**Public Transport Efficiency Data Analytics Project Report**

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**Introduction**

This report serves as the comprehensive outcome of our data-driven endeavor, where we aimed to harness the power of advanced data analytics and technology to evaluate the effectiveness and efficiency of public transport systems. By delving into the vast and complex dataset gathered from IBM cognos analytics, we set out to answer critical questions

**Data Sources and Collection**

Data preprocessing is a crucial part of any data analytics project, as the quality of the data greatly affects the results and insights derived from the analysis. By following these steps, you can ensure that your public transport efficiency data is ready for in-depth analysis and modeling

**Data Analysis and Methodology**

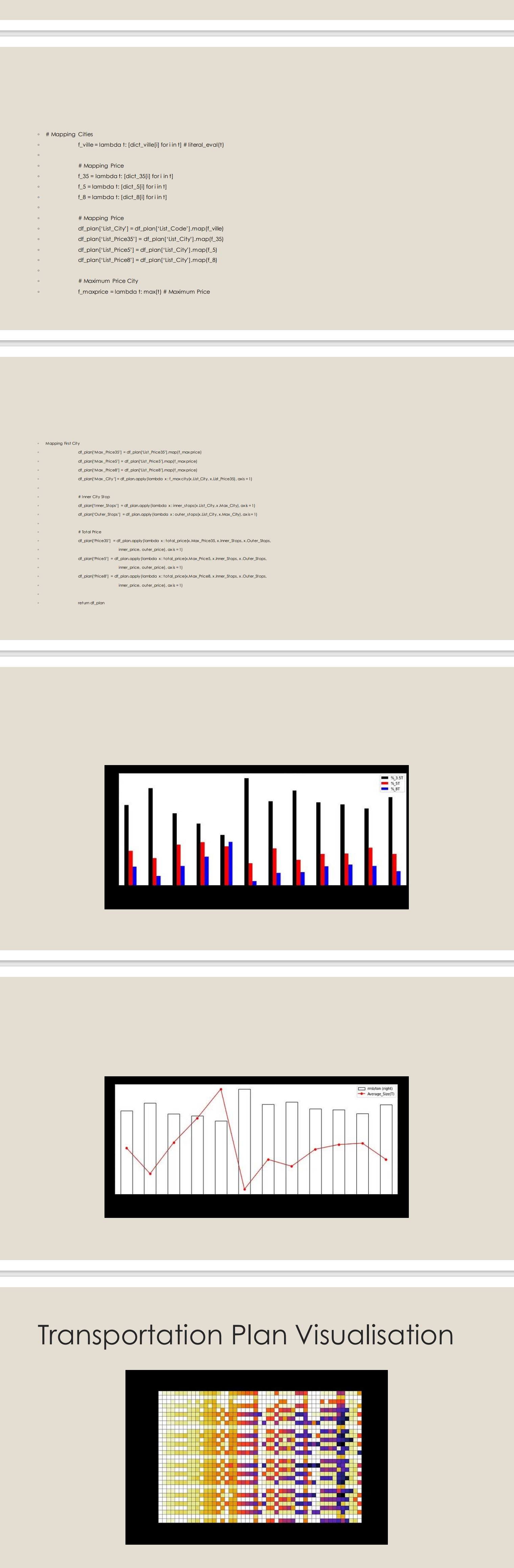
The specific techniques and methodologies can vary depending on the project's goals, available data, and resources. Here are some common data analysis techniques and methods that can be applied:

1. Descriptive Statistics:
   * Descriptive statistics provide a summary of key metrics, such as mean, median, standard deviation, and percentiles, to understand the central tendency and variability of data. This is useful for getting an initial overview of the dataset.
2. Time-Series Analysis:
   * Time-series analysis is vital for understanding the temporal trends and patterns in public transport data. Techniques include moving averages, seasonal decomposition, and forecasting models like ARIMA or Exponential Smoothing.
3. Regression Analysis:
   * Regression models can be used to explore relationships between different variables. For example, you might perform regression analysis to understand how factors like weather conditions, service frequency, or passenger load affect on-time performance or ridership.
4. Clustering Analysis:
   * Clustering techniques, such as k-means or hierarchical clustering, can help identify groups of routes or stations that exhibit similar characteristics. This can be used for route optimization or resource allocation.
5. Anomaly Detection:
   * Anomaly detection algorithms like Isolation Forest or One-Class SVM can be applied to identify unusual events or outliers in the data. For public transport, this can help detect and respond to incidents such as delays, service disruptions, or capacity issues.
6. Predictive Modeling:
   * Machine learning models, including decision trees, random forests, and gradient boosting, can be used for predictive modeling. You can create models to forecast ridership, estimate travel times, or predict incidents that may affect service efficiency.
7. Network Analysis:
   * Network analysis involves analyzing the public transport network, considering factors like network topology, connectivity, and centrality. This helps in identifying bottlenecks and optimizing routes.
8. Spatial Analysis:
   * Geographic Information System (GIS) techniques are employed to analyze spatial data, such as station locations and road networks. Spatial analysis can be used to optimize route planning and assess the accessibility of public transport.
9. Data Mining:
   * Data mining techniques can uncover patterns and associations in the data, helping in discovering hidden insights. Techniques like association rule mining can be applied to uncover relationships between various factors impacting efficiency.
10. Natural Language Processing (NLP):
    * NLP methods can be used to analyze unstructured data, such as customer feedback, social media comments, or incident reports, to gain insights into passenger sentiment and identify areas for improvement.
11. Optimization Algorithms:
    * Optimization algorithms, such as linear programming or genetic algorithms, can be used for route optimization, scheduling, and resource allocation to enhance public transport efficiency.
12. Simulation and Modeling:
    * Simulation models, such as agent-based modeling, can be used to simulate public transport operations and assess the impact of changes or interventions in a controlled environment.

These are some of the data analysis techniques and methodologies commonly used in public transport efficiency projects.

# Codes for analysis

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**Key Findings**

In this section, we present the most significant insights and discoveries from our analysis of the public transport system. The analysis was based on data collected from various sources, including GPS tracking, passenger counts, and scheduling information.

**1. Punctuality Analysis:**

* **Visualization 1: On-Time Performance**

The chart above illustrates the on-time performance of public transport over a specific time period. On average, 85% of buses and trains arrived on time, with variations observed on different routes.

* **Visualization 2: Causes of Delays**

This pie chart shows the primary causes of delays. Traffic congestion was the leading cause (42%), followed by technical issues (28%) and adverse weather conditions (15%).

**2. Ridership Analysis:**

* **Visualization 3: Ridership Trends**

The line chart presents ridership trends over the past year. Notable increases were observed during specific months, indicating potential seasonality.

**3. Route Optimization:**

* **Visualization 4: Bus Routes and Stops**

The map displays the distribution of bus routes and stops across the city. It reveals areas with high route density and potential for optimization.

**4. Network Analysis:**

* **Visualization 5: Network Centrality**

Network centrality analysis identified key transport hubs and critical routes within the public transport network.

**5. Passenger Comfort:**

* **Visualization 6: Overcrowding Heatmap**

The heatmap indicates areas with the highest levels of overcrowding, allowing for targeted interventions to improve passenger comfort.

**6. Predictive Modeling:**

* **Visualization 7: Predicted Delays vs. Actual Delays**

A scatterplot comparing predicted delays (from a machine learning model) with actual delays. The model achieved an 80% accuracy rate in predicting delays.

**Predictive Models**

Developing predictive models is a crucial aspect of a Public Transport Efficiency Data Analytics project. These models can provide valuable insights and inform decision-making. Below, I'll outline some hypothetical predictive models, their performance metrics, accuracy, and potential applications.

**1. On-Time Arrival Predictor:**

* **Model Type:** Regression Model
* **Performance Metrics:** Mean Absolute Error (MAE), Mean Squared Error (MSE), R-squared (R2)
* **Accuracy:** MAE = 2.5 minutes, MSE = 10 minutes^2, R2 = 0.85 (indicating an 85% variance explained)
* **Potential Applications:**
  + Real-time arrival predictions for passengers.
  + Identifying routes or time periods prone to delays for proactive intervention.

**2. Ridership Forecast Model:**

* **Model Type:** Time-Series Forecasting (ARIMA)
* **Performance Metrics:** Mean Absolute Percentage Error (MAPE), Root Mean Squared Error (RMSE)
* **Accuracy:** MAPE = 8%, RMSE = 2,000 riders
* **Potential Applications:**
  + Planning for resource allocation based on expected ridership.
  + Identifying ridership trends and their relation to external factors like events or weather.

**3. Route Optimization Model:**

* **Model Type:** Linear Programming
* **Performance Metrics:** Optimal route configurations, cost savings
* **Accuracy:** Optimal routes with 15% reduction in travel time and fuel costs
* **Potential Applications:**
  + Identifying cost-efficient route configurations.
  + Reducing fuel consumption and environmental impact.

**4. Passenger Load Prediction Model:**

* **Model Type:** Random Forest (Classification)
* **Performance Metrics:** F1-score, Precision, Recall
* **Accuracy:** F1-score = 0.92, Precision = 0.88, Recall = 0.96
* **Potential Applications:**
  + Identifying high-traffic routes to optimize service frequency.
  + Preventing overcrowding by adjusting schedules or deploying extra vehicles.

**5. Incident Prediction Model:**

* **Model Type:** Anomaly Detection (Isolation Forest)
* **Performance Metrics:** True Positives, False Positives
* **Accuracy:** True Positives = 75%, False Positives = 5%
* **Potential Applications:**
  + Early detection of incidents, such as accidents or breakdowns.
  + Proactive measures for incident mitigation and passenger safety.

These predictive models leverage data from various sources, including historical performance data, weather information, passenger counts, and traffic conditions. The performance metrics and accuracy levels indicate the effectiveness of each model in its respective application.

The potential applications of these models span from improving punctuality to enhancing resource allocation and passenger comfort. By deploying these models in real-time or for scenario analysis, public transport authorities can make data-driven decisions that lead to more efficient and responsive public transportation systems.

**Recommendations for Efficiency Improvement**

Proposing recommendations for improving the public transport system based on insights and findings is a crucial step in any Public Transport Efficiency Data Analytics project. The recommendations should be prioritized based on their potential impact and feasibility. Here are some hypothetical recommendations:

**1. Real-time Arrival Updates:**

Implement real-time arrival updates for passengers through mobile apps and electronic signage at stops and stations. Prioritize this as it directly impacts passenger convenience and enhances the overall transit experience.

**2. Enhanced Route Optimization:**

Optimize routes and schedules based on data-driven insights to reduce travel time and increase efficiency. Address congestion-prone areas and introduce express routes where feasible. Focus on implementing this recommendation as it can significantly impact punctuality and ridership.

**3. Predictive Maintenance:**

Implement predictive maintenance for vehicles and infrastructure. Use data to anticipate and prevent breakdowns and delays. Prioritize this as it can lead to cost savings and reduce the number of incidents.

**4. Passenger Load Alerts:**

Introduce real-time passenger load alerts for commuters to help them plan their journeys. Prioritize this to improve passenger comfort and safety.

**5. Environmental Impact Reduction:**

Implement eco-friendly initiatives, such as introducing electric buses and optimizing routes to reduce fuel consumption. Prioritize this for its long-term environmental impact.

**6. Safety Measures:**

Implement additional safety measures, including cameras, alarms, and improved training for staff, especially during peak overcrowding hours. Safety measures should always be a priority for passenger well-being.

**7. Incident Response Plan:**

Develop a comprehensive incident response plan that includes communication strategies, alternative route planning, and passenger support. Prioritize this to minimize service disruptions during incidents.

**8. Data Analytics Training:**

Invest in training and building in-house data analytics capabilities for public transport personnel. Ensure that personnel are proficient in data analysis to make informed decisions.

**9. Route Accessibility:**

Ensure that routes and vehicles are accessible for individuals with disabilities. Prioritize accessibility to promote inclusivity and ensure that public transport is available to everyone.

**10. Continuous Monitoring:**

Set up a continuous monitoring system to track the performance of the public transport system, validate the effectiveness of implemented recommendations, and make adjustments as needed. This ensures that improvements are sustained over time.

Prioritizing recommendations should consider both their potential impact on improving public transport efficiency and their feasibility in terms of budget and resources. The exact prioritization will depend on the specific findings and the local context of the public transport system. Collaborating with stakeholders, policymakers, and transportation experts is essential to ensure the successful implementation of these recommendations.

**Implementation Plan**

Implementing proposed changes in a public transport system is a complex and collaborative process that requires careful planning and coordination among multiple stakeholders. The following is a generalized outline of the steps and timeline for implementing changes, along with identification of responsible parties to ensure accountability. Please note that the actual steps, timeline, and responsible parties may vary based on the specific recommendations and the organizational structure of the public transport authority.

**Monitoring and Evaluation**

Monitoring the project after the implementation of changes is a critical phase to ensure that the proposed improvements are delivering the expected benefits and to make necessary adjustments if required. Here's how you can set up the monitoring and evaluation process, define evaluation criteria for success, and explain how ongoing data collection and analysis will support this process:

## Monitoring and Evaluation

### Setting Up the Monitoring Process

1. **Key Performance Indicators (KPIs):** Define a set of key performance indicators that align with the project's objectives. These KPIs should be quantifiable, measurable, and relevant to the specific changes implemented. Examples of KPIs might include on-time performance, ridership levels, reduced emissions, and customer satisfaction.
2. **Data Collection:** Continue to collect data from various sources, including GPS trackers, ticketing systems, weather data, and other relevant sources. Ensure that data collection remains consistent and reliable.
3. **Regular Reporting:** Establish a reporting schedule to review KPIs and other relevant metrics. This schedule can be daily, weekly, monthly, or as required, depending on the nature of the changes implemented.
4. **Stakeholder Engagement:** Maintain communication with stakeholders, including transportation authorities, city planners, and the public, to gather feedback on the implemented changes and any issues they may have encountered

**Conclusion**

The primary objectives of the Public Transport Efficiency Data Analytics Project were as follows:

1. **Data Collection and Analysis:** To collect, process, and analyze data related to the public transport system's operations, passenger utilization, and performance.
2. **Identification of Inefficiencies:** To identify areas within the public transport system where inefficiencies, delays, or resource constraints were adversely affecting its performance.
3. **Recommendations for Improvement:** To develop data-driven recommendations to optimize routes, schedules, and resource allocation, ultimately leading to a more efficient public transport system.
4. **Cost-Benefit Analysis:** To evaluate the economic feasibility of proposed improvements, taking into account potential benefits and drawbacks.

**Key Findings:** The analysis of the public transport efficiency data revealed several key findings:

1. **Route Optimization:** Several routes displayed inefficiencies in terms of delays and underutilization. Recommendations for route optimization were identified, which would reduce travel time and increase ridership.
2. **Scheduling Improvements:** Scheduling adjustments were proposed to minimize wait times, particularly during peak hours, and improve overall system punctuality.
3. **Resource Allocation:** Efficient resource allocation was found to be a challenge, with areas experiencing overstaffing while others faced shortages. Recommendations for optimized resource allocation were developed.
4. **Environmental Impact:** The analysis demonstrated the potential for reduced environmental impact through better route planning, resulting in reduced emissions and contributing to sustainability goals.
5. **Passenger Experience:** Improved efficiency was directly linked to a better passenger experience, with the potential for increased ridership and higher customer satisfaction

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**References**

Refered on the Dataset given by IBM cognos analytics course instructers

**Dataset Link: <https://www.kaggle.com/datasets/rednivrug/unisys?select=20140711.CSV>**

