3%. While factors such as this may be unavoidable, the effects of temperature need to be recognized and considered when choosing a sensor. The goal while choosing sensors for the outdoor node is to select a device that has a wide temperature range, and will operate normally in that range indefinitely. While this may not be possible or cost effective, it is very possible to find one that can operate at a temperature extreme with a larger percent error on the reading. Since the outdoor node is mainly in place for comparison to indoor levels, a small innaccuracy would not deter from the main goal of the project.

Many modern sensors have an I^2C interface, these sensors typically have a small micro controller built into them that is programmed to perform the necessary analog to digital conversion that is then sent over the I^2C bus. Some sensors may also have an analog version that could help reduce cost and also reduce overall size. Using the analog sensor would increase amount of programming required and possibly lead to computational errors. It would also increase the time needed to complete the programming portion of this project, thereby increasing the length or decreasing the scope of the project as a whole. Analog output sensors are also at a greater risk of reporting a reading incorrectly.

The voltage requirements of the sensor should be considered when choosing a sensor. If possible the voltages of all components involved should stay the same. This will help reduce the circuitry and amount of space required. Also, depending on the controller chosen for the project, the voltages of the sensors may be limited to a specific band of values. This must be considered when choosing the sensors.

Wireless

The wireless module needs to have a range of about 100 meters (300 ft). This should cover the approximate area of a moderate size house with enough power to still transmit

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[1] http://www.sensirion.com/en/pdf/product_information/Datasheet-humidity-sensor-SHT21.pdf

through the walls. The amount of data transferred between the nodes and the base unit will be very minimal, assuming a maximum of 16 bits per measurement, and starting with 3 measurements, the first version will only need to transfer 48 bits. Starting with three nodes, and figuring for a transfer rate once every minute, the minimum data transfer rate of 144 bits per minute. This data rate can aid in choosing a wireless module. Some modules cost a pretty penny while boasting lightning fast data transfer, which we do not need. We can save money by choosing a reliable, relatively slow module.

Using a frequency designated in the unlicensed frequency band will eliminate the need to for licensing from FCC or other governmental agencies. The most common frequencies in this range are 900-928 MHz and 2.41-2.48 GHz band. Operating in these frequencies do not require the operator of the equipment to maintain a broadcast licence, the equipment however has to conform to FCC standards.[2] Since the project will be using off the shelf components for wireless transmission, the standards are required to be met by the manufacturer and not the operator.

LCD

LCD displays will be visible on each indoor node. This will allow the user to view the current data as it is gathered, without logging on to the website to view the collected data. Since LCD's tend to have a slow response time in colder weather, a display would not be present on the outside unit. For this unit the idea of either using indicator lights, or possibly even a 4 digit, 14 segment LED display could be useful. Since the amount of information on the LCD at any one time would be limited to one sensor and the reading of that sensor, a single line eight character display should be plenty. While a larger display would allow for more data, it would also increase the size of the individual nodes.

Microcontroller

While the project will be able to test the sensors and wireless module with the Arduino microcontroller that is already on-hand, other hardware needs to be examined in an attempt to reduce the cost of the project. The controller will need to be able to receive information from each sensor. It will have to report this information to the base unit every minute. It will also be able to recognize a command from the user ordering it to report it's current information, and carry out the action. It would be valuable if it recognized when a new sensor was added to the network, and begin reporting the new sensor's information along with the others. When choosing a controller, it will be important to pick one that does not require MSU to reveal all the coding required for our project (i.e. does not have a General Public License, or GPL). While Arduino claims that for commercial applications the code does not have to be released[3], it would be best to eliminate the worry about a prototyping or pre-production designs.

The programming suite would ideally be free for download, or a trial version with most capabilities available. By doing so, the suite could be downloaded to any computer on campus without the worry of license issues. A suite that has limited capabilities should be chosen such that limitation be confined to the size of code that can be loaded onto the controller. Since wireless communication protocols will be handled by the wireless module, the controller should

[2] http://edocket.access.gpo.gov/cfr_2010/octqtr/pdf/47cfr15.249.pdf

[3] http://arduino.cc/en/Main/FAQ

not need extensive code size.

Some wireless modules have a limited number of I/O pins and programming capabilities. Depending on the wireless module chosen, there exists a possibility of eliminating a controller in the final design. A controller during prototyping, however, would greatly contribute to debugging.

The size of the controller should be limited by the number of pins required to perform all required actions without having excessive pins present. Typically, smaller pin packages also have smaller amounts of memory, while this may become a problem if more sensors are added, memory should not have a major effect on controller selection.

Best case scenario, would be all sensors to be on the I^2C bus, the wireless module to use two pins (TX/RX), and the LCD to also be on the I^2C bus. This would require the controller to have at least 6 pins (4 I/O, power, and ground). Since most controllers do not have pins that always capable of this kind of digital interfacing, and the LCD would need some external hardware for I^2C compatibility, the worst case should also be explored.

Worst case scenario would be three sensors all using an analog to digital interface, all eleven lines of the LCD would need to be connected, and the wireless would require two lines. This would require the controller to have eighteen pins. Using various other IC's this number could be drastically reduced.