Project Report

MetroRouteXpert

SUBMITTED IN THE PARTIAL FULFILLMENT REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR OF TECHNOLOGY

(Computer Science and Engineering)

SUBMITTED BY

Bhawna(220662)
Bhumika(220661)
Naman Sharma(220335)

UNDER THE SUPERVISION OF
Dr. Kiran Khattar

SCHOOL OF ENGINEERING AND TECHNOLOGY

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BML Munjal University Gurugram, Haryana – 122413

May 2024

CANDIDATE’S DECLARATION

We hereby certify that we have worked on a project entitled, ‘MetroRouteXpert’, in partial fulfillment of requirements for the award of Degree of Bachelor of Technology in Computer Science and Engineering at BML Munjal University, Gurugram, Haryana.

Our project is an authentic record of our own work carried out during the period: February-May 2024 under the supervision of Dr.Kiran Khattar.

Bhawna (220662)
Bhumika (220661)
Naman Sharma (220335)

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Dr. Kiran Khattar
(Signature)

ACKNOWLEDGEMENT

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Finally, we express our thanks to everyone who contributed to our project by offering guidance, assistance, and support. We are truly grateful for the collaborative spirit that made it possible.

Bhawna (220662)
Bhumika (220661)
Naman Sharma (220335)

ABSTRACT

The metro network in India's capital region has seen rapid expansion over the years, offering efficient and affordable public transportation options. However, navigating this extensive network and finding the most efficient routes can pose challenges for commuters, particularly those unfamiliar with the system. This project aimed to address this issue by developing a user-friendly web application named "Metro Route Xpert" to aid commuters in finding the shortest path between any two stations on the metro network, along with providing estimated fare charges.

The application utilizes comprehensive data on station locations, metro line trajectories, inter-station distances, and fare structures to calculate the most efficient route and corresponding fare based on the user's selected starting and destination stations. The algorithm takes into account various factors such as transfer points, line changes, travel times, and fare slabs, ensuring a thorough journey plan.

Metro Route Xpert boasts an intuitive interface, allowing users to easily select their starting and destination stations either from dropdown menus or an interactive map. Upon selection, the application displays the optimal route, including the sequence of stations, necessary line changes, approximate travel time, total distance, and estimated fare amount.

By providing a convenient and accurate route planning solution integrated with fare information, Metro Route Xpert aims to enhance the commuting experience for metro users in the region. This includes reducing travel times, minimizing confusion and delays, and enabling better trip planning and budgeting. The potential impact of this project extends beyond individual commuters, potentially contributing to reduced traffic congestion and environmental benefits by promoting the use of public transportation.

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1. INTRODUCTION

The "Metro Route Xpert" web application revolutionizes commuting on the Delhi metro system by offering a user-friendly solution for route planning and fare estimation. With a vast database encompassing station locations, line trajectories, and fare structures, the application calculates optimal routes and corresponding fare charges. Through an intuitive interface, users can effortlessly select starting and destination stations, receiving comprehensive journey plans that streamline travel and budgeting. "Metro Route Xpert" not only enhances individual commuting experiences but also contributes to broader goals of reducing traffic congestion and promoting sustainable urban mobility.

1.1 Objective

1. Simplify Commuting: The primary objective of the "Metro Route Xpert" project is to simplify commuting for users of the Delhi metro system. By providing a user-friendly interface, the project aims to alleviate the difficulties users face in navigating the complex route planning process. Through intuitive design and streamlined functionality, commuters can easily input their starting and destination stations, receiving clear and concise route suggestions. This simplification of the commuting process enhances user experience and encourages greater utilization of public transportation.

2. Optimize Route Planning and Fare Estimation: Another key objective is to optimize route planning and fare estimation for Delhi metro users. Leveraging comprehensive data on station locations, line trajectories, and fare structures, the project aims to provide accurate and efficient route suggestions. By considering factors such as transfer points, line changes, travel times, and fare slabs, the application ensures users receive the most optimal and cost-effective journey plans. This optimization not only saves commuters time and effort but also enables better budgeting for their travels.

1.2 User Requirement Analysis

1. **Identifying User Needs:** The project aims to conduct a thorough analysis of user requirements by engaging with Delhi metro commuters to understand their needs, preferences, and pain points. This involves gathering feedback through surveys, interviews, and user testing sessions to identify common challenges faced during route planning and fare estimation. By gaining insights into user behaviors and expectations, the project ensures that the final solution addresses the specific needs of the target audience.

2. **Defining Functional and Non-functional Requirements:** Based on the findings from user research, the project outlines both functional and non-functional requirements for the "Metro Route Xpert" application. Functional requirements specify the features and capabilities the application must possess, such as interactive route selection, fare estimation, and user-friendly interface design. Non-functional requirements encompass factors like performance, reliability, and accessibility, ensuring that the application meets quality standards and provides a seamless user experience across different devices and platforms.

By conducting a comprehensive user requirement analysis, the project aims to develop a tailored solution that effectively addresses the needs of Delhi metro commuters, ultimately enhancing their commuting experience and promoting the use of public transportation.

1.3 Feasibility Study

1. **Technical Feasibility:** The project assesses the technical feasibility of developing the "Metro Route Xpert" application by evaluating the availability of necessary resources, technology stack, and infrastructure. This involves analyzing factors such as the compatibility of chosen development frameworks with the required functionalities, scalability options for handling potential user traffic, and the availability of APIs or data sources for accessing metro network information. By ensuring the availability of the required technical resources and capabilities, the project can proceed with confidence in its development efforts.

2. **Financial Feasibility:** The project conducts a financial feasibility study to evaluate the cost-effectiveness of developing and maintaining the "Metro Route Xpert" application. This involves estimating the initial development costs, including expenses related to software development, user research, and infrastructure setup, as well as ongoing operational expenses such as hosting, maintenance, and support. Additionally, the project assesses potential revenue streams or funding sources, such as user subscriptions, advertisements, or partnerships, to ensure sustainability and return on investment over the long term.

3. **Operational Feasibility:** The project examines the operational feasibility of deploying and managing the "Metro Route Xpert" application within the existing ecosystem of the Delhi metro system. This involves assessing factors such as regulatory compliance, data privacy considerations, and integration with existing metro infrastructure or information systems. By addressing operational challenges proactively and ensuring alignment with stakeholder requirements, the project can mitigate risks and maximize the likelihood of successful implementation and adoption of the application.

2. LITERATURE REVIEW

2.1 Significance

Improved Efficiency: By offering the shortest path options, the website can help commuters save time during their journeys. This is particularly valuable in a busy city like Delhi where time is of the essence.

Cost Optimization: For those on a budget, the website's ability to identify the least expensive routes can lead to significant cost savings, especially when considering multiple transfers or travel during peak hours.

Tech Stack Innovation: Utilizing React for the frontend and Flask for the backend showcases a modern tech stack, positioning the Delhi Metro as a technologically progressive organization. This can attract talent and position the Delhi Metro for future technological advancements.

2.2 About the dataset:

The dataset "***map_data.csv***" containing the attributes:

- **ID (Station ID):** Unique identifier for each station.
- **Station Names:** Name of the metro station.
- **Dist. From First Station (km):** Distance of the station from the first station in kilometers.
- **Metro Line:** Name or identifier of the metro line to which the station belongs.
- **Latitude:** Geographic coordinate specifying the north-south position of the station.
- **Longitude:** Geographic coordinate specifying the east-west position of the station.

The dataset seems to cover multiple metro lines such as the Red Line, Yellow Line, Blue Line, Violet Line, Pink Line , Orange Line and Grey Line. Each line has its set of stations, and the dataset provides information about the geographical location of these stations along with their distances from the first station on their respective lines.

The dataset “***Links.csv***” containing the attributes:

- **Purpose:** The dataset provides information about the distances between stations along a metro or subway line. It is useful for analyzing the structure and characteristics of the metro system.
- **Path Structure**: Each row in the dataset represents a segment of the metro line, with columns indicating the starting station (`Start`), ending station (`End`), and the distance between them (`Dist`).
- **Station Connectivity:** The dataset allows for understanding the connectivity between different stations on the metro line. By examining the start and end stations for each segment, one can determine the routes passengers can take.
- **Distance Measurement:** Distances between stations are given in kilometers (`km`). This information is essential for estimating travel times between stations and planning routes.

3. METHODOLOGY

1. Frontend Implementation

1.1 User Interface Design:

- **Design Principles**: Incorporate principles of user-centered design to ensure the interface is intuitive and easy to navigate.
- **Input Fields**: Provide input fields for users to enter their starting and destination stations. Implement autocomplete or dropdown functionality to assist users in station selection.
- **Map Integration:** Utilize Leaflet.js, a popular open-source JavaScript library for interactive maps, to display the Delhi Metro network. Customize the map to highlight stations, lines, and connections.
- **Route Details**: Display route details dynamically, including distance, estimated travel time, and fare information. Ensure clear visualization of these details for user comprehension.
- **Path Cards**: Implement detailed cards or panels for each station along the route. Include information such as station name, line details, distance from the previous station, and any relevant landmarks or transfer points.

1.2 Map Visualization:

- **Leaflet.js Customization**: Customize the Leaflet.js map to accurately represent the Delhi Metro network. This includes adding markers for stations and polylines to depict metro lines and connections between stations.
- **Dynamic Updates:** Enable dynamic updates to the map based on user input. When users enter their starting and destination stations, highlight the shortest path on the map to provide visual confirmation of the selected route.

2. Backend Implementation

2.1 Flask Server Setup:

- **Flask Application Structure:** Organize the Flask application using best practices, such as the MVC (Model-View-Controller) architecture or similar patterns, to maintain code readability and scalability.
- **API Endpoint Definition:** Define RESTful API endpoints to handle incoming requests from the frontend. These endpoints should include routes for receiving user inputs and returning the shortest path details.
- **Request Handling:** Implement request handling logic to parse user inputs, validate data, and invoke the appropriate functions for calculating the shortest path.

2.2 Shortest Path Calculation:

- **Graph Representation:** Represent the Delhi Metro network as a graph data structure using an adjacency list or a similar approach. Each station is a node, and the connections between stations are represented as edges.
- **Dijkstra's Algorithm:** Implement Dijkstra's algorithm to calculate the shortest path between the user's selected starting and destination stations. Consider factors such as distance, travel time, and fare to determine the optimal route.
- **Route Details Formatting:** Calculate total distance, estimated travel time, and fare along the shortest path. Format the route details into a JSON response to be sent back to the frontend for display.

3. Integration

3.1 API Integration:

- **Axios Integration:** Connect the frontend components to the Flask backend using Axios, a promise-based HTTP client for JavaScript. Use Axios to send asynchronous requests to the backend API endpoints and handle responses.
- **Data Flow Management:** Ensure seamless data flow between the frontend and backend systems. Implement error handling mechanisms to gracefully manage exceptions and provide informative error messages to users when necessary.

3.2 Libraries / Packages

The several libraries and packages to streamline development and enhance functionality. Here's an overview of the key ones:

1. **Flask:**
    - Flask is a lightweight web framework for Python used for building web applications. We leverage Flask to develop the backend server that handles API requests and serves data to the frontend.
2. **Leaflet.js:**
    - Leaflet.js is an open-source JavaScript library for interactive maps. We integrate Leaflet.js into our frontend to visualize the metro network map and display station markers and route polylines.
3. **NetworkX:**
    - NetworkX is a Python library for the creation, manipulation, and study of complex networks. We use NetworkX to represent the metro network as a graph data structure and perform graph algorithms like Dijkstra's algorithm for finding the shortest path.
4. **NumPy and Pandas:**
    - NumPy and Pandas are essential libraries for data manipulation and analysis in Python. We utilize NumPy and Pandas to preprocess and analyze metro network data, such as station coordinates and distances between stations.

4. CHALLENGES

1. **Data Collection:**

   - Obtaining accurate and comprehensive data about the metro network, including station locations, connections, and distances, was challenging. Data cleaning was required to handle inconsistencies, missing values, and inaccuracies in the dataset.

2. **Algorithm Selection:**

   - Choosing the appropriate algorithm for calculating the shortest path between metro stations was crucial. We needed to consider factors such as efficiency, accuracy, and scalability to ensure optimal route planning for users.

3. **Map Visualization:**

   - Designing an intuitive and interactive map visualization of the metro network posed a challenge. We had to find a balance between displaying sufficient detail and maintaining clarity and usability for users navigating the map.

4. **Route Details and Fare Calculation:**

   - Users can access detailed information about their chosen route,including total distance, estimated travel time, and fare calculation. The application accurately calculates the fare based on the distance traveled, fare zones, and any applicable discounts or surcharges.

5. RESULTS

- The application successfully calculates the shortest and most efficient routes between starting and destination metro stations based on user input. Users can visualize the optimal path on the map and view detailed route information, including station names, distances, and estimated travel time.
- Users can access detailed information about their chosen route, including total distance, estimated travel time, and fare calculation. The application accurately calculates the fare based on the distance traveled, fare zones, and any applicable discounts or surcharges.
- The map visualization feature provides users with an interactive and intuitive interface to explore the metro network. Users can interact with markers representing metro stations, view route connections, and dynamically update the map based on their input.

Demonstration:

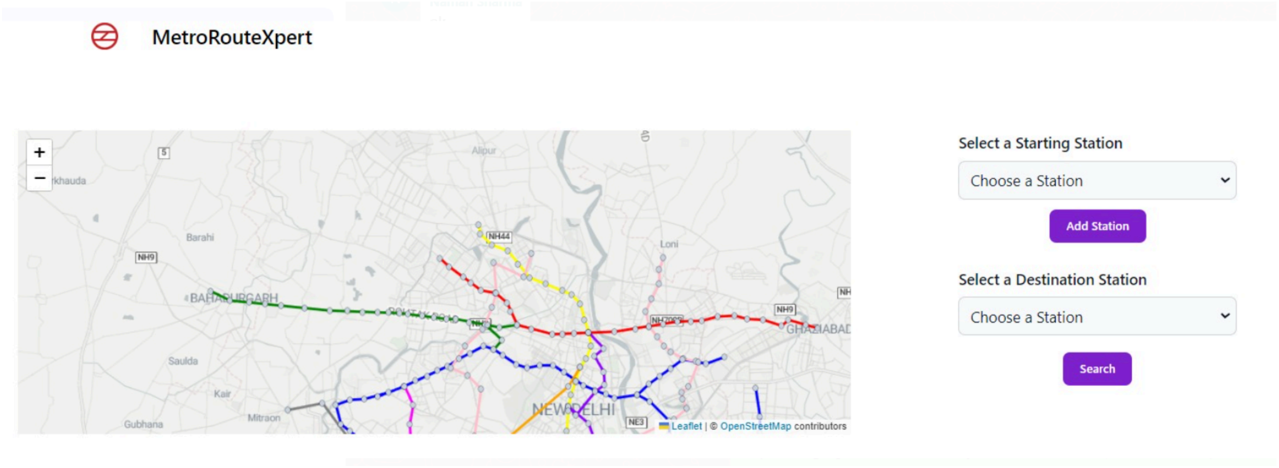
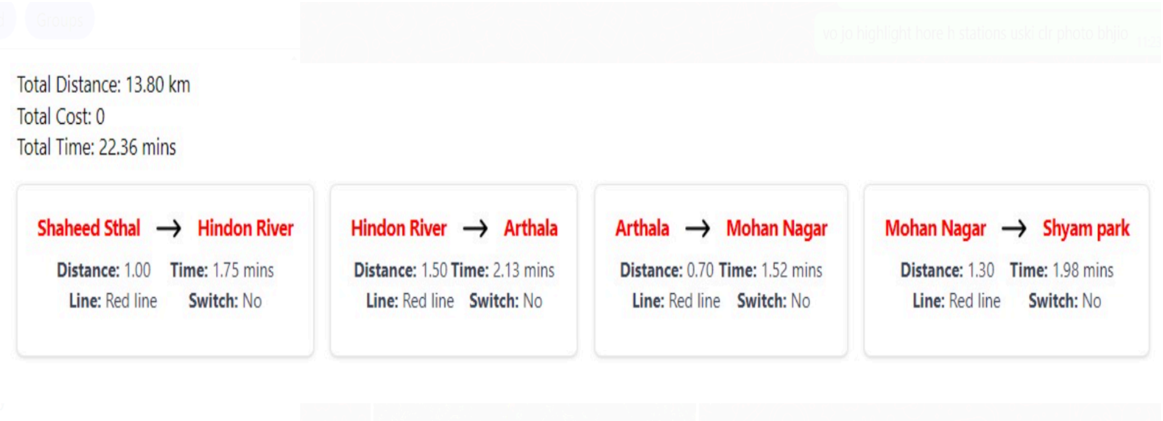


Fig 1 Station Selection Interface



Groups

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Total Distance: 13.80 km
Total Cost: 0
Total Time: 22.36 mins

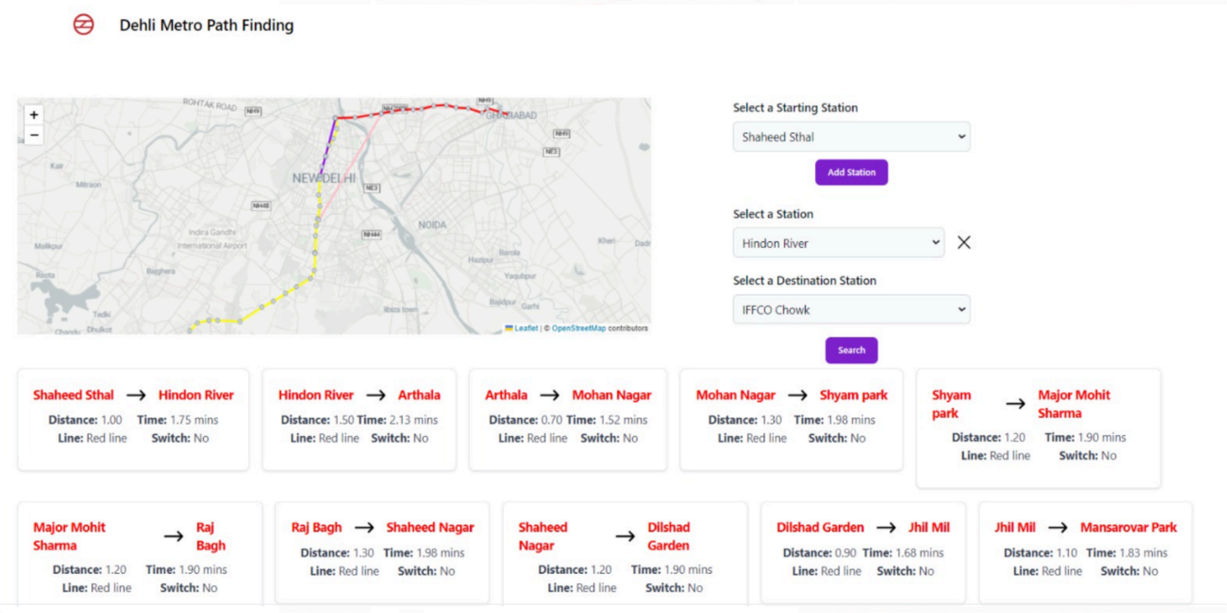
Shaheed Sthal → Hindon River
Distance: 1.00 **Time:** 1.75 mins
Line: Red line **Switch:** No

Hindon River → Arthala
Distance: 1.50 **Time:** 2.13 mins
Line: Red line **Switch:** No

Arthala → Mohan Nagar
Distance: 0.70 **Time:** 1.52 mins
Line: Red line **Switch:** No

Mohan Nagar → Shyam park
Distance: 1.30 **Time:** 1.98 mins
Line: Red line **Switch:** No

Fig 2 Route Details and Fare Calculation



Dehli Metro Path Finding

Select a Starting Station
Shaheed Sthal

Select a Station
Hindon River

Select a Destination Station
IFFCO Chowk

Shaheed Sthal → Hindon River
Distance: 1.00 **Time:** 1.75 mins
Line: Red line **Switch:** No

Hindon River → Arthala
Distance: 1.50 **Time:** 2.13 mins
Line: Red line **Switch:** No

Arthala → Mohan Nagar
Distance: 0.70 **Time:** 1.52 mins
Line: Red line **Switch:** No

Mohan Nagar → Shyam park
Distance: 1.30 **Time:** 1.98 mins
Line: Red line **Switch:** No

Shyam park → Major Mohit Sharma
Distance: 1.20 **Time:** 1.90 mins
Line: Red line **Switch:** No

Major Mohit Sharma → Raj Bagh
Distance: 1.20 **Time:** 1.90 mins
Line: Red line **Switch:** No

Raj Bagh → Shaheed Nagar
Distance: 1.30 **Time:** 1.98 mins
Line: Red line **Switch:** No

Shaheed Nagar → Dilshad Garden
Distance: 1.20 **Time:** 1.90 mins
Line: Red line **Switch:** No

Dilshad Garden → Jhil Mil
Distance: 0.90 **Time:** 1.68 mins
Line: Red line **Switch:** No

Jhil Mil → Mansarovar Park
Distance: 1.10 **Time:** 1.83 mins
Line: Red line **Switch:** No

Fig 3 Route from Shaheed Sthal to IFFCO Chowk

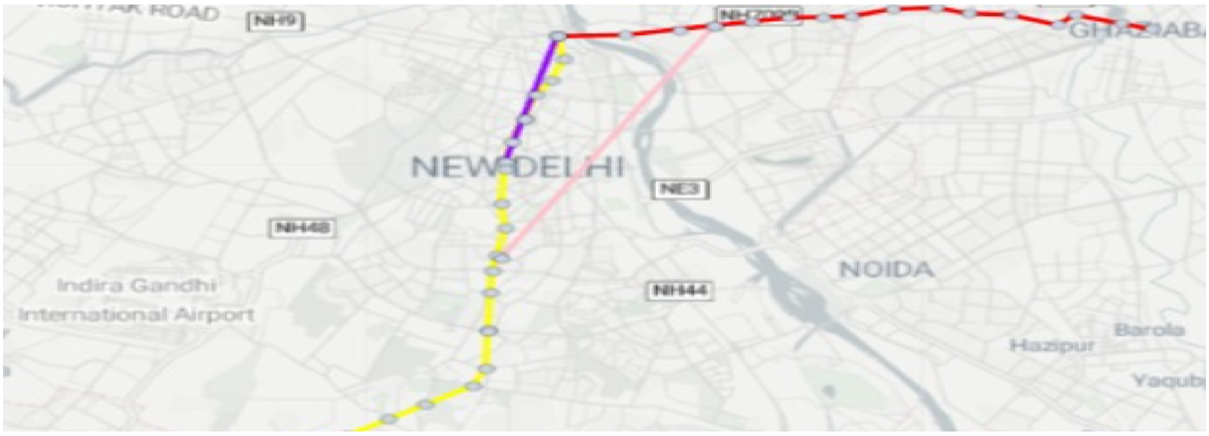


Fig 4 Map Navigation

6. CONCLUSION

In conclusion, the “MetroRouteXpert” project successfully demonstrates the integration of various technologies to create a user-friendly and efficient metro navigation system. By leveraging technologies such as Leaflet.js for map visualization, Flask for backend server setup, and Dijkstra's algorithm for route calculation, we have developed a comprehensive solution for metro navigation.

The project provides users with a seamless experience, allowing them to easily input their starting and destination stations, visualize the metro network on a map, and receive detailed route information including distance, travel time, and fare calculation. Additionally, the integration of fare calculation adds another layer of functionality, enhancing the overall utility of the application.

Moving forward, the project could be further enhanced by incorporating additional features such as real-time updates on metro schedules, integration with mobile platforms for on-the-go access, and optimization for scalability to accommodate a larger user base. Overall, the metro project serves as a testament to the power of technology in revolutionizing transportation systems and improving urban mobility.

7. FUTURE SCOPE

Real-time Integration: Integrate with the Delhi Metro's real-time data feeds to display live updates on delays, disruptions, and platform changes. This would provide users with the most up-to-date information for informed travel decisions.

Multimodal Integration: Expand the scope beyond the metro by incorporating other modes of transportation like buses, rickshaws, or carpooling services. This would create a comprehensive travel planning platform for users seeking the most efficient route combinations.

Personalized Recommendations: Leverage user data to personalize route suggestions. This could consider factors like preferred lines, walking distances from stations, or avoiding crowded routes during peak hours.

Accessibility Enhancements: Implement advanced accessibility features like voice commands, integration with screen reader software making the website truly inclusive.

Expanding Scope to Other Cities: Consider adapting the website model for other Indian cities with metro networks, potentially creating a national multi-city journey planner platform.

Multilingual Support: Offering the website in multiple languages can cater to a wider audience, including tourists and non-Hindi speaking residents, further improving accessibility.

8. REFERENCES

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