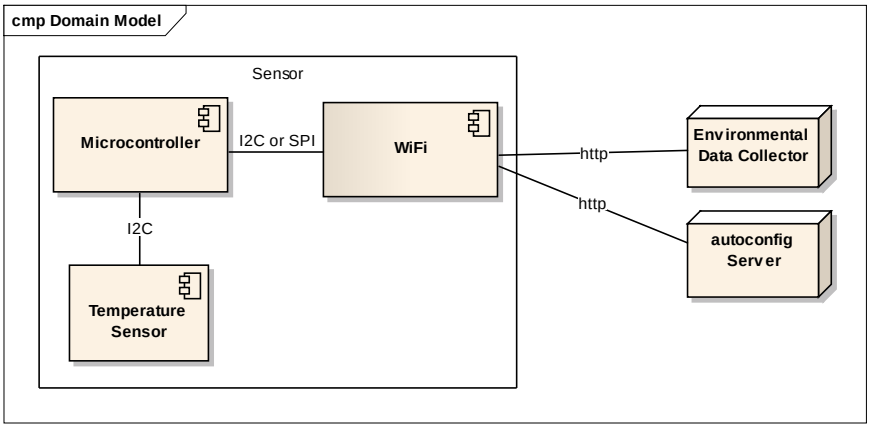
Temperature Sensor System Design

(http://kdobrien.github.io/Projects/EnvironmentalMonitor/)

Service environment temperature sensor

The temperature sensor is made up of three elements as shown below.



The requirements specified http capability, so an Ethernet or WiFi connection to the network will be required. Adding network wiring for each sensor would be costly so WiFi will be used.

The temperature sensor IC is considered a separate object because it has to be isolated from the heat sources in the assembled temperature sensor module. Without isolation, the sensor IC might read the temperature of the microcontroller (or WiFi) component rather than the ambient temperature.

The selected components and costs are listed below. Details for the tradeoffs and the selection process are found on the following pages. The $33.85 material cost is close to the preferred materials cost of $30 which meets the requirement.

Component	Estimated Cost	Notes
Power Supply	$12.00	Can choose 9-12V AC-DC converter or standard cell phone charger depending on mounting conditions.
Microcontroller	$9.95	Pro Trinket 5V from AdaFruit (lowest cost)
WiFi	$6.95	ESP8266 which is very popular for IoT projects
Temperature Sensor	$4.95	MCP9808 breakout board (AdaFruit) for fastest development. Will also try the HIH8120-021-001 in case metrology wants to include humidity ($10.55)
	$33.85 Total	Price goes to $39.45 to include humidity measurement

Suppliers considered (must meet anti-counterfeit policies for company suppliers):

- ***Amazon*** – for power supply cost comparisons – http://www.amazon.com
- ***Arduino*** – official board supplier https://www.arduino.cc/
- ***Newark*** – large electronics supply site – http://www.newark.com/
- ***Digikey*** – electronics supply site, used by hobbyists - http://www.digikey.com/
- ***AdaFruit*** – maker/arduino community supplier - https://www.adafruit.com/

Power Supply Estimation/Selection

The choices for power supply are either a USB charger or a 9-12V AC-DC converter (wall wart). The power supply needs to have a 2.1mm power plug with a center positive polarity (plus voltage on the center pin).

Power Supply	Price			Notes
	Newark	Digikey	Amazon	
9V Wall Adapter	$11 - $16	$10 - $12	$10 - $12	Could substitute 9V battery for on-site applications. Can also let sites order based on mounting and local power mains type.
USB Power	--	$8 - $47	$8 - $12	Standard cell phone charger.

Selection: Will use $12 for the estimated cost and will likely allow flexibility for each site based on local availability (i.e. the site can choose USB or 9-12V power source).

Mirocontroller Estimation/Selection

The following options are available for the microcontroller.

Arduino Model	Price				Size (inches)	Notes
	Newark	Arduino	Digikey	Adafruit		
UNO Rev 3	$22.88	$24.95	$21.54	$24.95	3.0x2.5	5V, 16 MHz (8 bit), 2 kB RAM, 32 kB Flash
Teensy LC	--	$11.65	--	--	1.4x0.7	3.3V, 48 MHz (32 bit), 8kB RAM, 62kB Flash
Mini 05	$13.73	(retired)	$14.00	$14.00	1.5x1.0	5V, 16 MHz (8 bit), 2 kB RAM, 32 kB Flash *No USB*
Pro Trinket 5V (ATMega328P)				$9.95	1.5x0.7	5V, 16 MHz (8 bit), 2 kB RAM, 28 kB Flash *No Serial to USB, FTDI to program*

Selection: The **Pro Trinket** from AdaFruit is the most attractive since it has been designed for lowest cost to support Internet of Things projects. In addition, the small size and relatively low power make this a good choice to minimize the temperature effect from the microcontroller on the temperature sensor. Changing to a different board will not be difficult if a better value is found later since all boards considered are Arduino compatible.

WiFi Estimation/Selection

There are three choices for the WiFi controller. Note that there is also a WiFi module based on the Texas Instruments CC3000 module but the cost is around $34.95 so it was not considered.

WiFi	Price				Size (inches)	Notes
	Newark	Arduino	Digikey	Adafruit		
WiFi Shield	$89.88	$49.90	$76.73	$49.95	3.0x2.5	Only if the Uno Rev3 board is chosen
ESP8266 SMT Module	--	--	$6.95	$6.95	1.0x1.5	Integrated antenna

Selection: The WiFi shield is outside the budget which means **the ESP8266** is the logical choice. The ESP8266 is a System on a Chip (SOC) device that includes a microcontroller along with support for WiFi control. The ESP8266 breakout board from AdaFruit includes 5V tolerance I2C lines for easy interfacing to a 3.3V or 5V Arduino.

In theory, the ESP8266 could be used without an Arduino but because the project time is short and there is no experience with the ESP8266 as a controller, the Arduino will be used. In addition, offloading the WiFi communication processing to a separate component reduces the risk of having the main processor busy with WiFi when a measurement is needed.

Temperature Sensor

There are three choices for the temperature sensor element.

Sensor IC	Price			Size (inches)	Notes
	Newark	Digikey	Adafruit		
MCP9808	$1.37	$1.13	$4.95 (breakout board)	0.8x0.5	High accuracy I2C temp sensor. Breakout board provides required extra components needed for connection to the Arduino.
HIH8120-021-001	$9.47	$10.55	--	0.2x0.4	Honewell 4 pin SIP temperature/humidity sensor (I2C). Requires extra capacitor between power and ground.
HIH6030-021-001	$3.90 (sale)	$8.61	--	SOIC-8	Honeywell IC temperature/humidity sensor (I2C). Requires extra capacitor between power and ground as well as a board to solder the component.

Selection: All three solutions meet the accuracy and speed requirements. **The MCP9808** is the clear winner on cost and will be selected for the project since it requires only a wire connection to the Arduino. The HIH8120-021-001 will also be considered in case humidity becomes a requirement for the extra $6.00 cost.