**Airline Company Data Warehouse**

**TEAM 1**

* Mohamed AlGhaly
* Salma Ahmed
* Ahmed Ali

**Project Documentation**

**STEPS**

1. Understanding the business.
   * Conduct research on how Major Airline Companies operate.
2. Requirements Gathering.
   * Understand Business Needs.
   * Identify Data Sources.
3. Analyzing Source Systems’ Data.
4. Defining Business KPIs & DWH Objectives.
5. Defining Business Processes.
6. Defining Granularity for each business process.
7. Choosing the Optimal DWH Architecture.
8. Deciding the technology stack.
9. Defining Dimensions and Fact Tables.
   * We need also to define the type of each (Fact table, Dimension Table, Measure)
10. Data Warehouse Modeling.
    * Creating the Logical Model (The Schema).
11. Creating the Physical Model.
12. Generating & Populating data.
    * In this step we will simulate data sources’ data by generating data using a Python script.
13. Data Integration.
    * Moving data from source Systems to the DWH.
14. Indexing & Partitioning.
15. Data Analysis.

PS:

* The mentioned steps show a more **generalized** DWH Modeling **approach**, some of the steps may not be applicable in our case.
* We have excluded some crucial steps like choosing the technology stack which includes hardware, database software (e.g., Oracle, SQL Server, Snowflake) and choosing between On-Premises and Cloud.
* We have also excluded other steps like choosing the DWH provider, estimating DWH size, defining sparsity of the data, and determining hardware specifications.
* We act as the business owners and we don’t have Data Sources to refer to, so any assumptions made will be from our point of view and we will try to include as detailed description as possible.

**STEP1**

Defining KPIs & DWH Objectives

DWH Objectives:

The objective of this project is to assist the executive management to analyze their current business processes and expand the company by discovering new opportunities.

We can achieve this by creating a robust and structured Data Warehouse that consolidates data from various sources, facilitating analytical reporting and business intelligence.

Business KPIs & Analysis Scope:

* Enhancing the overall business performance.
* Analyzing the behavior of company’s frequent flyers.
* Measuring the performance of our marketing team.
* Measuring the performance of our Loyalty Program.
* Analyzing the company’s profit.
* Which customers use our services more frequently.
* Analyzing our revenues in each country.
* Defining our main source of revenue.
* Which customer segmentation (gold, platinum, titanium) is most valuable.
* Our most popular booking channels.
* Improving customer satisfaction.
* What are the booking patterns of frequent flyers, and what types of fare classes do they typically book.
* How do customer demographics, such as age or income level, impact travel behavior and preferences.
* Ensure a seamless operation of our loyalty program.

**STEP2**

Defining Business Processes

1. Ticketing Transactions (Reservations):
   * This process captures transactional data related to bookings made by customers. It supports analyses of sales performance, customer booking behaviors, and revenue management.
   * This process is mainly concerned with the Finance Team.
   * The analysis scope is to analyze company’s revenues.
2. Frequent Flyers:
   * This process maintains detailed records of frequent flyer mileage transactions, supporting the management of the airline's loyalty program.
   * This process is mainly concerned with the Marketing Team.
   * The analysis scope is to analyze frequent flyer’s behavior.
3. Customer Care:
   * This process is mainly focused on achieving higher customer satisfaction.
   * It captures customers’ inquiries, complaints and keeps their feedback.
   * This process is mainly concerned with the Customer Support Team.
   * The analysis scope is to define any problems within the company and to ensure a better customer experience.
4. Flights:
   * This process records key operational data for each flight conducted by the airline. It supports performance analysis, operational planning, and decision-making processes related to flight operations.
   * It mainly focuses on our flight activity.
   * This process is mainly concerned with the Upper Management Team.
   * The analysis scope is to analyze the overall company’s performance.

**STEP3**

Defining Granularity

**Possible Granularities**

The following are the possible grains to consider across defined business processes.

* Transit:
  + The step from one airport to the other.
  + A flight from San Francisco to Minneapolis with a **stop/transit** in Denver will be mapped in **2 rows**:
    - San Francisco to Denver and Denver to San Francisco.
* Flight:
  + The flight from journey to destination.
  + A flight from San Francisco to Minneapolis with a stop/transit in Denver will be mapped in a **single** **row** holding data about the source and destination only.
* Trip:
  + A return flight that takes you from Paris to London and back from London to Paris is mapped in a **single row**.
* Daily, weekly, etc.

**Choosing Granularities for Each Fact Table**

Sample Ticket (Trip Level)

A blue and white ticket

Description automatically generated

1. **Ticketing Transactions:**

We will work on the grain of each **ticket** booked by any customer (**Trip Level**).

* A customer books a flight from San Francisco to Minneapolis with a stop/transit in Denver will be mapped in a **single** in this table.
* As shown in the above image (sample ticket), the passenger pays for the trip regardless of any stops/transits.
* A 2/3/.. flights trip containing transits will be mapped to a single row.
* The above sample ticket for example will be represented as a single row in the fact table.

1. **Frequent Flyers:**

The most detailed grain in this fact table will be of each **flight** booked by any customer **on the loyalty program.**

* + We will use this fact table to analyze frequent flyers’ behavior and their booking patterns in addition to how they redeem and earn flyer mileages.
  + The above Sample ticket will be mapped to 3 rows in our fact table, because it is a single trip with 2 transit steps or flights (flown on 3 legs).
  + If the above sample ticket is not reserved by one of our frequent flyers it **Won’t** be represented in the fact table.

1. **Customer Care:**

This most detailed grain is each action taken by a customer in our company, this action can be a complaint, feedback, or inquiry.

1. **Flights:**

The most detailed grain is each flight organized by the company (flight level).

* + The above ticket will be mapped as 3 rows across all passengers flying on the same flight.

**STEP4**

Choosing DWH Architecture & Technology Stack

* We have chosen a Typical Two-layer Architecture (Ralph Kimball’s) approach.
* It will be almost **impossible** to build a 3rd normal form Enterprise Data Warehouse without having a solid understanding of data sources.
* We will implement our DWH on Oracle DBMS.

**STEP5**

Defining Dimensions & Facts

Step five will be the capstone for the project which involves determining facts, dimensions, and measurements.

**FACTS & MEASUREMENTS:**

1. Ticketing Transactions (Transactional Fact Table)
   1. What?
      1. This is the core of our DWH which will help the financial team to analyze company’s revenue.
      2. BI Developers will use this fact table to derive ideas to increase sales and improve the company’s revenues.
   2. Measurements:
      1. Total Fare (additive).
         * The total charge for the ticket.
         * Back to the sample ticket this numeric value would be 558.00$.
      2. Ancillary Revenue (additive).
         * The total fare for using extra flight or airport services.
         * Back to the sample ticket this numeric value would be 37.76$.
      3. Governmental Taxes (additive).
         * The total taxes issued by the government not the company.
         * Back to the sample ticket this numeric value would be 1.05 + 1.2$.
      4. Airport Taxes (additive).
         * The total taxes issued by the company.
         * Back to the sample ticket this numeric value would be 18.38$.
      5. Security Fees
         * The security fees issued by the company.
         * Back to the sample ticket this numeric value would be 17.00$.
      6. Baggage Fees (additive).
         * Fees charged for extra baggage on the plane.
      7. Discount (additive). => As a numeric value not a percentage (that is why it is additive)
      8. Upgrade Fees (additive).
         * Fees charged for Upgrading the class for any of the booked flights.
      9. Other Fees (additive).
         * Any other fees issued by the company.
         * Back to the sample ticket this numeric value would be 15$.
   3. Dimensions:
      1. Passenger
      2. Date
      3. Channel
      4. Class
      5. Airport
      6. Passenger Profile
      7. Time
      8. Reservation ID (Degenerate Dimension)
      9. Fare Basis
2. Frequent Flyers (Transactional Fact Table)
   1. What?
      1. This is a fact table to keep track of each flight booked by a frequent flyer, this fact table will be valuable for the marketing team to measure the benefits of our **loyalty program**, **promotions**, and other marketing campaigns.
      2. This fact table will also be used to analyze the behavior of our **frequent flyers** to help us build brand loyalty.
   2. Measurements:
      1. Points Redeemed (additive).
         * Flyer Miles Redeemed by this frequent flyer in this flight.
         * The miles can be redeemed into discount, extra services, etc.
      2. Points Earned (additive).
         * Flyer Miles earned by this frequent flyer from this flight.
      3. Cancelled (additive).
         * This is a 0/1 value that represents whether the passenger has cancelled the reservation or not.
         * This is additive as we can sum it to get the total cancellation or average it to get cancellation rate.
         * Analyzing cancellation is a separate business process, we will only partially analyze cancellation patterns for our frequent flyers.
      4. Overnight Stand (additive).
         * This represents the hours passengers will wait in transit until the next flight takes off.
         * This is a derived attribute that calculates the **lag** between the flight’s arrival date and the next flight’s departure date, we have decided to add it to the fact table for performance’s sake.

Passengers can earn/redeem points from any other activities rather than booking a flight, those activities can even be conducted out of our company, but analyzing those activities are out of the analysis scope for this fact table (Will be a separate business process), so we will only be concerned about points earned from booking a flight or points redeemed as a discount on a ticket! (**When we say points, we refer to flyer miles)**

* 1. Dimensions:
     1. Passenger
     2. Passenger Profile
     3. Class
     4. Date
     5. AIRPORT
     6. Promotion
     7. Status
     8. Booking
     9. Flight
     10. Fare Basis
     11. Channel
     12. Reservation ID (Degenerate Dimension)

1. Customer Care (Accumulative Fact Table)
   1. What?
      1. This fact table keeps track of the process of submitting inquiry/complaint/feedback.
      2. It tracks all the steps in this process from submitting an application to getting your issue solved!
      3. This fact table keeps track of actions taken by customers, these actions can be of any type (complaint, feedback, inquiry) and of any severity.
   2. Measurements:
      1. Respond Delay (additive).
         * Time taken to respond to the application.
      2. Resolution Time (additive).
         * Time taken to resolve the issue.
      3. Duration (additive).
         * Time taken by the customer to fill the application.
      * We had an ongoing discussion about whether to put Severity as a measurement or an attribute in the dimension.
      * And because this is a non-additive measure we decided to go with the dimension.
      * There is no point in calculating the total Severity, that is why it is non-additive.
      * BI Developers would use this attribute as a categorical attribute anyway.
   3. Dimensions:
      1. Passenger
      2. Passenger Profile
      3. Flight
      4. Date
      5. Channel
      6. Employee
      7. Interaction
      8. Time

**NOTE:**

* Submitting a complaint or inquiry or whatsoever is an ongoing process that undergoes several steps, so we have decided that the best approach to model this business process will be using accumulative fact table.
* With accumulative fact tables we could track the process from opening an application to closing it!
* We have thought of the process as the following:
  + A customer can fill in an application, it can be filled from the website, mobile app, or a paper application.
  + The user being logged in we get the customer filling the application (for paper applications the customer is asked to provide his name).
  + Then he fills in the application details, he could specify one of his flown flights in the applications (optionally).
  + The customer can also fire a complain on a specific reservation channel (optionally).
  + The analysis team will keep track of this application from submitting it to resolving the issue to ensure a seamless flying experience and an optimal customer satisfaction.

1. Flights (Transactional Fact Table)
   1. What?
      1. This fact table keeps track of each flight organized by our company.
      2. This analysis scope for this fact table focuses on flight activity from a relatively higher picture.
      3. We will use this fact to analyze flight’s performance and get insights regarding:
         * Empty seats, not-showing passengers, fuel consumption, and so on.
   2. Measurements:
      1. Booked Seats
      2. Passengers Count
      3. Empty Seats
      4. Fuel Consumption
      5. Crew Count
   3. Dimensions:
      1. Airport
      2. Date
      3. Flight
      4. Aircraft
      5. Crew Member

**Dimensions:**

NOTE:

* The attributes of each dimension will be shown in the Model.
* We will only mention here the attributes that need to be described.

1. Date

* This is a typical calendar dimension for any DWH.
  + - **Season** can be (Summer, Winter, and so on).
* **Type:** Role-Playing Dimension over for some fact tables and conformed dimension for others.

1. Time

* We have conducted some research on how to present timestamp over different fact tables and we have found the best approach is to go with a Time Dimension (as suggested in The Data Warehouse Toolkit -Ralph Kimpall’s Book-).
* **Type:** Role-Playing Dimension over for some fact tables and conformed dimension for others.

1. Passenger

* **Type:** Slowly Changing Dimension.
* We will use the 4th Type SCD as suggested in the toolkit.
  + - The size of this table could go up to 10s of millions, so a typical type 2 SCD will be a huge load.
* This table holds the unchanging data for passengers.

1. Passenger Profile

* **Type:** Slowly Changing Dimension.
* This table holds the slowly changing data for each passenger.
* The table goes something like this:



* + - **Home Airport:** represents the home city’s airport for this frequent flyer.
    - **Passenger Profile Key of -1:** Represents a non-frequent flyer.
    - We could also represent non-frequent flyers by putting **nulls** in the passenger profile key.

1. Airport

* **Type:** Role-Playing Dimension.
* A dimension holding data about all airports that the company operates on.

1. Aircraft

* **Type:** Conformed Dimension.
* This table holds data about all the airplanes the company owns.

1. Flight

* **Type:** Conformed Dimension.
* This table holds data about flights organized by the company.
  + - At a first glance, one might get confused about the difference between this dimension and the Flight Activity fact table so let’s make sure this point is clear:
      * The fact table keeps records of each single flight organized by our company; it would help us to analyze our flight activity.
      * This dimension holds data for different flights organized by the company; and a flight is recognized by its duration, distance, arrival, and departure time stamp.
      * The dimension table records only flights having unique duration, distance, and schedule.

1. Employee

* **Type:** Conformed Dimension.
* This table holds data about the company’s employees.

1. Channel

* **Type:** Conformed Dimension.
* The channels the company supports for tickets’ reservation.

| **Column Name** | **Data Type** | **Description** |
| --- | --- | --- |
| ChannelKey | INT | Unique identifier for each reservation channel. |
| ChannelID | VARCHAR(50) | Short identifier or code for the channel. |
| Name | VARCHAR(250) | Name of the channel, such as "Website" or "Call Center". |
| Type | VARCHAR(100) | Type of channel, e.g., "Online", "Offline", "Third-party". |
| Category | VARCHAR(100) | Category to further classify the channel like "Direct", "Indirect", "Partner". |
| ContactMethod | VARCHAR(100) | Primary method of contact, e.g., "Phone", "Email", "In-person". |
| Accessibility | VARCHAR(100) | Accessibility of the channel, e.g., "24/7", "Business hours". |

1. Promotion

* **Type:** Conformed Dimension.
* This dimension holds data about the promotions the company offers.

| **Column Name** | **Data Type** | **Description** |
| --- | --- | --- |
| Name | VARCHAR(250) | The name of the promotion. |
| Type | VARCHAR(100) | Type of promotion, e.g., "Discount", "Bonus Miles", "Upgrade". |
| StartDate | DATE | The start date of the promotion. |
| EndDate | DATE | The end date of the promotion. |
| Terms | VARCHAR(250) | Description of the terms and conditions of the promotion. |
| Amount | INT | The discount/bonus miles amount provided by the promotion, if applicable. |

1. Interaction

* **Type:** Conformed Dimension.
* A dimension holding data about the customers’ interactions (Inquiry, Feedback, Complaint)

| **Column Name** | **Data Type** | **Description** |
| --- | --- | --- |
| InteractionKey | INT | Unique identifier for each interaction record. |
| InteractionID | VARCHAR(50) | A unique code or ID assigned to the interaction. |
| Type | VARCHAR(100) | Type of interaction, e.g., "Complaint", "Inquiry", "Feedback". |
| Description | VARCHAR(250) | Detailed description of the interaction. |
| Severity | VARCHAR(100) | Severity level of the interaction, e.g., "Low", "Medium", "High". |
| When\_ | VARCHAR(50) | When did the Interaction happen, “After”. “Within”, “Before”, “Not-Related”. |

1. Booking

* **Type:** Conformed Dimension.
* Holding data about the booking for passengers, like Seat Number, Gate, Confirmation Number.
  + - We saw this a context (descriptive) data rather that numeric (measurements).

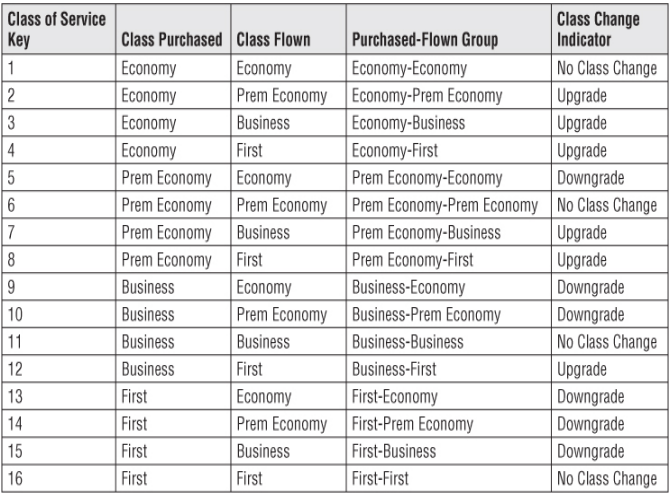
1. Reservation ID
   * **Type:** Degenerate Dimension.
   * The Reservation ID For any ticket a passenger books.
2. Status

* **Type:** Conformed Dimension.
* This dimension holds data for different frequent flyers (gold, platinum or titanium, and so on).

| **Column Name** | **Data Type** | **Description** |
| --- | --- | --- |
| StatusKey | INT | Unique identifier for each status record. |
| StatusID | VARCHAR(50) | A unique code or ID assigned to the status. |
| Name | VARCHAR(250) | The name of the status, such as "gold", “titanium”, or "platinum". |
| Description | VARCHAR(250) | Detailed description of what each status means. |
| UpgradePriority | INT | Numeric value indicating the priority for upgrades. |

1. Class

* **Type:** Conformed Dimension.
* The class of service flown describes whether the passenger sat in economy, premium economy, business, or first class.
  + 1. We need to keep track of upgrades in fare basis, that is why this table will be structured as follows:



1. Fare Basis

* **Type:** Conformed Dimension.
* The fare basis dimension describes the terms surrounding the fare; It would identify whether it's an unrestricted fare, a 21-day advance purchase fare with change and cancellation penalties, or a 10 percent off fare due to a special promotion.

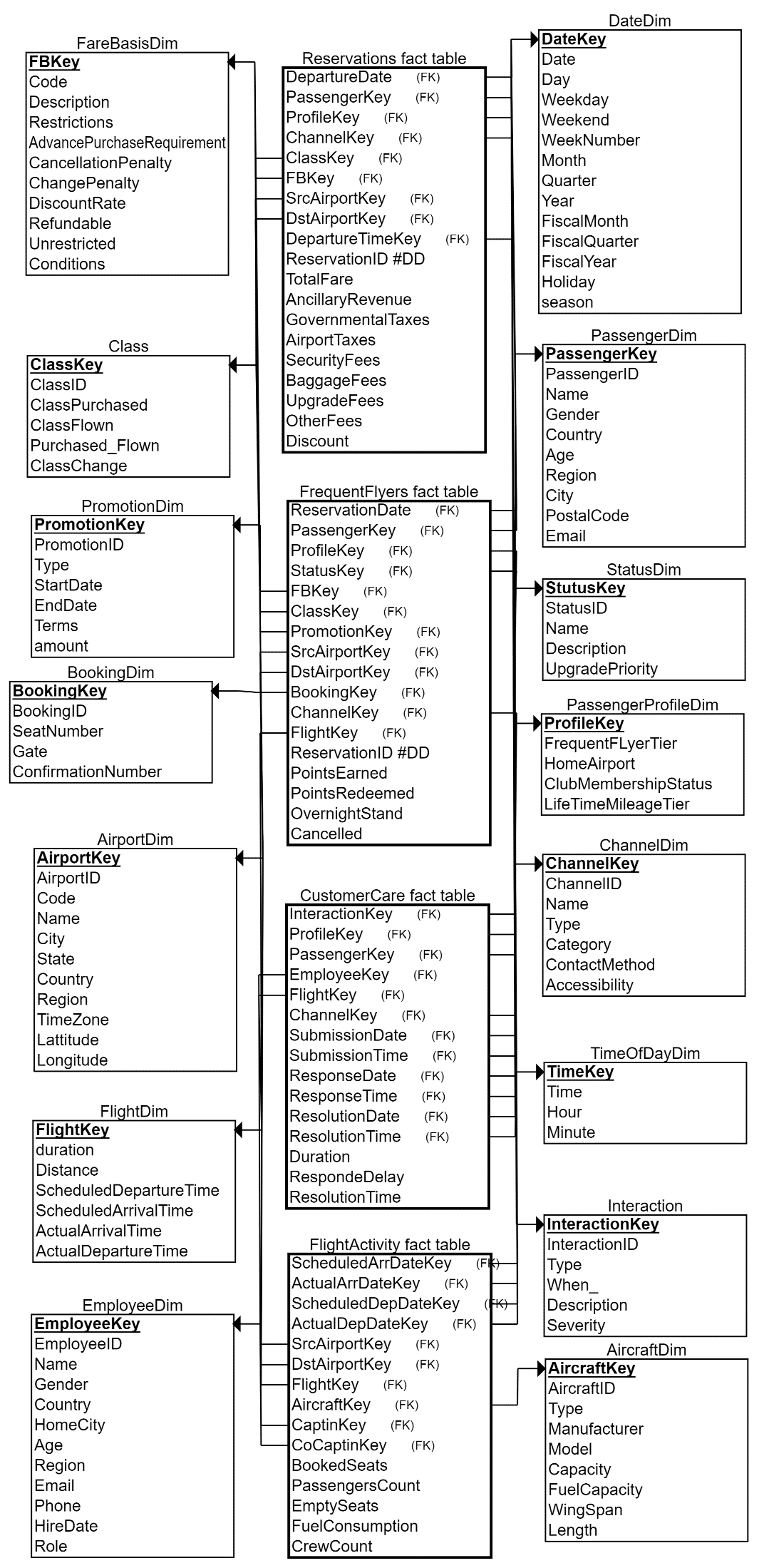
Dimension Description

| **Column Name** | **Data Type** | **Description** |
| --- | --- | --- |
| FBKey | INT | Unique identifier for each fare basis record. |
| Code | VARCHAR(50) | Short code representing the fare basis. |
| Description | VARCHAR(250) | Full description of the fare basis. |
| Restrictions | VARCHAR(250) | Describes restrictions such as non-refundable, non-transferable, etc. |
| AdvancePurchaseRequirement | INT | Number of days in advance the ticket must be purchased. |
| CancellationPenalty | FLOAT | Penalty for canceling the fare, often a percentage of the fare. |
| ChangePenalty | FLOAT | Penalty for changing the ticket. |
| DiscountRate | FLOAT | Any discount rate that applies to the fare, if applicable. |
| Refundable | INT | Indicates if the fare is refundable (1/0). |
| Unrestricted | INT | Indicates if the fare is unrestricted (1/0). |
| PromotionAssociated | INT | Indicates if the fare is part of a promotion (1/0). |
| Conditions | VARCHAR(250) | Describes other conditions for this fare basis. |

| **FBKey** | **Code** | **Description** | **Restrictions** | **…** |
| --- | --- | --- | --- | --- |
| 1 | U21 | Unrestricted fare | None |
| 2 | A21CP | 21-day advance purchase with penalties | Non-refundable, Non-changeable |
| 3 | P10SP | 10 percent discount due to special promotion | Purchase in advance required |

**STEP6**

DWH Modeling



DWH Model Discussion

* We have decided to go with a **Star Schema** for each data mart, with common conformed dimensions to unify the analysis.
* We have 4 fact tables each one is unique, unique in its grain, unique in its analysis scope, and each one represents a single business process associated with a single team.
* Each fact table has a wide variety of analysis and insight that can improve the business.
* The analysis scope will be covered in step 11, but now let’s demonstrate the assumptions made for each business process.
* We could have more fact tables on top of these ones, but for the first delivery these are enough.

WHY did we choose star schema modeling?

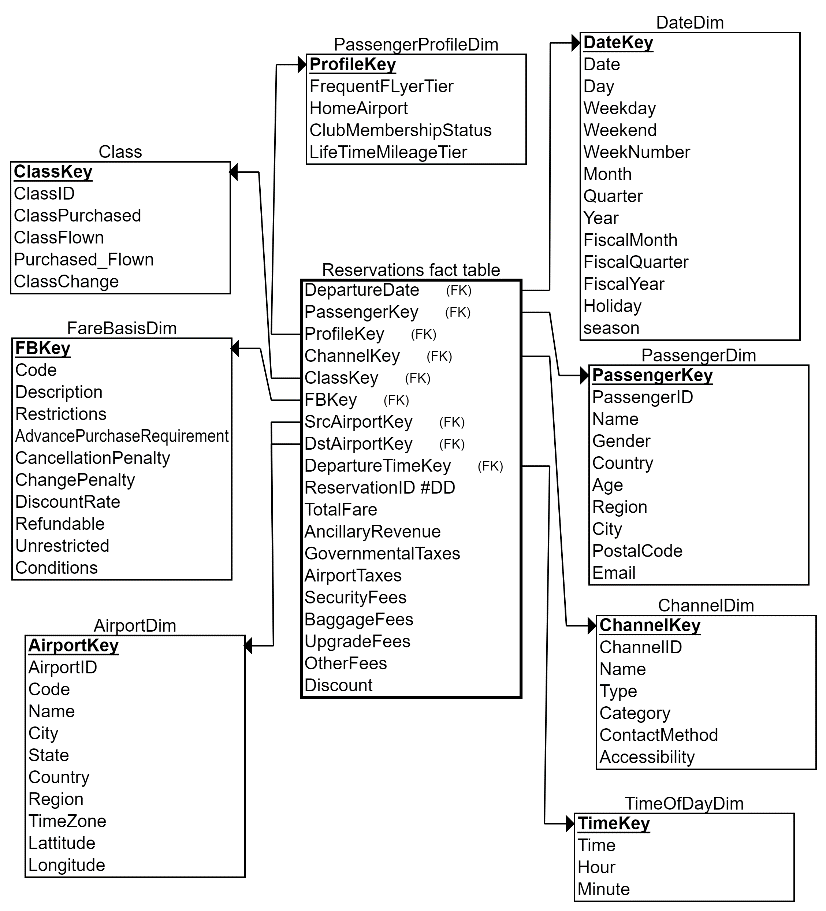
We chose a star schema for the airline data warehouse due to its simplicity and optimal performance in query handling, which is ideal for facilitating fast and intuitive reporting and analysis on specific key subjects, like flights and customer interactions.

Let’s now see a brief description of each fact table and the business assumptions made for the underlying business process.

* After conducting a deep market research on how Airline Companies operates, we have found that each company has its own assumptions and workflow.
* We have discussed the business and decided to go with the most common approach for each case, and follow our point of view for conflicting points.

**IMPORTANT NOTE**

* There are 2 types of revenue, **Earned Revenue** and **Unearned Revenue** those terms are vital in accounting, but to sum it up when a passenger pays for a service this is an unearned revenue, when he receives it, it becomes an earned revenue.
* We have decided to focus only on earned revenues (for finance team) as suggested on the toolkit, and that is why we are using **Departure Date** instead of ticket reservation date as the date for this reservation’s fact table.
* For the marketing team we need to focus also on cancellation patterns, so we have used reservation date as the date for Frequent Flyers Fact Table.

**Ticketing Transactions:**

* This fact table helps us analyze our revenues.
* We have decided to use transactional fact table to have a control over each component contributing to company’s profit.
* Using **Class** Dimension, we can identify which class (1st class, economic, ...) contribute the most to revenue.

We can also analyze impact of class upgrade on revenue.

* Using Fare Basis Dimension, we could analyze how each different component of the fare basis affects our performance.
* Using Airport, we can get insights about which Countries/Cities/… are most profitable for us.
* With this fact table we could get some insights about how our loyalty program is performing (financially).

Why did we choose to work on the grain of the Trip?

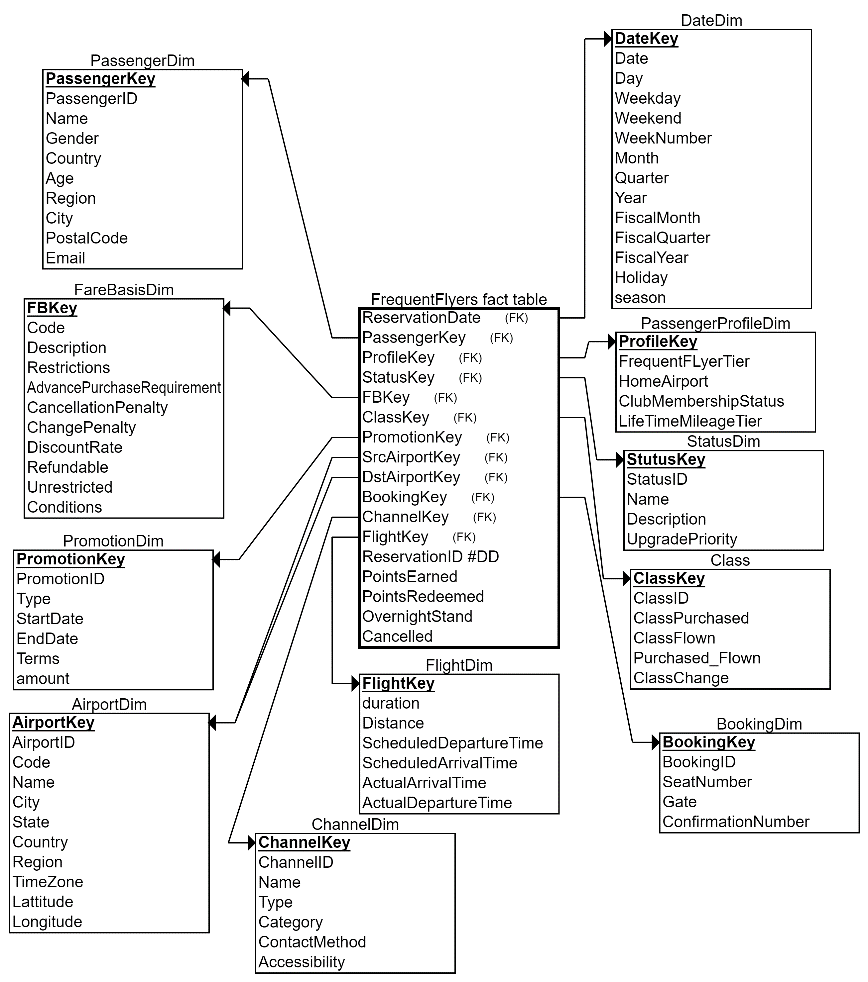
* After deep research, we decided to go with the following assumptions:
  + When a passenger pays for a ticket that has more than one flight or transit, this ticket is considered a single line item.

Limitations to this fact table:

* We **can’t** calculate profit from this fact table, as we will need integration with other business processes like maintenance, HR, and so on.
* For a sales company calculating the cost for an item is easy, making it possible to calculate profit from sales fact table, but as we are providing a service rather than a product, we can’t calculate the cost for each purchased ticket!

Enhancements:

* The first deliverable only focuses on flight activities, we can add new business processes to the next one to cover profit analysis.
* But focusing only on flight activities, we can’t analyze our profits.
* We can create more aggregated fact tables on top of this one for performance’s sake.
* For example, the Tool Kit suggests building a 90-day periodic fact table on top of this one, but for us this is enough.

**Frequent Flyers:**

* This fact table helps the marketing team to see the booking pattern for our frequent flyers.
* There are some duplications between this fact table and the previous one, but the 2 tables tackle 2 different business processes concerning 2 different teams and the 2 tables are built on different granularities.
* We have decided to use the reservation date to load this fact table and to add a cancellation measure to the fact table, to indicate whether or not the passenger has cancelled the trip.
* We know that trip cancellation is a separate business process that needs its own analysis, but defining cancellation pattern for frequent flyers would be helpful for the marketing team.

Why did we choose to work on the grain of the Flight?

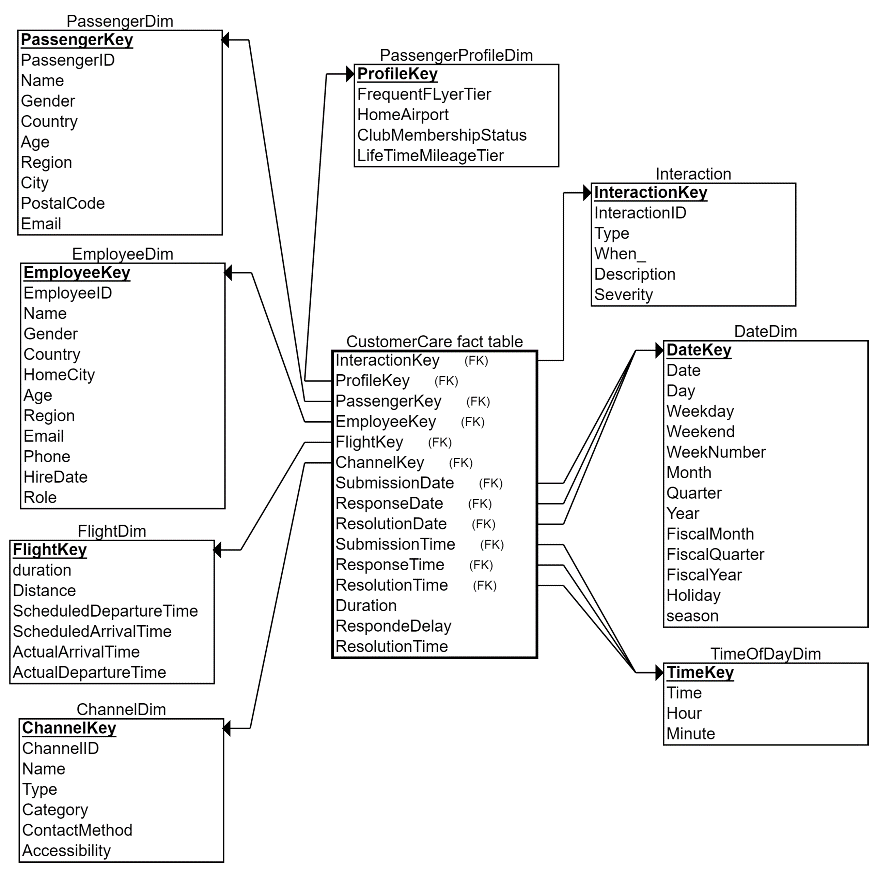
* After carefully going through the requirements, we have decided that to get an accurate estimation of frequent flyers’ behavior we need to analyze each single flight.
* Also, using this grain makes it easy to analyze overnight stand and transit steps for each flight.

Limitations to this fact table:

* Passengers can earn points from various channels, not only direct airlines, but also indirect airline partners such as cobranded credit cards, supermarkets, car rental companies, and international hotels and resorts. The points can be either redeemed for flights, flight upgrades or additional services such as extra baggage and airport lounge access.
* As stated on the business requirements (the first deliverable should focus on the flight activity), we are only considered with the flight activity, so we will ignore point earned/redeemed by using our partners’ services and we will only focus on point earned/redeemed by traveling with us!

Enhancements:

* The next deliverable can include a new fact table (for a separate business process) modeling loyalty program, including transactions across all partnered companies.

**Customer Care:**

* This fact table helps us to ensure an optimal customer experience.
* Customers can file a complaint because of an unpleasant flying experience with us.
* They can also make complaints about unpleasant situations while trying to book a ticket.
* It is not limited to complaints, inquiries and feedback are always welcomed.

Why did we choose an accumulative fact table?

* We see customer care as an ongoing process, that undergoes some constant steps, from hearing from customers, and communicating with them, to giving our valuable customers what they want.
* So, we need to be able to analyze each step along the way, making an accumulative fact table the best choice!

**Flights:**

* This fact table will be used to monitor the company’s performance and enhance its operation.
* A diagram of a data flow

  Description automatically generatedWe will use this fact table to gain some insights about booking behavior over different flights, different airports, different aircraft, and so on.
* For the upper management tier this fact table is very crucial, for instance we can know how many flights we organize monthly, and so on.

**STEP7**

Physical Model

Step nine will be creating the table in both excel sheet for validation and in oracle database for analysis.

The SQL Script for creating the DWH Tables using Oracle SQL can be found in a file named **Schema Creation.SQL,** while the excel file containing the tables, columns (name, data type), and indexes is named **Tables.XLXS.**

**STEP8**

Populating Data

The Python script for creating the sample data is in a file named **Data Generator.PY.**

The SQL Scripts for populating the data are included in Folder named D**ata Population.**

**STEP9**

Creating Data New Marts

**STEP10**

Indexing & Partitioning

**STEP11**

Gaining Insights