High Level Design Document for Intelligent Transport Management System (ITMS) for BEST Undertaking

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Date : 26-Apr-18

Revision History

Version No.	Date	Prepared by / Modified by	Significant Changes
0.1	10-Apr-2018	Nikhil Gupta – Solution Analyst	First draft
0.2	18-Apr-2018	Gopal Yadav – AVLS Team Lead	First Review
0.3	22-Apr-2018	Yogesh Khanduja – Project Manager	Review & Approval
1.0	26-Apr-2018	Neel Paliwal – Program Manager	Final Approval

Glossary / Abbreviation / Definition

Sl. No.	Glossary / Abbreviation / Definition	Description
1	ITMS	Intelligent Transport Management System
2	BEST	Brihanmumbai Electric Supply and Transport Undertaking
3	ETA	Estimated Time of Arrival
4	VTS	Vehicle Tracking System
5	GPS	Global Positioning System
6	AVLS	Automated Vehicle Location System
7	LED	Light Emitting Diode

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1 Background

The 21st century has posed newer and tougher challenges for the transport industry and the industry is looking towards technology to solve these problems.

The transport industry needs solutions to increase operational efficiency in order to save on costs and to keep providing transit services to the masses at affordable prices. There is even more pressing need to consider passenger safety and environment while providing services to the masses.

Due to the complexity of business and archaic processes there is not much that the organization can do on these fronts. Hence, there is a pressing need for transport organizations to undergo systemic change by embracing technology and process improvement.

BEST Undertaking has embarked on its journey towards modernization of its fleet, operations and business processes. As a part of this journey, the organization has decided to implement ITMS. As a part of ITMS implementation team, DIMTS has been chosen to provide solutions such as Vehicle Tracking System (VTS), Passenger Information System (PIS), Mobile Apps and MIS Analytics and decision support system to work seamlessly with other constituent systems of ITMS as well as an interface for relevant needs of BEST's other IT systems.

This document describes the high level design for the implementation of Intelligent Transportation Management System (ITMS) for Brihanmumbai Electric Supply and Transport Undertaking (BEST).

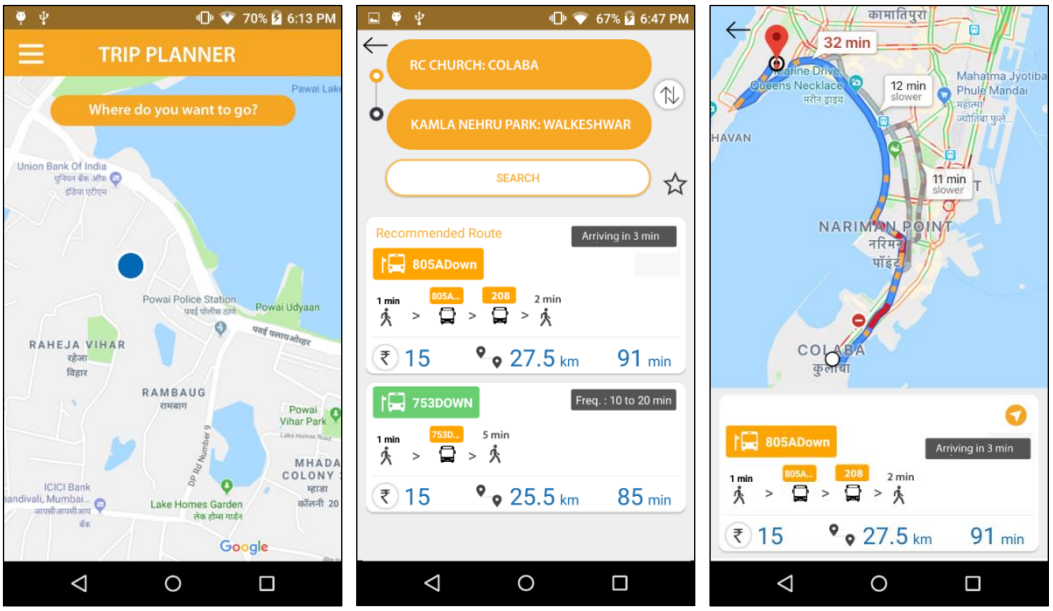
2 Design Approach

2.1 Assumptions and Constraints

1. All servers will be hosted on virtual machines on the cloud
2. DIMTS VTS system will be integrated with Trapeze Scheduling and Dispatch system
3. Master data of Bus stops, Crew, Chowkies, Vehicles, Depots, Time Table, Terminals and Trips will be created in Trapeze system.
4. The Master data will be maintained by Trapeze' system and provided to DIMTS' system as per requirements
5. Schedules and plans will be revised every 4th month and the changes will be to the tune of 50%
6. For first time creation, Master data will be provided by BEST

2.2 Design Principles

1. The modules and functionalities have been named as per RFP
2. Use of transport terms is as per Central Institute of Road Transport (CIRT) standards
3. User Interfaces - Following types of user interfaces have been designed:
    a. Graphical User Interface (GUI) – The overall experience of the system has been designed with color scheme and theme adopted as per BEST website (www.bestundertaking.com/in/) – For example, on the landing page of VTS, user can interact will Bell icons to check alerts on Route Deviation, Bunching, Power Disconnect etc. The Map Viewer functionality provides user the functionality to interact with city map by selecting on-screen buttons such as Zoom In/Out, Measure Distance, etc.
    b. Menu Driven Interface - In order to aid Passengers in travelling inside the city boundaries and beyond, a menu driven interface is provided on the Mobile App for passengers. In this app, the passenger can choose whether he/she wants to travel on a route or wants to plan the trip by selecting source and destination. The passenger can simply click on the buttons provided as per context in a wizard-type interface with minimal inputs, if any.



c. Form based Interface – At many screens, user will be required to feed data into the system through forms. For example – Adding a new Stop, adding a new Depot, etc.

4. For Estimated Time of Arrival and Departure (ETA & ETD), all the system information such as ETA, Stop Information, etc. will be in standard format across all types of vehicles, stops and Chowkies in the LED displays

2.3 Design Rationale

Cloud-based solution: Due to its many benefits such as faster time-to-market, process efficiency and reduced IT spending, organizations worldwide are adopting cloud-based solutions to manage their business. In tune with the modern times, leading cloud services from Tata Communications has been chosen to implement BEST ITMS system. By bringing cloud as the infrastructure backbone of the solution, following benefits are meant to be drawn out from the system:

- Cost Savings – The pay-as-you-go model of cloud ensures that the available resources are utilized to the fullest while minimizing idle resources. It also saves upfront costs required to procure data centre resources at the beginning of implementation.
- Security – In a cloud infrastructure, the organization benefits from the expertise of the cloud host in handling the security of the system infrastructure and data. As the data is not on-site, it prevents the chances of data leakage. It is also easier to fulfill the stringent

security compliance requirements that need to be met by the organization for implementing enterprise-wide solutions.

- Flexibility – In case of dynamic changes in resource requirements like bandwidth, user logins, computing resources, etc., cloud provides peace of mind to the business and rather than struggling to arrange such resources on a short notice, they can concentrate on their daily operations with minimal disruptions.
- Mobility – Since the system is now accessible over Internet, system users can access the system from anywhere and hence, the mobility provided really enhances employee satisfaction and makes business less dependent on location.

AVLS by DIMTS: DIMTS is implementing its product, the Automated Vehicle Location System (AVLS) to cater to the Vehicle Tracking System (VTS) needs of BEST to manage its 4000-strong bus fleet in Mumbai and its suburbs. AVLS is currently being used to manage a fleet of 1700 buses at Delhi (Cluster buses) and a fleet of around 300 buses in Nagpur (NMC)

Technologies used are:

- Alert Engine Server: Windows Server 2012 Enterprise R2
- Communication Server: RHEL 5.5
- Database Server: Window 2012 Enterprise R2
- Database: SQL Server 2016-Enterprise Edition-64 bit
- Platform: DOT NET 4.5, ASP Map, Actual Map

ETA and PIS System by DIMTS: When passengers want to know when the next bus on their desired route is coming, they rely on ETA system of DIMTS. The Estimated Time of Arrival provided by ETA system has very high accuracy of prediction with algorithms optimized for fast learning and optimization. It works in a very seamless manner with the AVLS system to process real-time GIS data. After processing, the system provides ETA for buses on the remaining bus stops along the trip.

The PIS system is aiding crores of passengers across metropolitan cities of India to provide passenger information inside bus and at different locations like bus stops, bus depots, bus stations and bus Chowkies.

Technologies used are:

- Server: Window 2012 Enterprise R2

- Database: MySQL 5+
- Platform: C++

Mobile App and Web Portal for Passenger: At the forefront of touching the lives through transportation, DIMTS has provided convenience at a click to the passengers through its innovative solutions. With the mobile app developed by DIMTS, passengers have the convenience to plan their trips. They have the power of information in their hands to see all the routes of the city, the ETA of buses at every route and every stop.
For those who would like to do this in the convenience of their homes or offices, DIMTS provide similar functionality through a web portal named BusInfo.
To fulfil the needs of commuters in Mumbai and beyond, DIMTS will be providing the same platform to BEST as per specific requirements.

Technologies used are:
Environment: Android Studio, Java SDK, Visual Studio 2010, X-Code, Rest API's
Database: MS-SQL, SQLite
Platform: Java, Android SDK and API's, C#, Swift, .Net

In total, there are 5 applications to be developed as per BEST requirement. These are:

- Passenger Mobile Application
- Workshop Mobile Application
- Starter Mobile Application
- Leadership mobile Application
- Conductor & Inspector Mobile Application

2.4 Non-functional Design Rationale

At a broader level, the system will show following design characteristics:

- API based approach to be interoperable with retained port system like control systems, navigations, access controls, GIS and other external systems
- Ease-of-use as a positive incentive for use of system to the users. This will help in encouraging the users to work within the integrated information environment. While

using different modules of the system, the user will experience similar look and feel and can use knowledge of operating one module in using others

- Use of open standards, open API and open source products will be considered at all stages during the design and development of the system
- N-Tier model framework will be used to define the logically separate tiers of application user interface, logic, data and their associated processing and tiers
- Interoperability will help applications and computers from different sources and platforms to work seamlessly together on and across networks
- Reliability of processing will be ensured in the system for the data received or accessed by the DIMTS' system

2.4.1 Scalability Rationale

DIMTS' system has multiple components catering to the various needs of the various users of the BEST ITMS system. The scalability of the design has the following rationale:

- Vehicle Tracking System will be able to cater to the navigation needs of a fleet of around 4000 buses
- Passenger Information System will feed the data to LED boards at around 6500 bus stops, 57 Bus stations, and 27 bus depots
- Passenger Mobile Application will be designed to cater to the needs of 20-40 lakh passengers per day
- BEST Leadership Mobile Application will cater well to more than 70 leaders of BEST Undertaking
- Starter Mobile Application will provide managed service to 600 Starters spread across 108 Bus Chowkies
- Workshop Mobile Application will be available to workshop users of 27 depot workshops and 2 central workshops
- Conductor & Inspector Mobile Application will be highly available to 12000 conductors and some functionality will also be available to around 11000 drivers

The system is so designed so that it can cater to the changed scale of business in the long run.

2.4.2 Maintainability Rationale

DIMTS' system will be designed for high maintainability from the very beginning. Following points will be taken care of during the design and development of the system:

- System will go through iterative development and regular reviews to keep improving quality
- The code written by developers will contain descriptive comments which will make it easy to read and understand
- Documentation will be done at every step to help stakeholders understand the system at every juncture
- System will go through rigorous testing and all bugs will be documented. Root cause analysis will be done for these bugs to avoid similar issues in future
- Code, test scripts and all documentation will be version controlled to synchronize and keep it up-to-date

2.4.3 Security Rationale

DIMTS' system will give considerations to points including, but not limited to, the points below:

- Information access according to pre-defined roles and responsibilities
- Read, write and modify access will be provided as per the business requirements and sensitivity of the data
- Previous transactions can be tracked in the system
- Sessions of every user, information accessed and transactions done will also be recorded
- System will go through rigorous testing to cover identified risks and security issues

3 System Architecture

3.1 Application Logical Architecture (System Boundary)

The six types of users of BEST ITMS are:

1. Passengers
2. BEST Leadership
3. Starters/Dispatchers
4. Drivers – There are no components to be built specifically for the drivers
5. Conductors
6. Other Users (BEST Users including Workshop employees)

The diagram below shows the interface of the six types of users with BEST ITMS system.

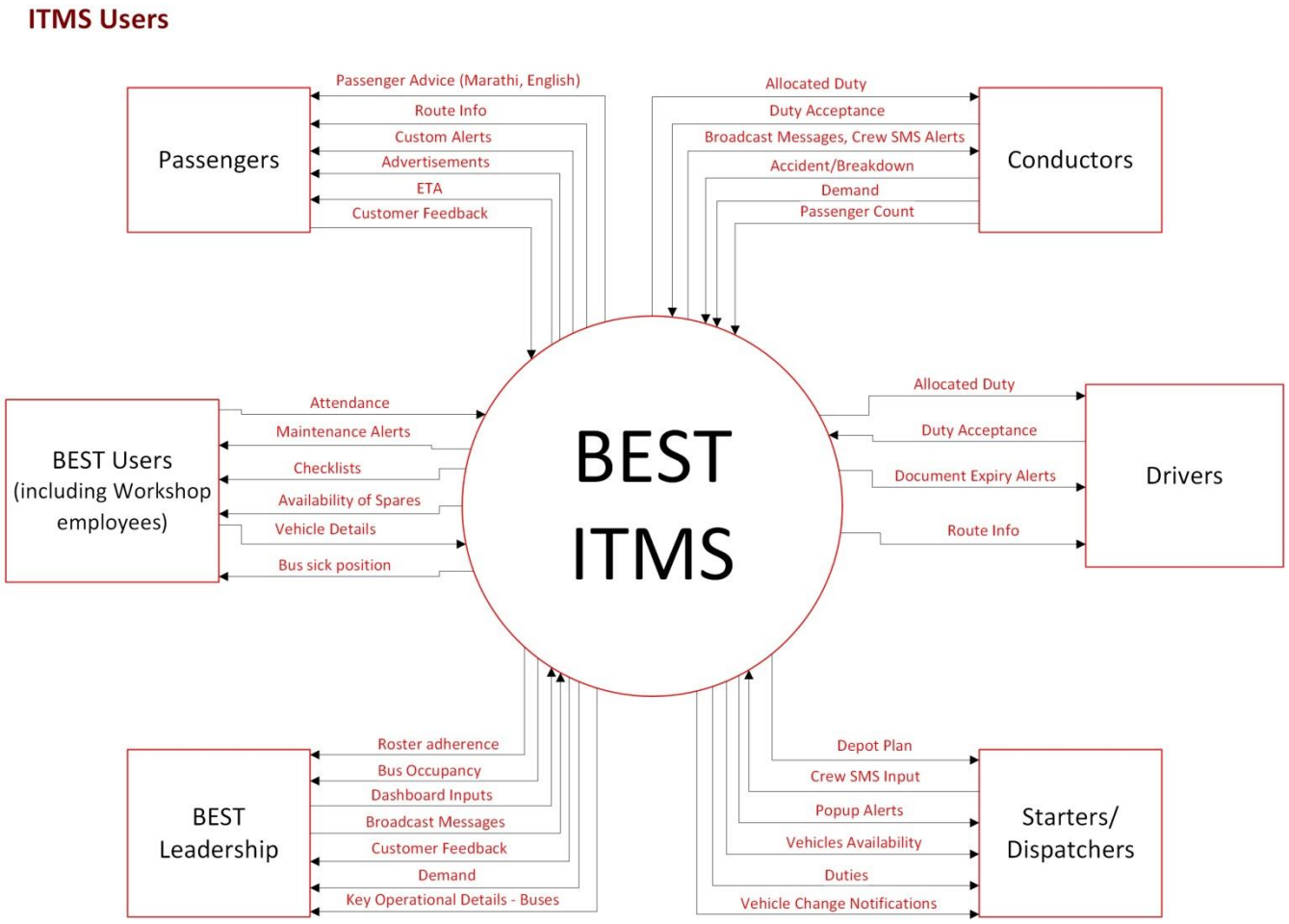


Figure 1: ITMS and its Users

3.2 Deployment Architecture

The BEST ITMS system comprises following different types of terminals:

1. On-bus GPS devices
2. PIS LED Boards
3. Desktops and Laptops
4. Mobile Phones and Tabs

The solution consists of a number of virtual machines over the cloud. These are divided among four categories. They are:

1. VTS machines – The virtual machines related to VTS system are as below:
    - VTS Communication Server – This machine will receive GPS signals from the GPS devices in real-time and provide these details to the VTS Service Engine and VTS DB Server. COM (communication) Server will use information from VTS DB Server to resolve the GPS details received from GPS Devices
    - VTS Services Engine – It hosts a number of services provided by VTS such as Real Time Alerts, Bunching Information, Location and Late Duty. It also has processing engines such as a Notification engine and a Tracking Engine. Notification engine ensures that events (SOS) received from VTU are notified to relevant display systems (AVL display). Tracking Engine interfaces with GPS based VTU position and speed inputs and display or store the inputs.
    - VTS Web App Server – This server provides input to the ETA Database server and communicates with GIS/Maps Config (configuration) Server. It also has Map files stored in it. These files are used to display vehicle location on map.
    - ETA Server – It takes input from the VTS Services Engine and calculated ETA for each bus in real time using the constantly changing positions of the buses and provides this information for consumption of various users. ETA logic computes expected time of arrival to be displayed at PIS installed at relevant bus stops and terminals.
    - PIS Server – This server will feed the data to PIS LED Boards installed at various locations like in vehicle, at bus stops, chowkies, etc. while taking its input from the ETA Server
    - Mobile/Web App Server – It will provide the inputs to various user terminals such as Mobile phones, desktops, tabs and laptops for all mobile applications and web portals of all types of BEST ITMS users
    - BEST Post Processer – This server will do the post processing of real-time transactional data recorded earlier. This includes the History Engine and the Duty Engine
    - VTS Integration Server – It is means to provide an interface for integration with remaining components of ITMS as well as with other IT systems at BEST and beyond
    - Database Servers – The solution will have following database servers:
        - VTS Database Server
        - ETA Database Server

The deployment of terminals and servers is as shown in the model below:

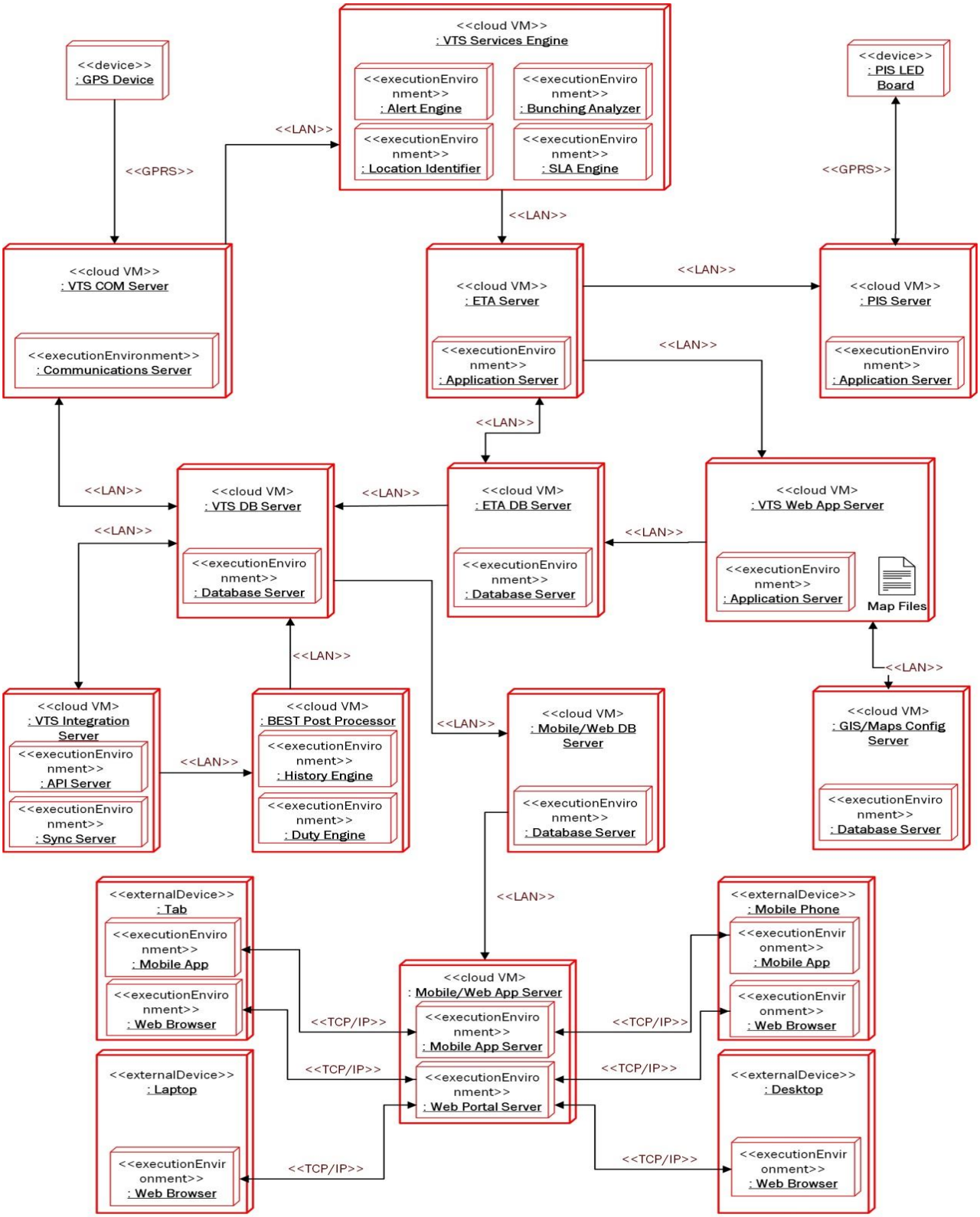


Figure 2: Deployment of DIMTS solution

3.3 User Layer

This layer consists of Users who will use the system. The following table below are the types of Users

Passengers	There are over 40 lakh passengers per day, who may travel on buses. These users will access the Passenger Mobile Application and use the LED displays which will be placed at Bus Stops. Through Mobile and PIS LED displays, users will be able to know the Bus Arrival and Scheduling timetable.
Conductors	There are 12000 conductors in BEST. Conductors will get information regarding their duties by using the Kiosk machines.
Bus Drivers	There are 11000 drivers who drive the Buses in the city. Drivers will also get information regarding their duties by using the Kiosk machines.
Starter/Dispatcher	There are 600 dispatchers in BEST. They will use the system to assign the crew/duties to buses and dispatching the buses from the starting point of routes.
Leadership	These are BEST officials who will use the system to track and monitor the operation performance. They will have access to the overall dashboard which will assist them with decision making.

3.4 Common Framework

3.4.1 Browser Support

The following browser are supported by the web application

Windows Internet Explorer 9.0 or later

Google Chrome Version 28.0 or later

3.4.2 Screen Resolution

The best view of the application resolution is 1280 x 1024.

3.4.3 Cookie Requirement

Cookies are not mandatory.

3.4.4 JavaScript Enabled

Support of Java Script is required for smooth functioning of the application.

3.4.5 Minimized use of Pop-Ups

Application will use minimum use of pop-ups windows, it will use for drill-down the reports and navigation.

3.5 Solution Architecture

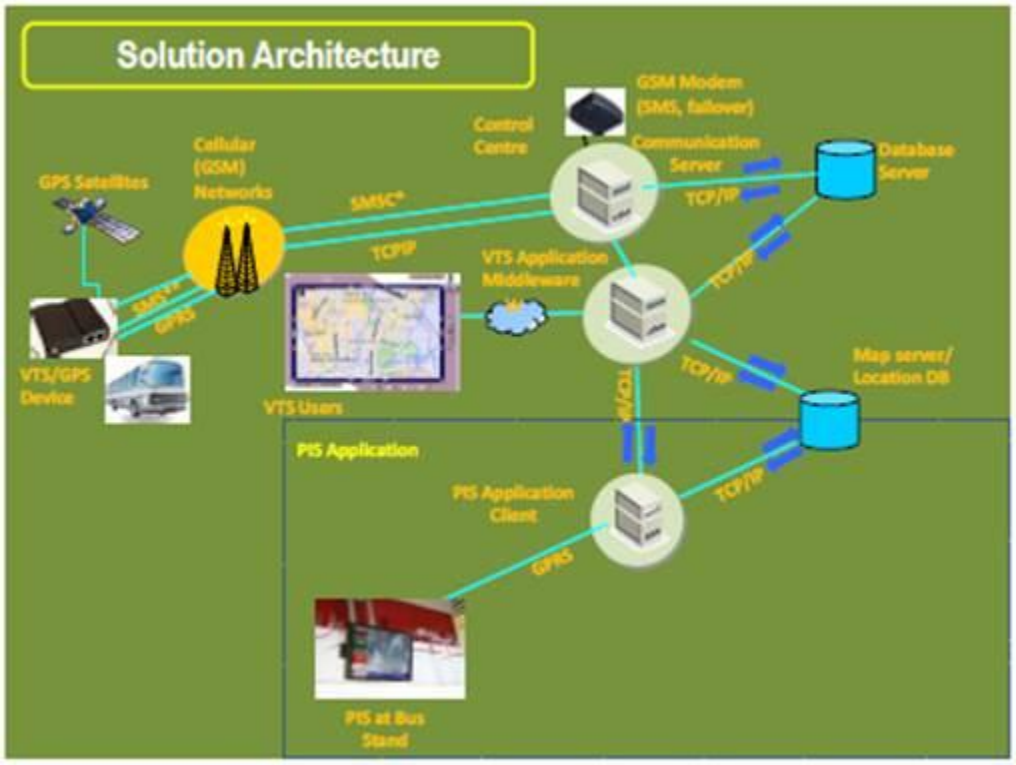
The logical architecture of the proposed application is as depicted below. It's a layered architecture with application front-end layer on the top.

Application Front-end

This layer provides the communication channel for the user. User will have two ways of communicating with the system.

User Management

User Management will be responsible for provisioning and management of users and assigning roles to the user.



Route Management

The application should enable viewing/updating of existing routes through front end.

MAP Engine

The GIS-API application is intended to serve following GIS requests by providing MAP / Attribute Information to the requesting application.

- Zooming
- Panning
- Show Map (Vector Layers at pre-defined levels of visibility)
- Identify Spatial Feature
- Return Route Length (from Start to End point of a polyline route layer)

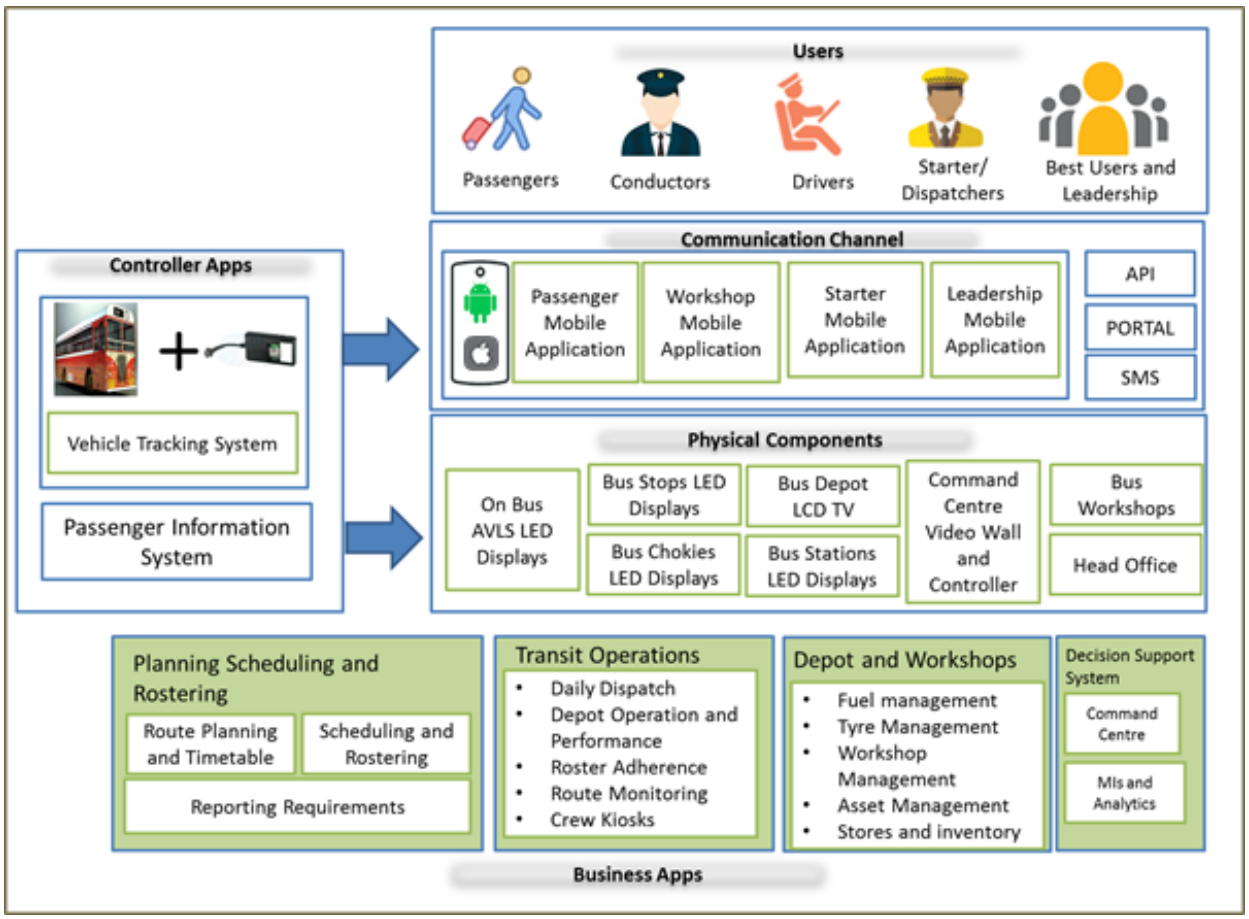


Figure 3: Logical Architecture

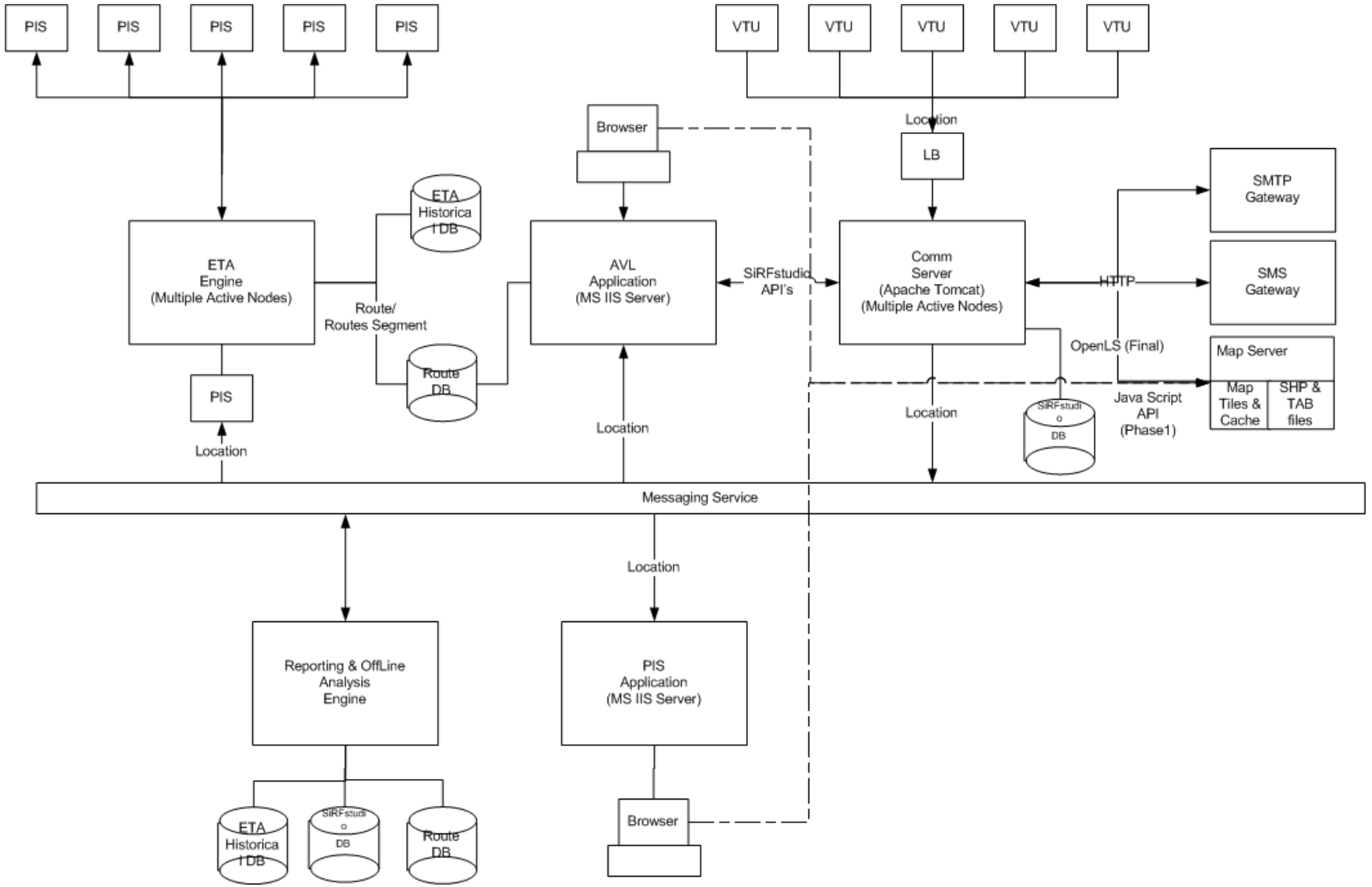


Figure 4: High Level Technical Architecture Diagram

3.6 Communication Tier Architecture

Communication tier will comprise highly available cluster of multiple servers which will interface with GPRS telecom network to receive vehicle tracking data, request from PIS boards as well as Mobile app. Since every vehicle would transmit vehicle tracking data at a defined frequency, communication layer would have the ability to support very high number of concurrent sessions. Apart from high availability, the communication layer would also be highly scalable as vehicles would continue to get added with the project roll out. This is the first layer interfacing with the field devices and would need to handle large number of transactions.

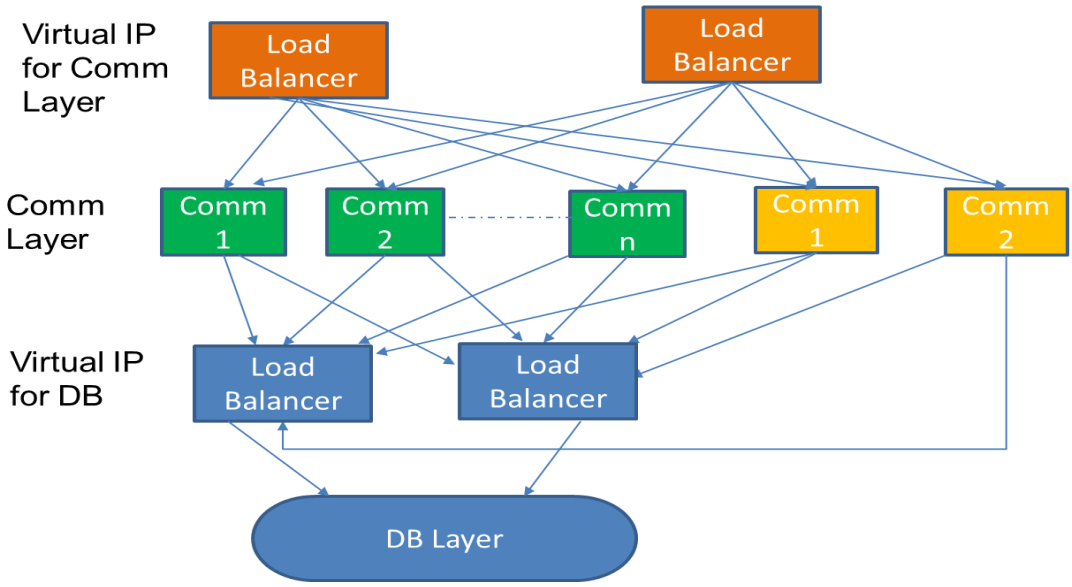


Figure 5: Communication Tier Architecture

3.7 Database Tier Architecture

The next important module of the backend system would be the database layer. As very large amount of data will be coming to the backend system, the database layer will be very important and critical part of the overall system. There will be following major types of data received at backend from on-board devices:

- Vehicles' location data including the current geo-spatial co-ordinates, speed, altitude, heading, etc. of the vehicles
- Alert data received from vehicles such as emergency alerts, ignition ON/OFF status, tampering of device, health status of devices, etc.

The backend system will have a robust database system with an ever growing storage area.

Main requirement from the database layer would be as follows:

(a) The database solution will address the storage requirement for structured data (tracking data).

(b) The database solution will have the ability to run in high-availability mode. The high availability mode can be achieved either as Active-Active or Active-Passive clustering configuration.

(c) It will be possible to add additional database nodes as well as storage devices, in run-time, depending upon the growth in the system.

(d) Database solution will have a proven data replication and syncing process so that database layer is able to support the desired RPO and RTO levels for disaster recovery.

(e) It will provide controlled data access that enables different types of users to have secure, direct access to mission-critical data and support the data encryption, so that sensitive data is not visible to any unauthorized users, gaining access to the system.

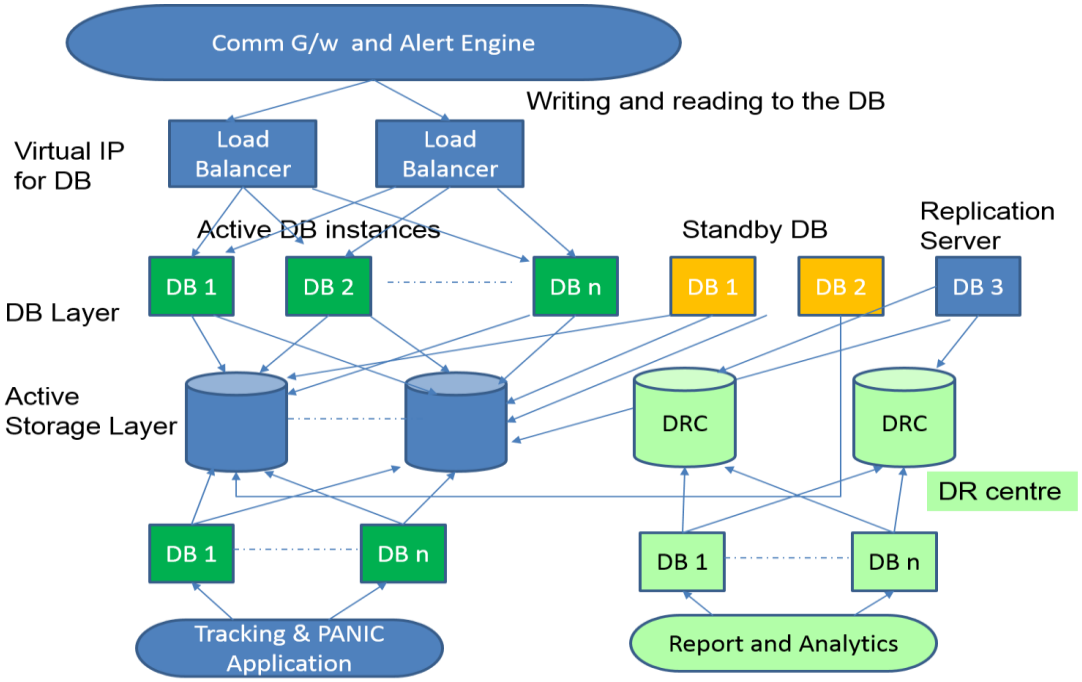


Figure 6: Database Architecture

4 High-Level Design

4.1 Process model

The features of Passenger Mobile App of BEST ITMS are as shown below:

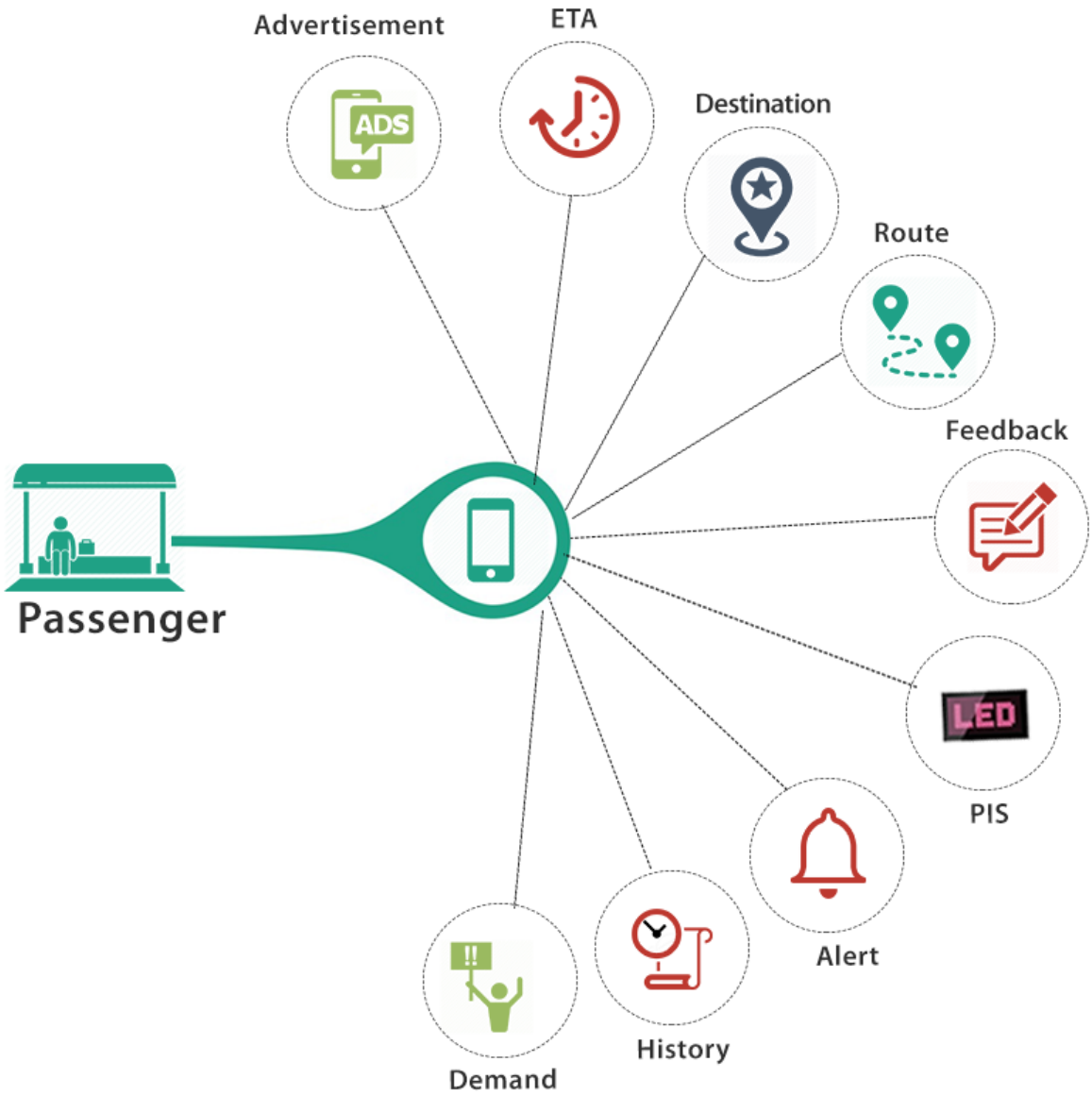


Figure 7: BEST ITMS – Passenger Mobile App

4.2 Data Model

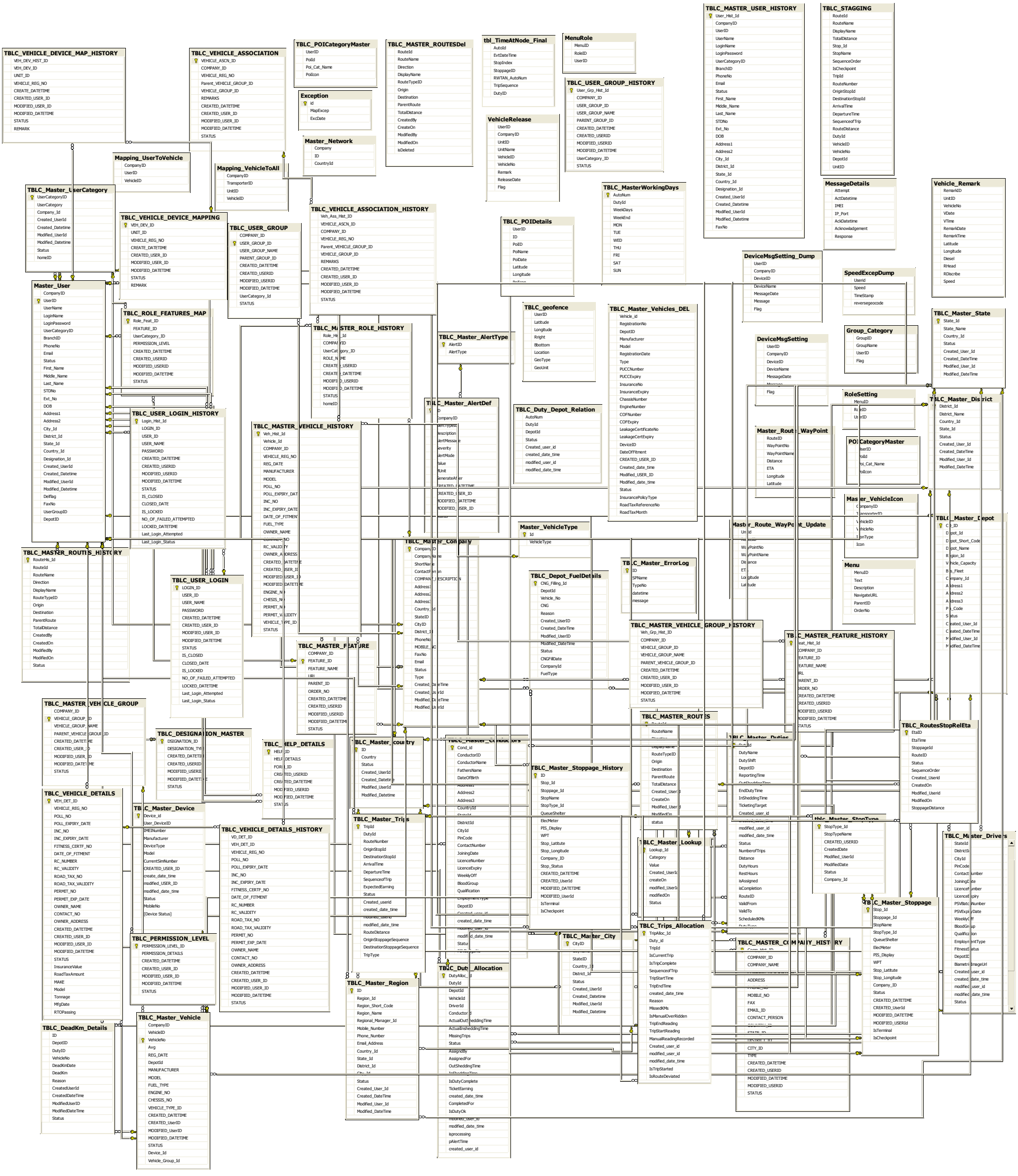


Figure 8: ER Diagram – DIMTS' VTS System

5 Modular Specifications / Subsystem specification

As part of BEST ITMS, the DIMTS' VTS system provides a number of services to their respective users. These services are provided with by the system as a combination of its various components working in tune with each other. These components are:

5.1 Vehicle Tracking System

This is the main subsystem of the solution. It consists of a vehicle mounted GPS (VTS) device with GPS tracking, data logging, two-way transmission and receipt facility and GPRS connectivity. The subsystem uses this device to provide the position of the bus in which it is installed.

The Control Centres setup at the Head Office (Central Control Centre) and the Regional Control Centres at Bus Stations and those at Bus Depots will facilitate monitoring of bus location and activity on digital maps. This includes tracking of bus location, speed, path followed and distance from nearest bus-stop.

Alerts can also be generated and using the location data for over-speeding, accidents and used by management to ensure passenger safety and handling emergencies, etc.

Data gathered from Vehicle Tracking System will be fed to other components of BEST ITMS such as Passenger Information System (PIS), Scheduling System, etc.

The subsystem will include interfaces related to master creation of Depot, Route, Duty and Trip, Bus Stop, Driver, Conductor and Vehicle.

5.2 Passenger Information System

Passenger Information System is another integral part of DIMTS' VTS system. As a subsystem of BEST ITMS, it is meant to provide a bus' performance against time to passengers and management. All mediums and devices of the PIS system installed at Bus stops, stations and depots will be used to display advertisements, arrival and departure times and to make related announcements.

The subsystem will calculate the ETA and ETD to facilitate the monitoring of this information at the control centres. Receiving the data continuously from the VTS, PIS will use current

location, speed and distance data of a bus to estimate, display and announce the arrival time of the at the subsequent bus stops/stations etc.

It will also be used to feed the data for advertisement space at the portal and mobile APP. On the same portal and mobile APP, the Passenger Information System will provide data to facilitate tracking of bus status by passengers.

5.3 Passenger Mobile Application and Web Portal

Passenger Mobile Application and Web Portal will be the two interfaces provided by BEST to its passengers. The subsystem will be integrated with the PIS system at the back end. At their front end, the passengers will access information such as ETA, ETD, Routes, Schedules, availability of seats, etc.

Using the system, passengers will be able to find available routes between source and destination bus stations at a particular time of journey with route's bus station names, schedule, next bus ETA. Passengers will be able to see scheduled and estimated time of arrival of next 3 buses on the selected route and can create related custom alerts such as 15-minute advance arrival alert, stop arrival alert, traffic diversion alert, etc.

Passengers will also be able to store personalized data such as preferred route, custom reminders and alerts, trip history and the data generated will be stored at the cloud based server.

The subsystem will also provide outreach to passengers by facilitating them to provide feedback, log complaints and to report lost items, demand, maintenance requests as well as to report emergencies.
BEST can also use the subsystem to publish dynamic advertisement content, disruption alerts, deviations, etc.

There will be an integration of this application with e-ticketing applications through provided APIs through a single interface to access e-ticketing apps and display number of passengers in upcoming bus in real time.

5.4 BEST Leadership Mobile Application and Web Portal

The two interfaces provided for BEST leadership will comprise an insightful dashboard showing key operational data like number of on-road buses, average occupancy, late buses, breakdowns, etc. Interface will be there to view customer feedback and customer sentiments (overall and analysis).

Using the subsystem the BEST leadership will also be able track buses in real time on a map, interact with any online staff like conductor, driver or inspector and broadcast messages for employees and passengers.

Real time heat maps in Red, Yellow, Green and other colors will be displayed to show reported demand and to show occupancy across all routes at a given time.

Integration will be there with workshop management module to report faults/defects in vehicle.

5.5 Dispatchers (Starters) Mobile Application and Web Portal

The two interfaces provided for dispatchers or starters to access the depot plan, view and sort vehicles/drivers/conductors, future and current duties and real time vehicle availability.

Using the subsystem, the dispatchers can also send SMS alerts and messages to the crew if there is any change of work. Popup alerts can also be pushed to crew in case they are late for shift. Expiry and renewal alerts related to a document can also be sent to various stakeholders.

The subsystem will also notify about vehicle changes due to accidents, breakdowns, etc.

5.6 Conductors/Inspectors Mobile Application and Web Portal

Using the mobile application and web portal services, the conductors/inspectors can achieve business functions such as report demand, check ETA, and communicate with control centre. They can also report accidents/breakdowns, maintenance requests, lost & found objects, count of passengers seated in a bus.

The subsystem can also be used to take photos of objects and upload to central server.

Other features include publishing of real time messages to senior management and control centre employees for traffic conditions, route deviations, overspeeding, escalations, etc.

5.7 Transit Web Portal

At BEST's transit web portal passengers will be able to download route information, route schedule and real-time ETA. It will have interfaces to log complaints, view information about city's transportation system, real-time updates, organizational structure, citizen blogs, etc.

The portal will provide facilities for pass application, card top-up using credit, debit cards, etc. Other sections will provide information related to travel advisories, camera still feeds and real time PIS locations on GIS map.
Users will also be able to access this web portal through WAP enabled mobile phones.

5.8 Component Interfaces with Trapeze's System

Components of DIMTS' VTS system and its Interfaces with Trapeze's Scheduling and Planning are as shown below:

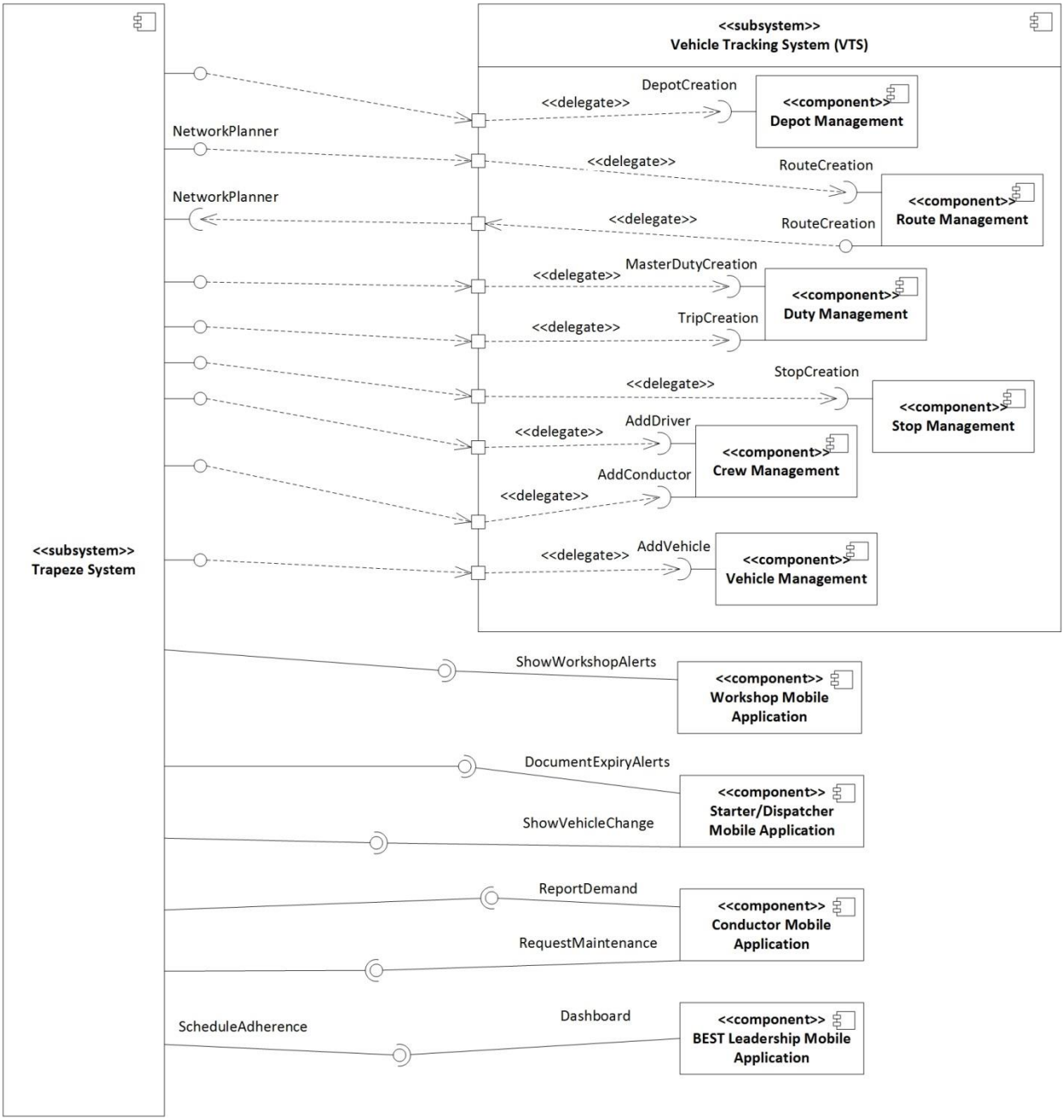


Figure 9: Components and Interfaces of DIMTS' VTS system

6 Integration Approach

To start the conference room pilot for BEST ITMS project, the integration between DIMTS' VTS system and Trapeze's Scheduling and Planning is required for information exchange.

For smooth operation of VTS and PIS of DIMTS' system the information from Planning, scheduling and rostering of Trapeze's system is required and for Trapeze's system the vehicle tracking data from DIMTS' system will be required.

6.1 Integration Data Points

Exchange of the following data between two systems is required for roll out of the system:

- Depot Master
- Vehicle Master
- Driver Master
- Conductor Master
- Bus Stop Master
- Duty (Shift) Master and Trip Master (including Schedules)
- Route Data (including Route Geometry)
- Depot Route Mapping
- Route Bus Stop Mapping
- Dispatch/Duty Allocation
- Bus Stop Alert

Note: - Sharing of data format in which Trapeze's system stores the Route Geometry is still pending at Trapeze end.

6.1.1 Details of Data Points Integration

S.No.	Data Points	Primary System	Integrated System	Trigger
1	Depot master	Both	None	NA
2	Vehicle Master	Trapeze	DIMTS	Add/Update
3	Driver Master	Trapeze	DIMTS	Add/Update
4	Conductor Master	Trapeze	DIMTS	Add/Update
5	Bus Stop Master	Trapeze	DIMTS	Add/Update
6	Duty (Shift) Master and Trip Master	Trapeze	DIMTS	Daily/Hourly
7	Route Data	Trapeze	DIMTS	Add/Update

8	Depot Route Mapping	Trapeze	DIMTS	Add/Update
9	Route Bus Stop Mapping	Trapeze	DIMTS	Add/Update
10	Dispatch/Duty Allocation	Trapeze	DIMTS	Add/Update, Ad-hoc
11	Bus Stop Alert	DIMTS	Trapeze	Real-Time

The details of integrated entities and their primary keys are shown below:

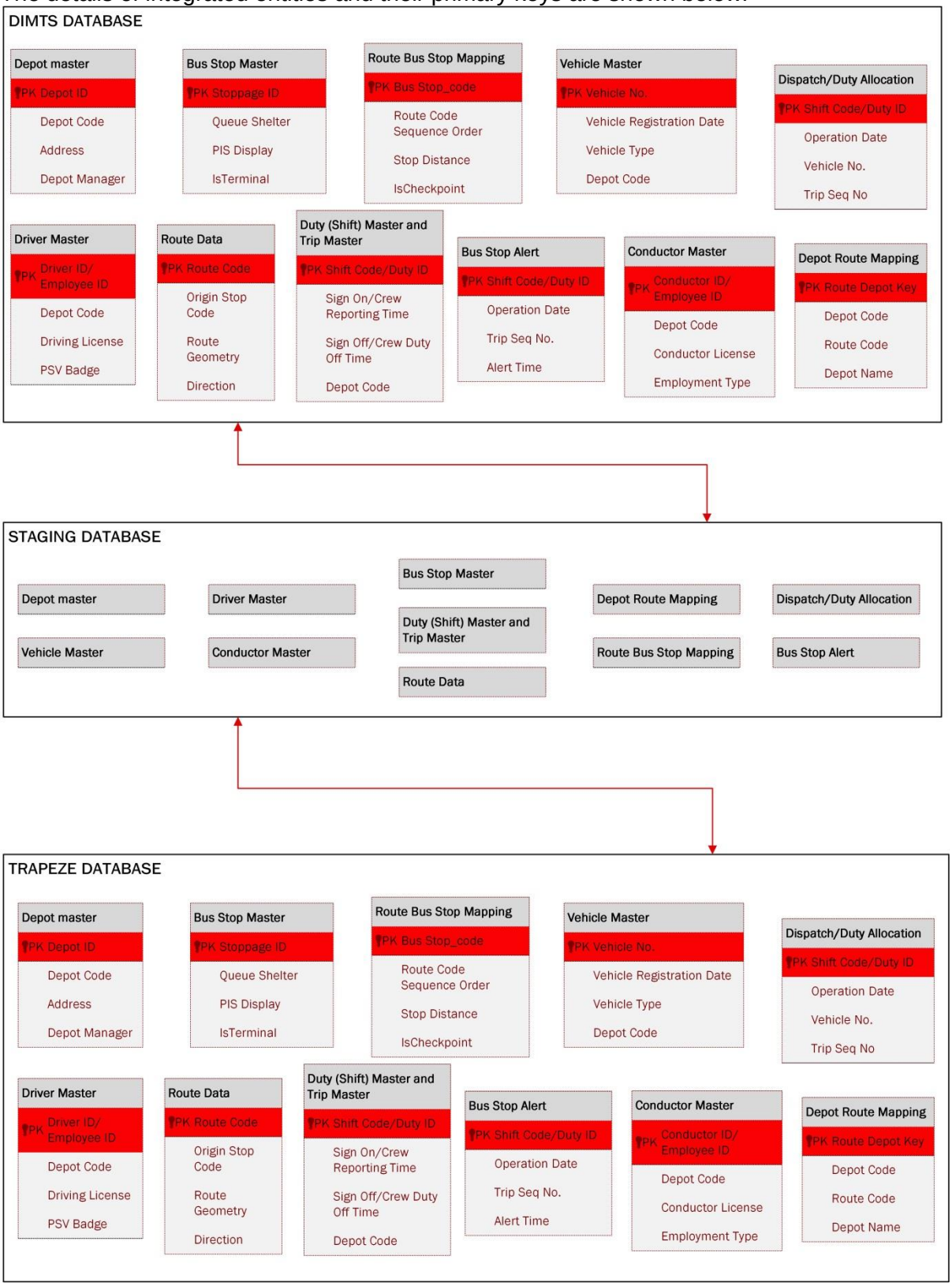


Figure 10: Entities and Attributes: DIMTS and Trapeze Integration

1. Data Point - Depot master
    a. Field
        i. Depot Short Code
        ii. Depot Name
        iii. Fleet Type
        iv. Address 1
        v. Address 2
        vi. Address 3
        vii. Pincode
        viii. Depot Manager Name
        ix. Depot Manager Email
    b. Primary Key
        i. Depot ID
    c. Common key for both system
        i. Depot Code

The depot detail will be provided by BEST and geom data of depot will be collected during route survey. Depot Master will be created in both the system and no integration will be required for Depot Manager. The same depot code shall be used by both the systems to enable other data points integration

2. Data Point – Vehicle Master
    a. Fields to be provided by Trapeze's system
        i. Vehicle No (primary key and common key between two systems)
        ii. Vehicle Registration Date (yyyy-mm-dd format)
        iii. Depot Code
        iv. Manufacturer
        v. Model
        vi. Fuel Type
        vii. Engine No
        viii. Chassis No
        ix. Vehicle Type
        x. Vehicle Variant
    b. Following field will be collected by the DIMTS' system at the time of device registration in DIMTS system-
        i. IMEI Number

ii. GPS Device ID

3. Data Point – Driver Master
    a. Fields to be provided by Trapeze's system
        i. Driver ID/Employee ID (primary key and common key between two systems)
        ii. Driver Name
        iii. Father Name
        iv. Date of Birth (yyyy-mm-dd format)
        v. Address 1
        vi. Address 2
        vii. Address 3
        viii. District
        ix. City
        x. Pincode
        xi. Mobile Number
        xii. Joining Date
        xiii. Driving License Number
        xiv. License Expiry Date
        xv. PSV Badge Number
        xvi. PSV Badge Expiry Date
        xvii. Blood Group
        xviii. Qualification
        xix. Depot Code/Depot Name
        xx. Employee Type
        xxi. Medical Certificate

4. Data Point – Conductor Master
    a. Fields to be provided by Trapeze's system
        i. Conductor ID/Employee ID (primary key and common key between two system)
        ii. Conductor Name
        iii. Fathers Name
        iv. Date of Birth
        v. Address1
        vi. Address2

vii. Address3
viii. District
ix. City
x. PinCode
xi. Mobile Number
xii. Joining Date
xiii. Conductor Licence Number
xiv. Licence Expiry Date
xv. Blood Group
xvi. Qualification
xvii. Employment Type
xviii. Depot code / Depot Name

5. Data Point – Bus Stop Master
    a. Fields to be provided by Trapeze's System
        i. Stoppage ID (the ID marked on bus shelter)
        ii. Queue Shelter
        iii. PIS Display
        iv. Isterminal
        v. IsChekpoint
    b. Stop ID, auto-generated id by DIMTS' system
    c. Stop latitud and Stop longitude will be collected by DIMTS under route survey
    d. The route survey data will be fed into Trapeze's system and same will be shared by Trapeze's system to DIMTS' system

6. Data Point – Duty Master and Trip Master
    a. Duty Master of DIMTS' system and Shift of Trapeze's system refer to the same data points.
    b. Following information will be shared by the Trapeze's system
        i. Signon/crew reporting time
        ii. Signoff/crew duty off time
        iii. Depart/Outshade time along with Depot code /chowki code , from where shift will be turned out/start
        iv. Depot Code (depot code from which this shift belongs i.e parent depot)

v. Arrive/ Inshed time along with Depot code /chowki code , from where shift will be stabling /chowki
vi. Origin trip start stop code and time along-with trips start flag
vii. Parent depot of shift
viii. Duty Shift Type
ix. Trip End (max value of stop code and stop time of a trip)
x. ShiftID/DutyID
xi. Route Code/Route Number
xii. Number of Trips (distinct count of Yes of start trip flag of a shift)
xiii. Sequence of Trip (Yes flag of trips start sorted by time)

c. On the basis of sum of distance between bus stop of Trapeze's trip of shift, trip schedule KM will be drived.
d. Duty Schedule KM will be drive in DIMTS' system on the basis of individual trip's schedule KM
e. All duties and trips will consider as normal duty and trip

7. Data Point – Route Data
    a. Route ID, internal id of record maintained by DIMTS' system
    b. Trapeze's system will provide the following fields:
        i. Route Name
        ii. Route code (primary key and common key between both the system)
        iii. Route Display Name
        iv. Direction
        v. Origin stop code
        vi. Destination stop code
        vii. Distance
    c. Note: - Route geometry data format is not finalized yet. For the same Trapeze will share the format of route geometry of their system.

8. Data Points – Depot Route Mapping
    a. Trapeze's system will provide the following fields:
        i. Route Depot Key (primary key)
        ii. Depot Code
        iii. Depot Name
        iv. Route Code
        v. Route Name

9. Data Point – Route Bus Stop Mapping
    a. Trapeze's system will provide the following fields:
        i. Bus Stop_code
        ii. Route Codeuence Order
        iii. Stop Distance
        iv. IsCheckpoint

10. Data Point – Dispatch/Duty Allocation
    a. Trapeze's system will provide the following field:
        i. Operation Date
        ii. Shift Code/Duty ID
        iii. Vehicle No
        iv. Driver ID
        v. Conductor ID
        vi. Creation Date Time
    b. For ad-hoc duty allocation the following field will be provided by Trapeze's system:
        i. Operation Date
        ii. Shift Code/Duty ID
        iii. Vehicle Number
        iv. Driver ID
        v. Conductor ID
        vi. Creation Date Time
        vii. Trip Seq No
        viii. Stop ID

11. Data Point – Bus Stop Alert
    a. DIMTS' system will provide the real time bus stop alert data. The following fields will be provided by DIMTS' system:
        i. Operation Date
        ii. Shift Code/Duty ID
        iii. Route Code
        iv. Trip Seq No
        v. Stop Code
        vi. Alert Time

6.1.2 Sample Data

Depot master

Depot_Short_Code	Depot_Name	Bus_Fleet_Type(AC/Non AC)
Td1	Test Depot	213

Address 1	Address2	Address3	Pin_Code	fence_geom	Depot Manager Name

Vehicle master

VehicleID	VehicleNo	REG_DATE	DepotNAme	MANUFACTURER
9439	DL1PD0002	31-Jan-14	Rajghat	Tata

MODEL	FUEL_TYPE	ENGINE_NO	CHESSIS_NO	VEHICLE_TYPE*	IMEINumber	GPS_DEVICE_DATE	VehicleVariant
2014	Diesel	Optional	Optional	8	110011101394	5-Feb-18	AC/Non AC

Driver master

DriverID	DriverName	FathersName	DateOfBirth	Address1	Address 2	Address 3	District
72970	NAVEEN	JAI PAL	8-Aug-78	C32	First Floor	Jankpuri D	West

City	PinCode	ContactNumber	JoiningDate	LicenceNumber	LicenceExpiry
Delhi	110046	9210122838	2-Aug-12	DL-1120070055301	12-Aug-20

PSVBatchNumber	PSVExpiryDate	BloodGroup	Qualification	EmploymentType	Medical Certificate	Depot code
DL0120089089765	12-Aug-20	O+	12th	NA	NA	Seemapuri

Conductor master

ConductorID	ConductorName	Fathers Name	DateOf Birth	Address1	Address2	Address3	District	City	PinCode
6922	GEETAM SINGH	RAJ SINGH	7/20/1975	G31	GT ROAD	NARELA	North West	DELHI	110040

Mobile Number	Joining Date	Licence Number	Licence Expiry	Weekly Off	Blood Group	Qualification	Employment Type	Depot code

9718773799	4-Apr-16	DL-04/CL/2016-2017/0987	3-Mar-20	NA	B+	10th	NA	Rajghat

Bus stop master

Stop_Id	Stoppage_Id	StopName	QueueShelter*	PIS_Display
7501	DC4587	Bamnoli More	1	0

Stop_Latitute	Stop_Longitude	IsTerminal	IsCheckpoint	TotalShelter	IsRoutePlateAvailable
28.53986	77.02976	0	0	0	0

Duty master and Trip master

Shift Sample data (Trapeze)

shift_code	effective_date	expiry_date	line_number	route_code	trip
1	1/8/2017	12/31/2150	10		
1	1/8/2017	12/31/2150	60	2	1
1	1/8/2017	12/31/2150	70	2	1
1	1/8/2017	12/31/2150	100	2	1
1	1/8/2017	12/31/2150	110	2	1
1	1/8/2017	12/31/2150	140	2	2

trip_start_flag	node_code	node_desc	node_time	travel_distance	trip_from_node_code	trip_to_node_code
No	ANAN1	SignOn	4:55:00	0		
Yes	ANAND	ANAND NAGAR DEPOT	5:15:00	0	ANAND	THANE
No	THANE	THANE	5:45:00	9800	ANAND	THANE
Yes	THANE	THANE	5:50:00	0	THANE	RABOD
No	RABOD	RABODI	6:00:00	2800	THANE	RABOD
Yes	RABOD	RABODI	6:05:00	0	RABOD	THANE

Duty Master (DIMTS)

DutyID	DutyName	Duty Shift	Depot	ReportingTime	OutSheddingTime	EndDuty Time	InSheddingTime	NumberofTrips
50049	410/4	Mor/ Eve	Seema puri	5:00:00 AM	5:30:00 AM	2:30:00 PM	3:00:00 PM	5

DutyHours	RestHours	ValidFrom	ValidTo	ScheduledKMs	DutyType
7	1	1-Jan-18	31-Dec-18	119.2	Normal

DutyStartStop	DutyEndStop	SinceOperation	Outshed_Depot	Inshed_Depot
Dilshad	Dilshad	12-May-14	Seemapuri	Seemapuri

Trip Master (DIMTS)

TripId	**DutyId**	**Duty Name**	**RouteNumber**	**Origin Stop**	**Destination Stop**	**Arrival Time**	**Departure Time**	**Sequenc Trip**
97752	16285	410/4	2008	Seemapuri	Okhla	5:30:00 AM	5:35:00 AM	
97753	16285	410/4	277	Okhla	Rajghat	6:30:00 AM	6:35:00 AM	
97754	16285	410/4	273	Rajghat	Okhla	7:00:00 AM	08:0000	
97755	16285	410/4	277	Okhla	Rajghat	8:00:00 AM	9:00:00 AM	
97756	16285	410/4	273	Rajghat	Seemapuri	9:30:00 AM	11:00:00 AM	

Expected Earning	**RouteDistance**	**OriginStoppageSequence**	**DestinationStoppageSequence**	**TripType**	**ScheduledStops**	**ScheduledKm**
NA	14.244	0	999	219	22	0
NA	17.014	0	999	219	30	17.8
NA	17.971	0	27	219	27	17.8
NA	17.014	0	999	219	30	17.8
NA	17.971	0	27	219	27	17.8

Route Data

RouteId	**RouteName**	**Direction**	**DisplayName**	**RouteTypeID**	**Origin**	**Destination**	**TotalDistance**
2835	711Ext	UP	Kair Depot to Sarai	226	644	1620	46.923

	Up		Kale Khan ISBT		1		

Route bus stop mapping

Stop_Code	Route_Code	SequenceOrder	StoppageDistance	StopCheckPoint
6339	2535	0	NULL	1
6353	2535	1	0.587	0
5741	2535	2	1.057	0
6341	2535	3	1.228	0
6342	2535	4	2.074	0
6352	2535	5	2.302	0
6343	2535	6	2.825	0
6354	2535	7	3.372	0

6.2 Integration Procedure / Criteria

For data exchange between two systems, various options like web services, intermediate database and push/pull data on TCP/IP stack (listener) were discussed.

The approach for web services is ruled out due to invoking of the web service on the basis of database operation, the requirement is to share the data from one system to another on insertion/updation of data in one system. The most of the data is required from one system to another on real time basis.

Typically this is a classical data replication modal instead of integration between two systems. After deliberating the following methodology adopted for the integration:

1) An intermediate database will be created in MS SQL server and shall be accessible to both the systems.

2) On the event of any record modify or insert (of data points to be shared), parent system (in which data created/modified) will insert the same data into the table of intermediate database with a flag of insertion/modification with timestamp.

3) Table for every data points (like bus stops, drivers) will be created in intermediate database and one system add/ update the data in table and other system will read from there.

   The data consumable system (database which pull the data from intermediate database) can convert the data as per their requirement/format. For this integration, Trapeze and DIMTS will share their data dictionary of the data points (to be integrated) with each other to start the actual development for integration.

   Trapeze system shall share the dispatch information in real time basis. Similarly, Bus stops alert data shall be shared by DIMTS in real time basis. For master data the information will be pull by consumable system on a fixed frequency (schedule job).

   For schedule data, Trapeze shall share data in its own format, from which DIMTS will convert the data as per their system requirement. For such arrangement, mapping between the fields of each system is required and the meaning/definition of the filed will not change in future.

   Data field of date type will be exchange in yyyy-mm-dd format, datetime field will be yyyy-mm-dd HH:MM:SS.NNN format (24 hours format) and only time field will be exchange in HH:MM:SS.NNN(24 Hours format).

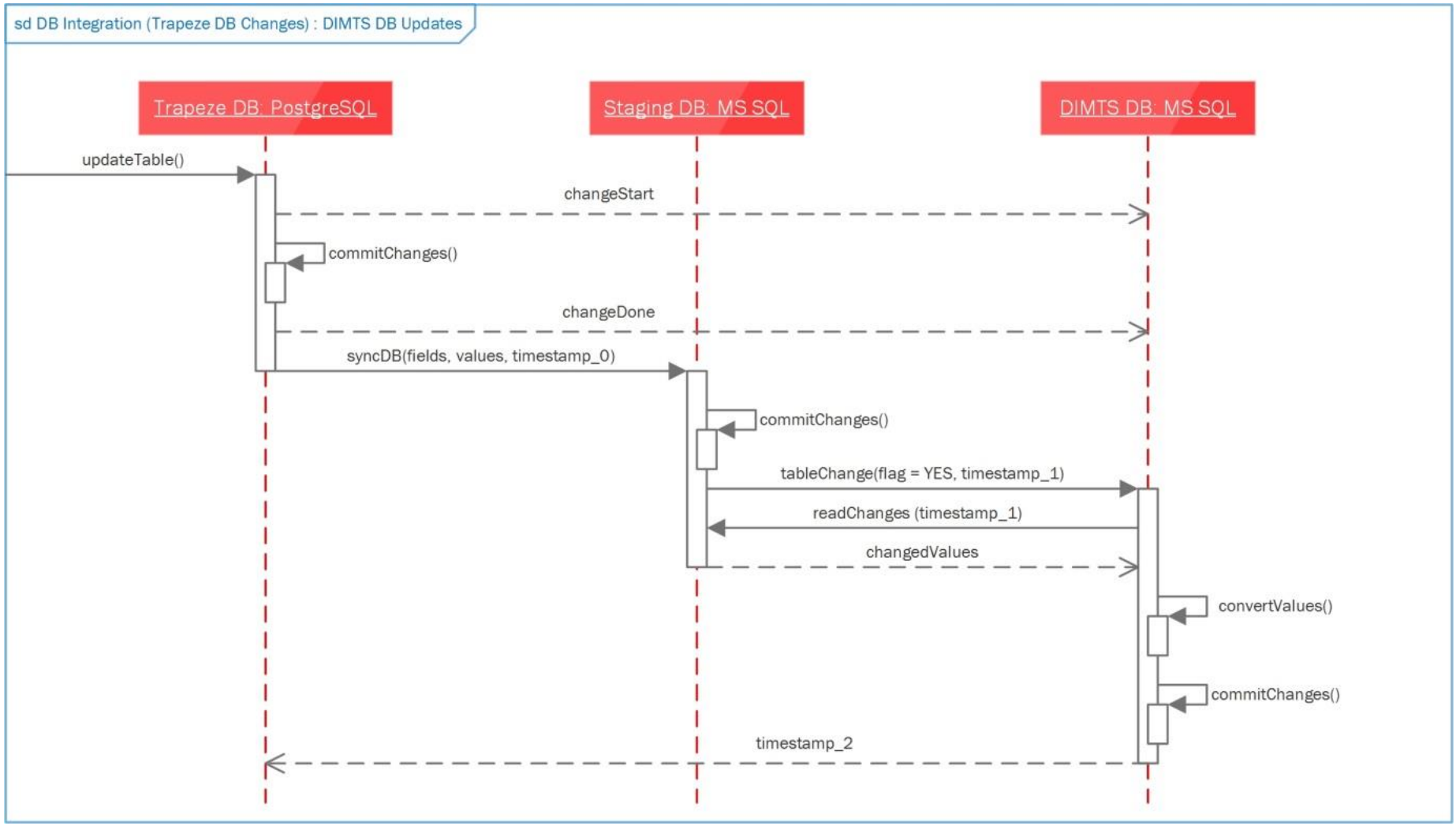


Figure 11: Integration Flow - A Scenario

7 References

- 288_40521_TENDER_DOCUMENTS (PDF) issued by BEST for ITMS Project
- BEST_ITMS_CORRIGENDUM_V5 (PDF) issued by BEST for ITMS Project