# SMART RASPBERRY PI NAS WITH AI FILE SORTING: DESIGN, IMPLEMENTATION AND EVALUATION

Engineering Clinics 2 - Final Project Report

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## TEAM MEMBERS

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# EXECUTIVE SUMMARY

This project presents a comprehensive solution for intelligent network storage through the development of a Smart Raspberry Pi NAS (Network Attached Storage) system enhanced with AI-powered file sorting capabilities. The system addresses critical challenges in modern data management including escalating cloud storage costs, data privacy concerns, and time-consuming manual file organization.

**Key Achievements:**

- Developed a cost-effective NAS solution at 5,820 (62% cost reduction compared to cloud storage over 5 years)
- Implemented AI-based file classification with 92% accuracy across multiple file types
- Achieved 8.8x faster file transfer speeds compared to cloud alternatives
- Created a secure, user-friendly system suitable for home and small business environments

The project successfully demonstrates that sophisticated storage and AI capabilities can be implemented on affordable hardware, making intelligent storage solutions accessible to a broader user base.

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# Chapter 1

# INTRODUCTION

## 1.1 Background

The exponential growth of digital content has created unprecedented storage challenges for individuals and organizations. Traditional solutions fall into two primary categories: cloud storage services and commercial Network Attached Storage (NAS) systems. While cloud storage offers convenience and accessibility, it presents significant limitations including recurring subscription costs, data privacy concerns, internet dependency, and lack of intelligent organization features.

Commercial NAS solutions, though offering local control and better performance, typically require substantial initial investments and often lack advanced file management capabilities. This gap in the market presents an opportunity for innovative, cost-effective solutions that combine the benefits of local storage with intelligent file management.

## 1.2 Motivation

The motivation for this project stems from several key observations:

- **Economic Factors:** Cloud storage costs accumulate significantly over time, with 1TB of storage costing approximately 3,600 annually
- **Privacy Concerns:** Growing awareness of data privacy issues with cloud service providers
- **Performance Limitations:** Internet-dependent access speeds and reliability issues
- **Manual Organization:** Time-consuming manual file organization processes
- **Accessibility Gap:** High-end NAS solutions remain financially inaccessible to many users

## 1.3 Project Scope

This project encompasses the complete development lifecycle of an intelligent NAS system, including:

- Hardware selection and optimization for the Raspberry Pi platform

- Development of robust file sharing and storage management systems
- Implementation of AI-powered content analysis and classification
- Creation of user-friendly management interfaces
- Comprehensive security framework development
- Performance evaluation and optimization

# Chapter 2

# PROBLEM STATEMENT AND OBJECTIVES

## 2.1 Problem Statement

**Primary Problem:** The lack of affordable, intelligent storage solutions that provide local control, automated organization, and cost-effective long-term ownership for home users and small businesses.

**Sub-problems:**

- High recurring costs of cloud storage services
- Privacy and security concerns with third-party storage providers
- Manual file organization requiring significant time investment
- Limited accessibility of commercial NAS solutions due to cost barriers
- Absence of intelligent file classification in affordable storage systems

## 2.2 Project Objectives

**Primary Objectives:**

- Design and implement a cost-effective NAS solution using Raspberry Pi hardware
- Develop AI-powered file sorting capabilities for automated organization
- Create intuitive user interfaces for system management and configuration
- Implement comprehensive security measures for data protection
- Achieve performance levels suitable for home and small business use

**Secondary Objectives:**

- Demonstrate significant cost savings compared to commercial alternatives
- Provide detailed documentation for reproducibility and maintenance
- Validate system performance through comprehensive testing
- Establish a foundation for future enhancements and scaling

## 2.3 Success Criteria

**Technical Criteria:**

- File transfer speeds exceeding 30 MB/s on local network
- AI classification accuracy above 85% across multiple file types
- System stability with 99%+ uptime during testing period
- Support for minimum 5 concurrent users without significant degradation

**Economic Criteria:**

- Total 5-year cost below 50% of equivalent cloud storage
- Hardware cost under 10,000 for complete system

**Usability Criteria:**

- Setup process completable by non-technical users within 2 hours
- Intuitive web interface requiring minimal training
- Automated backup and recovery capabilities

# Chapter 3

# LITERATURE REVIEW

## 3.1 Commercial NAS Solutions Analysis

### 3.1.1 Synology DiskStation Series

Synology's DiskStation products represent the premium segment of consumer NAS devices. Their proprietary DiskStation Manager (DSM) operating system provides comprehensive features including file sharing, media streaming, backup solutions, and third-party application support. However, entry-level 2-bay models typically cost 15,000-25,000, excluding drives.

### 3.1.2 QNAP NAS Systems

QNAP devices focus on virtualization capabilities and container support, targeting prosumer and small business markets. Their QTS operating system offers similar functionality to Synology but with greater emphasis on business applications. Pricing remains comparable to Synology products.

### 3.1.3 Western Digital My Cloud Series

WD's consumer-focused NAS solutions offer simplified setup and operation but with limited customization options. While more affordable than Synology or QNAP, they still represent 2-3x the cost of our Raspberry Pi implementation.

## 3.2 Open Source NAS Platforms

### 3.2.1 TrueNAS (formerly FreeNAS)

TrueNAS provides enterprise-grade features on FreeBSD, offering advanced storage management through ZFS filesystem. However, it requires dedicated x86 hardware with substantial RAM requirements (minimum 8GB), making it unsuitable for low-power ARM platforms.

### 3.2.2 OpenMediaVault

Based on Debian Linux, OMV offers a web-based interface for NAS functionality. While it can run on Raspberry Pi, it lacks the intelligent file organization capabilities that distinguish our implementation.

## 3.3 AI for File Organization

### 3.3.1 Content-Based Classification Research

Academic research in automated file organization has explored various approaches:

- TF-IDF (Term Frequency-Inverse Document Frequency) for document classification
- Convolutional Neural Networks for image recognition and categorization
- Metadata analysis for media file organization

Most existing research assumes cloud-scale computational resources, while our work focuses on edge computing constraints.

### 3.3.2 Commercial AI Solutions

Google Photos and iCloud Photos demonstrate successful AI-powered organization but require cloud processing and raise privacy concerns. Our approach brings similar capabilities to local, private environments.

## 3.4 Edge Computing and AI

Recent research in edge AI has demonstrated the feasibility of running machine learning models on resource-constrained devices. Key developments include:

- Model quantization techniques for reduced memory usage
- TensorFlow Lite for mobile and embedded deployment
- MobileNet architectures optimized for mobile devices

These advances enable our implementation of AI capabilities on Raspberry Pi hardware.

# Chapter 4

# SYSTEM DESIGN AND ARCHITECTURE

## 4.1 Overall System Architecture

The Smart Raspberry Pi NAS follows a modular, layered architecture designed for maintainability, scalability, and performance optimization.

```

                    User Interfaces


         Web Portal           File Share          Mobile App






                 Application Layer


            Samba             AI Sorter             Backup

           Server              Service              System






                  System Layer


         File System          Security             Monitoring

         Management           Framework             System






                 Hardware Layer
          Raspberry Pi 4 + External Storage

```

Figure 4.1: System Architecture Overview

## 4.2 Hardware Architecture

**Core Components:**

- **Raspberry Pi 4 Model B (4GB):** ARM Cortex-A72 quad-core processor at 1.5GHz provides sufficient computational power for file serving and AI processing
- **Storage Subsystem:** 16GB microSD for OS, external USB 3.0 drives for data storage
- **Network Interface:** Gigabit Ethernet ensures optimal transfer speeds
- **Power Management:** Official 5V 3A supply with power monitoring

**Storage Configuration Options:**

- **Single Drive:** Simple configuration for basic needs
- **RAID 1:** Mirror configuration for data redundancy
- **JBOD:** Multiple drives as separate shares for organization

## 4.3 Software Architecture Components

**Core Services Layer:**

- **Operating System:** Raspberry Pi OS (64-bit) optimized for file serving
- **File Sharing:** Samba server with performance optimization
- **Storage Management:** Linux LVM for flexible disk management
- **Security Framework:** Multi-layered security with authentication, encryption, and monitoring

**AI Processing Layer:**

- **File Monitor:** Python-based service using inotify for real-time file detection
- **Content Analyzer:** Multi-modal analysis supporting text, image, and media files
- **Classification Engine:** Lightweight ML models optimized for ARM architecture
- **Organization System:** Rule-based file movement and categorization

**Management Layer:**

- **Web Interface:** Node.js backend with Vue.js frontend
- **API Gateway:** RESTful API for system management
- **Configuration Management:** YAML-based configuration with validation
- **Logging System:** Centralized logging with rotation and analysis

# Chapter 5

# IMPLEMENTATION

## 5.1 Development Environment Setup

**Hardware Preparation:**

- Raspberry Pi 4 configuration with heat sinks and adequate cooling
- External storage preparation with performance testing
- Network infrastructure optimization for gigabit speeds
- Power supply validation and UPS integration for reliability

**Software Environment:**

- Raspberry Pi OS 64-bit installation with custom optimization
- Development tools installation (Python 3.9+, Node.js, Git)
- Cross-compilation setup for performance-critical components
- Testing framework establishment for continuous integration

## 5.2 Core System Implementation

**Base System Configuration:**

```
# System optimization for file serving
echo 'vm.dirty_ratio = 15' >> /etc/sysctl.conf
echo 'vm.dirty_background_ratio = 5' >> /etc/sysctl.conf
echo 'net.core.rmem_max = 16777216' >> /etc/sysctl.conf
echo 'net.core.wmem_max = 16777216' >> /etc/sysctl.conf

# CPU governor optimization
echo 'performance' > /sys/devices/system/cpu/cpu0/cpufreq/scaling_governor
```

Listing 5.1: System Optimization Configuration

**Storage Management Implementation:**

- LVM setup for flexible partition management

- ext4 filesystem with optimized mount options
- S.M.A.R.T monitoring implementation for predictive maintenance
- Automated disk health checking and alerting

## 5.3 AI File Sorting Implementation

**Core Processing Engine (Python):**

```python
class FileAnalyzer:
    def __init__(self):
        self.text_classifier = self.load_text_model()
        self.image_classifier = self.load_image_model()
        self.document_processor = DocumentProcessor()

    def analyze_file(self, file_path):
        file_type = self.detect_file_type(file_path)

        if file_type == 'text':
            return self.analyze_text_content(file_path)
        elif file_type == 'image':
            return self.analyze_image_content(file_path)
        elif file_type == 'document':
            return self.analyze_document_content(file_path)
        else:
            return self.analyze_generic_file(file_path)
```

Listing 5.2: File Analyzer Class Implementation

**File Organization Logic:**

```python
class FileOrganizer:
    def __init__(self, config):
        self.rules = self.load_organization_rules(config)
        self.categories = self.initialize_categories()

    def organize_file(self, file_path, classification):
        target_dir = self.determine_target_directory(classification)
        self.create_directory_structure(target_dir)
        self.move_file_safely(file_path, target_dir)
        self.update_database(file_path, target_dir, classification)
```

Listing 5.3: File Organizer Implementation

# Chapter 6

# TESTING AND VALIDATION

## 6.1 Testing Methodology

**Testing Phases:**

- **Unit Testing:** Individual component functionality validation
- **Integration Testing:** Inter-component communication and data flow
- **System Testing:** End-to-end functionality verification
- **Performance Testing:** Load testing and benchmark validation
- **Security Testing:** Vulnerability assessment and penetration testing
- **User Acceptance Testing:** Real-world usage scenario validation

## 6.2 Performance Testing

**File Transfer Performance:** Test configurations:

- Single large file transfers (1GB+)
- Multiple small file transfers (thousands of files)
- Concurrent user scenarios (1-10 users)
- Network congestion simulation

# Chapter 7

# RESULTS AND ANALYSIS

## 7.1 Performance Results

**File Transfer Performance Analysis:**

Table 7.1: File Transfer Performance Comparison

| Test Scenario | Local NAS Speed | Cloud Upload Speed | Performance |
|---|---|---|---|
| 100MB single file | 45 MB/s | 5.1 MB/s | 8.8x faster |
| 1GB single file | 42 MB/s | 4.8 MB/s | 8.75x faster |
| 10GB single file | 40 MB/s | 4.5 MB/s | 8.89x faster |
| 1000 small files (1MB each) | 38 MB/s | 3.2 MB/s | 11.9x faster |

**Concurrent User Performance:**

Table 7.2: Concurrent User Performance Analysis

| Users | Avg Speed (MB/s) | CPU Usage (%) | RAM Usage (GB) | Response Time |
|---|---|---|---|---|
| 1 | 45 | 15 | 0.5 | 12 |
| 3 | 42 | 28 | 0.8 | 18 |
| 5 | 38 | 45 | 1.2 | 25 |
| 10 | 30 | 78 | 1.8 | 42 |

## 7.2 AI Classification Results

**Classification Accuracy by File Type:**

Table 7.3: AI Classification Performance Results

| File Category | Test Files | Correct Classifications | Accuracy Rate |
|---|---|---|---|
| Text Documents | 500 | 470 | 94% |
| PDF Documents | 300 | 276 | 92% |
| Images (JPEG/PNG) | 800 | 720 | 90% |
| Video Files | 200 | 178 | 89% |
| Audio Files | 150 | 135 | 90% |
| Spreadsheets | 100 | 96 | 96% |
| Presentations | 75 | 69 | 92% |
| **Overall** | **2125** | **1944** | **92%** |

## 7.3 Cost Analysis

**5-Year Total Cost of Ownership:**

Table 7.4: Cost Comparison Analysis

| Solution Type | Initial Cost () | Annual Operating Cost () | 5-Year Total () |
|---|---|---|---|
| Raspberry Pi NAS | 5,820 | 200 | 6,820 |
| Google Drive (1TB) | 0 | 3,600 | 18,000 |
| iCloud (1TB) | 0 | 3,600 | 18,000 |
| Dropbox (1TB) | 0 | 4,800 | 24,000 |
| Synology DS220+ | 15,000 | 100 | 15,500 |
| QNAP TS-251D | 18,000 | 100 | 18,500 |

**Cost Savings Analysis:**

- 62% cost reduction compared to cloud storage
- 56% cost reduction compared to commercial NAS
- ROI achieved within 18 months compared to cloud alternatives

# Chapter 8

# DISCUSSION

## 8.1 Key Achievements

**Technical Achievements:**

- **Performance Excellence:** Achieved file transfer speeds 8.8x faster than cloud alternatives while maintaining system stability under concurrent user loads
- **AI Innovation:** Successfully implemented intelligent file classification on resource-constrained hardware with 92% accuracy
- **Cost Effectiveness:** Demonstrated 62% cost savings compared to cloud storage over 5-year period
- **Security Implementation:** Developed comprehensive security framework matching commercial NAS solutions
- **User Experience:** Created intuitive interfaces that simplified complex NAS functionality for non-technical users

## 8.2 Challenges and Solutions

**Challenge 1: Resource Constraints**

- **Problem:** Limited CPU and RAM on Raspberry Pi causing performance bottlenecks
- **Solution:**
  - Implemented intelligent task scheduling and priority management
  - Optimized code for memory efficiency using lightweight libraries
  - Used model quantization for AI components reducing memory usage by 75%

**Challenge 2: AI Model Optimization**

- **Problem:** Standard ML models too resource-intensive for edge deployment
- **Solution:**

- Employed TensorFlow Lite with custom model optimization
- Implemented progressive processing to balance accuracy and performance
- Created domain-specific training pipelines for improved efficiency

# Chapter 9

# CONCLUSION AND FUTURE WORK

## 9.1 Project Summary

This project successfully achieved its primary objective of creating an intelligent, cost-effective NAS solution using the Raspberry Pi platform. The implementation demonstrates that sophisticated storage management and AI capabilities can be delivered on affordable hardware, making intelligent storage solutions accessible to home users and small businesses.

**Key Accomplishments:**

- **Cost Effectiveness:** 62% cost reduction compared to cloud storage over 5 years
- **Performance Excellence:** 8.8x faster file transfer speeds than cloud alternatives
- **AI Innovation:** 92% classification accuracy on resource-constrained hardware
- **User Experience:** Intuitive interfaces suitable for non-technical users
- **Security Implementation:** Comprehensive security framework matching commercial solutions
- **Reliability Achievement:** 99.7% uptime during extended testing period

## 9.2 Future Work and Enhancements

### 9.2.1 Immediate Enhancements (3-6 months)

**Performance Optimizations:**

- Multi-Core Utilization: Implement parallel processing for AI classification tasks
- Caching System: Develop intelligent caching for frequently accessed files
- Network Optimization: Implement SMB3 multichannel for improved throughput
- Storage Optimization: Add SSD caching layer for frequently accessed data

### 9.2.2 Medium-Term Development (6-12 months)

**AI Enhancements:**

- Continuous Learning: Implement online learning algorithms for classification improvement
- Natural Language Processing: Add document content analysis for better categorization
- Video Analysis: Develop video content classification capabilities
- Personalization: Create user-specific organization preferences and learning

### 9.2.3 Long-Term Vision (1-2 years)

**Advanced AI Capabilities:**

- Multimodal AI: Develop unified models handling text, image, and audio classification
- Predictive Analytics: Implement predictive file access patterns for optimization
- Content Generation: Add AI-powered metadata and tag generation
- Intelligent Search: Develop semantic search capabilities across all file types

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# Appendix A

# Team Contributions and Responsibilities

Table A.1: Team Member Contributions

| **Team Member** | **Roll Number** | **Primary Responsibilities** | **Key Contributions** |
|---|---|---|---|
| Asneem Athar | 22BCE8807 | Team Lead & System Architect | Overall system architecture design, Project planning and coordination, Installation framework development, Backup system implementation, Final report compilation |
| Lakshmi Nikhitha | 22BCE20311 | Storage Specialist | Storage subsystem design, RAID configuration implementation, File system optimization, Performance benchmarking, Disk health monitoring system |
| M.A Afsheen | 22BCE8368 | Network Administrator | Network configuration and optimization, Samba server implementation, Remote access system development, Cross-platform compatibility testing, Network security implementation |
| A.Kohima | 22BCE9050 | Security Specialist | Security framework design, User authentication system, Access control implementation, Security testing and validation, Encryption system development |

Table A.1 continued from previous page

| Team Member | Roll Number | Primary Responsibilities | Key Contributions |
|---|---|---|---|
| K.Saidivya | 22BCE9489 | Quality Assurance & Testing | AI file sorting implementation, Comprehensive system testing, Performance benchmarking, Quality assurance protocols, Test automation framework |
| Sravan Kumar | 22BCE7192 | Documentation & UI/UX | Web interface development, User experience design, Documentation system creation, Usability testing coordination, Technical writing and editing |

# Appendix B

# Hardware Specifications and Costs

## B.1 Primary Hardware Components

Table B.1: Hardware Cost Analysis

| **Component** | **Specification** | **Vendor** | **Cost ()** | **Purpose** |
|---|---|---|---|---|
| Raspberry Pi 4 Model B | 4GB RAM, ARM Cortex-A72 | Element14 | 4,500 | Main processing unit |
| microSD Card | 32GB Class 10 U3 | SanDisk | 800 | Operating system storage |
| External HDD | 2TB USB 3.0 | Western Digital | 5,500 | Primary data storage |
| Ethernet Cable | CAT6, 2 meters | Generic | 200 | Network connectivity |
| Power Supply | 5V 3A USB-C | Raspberry Pi Foundation | 1,200 | Power delivery |
| Cooling Kit | Heat sinks + Fan | Generic | 400 | Thermal management |
| **Total** | | | **12,600** | |

## B.2 Optional Enhancement Components

Table B.2: Optional Hardware Components

| **Component** | **Specification** | **Cost ()** | **Purpose** |
|---|---|---|---|
| UPS Battery Pack | 5V Output, 4 hours backup | 2,800 | Power backup |
| Additional HDD | 2TB USB 3.0 | 5,500 | RAID configuration |
| Enclosure | Acrylic case with ventilation | 600 | Protection and aesthetics |
| USB Hub | 4-port USB 3.0 | 800 | Storage expansion |

# Appendix C

# Software Dependencies and Versions

## C.1 Core System Software

Table C.1: Core System Software

| Software | Version | Purpose | License |
|---|---|---|---|
| Raspberry Pi OS | 64-bit (Debian 11) | Base operating system | Free |
| Samba | 4.13.x | File sharing protocol | GPL v3 |
| Python | 3.9.x | AI processing and scripting | PSF |
| Node.js | 16.x LTS | Web backend | MIT |
| NGINX | 1.18.x | Web server | BSD-2-Clause |
| MariaDB | 10.5.x | Database management | GPL v2 |

## C.2 AI and Machine Learning Libraries

Table C.2: AI/ML Software Dependencies

| Library | Version | Purpose | License |
|---|---|---|---|
| TensorFlow Lite | 2.8.x | Machine learning inference | Apache 2.0 |
| scikit-learn | 1.1.x | Traditional ML algorithms | BSD |
| OpenCV | 4.5.x | Computer vision | Apache 2.0 |
| NLTK | 3.7.x | Natural language processing | Apache 2.0 |
| Pillow | 9.x | Image processing | PIL |

# Appendix D

# Installation and Configuration Guide

## D.1 Quick Start Installation

```
# 1. Download and flash Raspberry Pi OS to microSD card
# 2. Enable SSH and boot the Raspberry Pi
# 3. Update the system
sudo apt update && sudo apt upgrade -y

# 4. Clone the project repository
git clone https://github.com/asneem1234/raspberry-pi-nas.git
cd raspberry-pi-nas

# 5. Run the automated installation script
sudo ./install.sh

# 6. Follow the interactive setup prompts
# 7. Reboot the system
sudo reboot
```

Listing D.1: Automated Installation Script

## D.2 Manual Configuration Steps

**Storage Setup:**

```
# Format external drive
sudo mkfs.ext4 /dev/sda1

# Create mount point
sudo mkdir /mnt/nas-storage

# Add to fstab for persistent mounting
echo '/dev/sda1 /mnt/nas-storage ext4 defaults 0 2' | sudo tee -a /etc/
    fstab

# Mount the drive
sudo mount -a
```

Listing D.2: Storage Configuration

**Samba Configuration:**

```
# /etc/samba/smb.conf key sections
[global]
workgroup = WORKGROUP
security = user
map to guest = never
load printers = no

[shared]
path = /mnt/nas-storage/shared
browseable = yes
writeable = yes
valid users = @nasusers
```

Listing D.3: Samba Configuration File

# Appendix E

# Performance Benchmarking Results

## E.1 Detailed File Transfer Benchmarks

**Single User Performance:**

- Test: 1GB file transfer
- Protocol: SMB3
- Network: Gigabit Ethernet

Results:

- Iteration 1: 44.2 MB/s
- Iteration 2: 45.1 MB/s
- Iteration 3: 43.8 MB/s
- Iteration 4: 45.7 MB/s
- Iteration 5: 44.9 MB/s
- Average: 44.74 MB/s
- Standard Deviation: 0.71 MB/s

## E.2 AI Processing Benchmarks

**Document Classification Performance:**

- File Type: PDF Documents
- Sample Size: 500 files
- Average Size: 2.3 MB

Processing Times:

- Text extraction: 0.8s average

- Feature extraction: 0.4s average
- Classification: 0.3s average
- File organization: 0.2s average
- **Total average: 1.7s per document**

# Appendix F

# Security Configuration Details

## F.1 Firewall Configuration

```
# Basic iptables rules for NAS security
sudo iptables -F
sudo iptables -P INPUT DROP
sudo iptables -P FORWARD DROP
sudo iptables -P OUTPUT ACCEPT

# Allow loopback
sudo iptables -A INPUT -i lo -j ACCEPT

# Allow established connections
sudo iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT

# Allow SSH (change port as needed)
sudo iptables -A INPUT -p tcp --dport 22 -j ACCEPT

# Allow Samba
sudo iptables -A INPUT -p tcp --dport 445 -j ACCEPT
sudo iptables -A INPUT -p tcp --dport 139 -j ACCEPT

# Allow web interface
sudo iptables -A INPUT -p tcp --dport 80 -j ACCEPT
sudo iptables -A INPUT -p tcp --dport 443 -j ACCEPT

# Save rules
sudo iptables-save > /etc/iptables/rules.v4
```

Listing F.1: Firewall Setup Script

## F.2 SSL Certificate Generation

```
# Generate self-signed certificate for web interface
sudo openssl req -x509 -nodes -days 365 -newkey rsa:2048 \
    -keyout /etc/ssl/private/nas-selfsigned.key \
    -out /etc/ssl/certs/nas-selfsigned.crt \
    -subj "/C=IN/ST=Andhra Pradesh/L=Amaravati/O=Engineering Project/CN=
       nas.local"
```

Listing F.2: SSL Certificate Generation

# Appendix G

# Troubleshooting Guide

## G.1 Common Issues and Solutions

**Issue: Poor File Transfer Performance**

- **Symptoms:** Transfer speeds below 20 MB/s
- **Possible Causes:**
  - Network cable issues (use CAT6)
  - USB port power limitations
  - Thermal throttling
  - Incorrect Samba configuration
- **Solutions:**
  - Check network infrastructure
  - Monitor system temperature
  - Verify Samba optimization parameters
  - Check for background processes

**Issue: AI Service Not Starting**

- **Symptoms:** File sorting not working
- **Diagnostic Commands:**

```
sudo systemctl status ai-sorter.service
sudo journalctl -u ai-sorter.service -f
```

- **Common Fixes:**
  - Install missing Python dependencies
  - Check file permissions on watch directories
  - Verify TensorFlow Lite installation
  - Clear temporary processing files

# Appendix H

# Test Results Summary

## H.1 Comprehensive Test Results

Table H.1: Test Results Summary

| Test Category | Tests Executed | Passed | Failed | Success Rate |
|---|---|---|---|---|
| Unit Tests | 156 | 152 | 4 | 97.4% |
| Integration Tests | 48 | 46 | 2 | 95.8% |
| Performance Tests | 32 | 32 | 0 | 100% |
| Security Tests | 24 | 23 | 1 | 95.8% |
| User Acceptance Tests | 15 | 15 | 0 | 100% |
| **Total** | **275** | **268** | **7** | **97.5%** |

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- Dr. SK. Kareemulla, our project supervisor, for his invaluable guidance, technical insights, and continuous support throughout the project lifecycle
- School of Computer Science and Engineering faculty members for their expertise and resources

**Technical Support:**

- The Raspberry Pi Foundation for creating affordable, powerful hardware that made this project possible
- The open-source community whose tools, libraries, and documentation formed the foundation of our implementation
- Technical support staff at our institution for hardware setup assistance and troubleshooting support

**Testing and Validation:**

- Student volunteers who participated in usability testing and provided valuable feedback
- Family members and friends who allowed us to test the system in real-world home environments
- Local businesses that provided testing opportunities in small office environments

**Special Recognition:**

- TensorFlow and Google AI teams for TensorFlow Lite enabling AI on edge devices
- Samba development team for robust, cross-platform file sharing capabilities
- Vue.js and Node.js communities for excellent web development frameworks

This project would not have been possible without the collaborative spirit of the open-source community and the support of our academic institution. We are committed to giving back to this community by maintaining this project as an open-source resource for future students and developers.

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