Weather Data Aggregator - Project Documentation

Overview

The Weather Data Aggregator is a Java-based application designed to fetch and display real-time weather data for multiple cities using a graphical user interface (GUI). It uses a multi-threaded architecture to ensure responsiveness and efficiency, allowing weather data to be fetched concurrently for multiple cities.

Key Features

1. **Real-Time Weather Data:** Fetches current temperature, wind speed, and wind direction for selected cities.
2. **Graphical User Interface (GUI):** Built using Swing for user-friendly interaction.
3. **Multi-Threading:** Utilizes threads to handle concurrent API requests efficiently.
4. **Dynamic Updates:** Automatically updates the weather data every 5 seconds.
5. **City Selection:** Allows users to select from a predefined list of cities.
6. **Custom Thread Count:** Enables users to specify the number of threads for concurrent operations.
7. **Separate Windows:** Displays individual weather data in dedicated windows for each city.
8. **Table Display:** Summarizes weather data in a JTable for easy reference.

Technologies and Libraries Used

1. Programming Language:

- Java 17

2. Libraries and APIs:

- **Swing**: For building the graphical user interface.
- **Google GSON:** For parsing JSON responses from the weather API.

- **Java Concurrency Utilities:** To manage threads, including ExecutorService, Callable, Future, and ScheduledExecutorService.
- **HTTPURLConnection:** For making HTTP requests to the weather API.

3. API Used:

- **Open-Meteo API:** Provides real-time weather data based on latitude and longitude.

Components and Their Roles

1. Main Application:

- **WeatherProject**
    - Sets the default locale to English.
    - Launches the GUI by initializing WeatherAppGUI.

2. Graphical User Interface (GUI):

- **WeatherAppGUI**
    - Provides an interface for users to select cities, specify the number of threads, and view weather data.
    - Includes input fields, buttons, and a JTable to display weather data.

3. Weather Fetching:

- **WeatherFetcher**
    - Implements Callable<WeatherData>.
    - Fetches weather data using the Open-Meteo API based on city coordinates.
    - Parses JSON responses to extract temperature, wind speed, and wind direction.

4. Weather Data Model:

- **WeatherData**
    - A simple data class to store weather attributes (city, temperature, wind speed, wind direction).

5. Thread Management:

- **BuildThread**
  - Manages thread pools using ExecutorService.
  - Spawns threads to fetch weather data concurrently for multiple cities.
  - Updates the JTable and creates individual ThreadWindow instances for each city.

6. Individual Weather Display:

- **ThreadWindow**
  - Displays weather data for a single city in a dedicated window.
  - Updates dynamically as new data is fetched.

Multi-Threading Implementation

1. **ExecutorService:**
   - Fixed thread pool is used to manage threads efficiently based on the user-specified thread count.
2. **Concurrency Utilities:**
   - **Callable**: Fetches weather data asynchronously.
   - **Future**: Retrieves results of the Callable tasks.
   - **ScheduledExecutorService**: Schedules periodic weather data updates.
3. **Thread Safety:**
   - **ConcurrentHashMap:** Ensures safe access and updates to shared city window objects.
   - Swing updates are executed on the Event Dispatch Thread using SwingUtilities.invokeLater to prevent race conditions.
4. **Deadlock Prevention:**
   - No synchronized blocks or locks are used that could cause circular dependencies.

Challenges and Solutions

1. **Concurrency Issues:**

    - Ensured thread-safe operations using concurrent data structures and proper thread management.
2. **API Errors:**
    - Handled HTTP errors gracefully by throwing exceptions and logging errors.
3. **GUI Responsiveness:**
    - Performed all long-running tasks (e.g., API calls) on separate threads to keep the GUI responsive.

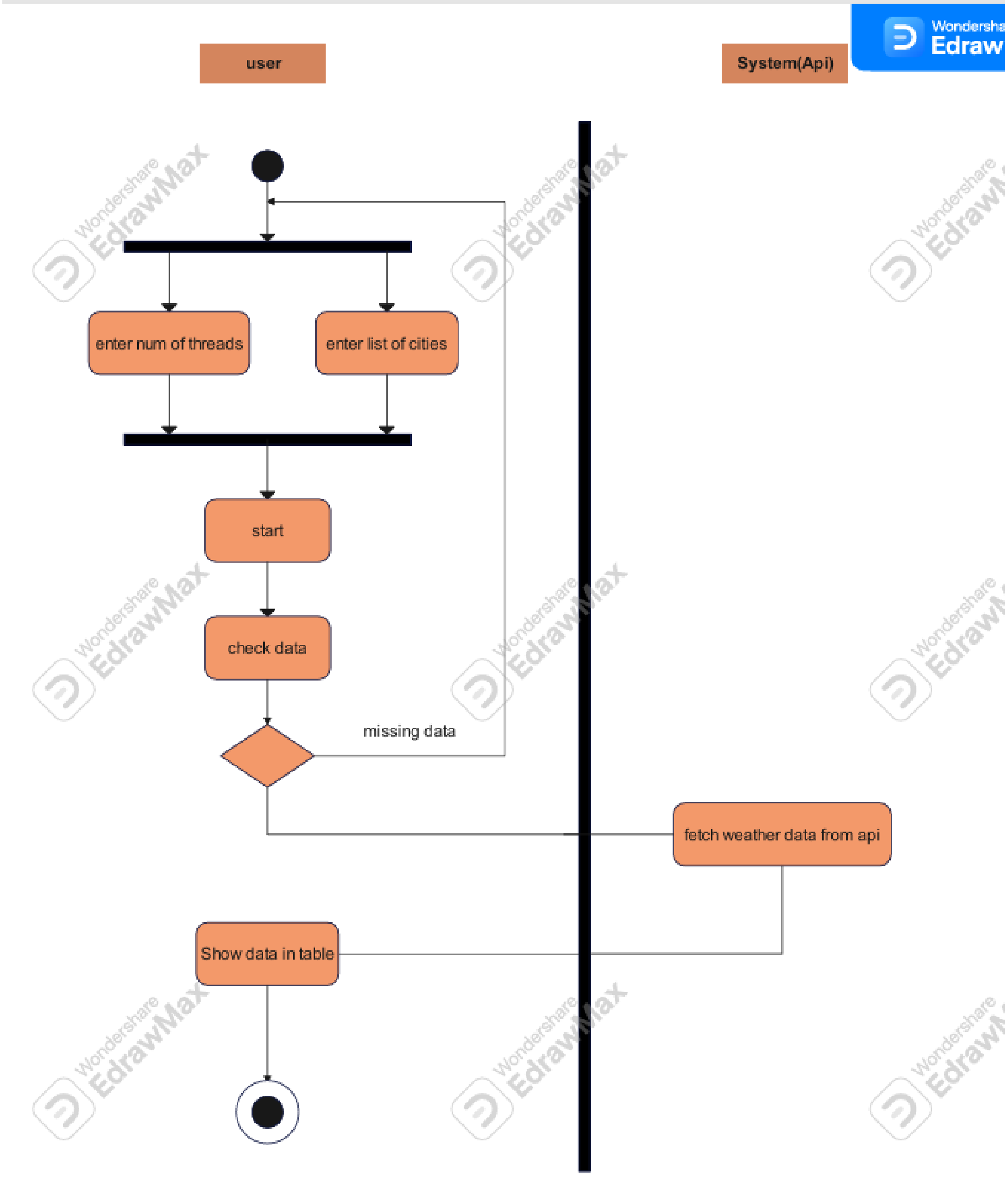
The efficiency of your system with multithreading compared to a single-threaded version largely depends on the following factors:

1. **Parallelism of Network Calls**:
    - **Multithreading**: Each weather data fetch operation runs independently in its own thread, utilizing network latency to process multiple cities simultaneously. While one thread waits for a network response, others can fetch data.
    - **Single-threading**: In a single-threaded version, the program would fetch data for one city at a time sequentially, wasting time during network waits.
2. **Number of Cities**:
    - If you are fetching data for many cities (e.g., 10+), multithreading will show a significant performance improvement because network calls are the primary bottleneck.
    - For a small number of cities, the difference might be negligible.
3. **Number of Threads**:
    - The thread pool size impacts performance. Too many threads can lead to overhead, while too few might underutilize available resources.
    - An optimal number of threads (e.g., equal to or slightly greater than the number of processor cores) can maximize efficiency.

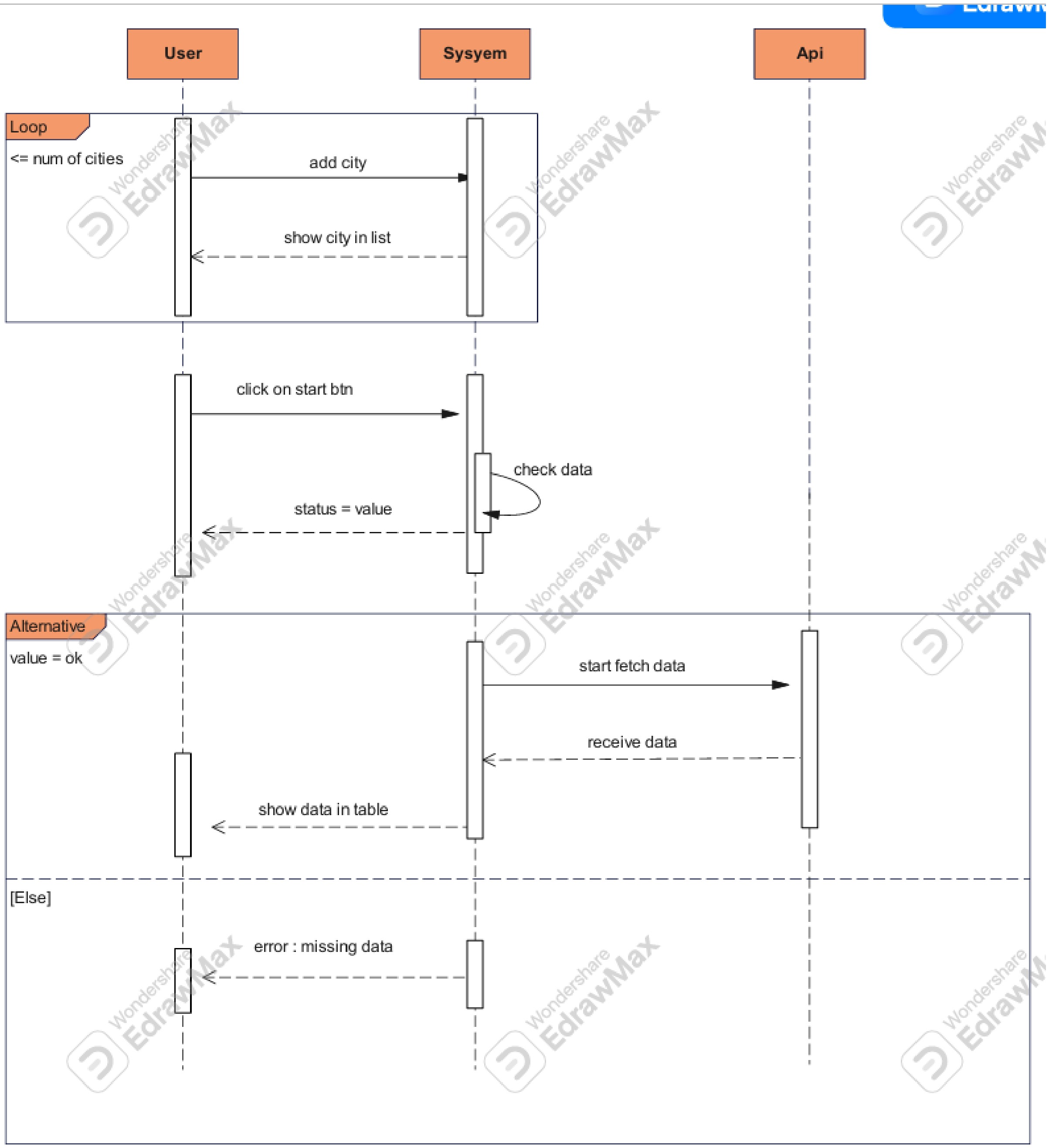
References

- Open-Meteo API Documentation

Activity Diagram



Sequence Diagram



Visual representation

```
          ┌───────────────┐
          │ User Submits  │
          │ WeatherFetch  │
          └───────────────┘
                 │
                 │
 ┌───────────────▼────────────────┐
 │     ExecutorService (Pool)     │
 │ ┌────────────┐ ┌────────────┐  │
 │ │ Thread 1   │ │ Thread 2   │  │
 │ └────────────┘ └────────────┘  │
 └────────────────────────────────┘
                 │
                 │
     Returns Future<WeatherData>
                 │
 ┌───────────────▼──────────────┐
 │ Collect Results via Future   │
 │ Update JTable and UI         │
 └──────────────────────────────┘
```