



SKYSCANNER
IN COLLABORATION WITH
UNIVERSITAT POLITÈCNICA DE CATALUNYA (UPC)

FINAL DEGREE PROJECT

Skyscanner offer and demand comparison

Skyscanner's data comparison

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*A Project for the Computer Engineering Degree in the
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working with
DeLorean squad from Marketplace Engine tribe*

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Abstract

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by Fèlix Arribas

In the last century, the world has become smaller. Communications are easier and faster than fifty years ago. Back then, you could talk through a fix phone, but you were not able to send any kind of media, like photos, videos, etc. Only the latest technology of that moment was able to do that. Since the smart phone revolution in 2007 almost everyone can text messages, sending images, share live videos or almost whatever you can imagine in less than a second.

But the internet, phones and communications are not the only thing that made the world smaller. Ways of traveling helped to this earth flattening too. In 1918 visiting another place was very difficult. If you wanted to go through the sea, you had to do it by boat. The fastest way to travel very far in a continent was by train, but not all places were connected with rails. Nowadays, all along with the internet revolution, anyone can travel to the other side of the world in less than a day by plane. Even for traveling inside the same country people use planes.

But, is the air industry as efficient enough? Are all airlines users satisfied with their purchases and possibilities? Skyscanner provides an easy to use tool to search cheap flights from any airport to another. Sadly, sometimes is difficult for users to find what they really want.

This project wants to help solving this problem, providing a HeatMap to explore differences and similarities between what users search and what airlines provides. Being able to compare between specific dates to guess user behavior.

Contents

Abstract	i
1 Context	1
1.1 Skyscanner	1
1.2 DeLorean squad	2
1.3 Marketplace Engine tribe	2
2 State-of-the-art	3
2.1 Fare aggregators and metasearch engines	3
2.1.1 Google Flights	3
2.1.2 Kayak	3
2.1.3 Expedia	3
2.2 Skyscanner services	3
2.2.1 Marketplace Engine	3
2.2.2 Data tribe	4
2.2.3 The gap	4
2.3 Resources	5
3 Offer and demand comparison	6
3.1 Formulation of the problem	6
3.2 Scope	6
3.2.1 Pipeline	7
3.2.2 Service	7
3.2.3 Visual representation	7
3.2.4 Not list	8
3.3 Risks	8
3.3.1 Routes contract	8
3.3.2 Users information	9
3.3.3 Amount of data	9
3.3.4 Kind of data	9
3.3.5 Web UI	9
3.4 Methodology and rigor	10
3.4.1 Extreme Programming	10
3.4.2 git	11
3.4.3 Continuous delivery	11
3.4.4 Tasks and issues	11
3.4.5 Environments	11
4 Stakeholders	13
4.1 DeLorean squad	13
4.1.1 Product Owner	13
4.1.2 DeLorean's squad Lead	13
4.2 Marketing Automation squad	13

4.3	Data tribe	14
4.4	Other Skyscanner developers	14
4.5	OAG	14
4.6	Providers	14
4.7	Traveler	14
A	Skyscanner structure	15
	Bibliography	16

Chapter 1

Context

This is a project developed in *Skyscanner* and evaluated by the *Universitat Politècnica de Catalunya (UPC)* as a Final Degree Project.

This project's purpose is to compare **user demand** and **flights provided** by airlines for routes. This comparison could improve flights advertisement according to user demand. The company could also develop complex software using the huge amount of data it will compare through an Application Programming Interface.

Skyscanner have more than 75 million flights information and about 13 million users queries every day. In order to compare all the data available and get significant results, the software should solve **Big Data**.

1.1 Skyscanner

Skyscanner[1] is a travel fare aggregate website. It was formed in 2004 when a group of people was frustrated by the difficulties of finding cheap flights.

In 12 years has evolved from a little office in the suburbs of Edinburgh to a world wide company with ten offices in seven different countries. In the next 5 years, Skyscanner wants to become the travel experience that people prefer to the myriad confusing and unconnected travel apps.

Now, is one of the top travel fare aggregate website. It has more than 4 million visitors every day and, more or less, a revenue of half a million pounds per day.

Before joining Skyscanner I wondered how they growth that fast and how they did this amount of money. Usually, *if you do not pay for the product, you are the product*, so my first thoughts were that Skyscanner sell user searches, and travel tendencies to airline companies. **Companies know what travelers buy, but now what they have searched before their final purchase.**

Once inside the company, I realized that it is not the way Skyscanner make money. Knowing that, when I joined DeLorean squad in Barcelona and had the opportunity to make the final degree project there, I proposed a tool to get traveler tendencies and compare them to DeLorean squad's data, timetables and flights.

1.2 DeLorean squad

DeLorean[2] is a squad of Marketplace Engine tribe¹, its mission is to provide the best data and services around the routes, timetables and modes of transportation to go from one point on Earth to another.

1.3 Marketplace Engine tribe

This tribe[3] is one of the most important tribes in Skyscanner, its mission is to provide the most comprehensive and accurate flight inventory for Skyscanner and her partners with minimum latency.

Its main goal is to evolve the search, pricing, routes and browse services to be horizontally scalable and set us up to build a lightning fast, super accurate and fully comprehensive flight search engine, enabling the traveler to instantly find the best flight at the best price with minimum effort.

¹Learn more about *Skyscanner structure* in Appendix A

Chapter 2

State-of-the-art

Since this project is not oriented for Skyscanner users but the company itself, the *State-of-the-art* relates to services inside Skyscanner. Even so, a brief explanation about other metasearch engines would help to find the gap this project is developed.

2.1 Fare aggregators and metasearch engines

2.1.1 Google Flights

In the last years Google Flights has become the main competitor of Skyscanner. The new version is very fast and has a complete new interface, following Android guidelines.

Google is one of the top tech companies worldwide and has a lot of different platforms. It is a competitor to be aware of, the integration with Gmail, Google Calendar and Android OS makes Google Flight a part of Google's ecosystem. The traveler may feel comfortable.

2.1.2 Kayak

Kayak has always been the main competitor, both companies started in 2004. Unlike Skyscanner, Kayak started with Flights, Hotels and Car hiring. Skyscanner added those two extra search engines between 2013 and 2014.

2.1.3 Expedia

Launched in November 1998, is one of the oldest fare aggregator and metasearch engine. Apart of its own website, is also a Skyscanner provider. Some of the prices are taken from Expedia and sometimes the user is redirected to their website to finish their purchase.

2.2 Skyscanner services

In Skyscanner the user has never been a product, in fact, one of the statements of Skyscanner's culture says *Traveler != Product*[4].

There has never been a project getting value from user information because it does not follows the company culture, so the definition of the problem and the scope of the project must be very accurate to ensure it is fulfilling with Skyscanner's strategy[1].

2.2.1 Marketplace Engine

This tribe is formed by five squads, those constantly work to improve the routes and pricing service all along with an efficient search.

Marketplace Engine works with data *from the provider to the user*. In other words, it just serves **information to the user** but does not get any from him/her. All five squads take all the **data from providers**.

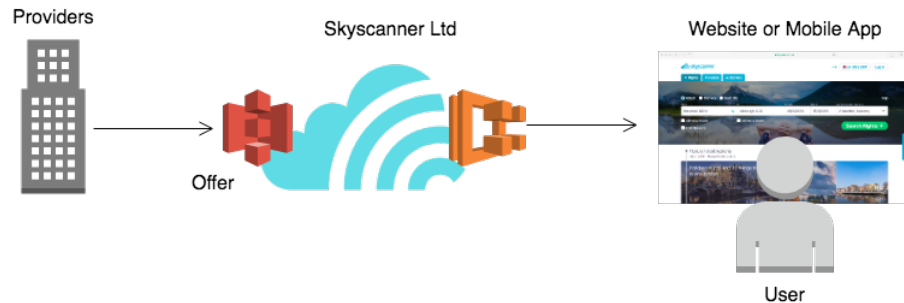


FIGURE 2.1: Simple explanation of Marketplace Engine data flow.

2.2.2 Data tribe

In the other hand, Data tribe has a lot of squads with services used to collect **data from user's activity**. The flow of the information is *from the user to Skyscanner*.

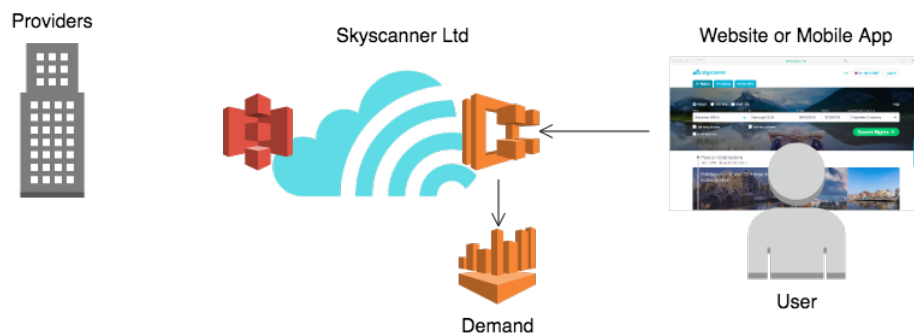


FIGURE 2.2: Simple explanation of Data Tribe data flow.

2.2.3 The gap

There is no tribe or squad that works with both **data sources**: Providers and Users. And here is where the **gap** will be.

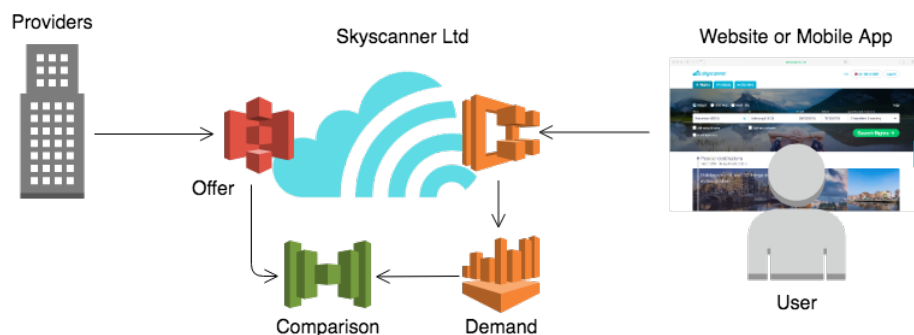


FIGURE 2.3: First approach of the Skyscanner offer and demand comparison data flow.

2.3 Resources

Skyscanner is already in the air, it is working and has been working for more than ten years. In the past two years it has been migrating all their services to Amazon Web Services[5].

Amazon Web Services have a lot of available different services in it for different purposes. The services that will be used or important for this projects are:

- Compute
 - Lambda
 - Batch
 - Elastic Container Service (ECS)
- Storage and Database
 - Simple Storage Service (S3)
 - Dynamic Database (DynamoDB)
 - Relational Database Service (RDS)
- Analytics
 - Athena
 - Elastic MapReduce (EMR)
 - Data Pipeline
- Others
 - CloudFormation (Management Tools)
 - API Gateway (Networking & Content Delivery)
 - Simple Notification Service (Application Integration)

Chapter 3

Offer and demand comparison

Knowing the context inside Skyscanner and all the state of the art of this project, the definition and scope is well defined.

3.1 Formulation of the problem

The main goal of this project is creating a tool for *Skyscanner* to ease the routes comparison with different parameters, taking into account values like **user demand** and **flights provided** by airlines.

In any team of Skyscanner, user queries and providers data is compared in order to guess valuable trends.

Found that gap, a bunch of new ideas appeared. After some talks with product owners of different squads and some senior engineers, a promising idea showed up:

Comparison of **user demand** and **flights offered** by airlines, enabling finding *over-requested* routes or airports. Those routes or airports with more user demand than offers by the providers.

DeLorean squad manages a huge amount of data: All flights planned for the next year and a half, these are more than 75 million records. The database of all user queries in the website or mobile application is even bigger, there are 4 million visitors per day and a total of 13 million queries per day. Not much more information needed to say that this is **Big Data** problem.

With DeLorean squad's product owner help, we found some use cases for the processing of those 75 million routes and all user session's queries to get some significant results:

Provide a **visual tool** to find routes with much **more demand than offer** and be able to observe the **evolution** of it through time:

- A route with a lot of demand, but not enough offer to cover it, will be **over-requested**.
- A route with much more offer, but not that amount of demand, will be **non-profitable**.

3.2 Scope

Merging both data sources (providers and users) generates a lot of new valuable data with a lot of different application: From simply selling it to providers, to complex deep learning systems.

The final goal of this project is displaying the comparison in a simple Web UI for Marketing squads or tribes. This can be split in three smaller goals or components:

3.2.1 Pipeline

Distributed application that maps and merge all the data from both sources in its given format to the required data model.

The pipeline reads from Marketplace Engine and Data tribe services. Then, it maps the provider and user data to the desired data model. The new entities are stored in a database where the service will read from.

The application will be split in two sub applications, one for providers data and other for users. So both of them can vary independently without depending on each others' sources and changes may have in the future.

3.2.2 Service

Simple HTTP Service with a basic Application Programming Interface to serve Pipeline's results. The service will have an internal endpoint only available for other Skyscanner applications or developers.

3.2.3 Visual representation

Website with a visual representation of the data. There are plenty of ways to draw charts and maps visualizations. The Web UI will be composed by two pages:

Browser

Simple browser with four input text fields, one for the origin airport, the second for the destination and the last two for the date, month and year.

Once the inputs are set, the user will be able to click the *Search* button and move to the next page.

Chart visualization

Simple chart with the comparison between providers offer and user demand of the selected entity through time.

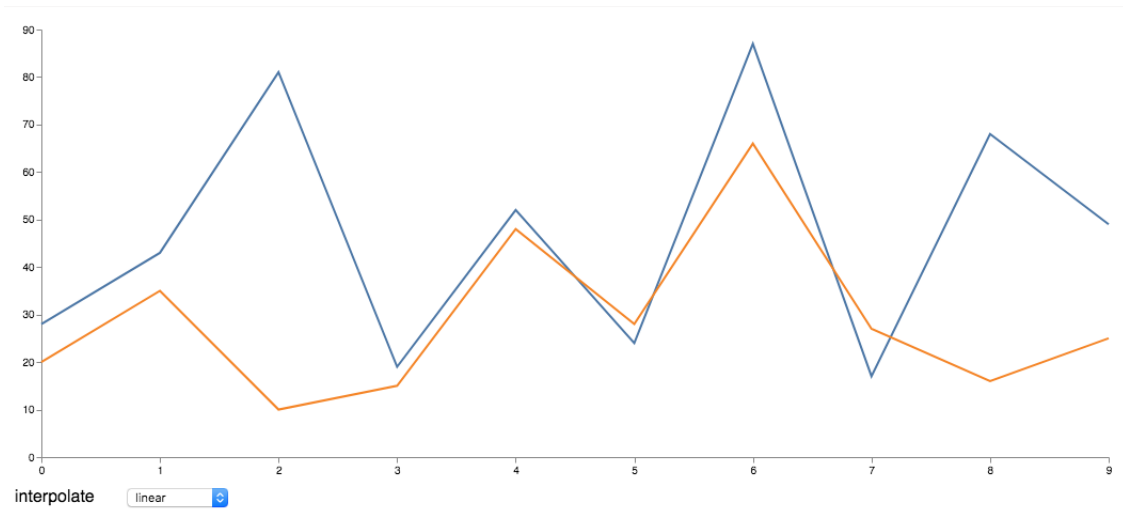


FIGURE 3.1: Chart mock-up. One color goes for Providers Offer and the other one for User Demand.

3.2.4 Not list

It is also important to define what this project will **not** be.

- **Prices or quotes:** In any moment will check for flight prices or quotes.
- **Carriers, cities and countries:** The comparison will be only available between routes and airports, not airlines (carriers), cities nor countries.
- **Create, update or delete data through the Server:** The only input will come from the pipeline. Entities are never deleted or modified in order to keep historical data.
- **Create, update or delete data through the Web UI:** The only input will come from the pipeline. Entities are never deleted or modified in order to keep historical data.

3.3 Risks

There are several risks can appear while developing the project. Most risks appear because of the dependencies with other tribes and squads and dependencies with other services. In the other hand, all performance risks of the Pipeline can be ignored because Skyscanner's hardware is enough for big applications, like this one.

3.3.1 Routes contract

DeLorean squad's routes service is under development and during the Skyscanner offer and demand comparison development the routes data model may change a little bit. For example, the origin and destination recently changed: In December 2017 the service was giving an *Airport ID*, but now is giving an *Airport* object with more parameters like IATA Code^[6], Country ID, City ID, etc.

Timetables are served, basically, in three different models: Unified Routes, Single Flight Number Routes and Summary Routes. Both Single Flight Number and Summary Routes stores timetables by days of week¹. The current **Unified Model** is supposed to be the final one, has been studied and refined by experts on the domain and DeLorean squad

¹Explanation of different models in section ??

has been adapting the output until reaching this final model. Even so, it is impossible to guess if there will be some changes.

3.3.2 Users information

In the website and mobile application, the user have plenty of different ways to search the perfect flight. The most common one is by origin, destination and date, but he/she can also search by month or by destination. Then, the user is not searching flights by route and date. It sets the period of time he/she can travel and Skyscanner offers cheap destinations.

Even searching by origin, destination and date, there can be invalid search queries. There are a lot of **cities with more than one airport** and usually when travelers search for traveling from there or to that city, they set the origin or destination **city**, but no the airport. For example: If you want to travel from New York to London, you have a lot of airports in New York (JFK, LGA, BUF, ROK, ALB, etc.), which provably only three will be useful for that search. And a total of six airports in London (LCY, LHR, LGW, LTN, STN, SEN). The final purchase, if there is, will be from two **airports**, but the Skyscanner offer and demand comparison looks for user intentions, not for final purchases.

3.3.3 Amount of data

As explained before in the Formulation of the problem, there is a very big amount of data that need to be mapped. Luckily, Skyscanner have great cloud machines and *unlimited* space². Anyway, still an issue to be aware of.

The data processing will not be an actual issue, other teams already process the same amount or more data than the Skyscanner offer and demand comparison will do. This project's data source is already processed data from its original sources. DeLorean squad gets much more data from OAG, filters it, aggregates it with other inside company sources and writes the whole dump. Data tribe processes all user queries, flights, hotels and car hires.

If in some point this became an issue I can ask for help to DeLorean squad members or data scientist.

3.3.4 Kind of data

User searches and flights offer have very similar parameters: origin, destination, date, etc. But can be very different. There are some facts that can give very different numbers for the same route and date, for example, seats in a plane. The flight offer pipeline counts number of flights, not of available seats. Is not the same one flight from Barcelona to Sydney that the aircraft will provably have 500 seats, than one flight Barcelona Mallorca that the aircraft will be much smaller and will barely reach 100 seats.

3.3.5 Web UI

Creating the interactive map and plots for the proposed website from zero, is a whole project itself. In order to avoid failing in the *Visual representation* goal, the best option is

²Read more in section Resources

to use reliable libraries, like Vega[7]. Combining it with React.js Skyscanner components, the Web UI development will be fast and easy.

3.4 Methodology and rigor

3.4.1 Extreme Programming

This project will be developed along with DeLorean squad's work. This squad is following Scrum, an agile methodology. After some research and discussions with the rest of the team, Extreme Programming (XP)[8] showed up as the best option.

Extreme Programming is a style of software development focused in excellent applications, programming techniques and clear communication. To accomplish that, XP includes a philosophy of software development, body of practices, complementary principles and a community that shares these values.

This methodology works with short development cycles, resulting in early, concrete and continuing feedback. Has an incremental approach, making way to a flexible schedule for the implementation. It relies in oral communication and tests to reach the goal of the project.

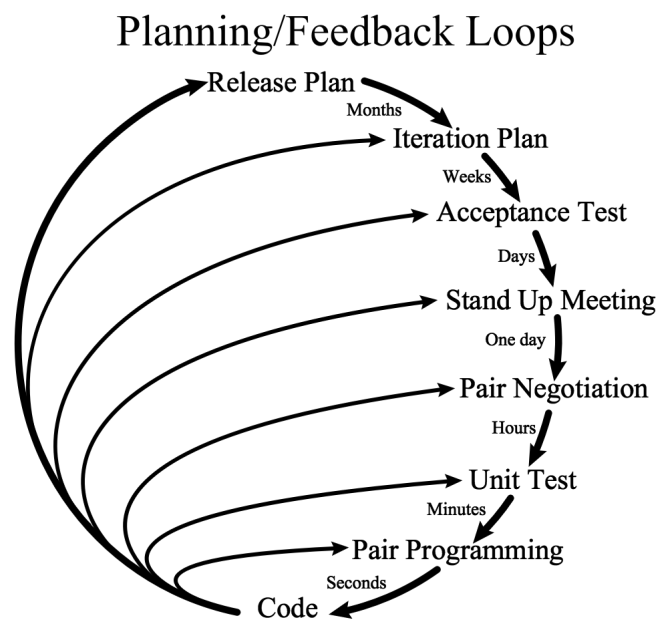


FIGURE 3.2: Extreme programming planning loops.

The original Extreme Programming methodology is for teams of developers, but this project will be only developed by myself, so the original idea has been modified a little bit. The pair programming and pair negotiation has been removed because I have nobody to pair with. In order to have some feedback and update the requirements properly with the supervisor approval, I will be attending all DeLorean squad stand up meetings and explaining my progress and, if necessary, create meetings with the product owner and the rest of the squad to take the project on the right track.

3.4.2 git

GitLab will be the main tool for version control of the source code and issue tracking of different tasks. GitLab[9] is very similar than the well known Bitbucket[10] and Github[11], all these tools are suitable for the development of the project, but Skyscanner uses only GitLab.

All code projects (pipelines, service and website) will be stored in a project space in Skyscanner's GitLab domain called Heatmap³. Using `git`, the versions will be forked in branches. Branches allow fork code versions and then merge them all together in a master single branch with a better conflict control. Each branch will stand for an specific issue, `master` will be the main branch where the latest production version will be.

- **master** branch will contain the accepted version of the project, this version must work in production with no error and must be tested in its development of task branch
- **Development branches** (named following the style `ISSUE_NUMBER-ISSUE_TITLE`) contains all development commits and code for a given task planned previously in the iteration plan. Those branches are tested in Sandbox environment
- **Bug fixing branches** (named `HOTFIX-BUG_NAME`) are branches created for fixing bug in production. The idea is to apply a fast solution in the branch and merge it directly to `master`, so the bug is fixed as fast as possible, then create an issue to find a better solution with more time.

3.4.3 Continuous delivery

In order to deploy pipelines and services automatically when merging to `master`, the projects have integration with Drone[12]. Every time it commit to a branch, the application is build, tested and, if everything goes well, it deploys to Sandbox. When merging to `master`, Drone automatically deploys to Prod.

3.4.4 Tasks and issues

The **issue tracker** provided by GitLab[9] will be very helpful in order to monitor the evolution of the project. Issues will be composed by a title, description, milestone, labels (if needed), due date and weight, and represents a new functionality. In order to know the status, issues will be listed in three columns:

- **Backlog:** Known tasks that haven been started yet. Could be a well defined task, with a very clear description, a due date and weight, or just a draft with empty fields.
- **WIP:** Work in Progress. The task is being considered, developed or tested.
- **Done:** Tasks finished, tested and working fine. Ready for merging into `master` and deploy to production.

3.4.5 Environments

In Skyscanner, for almost all Amazon Web Services resources, there are two different environments: Sandbox and Production, also known as *prod*.

³Heatmap was the original name of this project, the name remains the same since then

Sandbox

In this environment, every developer is allowed to do whatever they want, they can create, edit and remove every resource, execute whatever program, query, etc. For this project, all resources but user demand data source is available in sandbox.

Every three months, Cloud Operations squad cleans all Sandbox resources.

Prod

In prod things work little different, first of all, in order to get a profile you need a project, without project you cannot create anything. Once you have the project's profile, it have no permission to do anything, this is different than Sandbox as well. In order to get permissions you have to raise a ticket to Cloud Operations squad.

Chapter 4

Stakeholders

Initially it seemed difficult to find stakeholders and actors in these project apart from the providers. It is not a tool for the user of Skyscanner.

After talking with the squad Lead and then the Product Own of DeLorean squad a lot of stakeholders appeared: DeLorean squad, Marketing Automation squad, Data tribe, etc. Each of these stakeholders has different use cases and the project became very interesting for a considerable part of Skyscanner.

4.1 DeLorean squad

DeLorean's Single Flight Number service, also known as *Timetable SFN Service*, provides all the **current** flights. This is a little bit of a problem when trying to get historical data because Timetable SFN Service does not provide past flights information, it is always **up-to-date**. In order to get this data it is needed to go one step back in the whole DeLorean data processing: *Timetable Pipeline*.

The must look old versions of the file created by the *Timetable Pipeline* to get older routes. Then, DeLorean squad is interested in the because it will be using Pipeline's data.

4.1.1 Product Owner

Jen Agerton is the Product Owner of DeLorean squad. She realized that the is very useful for other squads like Marketing Automation squad and providers (air carrier companies).

4.1.2 DeLorean's squad Lead

Francisco López and I had the initial idea for this project. He saw an opportunity for the future (after project's delivery) orienting the or Machine Learning purpose: The information that the comparison stores is very useful for constructed routes.

4.2 Marketing Automation squad

Marketing Automation squad enables scalable growth by automating workflows, and the collection of insightful data. They have three main goals:

- Provide data to support decision making
- Automated, data driven campaign management
- Budget process automation

The will be very useful for the first goal. The data provided by the Heatmat has high value in marketing decisions. Looking at historical data, Marketing Automation squad could post an advertisement about trend routes in a specific time of the year.

4.3 Data tribe

In Data tribe, State Machine squad captures the user actions, so they know where the user gets stuck or if they finally reach the provider of the flight. Other squads like Clan A and Clan B just gets users queries in flights, hotels and car hiring. The second data source of the user requests and queries) will be obtained from these squads.

4.4 Other Skyscanner developers

Last but not least, a new service will appear in Skyscanner, all developers will be able to use it and build software using the s compared data. For instance, it can be used as a training for a complex Machine Learning[13].

The server Application Program Interface, used by the Web UI to visualize all data, will be public inside Skyscanner. This and all the documentation will be very helpful for developers.

4.5 OAG

OAG is a company that collects all logistic flights information. DeLorean squad reads data from them, it is the main provider of information regarding routes. They are the world's largest network of air travel data to provide accurate, timely, actionable digital information and applications to the world's airlines, airports, government agencies and travel-related service companies[14].

4.6 Providers

In the future, providers could take profit from omparison. Companies will be able to know which of their routes or airports work better with user tendencies, they will be able to improve the flights service and make it more efficient, reducing number of flights in *non-profitable* routes. They will also know which are the best places to invest looking at *over-requested* airports.

4.7 Traveler

Skyscanner users are one of the main sources of information. Without them, the comparison cannot be made. The results of the comparison can also help them, not directly, but if providers somehow manage flights and routes following the results, the traveler experience will improve.

Appendix A

Skyscanner structure

Skyscanner has a very horizontal structure, based on Spotify's[15].

In the top of the company hierarchy there is Gareth Williams (CEO and Co-founder). Below the rest of CxOs: CCO, CTO, CPO, CFO, CLO and the Senior Executive Assistant. Then vice presidents, senior managers, managers and then developers and interns[16].

Apart from this hierarchy structure, the whole team, except the CEO, CxOs and the Senior Executive Assistant, is mainly split in **Squads**, each of those belong to a **Tribes**. Apart from Squads and Tribes there are also Chapters, Guilds and XBT'S[17].

Squad

Are independent teams of no more than 8 people that are focused on delivering a core mission. Each squad has the freedom to act and be accountable to its mission.

Tribe

Squads belong to a Tribe. The tribe will have an aligning mission linking to each squad's mission and is only achievable depending on the success of each squad. The Tribe lead is responsible for providing the right environment to deliver and providing direction.

Chapters

Are people who do similar work. This is a secondary home, and how people are line managed. Chapter leads are responsible for developing people and in tribe practices.

Guilds

Are communities of interest of people who do not necessarily do similar work. It is people from across the business that want to share knowledge, tools, and word practices.

XBT'S (cross business teams)

XBT'S provide a platform to help solve business problems or opportunities with no natural home while giving all employees the ability to make an impact across any area of Skyscanner.

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