ROUTED – DYNAMIC BUS SCHEDULING

Under the guidance of

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INTRODUCTION

- Importance of bus transportation in public transport
- Shortcomings of bus transportation
- Reasons for the shortcomings
- Solution: Dynamic scheduling

PROBLEM STATEMENT

- Public transit - a mix of private business and government
- Current BEST bus services are static
- Inefficient as well as underutilization of resources

EXISTING SOLUTION

- Human schedulers.
- Demographics of regions(residential,commercial areas) are considered.
- Manual travelling by Schedulers.
- Large workforce required.
- Lengthy period of research.
- Benefits few compared to the effort required.

OUR PROPOSAL

- Predict number of trips required on each route based on passenger records
- Allocation of buses on each routes based on trip prediction
- Dynamic Schedule generation for coming day
- Reusable buses(i.e. Buses not fixed to a single route)
- Schedules and allocation based records for each route in both direction

LITERATURE SURVEY

- Our prime focus has been to find out research papers that can be realized or cited in our solution.
- Literature survey has been mainly focused in the fields of:
  - Optimal resource allocation
  - Bus Scheduling algorithms
- Primary hurdle has been finding relevant research in alignment with our project objectives .
- Another aspect has been identifying the trade-offs between different attributes/features that can affect the creation of Dynamic Bus Schedules.
- Papers on data cleaning have been considered during the review.

BUS ALLOCATION ALGORITHMS

- Primary aim has been to
  - Identify papers proposing mathematical models for Bus Allocation
  - Papers defining various angles to approach the problem of Bus Allocation
  - Papers focusing on the identification of different useful attributes/features in the data
- Some of the important research papers surveyed in this regard are:
  - Optimal Resource Allocation For Projects by Carbno Collin
  - The Allocation Of Buses In Heavily Utilized Networks With Overlapping Routes by Anthony F. Han and Nigel Wilson
- Our main focus in this survey was to understand different existing approaches.

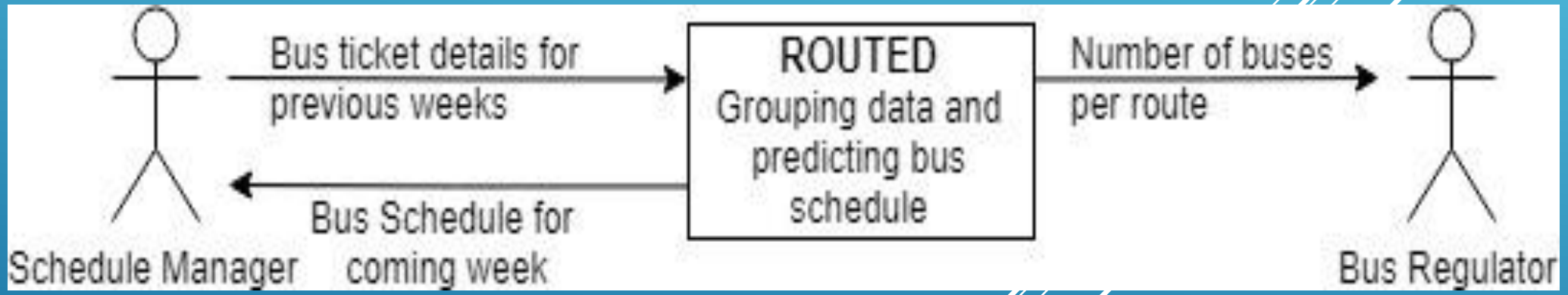
BUS SCHEDULING ALGORITHMS

- Approaches considered within the survey vary widely from statistical methods to data mining models and linear programming.
- Some of the important research papers surveyed in this regard are:
  - Bus Scheduling Model: A Literature Review by Mohammad HesamHafezi, Amiruddin Ismail and Ramez A. Al-Mansob
  - Optimal Multi-vehicle Type Transit Timetabling And Vehicle Scheduling by Avishai (Avi) Ceder
- Our main focus in this survey was to identify methods suitable for our solution.

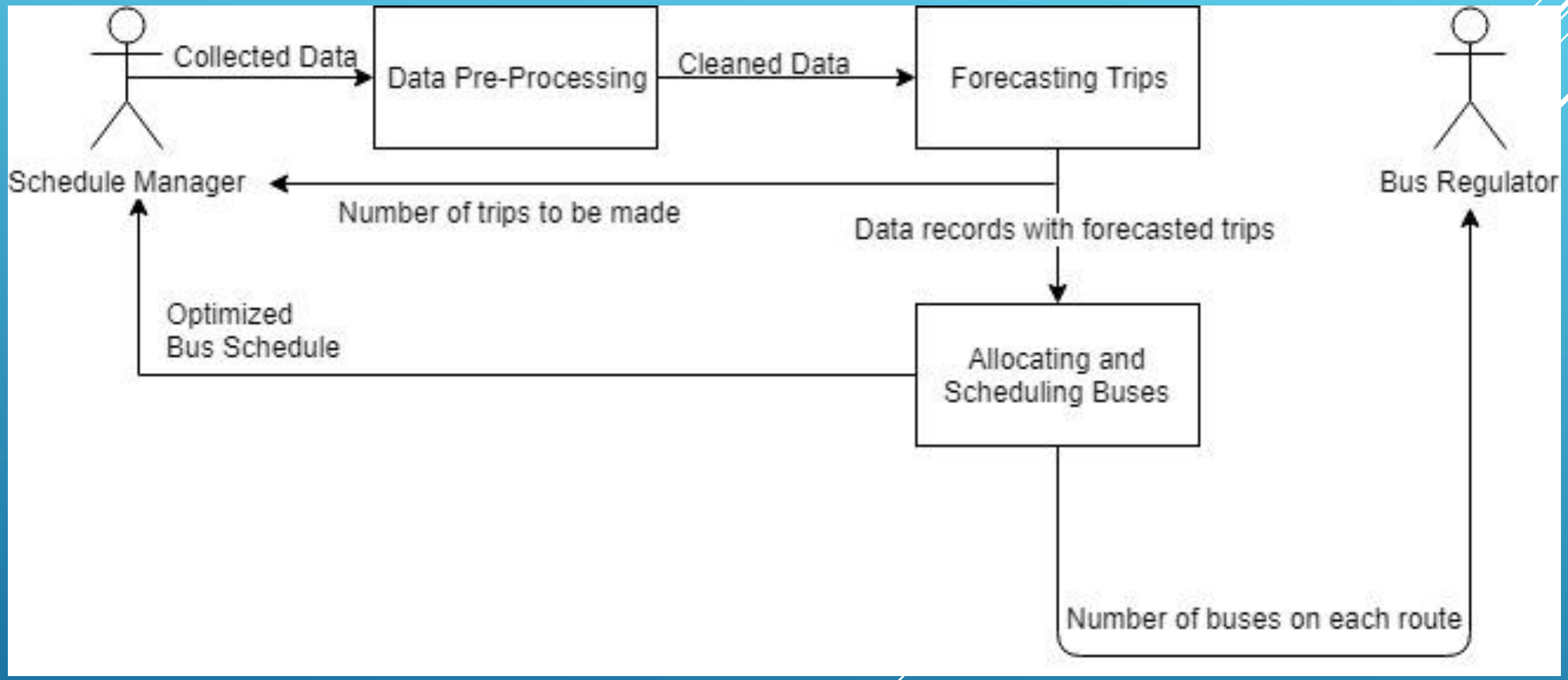
LITERATURE SURVEY OVERVIEW

- The literature available on the topics of our interest lack
  - Research papers that consider only ticket records for Bus scheduling and Allocation
  - Research papers that provide a complete model of Bus Scheduling and Allocation simultaneously
  - Clear distinction between the importance of different attributes that are used for clustering, scheduling and allocation
- As part of the review, we considered 18 research papers from relevant fields
- The research papers have been viewed as a guiding direction and not as a solution to be implemented and compared with the theoretical results

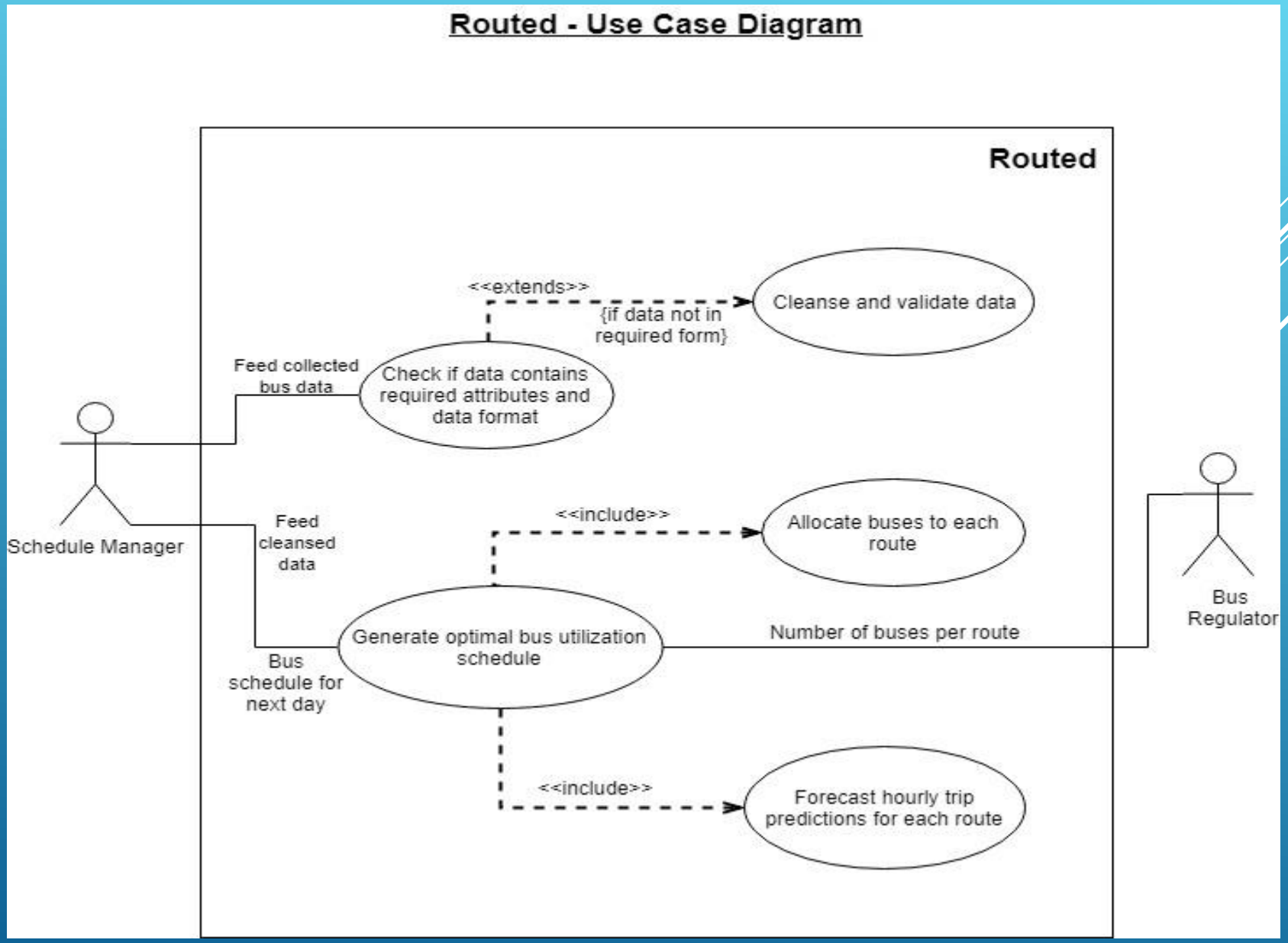
HIGH LEVEL ARCHITECTURAL DIAGRAM



LOW LEVEL ARCHITECTURAL DIAGRAM



USE CASE DIAGRAM



STEPS OF PROPOSED SOLUTION

The proposed solution can be broken down into four steps:

- Data Collection
- Data Pre-processing
- Trip Prediction
- Bus Allocation and Scheduling

DATA COLLECTION

- The input data for our project has been obtained from Vikhroli Bust Depot, Mumbai
- Contains information about 16 routes
- Input data contains attributes like number of trips, passengers, total km travelled for every timeslot in both directions
- Number of passengers ranged from as low as 50 to as high as 600 while the number of trips were in the range 0 to 10

DATA PRE-PROCESSING

- Raw data often incomplete, inconsistent and likely to be error prone
- Data pre-processing to the rescue. It ensures data is compatible with proposed method
- Split input data into different files for up and down direction
- Filling empty values with the constant zero
- Enumerating days of week. Monday = 1 and Sunday = 7
- Important in our proposed model to ensure appropriate trip forecast and subsequent bus allocation and scheduling

TRIP PREDICTION

- Chosen models have the ability to inherently identify trends, variations and seasonality
- Chosen models include ARIMAX, SARIMAX and LSTM RNNs
- These models consider passenger frequency on a day along a route for every timeslot and accordingly decide how many trips need to be made in order to service the passenger demands

ARIMAX, SARIMAX AND LSTM RNN

- The ARIMA (Auto-regressive integrated moving average) model is a time-series analysis model which considers future values of a variable (time series) to be dependent on its previous values.
- SARIMAX (Seasonal ARIMAX), like ARIMAX, is a time series analysis model that takes seasonality into consideration along with ARIMAX. In a seasonal ARIMA model, seasonal AR and MA terms predict attribute value using data values and errors at times with lags that are multiples of *S* (the span of the seasonality)
- LSTM units can store information and trends in the memory associated with it and thus, can remember inputs, associations, etc. over a long period of time.

BUS ALLOCATION AND SCHEDULING

- Bus scheduling (timetabling) and optimal allocation of buses help cut down the cost of resources
- Bus allocation refers to distributing buses across routes so as to meet the criteria of number of trips to be made
- Bus scheduling generates a timetable for the allocated buses with the help of reuse while maintaining an average headway

BUS ALLOCATION AND SCHEDULING

- This algorithm uses the trips for each slot to schedule the buses in each time slot with the aim of reducing the number of buses allocated for each route
- The algorithm uses the concept of empty trips (sending an empty trip from in one direction to reuse the bus in other direction if required) and allocating new buses when a given trip cannot be scheduled by using the allocated buses

EXPERIMENTAL SETUP

- In the ARIMAX model, after analysing trends and patterns in input data, a (1,1,0) model was chosen as it provides better flexibility and control over non-stationary trend. The 'I' component is not used as is but a difference function of our own is created
- In SARIMAX, parameters are chosen so as to stabilize the data and minimize seasonality for short term forecasts
- A two layered six node structure was used for the LSTM implementation

RESULTS

Date	SVM	ARIMAX	SARIMAX	Poly Regression	LSTM
8/2/18	5	5	4	6	5
9/2/18	5	7	5	5	8
10/2/18	3	5	5	6	6
11/2/18	2	3	4	5	4
12/2/18	5	3	3	5	5
13/2/18	7	3	5	7	7
14/2/18	5	3	5	5	7
Average	4.57	4.14	4.42	5.57	6

RESULTS (CONTINUED)

- The Polynomial Regression performs the worst due to the presence of outliers.
- LSTM and SVM show comparative results but do not show significant improvement over Polynomial Regression.
- ARIMAX and SARIMAX perform the best as they track the seasonality trends and patterns in our data and also keep a track of the outliers.

CONCLUSION

- The new system ensures that all the considerations of the current solution (availability of buses, reasonable waiting time for passengers and spare buses for unforeseen situations) are met
- It ensures that optimal number of buses are used for each route to cut down operational costs while maintaining an acceptable level of efficiency (in terms of headway).
- It helps overcome the problems in the current implementations where schedules are generated manually
- This can also lead to inconsistencies due to human interference which is alleviated to some extent in this system

FUTURE POSSIBILITIES

- Consideration of overlapping routes
- Dynamically altering buses on routes even during the day using live tracking
- Considering different types of buses that can be run on the routes, e.g. express buses, buses with different capacities
- Allowing the buses to run subsets of the entire routes and changing routes at intersection points

THANK YOU