Private Cloud Storage Using Raspberry Pi

Project Workbook

By

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Literature Search, State of the Art

Literature Search

The Internet of Things (IoT) has been defined in Recommendation ITU-T Y.2060 (06/2012) as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. [1]

According to Gartner's Hype Cycle of Emerging Technologies 2014 [2], Internet of Things is predicted to reach its maturity or the "Plateau of Productivity" in the next 5 to 10 years. This is a considerable improvement over Gartner's 2012 prediction of 10 to 20 years. This clearly implies that IoT is soon going to reach mainstream success and now is the perfect time for innovation.

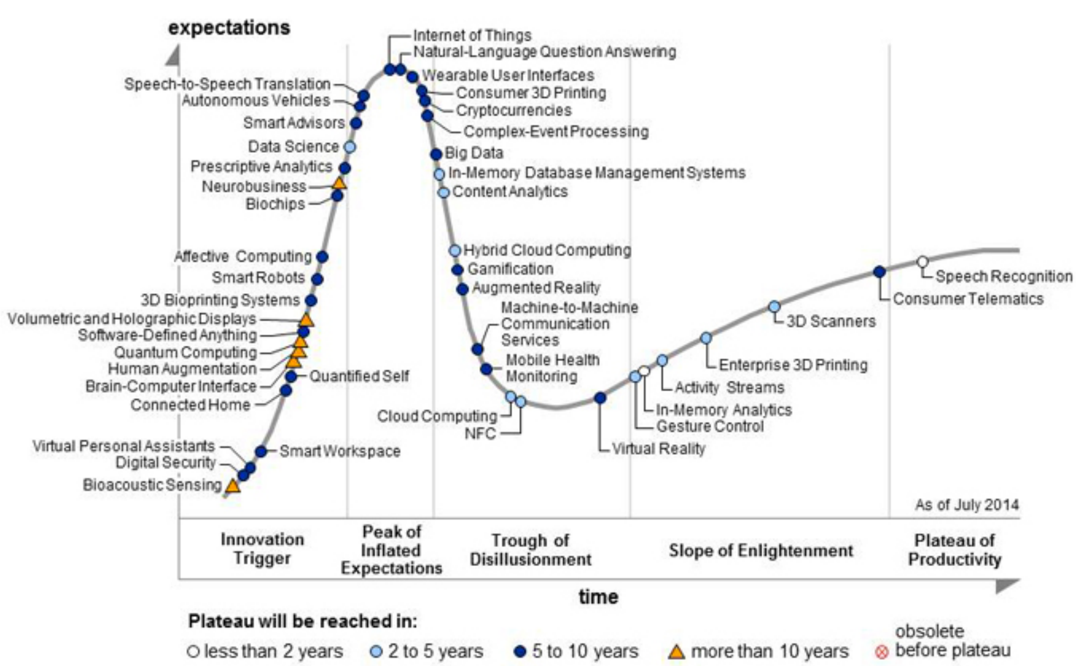


Figure 1. Gartner's Hype Cycle for Emergenging Technologies

Internet of Things in its most basic form is communicating with everyday objects with the help of the internet. The typical components of an IoT are *things,* which can be objects such as thermostats, light-switches, water-sprinklers, blenders, stovetops, etc.; *internet,* which wirelessly connects these objects to the internet and an *application,* which can be a web application, mobile application or simply a computer which can be used to manage the data transmitted by these objects. The main purpose of IoT is collecting data from these devices. This data collection is enabled by RFID tags or sensors embedded in the devices.

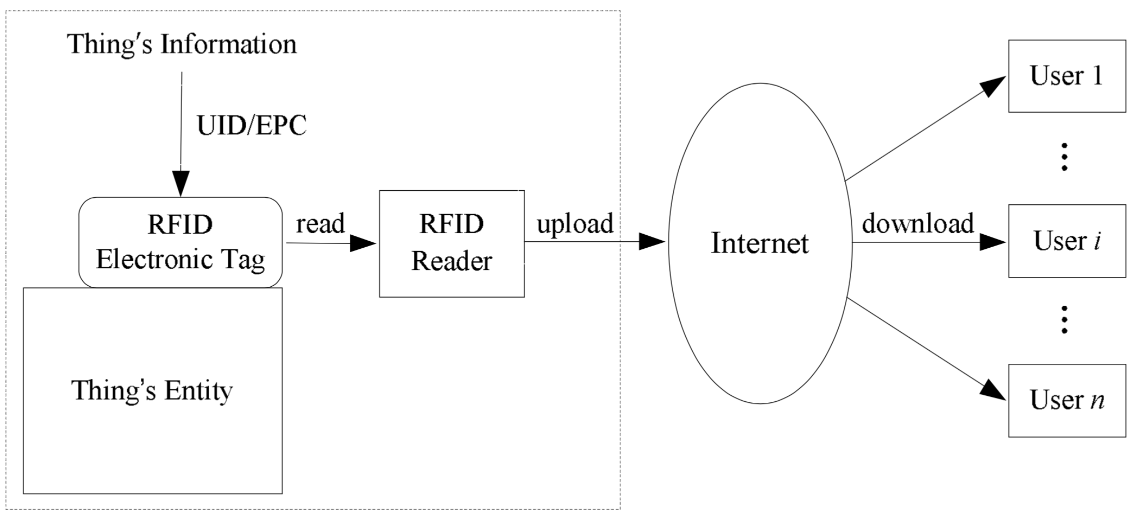


Figure 2. Architecture of IoT [3]

Smart homes are at the center of the IoT revolution because a large number of devices that can be connected to the Internet are available at our homes. Currently, the following IoT products are the most popular for smart homes:

Belkin WeMo

Canary

Our project lies under the smart home category. There are two parts to it: (1) An auto-backup feature and (2) a smart home-camera solution.

The auto-backup feature:

The purpose of the auto-backup feature is to trigger a backup from any of the connected smartphones to our Raspberry-Pi controller on a press of a single button. The idea is to create a mobile/web application that aims at backing up the entire phone data to our controller with minimal user input.

The smart home-camera solution:

This feature will keep a track of all the visitors visiting the user's home when he/she is away by clicking their picture from the home security camera and maintain a database. The user can then refer this database to look for any suspicious person who may have visited their property.

State-of-the-Art Summary

Following are the cutting-edge technologies that can be implemented in our project:

Sensors

Sensors are at the heart of IoT devices. For IoT applications various types of sensors that can be used are as follows:

Proximity sensors: They measure how close an object is to the sensor

Accelerometer: They measure the lateral movement of the sensor

Gyroscope: They measure the radial movement of the sensor

Temperature sensors, humidity sensors: Measures the ambient temperature and humidity

Light sensors: Measure the intensity of the ambient light

Pedometer: Measures the number of steps the user has taken

Communication Media

For the sensors to transmit their data they need a reliable medium, following are the latest developments: [4]

RFID: Radio Frequency Identification is one of the strongest contenders in implementation of IoT. Primarily because of its low power requirements and it does not need an additional power source. RFID has evolved to a very small size that is ideal for

IoT applications. [5] The recent advancements in RFID technology have been implementation of Wireless Power Transfer (WPT) and Energy Harvesting (EH)

IEEE 802.11: This communication standard commonly known as WiFi is used to send and receive wireless signals, data, etc. over a fixed short range. WiFi usually operates in 2.4GHz – 60GHz frequency band and supports data speeds upto 6Gbps. This is a strong candidate as a communication medium for IoT because of it's widespread use and ease of installation.

Bluetooth Low Energy: The latest Bluetooth core specification 4.2 brings improvements targeted specifically at IoT. It helps connect to IoT devices in a better and efficient way. The most important improvement is lower power IP connectivity that is essential in such small low-powered devices. It also implements a flexible version of Bluetooth Smart's GATT architecture. [6]

References

1. Y. Huang, G. L. (2010). Descriptive models for internet of things. *August 13-15,*
2. STAMFORD. (2014). **Gartner's 2014 hype cycle for emerging technologies maps the journey to digital business**. Retrieved from http://www.gartner.com/newsroom/id/2819918
3. Special Interest Group. (2015). Bluetooth 4.2. Retrieved from http://www.bluetooth.com/SiteCollectionDocuments/4-2/bluetooth4-2.aspx#control
4. Recommendation ITU-T Y.2060. (2012). Overview of the internet of things. Retrieved from http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=y.2060
5. P. Suresh, J. Vijay Daniel, V.Parthasarathy, R.H. Aswathy. (2014). A state of the art review on the internet of things (IoT) history, technology and fields of deployment
6. L. Roselli, C. Mariotti, P. Mezzanotte, F. Alimenti, G. Orecchini, M. Virili, N.B. Carvalho. (2015). Review of the present technologies concurrently contributing to the implementation of the internet of things (IoT) paradigm: RFID, green electronics, WPT and energy harvesting.

Project Justification

In the current age of technological advancement where everything is “online” and connected to the internet, there are a lot of IoT products available for home automation. Most of them deal with automating the home devices making it possible for the user to control them remotely with help of a smartphone.

Our ideology behind this project is (1) to free the user of any device storage capacity dependency and to automate the backup process from his smartphone to the cloud and (2) make a controller communicate with an external smart camera device placed outside the house which records images of the people visiting the user’s house while the user is away. Security of the house is one of the reasons that we are trying to address.

We are expecting to minimize a user’s interaction with the storage applications and to relieve the user from the daily hassle of backing up the data in order to keep the smartphone from running out of storage space. Additionally, the second feature of the system will be to provide a home monitoring solution that logs the visitors chronologically and provide the user with the data to help him follow-up accordingly.

Our controller (Raspberry Pi 2) will be programmed to collect the data from the home security camera and help the user track any suspicious visitors or get in touch with the visitors whom the user missed.

Recent improvements in chip design and communication technology is helping IoT reach mainstream adoption. This has been rightly predicted by Gartner’s 2014 report on Emerging technologies.

Project Requirements

Use Cases

Use case 1: Auto-backup of Smartphone data

When the user's smartphone is detected on the home network, he/she will be provided with a prompt to go ahead with a backup of the smartphone's data. This data will be first stored on our controller i.e. Raspberry Pi and later could be moved to the cloud.

To perform this backup, a mobile app will be developed through which the user can schedule/approve backups.

Use case 2: Capturing images of visitors and storing them chronologically

The home security camera will take pictures of visitors ringing the door bell and store them in a database on the Raspberry Pi. These pictures will be presented to the user with the help of a dashboard on a web application. The user can go through the pictures to review security of the house and monitor any unknown persons.

Requirements

Functional Requirements:

Essential

Auto-backup: The controller should store the data from the mobile phone automatically

Visitor capture: The home security camera should capture the picture of every visitor

Desired

Intelligent photo backup: Specifically backup pictures from the mobile phone

Facial recognition: Recognize the faces of visitors using previous visiting history

Optional

Send auto messages to the visitors: All the known visitors will be sent a message which says “I’ll back by 8 PM”

Non-functional Requirements:

The auto backup should be seamless with minimal user interaction

The backup should not take a very long time to complete. The user should be provided with a progress report with an estimated completion time.

The home security camera should be placed outside the home in a way that it can capture the entire face of the visitor.

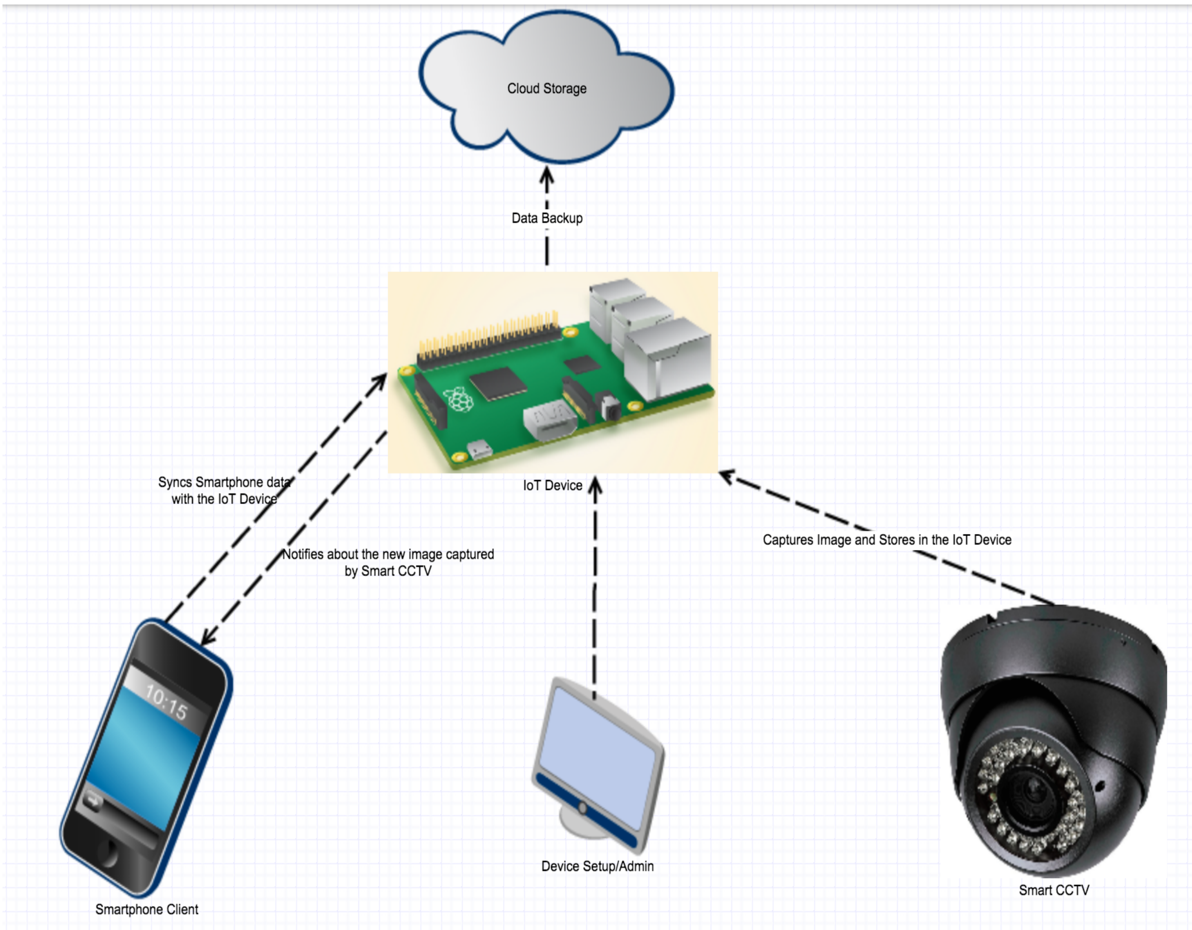
The controller (Raspberry Pi) should be configured to notify the user if and when it is running out of storage space.

Dependencies and Deliverables

Dependencies

1. Different set of sensors such as heat sensor, motion sensor etc. to test our system: This project is a prototype of IOT, built for a home to setup a private cloud for the home with a few extended features such as home security, temperature alerts etc. In order to test this system we require so sensors such as motion sensors which signal the camera to click pictures when something suspicious is sensed. As some of these sensors are not readily available and some of them are expensive, obtaining these sensors right in time might be a dependency for this project
2. Integration of the hardware sensors with the Raspberry Pi: The sensors have there own way of communicating their results with the controller, usually in the binary form 0's and 1's. Apart from the results they also send a garbage data which needs to be cleared before getting the actual values that are output by the sensor. Hence it is necessary to integrate the Raspberry Pi with the sensors so that it reads the actual values and discard the garbage values. In addition to this different sensors use different API's hence, integrating these sensors could be a dependency for this project.
3. Different set of home appliances such as printer, mobile phones and other wireless devices with wifi connectivity to test our system.

Project Architecture



Project Architecture

IoT Device: The IoT device could either be a Raspberry Pi or a Spark Photon. These devices entail all server related tasks such as syncing/storing data from the Smartphone, pictures taken by the CCTV and running application that notifies the client whenever the CCTV takes a new picture. The IoT device can either keep the data stored in its storage or can transfer data to the cloud for backup based on user preference. As an alternative user may have to delete old data from the IoT device once the storage is full in order to sync more data from their smartphone or store new images from the CCTV. Users can also connect to the IoT device to change default settings such as frequency of deleting old data, backing up data to the cloud, etc. of the device based on their own needs.

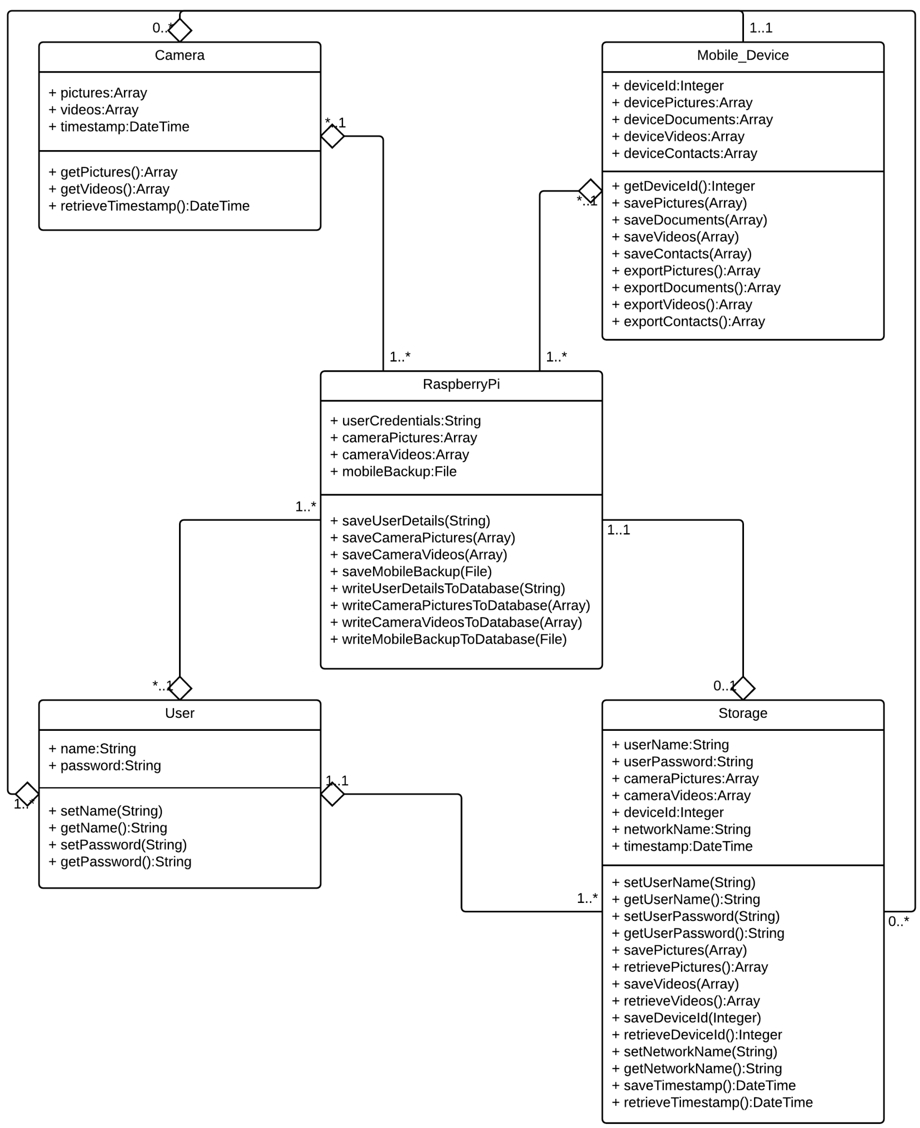
Smartphone Client: Client can be either an Android/iPhone smartphone, which directly interacts with the IoT Device over the local network. Once the smartphone is in the vicinity of the same network, authorized users can sync all their stored data from their smartphone client to the IoT device with a single click. This will allow the users to delete data from their smartphone without making an extra effort on filtering important data. The client receives a notification with attached picture that the CCTV camera takes and stores it in the IoT device. Thus, keeping the users updated about who all have been at their doorstep in their absence.

Smart CCTV: A motion sensor camera can be installed at the doorstep, which detects any movement and captures an image of the people who are at the doorstep. The CCTV is on the same network as that of the IoT device and sends the clicked picture to the IoT device over the network, which stores that picture.

Cloud Backup: The IoT device can connect to a public cloud storage, which allows the users to maintain backup of their data and delete the old data from the IoT device. This is an optional choice for the users based on their needs and preference. As an alternative user may have to delete old data from the IoT device once the storage is full in order to sync more data from their smartphone or store new images from the CCTV.

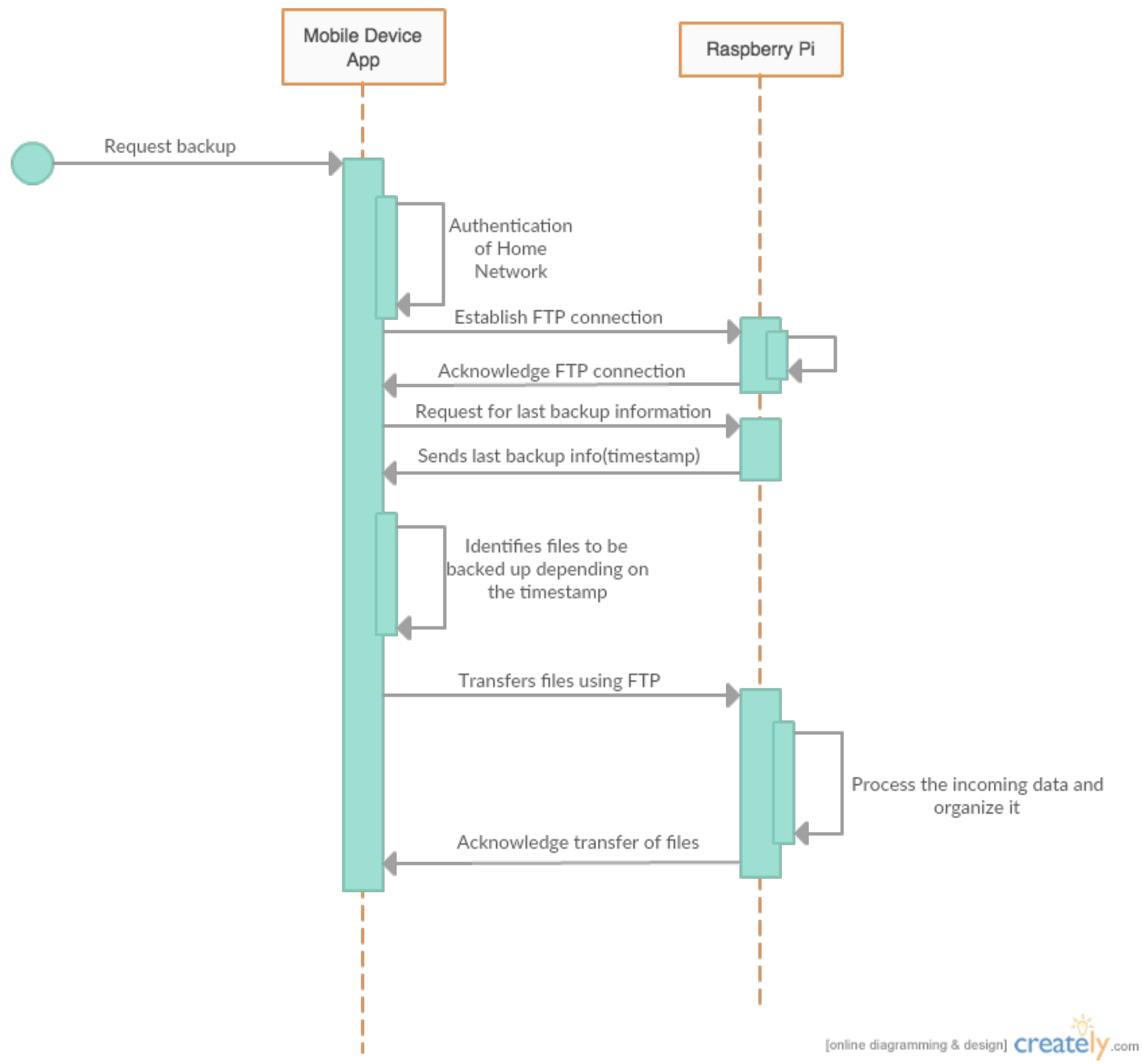
Project Design

Class Diagram

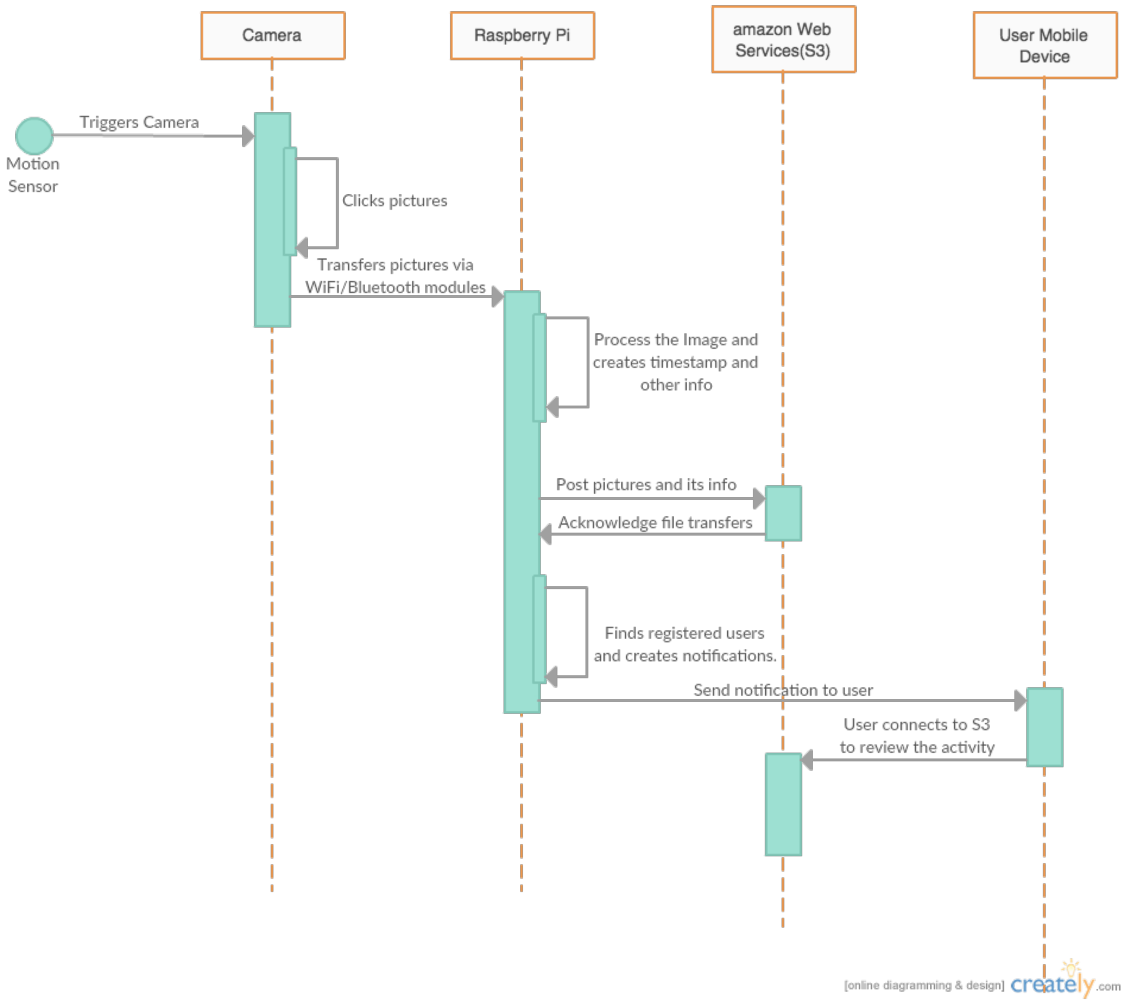


Sequence Diagrams:

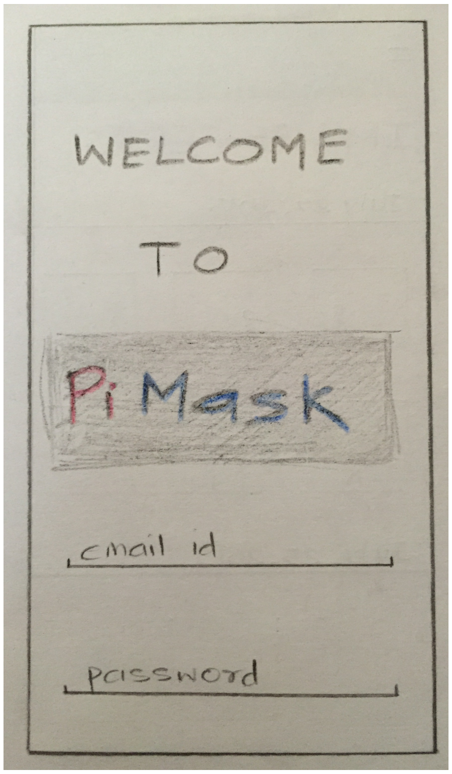
Use Case1:

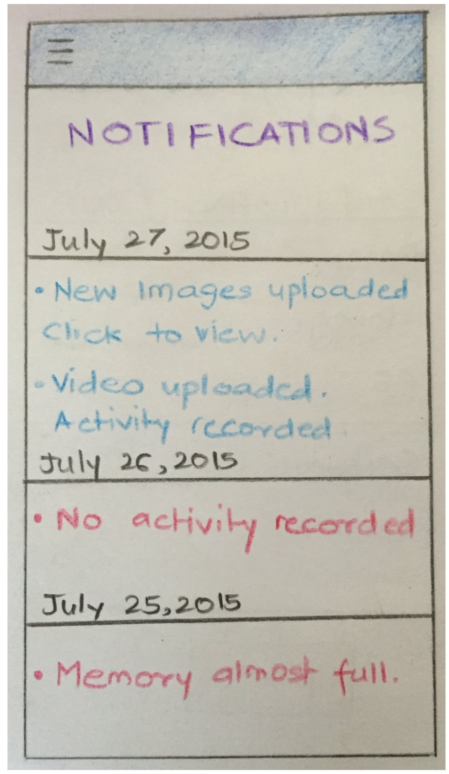


Use Case 2:


Camera
Raspberry Pi
amazon Web Services(S3)
User Mobile Device
Triggers Camera
Motion Sensor
Clicks pictures
Transfers pictures via WiFi/Bluetooth modules
Process the Image and creates timestamp and other info
Post pictures and its info
Acknowledge file transfers
Finds registered users and creates notifications.
Send notification to user
User connects to S3 to review the activity
[online diagramming & design] creately.com

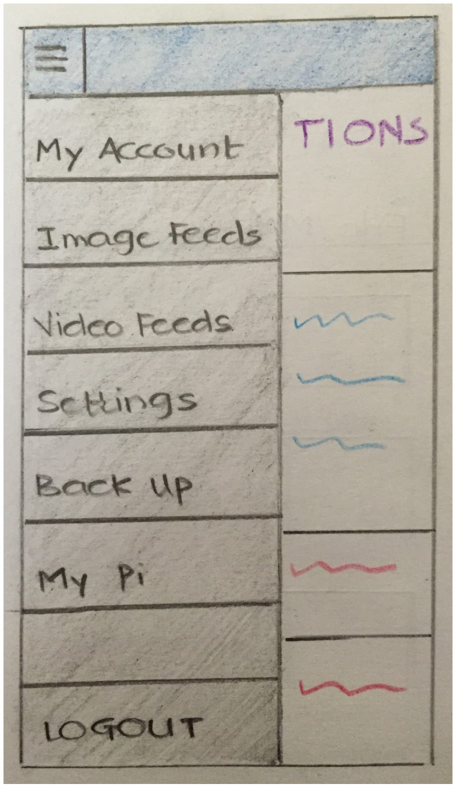
UI Mockup:

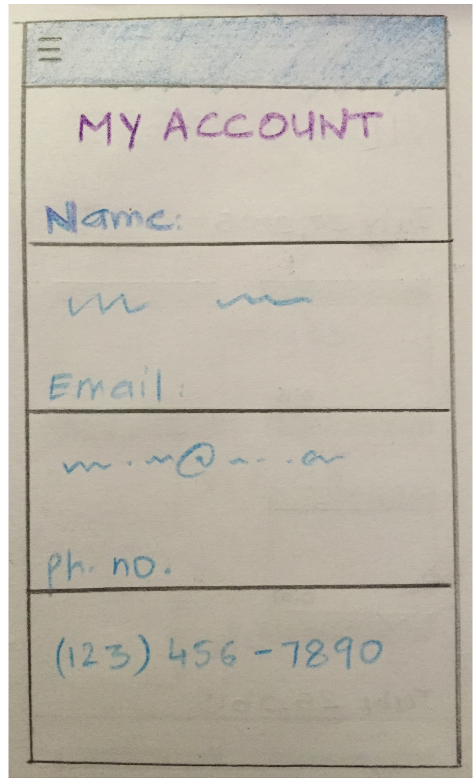


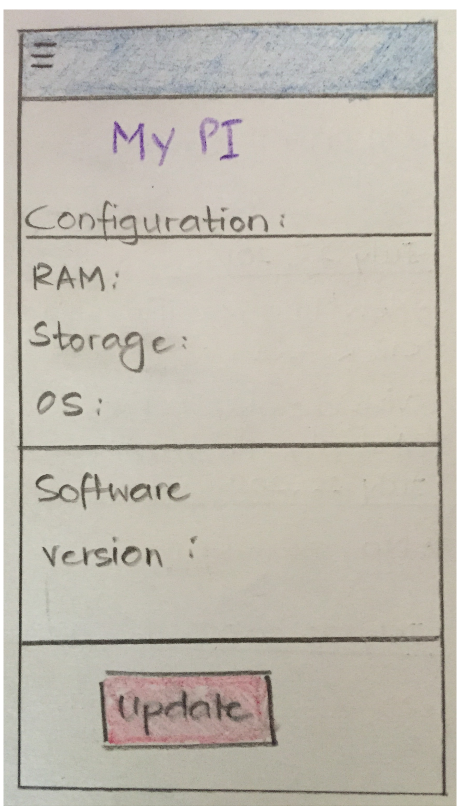


These eight mockups show the flow of the mobile application from the sign up page and going through each of the functionality.

The notification screen shows up once the user logs in. It is a summary of the updates of all the images and videos that were taken and uploaded by the security camera installed outside the user's house.


TIONS
My Account
Image Feeds
Video Feeds
Settings
Back up
My Pi
LOGOUT


MY ACCOUNT
Name:
Email:
ph. no.
(123) 456-7890


My PI
Configuration:
RAM:
Storage:
OS:
Software
version:
Update

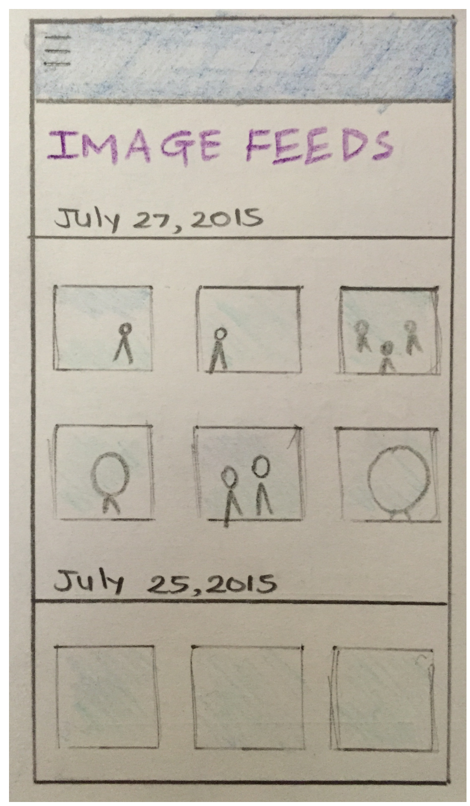
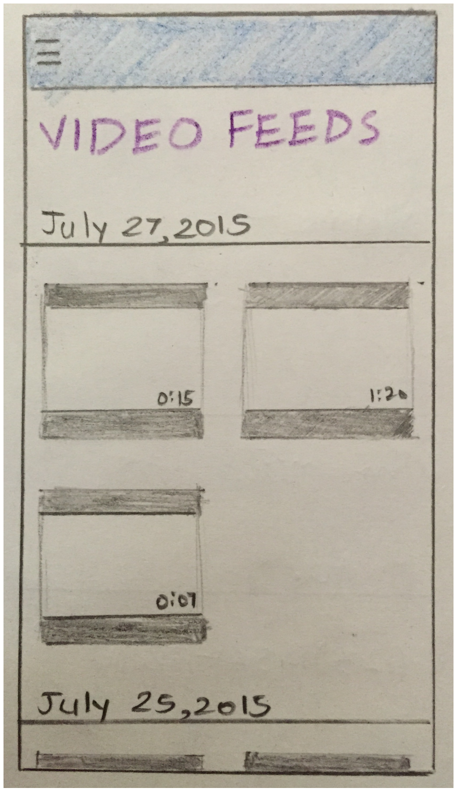
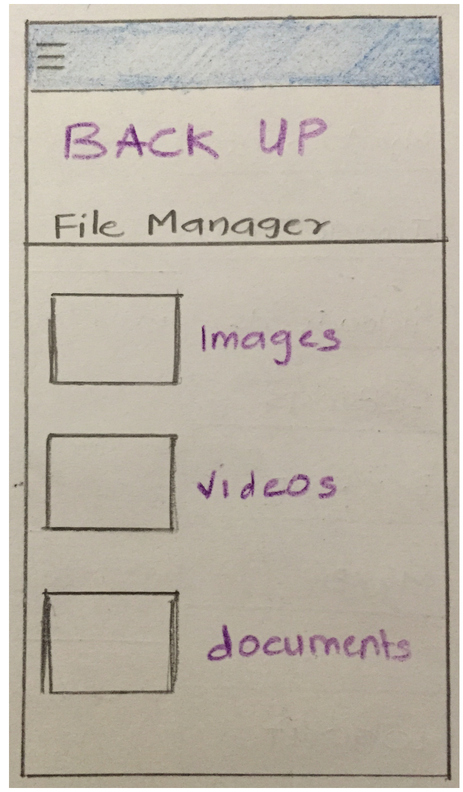


IMAGE FEEDS
July 27, 2015
July 25, 2015





The menu bar shows the other functionalities of the application:

1. User's Account details

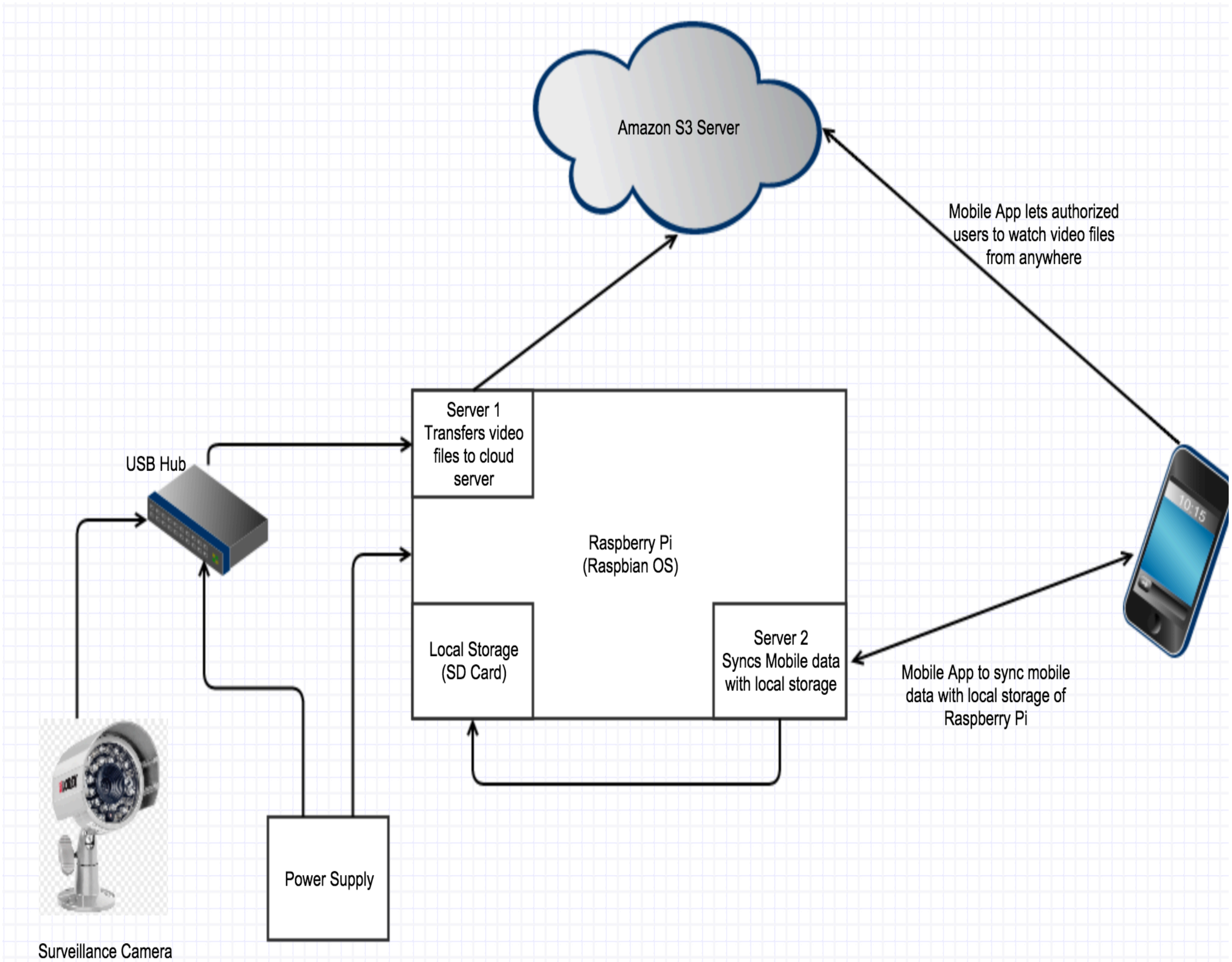
2. Controller's configuration

3. Images sent by the Camera

4. Videos uploaded by the camera

5. Backup file manager

Hardware Block Diagram:



QA, Performance, Deployment Plan

Quality Assurance:

1. Android UI Testing tool:

   One of the tools that we will use is the android UI testing tool. It will allow us, as developers, to estimate the quality of the user interface of the mobile application. It will also determine how effectively the users are able to use and understand the application and its functionalities.

   Once the test cases are written, it can be implemented in a separate test folder (src/androidTest/java). We will create a UI test that will span one single application. It is used to see if that particular app behaves the way in which the user expects while using it.

Deployment Plan:

- Mobile application for auto-syncing functionality will be developed first. This application is divided into two parts and they will be developed sequentially according to their logical order
  - First part of the application is implementing the file manager function
  - This is followed by developing functionality to sync the mobile device with the controller (RaspberryPi)

- This application will be required to be developed for two mobile platforms. Our team will be divided into two sub-teams, A and B. Teams A and B will pick one mobile platform each and develop the app respectively

- Team A will continue working with the auto-syncing application, now focusing on testing it thoroughly

- Team B will start the implementation of home security application. This application is also divided into two sub-tasks

    - First task is to trigger the home camera using motion-sensing technology and storing it into the controller

    - Second task is to upload the camera pictures and videos online providing a live feed to the user

- Again there will be a need to develop the application on two mobile platforms. Teams will work on the same platform which was assigned to them previously on the auto-syncing application

- Team B will then continue with the testing of the home security application

- Finally, both the applications will be tested simultaneously on multiple mobile platforms.

Performance Evaluation:

Auto-Backup performance Evaluation:

- Establish connections between the Raspberry Pi and ‘Things’ which include mobile devices, camera etc.
- Generate a series of numbers in the mobile device application and sync these numbers i.e; send these numbers to Raspberry Pi.
- Check the behaviour of Raspberry Pi when multiple mobile devices transfer data to it.
- Note the time for transfer of numbers, total turn around time to process the received data and required metrics.
- Depending on the obtained metrics optimize the application and devices for best performance.

Smart home security system:

- Establish connection between Raspberry Pi and smart camera.
- Generate motion for the motion sensor to detect motion.
- Find number of pictures clicked in a given time and rate at which it is transferring the captured images to Raspberry Pi.

- Observe the time taken by the Raspberry Pi to download and process the images sent by the camera.
- Note metrics to post these images to AWS(S3) and time of delivery of notifications to the user.

Implementation Plan and Progress

Setting up a programming and execution environment.

Acquiring development tools.

Obtaining a hardware prototyping and simulation environment.

Understanding/executing example programs or hardware simulations.

Implementing a vertical slice (for example, from UI to database) of your project so the use of all technologies is understood.

Implementing the Essential feature set.

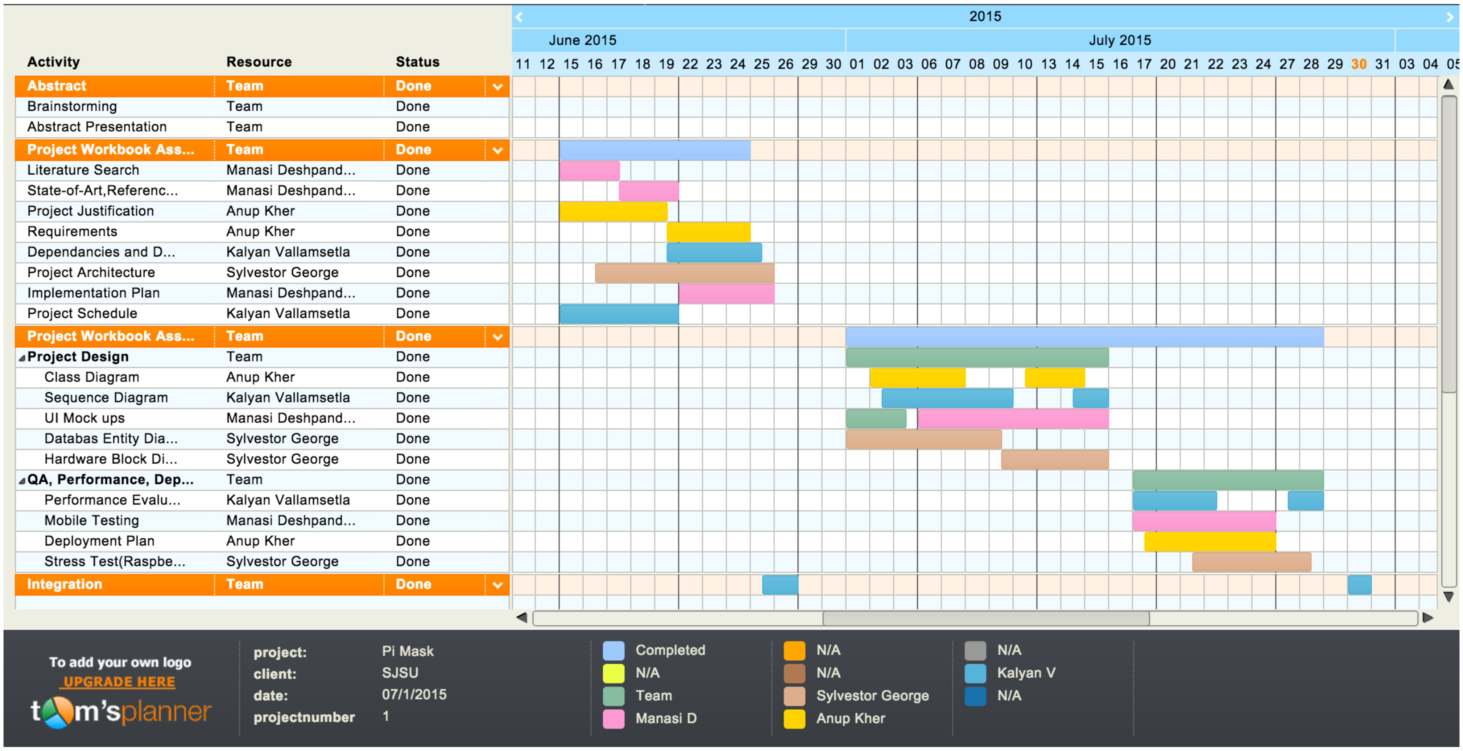
Implementing the Desired and Optional Features

Project Schedule

Task Name	Start Date	End Date	Duration	% Complete	Assigned To
Abstract	**06/03/15**	**06/04/15**	**2**	**100%**	**Team**
Brainstorming	06/03/15	06/03/15	1	100%	Team
Abstract Preperation	06/04/15	06/04/15	1	100%	Team
Abstract Presentation			1	100%	Team
Project Workbook Assignment 1	**06/15/15**	**06/25/15**	**9**	**100%**	
Literature Search	06/15/15	06/17/15	3	100%	Manasi Deshpande
State-of-the-Art, References	06/17/15	06/19/15	3	100%	Manasi Deshpande
Justification	06/15/15	06/19/15	5	100%	Anup Kher
Requirements	06/20/15	06/25/15	5	100%	Anup Kher
Dependencies and Deliverables	06/20/15	06/25/15	5	100%	Kalyan Vallamsetla
Project Architecture	06/16/15	06/25/15	8	100%	Sylvestor George

Implementation Plan	06/20/15	06/25/15	5	100%	Manasi Deshpande
Project Schedule	06/15/15	06/19/15	5	100%	Kalyan Vallamsetla
Project Workbook Assignment 2	**07/01/15**	**07/31/15**	**23**	100%	
Project Design	07/01/15	07/15/15	14	100%	Kalyan Vallamsetla,Sylvestor George, Manasi Deshpande, Anup Kher
QA, Performance, Deployment Plan	07/17/15	07/28/15	11	100%	Manasi Deshpande, Anup Kher, Kalyan Vallamsetla,Sylvestor
Integration	07/29/15	07/30/15	2	100%	Manasi Deshpande, Anup Kher, Kalyan Vallamsetla,Sylvestor

Gantt Chart:


2015
June 2015
July 2015
Activity
Resource
Status
11 12 15 16 17 18 19 22 23 24 25 26 29 30 01 02 03 06 07 08 09 10 13 14 15 16 17 20 21 22 23 24 27 28 29 30 31 03 04 05
Abstract | Team | Done
Brainstorming | Team | Done
Abstract Presentation | Team | Done
Project Workbook Ass... | Team | Done
Literature Search | Manasi Deshpand... | Done
State-of-Art,Referenc... | Manasi Deshpand... | Done
Project Justification | Anup Kher | Done
Requirements | Anup Kher | Done
Dependancies and D... | Kalyan Vallamsetla | Done
Project Architecture | Sylvestor George | Done
Implementation Plan | Manasi Deshpand... | Done
Project Schedule | Kalyan Vallamsetla | Done
Project Workbook Ass... | Team | Done
Project Design | Team | Done
Class Diagram | Anup Kher | Done
Sequence Diagram | Kalyan Vallamsetla | Done
UI Mock ups | Manasi Deshpand... | Done
Databas Entity Dia... | Sylvestor George | Done
Hardware Block Di... | Sylvestor George | Done
QA, Performance, Dep... | Team | Done
Performance Evalu... | Kalyan Vallamsetla | Done
Mobile Testing | Manasi Deshpand... | Done
Deployment Plan | Anup Kher | Done
Stress Test(Raspbe... | Sylvestor George | Done
Integration | Team | Done
To add your own logo
UPGRADE HERE
tom'splanner
project: Pi Mask
client: SJSU
date: 07/1/2015
projectnumber 1
Completed
N/A
Team
Manasi D
N/A
N/A
Sylvestor George
Anup Kher
N/A
Kalyan V
N/A

Pert Chart:

	Activity	Duration (days)
A	Abstract	1
B	Workbook Assignment 1	9
C	Workbook Assignment 2	20
D	Functional Specifications	10
E	Final Report	7