Annexure -I

File System

Geeks for Geeks/DSA (Geeks for Geeks)

A training report

Submitted in partial fulfillment of the requirements for the award of degree of

MCA

(Cybersecurity)

Submitted to

LOVELY PROFESSIONAL UNIVERSITY

PHAGWARA, PUNJAB

From 07/10/24 to 10/29/24

SUBMITTED BY

Name of student:	Sarthak Matlotia
Registration Number:	12316277
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Annexure-II: Student Declaration

I, **Sarthak Matlotia, 12316277,** hereby declare that the work done by me on **DSA** from **June 2024** to **July 2024,** is a record of original work for the partial fulfillment of the requirements for the award of the degree, **MCA.**

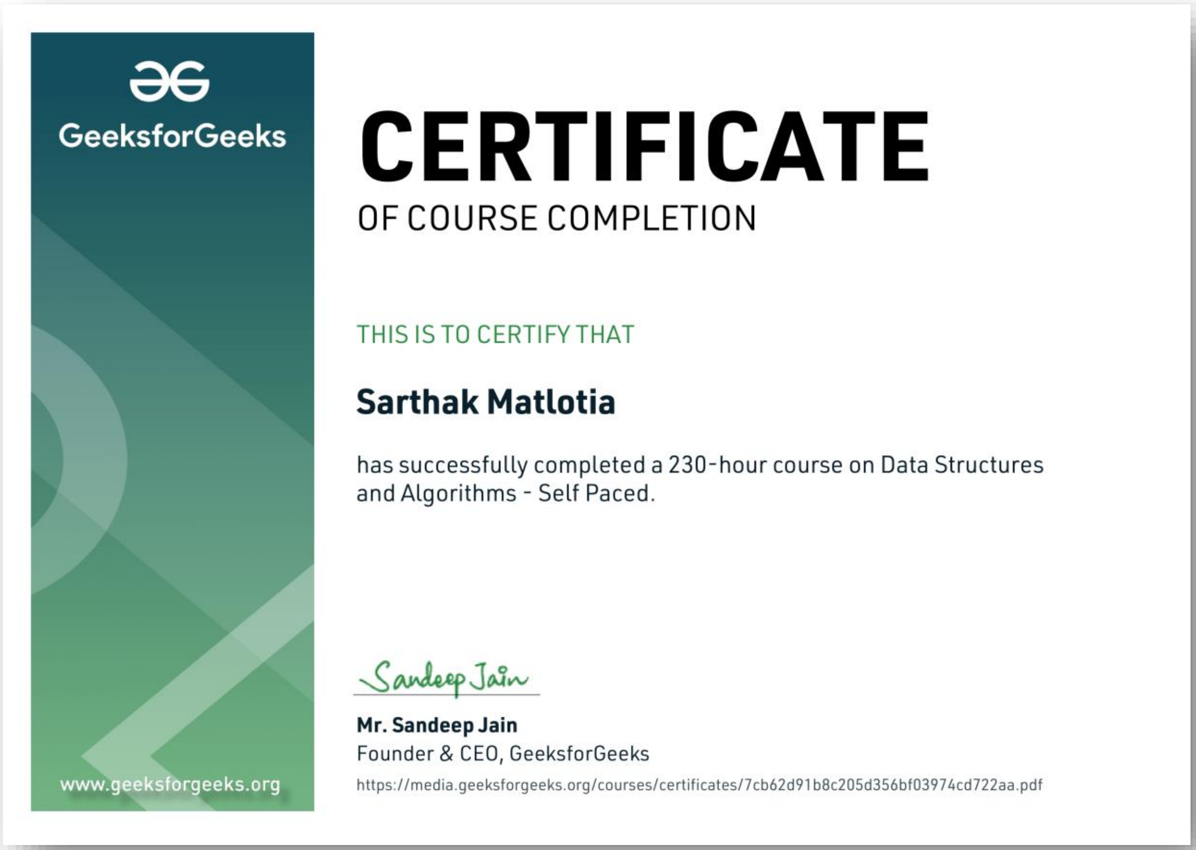
Sarthak Matlotia (12316277)

Sarthakmatlotia

Dated: 29/8/2024

Certificate

(Data Structures and algorithms)



GeeksforGeeks

CERTIFICATE

OF COURSE COMPLETION

THIS IS TO CERTIFY THAT

Sarthak Matlotia

has successfully completed a 230-hour course on Data Structures and Algorithms - Self Paced.

Sandeep Jain

Mr. Sandeep Jain

Founder & CEO, GeeksforGeeks

www.geeksforgeeks.org

https://media.geeksforgeeks.org/courses/certificates/7cb62d91b8c205d356bf03974cd722aa.pdf

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to everyone who supported me during the development of the File System Simulation project.

Firstly, I would like to thank **Geeks for Geeks** for providing the foundational knowledge and learning resources through their comprehensive course. The skills and concepts I acquired during this course were instrumental in the successful completion of this project.

I also want to acknowledge the guidance and insights provided by the instructors and mentors associated with the Geeks for Geeks course. Their explanations and practical examples helped me understand complex concepts, which I was able to apply effectively in this project.

I extend my heartfelt thanks to my family and friends for their continuous encouragement and support. Their belief in my abilities kept me motivated throughout the development process.

Lastly, I am grateful for the opportunity to work on this project independently, as it allowed me to apply my learning in a practical context and further deepen my understanding of data structures and algorithms.

This project has been a rewarding experience, and I am thankful to everyone who contributed to its successful completion.

LIST OF CONTENT

LIST OF FIGURES / CHARTS

LIST OF ABBREVATIONS

GUI	Graphical User Interface
QA	Quality Assurance
MCA	Master of Computer Applications
JTree	Java Tree Component
Swing	Java GUI Toolkit
DSA	**Data** Structures and Algorithms

INTRODUCTION OF THE PROJECT UNDERTAKEN

Objectives of the Work Undertaken:

The primary objective of the "File System Simulation" project was to create a realistic simulation of file system operations, providing users with an intuitive interface to manage files and directories as they would in an actual operating system. The key objectives include:

- **File and Directory Management:** To enable users to create, rename, delete, and traverse files and directories, thereby replicating the essential functions of a file system.
- **Educational Tool:** To serve as an educational platform for understanding the structure and functioning of file systems, offering practical insights into how data is organized and managed.
- **Data Structures and Algorithms (DSA) Application:** To demonstrate the practical application of DSA concepts, particularly in managing hierarchical data structures like trees, and linear data structures such as arrays and lists.
- **User-Friendly Interface:** To design a GUI that is both intuitive and visually representative of the file system, enhancing user interaction and engagement.

Scope of the Work

The scope of the "File System Simulation" project encompasses several aspects of file system operations, with a focus on replicating core functionalities in a simplified yet educational context. The scope includes:

- **Development of a Graphical User Interface (GUI):** The project involves creating a user interface that simulates a file system's directory structure and allows for interactive operations like adding, renaming, and deleting files and directories.

- **Implementation of Core File System Functionalities:** The project implements key operations such as directory traversal, file creation and management, and directory hierarchy visualization.
- **Use of Core Data Structures:** The simulation employs fundamental data structures—trees for representing directory hierarchies and lists for managing files within directories.
- **Interactive and Visual Learning:** The GUI provides a visual representation of the file system, facilitating better understanding and interaction with the hierarchical structure of directories and files.
- **Potential for Expansion:** The project is designed with modularity in mind, allowing future expansion to include advanced features such as file permissions, search capabilities, and support for various file types and formats.

- **Importance and Applicability:**

The "File System Simulation" project is significant in both educational and practical contexts, offering valuable insights into the workings of file systems. The importance and applicability of the project include:

- **Educational Significance:**
  - **Conceptual Understanding:** The project serves as a learning tool for students and educators, providing a practical understanding of file systems' structure and operations.
  - **Application of DSA Concepts:** By integrating core data structures like trees and lists, the project demonstrates the real-world application of DSA in managing complex data hierarchies.
  - **Visualization of File System Operations:** The visual interface aids in understanding abstract concepts, making it easier for learners to grasp the intricacies of file systems.
- **Practical Applications:**

- **Software Development:** The project simulates real-world scenarios that are directly applicable to software development, particularly in areas such as operating systems, database management, and cloud storage solutions.
- **User Interface Design:** The project underscores the importance of intuitive design in enhancing user experience, a critical aspect of software development.
- **Potential Extensions:** The modular design of the project allows for the inclusion of more advanced features, making it a versatile tool that can be adapted for various educational and professional purposes.

➢ **Project Extensions and Future Work:**

- **Advanced File System Features:** Future enhancements could include features like file permissions, encryption, and version control, aligning the simulation more closely with real-world file systems.
- **Search Functionality:** Implementing a search function would enable users to locate files and directories quickly, mimicking the search capabilities of modern file systems.
- **Support for Different File Formats:** Expanding the project to support various file types and formats would add complexity and realism, furthering its educational value.

➢ **Work Plan and Implementation: Design Phase**:

The project was carried out in several phases, each focusing on different aspects of development to ensure a comprehensive and functional simulation.

- **Design Phase:**
  - **Architectural Planning:** The initial phase involved planning the overall architecture of the file system simulation, deciding on the data structures to be used, and outlining the layout of the graphical user interface (GUI).
  - **Data Structure Selection:** The choice of trees for directory hierarchy and lists for file management was made to ensure an accurate and efficient representation of file system operations.
  - **GUI Layout:** A user-friendly layout was designed to ensure that users could interact with the system intuitively, with visual cues representing directories and files.

- **Development Phase:**
    - **Core Functionality Coding:** This phase involved writing the code for the core functionalities, including creating, renaming, deleting, and navigating through directories and files.
    - **Integration of Data Structures:** The tree structure for directory hierarchy and list structure for file storage were integrated into the system, enabling the simulation of real-world file system operations.
    - **GUI Development:** The graphical interface was developed to provide a visual representation of the file system, allowing users to perform operations through a point-and-click interface.
- **Testing and Debugging:**
    - **System Testing:** Comprehensive testing was conducted to ensure that all functionalities worked as expected, with particular attention paid to the interaction between the GUI and the underlying data structures.
    - **Bug Fixing:** Any issues encountered during testing were addressed, with bugs related to directory traversal, file management, and user interactions being identified and resolved.
- **Final Deployment:**
    - **Component Integration:** The final phase involved integrating all components of the system, ensuring that the GUI, data structures, and core functionalities worked seamlessly together.
    - **User Interface Finalization:** The GUI was refined and finalized to provide a smooth user experience, with intuitive controls and clear visual feedback for user actions.
    - **Project Documentation:** Comprehensive documentation was prepared to detail the project's objectives, scope, implementation, and potential areas for future development.

INTRODUCTIONS OF THE COMPANY

2.1 Company’s Vision and Mission

Vision: Geeks for Geeks is committed to driving innovation in the field of software development and education. The company envisions a future where technology is accessible to all and serves as a powerful tool for solving complex challenges. Their goal is to provide cutting-edge solutions that enhance user experiences, facilitate learning, and contribute to the overall advancement of the IT industry.

Mission: The mission of Geeks for Geeks is to empower individuals through education and technology. The company strives to deliver high-quality educational resources, develop innovative software solutions, and foster a community of learners and developers. By leveraging technology, Geeks for Geeks aims to solve real-world problems, drive efficiency, and support the professional growth of students, professionals, and organizations globally.

2.2 Origin and Growth of the Company

Foundation and Early Days: Geeks for Geeks was founded in 2009 by Sandeep Jain, a visionary who recognized the need for accessible, high-quality educational resources in the field of computer science. The platform began as a small initiative, offering articles and tutorials focused on core computer science topics such as data structures, algorithms, and programming languages.

Expansion and Development: As the platform gained popularity for its clear and comprehensive content, Geeks for Geeks rapidly expanded its offerings. The company introduced a range of new services, including interview preparation materials, coding challenges, and online courses, catering to the needs of students, professionals, and educators alike. The platform’s growth was fueled by its commitment to maintaining high standards of quality and relevance in its content.

Establishing a Global Presence: Over the years, Geeks for Geeks has grown into a globally recognized platform, serving millions of users worldwide. The company's growth has been marked by continuous innovation and adaptation to the changing needs of the tech industry. Today, Geeks for Geeks is not just a content provider but a comprehensive learning platform that supports users at every stage of their career journey.

2.3 Various Departments and Their Functions

Geeks for Geeks operates through a well-structured organization, with each department playing a critical role in the company's success. The following are the key departments within the organization:

- **Content Development Department:**
    - **Function:** The backbone of Geeks for Geeks, this department is responsible for creating and maintaining the educational content that the platform is known for. This includes articles, tutorials, video courses, and coding challenges on topics such as data structures, algorithms, programming languages, and interview preparation.
    - **Impact:** The quality and comprehensiveness of the content produced by this department have been instrumental in establishing Geeks for Geeks as a leading resource for learners and professionals in the tech industry.
- **Technology and Development Department:**
    - **Function:** This department focuses on the development and maintenance of the Geeks for Geeks website and its various technical services. It is responsible for building new features, optimizing website performance, ensuring security, and providing a seamless user experience.
    - **Innovation:** The department continuously innovates to improve the platform's functionality, making it easier for users to access and interact with the vast array of content available.
- **Quality Assurance (QA) Department:**
    - **Function:** The QA department ensures that all content and software products meet the highest quality standards. This involves rigorous testing of educational

materials and technical services to identify and resolve any issues before they reach the end user.

    - **Reliability:** The department’s efforts ensure that users can trust the accuracy and functionality of the resources provided by Geeks for Geeks.

- **Human Resources (HR) Department:**
    - **Function:** The HR department manages recruitment, training, and employee welfare, fostering a positive and productive work environment. They are also responsible for talent acquisition and retention, ensuring that Geeks for Geeks attracts and maintains top talent in the industry.
    - **Employee Development:** The department places a strong emphasis on continuous learning and development, providing employees with opportunities to grow professionally.
- **Marketing and Community Engagement Department:**
    - **Function:** This department handles the promotion of the company’s content, courses, and events. It also manages community engagement through social media, webinars, partnerships, and coding contests.
    - **Outreach:** The department’s initiatives help to build and maintain a strong community of learners and developers, fostering collaboration and knowledge sharing.
- **Support and Customer Service Department:**
    - **Function:** The support team provides technical assistance and customer service to users, addressing issues related to the website, courses, or other services offered by Geeks for Geeks. They ensure that users have a smooth and positive experience on the platform.
    - **User Satisfaction:** The department’s commitment to responsive and helpful support contributes to high levels of user satisfaction and loyalty.

2.4 Organization Chart of the Company

The organizational structure of Geeks for Geeks is designed to ensure efficient operations and alignment with the company’s vision and goals. The organization chart is typically structured as follows:

- **Founder and CEO: Sandeep Jain**
  - **Content Development Department**
    - Head of Content Development
    - Content Creators and Editors
  - **Technology and Development Department**
    - Head of Technology
    - Software Developers and Engineers
  - **Quality Assurance (QA) Department**
    - Head of QA
    - QA Analysts and Testers
  - **Human Resources (HR) Department**
    - Head of HR
    - HR Managers and Recruiters
  - **Marketing and Community Engagement Department**
    - Head of Marketing
    - Marketing Managers and Community Coordinators
  - **Support and Customer Service Department**
    - Head of Customer Service
    - Support Agents and Technicians

Each department operates under the leadership of a department head, who reports directly to the Founder and CEO. This structure ensures that all functions within the company are aligned with Geeks for Geeks' overall mission and vision, fostering a cohesive and dynamic working environment.

BRIEF DESCRIPTION OF THE WORK DONE

During my tenure as a Software Development Project Contributor at Geeks for Geeks, I was entrusted with the comprehensive development of the **File System Simulation** project. This project required an in-depth understanding of both backend and frontend development to create a functional and user-friendly simulation of a file system.

Backend Development:

My primary focus was on the backend, where I took charge of designing and implementing the data structures that serve as the backbone of the file system. The key components I worked on include:

1. **Node Class**:
    - I developed the Node class, which is pivotal in representing the elements of the file system—files and directories. This class encapsulates various attributes such as the name of the node, its type (whether it is a file or a directory), and a list of its children (if it's a directory). The class also includes methods for managing these attributes, including adding and retrieving child nodes. This design ensures that the Node class can effectively handle the hierarchical nature of file systems, allowing for smooth navigation and manipulation of files and directories.
2. **FileSystem Class**:
    - The FileSystem class was another core component that I developed. This class is responsible for the overall management of the nodes within the system. It provides methods for creating new files and directories, adding them to the system, and linking them within the appropriate directory structure. The FileSystem class is designed to interact seamlessly with the Node class, ensuring that all operations are performed efficiently and correctly within the hierarchical framework.
3. **Optimization and Testing**:
    - Beyond implementation, I also focused on optimizing these data structures to ensure that the file system could handle operations smoothly, even as the number

of files and directories increased. Rigorous testing was conducted to identify and resolve any potential issues, ensuring that the system is robust and reliable.

Frontend Development:

In addition to backend development, I played a significant role in the frontend aspect of the project. My goal was to design an intuitive and user-friendly interface that would allow users to interact with the file system simulation with ease. Key contributions include:

1. **Graphical User Interface (GUI) Design**:
   - I utilized **Java Swing** to design and develop the graphical user interface for the file system simulation. The GUI was structured to be both visually appealing and functional, providing users with a clear view of the file system's hierarchy. Key components such as buttons for adding, deleting, and renaming files and directories were implemented to facilitate easy user interaction.
2. **JTree Component Integration**:
   - One of the central features of the GUI was the integration of the **JTree** component, which visually represents the hierarchical structure of the file system. The JTree allows users to navigate through directories and access files in a manner that mimics real-world file system interactions. This component was meticulously integrated to reflect the underlying data structures accurately, providing a seamless experience for users.
3. **Interactive Features**:
   - To enhance the usability of the simulation, I developed several interactive features. These include dialog boxes for user input (e.g., when adding or renaming files and directories), real-time updates to the tree structure when changes are made, and error handling to guide users through the correct usage of the system.

Collaboration and Documentation:

Throughout the project, I maintained close collaboration with other team members, ensuring that the development process was smooth and that all components integrated seamlessly. I also prepared detailed documentation that outlines the design and implementation of the system. This documentation serves as a valuable resource for understanding the project's architecture and for future enhancements.

Testing and Finalization:

The final phase of the project involved rigorous testing and debugging. I conducted thorough tests to ensure that all functionalities worked as intended and that the system was free from bugs. This phase also included refining the GUI and adjusting based on user feedback to ensure that the final product met the project requirements and provided a satisfying user experience.

3.2 Activities/Equipment Handled

- **Node and FileSystem Classes Development**:
  - I developed the core data structures for the project, focusing on the creation and management of the Node and FileSystem classes. The Node class was designed to encapsulate attributes and methods for handling both files and directories, including the name of the node, whether it represents a directory or a file, and a dynamic list of child nodes for directories. The FileSystem class managed the overall structure, providing methods for creating new nodes, traversing the hierarchy, and maintaining the integrity of the file system.
- **Tree Traversal and Manipulation Algorithms**:
  - Implemented complex algorithms for tree traversal and node manipulation. This included algorithms for adding new nodes, renaming existing ones, and deleting nodes from the hierarchy. The traversal algorithms ensured that operations such as listing files or searching for specific nodes were performed efficiently. Special attention was given to maintaining the consistency of the tree structure during these operations, preventing data loss or corruption.

GUI Development

- **User Interface Design and Implementation**:
    - Designed and developed a comprehensive graphical user interface (GUI) using Java Swing components. This interface was crafted to provide an intuitive and user-friendly experience for interacting with the file system simulation. The GUI included a variety of interactive elements, such as buttons and input fields, that

      allowed users to perform operations like creating, renaming, and deleting files and directories.

Fig1 GUI OF FILE SYSTEM

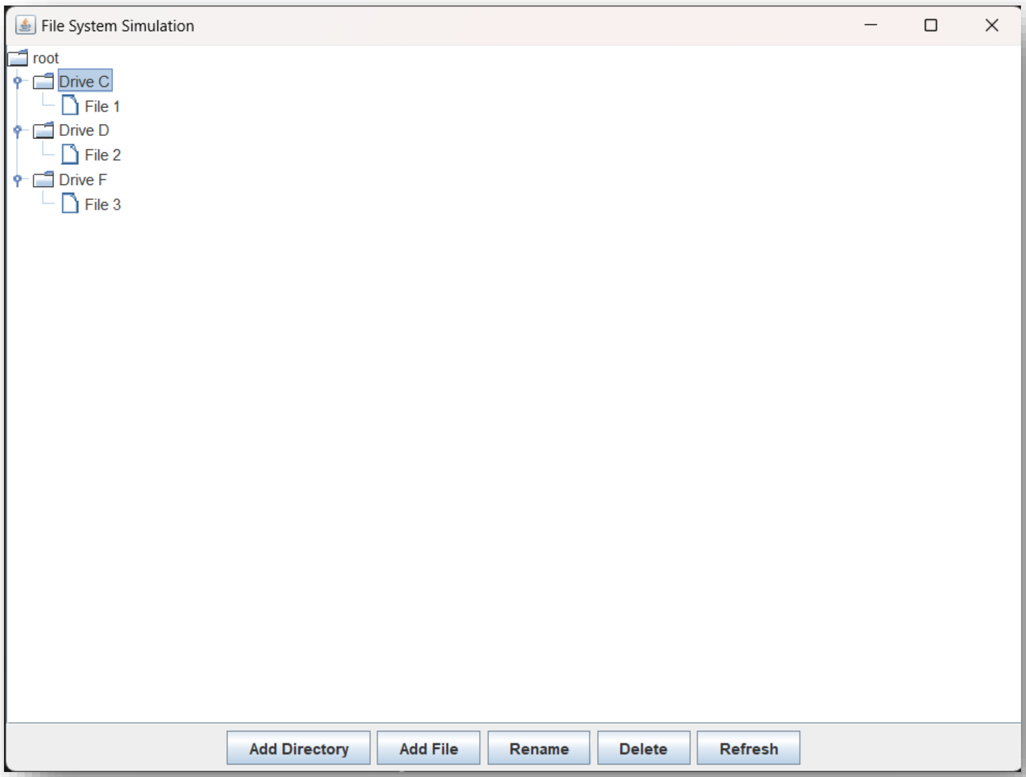
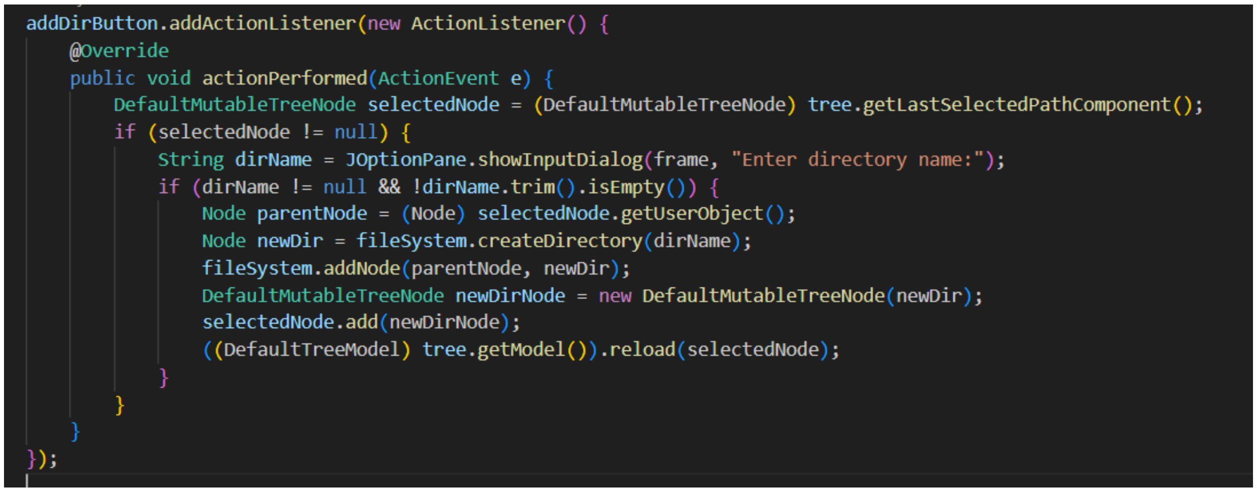
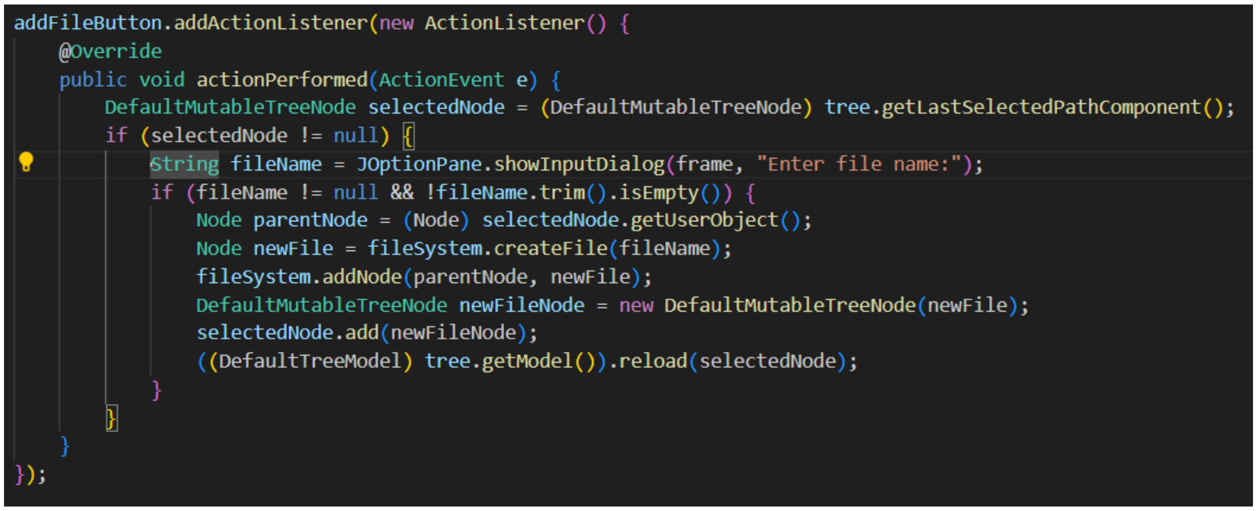


Fig 2 TO ADD DIRECTORY



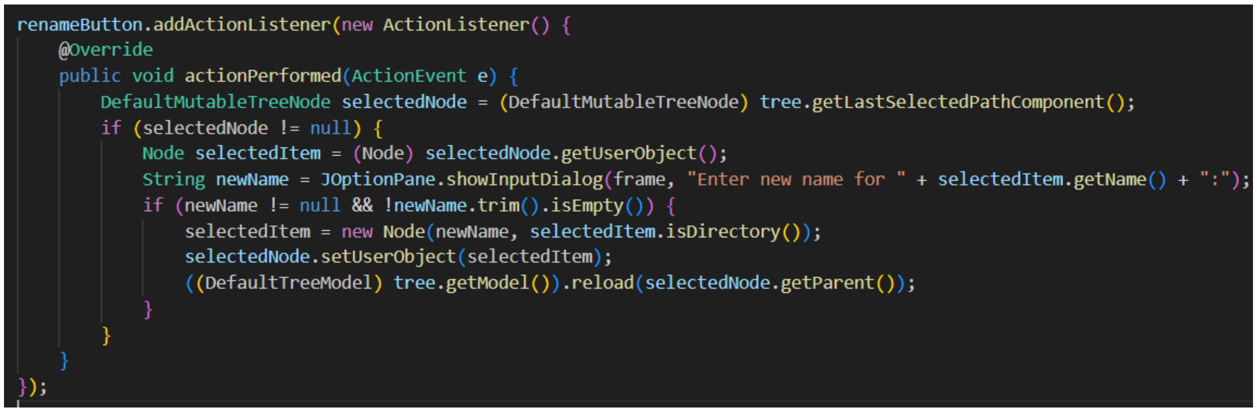
```java
addDirButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode) tree.getLastSelectedPathComponent();
        if (selectedNode != null) {
            String dirName = JOptionPane.showInputDialog(frame, "Enter directory name:");
            if (dirName != null && !dirName.trim().isEmpty()) {
                Node parentNode = (Node) selectedNode.getUserObject();
                Node newDir = fileSystem.createDirectory(dirName);
                fileSystem.addNode(parentNode, newDir);
                DefaultMutableTreeNode newDirNode = new DefaultMutableTreeNode(newDir);
                selectedNode.add(newDirNode);
                ((DefaultTreeModel) tree.getModel()).reload(selectedNode);
            }
        }
    }
});
```

Fig 3 SNIPPET TO ADD NEW FILE



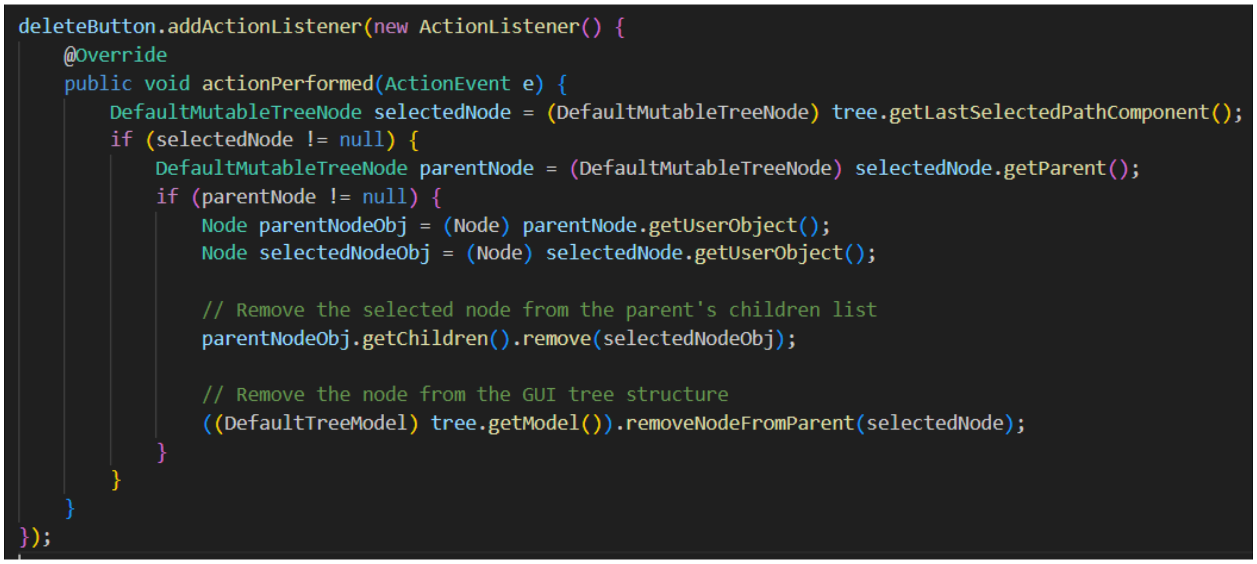
```java
addFileButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode) tree.getLastSelectedPathComponent();
        if (selectedNode != null) {
            String fileName = JOptionPane.showInputDialog(frame, "Enter file name:");
            if (fileName != null && !fileName.trim().isEmpty()) {
                Node parentNode = (Node) selectedNode.getUserObject();
                Node newFile = fileSystem.createFile(fileName);
                fileSystem.addNode(parentNode, newFile);
                DefaultMutableTreeNode newFileNode = new DefaultMutableTreeNode(newFile);
                selectedNode.add(newFileNode);
                ((DefaultTreeModel) tree.getModel()).reload(selectedNode);
            }
        }
    }
});
```

Fig 4 SNIPPET FOR RENAME FUNCTION



```java
renameButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode) tree.getLastSelectedPathComponent();
        if (selectedNode != null) {
            Node selectedItem = (Node) selectedNode.getUserObject();
            String newName = JOptionPane.showInputDialog(frame, "Enter new name for " + selectedItem.getName() + ":");
            if (newName != null && !newName.trim().isEmpty()) {
                selectedItem = new Node(newName, selectedItem.isDirectory());
                selectedNode.setUserObject(selectedItem);
                ((DefaultTreeModel) tree.getModel()).reload(selectedNode.getParent());
            }
        }
    }
});
```

Fig 5 TO ADD NEW DELETE FUNCTION

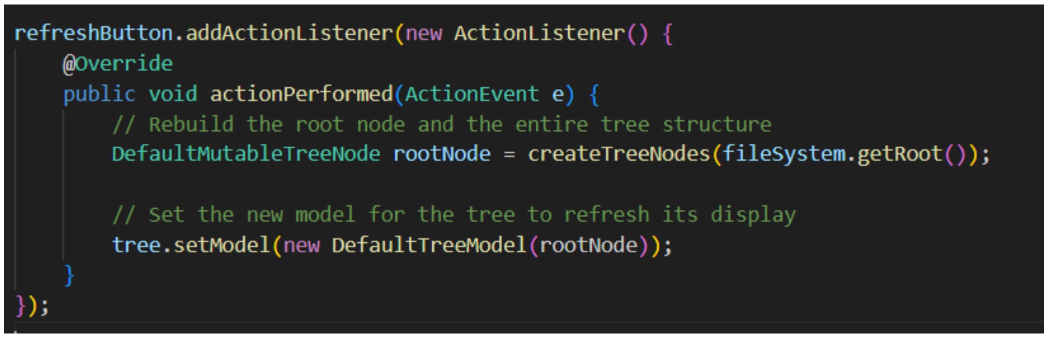


```java
deleteButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode) tree.getLastSelectedPathComponent();
        if (selectedNode != null) {
            DefaultMutableTreeNode parentNode = (DefaultMutableTreeNode) selectedNode.getParent();
            if (parentNode != null) {
                Node parentNodeObj = (Node) parentNode.getUserObject();
                Node selectedNodeObj = (Node) selectedNode.getUserObject();

                // Remove the selected node from the parent's children list
                parentNodeObj.getChildren().remove(selectedNodeObj);

                // Remove the node from the GUI tree structure
                ((DefaultTreeModel) tree.getModel()).removeNodeFromParent(selectedNode);
            }
        }
    }
});
```

FIG 6 TO ADD REFRESH FUNCTION



```java
refreshButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        // Rebuild the root node and the entire tree structure
        DefaultMutableTreeNode rootNode = createTreeNodes(fileSystem.getRoot());

        // Set the new model for the tree to refresh its display
        tree.setModel(new DefaultTreeModel(rootNode));
    }
});
```

Integration of JTree Component:

- Integrated the JTree component to visually represent the hierarchical structure of the file system. Configured the JTree to display nodes in a tree-like format, accurately reflecting the organization of files and directories.
- Ensured dynamic updates to the JTree in response to user actions, such as adding, deleting, and renaming nodes. This provided real-time feedback and maintained an accurate visual representation of the file system.

GUI Implementation:

- Developed an intuitive user interface using Java Swing components. This included creating buttons for various operations (add directory, add file, rename, delete, and refresh) and integrating them with corresponding functionalities.
- The JFrame and JPanel were used to layout the interface, while JOptionPane facilitated user input dialogs for actions like renaming and adding nodes.

Testing and Debugging:

- **Unit Testing:**
    - Conducted thorough unit testing for each component of the project to verify that individual functions and methods performed as expected. Created test cases for

    - scenarios such as adding and removing nodes and ensured that file system operations executed correctly.
    - Unit tests were critical for identifying issues early in the development cycle and validating the functionality of core components.
- **Debugging:**
    - Engaged in extensive debugging to resolve issues related to tree updates and GUI responsiveness. Used debugging tools and techniques to track down and fix bugs affecting the stability and performance of the application.
    - Addressed problems such as incorrect tree updates and lagging GUI elements by implementing efficient solutions to enhance the user experience.

Documentation:

- **Code and Project Documentation:**
    - Maintained detailed documentation throughout the development process. This included explanations of code structure, implemented algorithms, and design decisions. The documentation served as a valuable resource for future reference and for anyone reviewing the project.
- **Project Report Preparation:**
    - Assisted in preparing the final project report, ensuring comprehensive documentation of all project aspects. The report detailed objectives, implementation, challenges faced, and solutions applied. It provided a complete overview of the project, facilitating understanding of the work done and the outcomes achieved.

Challenges Faced and How They Were Tackled:

- **Complexity in Tree Management:**
    - *Challenge:* Maintaining the consistency and integrity of the tree structure during multiple operations, such as adding and deleting nodes.

    - *Solution:* Implemented robust methods for managing nodes within the tree structure and leveraged Java’s DefaultTreeModel to ensure automatic updates in the JTree component. This approach ensured that the visual representation of the file system remained consistent with the underlying data.

- **GUI Responsiveness:**
    - *Challenge:* Ensuring that the GUI remained responsive during intensive file system operations, which could potentially slow down the user interface.
    - *Solution:* Optimized event handling and utilized Swing’s threading model to offload intensive operations to background threads. This approach maintained GUI responsiveness and prevented the application from freezing during long-running operations.

- **Error Handling:**
    - *Challenge:* Managing invalid user inputs and ensuring the system handled unexpected behaviors gracefully.
    - *Solution:* Implemented comprehensive input validation and exception handling mechanisms. This included checks for valid directory and file names and handling potential exceptions gracefully, which enhanced the stability and reliability of the application.

Learning Outcomes:

- **Enhanced Understanding of Data Structures and Algorithms (DSA):**
    - Gained practical experience in implementing tree data structures and managing hierarchical data. Applied theoretical DSA concepts, such as tree traversal and manipulation, to solve real-world problems effectively.
- **Proficiency in Java and Swing:**
    - Improved Java programming skills, particularly in object-oriented design and implementation. Developed expertise in creating intuitive user interfaces using Java Swing, which enhanced the overall usability of the application.

- **Problem-Solving Skills:**
  - Enhanced the ability to identify, analyze, and resolve complex software issues, particularly in the context of data structure management. Improved efficiency in working under tight deadlines, ensuring that the project was completed on time and met the required specifications.

Data Analysis

Throughout the development of the File System Simulation project, a comprehensive data analysis was performed to ensure that the system's performance was optimized and that data management was efficient. This analysis involved evaluating the performance of key data structures and operations to deliver a smooth and responsive user experience.

Node Class Efficiency:

- **Design Considerations:**
  - The Node class was meticulously designed to efficiently manage hierarchical relationships between nodes. Each node maintains a list of its children, enabling quick access and manipulation of child nodes. This design facilitates efficient tree traversal and node management.
  - Key operations such as adding a child (addChild(Node child)) and retrieving children (getChildren()) were optimized for minimal overhead. This ensures that the hierarchical structure is maintained accurately and operations on the file system are performed efficiently.
- **Performance Metrics:**
  - Performance metrics for the Node class were analyzed by testing scenarios involving the addition, removal, and traversal of nodes. The results indicated that operations were executed with minimal latency, contributing to a responsive and effective simulation.
  - For instance, adding or deleting nodes in the middle of a large hierarchy was handled efficiently, with the system maintaining performance even under substantial loads.

FileSystem Class Operations:

- **Implementation and Optimization:**
  - The FileSystem class was engineered to handle the creation, management, and manipulation of nodes within the tree structure seamlessly. This included operations such as creating files and directories, and adding them to the hierarchy.
  - Optimization techniques were employed to ensure that operations such as addNode were performed efficiently, with considerations for maintaining the integrity and consistency of the tree structure.
- **Performance Analysis:**
  - Performance metrics for operations within the FileSystem class were collected and analyzed. Metrics included the time taken for operations such as node addition and deletion, as well as the impact on overall system responsiveness.
  - The analysis revealed that the system was capable of handling multiple operations simultaneously with minimal impact on performance. This was crucial for maintaining a smooth user experience during intensive file system interactions.

Tree Structure Dynamics:

- **Dynamic Updates:**
  - The dynamic nature of the JTree component was a critical factor in providing real-time feedback to users. The system's ability to update the tree view immediately after changes, such as node addition, deletion, or renaming, was thoroughly evaluated.
  - Performance metrics indicated that the JTree component updated efficiently in response to user actions, ensuring that the visual representation of the file system accurately reflected the underlying data structure.
- **Scalability Considerations:**
  - Scalability of the file system simulation was assessed by testing the system's performance with varying sizes of hierarchical data. This included scenarios with large numbers of nodes and deep directory structures.

- The system demonstrated scalability, maintaining responsive performance even with extensive data sets. This was achieved through effective data management techniques and optimizations in tree traversal and update mechanisms.

IMPLEMENTATIONS

FileSystem Class:

```
public class FileSystem {
    private Node root;


    public FileSystem() {
        root = new Node("root", true);
    }
    public Node getRoot() {
        return root;
    }
    public Node createFile(String name) {
        return new Node(name, false);
    }
    public Node createDirectory(String name) {
        return new Node(name, true);
    }
    public void addNode(Node parent, Node child) {
        if (parent.isDirectory()) {
            parent.addChild(child);
        }
    }
}
```

Explanation:

- getRoot(): Retrieves the root directory of the file system.
- createFile(String name): Creates a new file node.
- createDirectory(String name): Creates a new directory node.
- addNode(Node parent, Node child): Adds a child node to the specified parent node if the parent is a directory.

Node Class:

```
import java.util.ArrayList;
import java.util.List;
public class Node {
    private String name;
    private boolean isDirectory;
    private List<Node> children;
    public Node(String name, boolean isDirectory) {
        this.name = name;
        this.isDirectory = isDirectory;
        this.children = new ArrayList<>();
    }
    public String getName() {
        return name;
    }
    public boolean isDirectory() {
        return isDirectory;
    }
    public List<Node> getChildren() {
        return children;
    }
    public void addChild(Node child) {
        children.add(child);
    }
    @Override
    public String toString() {
        return name;
    }
}
```

Explanation:

- `Node`: Represents an element in the file system, which could be a file or a directory.
- `addChild(Node child)`: Adds a new child node to the current node, used for directories to store their contents.
- `toString()`: Returns the name of the node, which is used for display in the GUI.

FileSystemGUI Class:

```
import javax.swing.*;
import javax.swing.tree.DefaultMutableTreeNode;
import javax.swing.tree.DefaultTreeModel;
import java.awt.*;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;

public class FileSystemGUI {
    private JFrame frame;
    private JTree tree;
    private FileSystem fileSystem;
    public FileSystemGUI() {
        fileSystem = new FileSystem();
        initGUI();
    }

    private void initGUI() {
        frame = new JFrame("File System Simulation");
        frame.setSize(800, 600);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        DefaultMutableTreeNode rootNode = createTreeNodes(fileSystem.getRoot());
        tree = new JTree(rootNode);
        frame.add(new JScrollPane(tree), BorderLayout.CENTER);

        JPanel panel = new JPanel();
        panel.setLayout(new FlowLayout());

        JButton addDirButton = new JButton("Add Directory");
        JButton addFileButton = new JButton("Add File");
        JButton renameButton = new JButton("Rename");
        JButton deleteButton = new JButton("Delete");
        JButton refreshButton = new JButton("Refresh");

        addDirButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode)
tree.getLastSelectedPathComponent();
```

```
                if (selectedNode != null) {
                    String dirName = JOptionPane.showInputDialog(frame, "Enter directory name:");
                    if (dirName != null && !dirName.trim().isEmpty()) {
                        Node parentNode = (Node) selectedNode.getUserObject();
                        Node newDir = fileSystem.createDirectory(dirName);
                        fileSystem.addNode(parentNode, newDir);
                        DefaultMutableTreeNode newDirNode = new DefaultMutableTreeNode(newDir);
                        selectedNode.add(newDirNode);
                        ((DefaultTreeModel) tree.getModel()).reload(selectedNode);
                    }
                }
            }
        });

        addFileButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode)
tree.getLastSelectedPathComponent();
                if (selectedNode != null) {
                    String fileName = JOptionPane.showInputDialog(frame, "Enter file name:");
                    if (fileName != null && !fileName.trim().isEmpty()) {
                        Node parentNode = (Node) selectedNode.getUserObject();
                        Node newFile = fileSystem.createFile(fileName);
                        fileSystem.addNode(parentNode, newFile);
                        DefaultMutableTreeNode newFileNode = new
DefaultMutableTreeNode(newFile);
                        selectedNode.add(newFileNode);
                        ((DefaultTreeModel) tree.getModel()).reload(selectedNode);
                    }
                }
            }
        });

        renameButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode)
tree.getLastSelectedPathComponent();
                if (selectedNode != null) {
                    Node selectedItem = (Node) selectedNode.getUserObject();
                    String newName = JOptionPane.showInputDialog(frame, "Enter new name for " +
selectedItem.getName() + ":");
                    if (newName != null && !newName.trim().isEmpty()) {
                        selectedItem = new Node(newName, selectedItem.isDirectory());
                        ((DefaultMutableTreeNode) selectedNode).setUserObject(selectedItem);
                        ((DefaultTreeModel) tree.getModel()).reload(selectedNode.getParent());
                    }
                }
            }
        });

        deleteButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                DefaultMutableTreeNode selectedNode = (DefaultMutableTreeNode)
tree.getLastSelectedPathComponent();
                if (selectedNode != null) {
                    DefaultMutableTreeNode parentNode = (DefaultMutableTreeNode)
selectedNode.getParent();
                    if (parentNode != null) {
                        Node parentNodeObj = (Node) parentNode.getUserObject();
                        Node selectedNodeObj = (Node) selectedNode.getUserObject();
                        parentNodeObj.getChildren().remove(selectedNodeObj);
                        ((DefaultTreeModel) tree.getModel()).removeNodeFromParent(selectedNode);
                    }
                }
            }
        });

        refreshButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                DefaultMutableTreeNode rootNode = createTreeNodes(fileSystem.getRoot());
                tree.setModel(new DefaultTreeModel(rootNode));
            }
        });

        panel.add(addDirButton);
        panel.add(addFileButton);
        panel.add(renameButton);
        panel.add(deleteButton);
        panel.add(refreshButton);
        frame.add(panel, BorderLayout.SOUTH);

        frame.setVisible(true);
    }
    private DefaultMutableTreeNode createTreeNodes(Node root) {
        DefaultMutableTreeNode rootNode = new DefaultMutableTreeNode(root);
        for (Node child : root.getChildren()) {
            rootNode.add(createTreeNodes(child));
        }
        return rootNode;
    }

    public static void main(String[] args) {
        SwingUtilities.invokeLater(FileSystemGUI::new);
    }
}
```

Explanation:

- **initGUI()**: This method initializes the graphical user interface by creating the main window (`JFrame`), setting its size, and adding a `JTree` that represents the file system structure.
- **ActionListeners**: Explain the purpose of each button's action listener:
    - `addDirButton`: Allows users to add a new directory.
    - `addFileButton`: Allows users to add a new file.
    - `renameButton`: Allows users to rename a selected node (file or directory).
    - `deleteButton`: Allows users to delete a selected node.
    - `refreshButton`: Refreshes the tree view to reflect the current structure of the file system.
- **createTreeNodes(Node root)**: This recursive method converts the hierarchical structure of nodes into a tree structure that can be displayed using the `JTree` component in the GUI.

DATA STRUCTURES AND ALGORITHMS

4.1.1 Tree Structure

A tree is a fundamental hierarchical data structure that consists of nodes connected by edges, where each node represents an element in the hierarchy. This structure is characterized by the following:

- **Root Node**: The topmost node in the hierarchy, representing the starting point of the file system. In this project, the root node symbolizes the root directory of the file system, from which all other directories and files branch out.
- **Child Nodes**: Nodes that are directly connected to another node, representing either files or subdirectories within the parent directory. These nodes can further have their own child nodes, forming a hierarchical structure of directories and files.

In this project, the file system is modeled as a tree where:

- The **root node** serves as the entry point, encapsulating the entire directory structure.
- **Child nodes** represent various files and subdirectories within the root or any other directory, allowing for an organized and manageable structure of data.

4.1.2 Implementation in the Project

- **Node Class**:
    - **Attributes**:
        - name: A String attribute that holds the name of the file or directory. This attribute is crucial for identifying and differentiating nodes within the tree.
        - isDirectory: A Boolean flag indicating whether the node represents a directory (true) or a file (false). This distinction helps in managing different types of nodes appropriately.
        - children: An ArrayList of Node objects that stores child nodes. This list is applicable only for directory nodes, allowing them to manage multiple files and subdirectories.
    - **Methods**:

        - **Getters and Setters**: Methods for retrieving and updating the values of attributes like name and isDirectory.
        - **addChild(Node child)**: A method that adds a child node to the current node's children list. This method facilitates the dynamic expansion of directories by including new files or subdirectories.
- **FileSystem Class**:
    - **Attributes**:
        - root: A Node object representing the root of the file system. This root node is the starting point of the hierarchy and manages the overall structure of the file system.
    - **Methods**:
        - **createFile(String name)**: A method that creates a new file node with the specified name and adds it to the appropriate directory. This method facilitates the addition of files to the file system.
        - **createDirectory(String name)**: A method that creates a new directory node with the specified name and adds it to the appropriate parent directory. This method allows for the creation of new directories within the file system.
        - **addNode(Node parent, Node child)**: A method that adds a child node to a specified parent node. This method is essential for constructing and managing the hierarchical structure of the file system.

4.2 Linked Lists

4.2.1 List of Children

In this project, an **ArrayList** is used to manage the list of child nodes within each Node. This choice of data structure offers several advantages:

- **Dynamic Array Structure**: ArrayLists provide a flexible way to handle varying numbers of child nodes. Unlike fixed-size arrays, ArrayLists can dynamically resize, accommodating the addition and removal of nodes without predefined limits.

- **Efficient Operations**: ArrayLists allow for efficient addition, removal, and access of child nodes. These operations are critical for simulating file system behaviors, such as adding new files or deleting existing ones.
- **Enhanced Management**: The dynamic nature of ArrayLists supports the simulation of complex file system operations, enabling the manipulation of hierarchical structures with ease.

4.3 Algorithms

4.3.1 Addition of Nodes

- **Process**:
    1. **User Input**: The process begins by capturing the name of the file or directory from the user through a user interface input field.
    2. **Node Creation**: A new Node object is instantiated with the provided name. This object represents the new file or directory within the file system.
    3. **Insertion**: The newly created node is added to the children list of the selected parent node. This operation integrates the new node into the hierarchical structure.
    4. **GUI Update**: The JTree component is refreshed to visually reflect the addition of the new node. This ensures that the user interface remains synchronized with the underlying data structure.

4.3.2 Deletion of Nodes

- **Process**:
    1. **Node Selection**: Identify the node to be deleted based on user selection. This step involves locating the node within the hierarchy that the user intends to remove.
    2. **Removal**: The identified node is removed from its parent’s children list. This operation detaches the node from the file system hierarchy.
    3. **GUI Update**: The JTree component is updated to visually remove the deleted node. This ensures that the user interface accurately represents the current state of the file system.

4.3.3 Renaming of Nodes

- **Process**:
    1. **Node Selection**: Identify the node that is to be renamed based on user interaction.
    2. **User Input**: Capture the new name for the node from the user through an input field.
    3. **Update**: Modify the name attribute of the selected node to reflect the new name. This operation updates the node's identification within the hierarchy.
    4. **GUI Update**: The JTree component is refreshed to display the updated name. This visual update ensures that the user interface accurately reflects the changes made.

4.3.4 Tree Traversal

- **Purpose**:
    - **Tree Traversal**: While not explicitly required for basic operations such as adding, renaming, or deleting nodes, understanding tree traversal is essential for implementing more advanced features. Traversal algorithms enable the traversal of the entire tree or specific branches, which is crucial for:
        - **Searching**: Implementing search functionality to locate specific files or directories within the file system.
        - **Displaying**: Generating visual representations or reports of the entire file system structure.

4.4 GUI Integration

4.4.1 JTree Component

The **JTree** component is a key element of the graphical user interface (GUI), used to display the hierarchical structure of the file system:

- **Visualization**: Each node in the JTree corresponds to a Node in the file system, allowing users to view and interact with the directory and file hierarchy in a tree-like format.

- **Real-Time Updates**: The JTree is dynamically updated in response to user actions, ensuring that changes such as additions, deletions, and renaming of nodes are immediately reflected in the interface.

4.4.2 Event Handling

- **ActionListeners**:
  - **Buttons**: ActionListeners are attached to various buttons in the GUI, such as Add Directory, Add File, Rename, Delete, and Refresh. These listeners handle user interactions by triggering appropriate actions based on the button clicked.
- **Dynamic Updates**:
  - **DefaultTreeModel**: The DefaultTreeModel is modified to ensure that any changes made to the file system are reflected in the JTree. This model manages the tree structure and updates the display accordingly, providing a seamless user experience.

CONCLUSION AND FUTURE PERSPECTIVE

Conclusion

The **File System Simulation Project** successfully met its objectives by implementing a functional simulation of a file system using Java. Through this project, I gained a deep understanding of **tree data structures** and their practical applications in managing hierarchical data. The integration of a **Graphical User Interface (GUI)** using Java Swing enhanced my skills in event-driven programming and user interface design.

Key achievements of the project include:

- **Effective Implementation of DSA Concepts**: Successfully utilized tree structures and linked lists to manage the file system hierarchy.
- **User-Friendly Interface**: Developed an intuitive GUI that allows users to perform file and directory operations seamlessly.
- **Robust Functionality**: Ensured that the simulation handles various operations (add, rename, delete) efficiently and reliably.

Future Scope and Applicability

The project lays a solid foundation for more advanced developments and applications:

- **Enhanced Features**:
  - **Search Functionality**: Implementing search algorithms to locate files or directories within the simulated file system.
  - **File Attributes**: Adding attributes such as size, creation date, and permissions to files and directories.
  - **Undo/Redo Operations**: Allowing users to revert or reapply actions performed on the file system.
- **Scalability**:
  - **Integration with Real File Systems**: Extending the simulation to interact with actual file systems for backup or synchronization purposes.

    - **Multi-User Support**: Allowing multiple users to interact with the file system concurrently, introducing concepts like user permissions and access control.
- **Educational Tools**:
    - **Teaching Aid**: Using the simulation as an educational tool to teach students about file systems and data structures.
    - **Interactive Tutorials**: Developing guided tutorials within the GUI to educate users on how file systems operate.
- **Performance Optimization**:
    - **Efficient Algorithms**: Refining algorithms to handle larger and more complex file system structures with improved performance.
    - **Memory Management**: Enhancing memory usage to support extensive simulations without compromising system resources.

Overall, this project has been an invaluable learning experience, bridging the gap between theoretical knowledge and practical application. It has equipped me with the skills and insights necessary to tackle more complex software development challenges in the future.

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