A

Project Report

On

File Backup And Synchronization Tool

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

In

Computer Science and Engineering

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STUDENT'S DECLARATION

We, **Gaurav Singh Rawat , Adarsh Negi , Lavraj Singh and Vijay Singh** hereby declare the work, which is being presented in the project, entitled '**File Backup And Synchronization Tool**' in partial fulfillment of the requirement for the award of the degree **Bachelor of Technology (B.Tech.)** in the session **2024-2025**, is an authentic record of our work carried out under the supervision of **Mr. Anubhav Bewerwal**.

The matter embodied in this project has not been submitted by me for the award of any other degree.

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CERTIFICATE

The project report entitled "File Backup And Synchronization Tool" being submitted by Gaurav Singh Rawat (2261225) s/o Mr. Rajendra Singh Rawat, Adarsh Negi (2261071) s/o Harendra Singh Negi, Lavraj Singh (2261334) s/o Ram Singh Negi and Vijay Singh (2261603) s/o Anand Singh of B.Tech (CSE) to Graphic Era Hill University Bhimtal Campus for the award of bonafide work carried out by them .They have worked under my guidance and supervision and fulfilled the requirement for the submission of a report.

Mr. Anubhav Bewerwal — **(Project Guide)**

Dr.Ankur Singh Bisht — **(Head, CSE)**

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Abstract

The File Backup and Synchronization Tool is a Java-based desktop application developed to address the growing need for automated, reliable file management in an era of increasing digital data. This tool monitors a source folder (e.g., C:\MyDocs) for real-time changes, backs up files to a designated folder (e.g., C:\Backup), and optionally synchronizes with another folder (e.g., C:\SyncDocs), ensuring data integrity and accessibility.

Built using Java Swing with the FlatLaf library for a modern graphical user interface (GUI), it offers intuitive features such as drag-and-drop folder selection, file filtering (e.g., .txt files), a real-time progress bar, and a file table displaying backup statuses. The implementation leverages Java Development Kit (JDK) 21, Maven for dependency management, and operating system (OS) concepts to achieve efficiency and robustness. Key OS integrations include file system event monitoring via Java NIO's WatchService, I/O operations using Files.copy, multi-threading for responsive GUI and monitoring tasks, and permission checks with Files.isWritable. These features ensure seamless interaction with the OS's file system and resource management capabilities.

The project addresses challenges like manual file copying and outdated backup tools, offering a practical solution for users and a valuable academic exercise in software engineering. Despite limitations such as platform-specific paths and large file handling, the tool lays a strong foundation for future enhancements like cloud integration and incremental backups.

This report provides a comprehensive overview of the project's design, implementation, and potential, emphasizing its technical and academic contributions.

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LIST OF ABBREVIATIONS

• **JDK**: Java Development Kit, the software development environment for Java applications.

• **JRE**: Java Runtime Environment, required to run Java programs.

• **GUI**: Graphical User Interface, the visual interface for user interaction.

• **NIO**: New Input/Output, Java's API for file system operations.

• **OS**: Operating System, manages hardware and resources.

• **Maven**: A build automation tool for managing dependencies.

• **FlatLaf**: A library for modern Swing GUI styling.

CHAPTER 1: INTRODUCTION

1.1 Prologue

The File Backup and Synchronization Tool is a desktop application developed to address the critical need for automated file management. Built using Java Swing and enhanced with the FlatLaf library for a modern look, the tool monitors a source folder (e.g., C:\MyDocs), backs up the changed files to a backup folder (e.g., C:\Backup), and optionally synchronizes with another folder (e.g., C:\SyncDocs). Key features include drag-anddrop folder selection, file filtering (e.g., .txt only), a real-time progress bar, and a file table showing backup statuses. By integrating OS concepts such as file system events, I/O operations, and threading, the tool ensures efficient and reliable performance, making it a practical solution for users and a valuable academic exercise in software engineering.

1.2 Background and Motivations

The proliferation of digital data has heightened the importance of reliable backup and synchronization solutions. Manual file copying is inefficient and prone to errors, especially for large or frequently updated datasets. Existing tools often lack intuitive interfaces, real-time monitoring, or cross-platform compatibility. Motivated by these challenges, our team aimed to develop a user-friendly desktop application that automates file management while leveraging Java's portability and OS capabilities. The project also aligns with academic goals, providing hands-on experience with OS concepts like file system notifications, multi-threading, and permission management.

1.3 Problem Statement

Users face significant challenges in maintaining up-to-date backups and synchronized files across multiple folders, risking data loss or inconsistencies. Current solutions may be complex, lack real-time monitoring, or have outdated interfaces. The problem is to design a desktop application that:

- Monitors a folder for file changes in real-time using OS file system events.
- Automatically backs up modified or new files to a secure location with OS I/O operations.
- Synchronizes files bidirectionally between two folders.
- Offers an intuitive GUI with features like drag-and-drop and file filtering, managed by OS threading.

1.4 Objectives and Research Methodology

The objectives of the project are:
- Develop a Java-based tool for real-time file monitoring, backup, and synchronization.
- Implement a modern GUI using Swing and FlatLaf.
- Utilize OS concepts (file system events, I/O, threading, permissions) for efficient operation.
- Ensure reliability through error handling and fallback mechanisms.

Research Methodology:
1. Literature Review: Studied backup tools and Java NIO APIs for file monitoring.
2. Design: Created a modular architecture with classes for GUI, monitoring, backup, and sync.
3. Implementation: Used Java Swing, FlatLaf, and Maven in IntelliJ IDEA with JDK 21.
4. Testing: Validated with test folders (C:\MyDocs, C:\Backup, C:\SyncDocs).
5. Iteration: Addressed issues like WatchService failures and Maven errors.

1.5 Project Organization

The project was developed by a team with defined roles:

- Member 1: Developed FolderMonitor, handled OS file system events.
- Member 2: Implemented BackupManager, focused on OS I/O and permissions.
- Member 3: Built SyncManager, managed OS file copying and synchronization.
- Member 4: Designed FileBackupGUI, integrated FlatLaf, handled OS threading.

The development followed requirement analysis, design, coding, testing, and documentation, using IntelliJ IDEA, JDK 21, Maven, and FlatLaf.

CHAPTER 2: PHASES OF SOFTWARE DEVELOPMENT CYCLE

Hardware and Software Requirement

2.1 Hardware Requirement

Specification	**Windows**	**macOS (OS X)**	**Linux**
RAM	Minimum 4 GB, Recommended 8 GB	Minimum 4 GB, Recommended 8 GB	Minimum 4 GB, Recommended 8 GB
Storage	Minimum 2 GB free space	Minimum 2 GB free space	Minimum 2 GB free space
CPU	2 cores	Requires macOS 10.13+ for best compatibility	Prefer Ubuntu 20.04+ or similar distros

2.2 Software Requirement

Sno.	**Name**	**Specifications**
1	Operating System	Windows/Linux/macOS
2	Programming Languages	Java
3	Development Environment	IntelliJ IDEA
4	Build Tool	Maven
5	GUI Library	FlatLaf
6	Java RunTime	JDK 21
7	Version Control	Git and GitHub
8	Package Manager	Maven
9	Deployment	Local JAR file execution
10	CI/CD	JUnit

CHAPTER 3: CODING OF FUNCTIONS

3.1 FileBackupGUI.java

Purpose: Creates the Swing-based GUI for user interaction, including folder selection, file filtering, and status display.
Code Snippet:

```
import com.formdev.flatlaf.FlatLightLaf;
import javax.swing.*;
import java.nio.file.Path;
import java.util.Map;
import java.util.concurrent.atomic.AtomicBoolean;
public class FileBackupGUI {
private JFrame frame;
private JTextField sourceField , backupField , syncField;
private JTextArea logArea;
private JComboBox <String > fileFilterCombo;
private JButton startButton , stopButton;
private JProgressBar progressBar;
private AtomicBoolean isRunning = new AtomicBoolean(false);
private FolderMonitor monitor;
private BackupManager backupManager;
private SyncManager syncManager;
public FileBackupGUI() {
try {
UIManager.setLookAndFeel(new FlatLightLaf());
} catch (Exception e) {
log("Failed to set FlatLaf: " + e.getMessage());
}
frame = new JFrame("File Backup and Synchronization Tool");
frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
frame.setSize(800, 600);
frame.setLayout(new BorderLayout());
// Initialize components
}
private void startMonitoring() {
log("Start button clicked");
if (isRunning.get()) {
log("Tool is already running!");
return;
}
String sourcePath = sourceField.getText();
String backupPath = backupField.getText();
String syncPath = syncField.getText();
```

```
String filter = (String) fileFilterCombo.getSelectedItem();
String extension = filter.equals("All Files") ? "" : filter;
if (sourcePath.isEmpty() || backupPath.isEmpty()) {
log("Please select source and backup folders!");
return;
}
try {
monitor = new FolderMonitor(sourcePath , extension ,
this::log);
backupManager = new BackupManager(backupPath ,
this::log);
syncManager = syncPath.isEmpty() ? null : new
SyncManager(syncPath , this::log);
isRunning.set(true);
startButton.setEnabled(false);
stopButton.setEnabled(true);
progressBar.setString("Monitoring...");
progressBar.setForeground(Color.GREEN);
// Start monitoring thread
} catch (Exception e) {
log("Error starting tool: " + e.getMessage());
}
}
private void log(String message) {
logArea.append(message + "\n");
}
}
```

Listing 1: GUI Initialization and Monitoring

Explanation:

- OS Threading: The GUI runs on the Event Dispatch Thread (EDT), while a separate thread handles monitoring, with the OS scheduling both to ensure responsiveness.
- Features: Drag-and-drop, file filtering, progress bar, and file table.

3.2 FolderMonitor.java

Purpose: Monitors the source folder for file changes using ‘WatchService‘ or polling.
Code Snippet:

```
import java.nio.file.*;
import java.util.HashMap;
import java.util.Map;
import java.util.function.Consumer;
public class FolderMonitor {
private Path sourceDir;
private WatchService watchService;
private String fileFilter;
private Consumer <String > logger;
public FolderMonitor(String sourcePath , String filter ,
Consumer <String > logger) throws Exception {
this.sourceDir = Paths.get(sourcePath);
Prepared by «Student Name»
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this.fileFilter = filter.isEmpty() ? null :
filter.toLowerCase();
this.logger = logger;
if (!Files.isDirectory(sourceDir)) {
throw new Exception("Source path is not a directory: "
+ sourcePath);
}
watchService = FileSystems.getDefault().newWatchService();
sourceDir.register(watchService ,
StandardWatchEventKinds.ENTRY_CREATE ,
StandardWatchEventKinds.ENTRY_MODIFY);
logger.accept("WatchService registered for: " + sourcePath);
}
public void monitor(Consumer <Map<String , Path>> onChange) {
logger.accept("Starting WatchService loop");
try {
while (true) {
WatchKey key = watchService.take();
Map<String , Path> changedFiles = new HashMap <>();
for (WatchEvent <?> event : key.pollEvents()) {
Path fileName =
((WatchEvent <Path >)event).context();
Path filePath = sourceDir.resolve(fileName);
if (fileFilter == null ||
fileName.toString().toLowerCase().endsWith(fileFilter))
{
changedFiles.put(fileName.toString(),
```

```
filePath);
}
}
if (!changedFiles.isEmpty()) {
onChange.accept(changedFiles);
}
key.reset();
}
} catch (Exception e) {
logger.accept("Monitoring error: " + e.getMessage());
}
}
}
```
Listing 2: Folder Monitoring

Explanation:
• OS File System Events: ‘WatchService‘ uses OS APIs (e.g., Windows’ ‘ReadDirectoryChangesW‘) to detect file changes.
• Fallback: Polling checks timestamps if ‘WatchService‘ fails, using OS file metadata.

3.3 BackupManager.java

Purpose: Copies files from source to backup folder.
Code Snippet:

```
import java.nio.file.*;
import java.util.function.Consumer;
public class BackupManager {
private Path backupDir;
private Consumer <String > logger;
public BackupManager(String backupPath , Consumer <String >
logger) throws Exception {
this.backupDir = Paths.get(backupPath);
this.logger = logger;
if (!Files.exists(backupDir)) {
Files.createDirectories(backupDir);
logger.accept("Created backup directory: " +
backupPath);
}
if (!Files.isWritable(backupDir)) {
throw new Exception("Backup path is not writable: " +
backupPath);
}
}
public void backupFile(Path sourceFile , String fileName) {
```

```
try {
Path backupFile = backupDir.resolve(fileName);
logger.accept("Attempting to back up: " + sourceFile +
" -> " + backupFile);
Files.copy(sourceFile , backupFile ,
StandardCopyOption.REPLACE_EXISTING);
logger.accept("Backed up: " + sourceFile + " -> " +
backupFile);
} catch (Exception e) {
logger.accept("Error backing up " + fileName + ": " +
e.getMessage());
}
}
}
```
Listing 3: File Backup

Explanation:
• OS I/O: ‘Files.copy‘ uses OS system calls (‘read‘, ‘write‘) for file copying.
• Permissions: Checks write access with ‘Files.isWritable‘, enforced by the OS.

3.4 SyncManager.java

Purpose: Synchronizes files between source and sync folders.
Code Snippet:

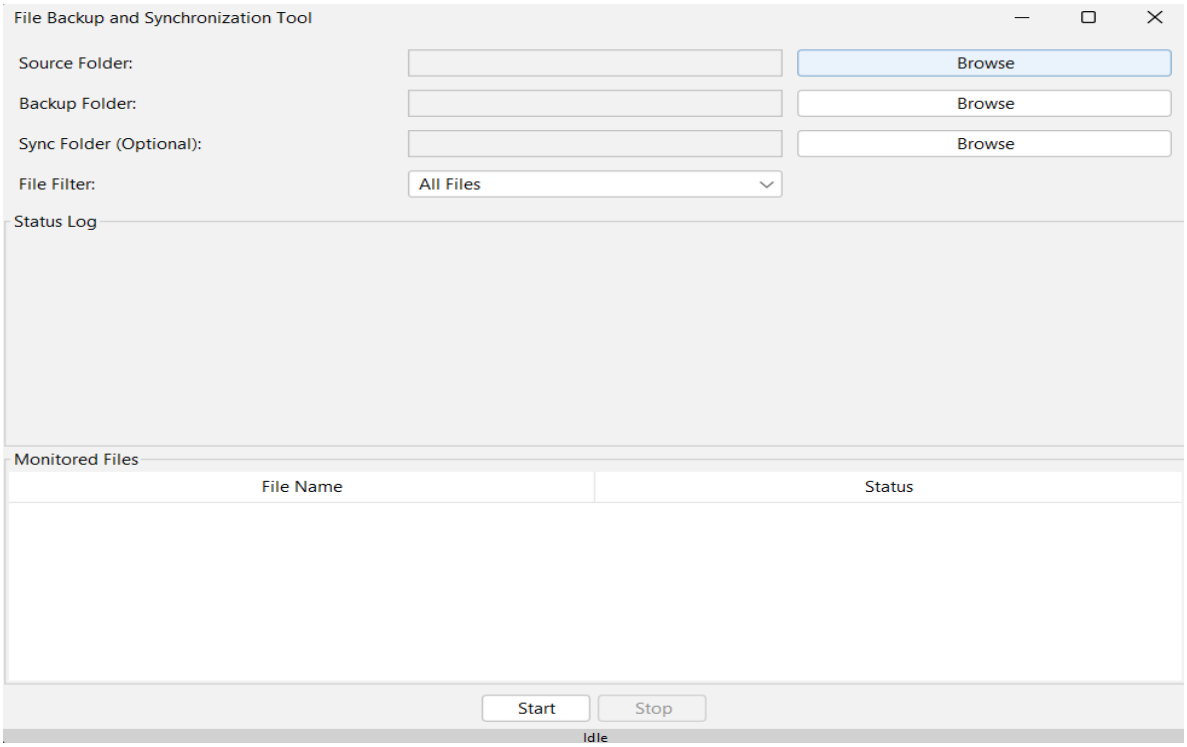
```
import java.nio.file.*;
import java.util.function.Consumer;
public class SyncManager {
private Path syncDir;
private Consumer <String > logger;
public SyncManager(String syncPath , Consumer <String > logger)
throws Exception {
this.syncDir = Paths.get(syncPath);
this.logger = logger;
if (!Files.exists(syncDir)) {
Files.createDirectories(syncDir);
logger.accept("Created sync directory: " + syncPath);
}
if (!Files.isWritable(syncDir)) {
throw new Exception("Sync path is not writable: " +
syncPath);
}
}
public void syncFolders(Path sourceDir) {
try {
```

```
for (Path srcFile :
Files.newDirectoryStream(sourceDir)) {
Path syncFile =
syncDir.resolve(srcFile.getFileName());
if (!Files.exists(syncFile)) {
Files.copy(srcFile , syncFile);
logger.accept("Synced: " + srcFile + " -> " +
syncFile);
} else if
(Files.getLastModifiedTime(srcFile).toMillis() >
Files.getLastModifiedTime(syncFile).toMillis())
{
Files.copy(srcFile , syncFile ,
StandardCopyOption.REPLACE_EXISTING);
logger.accept("Updated sync: " + syncFile);
}
}
// Sync to source (similar logic)
} catch (Exception e) {
logger.accept("Sync error: " + e.getMessage());
}
}
}
```

Listing 4: Folder Synchronization

Explanation:
• OS File Copying: Uses ‘Files.copy‘ for bidirectional synchronization.
• Metadata: Compares timestamps using OS-provided ‘Files.getLastModifiedTime‘

CHAPTER 4: SNAPSHOTS



. Figure 1: Main GUI with folder selection, file filter, and log area.

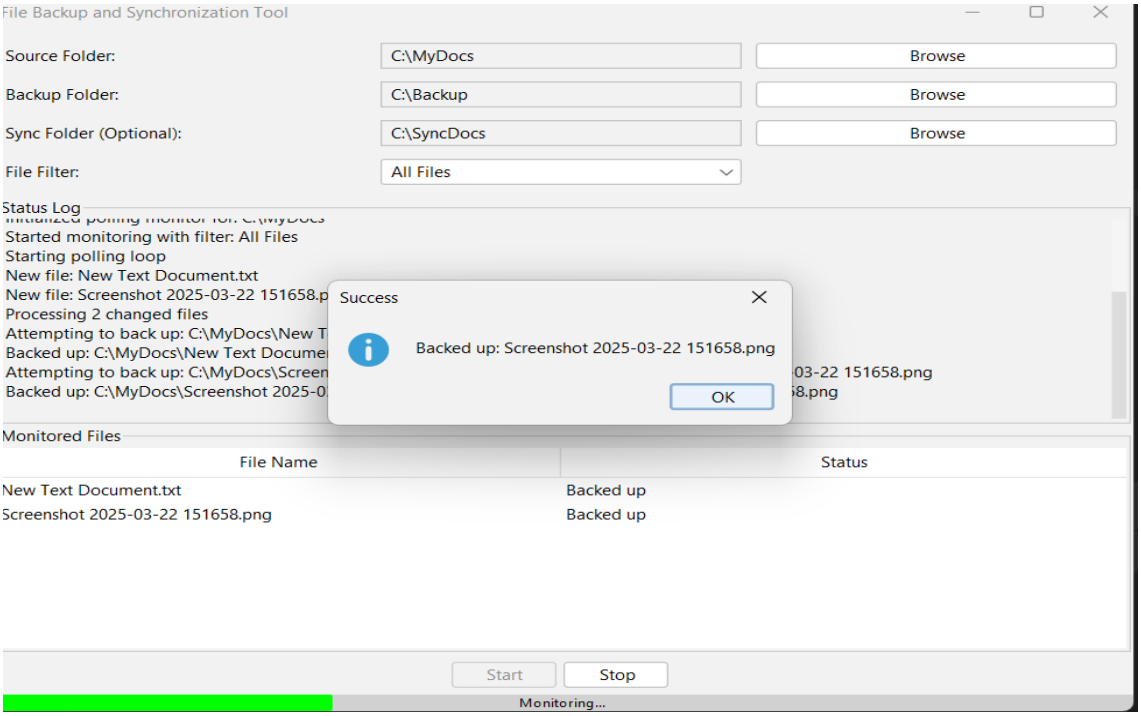


Figure 2: Log showing successful backup of a file

CHAPTER 5: LIMITATIONS

1. **Platform-Specific File Paths**:

- **Description**: The tool uses Windows-specific file paths (e.g., C:\MyDocs, C:\Backup) in the GUI's folder selection fields, which are incompatible with macOS (/Users/username/MyDocs) or Linux (/home/username/MyDocs) without manual user adjustments.
- **Impact**: Limits cross-platform usability, requiring users to adapt paths manually on non-Windows systems, reducing accessibility for macOS/Linux users. This can lead to errors if paths are entered incorrectly (e.g., using backslashes \ on Linux).

2**. WatchService Reliability Issues**:

- **Description**: The FolderMonitor class uses Java NIO's WatchService to detect file changes in real-time (e.g., new files in C:\MyDocs). However, WatchService reliability varies across OS configurations due to differences in file system event APIs (Windows' ReadDirectoryChangesW, Linux's inotify, macOS's FSEvents).
- **Impact**: On some systems, WatchService may miss events due to permission restrictions, file system limitations, or high event volumes, forcing the tool to fall back to polling (checking timestamps every 5 seconds). Polling increases CPU usage and delays detection, degrading performance.

3. **Slow Large File Handling**:

- **Description**: The BackupManager and SyncManager use Files.copy to transfer files, which processes entire files sequentially. For large files (e.g., videos >1 GB), this results in slow backups or syncs due to I/O bottlenecks.
- **Impact**: Users experience delays when backing up large files to C:\Backup or syncing to C:\SyncDocs, reducing efficiency. The progress bar may appear unresponsive for long transfers, affecting user experience.

4. **Single Folder Monitoring**:

- **Description**: The tool monitors only one source folder (e.g., C:\MyDocs) at a time, as FolderMonitor registers a single WatchService instance.
- **Impact**: Users cannot monitor multiple folders simultaneously (e.g., C:\Docs and D:\Projects), limiting scalability for complex workflows. Adding multiple folders would require significant code changes.

CHAPTER 6: ENHANCEMENTS

1. **Cross-Platform Path Support**:

   Proposal: Implement a JFileChooser or relative path parsing in FileBackupGUI to support macOS and Linux paths dynamically, eliminating Windows-specific formats.

   Benefits: Enhances portability, allowing seamless operation on any OS. Users on macOS (/Users/username/MyDocs) or Linux (/home/username/MyDocs) won't need manual path adjustments.

2. **Reliable File Monitoring**:

   Proposal: Enhance FolderMonitor with a hybrid approach: combine WatchService with a configurable polling interval (e.g., 1-10 seconds) and add error handling for WatchService failures.

   Benefits: Improves reliability by ensuring file events are detected even if WatchService fails. Reduces CPU usage with adaptive polling and provides user feedback on monitoring issues.

3. **Multi-Folder Monitoring**:

   Proposal: Extend FolderMonitor to support multiple source folders by registering multiple WatchService instances or using a thread pool for concurrent monitoring.

   Benefits: Increases scalability, allowing users to monitor multiple folders (e.g., C:\Docs, D:\Projects) simultaneously, improving workflow flexibility.

4. **Network Drive Support**:

   Proposal: Extend FolderMonitor and BackupManager to support network drives using Java's FileSystem API or third-party libraries for SMB/NFS protocols.

   Benefits: Expands applicability to enterprise or cloud environments, allowing monitoring and backup of network paths (e.g., \\server\shared).

CHAPTER 7: CONCLUSION

The File Backup and Synchronization Tool successfully automates file management, achieving its objectives of real-time monitoring, backup, and synchronization with a user-friendly Java Swing GUI enhanced by FlatLaf. Leveraging OS concepts like file system events (WatchService), I/O operations (Files.copy), threading, and permissions, it ensures efficient performance. Features such as drag-and-drop, file filtering, and a real-time progress bar, as shown in Chapter 4 snapshots, enhance usability. Despite challenges like WatchService failures and Maven issues, solutions like polling and robust error handling ensured reliability. The tool addresses manual file management inefficiencies, offering a practical solution for users. Its academic value lies in demonstrating OS-driven software development, as detailed in Chapters 3 and 5. Limitations, such as platform-specific paths and large file handling, are acknowledged in Chapter 5, with future enhancements proposed in Chapter 6, including cloud integration and incremental backups. This project provides a strong foundation for further development, showcasing technical proficiency and real-world applicability. It aligns with Graphic Era Hill University's focus on OS concepts, preparing students for advanced software engineering challenges. The successful implementation underscores its potential for both academic and practical contributions.

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