**(ADDED TO PAPER)**

**Controller for Hub**

For our project, we would like to choose a development board that could be used as a hub for our smart fire alarm system. This hub would need to wirelessly send signals to the other fire alarm systems telling each alarm what direction to send users and when to go off. We decided on creating a hub for this system because without a hub, each fire alarm would need to be programed separately with its own location relative to the other alarms. Each alarm would also need to know it’s location relative to the suitable exits. With the use of the hub, we can choose one central system to program and do computation and that system would send the signals to the other alarms. A central hub would allow set up to go smoothly as a user would just have to set up the alarms and then program the hub with the locations of the alarms and exits. This greatly increases the ease of use for our system. A hub would also allow us to easily change the locations of our alarms after set up and also send software updates to the entire system easily. As ease of use and installation was an important factor for the design of our system, the choice for this unit is something that requires much research. When choosing a development board for projects, three units generally come to mind. These are the Arduino Uno, the Raspberry Pi, and the Beaglebone. We will evaluate each board, provide technical specifications for each, and weigh our options in the following text.

**Arduino Uno**

The Arduino is a development board that has become extremely popular among the maker community to design small projects and perform prototyping on potential system ideas. The Arduino is a microcontroller that specializes in executing simple code directly with no operating system performing operations in the back ground. It specializes is connecting to sensors though it’s GPIO pins and sending simple signals through those pins to read data signals. The microcontroller that is included on the Arduino Uno development board is the ATmega328P which is designed by Atmel. It is a low-power CMOS 8 bit microcontroller that uses the RISC instruction set. The Arduino board has an operating voltage of 5 volts with a recommending input voltage of between 7 and 12 volts. The board contains 14 digital input output pins of which 6 of those provide output for pulse width modulation (PWM). (<https://www.arduino.cc/en/Main/ArduinoBoardUno)> It also includes 6 pins for analog input. The ATmega328P Atmel chip includes only 32 KB of flash memory of which 0.5 KB are used by the bootloader. This microcontroller ship has a clock speed of 16 MHz. (<http://www.atmel.com/Images/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_Datasheet.pdf)> The power input specifications for this board allow it to be extremely low power and can be powered via a simple USB connection or with an external power supply. The reason this development board has become so popular among the maker community is that it is cheap and low powered while providing enough ease of use and input output pins to control external sensors. The board retails for $24.95 but can be very easily replicated using similar parts for much cheaper. The Arduino Uno does not come with build in wireless connections such as Bluetooth or Wi-Fi but comes with UART serial interface connections. The Arduino can communicate with a PC using original STK500 protocol. It features the Atmega16U2 programmed as a USB-to-serial converter and generally uses the Arduino IDE to be programmed.

**Raspberry Pi**

While the Arduino board is a small affordable micro-controller, the Raspberry Pi can be considered the most popular micro-processor among community designers. Instead of just being able to do simple calculations the Raspberry Pi can be considered a full blown personal computer. This development board is powered by the Broadcom BCM2837 quad core Cortex A53 processor. This processor runs at a relatively speedy 1.2 GHz frequency. The Cortex A53 is capable of running both 32 bit and 64 bit instruction sets. It is based on the ARM architecture that has become very popular among smartphones and other small computing devices. The Raspberry Pi also comes with a VideoCore IV graphics processing unit that runs at 400 MHz. While this is not as powerful as most modern day PCs, this is more than enough processing power to run simple graphics processes and display them over the included HDMI connection. The board also comes with 1GB of build in LPDDR2 RAM for running multiple processes. The Raspberry Pi also comes with a microSD card slot and USB port for storing external memory. The newest Raspberry Pi 3 model also comes with a much desired addition of wireless connectivity. Included on the board are a WiFi 802.11 b/g/n adapter running at 2.4GHz as well as a Bluetooth 4.1 LE transceiver and receiver. In terms of input/output capabilities, the Raspberry Pi comes with a 40 pin header of which 26 are general purpose IO pins. It also includes 1 UART pin for debugging and 2 pins that can be used for pulse width modulation. Two pins are also dedicated so a camera serial interface as well as a display serial interface. The device can be powered by 5 volts via a micro USB cable. The Raspberry Pi will take up 0.31 amps at 5V during idle mode with a Raspbian UI or 0.22 amps at 5.19 volts while using the terminal only in idle mode (<http://www.cnx-software.com/2016/03/01/raspberry-pi-3-odroid-c2-and-pine-a64-development-boards-comparison/>). One advantage that a board this powerful gives is its’ ability to run full 32 bit Linux distributions such as Ubuntu or Raspbian. This allows the programmer to design full applications that can be accessed via this device and a keyboard, mouse and monitor. Lastly, the Raspberry Pi retails for $35

**Beaglebone Black**

The last development board up for consideration for use as the controller for our hub is the Beaglebone black. The Beaglebone is a microprocessor development board similar to the Raspberry Pi. This board is powered by a AM3358 Sitara processor developed by Texas Instruments. This processor is based on the ARM Cortex A8 processor but is enhanced with image, graphics processing and other peripherals (​<http://www.ti.com/product/AM3358>). This processor runs at a 1GHz frequency and is capable of 2000 MIPS. The beaglebone is also powered by a SGX530 3D graphics engine specifically designed for 3D rendering. This is more than enough processing power to be able to run a full functioning Linux distribution and in fact comes pre loaded with Debian Linux with a 3.8.13-bone kernel. In terms of memory, this board comes with 512 MB of DDR3L RAM running at 606 MHZ and 4GB of onboard flash memory to hold code data and any other resources you might need. Interestingly, this board also comes with a TPS65217C dedicated power management module and optional 20 pin options JTAG serial header for debug support. It can be powered by miniUSB or a DC jack and uses 5V of DC power consumption. This board also comes with large amount of input/ouput access as it has two separate 46-pin headers of which 65 are GPIO and two are for pulse width modulation, a micro HDMI for audio and video output, and two USB ports. One thing that is of special note to this board, however, is that it contains a 10/100 Ethernet port but does not include built in WiFi or Bluetooth capability. The last article of note is that this board retails for at least $55 from many different distributors (<https://www.adafruit.com/product/1876>).

**Comparison of Development Boards Table**

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| --- | --- | --- | --- |
|  | **Arduino Uno** | **Raspberry Pi 3 Model B** | **Beaglebone Black** |
| Processor Speed | 16 MHz | 1.2 GHz | 1 GHz |
| Dedicated GPU | No | Yes | Yes |
| GPU Speed | N/A | 400 MHz | 200 MHz |
| Memory | 2 KB | 1GB | 512 MB of DDR3L |
| Input Voltage | 7-12 V | 5 V | 5V |
| Flash | 32 KB | SD Card | 4GB |
| Operating System | None | Linux Distributions | Linux Distributions |
| Multitasking | None | Yes | Yes |
| On board Wi-Fi | None | Yes | No, but Ethernet port |
| On board Bluetooth | None | Yes | No |
| GPIO Pins | 14 | 26 of 40 pin header | 65 of 92 pins |
| PWM Pins | 6 | 2 | 2 |
| USB | One, input only | Two ports | Two Ports |
| UART | Yes | 1 pin | 1 pin |
| On board HDMI | No | Yes | Yes |
| Price | $24.95 | $35 | $55 |

**Hub Comparison Conclusion**

The development board we choose as our hub for the smart fire alarm system could very well be the most important piece of technology we choose for this project. This development board would be handling all of the computation for our system. This device would also be the central location from where all installation would be configured. An initial vision for our project is that customers would use the hub to configure and tell the system where the location of the smoke and fire alarm sensors are relative to each other as well as relative to the exits to the building. With this in mind, we have decided that this would make the Arduino Uno not the best choice to control the hub. Since the Arduino Uno does not have the processor speed or the capability to run an operating system, the Arduino would have to be connected to a computer in order for new updates or initial configuration to be handled. It also would have to be expanded with more flash memory and wireless peripherals in order for it to function as the hub. This would bring the price up to at least that of the Raspberry Pi while the Pi offers much more at this price point. Because the Raspberry Pi and Beaglebone Black have high amounts of processing power and graphics capabilities, these devices would have the ability to run full operating systems and function as a stand-alone service. This would eliminate the need for an installer or user to have a computer connected for set up and additional functionality. The installer would just have to connect a keyboard and screen to these devices for installation. This allows for the potential of developing an easy to use graphics program for set up in future development.

When just comparing the Raspberry Pi 3 and Beaglebone black, analysis shows that these two devices are very comparable. These devices have similar processor speeds, both contain a dedicated graphics processing unit, and both come with a substantial amount of on board memory. The Beaglebone does have 4GB of on board flash memory but that will be more than enough for our project while a Raspberry Pi can easily be expanded through the use of an SD card. The Raspberry Pi 3 comes with plenty of GPIO pins as 26 of the pins on the 40 pin header can be used as general purpose. The Beaglebone Black manages to more than double this amount with 65 pins which would be more than overkill for use as a wireless hub for our smart fire alarm system. The two places where a major difference between the Raspberry Pi 3 and Beaglebone Black finally start to show are the on board wireless connectivity and price points for each device. While the Raspberry Pi 3 comes with on board Wi-Fi and Bluetooth functionality, the Beaglebone bone falls short in this category. The Beaglebone only gives access to wired internet access through an Ethernet port. The Raspberry Pi would be able to provide wireless control over the sensors as well as download any updates or alerts over WiFi while the Beaglebone would need to be expanded to provide this. Lastly, while the Beaglebone may provide a large amount of GPIO pins and 4GB of RAM, we believe that these gains are not worth the $20 different in price that would be required versus the Raspberry Pi 3. The Raspberry Pi 3 provides everything our Hub would need while also having on board wireless connectivity for a price $35 while the Beaglebone Black retails for $55 or higher. For these reasons, we have chosen to use the Raspberry Pi 3 model B as the micro processing unit to control our hub.