Proposed Database Design for Transport for Wales

KTK Consultants

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Table of Contents

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By KTK Consultants

Introduction

In 2021, the Ministry of Transport and Economy for Wales launched the Llwybr Newydd – the Wales Transport Strategy 2021. This 20-year strategy aims to reshape the transport system and focuses on people and climate.

KTK Consultants (KTK) have been commissioned to design a logical database that will be the backbone of the integrated ticketing system. This system will allow passengers to purchase tickets and use them across all modes of transport provided by Transport for Wales (TFW) (one card, all services). KTK is pleased to present a proposal design report for the Transport for Wales (TFW) data management system.

Logical Design

The logical design showcasing the data points, entities, attributes and relationships is presented below. It must be noted that the logical design presented in this section follows the database schema, but it serves only as a high-level presentation of the data overview and is meant to be human-friendly. See the section "Database Design" for the technical details.

Purpose Specification

The features of the developed system are explained below:
-**Customer management**: This feature collects and holds personal information about the customers, aiming to personalized ads, better customer relationship management, transaction tracking and fraud prevention;
-**Reservation management:** Reservation management allows the handling of specific routes, mainly for fixed track means of transport with numbered seats. Indicatively the feature allows the management of date, time, point of departure, point of arrival and the mode of transport;
- **Availability management:** Tracking the availability of specific routes for specific times and dates, allowing the reservation of available seats;
-**Ticket management:** It involves identification information for the tickets purchased by the customers, such as the ticket number and the ticket ID;
-**Purchase channel:** This feature specifies the method of booking the ticket, being online, through the app or the web, or through one of the certified agents.

Entity Relationship Definition
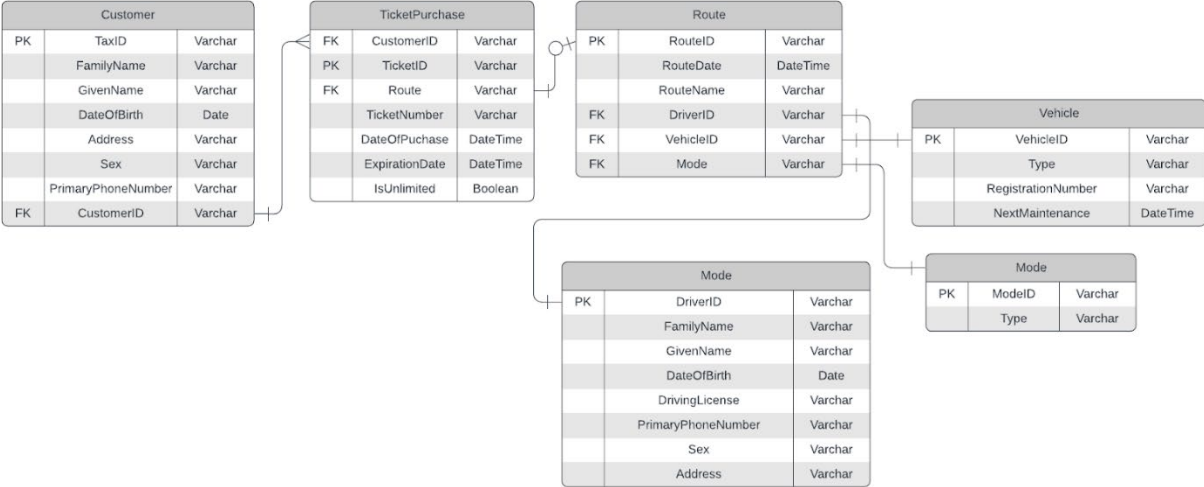
The data will be pushed in a XML format during the transactions between the systems (embedded sensors, front-end applications) to the database. The format has been selected due to its reusability, extensibility and ease of parsin (IBM, 2021). Standard and simple data types have been used with varchar between variable length strings (texts) and Date and Date Times being ISO formatted date or date time values in UTC (e.g. 2022-10-31T17:44:05+00:00) (IONOS, 2020).

Data Management Pipeline

The integrated ticketing system will allow passengers to purchase tickets or load their travel cards; these tickets and cards can be used to access any mode of transport service provided by Transport for Wales. Customers should be able to purchase tickets across the various sales channels offered by Transport for Wales, mainly through the mobile App, on the official website, at the various transport stations, and at selected retail outlets.

In addition, TFW would want to analyze information related to popular service routes, sales by mode of transport, and busiest routes by the hour, week, or month. For this purpose, we propose a data management pipeline that collects data from multiple sources, transforms it and consolidates it into one data storage hub. KTK proposes a combination of batch processing and streaming processing pipelines to take into account the time-sensitive nature of the data being collected. The streaming processing pipeline allows TFW to receive up-to-date information on ticket sales and fleet movements and forecast the demand for transport services along routes, while batch processing will be essential for analyzing historical data to understand medium to long-term trends (Altexsoft, 2022).

In order to achieve this, three crucial steps must be considered and undertaken. These are identifying the source of the data, the processing steps, and the destination of the processed data.

Data Source

For the integrated ticketing system, data will be sourced from IoT device sensors located at train stations, in buses, and at bicycle sharing stations, the Customer Relationship Management (CRM) system that processes ticket purchases, and the Enterprise Resource Management system which manages the fleet, accounting, and supply chain for Transport for Wales.

Processing

The processing stage is where data cleansing will occur. This involves error detection and repairing of detected errors. During this stage, we propose the use of data-cleaning pipelines, which use automated data-cleaning libraries (Krishan & Wu, 2019). Another alternative method would be to generate small random samples of data and explore the statistical properties, and set cleaning rules. Salloum (2019) describes Random Sample Partitions (RSP) which is a distributed data model used to represent a large dataset through ready-to-use sample data blocks. Using this method, we can identify potential types of value errors, understand the data and retrieve samples of clean data.

Destination

For this logical database design KTK proposes using both a data warehouse and a data lake to store data. The data warehouse will house historic data that are summarized. The data lake will store all the unstructured data such as data from the IoT sensors, files or even video footage captured at bus and train stations for example. A data lake will allow TFW to store large amounts of data which can be used in machine learning and artificial intelligence at a later stage.

Database Design

The Entity Relationship Diagram (ERD) following below is already adapted to conform with the database design normal forms, up to BCNF (Date, 2019).

1NF

For a table to be in the 1st normal form, every value should be atomic, each record needs to be unique, values should be of the same domain and all the columns per each table should have unique names.

2NF

For a table to be in the 2nd normal form it should be already in 1st normal form and also have no partial dependency..

3NF

In order for a database to be in the 3rd normal form it should be in the 2nd normal form and also have no transitive dependencies. Transitive dependencies are found when a 'non prime attribute depends on other non-prime attributes rather than the prime attributes or prime key' (StudyTonight, no date) - if the prime key is composite. All the tables therefore are in the 3rd normal form.

BCNF

In order for a database to be in Boyce-Codd Normal Form (BCNF) it needs to be in third normal form and also for any dependency x to y, the x cannot be a non prime attribute if y is a prime attribute (StudyTonight, no date).

ERD
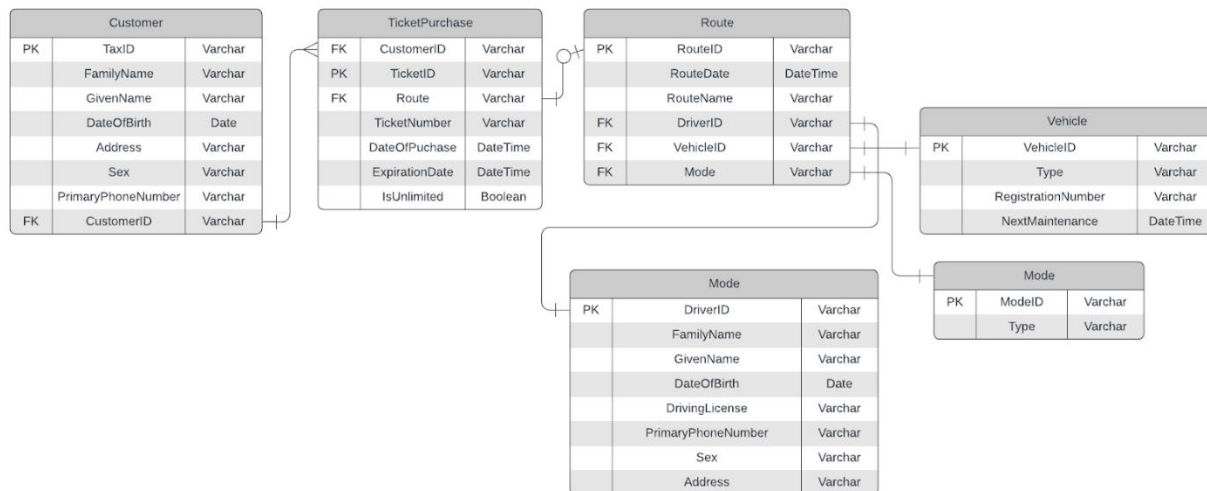
Summary

The needs of Transport for Wales are dynamic and as such the single logical database design aims to incorporate this in the proposed design.

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