

# CEN 5035 Principles of Software Engineering, Fall 2019

Group 5 - The Smart Security System

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## Contents

<b>1</b>	<b>Revision History</b>	<b>4</b>
<b>2</b>	<b>Executive Summary</b>	<b>5</b>
<b>3</b>	<b>Competitive Analysis</b>	<b>6</b>
<b>4</b>	<b>Data Definition</b>	<b>6</b>
<b>5</b>	<b>Overview of Scenarios and Use Cases</b>	<b>6</b>
<b>6</b>	<b>High-Level functional requirements</b>	<b>8</b>
6.1	Detection System . . . . .	8
6.2	Automated Monitoring Calendar . . . . .	8
6.3	Recording System . . . . .	8
6.4	User Interface . . . . .	8
6.5	Alert System . . . . .	8
6.6	Reporting System . . . . .	8
6.7	Watson . . . . .	8
<b>7</b>	<b>List of non-functional requirements</b>	<b>9</b>
<b>8</b>	<b>High-Level System Architecture</b>	<b>9</b>
<b>9</b>	<b>Implementation details</b>	<b>10</b>
9.1	Inputs . . . . .	10
9.1.1	PIR Sensor . . . . .	10
9.1.2	4x4 Membrane Matrix Switch . . . . .	12
9.1.3	Playstation Eye Camera . . . . .	13
9.1.4	Ultrasonic Sound Distance Sensor(HC-SR04) . . . . .	13
9.2	Outputs . . . . .	14
9.2.1	LED Module . . . . .	14
9.3	Services . . . . .	15
9.3.1	Watson Graphs . . . . .	15
9.3.2	Google Calendar as smart enable system . . . . .	17
9.3.3	Motion library . . . . .	17
9.3.4	Flask framework . . . . .	18
9.3.5	Twilio notifications . . . . .	18
9.4	Class Diagrams . . . . .	19
9.4.1	System class . . . . .	19
9.4.2	Sys Client . . . . .	20
9.4.3	LED module . . . . .	20
9.4.4	Keypad . . . . .	21
9.4.5	PIR Sensor . . . . .	21
9.4.6	PIR Event . . . . .	22
9.4.7	Notifications . . . . .	22
9.4.8	Ultrasonic Distance Sensor . . . . .	23
9.4.9	Watson . . . . .	23
9.4.10	System Integration Testing . . . . .	24
9.4.11	Manual Testing . . . . .	24
9.5	Development Environment setup . . . . .	24
9.5.1	Tools . . . . .	24
9.5.2	Port Forwarding on router for SSH . . . . .	25
9.5.3	Work flow to editing and testing out code . . . . .	25
9.5.4	Real VNC . . . . .	26

10 Verification	26
11 Team Member Contribution	26

## 1 Revision History

Description	Date	Revision number
Initial proposal submission	9/27/2019	v1
Final report submission	12/4/2019	v2

## 2 Executive Summary

Our group project during the Fall 2019 semester in CEN 5035 Software Engineering will be a Smart Security System. We have found there is a lack of flexibility to set up schedules for a security system which lead us down this path. We are looking to solve this problem by having an easily configurable way to schedule when the alarm should be enabled or disabled. This system will also have the standard features of a typical alarm system.

The Smart Security System breaks away from the competition in its ability to connect to and utilize with the owner's digital calendar to automatically create a detection schedule. To reduce the risk of failure, the system will also have a backup keypad to enable or disable the detection system in the event the Google Calendar schedule was not enough.

The security system will include cutting edge passive infrared motion sensing technology to be able to detect any movement in the desired location. For added security, the system will capture images, video and audio to relay back to the system owner and or authorities should a break-in occur. The system will also have the ability to disable the alarm from the web interface. Giving the owner a short time frame to disregard the event before the authorities are notified. Finally the system will have a secured web interface to be able to view and update the monitoring schedule through the Google Calendar. The web system will provide the user the ability to activate or disarm the alarm and view a live stream of their camera at any given time.

Our target audience will be for anyone who wants to have a security system that has a busy schedule where they might be traveling often. This will help ensure that the alarm system will always be active when the home owner is away.

### 3 Competitive Analysis

	ADT Pulse	Vivint	Ring Alarm	FrontPoint	SimpliSafe	Smart Security System
<b>24/7 Monitoring</b>	X	X	X	X	X	X
<b>Live Alerts</b>	X	X	X	X	X	X
<b>Motion Detection</b>	X	X	X	X	X	X
<b>Voice Control</b>	O	X	X	X	X	X
<b>Arm/Disarm Remotely</b>	X	X	X	X	X	X
<b>Schedule sync</b>	O	O	O	X	O	X

Symboal	Meaning
X	Includes
O	Excludes

TODO - Consider beefing this up a little. In the first example given in class they have 2 sections: Competitive relationship and Competitive advantages

An advantage that our Smart Security System is that the system will be able to connect up with the owner's digital schedule. There is only one other system that has that capability, FrontPoint. The advantage our system has over FrontPoint, along with the other systems, is the ability to receive these alerts quick enough in order to determine whether the alert was real or not. Our system will be able to notify authorities quickly enough after confirmation.

### 4 Data Definition

TODO - Consider going back and seeing we need to add anymore definitions. Also probably need to go into a little more detail

- Enable/arm - Turning the system on to monitor for intruders.
- Active - Currently the system monitoring for intruders or any disturbance from the motion sensors.
- Disarm - The act acknowledging the system of a false alarm or making the system inactive meaning that the system is no monitoring for movement.
- Notification - sending an alert through a SMS/MMS to the system owner.
- System owner - User in control of the system who can enable/disable the system.
- Detect - System has found a disturbance from one of the motion sensors.
- Monitor - the act of checking the sensors to see if the signals are out of normal range.
- Record - Using the PS3 Eye to capture video and or pictures and save it to the system.
- Sensing - This the period where the system has been Armed and the waiting period has lapsed. During this time if there has been activity spotted by the PIR then the alarm will be activated.
- Locked - The system we become locked upon 4 incorrect pin entries.

### 5 Overview of Scenarios and Use Cases

#### Use Case: Enable Alarm

**Brief Description :** System owner arms the monitoring service

#### Basic Flow :

1. System owner chooses to enable monitoring service
2. System asks for code to arm monitoring service
  - System verifies that system owner would like to arm monitoring service

- Once verified, system arms monitoring service
- 3. System Owner is notified that monitoring service has been armed on user interface

**Alternate Flow :**

1. System Owner chooses to enable monitoring service
  2. System asks for code to arm monitoring service
    - Code provided is incorrect, system allows for another try
    - Code provided is incorrect, system is locked
  3. System Owner must verify identity to unlock system
- 

**Use Case: Disable Alarm**

**Brief Description :** System owner disarms monitoring service

**Basic Flow :**

1. System owner chooses to disable monitoring service
2. System asks for code to disarm monitoring service
  - System verifies that system owner would like to disarm monitoring service
  - Once verified, system disarms monitoring service
3. System Owner is notified that monitoring service has been disarmed on user interface

**Alternate Flow :**

1. System Owner chooses to disable monitoring service
  2. System asks for code to disarm monitoring service
    - Code provided is incorrect, system allows for another try
    - Code provided is incorrect, system is locked for 10 minutes
- 

**Use Case: Disable False Alarm**

**Brief Description :** System owner disarms monitoring service after an incident

**Basic Flow :**

1. System owner is notified of possible disturbance
  2. A video/picture is sent to system owner
    - If disturbance occurs outside of normal range
      - i. System owner can choose to dispatch authorities
      - ii. Or system owner can choose to disable alarm
  3. See **Use Case Disable Alarm**
- 

**Use Case: Notify System Owner**

**Brief Description :** System notifies system owner if monitoring service was triggered

**Basic Flow:**

1. Monitoring service is triggered
2. Monitoring service takes video/picture of surrounding area
3. Monitoring service sends an SMS to system owner that the service was triggered
4. If disturbance occurred outside of range of camera but within range of motion sensor
  - System owner is given option to dispatch authorities or disable alarm
  - If user chooses to dispatch authorities
    - i. User then has option to contact authorities
  - If user chooses to disarm the alarm
    - i. See **Use Case Disable False Alarm**

## 6 High-Level functional requirements

### 6.1 Detection System

- **HLR.REQ-1** - The system shall monitor user designated areas for any signs of movement when the system has been armed.

### 6.2 Automated Monitoring Calendar

- **HLR.REQ-2** - The system shall provide the user with a calendar that can be utilized to schedule times when the system should arm and disarm automatically.
- **HLR.REQ-31** - The system shall be able to detect new calendar events within 10 seconds.

### 6.3 Recording System

- **HLR.REQ-3** - The system shall stream video, and audio from an area designated by the user.
- **HLR.REQ-4** - The system shall capture pictures and record audio/video when the system has been armed and triggered.

### 6.4 User Interface

- **HLR.REQ-5** - The user interface shall have the ability to view the live stream.
- **HLR.REQ-6** - The interface shall provide the user the ability to view and edit the monitoring calendar from the Google Calendar.
- **HLR.REQ-7** - The system shall provide the user with the ability to arm and disarm the system.
- **HLR.REQ-28** - The user interface shall provide the color and enabled status of the LED
- **HLR.REQ-29** - The user interface shall have a link to the Watson service

### 6.5 Alert System

- **HLR.REQ-8** - The system shall flash the LED green 5 times and then lock on blue for a successful arming of the system.
- **HLR.REQ-22** - The system shall flash the LED green 5 times and the shut off the LED for a successful disarming of the system.
- **HLR.REQ-23** - The System shall flash the LED yellow 2 times when the pin was incorrectly entered
- **HLR.REQ-24** - The system shall continue to flash red when the system alarm becomes activated
- **HLR.REQ-26** - The system shall become locked when the PIN was incorrectly entered 4 times in a row
- **HLR.REQ-27** - The system shall remain locked for 5 minutes when the system becomes locked.
- **HLR.REQ-25** - The system shall turn the LED on red when the system becomes locked

### 6.6 Reporting System

- **HLR.REQ-9** - The system shall send messages to the user when the system has been armed and triggered.
- **HLR.REQ-19** - The notifications shall have an image capture when the trigger happened, the date & time, and a link to the stream.
- **HLR.REQ-20** - The system shall send a notification when the system has been armed.
- **HLR.REQ-21** - The system shall send a notification when the system has been disarmed.

### 6.7 Watson

- **HLR.REQ-30** - The system shall send the following events to the Watson service to be able to graph:
  - Arming/Disarming the system
  - System Alarm triggered
  - Motion detected



## 7 List of non-functional requirements

- **HLR.REQ-11** - The system shall handle erroneous inputs from the user.
- **HLR.REQ-13** - The system shall be easy to learn, taking no more than 15 minutes for new users to start utilizing all of the system's features.
- **HLR.REQ-14** - The user interface shall be capable of being accessed from any device with internet access.
- **HLR.REQ-16** - The system shall restrict read/write/modify access to video/audio streams, pictures, video/audio recording to the owning user.
- **HLR.REQ-17** - The system shall respond to user reporting feedback within 60 seconds.
- **HLR.REQ-18** - The system shall store 1GB of video recordings and 250MB of pictures.

## 8 High-Level System Architecture

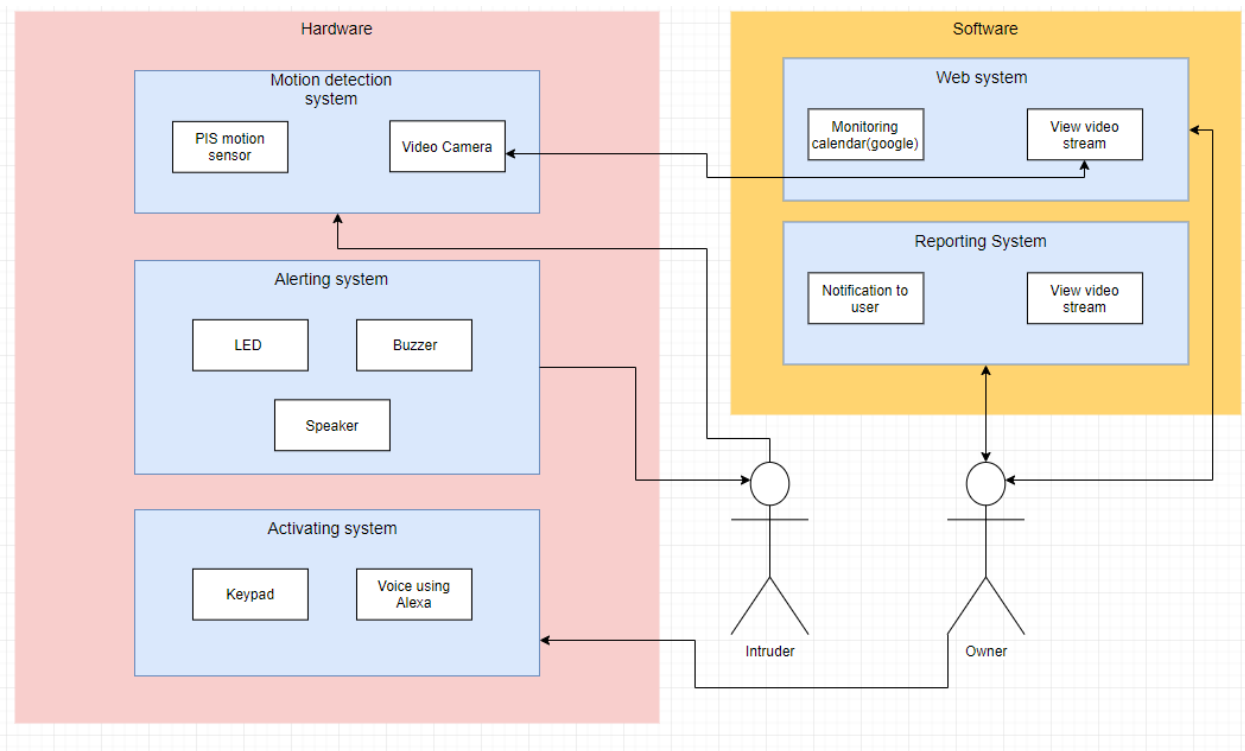


Figure 1: System Architecture

Link:<https://www.draw.io/#G1RfKGCPj4uxjit77ksxuVJuZhFB1gMUyB> TODO - update the graph to remove the buzzer and speaker and alexa. Add the Ultrasonic sensor in the Motion Detection system TODO - Explain text based on the interactions between the sub-systems

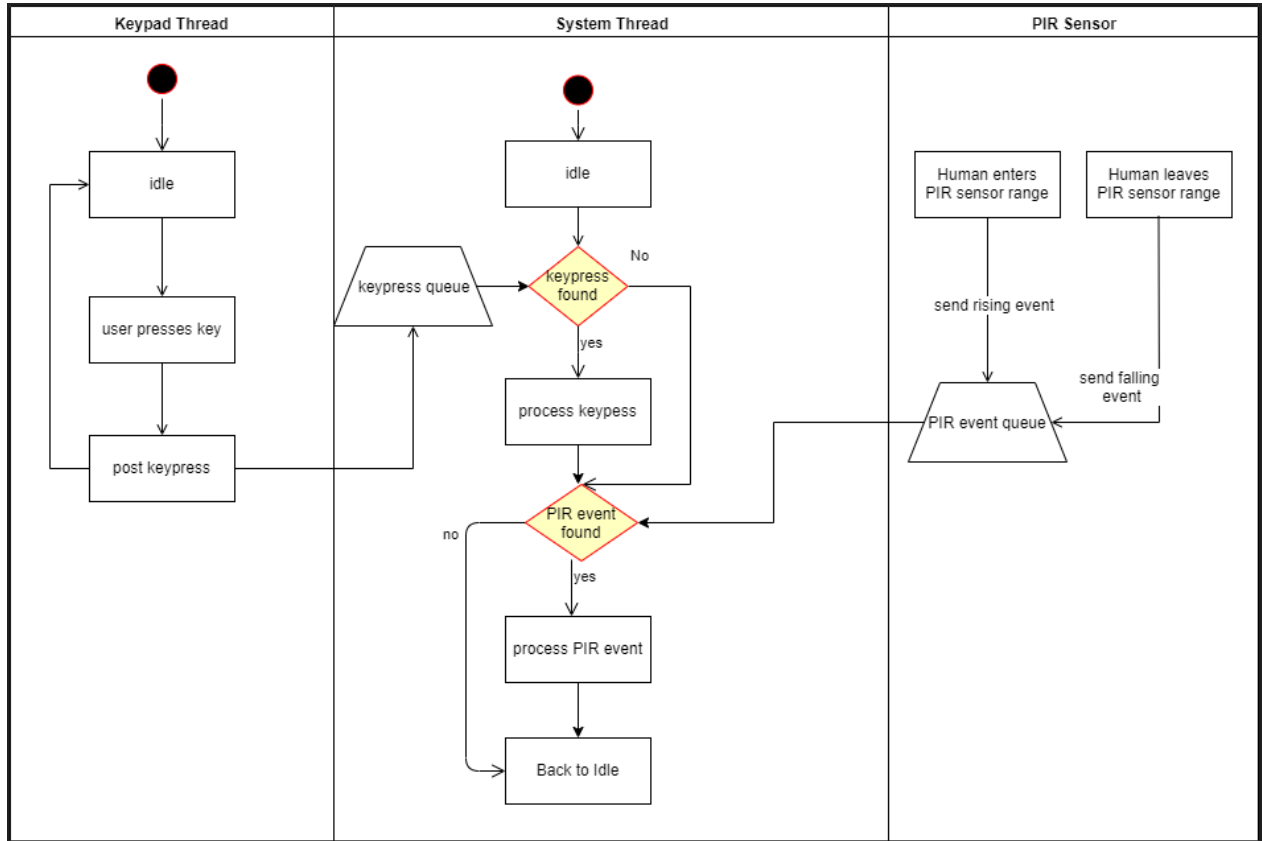


Figure 2: Activity Flow diagram between Keypad, system, and sensor thread

## 9 Implementation details

### 9.1 Inputs

#### 9.1.1 PIR Sensor

The PIR Sensor will be used to detect movement within a room. For this project we will be using the HC-SR501 PIR Motion Sensor. PIR stands for Passive Infrared which means it doesn't use any energy to detect signals. The PIR sensor consists of a main component of the pyroelectric sensor which when exposed to heat generates an electric signal. A warm body emits infrared radiation (IR) and this pyroelectric sensor picks up this IR signal. On top of the pyroelectric sensor there is a Fresnel lens that bounces the IR signals onto the pyroelectric sensor.

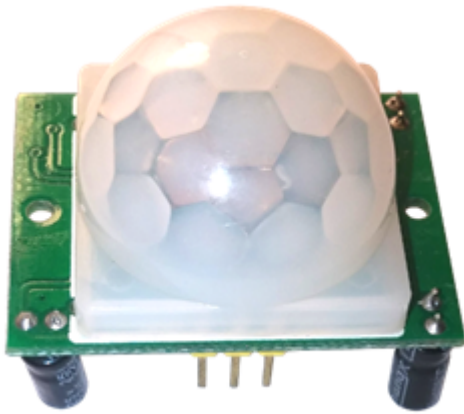


Figure 3: HC-SR501 PIR sensor

**9.1.1.1 PIR Sensor pin description** This PIR Sensor has 3 different pins: power, ground, and the output. The output pin will give a 5v or a 0v signal representing if the sensor has detected anything. 5v being that the sensor has detected IR signals and 0v for lack of IR signals. The power is expected to use 5v-20v input with 65mA current consumption.

**9.1.1.2 Adjusting the PIR Sensor** The PIR Sensor module has 2 potentiometers. 1. Adjusting the sensitivity of the sensor to reach up to 7 meters 2. Adjusting the time the output signal stays high when IR signals have been detected. The time can be adjusted between 0.3 seconds to 5 minutes.

**9.1.1.3 Trigger modes** The PIR Sensor module has a set of 3 pins to select the different types of trigger modes. 1. Non-repeatable trigger mode : This is when the PIR Sensor has been triggered and the output time has lapsed, the output signal will automatically go back to zero 2. Repeatable trigger mode : Similar to mode 1 but once the output time has lapsed and the IR signals still are detected the output would remain high. In a security system the Repeatable trigger mode is what we are looking for. For different applications like backyard light for night where you might only want to have it on for a short period of time.

**9.1.1.4 PIR Sensor stabilization** The PIR Sensor when powering up needs to have about a minute to stabilize to adjust to the area before any valid outputs will occur. The average IR gets computed during this time and when a warm body comes into range, that's where the spike of IR signal will occur causing the PIR Sensor to signal activity has occurred.

**9.1.1.5 PIR Sensor add ons** The HC-SR501 PIR Motion Sensor has the ability to connect up to a few other modules right on this board for different applications. You can add a light sensitive resistor or a photo resistor. This can be used with the PIR Sensor so that it will make it only active in the dark. There is another place to add a thermal sensor which can factor readings into the PIR Motion Sensor.

**9.1.1.6 Initial testing** Before connecting up the Raspberry Pi this PIR Sensor can be tested without reading the output values pin. To do this experiment there needs to be an LED connected from the output pin to the ground pin. After the PIR Sensor has stabilized the LED will then turn on when IR signals have triggered the PIR Sensor. This was a good way to test out the PIR Sensor before adding any of the complexity of the Raspberry Pi.

**9.1.1.7 Interference** Late into the project we experienced some weird behaviors where the PIR sensor would keep triggering movement even though there was no movement in the room. After some research it looked like it could have been the Raspberry Pi Bluetooth module and/or the WiFi module causing interference. Turning off the Bluetooth module did not help and we needed to have the WiFi on in order to connect to the internet. That being said we decided to add in another monitoring sensor as a back up which was the Ultrasonic Sound Distance Sensor.

Source for some of this data: [https://www.youtube.com/watch?v=ZC\\_sEW3\\_694](https://www.youtube.com/watch?v=ZC_sEW3_694)

### 9.1.2 4x4 Membrane Matrix Switch

In typical security systems the Smart Security System needed a physical device for a user to arm and disarm the security system. The sensor kit that we used had a 4x4 membrane matrix switch that would work perfectly in our prototype.

This keypad has 16 individual keys but our Raspberry Pi only has a limited number of inputs. That means we need to multiplex the keys in order to achieve less inputs into the Raspberry Pi. Here are the following steps in order to achieve our matrix 4x4 for all 16 keys 1. Set the columns as outputs to High 2. Set the rows pins as inputs with pull-up resistors 3. While checking for an individual key has been pressed, 1 at a time the output will be set to Low. 4. While the 1 output is set to low, we will check if any of the inputs as set to Low, this will indicate that a button as been pressed 5. In order to avoid sending multiple keypress events while the button is held down, the system will wait till that Low becomes High again

System design on how to use the keypad class: <https://drive.google.com/file/d/1uPLhLkEPWDThYCvWuJ4w6HXwep1SSEe/v>

The Keypad creates its own thread to capture all the key presses and then sends each key press into the queue. The intention would be there is a separate thread that would process the keys using the queue



Figure 4: 4x4 Matrix membrane switch

### 9.1.3 Playstation Eye Camera

When looking for camera modules for the Raspberry Pi there were many different options. Some camera modules used the on board camera connections but they ended up being more expensive. It was a surprise that the PS3 Eye which was intended for the Playstation 3 for their motion controllers were the lowest cost at \$10 and they had support for the Raspberry Pi's using the motion library. This made an easy decision and was relatively easy to integrate with the Raspberry Pi. We did have to end up upgrading the USB Power supply to Raspberry Pi to make sure it would get enough current to support driving the PS3 Eye.



Figure 5: PS3 Eye

### 9.1.4 Ultrasonic Sound Distance Sensor(HC-SR04)

The HC-SR04 was a late addition to the hardware components but was required due to challenges with the PIR sensor which was highlighted in the PIR Sensor section. The Ultrasonic Sound Distance sensor is an amazing little device that uses sound to measure distance to the 3mm resolution. It can measure distances between 2cm and up to 4m or 13 feet which is perfect for our prototype.

**9.1.4.1 How it works** The Ultrasonic Sound Sensory works by shooting out 40kHz sound from 1 speaker and then listening using the other speaker for the sound to return. Using the speed of sound we can calculate how far an object is from the sensor. There are 4 pins on the device: ground, vcc(5v power), echo, and trigger. In the software the Trigger pin is set to high for 1 microsecond, then we measure the time it takes for the echo pin to go from low to high and back to low. We can calculate the distance with the following formula  $\text{distance} = \text{time} * \text{speed}$ . We know the time in micro seconds. The speed is the speed of sound which is 340

m/s. We can then use this formula to calculate the distance in cm:  $\text{distance} = \text{measured\_time} * 34300 / 2$ . We divide by 2 since the distance was down and back.

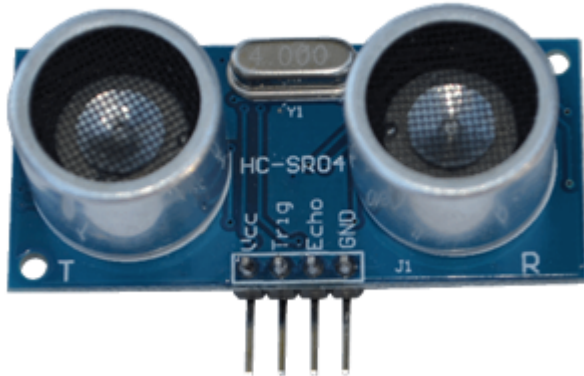


Figure 6: HC-SR04 Ultrasonic Distance Sensor

## 9.2 Outputs

### 9.2.1 LED Module

The LED module is the main localized visual to let the system owner know what the system is doing. This LED will give live feedback in the event the user enters the PIN from the keypad acknowledging of a successful entry or a bad entry. This is an RGB led that allows for red, green, blue or any combination of the colors to represent status of the system. It was found out that the only combination of colors that was dent was green and red to make yellow.



Figure 7: HC-SR04 Ultrasonic Distance Sensor

## 9.3 Services

### 9.3.1 Watson Graphs

The IBM Watson service has a ton of different things from processing speech to text, text to speech, searching things online, and many more. While investigating how Watson could be integrated with the Smart Security system it was found that Watson could create time series graphs of events. This complemented the Smart Security system well since we have many different events such as movement detection, arming the system, and when the alarm is sounded.

Integrating the Watson graphs were relatively easy to set up. The events just needed to be created from the Watson web interface and then the system just needed to connect up to Watson and send the defined events.

Here are some pictures of the graphs that Watson creates

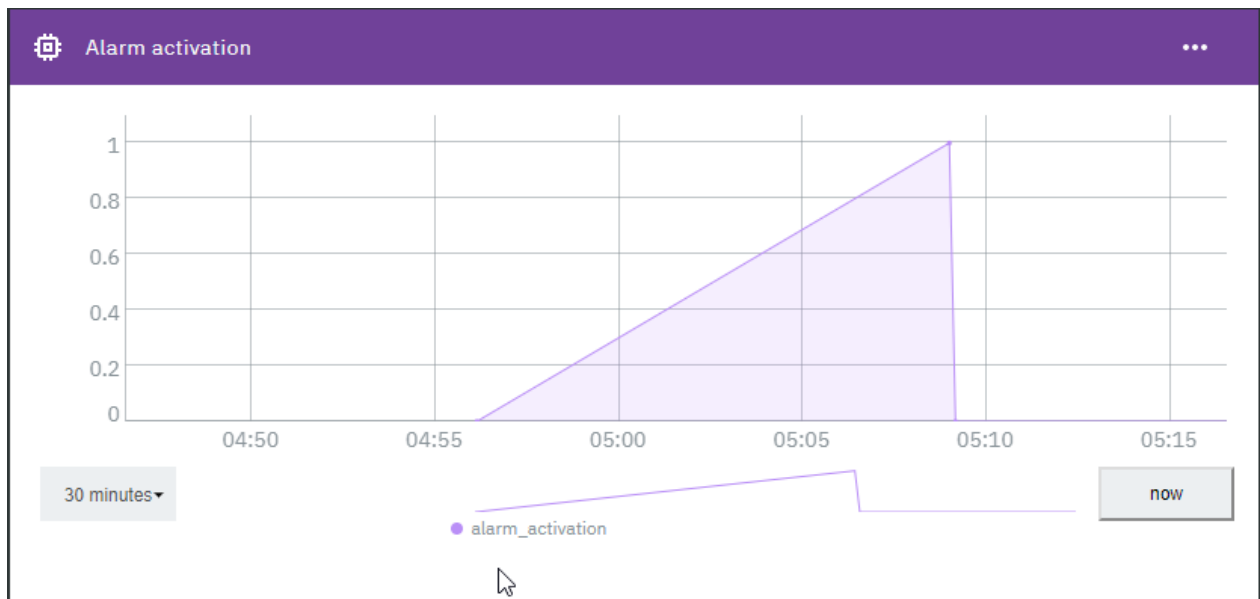


Figure 8: Alarm activation

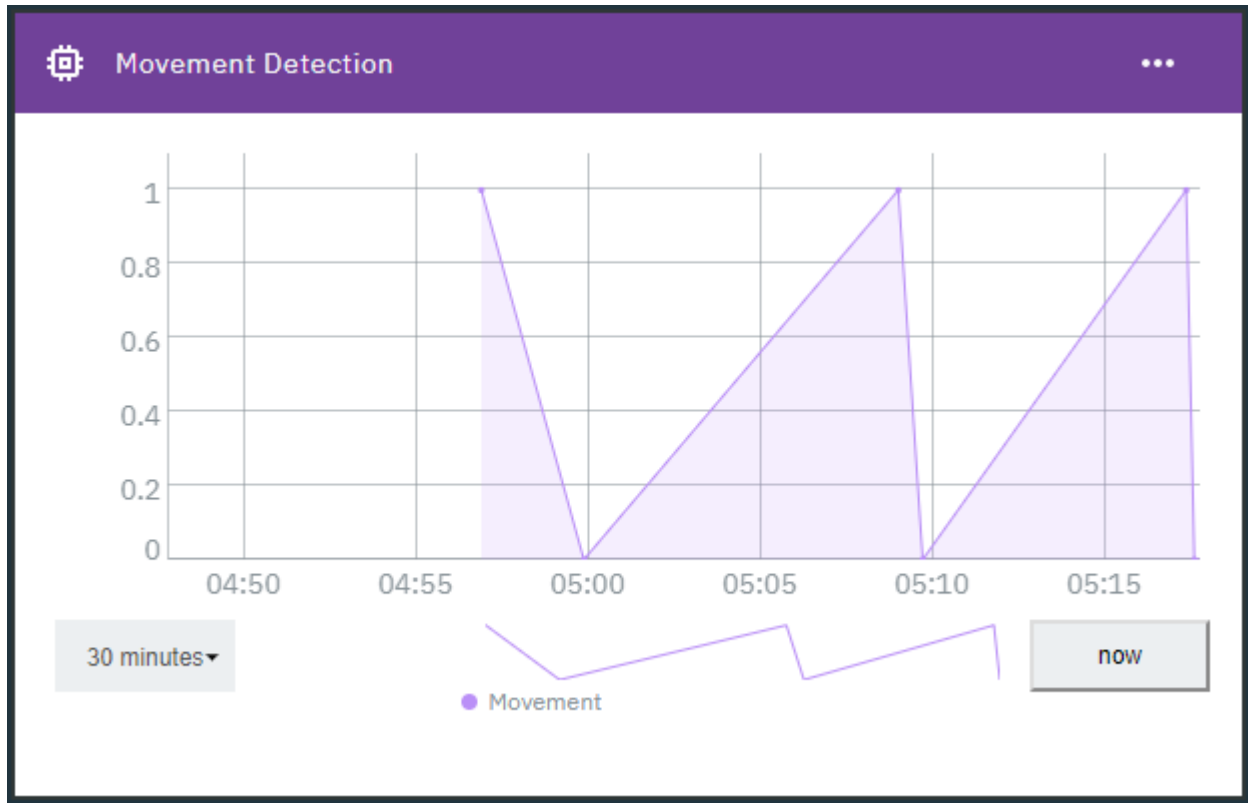


Figure 9: Movement Detection

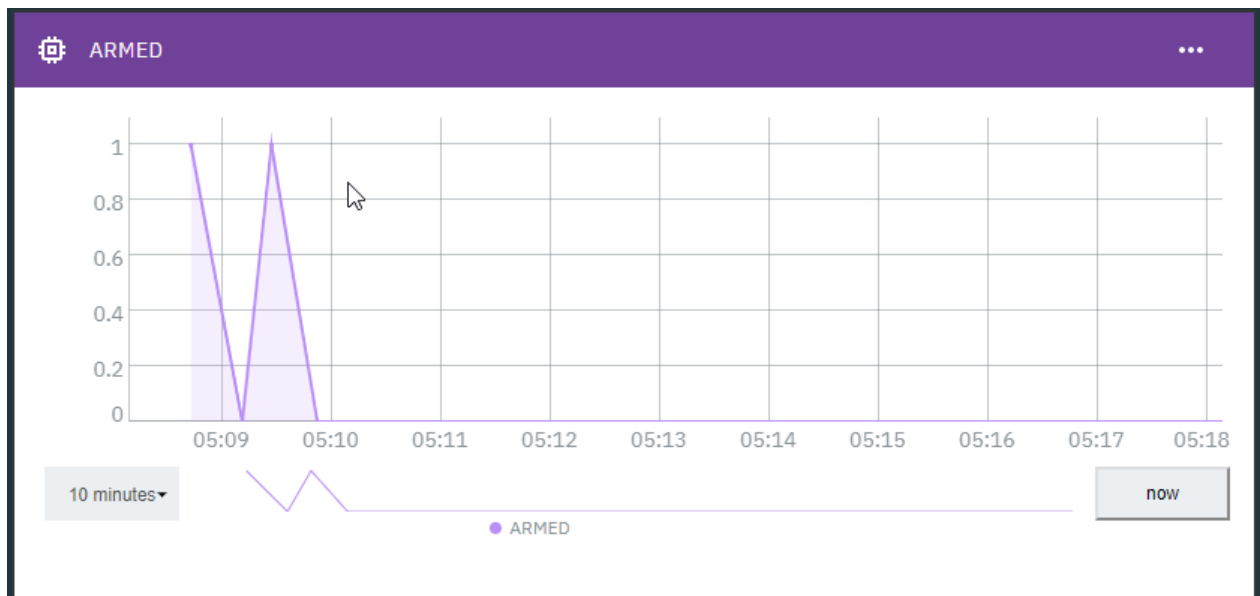


Figure 10: System Armed



**9.3.1.1 Challenges** Ideally it would be nice to embed these graphs in our user interface but it doesn't look like Watson has the capability to share these graphs publicly. The only way you can view them is to be on an authorized email list and you have to login to IBM's Watson system.

**9.3.1.2 Considerations** For the Smart Security system we considered using voice activation to arm and disarm the system but in the end it seemed like a security risk in the event that it didn't function properly or if an unauthorized user found out about the verbal pass code. Possibly in the future when Watson can self identify someone based on their voice then this could be a great feature to add to this Smart Security System

### 9.3.2 Google Calendar as smart enable system

The concept of the Smart Security System would to leverage the use of the Google Calendar to know when the system should be monitoring for intruders. The system will periodically monitor for calendar updates. It will also activate and deactivate the alarm system based on which events are running.

**9.3.2.1 Determining when to monitor** There can be a few different ways to determine when the alarm system should be activated.

1. Alarm only on during meetings - With little interactions this will make it simple for the system to only be monitoring when there is a meeting happening. This could be problematic too because its possible that someone might be working from home and they might have a false positive . A way to combat this will be introduced in the next option
2. Labeled meetings - Adding some keyword to signify if during this meeting the system should be be monitor mode. This does leave some room for error if someone forgets to tag the meeting that the system should be monitoring.
3. Complete separate alarm events - Another option would be to completely separate the events in their own type of meeting to signify only for monitoring.
4. First and Last meetings - Automatically create a range where the system will be active the start of the first meeting till the end of the last meeting. This still has holes since some meetings might take place at the home of the system owner.

Due to the time constraints we will be using 1, for our purposes to show that we can interact with the Google Calender

**9.3.2.2 Considerations** Along with the alarm events is possible to connect up with the user's phone GPS to allow for the system to automatically activate based on the GPS coordinates. Having some kind of range when someone leaves 0.5miles from home then the system could be activated automatically.

### 9.3.3 Motion library

Since the semester is a short time frame our team tried to leverage as much open source software as much as possible. Our initial setup of getting the PS3 Eye Camera working used a library called motion. This library is highly configurable and can support many different types of cameras. It was not designed specifically for the Raspberry Pi but has supporting plugins to help communicate to the cameras. Its intended platform is Linux based and was also intended to be used as a way to monitor multiple cameras. Project website: [https://motion-project.github.io/motion\\_config.html](https://motion-project.github.io/motion_config.html)

This library was used to capture images from the PS3 eye and also record video when requested. When viewing the live stream the image will update once a second. Because the Raspberry Pi doesn't have a strong CPU, the stream only updates the image once a second. It is possible to update to have more frames per second but based on the research the Raspberry Pi can get bogged down quickly and we don't want this library to interfere with the main security system.

**9.3.4 Flask framework**

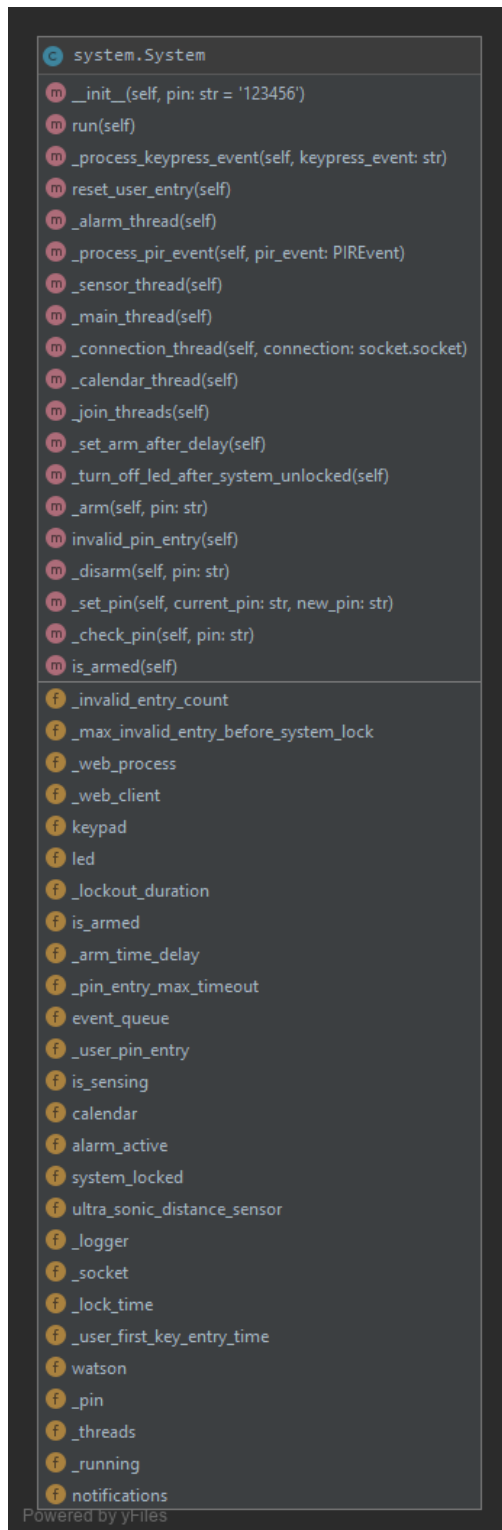
TODO - Add details as to why Flask was chosen TODO - add details how it works & how it interacts with the main system TODO - Add screenshots of the UI TODO - add any considerations we might have

**9.3.5 Twilio notifications**

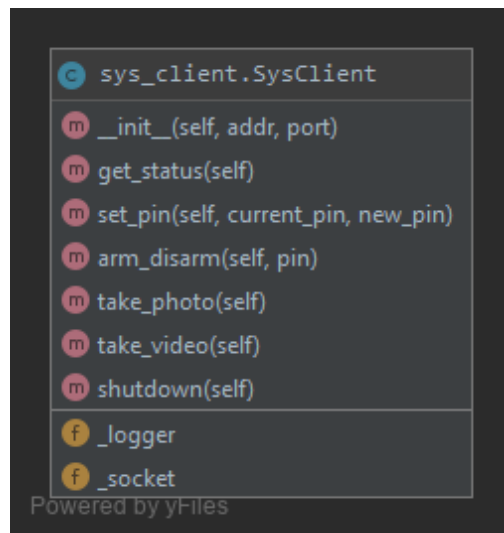
TODO - Add details as to why Twilio was chosen TODO - add details on how it works and how it was integrated into the main system TODO - add any considerations

## 9.4 Class Diagrams

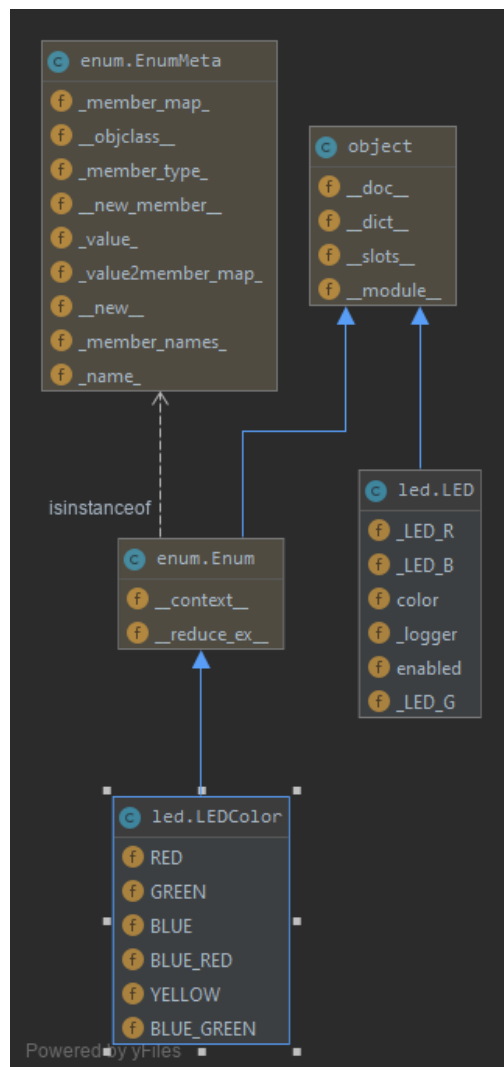
### 9.4.1 System class



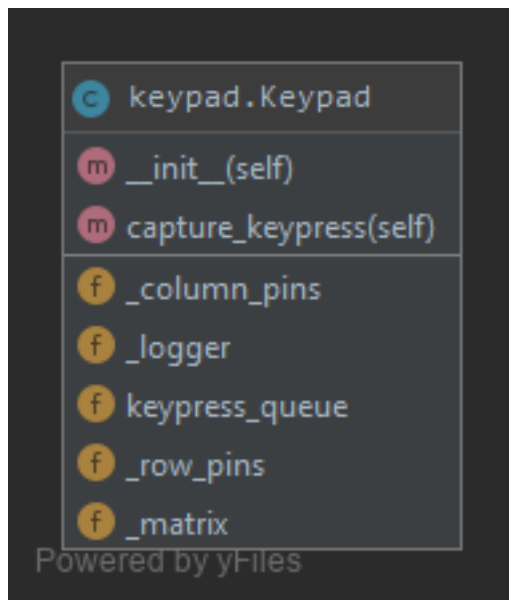
## 9.4.2 Sys Client



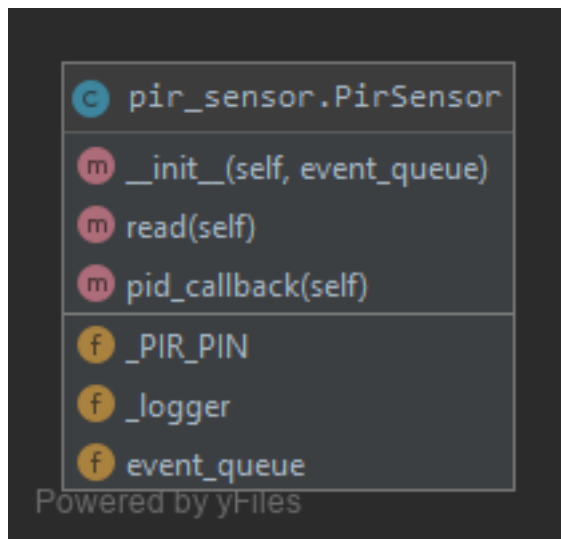
## 9.4.3 LED module



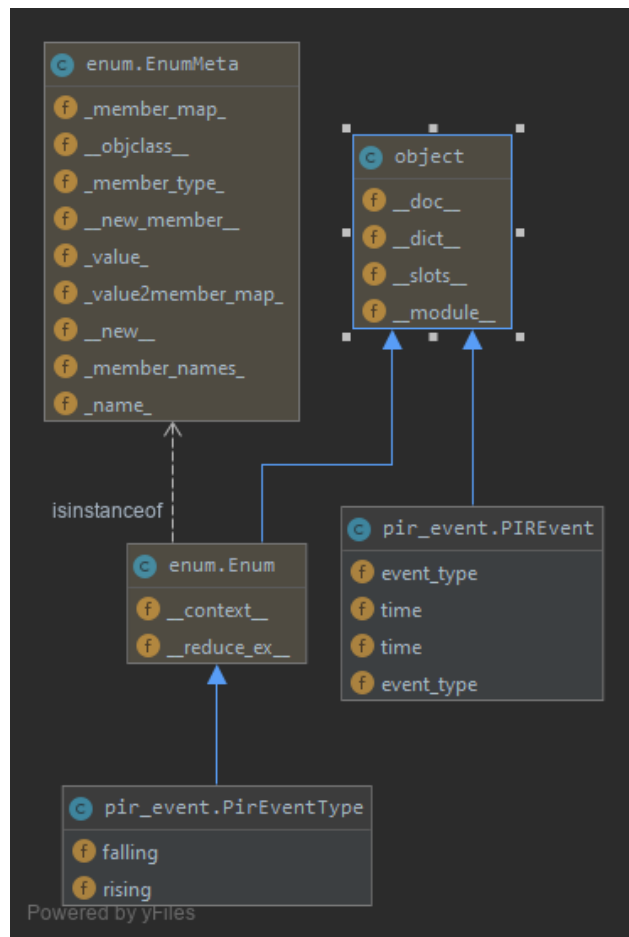
#### 9.4.4 Keypad



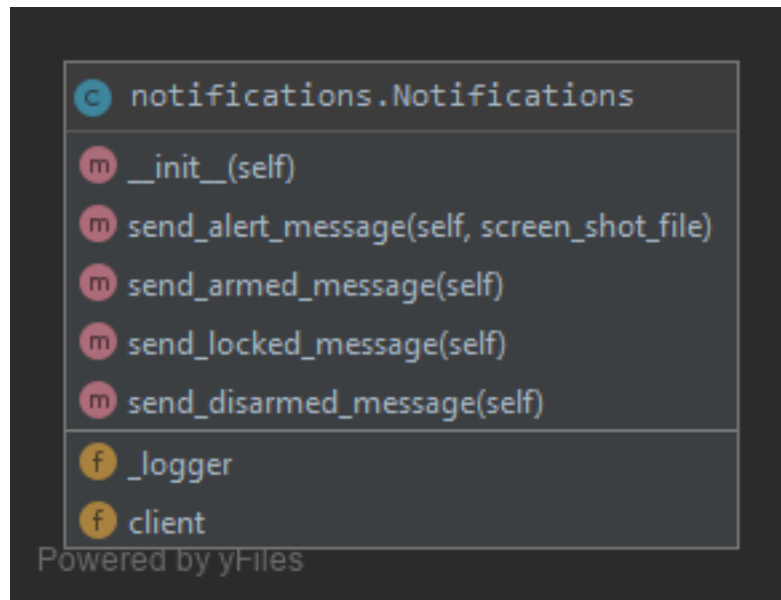
#### 9.4.5 PIR Sensor



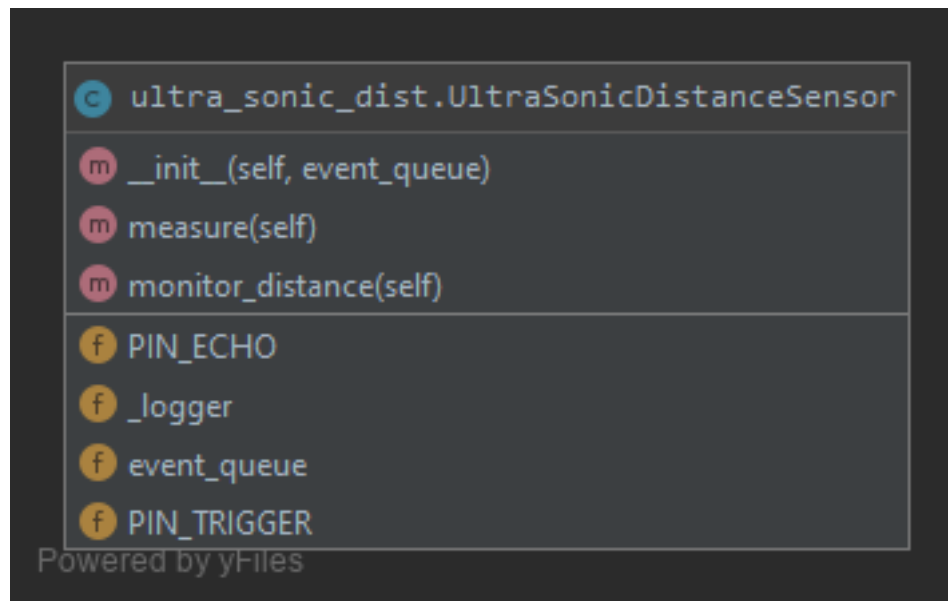
## 9.4.6 PIR Event



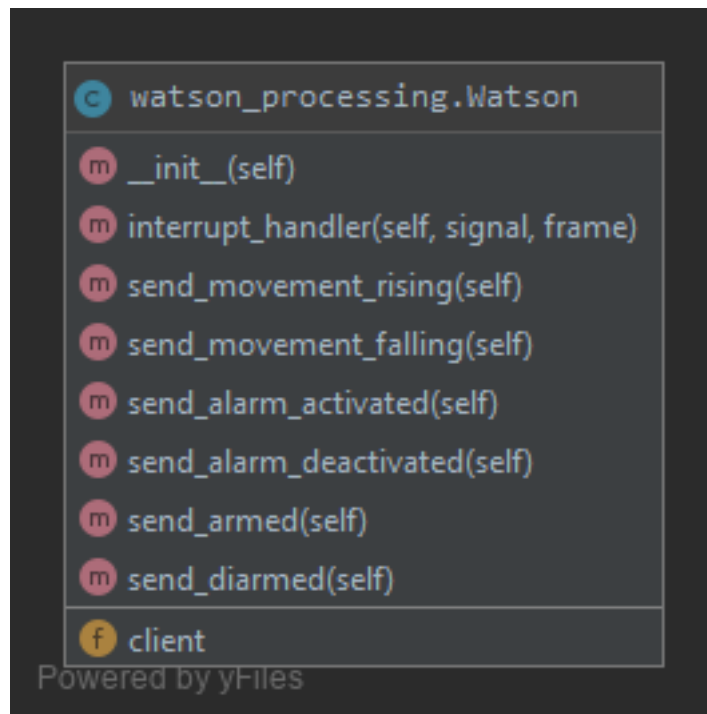
## 9.4.7 Notifications



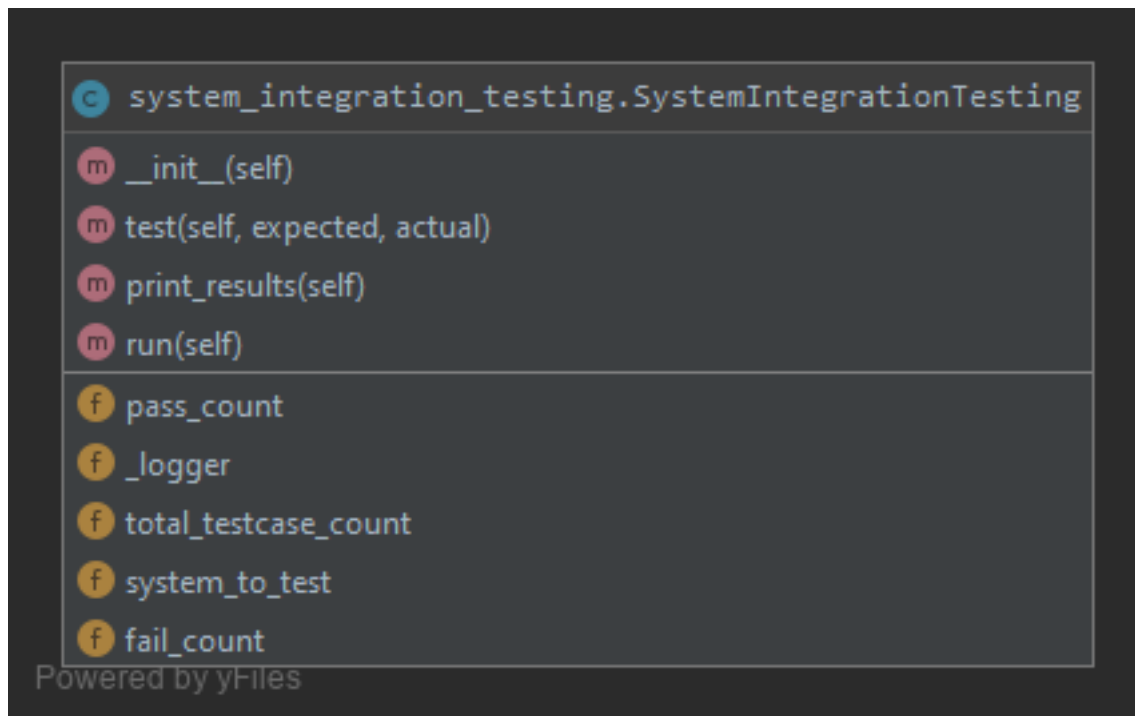
## 9.4.8 Ultrasonic Distance Sensor



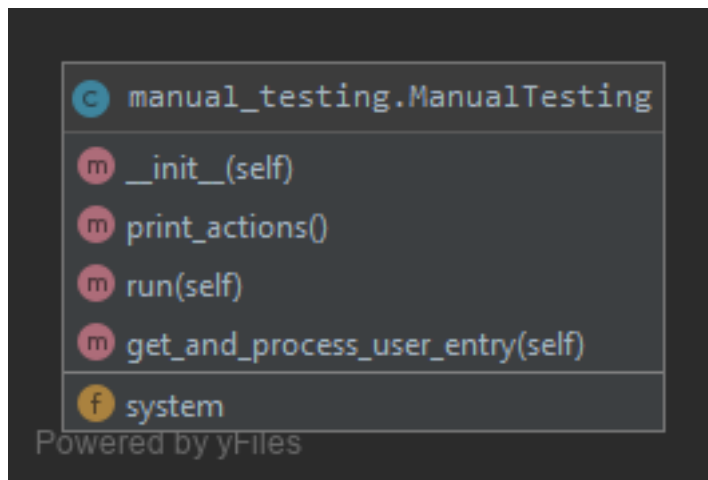
## 9.4.9 Watson



#### 9.4.10 System Integration Testing



#### 9.4.11 Manual Testing



### 9.5 Development Environment setup

Since our team was made up of people in many different locations we needed a good way to communicate, develop, and test our system. For our source control and task management, we used GitHub. It was a nice way to organize our work and prioritize what needed to get done. In order to use the actual Raspberry Pi remotely there needed to be some channels opened up to allow for file transfer and remote access. FTP/SSH was opened up for that purpose and VNC was enabled for remote access to the Raspberry Pi.

#### 9.5.1 Tools

- Filezilla - File transfer system to move files from a local computer to the remote Raspberry Pi



- Putty or any SSH program - This program is used to tunnel into the terminal of the Raspberry Pi which would be used to run scripts
- Python file editor like Notepad++ or PyCharm - This is intended to be used to create the python files on your local host. Because some of the scripts need hardware outputs, most might only be able to be tested using the remote Raspberry Pi
- Real VNC client - This will be used if someone wants to visually see the Raspberry Pi desktop. In most cases this might not be needed but its good to have this option available

### 9.5.2 Port Forwarding on router for SSH

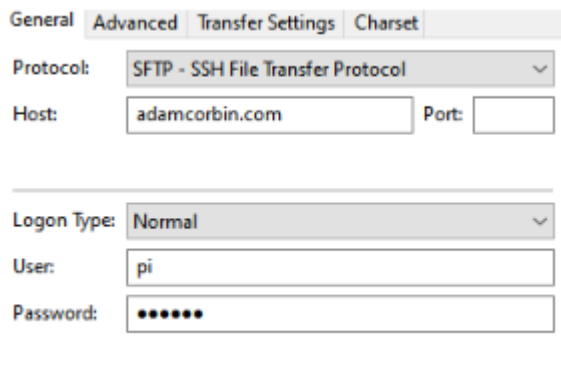
In order to get the SSH and FTP working the router need to open up the ports to the outside world. Otherwise the router would just block all requests and it would appear if something isn't working.

The following ports were opened up:

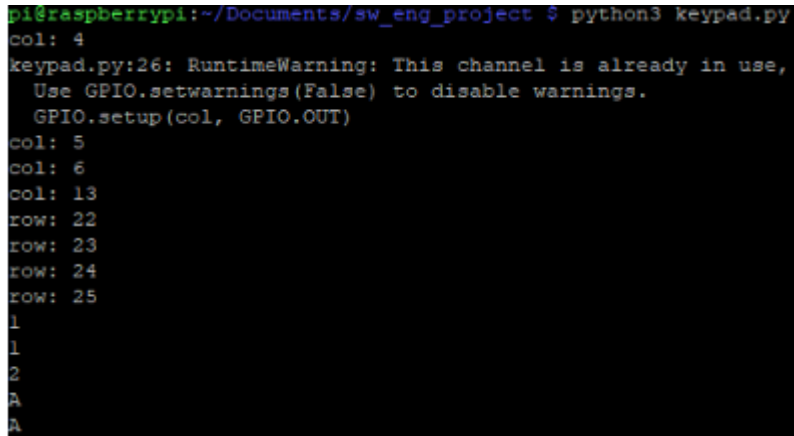
- Port 22 for SFTP transfers
- Port 2022 for SSH communications
- Port 5901 for VNC
- Port 8081 for camera streaming using motion

### 9.5.3 Work flow to editing and testing out code

1. Locally clone repo from <https://github.com/AdamCorbinFAUPhD/CEN5035-Software-Engineering-Course-Project>
2. Make changes to the files if necessary
3. Send files using FileZilla
  - Setup of FileZilla
  - Screenshot of the settings of the server



4. From putty you can run the python files by doing: "python3 file.py"



```
pi@raspberrypi:~/Documents/sw_eng_project $ python3 keypad.py
col: 4
keypad.py:26: RuntimeWarning: This channel is already in use,
  Use GPIO.setwarnings(False) to disable warnings.
  GPIO.setup(col, GPIO.OUT)
col: 5
col: 6
col: 13
row: 22
row: 23
row: 24
row: 25
1
1
2
A
1
1
2
A
2
2
3
3
A
A
A
A
```

5. If you need to make any changes do it from your local computer and then use FileZila to transfer the file over to retest

#### 9.5.4 Real VNC

In the event that someone would like to remote into the Raspberry Pi desktop RealVNC was installed on the Pi. In order for this to work on someones local computer, their email would need to be added to the approved email list. Once added to the list, all thats needed is to download the local client to communicate to the server on the Raspberry Pi.

## 10 Verification

TODO go into some test cases

TODO go into the manual testing

TODO go into the auto testing

## 11 Team Member Contribution

1. Adam Corbin: Product Owner
2. Malia Kency: Individual Contributor
3. Stincy Dumerjean: Individual Contributor
4. Jared Peterson: Scrum Master