A Report on Major project

Network Attached Storage using Raspberry Pi

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

COMPUTER ENGINEERING

OF

VISHWAKARMA INSTITUTE OF TECHNOLOGY

Savitribai Phule Pune University

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UNDER THE GUIDANCE OF

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BANSILAL RAMNATH AGARWAL CHARITABLE TRUST'S
VISHWAKARMA INSTITUTE OF TECHNOLOGY
(An Autonomous Institute affiliated to Savitribai Phule Pune University)
PUNE - 411037

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CERTIFICATE

This is to certify that the Major Project titled **Network Attached Storage using Raspberry Pi** submitted by **Juilee Katpatal (GR-161777), Monica Kawade (GR-161779)** and **Chinmay Kulkarni (GR-161278)** is in partial fulfillment for the award of Degree of Bachelor of Technology in Computer Engineering of Vishwakarma Institute of Technology, Savitribai Phule Pune University. This project report is a record of bonafide work carried out by him under my guidance during the academic year 2019-20.

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PROJECT SYNOPSIS

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Project Title : Network Attached Storage using Raspberry Pi

Project Area : Computer Networks, Web Technology

Sponsor Company : -
Company Address : -

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Signature of Internal Guide

ACKNOWLEDGEMENT

It gives us great satisfaction to be able to present this project on Network Attached Storage using Raspberry Pi. We would like to express our deep gratitude towards our project guide Prof. Ashwini Shingare, for all the guidance and the co-operation, without whom this project would have been an uphill task. We would also like to thank Prof. Dr. Sandeep Shinde for his invaluable guidance on how to robustly secure the web application.

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Software Project Synopsis

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1. CONTEXT

The 21st century saw the advent of cloud computing which completely transformed the way software was developed earlier. This mainly includes providing software, storage and computation as a service to people. We all use this powerful service almost every day in our life. But often cloud storage services provided by all the cloud computing companies come with a limited free quota after which the user has to pay in order to continue the service.

2. PROBLEM

We often face the problem of our cloud storage space getting exhausted and we are left with the option of either paying for more storage or to clear the existing files which are not required. This is mainly because the amount of data an individual requires is increasing day by day. All the important documents, registrations, images, videos are often backed up to a cloud storage that can be accessed from anywhere. With the help of this application, if the user has an external storage device, we can have a backup of all the data and also free some space on handheld devices by moving data into this external storage.

3. SOLUTION

The proposed approach will provide “Network Attached Storage” along with functionalities of a Web Server. The main advantage of using a NAS device over a physical storage drive is that many devices can access it at the same time. A USB Disk Drive provides finite access to only the device to which it is connected; on the other hand the files which are available on NAS can be accessed by any computer.

Feasibility Study Report

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1. Purpose

The purpose of NAS with RPi is to provide a cost efficient and secured alternative to existing cloud storage solutions. We identified the existing NAS/Cloud Storage solutions on the market and observed that most of the solutions are ideal for office use. Which means they are very costly for home users. We wanted to provide a simple, easy to use and cost effective solution for home users so that they can enjoy the advantages of Network Attached Storage as an alternative to Cloud Storage.

2. Current Systems and Processes

With the ever increasing developments in the field of consumer technology the data users hoard has significantly gone up leading to the personal storage devices filling up at a pace the user virtually cannot cope up with. The data pillig on is a one way process as none of the data gets deleted unless there is a need for storage. This has given rise to a host of storage technologies that help store more data. The drawback here is that these are physical devices that can function only when connected to a processing device, unavailability of the later might lead to the user not being able to access the data.It is also inconvenient to carry around the storage devices. The age of the internet has a proposed solution to this problem i.e Cloud Storage. However this facility demands the user to store their data on third party paid servers with security compromised.

3. System Objectives

The NAS solution presents an opportunity for a lower budget; lesser risk alternative as opposed to cloud storage. The NAS solutions available in the market today are for enterprises with the need of maintaining private data and are expensive. NAS solutions for home usage is a newer market and full fledged products have not made their way.

4. Issues

1. NAS solutions are extremely costly and require additional installation & maintenance costs. They are mostly only feasible for large enterprises.
2. Cloud storage is more beneficial for small and medium businesses. However, they come with a limited quota after which monthly subscription costs add up to be costly. Security is also risky with cloud solutions since we don’t know where our data is being stored.
3. After cloud storage is exhausted, users either pay more or clear data.

5. Assumptions and Constraints

Assumptions

1. The user should have all the physical devices - router, raspberry pi and a hard drive for the implementation to work.
2. All the users will use the implementation on a local network in order to ensure security.

Constraints

1. Concurrent access to the documents is not possible for editing.
2. Users cannot use the system on a public network.
3. Purchasing Hard Drive & Raspberry Pi may add up the costs of the system.

6. Alternatives

There are plenty of alternatives to noth Network Attached Storage and Cloud Storage providers in the market. Every solution has its pros and cons with respect to the cost, available features and security.

Network Attached Storage Providers	Cloud Storage Providers
1. LenovoEMC Network Storage 2. Synology DiskStation 3. QNAP Turbo NAS 4. Seagate business storage 5. StoneFly 6. Western Digital 7. Netgear ReadyNAS 8. Drobo NAS 9. Netgear 10. Promise Technology 11. Synology	1. Microsoft OneDrive 2. Google drive 3. Dropbox 4. Amazon AWS 5. Apple iCloud 6. Box

Use Case Analysis Document

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USE CASE TEMPLATE

USE CASE	Accessing and modifying local files remotely through a web client.	
Goal	To transform an existing external hard drive into a cloud storage device, connected to a network which will be accessed via a web application.	
Purpose	1. Reduce the need of purchasing costly technology like NAS or Cloud Storage. 2. Be able to access personal files remotely through a network.	
Preconditions	The user should have all the hardware - router, Raspberry Pi and a hard drive for the implementation to work.	
Success Condition	User is able to access and perform actions on his files through the web client.	
Failed Condition	Files are not accessible.	
Primary Actors	Hard Drive Raspberry Pi Web Application	
Secondary Actors	Active network connection	
Trigger	Sign up / Sign in to the web client.	
DESCRIPTION	**Step**	**Basic Course of Action**
	1	Connect the hard drive to the Raspberry Pi.
	2	Connect Raspberry Pi to a router/network.
	3	Open the web application by providing the correct link.
	4	Create an account on the web application by providing username & password.
	5	The files & directories will be displayed. Users can upload, delete, create new folders and view activities taking place.

Software Requirements Specification

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1. SCOPE

The goal of the project is to transform an existing external hard drive into a cloud storage device, connected to a network which will be accessed via a web application. Hence the scope includes the following functionalities -

1. Developing a backend server containing APIs to handle incoming requests to the hard drive. The backend server is deployed on the Raspberry Pi. This server will be developed in Java using Spring Boot framework using the Model View Controller methodology.

2. Designing the UI/UX of the web application in Adobe XD.

3. Creating a web application in Angular with the following operations -
    a. View all files and folders and subdirectories
    b. Create new folder
    c. Move files and folders to other directories
    d. Delete files and folders
    e. Upload and Download Files
    f. Storage Analysis

Not included in the current scope of the project

1. Enhanced security system
2. Ability to partition the hard drive as per request.
3. User Management
4. Data analysis on files (tagging, recommendation, etc.)
5. Port forwarding on the router

2. REQUIREMENTS

1. **External Storage** - This comprises any storage device that can be connected to the development board, in our case Raspberry Pi. If the user wishes to increase the storage capacity of the cloud, all he/she needs to do is replace the external storage with the one which has more storage capacity than the one currently in use or add another external storage if there are sufficient USB ports on the development board that is in use. If the user suspects of a security breach, he/she can simply disconnect the Development Board from the router or remove the external storage devices thereby protecting their personal data.

2. **Development Board (Raspberry Pi)** - The development board typically must be capable of hosting a Linux operating system. It must also provide WiFi or Ethernet

support which will be required to connect the device to the router. The board must contain at least 1 USB port that can be used to connect the external hard drive. In our solution we have used a Raspberry 3B+ model which satisfies all the above requirements. Users are free to choose the development board of their choice as long as it supports the above functionalities.

3. **Router** - Any home router that supports the connection of multiple devices at the same time should be sufficient to use. It is recommended that the router should be dual channel which supports 2.4 GHz and 5.0 GHz frequencies. This is necessary when the user wants to stream audio or video from the personal cloud service. To enable the user to access the personal cloud storage service from outside the local network, Port Forwarding is to be performed on the router. This will generate a public IP address which can be accessed from anywhere.

4. **Web Server** - This is the heart of the complete solution. The web server is a spring boot web application server that is deployed on the development board. The web server provides the core storage service that is utilized by the client application to provide services to the user. It consists of a rich set of REST APIs that are written purely in Java which expose the underlying services of the Personal Cloud Storage Service.

5. **Client Application** - The client application, written in Angular provides the main User Interface for the user to access the personal cloud storage.

Software Project Plan

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1. Overview

We adopted the Agile methodology of Software development to complete the project. We planned a sprint of 1 week. At the end of each week, we reviewed and merged all the code written during the sprint and also panned the tasks for the next week. We used GitHub to manage the source code for backend and frontend.

2. Project Goals

The main goal of the project was to build a solution which consisted of a web application and raspberry pi connected to a router. The complete setup should serve the following purpose:

- Provide a web interface for the user to be able to access his/her files stored on external storage
- The user should be able to expand the external storage easily
- The solution should be able to handle multiple users.
- To create APIs for manipulating the data stored on the external storage devices.

Project Goal	Priority	Comment/Description/Reference
Functional Goals:		
Hardware Setup of NAS	3	Connect raspberry pi to the router. Connect external storage devices to raspberry pi.
Access Raspberry Pi	3	Use VNCViewer and Angry IP Scanner to access raspberry pi
Business Goals:		
Build the solution	3	Build a shippable complete solution which can be directly used by customers.
Technological Goals:		
Develop backend APIs	1	Develop all the APIs required by the web application to get data from the external storage
Develop frontend UI	2	Develop the Web Interface UI

System Implementation Document

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1. IMPLEMENTATION

The proposed solution can be used to convert any external storage into a personal cloud storage service that can be accessed from anywhere through a web-based client application. To make the storage service available to external networks, we use the concept of Port Forwarding which will be discussed in detail in the further sections. Following are the basic components of the solution:

1. External Storage
2. Development Board (Raspberry Pi)
3. Router
4. Web Server
5. Client Application

External Storage - This comprises any storage device that can be connected to the development board, in our case Raspberry Pi. If the user wishes to increase the storage capacity of the cloud, all he/she needs to do is replace the external storage with the one which has more storage capacity than the one currently in use or add another external storage if there are sufficient USB ports on the development board that is in use. If the user suspects of a security breach, he/she can simply disconnect the Development Board from the router or remove the external storage devices thereby protecting their personal data.

Development Board - The development board typically must be capable of hosting a Linux operating system. It must also provide WiFi or Ethernet support which will be required to connect the device to the router. The board must contain at least 1 USB port that can be used to connect the external hard drive. In our solution we have used a Raspberry 3B+ model which satisfies all the above requirements. Users are free to choose the development board of their choice as long as it supports the above functionalities

Router - Any home router that supports the connection of multiple devices at the same time should be sufficient to use. It is recommended that the router should be dual channel which supports 2.4 GHz and 5.0 GHz frequencies. This is necessary when the user wants to stream audio or video from the personal cloud service. To enable the user to access the personal cloud storage service from outside the local network, Port Forwarding is to be performed on the router. This will generate a public IP address which can be accessed from anywhere.

Web Server - This is the heart of the complete solution. The web server is a spring boot web application server that is deployed on the development board. The web server provides the core storage service that is utilized by the client application to provide services to the user. It consists of a rich set of REST APIs that are written purely in Java which expose the underlying services of the Personal Cloud Storage Service.

Client Application - The client application, written in Angular provides the main User Interface for the user to access the personal cloud storage. It provides the following cloud storage services:

1. View all files and folders and subdirectories
2. Create new folder
3. Move files and folders to other directories
4. Delete files and folders
5. Upload and Download Files
6. View recent files
7. Storage Analysis
8. User Management
9. Settings

Flow Diagram

The flow for the architecture is displayed in Figure 1.0 below.

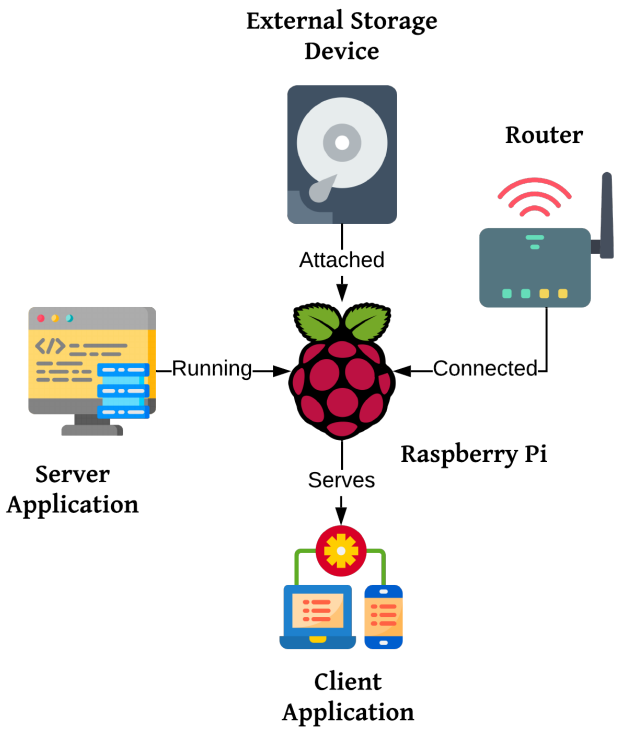


Figure 1.0: Architecture of NAS with Raspberry Pi 3B+

Implementation

As illustrated in Figure 1.0, the five main components are integrated with each other in the above manner. The external storage device is attached to the Raspberry Pi through USB Port. There can be multiple external storages connected to the development board. Next, the board is connected to the router which provides the public IP address to access the web application. The web server application is deployed on Raspberry Pi and lastly, the client application which is a

web based client is used by the user to access his/her personal data present on the hard drive. The client application lets the user perform all the operations described in the ***Client Application*** section. Since port forwarding is enabled on the router, the application can be accessed from outside the network also.

Security Concerns

In any type of application, we must always address the increasing security concerns and threats to the application.

2. Development and Testing

We adopted the Agile methodology of Software development to complete the project. We planned a sprint of 1 week. At the end of each week, we reviewed and merged all the code written during the sprint and also panned the tasks for the next week. We used GitHub to manage the source code for backend and frontend.

ClickUp

ClickUp is a free web app for managing a complete software development life cycle. We used ClickUp to keep a track of tasks, assign them to members and decide the next cycle of sprints. It helped us extensively to manage the project easily and efficiently.

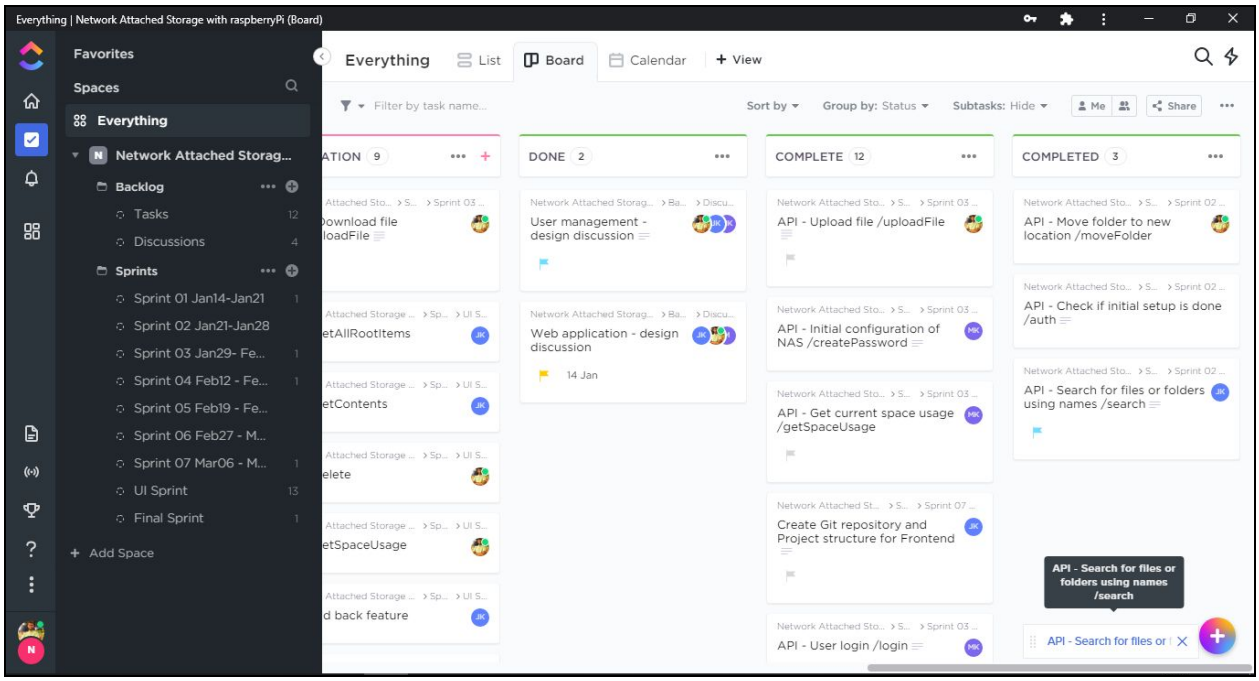
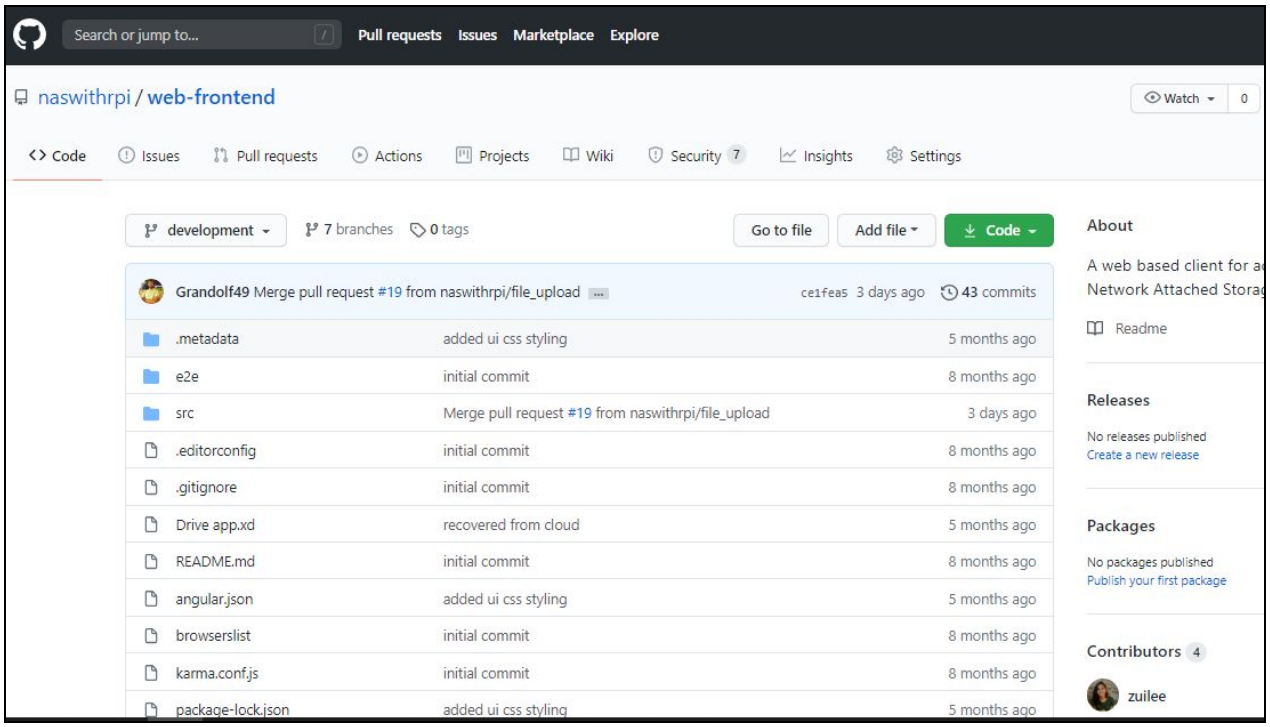


Fig 2.0: Weekly Sprint - Task distribution and current statuses

GitHub

GitHub is the most popular web platform for hosting and managing source code repositories. Multiple developers can work on the same project simultaneously without any hassle. We used GitHub to keep track of our source code for Backend and Frontend.



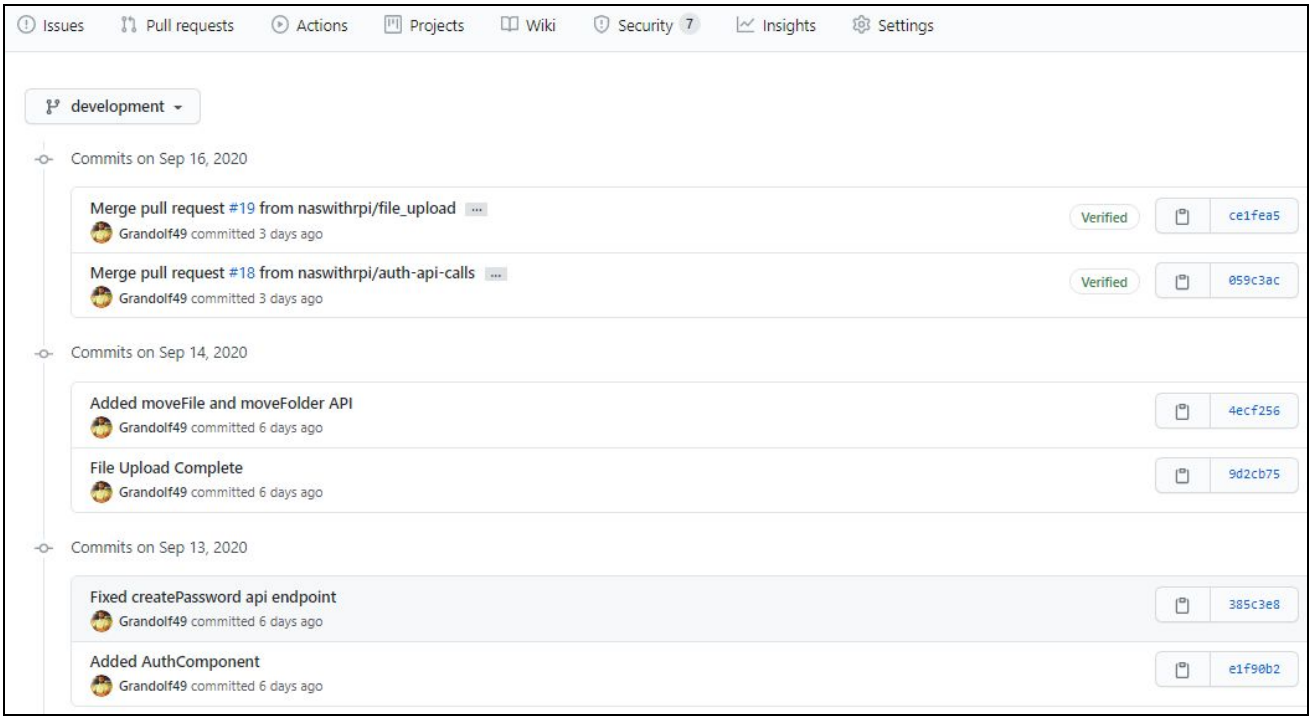
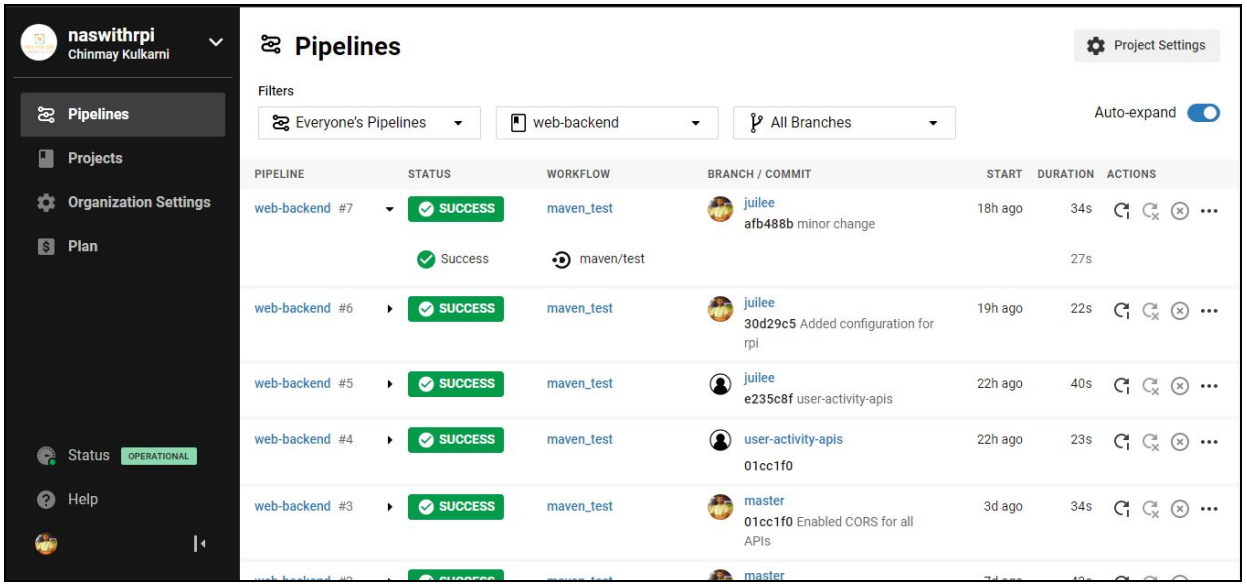


Fig 3.1 & 3.2: GitHub Repository for the frontend of the web application



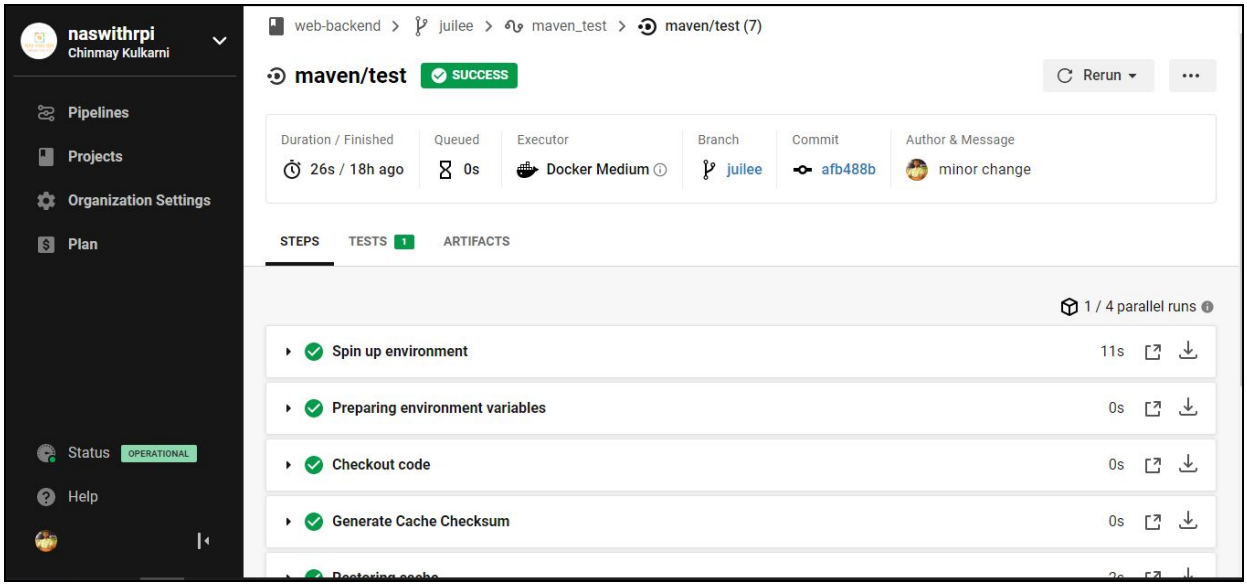


Fig. 3.3 & 3.4 CircleCI Continuous Integration for testing every commit done to the backend code

3. RESULTS

The web application consists of 2 pages namely, Login/Authorization page and the Home page. On sign in to the application, the user could view all his folders and files on the Dashboard. From this screen he can also upload files, create new folders, delete files and directories, view space usage and view recent activities performed on the files.

Login page

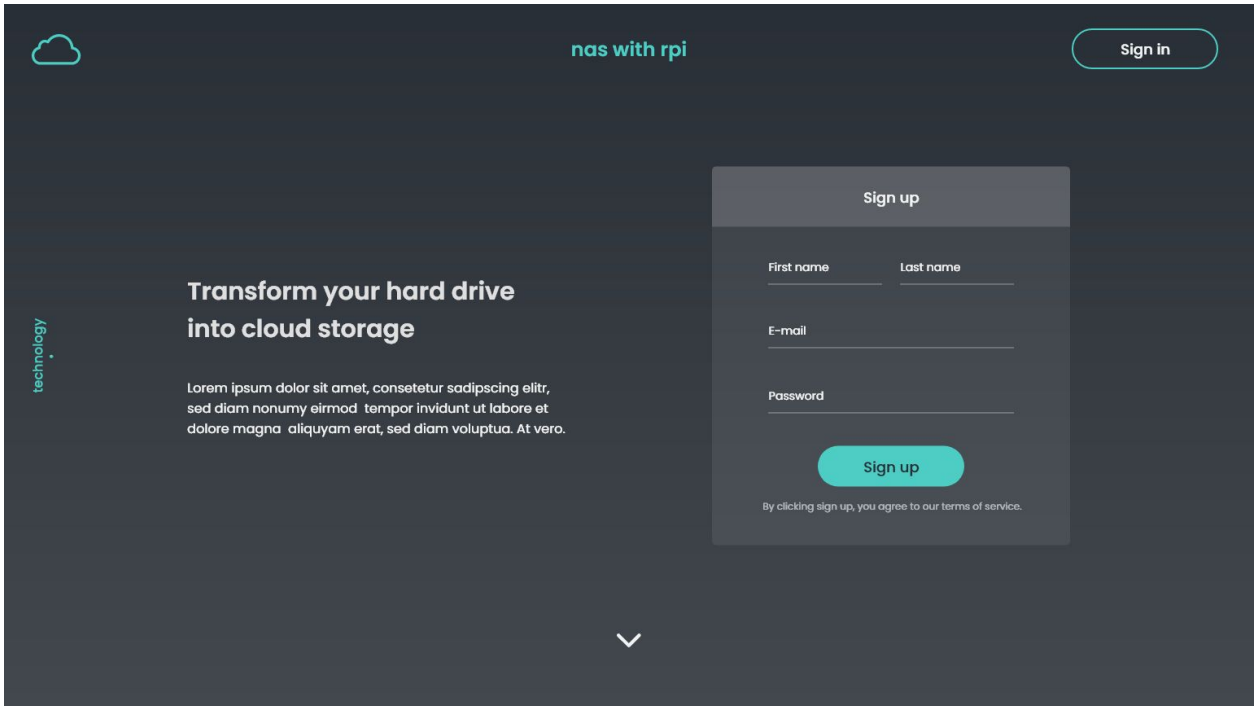


Figure 4.0: Login page of NAS with Raspberry Pi 3B+

Home Page/ Dashboard

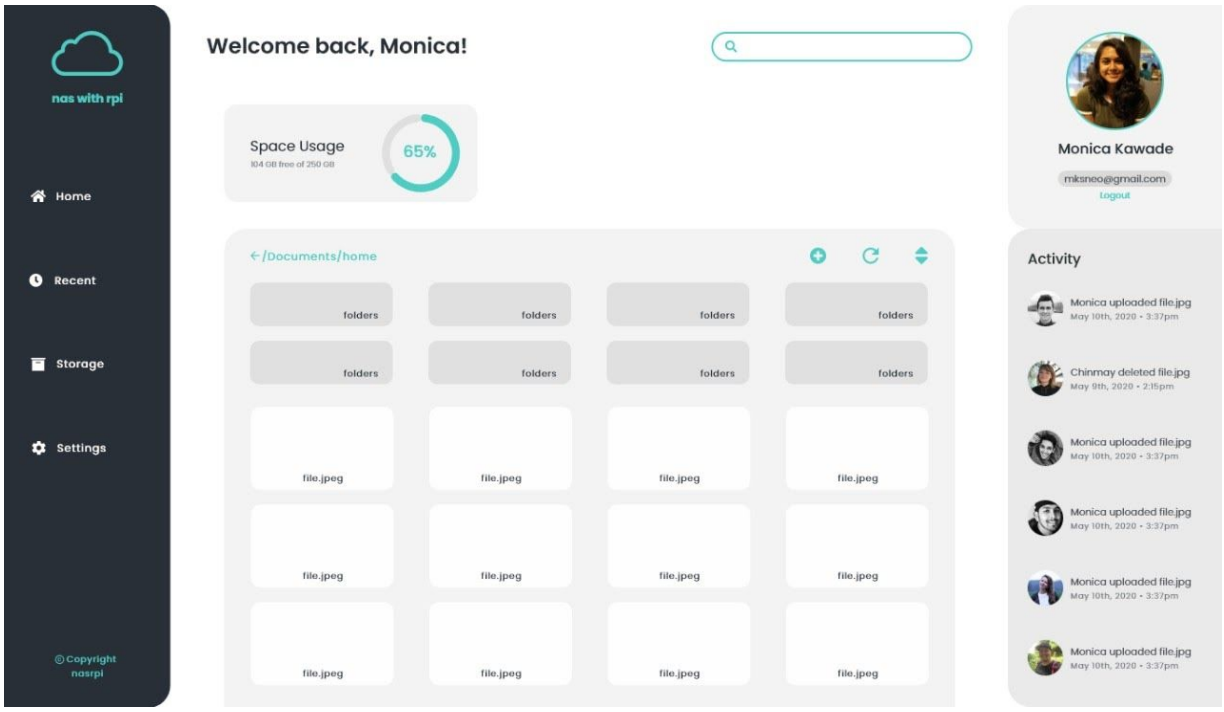


Figure 5.0: Dashboard of NAS with Raspberry Pi 3B+

MySQL Database

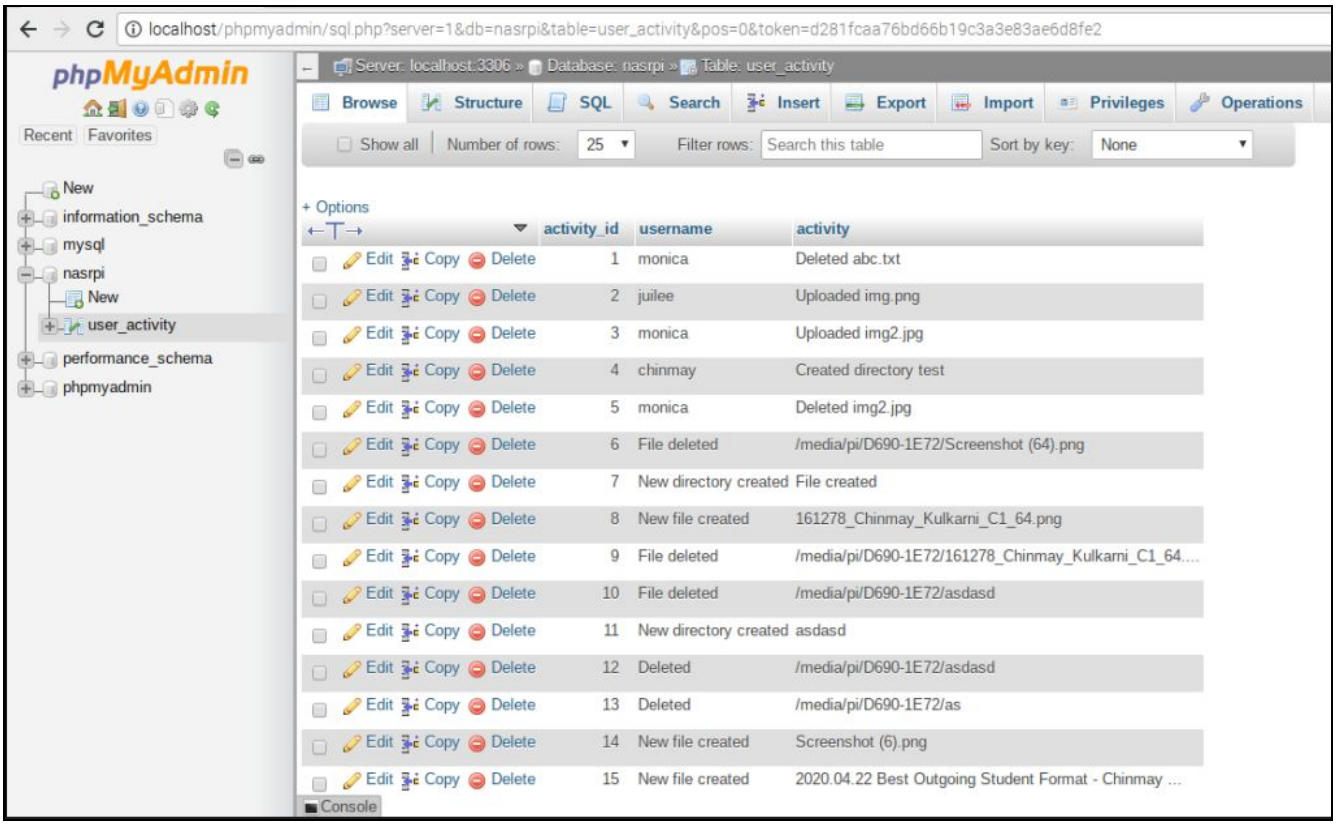


Figure 6.0: SQL Database implemented on Raspberry Pi to track the User Activity on the Hard Drive.

4. CHALLENGES

1. **Security**
    a. Since the system is on an open network, anyone that has access to the web application link can get unauthorized access to the user's files and folders.
    b. API requests and responses are automatically HTTP encrypted, however this could be insufficient security for the system when being used outside of the home or in public.

2. **Cost**
    In case the user does not already have a storage device (HDD, SDD), then the cost of the system could increase, as the user would have to purchase a Raspberry Pi, Router and Storage device. Though these are one time costs, they can add up.

5. Future Scope

There is good scope for improving the current solution for cloud storage. The application serves basic functionalities but can be extended to provide some advanced features.

Performing Port Forwarding on Router

Port forwarding would enable users to access the storage from outside the network. This is very useful in situations where you are not connected to the local network and you want to get or store data to your NAS. This comes with a lot of security concerns. For example, hackers can get into the local network of a home if the router is accessible from outside the network.

Data Analysis on Files

Machine Learning algorithms can be applied to the files present on the storage to obtain insights. Users can get an overview of the most used files, large files, unused files.

Ability to partition external storage on user demand

Partitioning a hard drive can be a useful feature as far as security is concerned. Users might want to have their own partitions for storing their data on external storage. This raises additional storage concerns.

Searching file system based on content

Content based searching of files would save a lot of time for users to find particular files. After a certain period of time, when user data increases on the external storage, it becomes difficult to even search by name. In such scenarios, users could search the file based on its contents.

CONCLUSION

Network Attached Storage implemented with Raspberry Pi provides the users the ability to to convert their personal storage to shared devices accessible over the network. Users have full access to their file system remotely and can even perform operations such as creating folders, uploading files, viewing activity and more. The one time cost of setting up the system is significantly lower than the recurring costs of using the cloud based storage solutions or existing Network Attached Storage solutions. The privacy of user data is honoured. With this system any storage drive can be made a network attached storage.

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