Electrical Overview

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1.0 Electrical Overview

There are two primary computational components in the system, a 32-bit 100 pin microcontroller and a Raspberry Pi, a small single board computer. The microcontroller handles inputs/outputs from a button, switch, keypad and lock mechanism while maintaining communication with the Raspberry Pi via a Bluetooth module. The Raspberry Pi captures images from a camera and sends them to a remote server capable of running facial recognition algorithms to verify a user. Additionally, a Hall effect sensor will be used to determine when the door is closed and send a signal to the microcontroller. When the door needs to be unlocked, the microcontroller will send a signal to the door lock solenoid mechanism, which has its own independent power systems, and will hold it unlocked until a signal is received from the Hall effect sensor indicating that the door is closed, or if the door has been held open for a period of 10 seconds. With the push bar, locking while open will allow the door to still close, unlike a bolt lock. This would be a simple change of logic to account for though, as our system would instead wait until the Hall effect sensor registered the door as closed.

2.0 Electrical Considerations

2.1 Operating Voltage

The Raspberry Pi 3 Model B+, a small single board computer chosen for the project, has a Broadcom BCM2837B0, Cortex-A53 64-bit SoC that operates at a 1.4GHz frequency [4]. Its input power specs are 5V/2.5A DC via micro USB connector, which brings it to a total of 12.5W of power required for operation. The Pi does not have any components directly connected to it besides the Pi camera. It communicates with the microcontroller and server wirelessly, via Bluetooth and Wi-Fi, respectively.

The MSP432P401R microcontroller has an operating voltage range between 3.3V and 5V and operating frequencies between 3 Mhz and 48Mhz [5]. The HC-05 bluetooth module operates in a 3.3V to 6V range and as such can share a power supply with the microcontroller [3]. The keypad, LED, button, and switch only require passive power, meaning that they do not require their own power electronics.

2.2 Operating Frequency

The system tries to minimize the time a user has to spend unlocking a door to make it a seamless experience for the user. The large majority of delay within our system extends from the processing time for the facial recognition algorithm, since sending the images and acknowledgement signals over WiFi and Bluetooth takes a fairly negligible amount of time. The Raspberry Pi will operate at 1.2Ghz and can capture up to 30fps. The actual fps will be lower, in order to reduce the amount of frames that need to be processed. The MSP432P401R microcontroller doesn't have to perform any computationally heavy tasks, so it can run at a lower frequency of 3 Mhz, in order to complete its tasks.

2.3 Power Supply

The Raspberry Pi will be powered by a 5V Micro-USB wall adapter, due to the high current requirements needed to run it (2.5A), for which a battery would not suffice. The door lock motor has its own power systems, where it plugs into a 24V/1A power source, and only accepts a signal from an NMOS on the main PCB. Finally, the microcontroller, Bluetooth module, and Hall effect sensor will run off the same 5V on-board power supply, but in order to minimize noise and interference, will be filtered and separated with decoupling capacitors and bandpass filters. The electrical loading considerations for power consuming components are as follows:

MSP432P401R - 100mA [5]
Raspberry Pi Model 3 - 140mA [4]
Electrical Latch - 1A [1]
HC-05 Bluetooth module - 10mA [2]

3.0 Interface Considerations

UART (TL16C550 standard)

The communication between the MSP432P401R microcontroller and the HC-05 bluetooth module will use the serial UART protocol. The protocol will utilize a predetermined baud rate of 9600 to make sure both sides are synchronized. Implementation will require two of the microcontrollers' GPIO pins to handle the TXD and RXD signals operating at 3.3V [3]. The data will be shifted in and out of the microcontroller with a packet size of two bytes, consisting of a start bit, and a single char. These operations are primarily used for handshake signals, so the interface considerations are fairly negligible.

Bluetooth 4.2

Communication between the Bluetooth module and Raspberry Pi will use Bluetooth 4.2, which is a low energy protocol ideal for IoT solutions. The protocol uses 2 Mhz spacing and has a master/slave relationship between devices. The Raspberry Pi will act as the master and the microcontroller will be the slave. Data transfers between the bluetooth module and the Raspberry Pi will use the BLE packet Protocol Data Unit (PDU) which specifies the packet formats for initial pairing and payload transfers [3].

Note: These are the industry standard interfaces used in the system, other interfacing will occur with devices such as buttons, switches, and motors and will require custom drivers.

4.0 Sources Cited:

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5. Texas Instruments (2017). MSP432P401R, MSP432P401M SimpleLink™ Mixed-Signal Microcontrollers. [online] Available at: http://www.ti.com/lit/ds/symlink/msp432p401r.pdf [Accessed 1 Feb. 2019].

Appendix 1: System Block Diagram

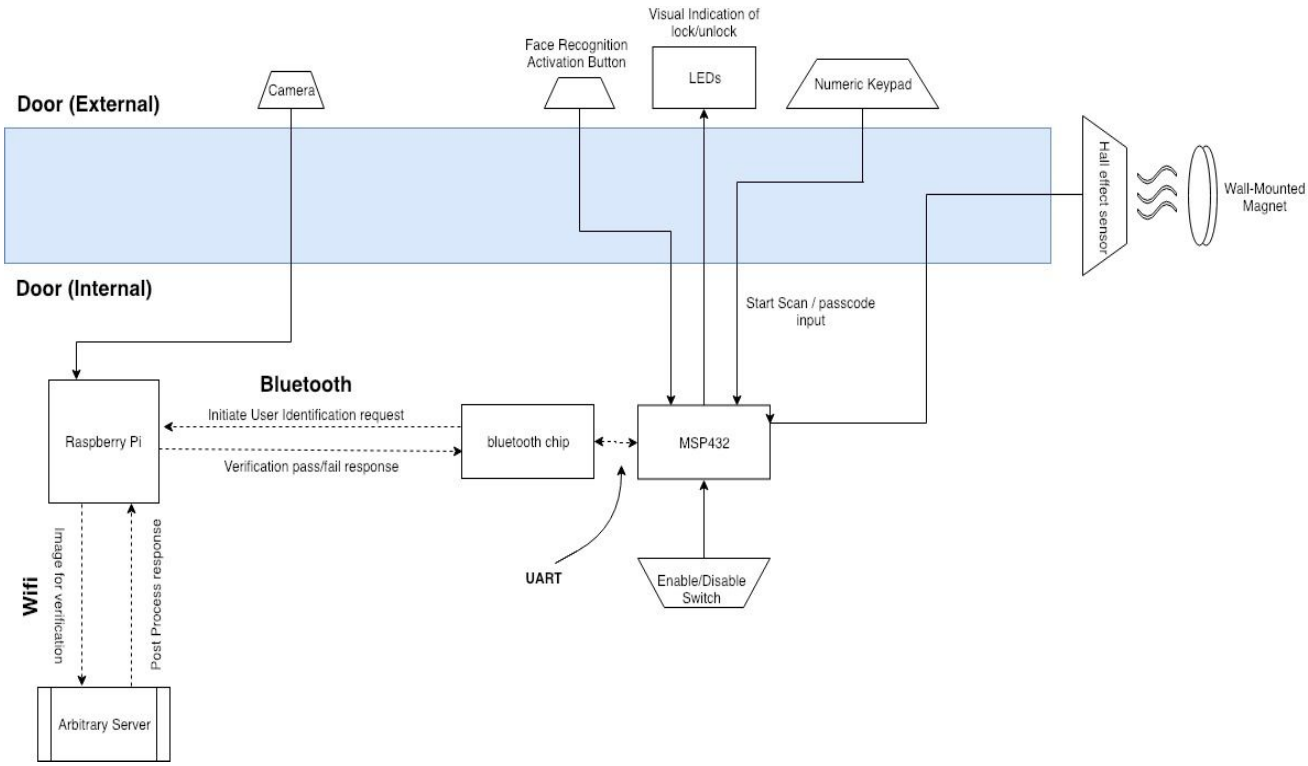

Figure 1: System Block Diagram