File Wizard

A Scalable File Management Application

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File Wizard

The **File Wizard** application is a desktop utility designed to streamline file system management through an intuitive user interface and powerful backend operations. It combines modern web technologies with a robust backend to deliver seamless and efficient functionality.

Overview

File Wizard simplifies file organization, search, and metadata management for users, leveraging a modular architecture that separates concerns between the frontend and backend. It is designed to be scalable, maintainable, and extendable for future enhancements.

Technology Stack

File Wizard leverages a modern technology stack, employing powerful tools and languages for performance, scalability, and maintainability:

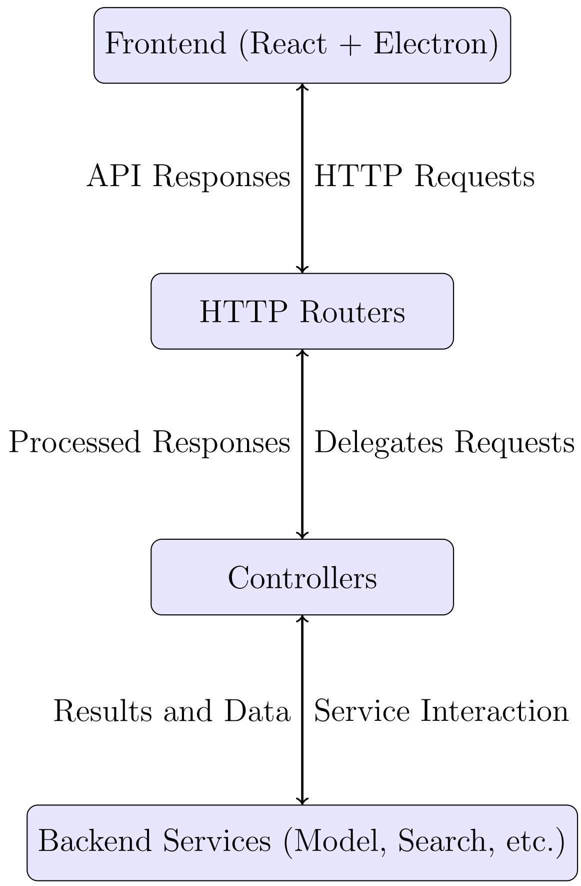
- **Frontend:**
  - **Languages:** JavaScript (ES6+), TypeScript.
  - **Libraries and Frameworks:** React (for UI components), Electron (for desktop application support).
  - **Build Tools:** Webpack (for module bundling), npm (for dependency management).
- **Backend:**
  - **Language:** Rust.
  - **Concurrency:** Uses Rust's `std::thread`, `Arc`, and `Mutex` for thread-safe operations and efficient parallelism.
- **Communication:**
  - **Language:** Rust.
  - **Protocol:** HTTP.
  - **Libraries:** Actix Web (for HTTP routers), Serde (for JSON serialization/deserialization).

Architecture Schema

The diagram below represents the overall architecture of File Wizard, illustrating the interaction between its components.

Architecture Schema

The diagram below represents the overall architecture of File Wizard, illustrating the bidirectional interaction between its components.



Key Highlights

- **Frontend-Backend Interaction:** The React-based frontend communicates with the backend exclusively through HTTP requests to routers, ensuring a clean separation of concerns and scalable integration.
- **Router Layer:** The routers, implemented in Rust, handle HTTP requests from the frontend. These routers delegate the requests to controllers for further processing.
- **Controller Layer:** Controllers process requests from the routers and interact with backend services to execute application logic.
- **Backend Services:** The backend folder hosts core services, which implement essential functionality such as file system management, search operations, and metadata handling.
- **Scalable Frontend Architecture:** Built with React and Electron, the frontend UI is modular and designed to support responsiveness and the seamless addition of new features.
- **Thread-Safe Design:** Rust's `Arc` and `Mutex` ensure robust handling of concurrent operations within the backend services, enabling safe parallel execution.

Backend Design

Model

The **Model** folder is a core part of the File Wizard backend, responsible for representing and handling files, folders, and their associated metadata. This design ensures thread safety, modularity, and extensibility for managing a file system structure.

File.rs

The `File.rs` module defines the `File` struct, which represents individual files in the file system. It includes methods for retrieving file metadata and interacting with parent folders. Key features include:

- **Thread Safety:** The `parent` attribute uses `Arc<Mutex<Folder>>` for shared, thread-safe access to parent folders.
- **Metadata Management:** Uses a `HashMap` to store metadata such as size, creation date, and file-specific attributes (e.g., file extension).
- **Helper Methods:**
  - `new`: Constructs a `File` instance from a given `Path`.
  - `get_metadata`: Returns a reference to the metadata.
  - `get_raw_size`: Retrieves the file's size from the metadata.

Folder.rs

The `Folder.rs` module defines the `Folder` struct, representing directories in the file system. This module supports hierarchical relationships and metadata aggregation for child elements. Key features include:

- **Hierarchical Structure:** Tracks child files and folders using a `Vec<PathType>`.
- **Thread-Safe Mutability:** Uses `Arc<Mutex<Folder>>` for safe updates to parent references.
- **Metadata Aggregation:** Automatically updates size and metadata based on child elements.
- **Helper Methods:**
  - `new`: Constructs a `Folder` instance from a given `Path`.
  - `add_child`: Adds a child `PathType` (file or folder) and propagates metadata updates.
  - `update_size`: Updates folder size and propagates changes up the hierarchy.

Metadata.rs

The `Metadata.rs` module provides utility functions to extract and manage metadata for files and folders. It handles operations like size formatting and timestamps. Key features include:

- **Unified Metadata Extraction:** Functions like `file_folder_metadata` ensure consistent metadata handling for both files and folders.
- **Platform-Specific Access Control:** Includes functions to check accessibility (e.g., read permissions).
- **Human-Readable Formats:** Converts raw sizes into readable strings (e.g., KB, MB).

PathType.rs

The `PathType.rs` module defines the `PathType` enum to unify the representation of files and folders. Key features include:

- **Enum Variants:**
  - `File`: Represents a file using `Arc<Mutex<File>>`.
  - `Folder`: Represents a folder using `Arc<Mutex<Folder>>`.
  - `None`: Represents an invalid or inaccessible path.
- **Display Implementation:** Implements the `fmt::Display` trait for human-readable descriptions of files and folders.

The **Model** folder ensures modular handling of file system entities while maintaining thread-safe operations and clear hierarchy management.

Search

The **Search** folder implements the core logic and utilities for exploring and managing file system searches. It leverages modular design to maintain clarity, thread-safety, and extensibility.

PathMap.rs

The `PathMap.rs` module defines the `PathMap` structure, a custom data structure for managing mappings between URLs and their corresponding entities (`File` and `Folder`). Key features include:

- **Folder and File Tracking:** Manages two `HashMap` instances for efficient retrieval of files and folders by their URLs.
- **Thread-Safe Ownership:** Uses `Arc<Mutex<Folder>>/Arc<Mutex<File>>` for shared ownership and safe concurrent access.
- **Operations:**
  - `add`: Adds a `PathType` (either file or folder) to the appropriate map.

- get, get_folder, get_file: Retrieve entries by URL.
- contains: Checks if a URL exists in the maps.
- remove: Removes an entry and returns it as a PathType.

ThreadManager.rs

The ThreadManager.rs module provides utilities for managing the lifecycle of search threads. It ensures seamless thread creation, state transitions, and termination. Key components include:

- **Thread States:** Uses the State enum to represent the thread's status (RunningInit, Paused, Stopped, etc.).
- **Thread Lifecycle Management:**
  - spawn_thread: Spawns a new thread to execute search operations.
  - pause_thread, resume_thread, stop_thread: Manage thread states dynamically.
- **Safe Multithreading:** Shares access to thread state and search operations using Arc<Mutex> for synchronization.

Utils.rs

The Utils.rs module implements the main Search struct and related search logic. It orchestrates the folder and file traversal process and integrates with PathMap and thread management. Key features include:

- **Search Initialization:**
  - initialize_search: Initializes the search by setting the root directory, creating entries in PathMap, and discovering children.
  - set_root_search_directory: Validates and normalizes the root search directory path.
- **Search Execution:**
  - execute_search: Executes the search process, managing the frontier_map and assigning the next directory to current_dir.
  - discover_immediate_children: Traverses the current directory to discover and classify child entries as files or folders.
- **Frontier Management:**
  - sort_frontier_list: Sorts the frontier list based on future heuristics.
  - pop_frontier_entry: Removes and returns the next folder to process.
- **Path Management:** Leverages PathMap for adding and retrieving file and folder paths during traversal.

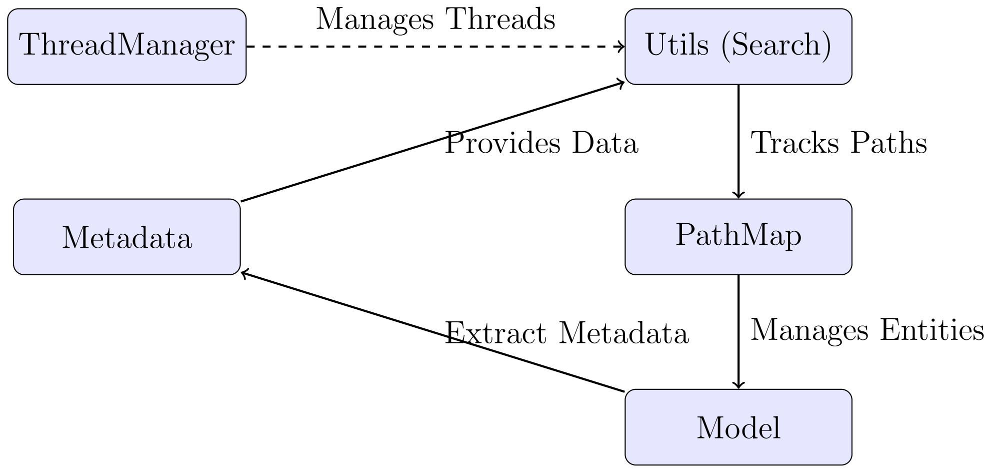
Relationships Between Components

- `Utils.rs` acts as the orchestrator for search logic, integrating with:
  - `PathMap.rs` for path tracking.
  - `ThreadManager.rs` for thread management during long-running operations.
  - The `Model` folder (`File`, `Folder`, `PathType`) for file system entities.
- `PathMap.rs` serves as the storage and retrieval backbone for search operations.
- `ThreadManager.rs` ensures that search operations run in a non-blocking, thread-safe manner.

The **Search** folder enables modular and efficient search processes while maintaining clear separation of concerns between thread management, path tracking, and search logic.

Search Schema

The following diagram illustrates the interaction between the **Search** components, highlighting the flow of metadata, thread management, and path tracking.



Key Points:

- **Utils (Search)**: Orchestrates search operations, integrating with `PathMap`, `ThreadManager`, and `Model`.
- **PathMap**: Tracks and retrieves file and folder paths for search traversal.
- **ThreadManager**: Manages thread states (e.g., running, paused) for non-blocking operations.
- **Model**: Represents file and folder structures, providing metadata and hierarchical relationships.
- **Metadata**: Extracted from file and folder entities, used to support search operations.

Controllers

The **Controllers** section details the interface layer connecting backend components to the user or higher-level application logic. Each controller is responsible for managing a specific aspect of the backend functionality. Unlike the **Search** module, the controllers do not depend on enums or hierarchical structures but rather act as standalone modules, each tightly coupled with the backend components they serve.

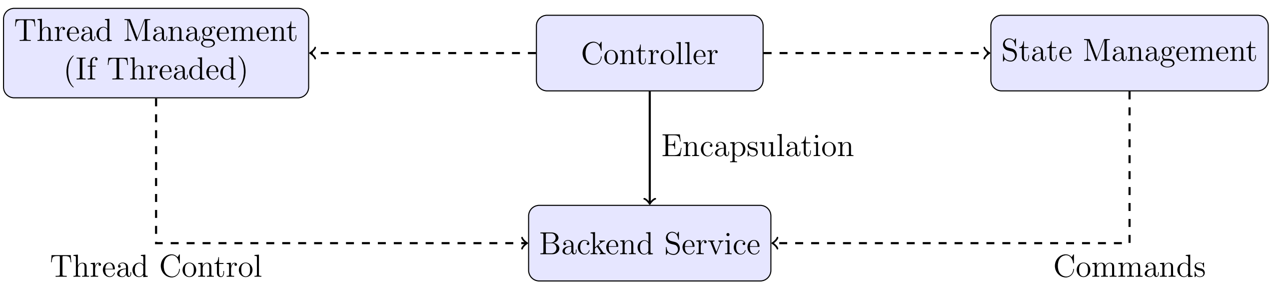
General Overview

Controllers follow a consistent design schema:

- **Encapsulation of Backend Logic:** Each controller encapsulates backend functionality, exposing methods for interacting with underlying services (e.g., search, database).
- **Thread-Safe Operations:** Use of `Arc<Mutex<T>>` ensures safe concurrent access to backend components, maintaining synchronization across threads.
- **State Management:** Controllers often manage the state of their associated backend service, allowing operations such as starting, pausing, resuming, and stopping processes.
- **Thread Management (If Applicable):** Some controllers handle thread management for backend services that require multithreading, such as search or background operations.
- **Modular Interaction:** Designed to be modular, each controller can be extended or modified without affecting other controllers.

Controller Design Schema

The following diagram represents the typical interaction between a controller and its backend service:



Key Points:

- Controllers wrap backend logic, exposing high-level methods to external interfaces.
- Shared states (e.g., thread states, data models) are managed using thread-safe abstractions such as `Arc` and `Mutex`.

- Some controllers manage threads for backend services that require multithreading.
- Modular design allows for the addition of new controllers without impacting existing functionality.

Interaction with Backend Components

The controllers interact closely with backend services, adhering to the following principles:

- **Encapsulation:** Backend components such as database models or search utilities are never directly exposed to the user or higher-level modules; controllers provide controlled access.
- **Synchronization:** Use of shared ownership (`Arc`) and locking mechanisms (`Mutex`) ensures safe concurrent modifications.
- **Extensibility:** Each controller is designed to be self-contained, allowing new controllers to be added without significant changes to the existing architecture.

Modularity and Scalability

By maintaining loose coupling and strong encapsulation, the controller layer supports the following:

- **Scalability:** Adding new backend components requires only the creation of corresponding controllers.
- **Maintenance:** Controllers abstract the backend logic, isolating changes to a single layer.
- **Flexibility:** Controllers can expose additional features or adapt existing ones without interfering with other modules.

Ports

The **Ports** layer serves as the entry point for external interactions with the application, handling communication through various protocols. This layer defines and manages components like HTTP routers and will eventually include other mechanisms like WebSockets or message queues.

Routers

The **Routers** subsection focuses on the HTTP-based routing components of the `Ports` layer. Routers define endpoints for external clients, map requests to backend controllers, and encapsulate logic for handling incoming traffic.

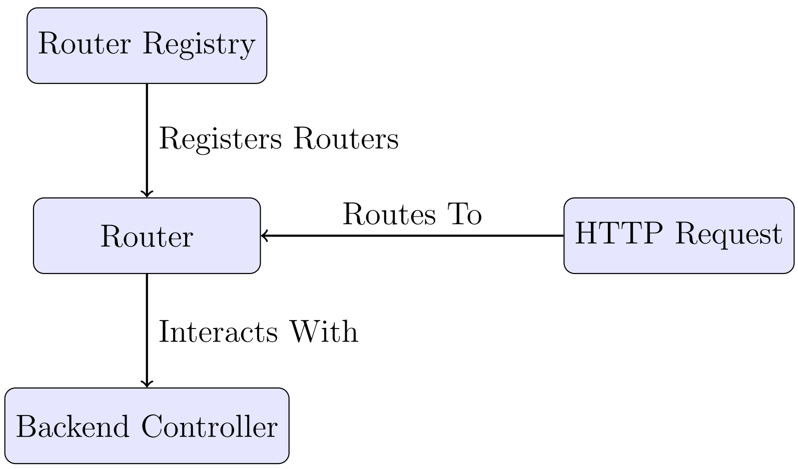
General Overview

Routers follow a standardized design schema:

- **Dynamic Routing:** Routers define and handle HTTP endpoints that interact with specific backend controllers.
- **Trait-Based Abstraction:** The `Router` trait ensures a consistent interface for all routers, with methods for initialization and request handling.
- **Concurrent Operations:** Leveraging `async` functions and the `RouterRegistry`, routers can initialize and handle multiple requests concurrently.
- **Extensibility:** The `RouterRegistry` allows for easy addition of new routers, enabling modular growth of the application's routing layer.

Router Design Schema

The following diagram illustrates the interaction between the `RouterRegistry`, individual routers, and backend controllers:



Key Points:

- The `RouterRegistry` serves as a central hub for registering and managing routers.
- Routers map HTTP requests to backend controllers, ensuring efficient and modular handling of external interactions.
- Each router defines endpoints and the logic to handle requests, often leveraging backend controllers for business logic.

Interaction with Backend Components

Routers interact with backend controllers through the following principles:

- **Decoupling:** Routers abstract backend functionality, exposing only the endpoints required for client interaction.
- **Thread Safety:** Use of `Arc<Mutex<T>>` ensures safe, concurrent access to backend controllers.
- **Modularity:** Each router is dedicated to a specific backend functionality, such as search or file management, allowing independent development and testing.

Modularity and Scalability

The **Routers** subsection is designed for scalability and ease of maintenance:

- **Extensibility:** New routers can be added by implementing the `Router` trait and registering them with the `RouterRegistry`.
- **Concurrency:** Asynchronous design ensures routers can handle multiple requests simultaneously.
- **Adaptability:** The centralized `RouterRegistry` allows for easy configuration and management of all application routers.

Frontend Design

The **Frontend Design** section outlines the architecture and structure of the File Wizard application's user interface. Built with **Electron** and **React**, the frontend leverages modern web technologies to deliver a seamless, interactive desktop experience.

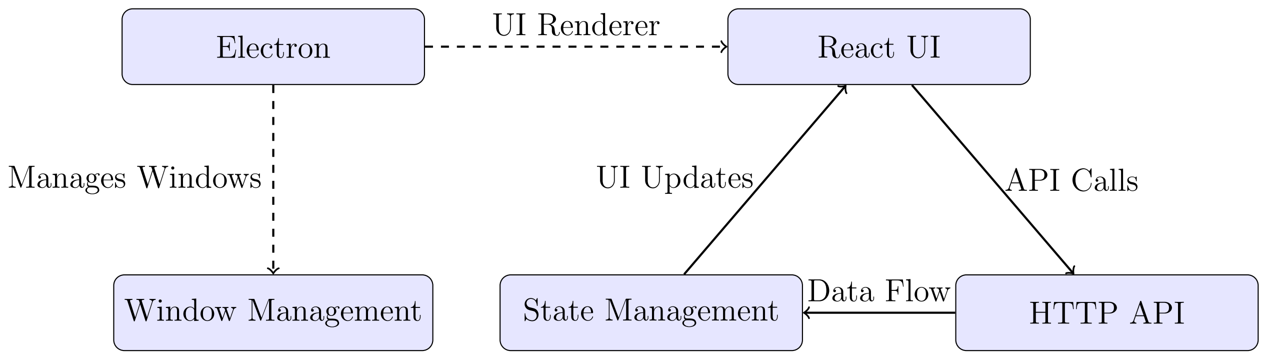
General Overview

The frontend architecture is designed to balance modularity, responsiveness, and interactivity, adhering to the following principles:

- **Separation of Concerns:**
  - **Electron Layer:** Manages desktop-specific functionality, such as window creation, application lifecycle management, and rendering the React UI.
  - **React Layer:** Handles UI components, state management, and user interactions within the Electron environment.
- **Modularity:** Components are organized into reusable and self-contained modules, enabling scalability and easier maintenance.
- **State Management:** Employs a centralized state management solution to ensure consistent behavior and synchronize data across components. This ensures that updates to backend data are reflected seamlessly in the UI.
- **Backend Integration:** Uses HTTP requests via a dedicated API layer to interact with backend services. This approach provides a clean interface for accessing system-level operations and ensures flexibility for future backend updates.
- **Scalability:** The design supports the addition of new pages or features with minimal refactoring by adhering to a modular and loosely coupled architecture.

Frontend Architecture

The following diagram illustrates the high-level architecture of the frontend:



Electron Layer

The Electron layer provides the desktop application framework, enabling access to system-level features and managing the overall application lifecycle. Key responsibilities include:

- **Window Management:** Creates and manages application windows, including handling resizing, minimizing, and maximizing.
- **Application Lifecycle:** Oversees the startup, shutdown, and reload processes for the desktop application.
- **File System Access:** Supports system-level operations such as file selection, directory traversal, and handling dialogs for user interactions.

React Layer

The React layer powers the user interface, providing interactive components and seamless user experiences. Key responsibilities include:

- **UI Components:** Modular and reusable components for building pages and user interactions.
- **State Management:** Synchronizes data across the UI using a centralized state management solution to ensure consistency and responsiveness.
- **Dynamic Rendering:** React's virtual DOM ensures efficient rendering of UI changes and improves performance.

Backend Integration

The frontend integrates with backend services using **HTTP API** calls, ensuring a clear and scalable communication mechanism. This allows the React UI to:

- Initiate backend operations (e.g., file system searches, metadata updates) through defined API endpoints.
- Retrieve and display backend results in a user-friendly format, updating the UI dynamically based on state changes.
- Handle errors gracefully, providing meaningful feedback to users when operations fail.

Modularity and Scalability

The frontend architecture is designed for scalability and maintainability:

- **Component Reusability:** UI components are modular, ensuring easy extension or modification of the application.
- **Layered Communication:** The clear separation between Electron, React, and the backend ensures smooth interaction and reduces tight coupling.
- **Future-Ready Design:** The architecture supports the addition of new pages, features, or backend APIs without significant restructuring.