Component Analysis

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1.0 Component Analysis:

The primary components of our design are a low power microcontroller, a single board computer, and a Bluetooth module. The microcontroller is responsible for interacting with several physical inputs in our system, such as a keypad and button, and controls the doors' locking mechanism. The single board computer will send images to a remote server that runs a facial recognition algorithm and receive a response via WiFi. To make the system coherent, the microcontroller will need a bluetooth module to communicate with the single board computer. A rationale as to how we chose each of these major components for our system is described in detail in the following sections.

1.1 Analysis of Component 1:

The single board computer component that was chosen for the project is Raspberry Pi 3 Model B+ (referred to as 'the Pi'). This model is cost effective ($35) for the wide range of features and functionality it provides (ASUS USA, 2019). As well as its potential competitors (Raspberry Pi Zero and ASUS Tinker Board S (LTD, 2019)), it has 40 IO pins, same operating voltage of 5.1V at 2.5A, standard on-board WiFi 802.11ac 2.4/5Ghz capability, and an option of memory expansion in the form of MicroSD. The amount of IO pins is sufficient for the external interfacing with bluetooth module as well as the microcontroller in the system. On-board WiFi capability makes it possible for external communications with a remote server. The on-board CPU is ARM Cortex A53 which has enough computing power with its 4 cores at 1.2 GHz to handle image processing for the project. The other two options have ARM1176JZF-S CPU with 1 core at 1 GHz, which is not enough for the task, and ARM Cortex-A17 with 4 cores at 1.8 GHz cores, which is an overhead option that is also much more expensive. The amount of RAM that Pi 3 B+ provides, 1 GB, is enough for the task that is assigned to Pi - simple image processing and wireless data transactions. It competes with 512Mb on Zero and 2GB on Tinker. Again, 1GB is an acceptable middle ground with sufficient RAM. In case where faster network speeds might be required, the Pi also has an Ethernet port on-board. The operating system that Pi supports is Unix-like OS Raspbian, which is makes it an optimal choice because of team's past experiences with such systems.

Feature	Raspberry Pi 3 Model B+	Raspberry Pi Zero	ASUS Tinker Board S
Cost	$35.00	$10.00	$91.99
# IO pins	40	40 (Header not installed)	40
CPU	ARM Cortex A53	ARM1176JZF-S	ARM Cortex-A17
Cores / Clock Speed	4 @ 1.2 GHz	1 @ 1 GHz	4 @ 1.8GHz
Architecture	ARMv8-A (32/64 bit)	ARMv6z (32bit)	ARMv7-A (32 bit)
Manufacturer	Raspberry Pi Foundation	Raspberry Pi Foundation	ASUS
RAM	1GB	512Mb	2GB
Operating Voltage	5.1V @ 2.5A	5.1V @ 2.5A	
Wifi Capable	On board 802.11ac 2.4/5Ghz	On board 802.11n	On Board 802.11 b/g/n
Bluetooth Capable (version)	On board 2.1/4.1/4.2/BLE	On board 2.1/4.0	
Ethernet	~300Mbs Ethernet port		
Operating Systems	Raspbian	Raspbian	TinkerOS/Debian Linux
Expandable Memory	MicroSD	MicroSD	

Table 1: SBC Component Comparison

1.2 Analysis of Component 2:

In order to interface with all the electronic components in the system, the MSP432P401R microcontroller is chosen (MSP432P401R, 2019). This microcontroller has come out last year as a new addition to the MSP43x family. Even though it's the most expensive option out of the three that were considered, including the separate micro for the final product ($7.72) and the development board for prototyping ($29.99), it has a newer ARM Cortex-M4F CPU and operates @ 48 MHz operating frequency, as opposed to STM32F401RE (STM32F401RE, 2019) with ARM Cortex-M4 @ 84 MHz and S9S12G96F0MLFR (S9S12GA192F0MLFR NXP / Freescale | Mouser, 2019) with CPU12 @ 16MHz. The "middle ground" option of MSP432P401R is chosen because the project does not need a lot computing overhead wthat STM32 provides, but it has to be able to have more computing power than the one S9S12 provides. There are 48 GPIO pins that MSP432 has, which makes it an easier logistical problem to solve when it comes to programming and soldering the micro. Since the project will be utilizing UART interfacing capability, it is valuable to have 4 vs 3 (MSP432) interfaces on the chip. Other specifications like operating voltage, timers and temperature range are similar across all three options.

Feature	MSP432P401R	STM32F401RE	S9S12G96F0MLFR
Cost	$7.72 (Micro), $29.99 (Development Board)	$7.56 (Micro), $13.83 (Development Board)	$6.58 (Micro)
CPU	ARM Cortex-M4F	ARM Cortex-M4	CPU12
Operating Frequency	48MHz	84MHz	16MHz
Memory (Flash/SRAM)	256Kb / 64Kb	512Kb / 96Kb	240Kb / 11Kb
GPIO	48	81	40
SPI	8 max (4 eUSCI_A, 4 eUSCI_B)	4 max (up to 42Mbit/s at fCPU = 84 MHz)	3
I2C	4 max	3 max	-
UART	4 max	3 max (2 x 10.5 Mbit/s, 1 x 5.25 Mbit/s)	-
Software	SimpleLink SDK	ARM ETM	ECAD Tool
operating voltage	1.62V to 3.7V	1.7V to 3.6V	3.15V to 5.5V
timers	4 16-bit, 2 32-bit	6 16-bit, 2 32-bit	8 16-bit
Temperature Range	-40C to 85C	-40C to 85C	-40C to 85C

Table 2: Microcontroller Comparison

1.3 Analysis of Component 3:

A Bluetooth module is needed to enable communications between our microcontroller and Raspberry Pi, and the decision rested on deciding which peripheral to use: UART or I2C. In order to use I2C, we would need to use a Bluetooth System-on-a-Chip (SoC) with an onboard microcontroller, which was I2C capable, while an independent module usually relies on a UART peripheral. An SoC, such as the would introduce more complexity into the design, but would also provide much more functionality to the Bluetooth capabilities. However, since the only thing that will be sent over Bluetooth will be simple acknowledgement signals, as opposed to image data, there is no present need for a more powerful solution. In addition, these increased capabilities come at cost, with the SoC modules costing nearly 2x to 3x (nRF52832 @ $19.95, nRF52840 Mini @ $29.95) as much as the other options. Therefore, the module we decided to use was the Atomic Market HC-06 Bluetooth Serial Module, which relies on UART communication. The embedded components consist of a BC417 radio and baseband IC (1.8V to 3.6V), along with external Flash memory for power-up functionality. Integrating this module with the final design would be easier as well, since the embedded voltage is at a similar range with the microcontroller and other components. Since this unit is used very often alongside Arduino's, there are several well-documented tutorials.

Feature	SparkFun nRF52832 Breakout	SparkFun Pro nRF52840 Mini	HC-06 Bluetooth Serial Module
Cost	$19.95	$29.95	$8.99
Bluetooth support	BLE	BLE, 5.0	BLE 2.0 + EDR
CPU	ARM Cortex-M4F (32-bit)	ARM Cortex-M4 @ 64Mhz	-
Memory (flash/RAM)	512Kb / 65Kb	1MB / 256Kb	8Kb
GPIO	32	48	-
Data transfer	SPI, I2C, UART, PWM	SPI, I2C, UART, PWM, USB	UART @ 9600 baud
Dev Board	No	Yes	Yes
Support	Schematic, Eagle	Schematic, Eagle	EAGLE
Software	-	Nordic nRF5 SDK(C)	-
Operating Voltage	1.7V to 3.6V	1.7V to 5.5V	3.3V to 6V

Table 3: Bluetooth Comparison

2.0 Sources Cited:

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