Smart City: Public Parking Dashboard

1st Ivan Klandev
Back-end Engineer
IT Labs
Skopje, Republic of North Macedonia
klandev.ivan@students.finki.ukim.mk

2nd Marta Tolevska
Faculty of Computer Science and Eng.
St. Cyril and Methodius University
Skopje, Republic of North Macedonia
marta.tolevska@students.finki.ukim.mk

3rd Dimitar Trajanov
Faculty of Computer Science and Eng.
St. Cyril and Methodius University
Skopje, Republic of North Macedonia
dimitar.trajanov@finki.ukim.mk

***Abstract*—It is widely known that finding an available parking slot during peak hour is a significant issue in cities. Drivers are spending large amount of time in search of a free spot where they can properly park their car. The purpose of providing these visualizations is to have a visualized preview of the data collected from different parking events, in order to spot improper parked vehicles, find causes for jammed areas, find places where there is a need for building a parking garage and etc. Considering the popularity and evolution of Internet of Things and their usage in the development of smart cities, these visualizations are providing crucial information. That information will help distinct areas that have a need of implementing some system regarding smart city, from another areas that are not that crowded and there is no need of any changes. All these benefits will also lead to reduction of expenses, pollution and traffic jams, while the income will rise.**

***Index Terms*—smart city, public parking, visualization, dashboard**

I. Introduction

The interest in the concept of smart cities has been increasing constantly. After the expansion of Internet of Things, the idea of creating a smart city seems to be much more realizable. As a result, consistent efforts are being made in the field of IoT in order to enlarge the productivity and reliability of urban infrastructure. Nowadays, parking is becoming one of the major problems for drivers in the cities, and it tends to become even harder as a result of the continuous increase of car users. Because of this, parking is limited in major cities including universities and major attractions all around the world [1]–[4]. For instance, finding parking space during major events such as during game day or graduation day is very challenging. Although parking lot occupancy could be significantly reduced by an increase of parking fee [5], that is not a durable solution and does not fix the problem. On the other hand, this situation can be seen as a motive for smart cities to take actions in order to reinforce the efficiency of the parking resources therefore leading to decrease in traffic congestion, air pollution and road accidents as well [6].

Considering the rise of urban population, the land reduction and traffic jams increase, it is beyond clear that the problems associated with parking impose significant societal costs, both economically and ecologically [7]. Furthermore, Manville and Shoup [8] surveyed the percentage of total parking areas in the central business district of different cities. Averagely, parking coverage takes 31% of land use in big cities, like San Francisco, and even more, 81% in Los Angeles and 76% in Melbourne, while at the lower end we find New York (18%), London (16%), and Tokyo (7%). Such a super high parking coverage density in Los Angeles can be a constraint on urban redevelopment [9]. Another alarming fact is that 100% of Parisian drivers ever abandoned their trips because of annoying and endless parking searches, while other drivers park their cars on unauthorized areas (Association for European Transport 2006). Concerning the phenomenon that common parking service could not satisfy the increasing demand of the private vehicle owners [10], we created a dashboard that provides analysis and visualizations of data regarding occupation, income and duration of various parking events. Using an existing parking system as a data source, a software was created in order to address the issue and help more efficiently and easily understand the meaning of collected data, as well as discover models and correlations between that data. The current works on smart parking, as a component/part of the concept of smart cities, are complex and multidisciplinary [9]. It is known for a fact that when implementing a smart parking system, a large amount of time is needed in order to inspect all the areas and their parking lots occupancy. Consequently, we created this dashboard which helps easily get the necessary information, by having a simple but very straightforward and visualized preview. As an example, if an area is spotted that has less parking slots occupied and at the same time has less traffic, then that will lead to a conclusion that in that area there is no need for implementation of smart parking systems or building new parking garage. In contrary, if a location that has a lot of traffic and no available parking slots is identified, then that will be an indicator of the need to take proper actions. Moreover, another benefit of having this type of textual data visualized is that it could be seen as a cause for further research like, why in some areas there are more parking events made compared to other areas? Is that a consequence of the larger parking fee in that area or is it a result only by its location? Actually, these are the issues that the city council should be aware of and if resolved properly they will result in increase of public transportation's use rate and cities' revenues, while reducing traffic jams, consumption and pollution. On the other hand, without this information there is a great possibility that an inadequate decision could be made, about where and what techniques and technologies to deploy, which later can lead to a large capital loss.

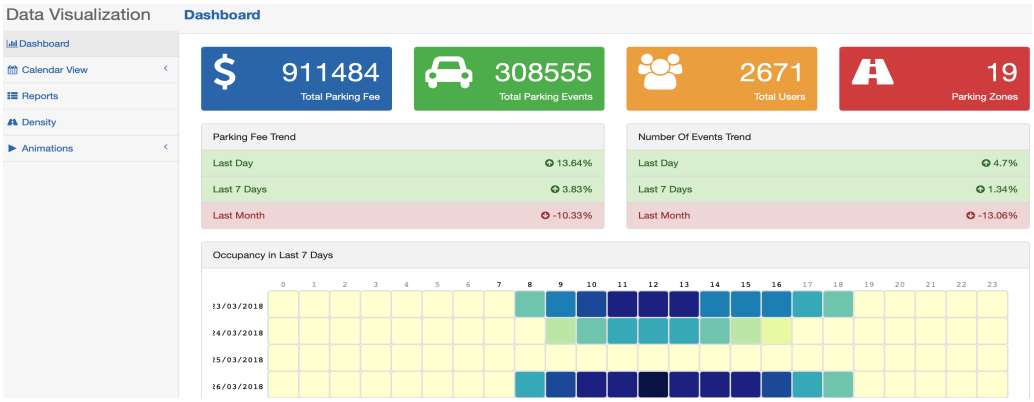

Fig. 1: Dashboard with summary view of data from parking events

II. Analytics and Visualizations

This paper analyzes and visualizes parking events from an existing parking system in order to understand the meaning of the data, to identify patterns and correlations that are not easily recognizable when in a textual presentation. The data used in our application is obtained from PARX Ltd., a company that offers parking systems to municipalities and parking operators around the world. PARX Ltd. system called - EasyPark Mobile System, has been used in many different countries among which is Bermuda. This system collects the data by locating the person when launching a new parking event. If that person is using the mobile application, the system, if allowed, gets the exact coordinates where the event started. Having in mind that all of the parking zones are geotagged in the system, if some user does not allow the application to send his exact location, then the coordinates of the parking zone are obtained. The data set consists of parking events starting from 01.01.2014 to 31.03.2018. Each parking event consists of the following attributes:

- STARTDATE - the date the parking event started
- STARTTIME - time when the parking event started
- ENDDATE - the date when the parking event is over
- ENDTIME - time when the parking event is over
- LONGITUDE - longitude where the parking event occurred
- LATITUDE - latitude where the parking event occurred
- DURATION - duration of the parking event in minutes
- CLIENT - identifier of the client who parked
- DAYTYPE - day of the week when the parking event occurred
- PRICE - parking event fee in dollars
- ZONEID - identifier of the parking area where the parking event occurred
- MONTH - month of the year when the parking event occurred

The application for visualizing parking events is implemented with the Django framework. The Django framework enables easy server-side implementation of the Python programming language in a web application. Bootstrap CSS is used for the design of the application and the D3.js library is used to display graphics, which enables easy drawing of graphics in JavaScript. In the following chapters, the visualizations will be explained and presented in detail.

A. Summary View

"Summary view" is the introductory page of the application. This page shows summary of parking information, where at the top of the page are summarized data and trends grouped into four groups, Figure 1.

- Earnings - Total earnings from all parking events in US dollars
- Parking events - The total number of parking events
- Users - Total number of different users who parked in the parking zones

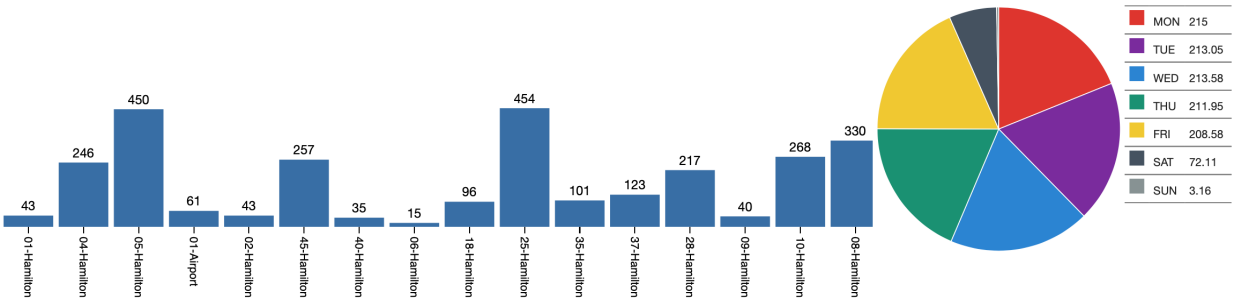

Fig. 2: Pie chart representing average parking event duration per day of the week and per parking area

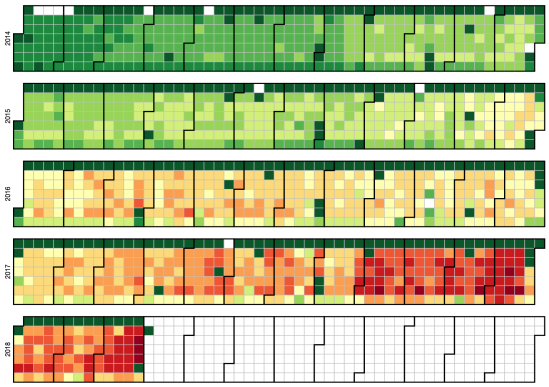

Fig. 3: Calendar view of total number of parking events per day, summed for all parking zones

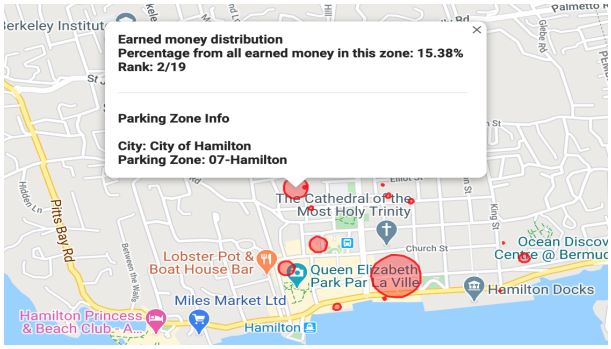

Fig. 4: Distribution of earnings from parking events by parking area

- Parking Zones - Total number of parking zones where one can park

This page also shows the earnings trend and the number of parking events, Figure 1. The percentage of increase or decrease is shown for each trend. Each of the trends displays the following information:

- Previous day - This shows the upward or downward trend in earnings or the number of parking events compared to the previous day and the day before.
- Previous 7 days - This shows the upward or downward trend in earnings or the number of parking events compared to the last 7 days and the 7 days before them.
- Previous month - This shows the upward or downward trend in earnings or the number of parking events compared to the last month and the month before it.

The Summary page also shows the time distribution of parking events in the last 7 days, Figure 1. The y-axis shows the dates of the last 7 days while the x-axis represents the hour (24 hour format) that the parking event started. The visualization shows the total number of parking events that started at a given hour and on a given date represented by density cubes where a larger number of parking events means a darker color displayed.

B. Calendar View

The ”Calendar view” visualizes parking events and earnings. Figure 3 shows the total number of parking events per day summed for all parking zones, so that the greater the number of parking events the more the color moves from green to yellow which represents some intermediate level and ultimately to red.

C. Distribution of Parking Events by Parking Area

This visualization shows the total number of parking events in each zone. Each zone is represented on a geo-map with a proportional circle where the center of the circle is the geo location of the parking zone, Figure 4. The radius of the circle depends on the total number of parking events in the zone, that is, the greater the number of parking events, the greater the radius and thus the larger circle on the geo map.

Clicking on one of the zones will display an info window showing parking zone information:

- Percentage of all parking events - What is the percentage of parking events in this zone out of the total number of parking events in all parking zones?
- Rank - Ranking compared to other zones in terms of percentage of parking events
- Parking zone information - Parking zone information such as name, number and city

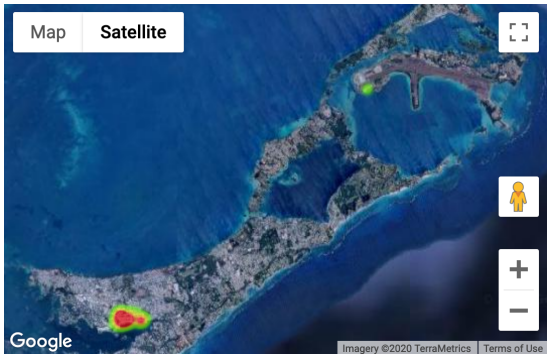

Fig. 5: Geographical distribution of parking events during workday

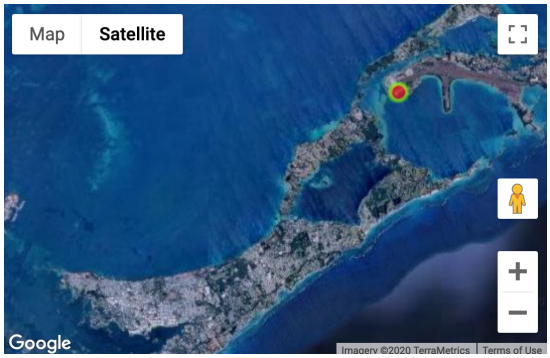

Fig. 6: Geographical distribution of parking events during weekend

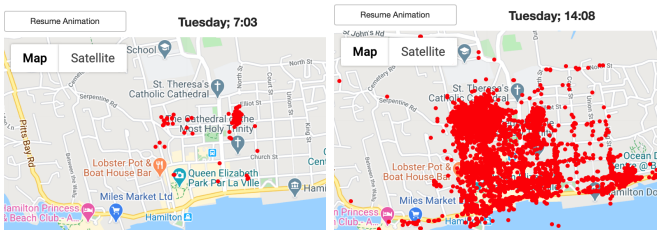

Fig. 7: Point map of parking events at chosen time and day

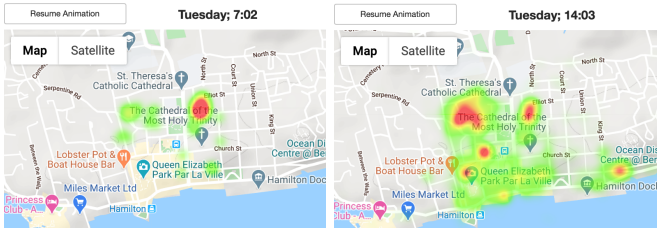

Fig. 8: Heat map of parking events at chosen time and day

D. Average Parking Duration Per Day of The Week and Per Parking Area

This visualization shows the average duration of a parking event in minutes per day of the week for each parking zone, Figure 2. On the right, the legend shows the average duration of a parking event for each day of the week. This average duration is calculated based on all parking events grouped by day from all parking zones. By clicking on the appropriate day, the graph changes and displays the average duration of a parking event for that day and for each zone respectively.

E. Geographical Distribution of Parking Event

In this part, on a map is shown the density of parking events for each day of the week. Because there is an identical distribution pattern for the days from Monday to Saturday, in this paper are shown the map of density of parking events for Friday and Sunday, Figure 5 and Figure 6. The geo location of parking events is obtained from the mobile apps for Android and iOS platforms. When the user launches the parking event through the mobile app, besides the parking data (parking zone, registration, user etc.) if available, data is also sent on the current location of the user (mobile device).

III. Animations

The animations depict parking events. Each parking event is displayed on a geo map depending on the start date and time of the event and stays on the map until the hour when the parking event is over. Two types of animations are visualized:

- Density animation of parking events. As shown in Figure 8, the animation applies to 28/03/2018 and there can be a different density of parking events at different times of the day.
- Detailed map showing each parking event. As shown in Figure 7. So , the animation applies to 28/03/2018 and a different distribution of individual parking events can be observed at different times of the day.

Conclusion

The constant rise of everyday car users and lack of available parking slots, results in having many improper parked vehicles and consistent traffic jams. Not only does this lead to large amount of driver's time wasted, but also increases the air pollution. When implementing a smart parking system as a component of a smart city, it is known for a fact that a large amount of time is needed for doing a proper research by inspecting all the areas and their parking lots occupancy. In order to help speed up that process, by having an easier way of pattern recognition and spotting repetitive problems, we provide a dashboard with simple and straightforward visualized preview of data. Another benefit of having different types of data visualized, like daily income, number of parking events per hour and area, as well as trends in earnings or number of parking events, is to show different companies from economical and ecological spheres how they could be affected and what they can do to improve the situation.

The next step that we are planning to do is to incorporate the collected data in a much bigger system which will be used for smart parking prediction and navigation to nearby available space in real time, according to data from previous similar events. The visualizations will help easily spot and distinct areas where there is a need of implementing this system, from areas that there is not.

Acknowledgement

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