**Platform/Board Research**

The goal of this research was to compare the various devices we had available to use for our project. Dr. Conte de Leon asked us to perform more extensive research for the project, due to its more open-ended nature. The multitude of devices and platforms available for us to use made more research necessary in order to nail down which platform to use. I ended up looking at 4 different devices: Arduino Mega, Raspberry Pi 3, Espressif ESP32, and Raspberry Pi Zero W.

Each platform has its strengths and weaknesses. The Arduino Mega has more IO pins and processing power than a standard Arduino Uno, but it is still limited compared to some other microcontrollers on the market. The ESP32 is a more powerful microcontroller with WiFi and Bluetooth, but without the support available for Arduino. The Raspberry Pi 3 and Pi Zero W are both full computers, rather than just microcontrollers. While they are more capable, their increased cost and power consumption limits their usefulness as IoT sensors. The Pi Zero is limited by its lack of IO, and it consumes more power than an Arduino or ESP32.

In the end, we decided that the ESP32 would be the best choice for controlling the IoT sensor device, since it has more processing power than an Arduino while still being able to run off battery. It is much cheaper than a Raspberry Pi 3, which would be overkill for this use case. We plan on using AWS IoT Greengrass, and the ESP32 is a supported device for Amazon FreeRTOS.

We plan on using a Pi 3 as a “hub” device, which would collect data from all the sensors and relay it back to a server (either AWS cloud or our own). The Pi 3 is most suited to this because it supports AWS IoT Greengrass core software. We chose it over the Pi Zero because it had more IO ports (USB, Ethernet, etc.) while not being too much more expensive. The power requirements here are not as restrictive, since wall power will be available for hub devices. It will ideally have a wired connection with the server, while the communication between sensors will be handled over WiFi.

Espressif

ESP32 Development Board: $15

* 3.3V
* 0.1” headers
* USB – TTL serial adapter
* 160MHz
* Would be harder to use with ethernet; HUZZAH32 has support for ethernet & other modules

HUZZAH32 Feather Board: $20-22

* Compatible with other adafruit feather modules
* 240MHz
* 3.7-4.2V

ESP32 specs:

* Dual-core processor
* Integrated 802.11b/g/n wifi
* Integrated Bluetooth classic & LE
* Hall sensor
* SPI
* I2C
* 12x ADC input channels
* 2x DAC
* PWM/timer input/output available on each GPIO pin
* Sd card support
* Run off battery or usb cable
* 4MB flash
* 520KB SRAM
* Many sensors working with Arduino IDE but not full support

Peripherals

* Adafruit Ethernet FeatherWing (compatible with HUZZAH32): $20
* 5V microUSB adapter: $6.79

Arduino

ATmega2560 (Arduino Mega): $15

* 54 digital I/O
* 16 analog inputs
* 4 UARTs
* 256KB flash memory
* 8KB SRAM
* 4KB EEPROM
* 7-9V input voltage
* Fully compatible with Arduino IDE and shields
* Wi-fi not included, would need extra coprocessor to enable.
* Larger RAM capacity than Arduino Uno; would be able to run basic encryption algorithm that the Uno cannot run.
* Fully supported by Arduino IDE, possibly more documentation/libraries than ESP32 or other microcontrollers

Peripherals

* Arduino Ethernet Shield: $15
* 9V battery adapter: $5.39
* 7.5V DC adapter: $5.80

Raspberry Pi

Raspberry Pi 3 Model B: $35

* Quad-core ARM processor
* 1GB RAM
* Onboard WiFi
* Onboard Bluetooth LE
* 4x USB 2.0
* HDMI
* MicroSD port
* 40-pin GPIO
* GPIO can be programmed with Scratch or Python
* More like a full computer than a microcontroller; possibly a bit overkill for one single sensor but would have all the necessary IO and processing capability
* Requires:
  + microSD card: $5.79
  + power adapter: $6.79

Raspberry Pi Zero W: $10

* Single-core CPU
* 512MB RAM
* Mini HDMI
* USB OTG
* 40-pin header (unpopulated)
* Onboard Bluetooth 4.0 & LE
* Onboard WiFi
* MicroUSB power
* Requires:
  + microSD card: $5.79
  + power adapter: $6.79 (ignore if using Chromecast ethernet adapter)
  + powered USB hub (for setup, can provide)
  + microHDMI adapter: $5.98
  + Google Chromecast Ethernet adapter: $15 (also provides power to unit)
* Small size and limited ports reduce usefulness; main benefit is cost of unit since it has much more resources than Arduino Mega.
* Would be hard to transition from prototype model to something that could be implemented in building.
* GPIO header would need to be soldered in separately

Sensors

PIR (motion) sensor: $9.95

* Detect unexpected motion inside a room/hallway

IR Break Beam sensor: $6.50 (5mm LEDs) or $1.95 (3mm LEDs, out of stock)

* Essentially a tripwire, could be used to detect whether someone walks through a doorway, or to detect if computer removed from desk/classroom

Photo Transistor Light Sensor $0.95 (out of stock)

* Detect whether lights turned on/off at unexpected times

Temperature-humidity sensor: $5.00

* Detect changes in temperature or humidity in a room, possibly as a result of an outside door opening

Photoresistor + laser: $6.90

* Detect whether a door opened; if laser stops hitting photoresistor then open, and vice versa

Accelerometer: $4.50

* Detect movement of door, computer, etc.

Network monitoring: $9.55 for additional ethernet adapter, unless using wifi to connect to Mahive system. Monitor traffic coming through router in building, scan for any unusual packets or sources. (Might be further down the line)

Other

Solder: $6.99

Batteries: ~$5.00

**Cost Comparison:**

Raspberry Pi 3:

* Unit: $35
* Power adapter: $6.79
* MicroSD card: $5.79
* Total (before shipping/tax): $47.58

Raspberry Pi Zero W:

* Unit: $10
* Power/ethernet adapter: $15
* Micro HDMI cable: $5.98
* MicroSD card: $5.79
* 40-pin header: $0.95
* Total (before shipping/tax): $37.72

Espressif:

* Unit: $20
* Ethernet Feather board: $20
* Power adapter: $5.79
* Total (before shipping/tax): $45.79

Arduino Mega:

* Unit: $15
* Ethernet Shield: $15
* Battery/DC adapter: $5.80
* Total (before shipping/tax): $35.80

Arduino/Pi Zero: $12-14 left for sensors (PIR, laser/break beam/accelerometer/temperature-humidity)

Espressif/Pi 3: $2-4 left for sensors (accelerometer/break beam/temperature-humidity)

For individual sensor devices, the Pi Zero or Arduino Mega seem like the best bet.

The Arduino has less power, but optimized libraries are available to perform public key encryption. The Pi Zero has more power and would definitely be able to run Python-Crypto to perform RSA encryption.