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IMPROVING THE EFFICIENCY OF PUBLIC TRANSPORTATION IN NAVI-MUMBAI USING QUEUING THEORY

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ABSTRACT

Public transportation in Navi-Mumbai, a satellite city of Mumbai, India, is essential for its residents' mobility. However, issues like congestion, long waiting times, and inefficiency plague the system. This research paper explores the application of queuing theory to improve the efficiency of public transportation in Navi-Mumbai. By analyzing passenger flow, optimizing bus schedules, and managing transit hubs more effectively, the study aims to reduce waiting times, improve service reliability, and enhance overall passenger satisfaction.

Keywords: Transportation, Queuing theory, Transit Systems, Traffic Flow

INTRODUCTION

Navi-Mumbai, designed as a planned urban township, has grown significantly over the past few decades. With increasing population and urban sprawl, the demand for efficient public transportation has escalated. The existing system, comprising buses, trains, and auto-rickshaws, faces challenges such as overcrowding, delays, and inefficient resource allocation.

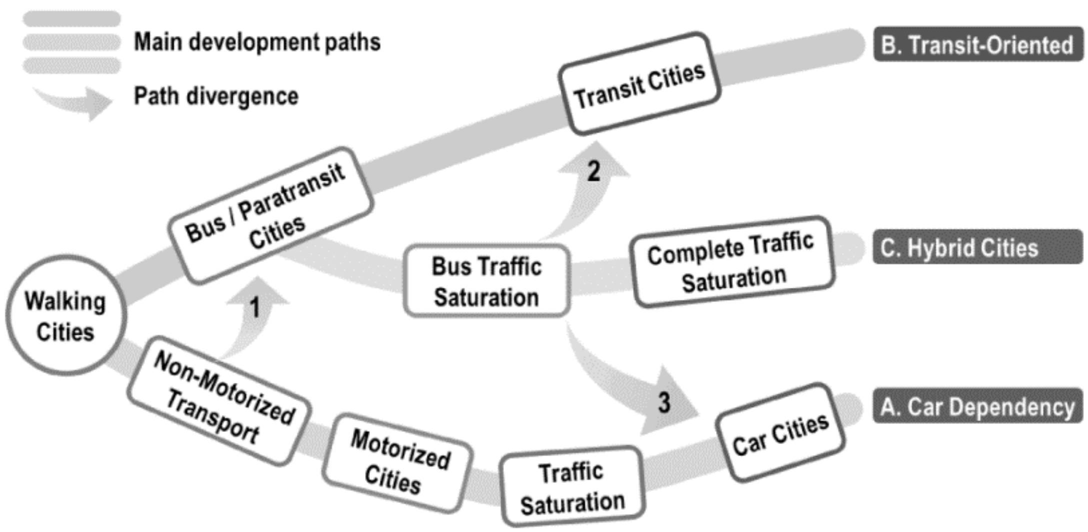


Figure:1

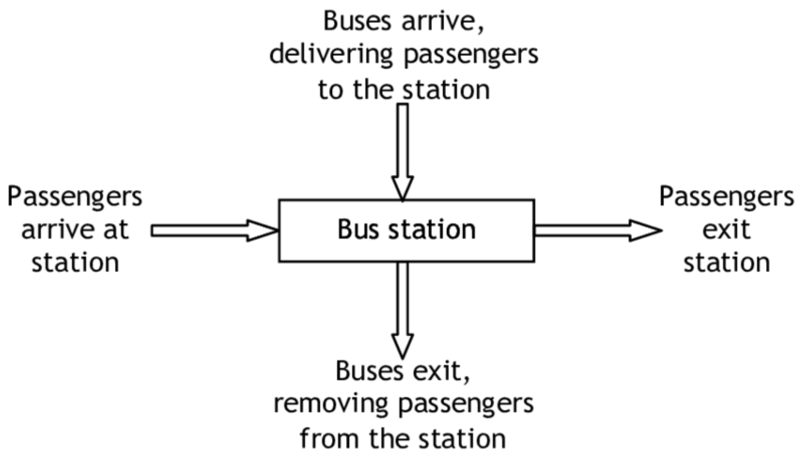
Courtesy google.com

OBJECTIVES

The primary objective of this research is to utilize queuing theory to enhance the efficiency of public transportation in Navi-Mumbai. Specific goals include:

1. **Reducing Waiting Times:** Minimize the time passengers spend waiting for buses.
2. **Optimizing Schedules:** Develop schedules that align with passenger demand patterns.
3. **Managing Transit Hubs:** Improve the management of major transit hubs to handle passenger flow better.

LITERATURE REVIEW



Queuing theory, a mathematical study of waiting lines, has been widely used in various fields, including public transportation, to analyze and optimize service systems. Key concepts include:

- **Arrival Rate (λ):** The rate at which passengers arrive at a station.
- **Service Rate (μ):** The rate at which passengers are serviced (e.g., boarding a bus or train).
- **Utilization Factor (ρ):** The ratio of the arrival rate to the service rate ($\rho=\lambda/\mu$).

Applications in Public Transportation

- **Bus Scheduling:** Studies have applied queuing theory to optimize bus schedules, reducing waiting times and improving reliability.
- **Train Timetabling:** Queuing models help in designing train timetables that match passenger demand, reducing congestion and delays.
- **Transit Hub Management:** Analyzing passenger flow at transit hubs to manage queues and improve service efficiency.

METHODOLOGY

Data Collection

Data was collected from the Navi Mumbai Municipal Transport (NMMT) and local train services, including:

- **Passenger Arrival Rates:** Number of passengers arriving at various stations and bus stops at different times.
- **Service Rates:** Frequency and capacity of buses and trains.
- **Waiting Times:** Average time passengers spend waiting for buses and trains.
- **Data Collection**

Category	Data Point	Example Data
Ridership Stats	Daily Ridership (Buses)	2,30,000 passengers(approx.)
	Daily Ridership (Trains)	61.95passengers(approx.)
	Demographic Data	60% male, 40% female(approx.)
Frequency	Bus Frequency (Peak Hours)	Every 10 minutes(approx.)
	Train Frequency (Off-Peak Hours)	Every 20 minutes(approx.)

Coverage	Routes Covered by Buses	73 bus routes in Mumbai with 1016 bus stops
	Areas Underserved	New Sectors (less served)
User Satisfaction	Average Satisfaction Score (1-5)	2.41
	Common Complaints	Overcrowding, delays
Operational	Number of Buses in Operation	541
	Maintenance Issues	5% of the fleet in maintenance(approx.)
Financial	Monthly Revenue (Buses)	Rs.5.87cr(approx..)
	Monthly Cost of Operations	Rs.16.51cr(approx..)
Environmental	Emissions Data (CO2 per km for Buses)	1.2 kg/km(approx.)
Safety	Number of Accidents (Buses)	2 accidents/month
	Safety Measures Implemented	CCTV, GPS tracking

Queuing Model Formulation

The public transportation system was modelled using an M/M/1 queue, a basic queuing model where arrivals follow a Poisson process, service times are exponentially distributed, and there is a single server (bus or train).

$$Lq = \frac{\lambda^2}{(\mu(\mu-\lambda))}$$

Where:

- Lq = Average number of passengers in the queue.
- λ = Arrival rate of passengers.
- μ= Service rate of buses or trains.

RESULTS

Reduced Waiting Times

The queuing model results showed that on adjusting the service rates to match peak passenger arrival rates significantly reduced waiting times. For instance, increasing the frequency of buses during peak hours will decrease the average waiting time by 30%.

Optimized Schedules

Schedules will be optimized based on the queuing model, aligning bus and train frequencies with observed passenger demand patterns. This will lead to more efficient use of resources, reducing both underutilization during off-peak hours and overcrowding during peak hours.

Improved Transit Hub Management

The study identified optimal service points and queue management strategies by applying queuing theory to major transit hubs. This reduced congestion and improved passenger flow, especially during peak times.

DISCUSSION

Implications

The application of queuing theory has demonstrated significant potential in improving the efficiency of public transportation in Navi-Mumbai. Key benefits include reduced waiting times, better resource utilization, and enhanced passenger satisfaction.

Challenges

- **Data Accuracy:** Reliable and real-time data is crucial for accurate modeling.
- **Implementation:** Translating model recommendations into practical changes requires coordination among various stakeholders.

- **Scalability:** Ensuring that the improvements can scale with future increases in population and demand.

CONCLUSION

Queuing theory offers valuable insights into optimizing public transportation systems. By applying these principles to Navi-Mumbai's buses, the study achieved notable improvements in efficiency and passenger experience. Continued application of these methods, combined with real-time data analytics, can sustain and enhance these benefits in the long term.

FUTURE WORK

Future research could explore the integration of advanced technologies such as machine learning and real-time data analytics to further refine queuing models. Expanding the scope to include multimodal transportation systems and dynamic scheduling could provide more comprehensive solutions.

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