Design of a Database for Bus Fleet Management

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ABSTRACT
State transport buses are a means of efficient mass transport in a populous country like India. But, the efficiency of this system is threatened by over dependence on file management system. Unexpected and unusual road conditions aggravate this problem. Frequent on-road breakdowns, poor punctuality, and poor bus conditions are reasons enough for travelers to ditch the state transport in favor of private bus operators, thus, no wonder the state transports are currently in huge losses. In this fast paced world, none is willing to lose time waiting for the bus. Using a simple system of RFID, some sensors, and a GSM module coupled with database based on MS Excel, this paper presents a very simple and a cost – effective solution thus, helping to maintain a healthy, punctual bus fleet while also serving as an effective medium for bus health monitoring and tracking by both, the fleet owners as well as the consumers.

Keywords
State transport, MSRTC, Radio Frequency Identification (RFID), Global System for Mobile Communication (GSM), Database Management System (DBMS), Fleet Management

1. INTRODUCTION
Mobility of goods, people and services is of extreme importance in today's era. This mobility which is being imparted can also be termed as transportation which might be on an individual or private level or at a mass level. Buses are an extremely convenient and efficient means of mass transport. But, in India, the scenario is a bit different. We rarely see systems which are efficient yet operating in losses. [1]Almost all the states of India have their own bus transport system. Maharashtra State Transport Corporation, MSRTC, is the second most efficient state run transport undertaking after Karnataka State Transport Corporation, KSRTC. MSRTC, state run bus service of Maharashtra has a fleet of 18000 buses ranging from normal ordinary buses to Volvos and Scania. The ordinary buses are basically local buses, non – air conditioned with bench type of seats and stop at all authorized bus stops. Luxury buses are air – conditioned with reclining seats, also available with air suspension in cases where they are supplied by Volvo or Scania. The luxury bus services are mostly of non– stop type where the buses ply only along the highway. There are no conductors in these buses and these don't halt at local bus depots or at depots which are situated in the heart of city. The fare of the luxury buses is 20 – 30% higher than the ordinary bus service and are faster resulting in shorter trip times. The MSRTC serves 7 million passengers daily plying on routes to towns and cities within Maharashtra and its neighboring states. The buses are built at MSRTC's in-house workshops at Dapodi, Aurangabad and Nagpur on Ashok Leyland and TATA source chassis. The workshop produces an average of 2000 buses per annum and the fleet of 18000 buses is maintained at 32 divisional workshops. The corporation had 92% – 94% of its fleet active and running on roads during the year 2017 – 2018. Still MSRTC is facing losses to the tune of INR 32.54 crore.[2] MSRTC has detailed paperwork dating right from the date of purchase covering daily running, maintenance records, personnel performing maintenance on the bus on a given day, daily fuel efficiency, daily earnings, drivers allocated in its lifetime since the buses' induction. This entire data is currently stored in a very well maintained and systematic file system. But the losses MSRTC faces is due to its inability to provide customer satisfaction. Customers are plagued by poor punctuality, poor condition of the buses and on-duty breakdowns [3] and hence, they turn to more expensive, but somewhat reliable private operators. MSRTC performs three stage maintenance of its buses.

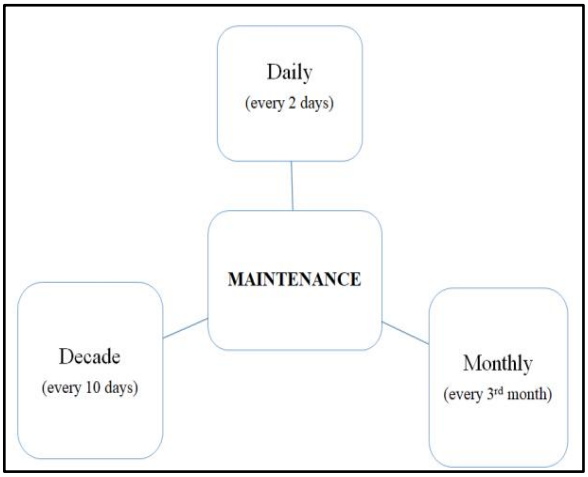

Fig. 1: Tree-diagram of maintenance by MSRTC

The losses are reported due to inability to stick this schedule at all times as a robust check mechanism is not in place.

Fig. 2: 3 people were killed by the loose boot door of the luxury bus [4]

Fig. 3: A report on the sorry state of MSRTC buses by Pune Mirror [5]

2. LITERATURE REVIEW

Sarithaet. al. [6] proposes that when a mobile phone user gets on a bus, the mobile phone samples a sequence of cell tower IDs and reports the information to the backend server. The backend server aggregates the inputs from massive mobile phones and classifies the inputs into different bus routes. The statuses of the bus routes are then updated accordingly.

Bandhanet. al. [7] proposes a system that handles all the data like current location of bus, management of buses, its schedule and security of passengers. Some technologies like GPS, RFID are used for development purpose. The proposed system provides the relevant information regarding all the buses from source and destination with the route details, real time location, availability, and passenger's information and security, and driver details.

Ashouret. al. [8] proposes a system where data is transferred between the buses, the main servers, and the end users are managed via mobile networks andinternet. The hardware and firmware units in the buses collect, control, and process the data while hardware and firmware units at bus stops "Bus station Unit" controls and display data received from server. The bus and station units can be a hardware-based unit or android-based unit. The servers host the system management and processing algorithms, system database, and web applications. A portal is included to give the necessary information to the end-users. At server and based on the collected data from buses, bus arrival times will be computed and transmitted to all relevant stations. The prediction time for the next bus(es) to arrive will be displayed on screens on the bus station. The proposed system is composed of three main parts: servers, in-bus unit and bus stop (station) unit.

Malleswariet. al. [9] propose a system consisting of two modules: in-bus module and base station module. The system proposed consists of an id card allocated to every authorised passenger of the bus. Every time the passenger avails the bus service, he has to scan the id card embedded with a RFID tag by a RFID scanner, a part of the in-bus module. If the passenger is authorised, he receives a message through which he can track the bus.

Basriet. al. [10] proposes a system that integrates the theories for RFID and sensing technologies on a bus platform to monitor and manage bus transportation. The theoretical framework of the bus monitoring and management system is based on data communication among an RFID tag and reader, GPS data transmission using GSM & GPRS networks, and a retrieved data interface with GIS. The RFID reader has to obtain the data from the tag.

3. PROPOSED SYSTEM

The entire workload of MSRTC is shared by two separate departments:

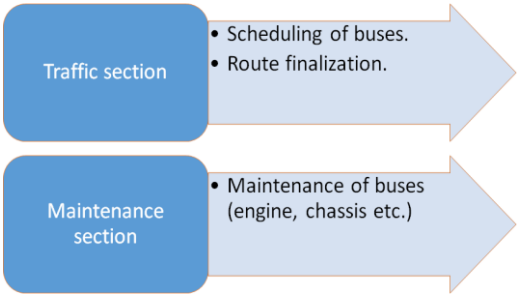

Fig. 4: Work distribution in MSRTC

Our system proposes creation of two separate databases, one each for the traffic and the maintenance section. The respective tuples in each of the databases are as follows:

Table 1: Various columns in the different sections (bus, driver/conductor and timetable) of the database for traffic section

Bus	Driver/Conductor	Timetable
Chassis no.	Name	Route no.
Engine no.	Gender	Scheduled time of departure
RFID	Phone	Bus type
Bus type	DOB	Type of service
Date of purchase	Date of joining	
Seating capacity	Blood group	
Last check up date	License no.	
Total no. of trips completed	Emergency contact	
Total kms. driven	Badge no.	
Fuel available	Total no. of trips	
Brake lining		
Tyre pressures		

Table 2: Various columns in the different types of maintenance section of the database

Daily	Weekly	Monthly	Yearly (Divisional Workshop)	After 3 Years (Divisional Workshop)
Engine (Oil, Water)	Engine (Oil, Water)	Engine (Oil, Water)	Engine (Oil, Water)	Engine (Oil, Water)
Chassis (Gearbox, Clutch-plate, Pressure-plate, Joints)	Chassis (Gearbox, Clutch-plate, Pressure-plate, Joints)	Chassis (Gearbox, Clutch-plate, Pressure-plate, Joints)	Chassis (Gearbox, Clutch-plate, Pressure-plate, Joints)	Chassis (Gearbox, Clutch-plate, Pressure-plate, Joints)
Tie Rod	Tie Rod	Tie Rod	Tie Rod	Tie Rod
Rear Axle Housing	Rear Axle Housing	Rear Axle Housing	Rear Axle Housing	Rear Axle Housing
Tyre Pressure	Tyre Pressure	Tyre Pressure	Tyre Pressure	Tyre Pressure
	Point Greasing	Point Greasing	Point Greasing	Point Greasing
	Joint and Wheel Alignment	Joint and Wheel Alignment	Joint and Wheel Alignment	Joint and Wheel Alignment
		Hub Overall (All 4 Hubs)	Hub Overall (All 4 Hubs)	Hub Overall (All 4 Hubs)
		Brake Lining (Check & Change)	Brake Lining (Check & Change)	Brake Lining (Check & Change)
		Brake Drum (Check & Change)	Brake Drum (Check & Change)	Brake Drum (Check & Change)
		Clutch Plate	Clutch Plate	Clutch Plate
		Pressure Plate	Pressure Plate	Pressure Plate
		Coolant (Change)	Coolant (Change)	Coolant (Change)
			Paint Job	Paint Job
			RTO Check	Re-Conditioning

The major reason why MSRTC services don't have high amount of customers is due to its unreliability. The buses are prone to in-service breakdowns and extremely poor punctuality. In addition to that, travelers are also discouraged due to the absence of an effective tracking mechanism of their ride. Our system provides an efficient and a cost effective solution to all these problems.

3.1 Modifications required in the existing system

The current system employed by MSRTC consists of an exhaustive file system where every event is recorded or updated manually. There is almost no automation. Our system will require fitting of all depot entry and exit gates maintenance depot entry – exit gates and authorized rest stops to be fitted with a RFID scanner. Each bus will be allocated an unique RFID code which will be stuck on the windshield. Also, all buses currently are fitted with KIVI wifi box for on-demand entertainment for customers. An additional GSM module will be required to be fit inside these boxes.

3.2 Working of the DBMS

3.2.1 Traffic section

3.2.1.1 Bus selection

The front end of the DBMS will be a user friendly interface where the traffic controller chooses the route number along with the scheduled time of departure. Currently, MSRTC has already fixed the type of service that is, day ordinary or semi – luxury or luxury. It will operate on a specified route at a specified time. Incorporating the same schedule in our system, as a controller enters the pre-requisites, based on the schedule specified, a list of buses of the particular assigned type, available at the depot for service will be enlisted. The RFIDs which are already in an active trip will too be filtered out of thelist. Now, to prevent in – service failures, a check mechanism is in place. This check mechanism takes data from the following tuples of the bus section of a database:

- From traffic database:
  - Fuel available
  - Brake lining
  - Tyre pressures
  - Last check-up date
- From maintenance database:
  - Operation clearance

Each of these check mechanisms give a "true" value only if the attributes are within a safe range. The safe range is:

- Fuel available >= 50 L.
- Brake lining >= 3 mm.
- Tyre pressures between 120 to 125 psi in all 6 tyres.
- Last checkup date <= 2 days from current date.
- Operation clearance = Yes.

Based on these checks, buses which fail even one of the four checks are removed from the list. Thus, what the traffic controller sees is a list of "fit" buses ready for the trip.

3.1.1.2 Driver/conductor selection

Now, as a bus is selected, the control moves to the driver selection phase. Every time a bus returns to its home depot after completing a trip, the RFID of the bus is scanned by the RFID scanner at the entry gate of the depot. According to MSRTC rules, after completion of a trip on normal days, the drivers and the conductors are allocated a rest period of 7 hours before they report back for a new trip. So as the RFID is scanned at the entry gate of depot the time of the end of trip is recorded and a timer of 7 hours starts for the driver – conductor pair. Unless the rest period quota of 7 hours is fulfilled, names of either of the conductor or the driver will not appear to the controller while starting a new trip. As soon as the break is over, the names reappear on the list. This ensures that all drivers and conductors are properly rotated and rested without over - stressing anyone.

3.1.1.3 Route activation

Activating the route basically means activation of the RFID. The RFID now appears in the "active trips", and hence, the bus is now available for tracking. As the bus leaves the depots from its source to destination, the entry and exit times are recorded as trip data. Passengers earlier used to complain of the buses not halting at MSRTC authorized rest stops. This problem can now be checked as the rest stops too have RFID scanners. Drivers skipping the authorized stops can now be easily identified and penalized which was not possible earlier.

3.2.2 Maintenance section

As mentioned above, MSRTC performs three types of maintenance - daily, decade and monthly. The parts of the bus which are worked upon in each of these maintenance schedules have been mentioned in table 2. In daily and decade maintenance regimes, the oil and water levels are checked and top upped if required. The chassis is checked for bends, cracks, a 37 point greasing is carried out in the decade maintenance and the bus is cleaned from inside. The daily and decade maintenance majorly involve inspection and refilling

parts of maintenance. In monthly maintenance, the bus is taken out of service for a duration of 8 hours. In this duration, all the major wear and tear prone parts are disassembled and closely inspected for damages, ex – wheel hubs, brake drums etc. Electrical connections are checked and repaired, all oils and coolant are completely drained and refilled. Every three years, the bus needs to be taken to its home regional transport office (RTO) where it has been registered. A fitness test is performed by RTO officers and if successful, a fitness certificate is issued to the bus. As per government norms, any type of transport vehicle requires a fitness certificate to run on the road. For this the bus is repainted and thoroughly serviced. The current MSRTC system, has a maintenance record of the bus right from the day it was inducted into service. Detailed records of who performed maintenance activities on what parts of the bus and what issues were observed and sorted are kept till the entire lifecycle of the bus. But these records are currently in the form of written documents. Our solution proposes to transfer this entire document system online which not only results in paper saving, but also helps to systematically and securely save the data in a much more efficient way. Unless and until the workshop in-charge authorizes the maintenance activities carried out, the bus is not inducted back in service. Similarly, unless the maintenance in-charge provides an operational clearance to the bus, the bus won't appear in the list which appears when the traffic controller is assigning a bus for a trip. This ensures that only fit to run buses are plying on the roads.

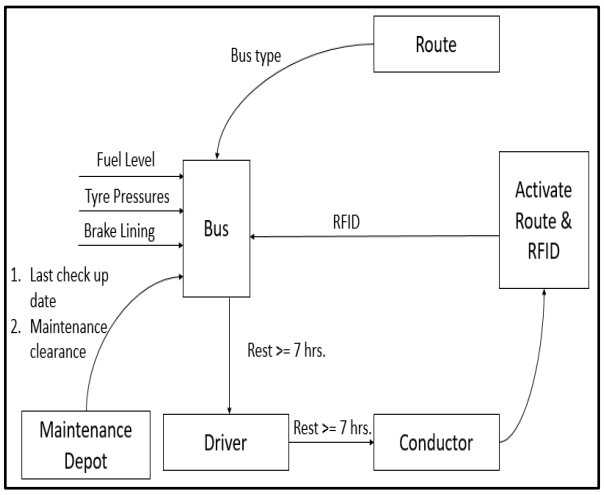

Fig. 5: Summary of data flow within the system

3.2.3 Bus tracking

For tracking their ride, the passengers will enter the schedule time of departure of their bus and the bus route number on a mobile application. This mobile application will transmit the data to the MSRTC server which will access the database to determine the allocated RFID for the trip, that is, it determines the bus which has been allocated for the trip. The database runs a query to in the "active trips" data to retrieve the last depot the bus left or arrived at. The database will then return to the server last depot departure time of the RFID or the bus. Simultaneously, the server then directly contacts the bus through the GSM module situated in the KIVI Wi-Fi box to retrieve the current location of the bus. Both information are then returned to the user who requested for it, thus, enabling the passenger to effectively track the bus.

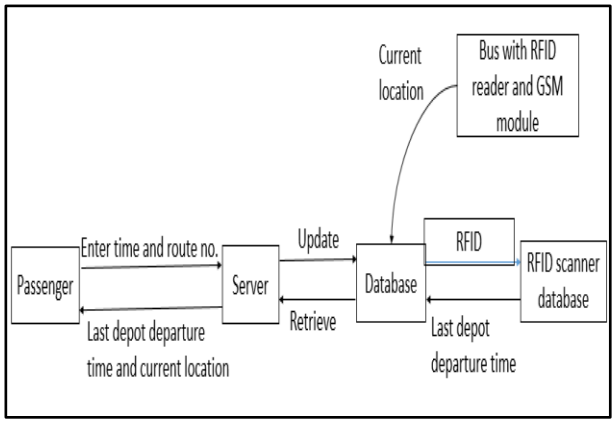

Fig. 6: Proposed bus tracking system

Based on the same system, bus stations can be fit with bus indicators where passengers can be updated about the arrival status of their bus.

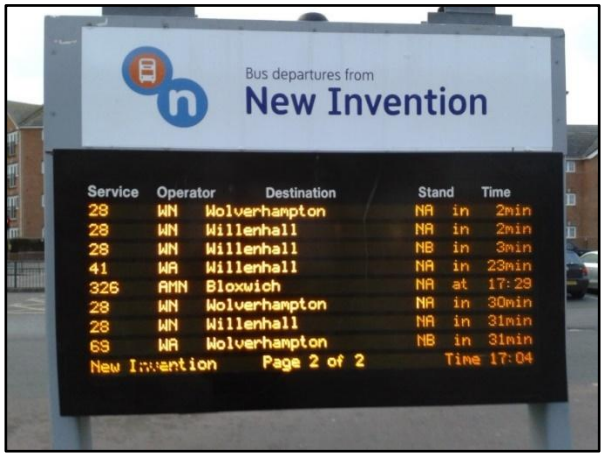

Fig. 7: An example of the live bus monitors which will employ the proposed bus tracking system [12]

4. CONCLUSION

- By the implementation of the proposed system, the customer satisfaction levels can be significantly enhanced since the customers can be assured of more fit buses going for the journeys through the check mechanisms employed and also by the tracking system, the customers can track their buses live.
- The active fleet on road are expected to increase to 97 – 98% in comparison to current situation of 93 – 94%.
- 99% practical implementation of the rules and regulations due to the various check mechanisms in place.
- Revenue generation is expected to increase by 40% due to more customers courtesy of increased reliability of the system.
- Using the live bus tracking system, an audio annunciation system can be employed which will announce the upcoming towns or cities relegating the risk of the passengers missing their stops.
- A central control room in each depot will live monitor each of its buses and the controllers will be notified of any malfunctions by the on-board diagnostic system on the bus. This way, the "time of inconvenience" for the passengers can be reduced drastically.

- Implementation of the system won't be a reason for unemployment as the same workforce would be required for bus monitoring and allocation purposes.

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