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Chapter IV: Design Specifications

The wireless network of indoor air quality sensors will be able to fulfill certain basic requirements in order for it to solve the problem stated in Chapter I of this document.

1. The IAQ system will gather data from air quality sensors and transmit this data via wireless communication to the base unit.
2. The sensors must send data when prompted.
3. The node will be able to recognize a manual command to send data, and 'wake up' the sensors to report their collected data.
4. The base unit will link to the internet and upload this data onto the internet using an open source data logger.
5. One node per unit must be operational outdoors under harsh conditions.
6. The nodes must operate for a long period of time without recalibration of sensors.
7. Individual nodes should display sensor data, and alarm indicators.(due to harsh conditions, display will be omitted on outdoor unit, data from outdoor will be displayed on base unit)
8. In order to provide optimal portability, nodes should NOT be restricted to a single base unit. (Channel Programability)

Given these simple base requirements, the specifications followed accordingly.

- Wireless communication will be achieved using Zigbee Pro Series 2 modules in the 2.4GHz band (license free).
- A microcontroller will be used to interface with the sensors using an I^2C bus.
- The sensors will operate without recalibration for 12 months.
- The outdoor node will operate accurately between -40 and 120 degrees Celsius
- The microcontroller will convert any non-digital signal received from a sensor into a digital signal before sending it to the base unit.

Chapter V. Design Alternatives Creation and Evaluation

Wireless Communication

The three main type of wireless protocol include Blue tooth, WiFi, and Zigbee modules. While they all typically operate at 2.4GHz, there is a module for Zigbee that operates at 900Mhz.

Bluetooth is typically designed to operate at closer ranges, typically 60 ft[1][2]. This lack of range would make it impractical for this application.

The WiFi uses an embedded chip to automatically connect to the interenet. This would require the base unit to also be equipped with a WiFi module, and an ethernet cabling. If the final product was used in an area with wireless internet this option might prove practical.

The Zigbee modules come in three different versions, Series 1, Series 2, and a 900MHz version. All Zigbees are rated for industrial temperatures (-40 to 85 C), this will allow for the outdoor unit to use the same communication as the indoor units. The series 1 modules do not allow for mesh networking, where the series 2 and 900MHz do allow for this. Mesh networking would allow the nodes to communicate with each other along with the base unit. Since initially the nodes should have no reason to communicate with each other, any of the series modules will work. The series only communicate between like series, so all modules will need to be of the same series. The 900MHz module allows for slower communiction time over that of the 2.4GHz modules 156kbs[3] vs 250kbs[4], however with improved indoor range (450 ft vs 133 ft) the ideal selection would be the 900MHz.

While ideally the final production would use the 900MHz module, for initial development the Zigbee Series 2 will be used. These are currently on hand, and interchangeable with very little effort to the 900MHz modules. Using units that are on hand should help keep production cost, and development time to a minimum.

Controller

Seemless integration between the sensors and the wireless communication is the main purpose of the microcontroller. There are already several HCS12 modules, and HCS08 microcontrollers on hand. While they both operate at 3.3V, the HCS12 has more memory and pins available, this will allow for quicker prototyping. With proper coding techniques it should be possible to switch to the HCS08 easily. Switching to the HCS08 for production should be kept in mind to keep cost low. The PicAxe brand of controllers have easily programmed routines and could be be used if programming in the field is required, these units come with a bootloader already installed and cost slightly more than the regular Pic controllers on which they are based. However, if the need to program in the field ever arose, the PicAxe could simplify things and reduce the need for a specially trained technician.

Sensor communication

Ideally all sensors will communicate to the microcontroller using the I2C bus. Howerever some sensors do not have that ability. Some alternatives for this is to use the ATD functions of the microcontroller to convert and interpret the data. This would only become a problem if there

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[1] Since range depends on Class 1 Devices or Class 2 devices these are approximate, assuming a Class 2 device.

[2] http://www.rovingnetworks.com/products/RN_42

[3] http://www.sparkfun.com/datasheets/Wireless/Zigbee/XBee-900-Manual.pdf

[4] http://ftp1.digi.com/support/documentation/90000976_G.pdf

are not any available pins on the microcontroller, in which case it would be possible to program a second smaller microcontroller to perform the ATD conversion and place it on the I2C bus. This method is essentially how all I2C sensor perform.

Channel Designation

Since there exists the possibility of several base units communicating to nodes within range of the sensors, a method needs to be put in place to avoid communication conflicts. The Zigbee modules have the ability to "self heal" the networks. This should not be used as it may contribute to nodes reporting data to a base unit that is not their unit. There are protocols in place to request the node to be added to a network, this could be beneficial, but there would need to be a human interface to ensure the node does belong to that base unit. Programming individual nodes to a specific channel would be possible and might be the best route. Using a simple 2 or 4 button interface the LCD would then prompt the user to select the corresponding base units channel. Number of buttons would be determined by possible selections of channels available. If the channel number was limited to 15 possible combinations(8-Bit), it would not be unreasonable to ask the user to scroll through those numbers, however if channel combinations exceeded this number, 4 buttons might be needed to select digit, then select number. Using jumpers or switches inside the unit would also accomplish the same task, opening a unit everytime it is used with another base unit could degrade the lifespan of the entire unit by allowing moisture and contaminants inside the unit.

	Preliminary	**Alternative #1**	**Alternative #2**
Wireless	Zigbee	Wifi	Bluetooth
MicroController	HCS08	HCS12	PICAXE
Sensor Communication	I2C	ATD	ATD w/ Micro to I2C
Channel Designation	User Selected on node	User selected inside unit	Base unit detection