# Geo-Time Broker: a Web Agent of Dynamic flows of Geo-Temporal Activity for Smart Cities

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**Abstract.** In the last years, the Smart City term has appeared in roadmaps and digital agendas for many public administrations in both regional and national contexts. Following this trend, many cities have made important efforts to deploy a network of sensors with the aim of gathering a huge amount of networking related data. Most of these cities are publishing their data through Open Data portals in order to facilitate access and re-use of these data by third parties. Unfortunately, just 5% of the gathered data are currently processed; therefore, the actual contributions extracted from the usage of these data are far from the potential benefits that they may offer. This work presents a first prototype based on the Geo-Temporal Dynamic Activity Flows concept that ease processing and consuming these data. These Dynamic Activity Flows are based on the usage of a resource commonly used to represent cities, their maps.

**Keywords:** Smart Cities, Intelligent Data Flows, Open Data.

## 1 Introduction

The 21st century is destined to be the century of cities. According to studies by the United Nations Organisation (UNO), in July of 2007 urban population exceeded rural population in the world. Moreover, the forecast is that this proportion will increase considerably over coming years, to the extent that, according to some estimates, in the year 2050 practically 70% of the world's population may be urban and many cities will have more than 10 million inhabitants [1][2].

The Smart City concept [3] has been developed over recent years with a sharp focus on the introduction of sensor systems, measuring and control infrastructures, and closely connected to energy efficiency and optimisation [4]. Recently, the model has been reconceived in accordance with the demands of the different actors who intervene in a city on the improvement and everyday usage of the new technologies [5], until reaching the well-known present-day smart city concepts such as government [6], mobility[7], energy and environment[8], etc.

So far, any city that has decided to set in motion the advantages that technology lavishes on us solves its problems by using the aforementioned technologies, and has made significant investments in physical devices and infrastructures [9]. Over these last few years the introduction of data acquisition systems has increased exponentially. This new infrastructure is generating a huge volume of city activity data [10] that are originated from multiple sources and coming in extremely diverse formats, normally conceived with different ends, methods, profiles, production rates and consumption rate. In this sense, it is acknowledged that the availability of an open data portal providing accurate public data is one of the foundations of Smart Cities [11] [12]. So, many Smart Cities are releasing great part of their data through these portals trying to encourage the reuse and combination of such data by third parties. Even though, we are faced with a situation where, in some cases, we are only capable of processing 5% of the whole mass of data [13].

These are highly relevant data, that should be considered when designing and developing the cities of the future (re-designing the cities of the present). The proper evolution of cities is of utmost importance, since they have a huge impact on the economic and social development of the regions they belong to. They are authentic platforms where people work and live, where companies perform their activity, where the public authorities must work for the wellbeing of their citizens.

To date, the solutions proposed have been disjointed, actions put into practice because of fashions or through the deployment of a certain known technology, but without a perspective of the specific necessities of the city. The challenge is no longer the evolution and development of the technology, the problem is no longer the generation and acquisition of data – now we are faced with new challenges and new problems concerning the treatment of these data. At present, these affairs have little to do with the technological infrastructures of the city and data gathering, but they are closely related to the treatment and transformation of these data into information.

Therefore, it is important to design a system that aids the transformation of this data diversity into information according to the user profiles of citizens who are consumers within the city system environment. Under this concept we define Business Intelligence (BI) [14][15]. BI is described as the capacity to create analytical models to aid decision making, as well as the determination of business keys [16]. Following the study of these models the idea of Business Analytics (BA) arose [17]. We define BA as the people, processes and technologies needed to analyse the past, in order to understand the operation of an organization and be able to predict the future, and hence take actions accordingly [18]. Definitively, the objective of BI and BA is to transform data into useful and relevant information (in time and format) for the consumer.

Bearing these ideas in mind, this paper presents a prototype called Geotime Broker, a Web Agent of Dynamic flows of Geo-Temporal Activity for Smart Cities for the design and visualization of the behaviours of Smart Cities. This prototype tackles the complexity generated by the increasing volumes of data generated by the city based on their encapsulation into the concept called Dynamic Activity Flows (DAFs) for the Smart City.

The rest of the paper is organized as follows: section 2 introduces Geo-Time Broker and section 3 describes the first case where it has been applied to, the school allocation of freshman primary students.

# 2 GeoTime Broker

In this section we firstly provide the definition of DAFs. Then, the main goals of the approach (GeoTime Broker) are presented together with an application scenario where a first prototype has been developed.

## 2.1 Dynamic Activity Flows

The DAFs concept is inspired by the traditional representation that has been used over the history for representing cities, the map. The maps have been always used as a geo-referencing frame for the different facts that occur in a city. So, based on this assumption, it is natural to use this tool for representing the knowledge that is generated from the Smart City data considering three different dimensions: i) what, i.e. the data that are being represented; ii) where, i.e. their geo-localization based on the coordinates and the influence areas; iii) when, i.e. the temporal range when this information has been generated.

The combination of the aforementioned dimensions conforms the concept of DAFs, being an entity at a higher abstraction level than just the data. In other words, this concept comprises the result of selecting, processing and combining data and showing how these data are generated in a particular temporal range in a city.

## 2.2 Goals

Geo-Time Broker aims at easing the next activities:

1. Setting a framework for the design of behavioural patterns by identifying, orchestrating and processing data sets that a city generates,
2. Setting an interface for the definition of intelligence rules, processing capabilities and scaling analytics for the data generated so that they may be dynamically transformed into useful and relevant information according to the consumer profile,
3. Designing visualization and interaction capabilities for the DAFs that allow the users to build behaviours based on the three dimensions over a particular range of city data in a flexible way,
4. Incorporating self-adaptation capabilities that allow discovering new behaviours based on machine learning and reasoning.

## 3 Application scenario: school allocation of freshman primary students

This section describes an application scenario that has been used to illustrate the first version of the prototype that has been built for Geo-Time Broker. This scenario tries to solve the problem of allocating new students at the primary schools of a city. This is a recurrent problem that most cities in Spain (and other countries) must face at the beginning of every academic year. To tackle the problem, not only the existing schools in the city must be considered but also the population around each school. However, there is a challenge that has not been solved yet: would it be feasible to dynamically and automatically adapt the influence area of each school according to the actual population (at any time) and necessities around each school?

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Currently, solving this problem is complex since performing any change at real time becomes highly expensive (in both, time and effort). However, based on the usage of DAFs we may combine and orchestrate the locations of the schools over the city map and define, for each one, the optimum capacity of the classrooms or the estimated surrounding area according to the actual population, the families with children in scholar age, the distance to the homes by walking, the combination of public transports for reaching the school and the number of private vehicles existing within the context of the school. This may be automatically and optimally provided in a system that covers the whole city. Moreover, considering the time dimension, this information may be also compared with rush-hour traffic according to the entrance and exit times for schools so that graphical simulations with different DAFs configurations may be executed at real time. So, a visualization dashboard may be created that offers the optimal information for taking the corresponding decisions according to the current data. A first version of this prototype has been deployed for the city of Cáceres, in Spain. For this city, the prototype already includes all the needed data for the design of the DAFs for the problem described. Thus, the prototype uses open datasets provided by the city of Cáceres through its open data portal. Concretely, they are using a dataset with information of the schools[1] of the city and a dataset with the census[2] of the city.

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[1] http://opendata.caceres.es/dataset/centros-docentes-caceres

[2] http://opendata.caceres.es/dataset/informacion-del-padron-de-caceres-2017

For this particular case, the prototype is using two different approaches to solve the problem. The first approach prioritizes that the occupation ratio of schools is as high as possible. That is, in the first implemented algorithm each school tries to “greedy” get as many students as it can even if those students live in areas far from the school. So, Fig. 1.a. shows that the outcome of this approach is that that the first schools handled by the algorithm are getting more students than the last ones, no matter how far the location of the students is. On the other hand, the second approach prioritizes the distance from the students location to the schools. So, Fig. 1.b. shows the outcome of this approach that seems, for this city, a more rational distribution that the one obtained with the first approach. Obviously, this case may be easily extrapolated and applied to other similar situations in other cities.

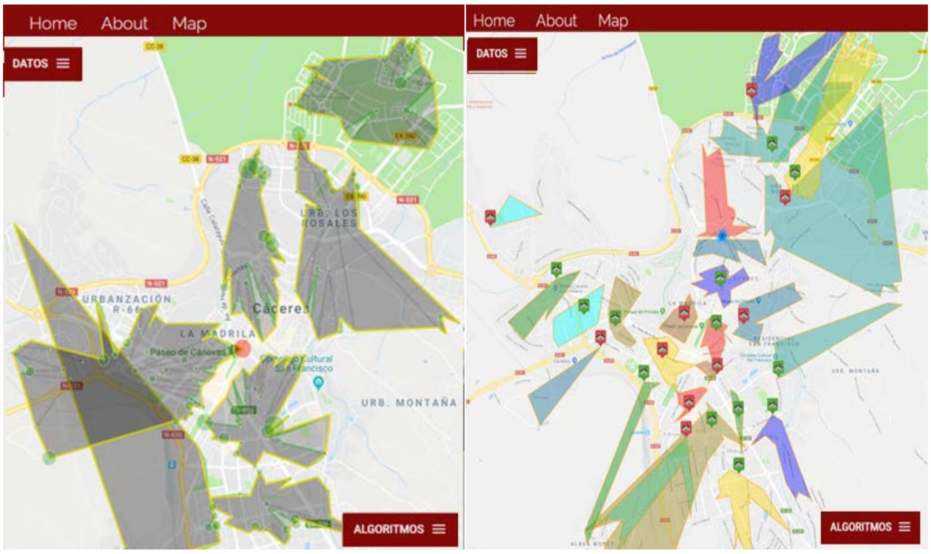


**Fig. 1.** a. Allocation prioritizing occupation ratio b. Allocation prioritizing students distance

# 4 Conclusions

This work has presented the first version of the Geo-Time Broker prototype that uses DAFs of a Smart City to design and visualize complex behaviours in the city based on maps. Moreover, an application scenario has been introduced that allows illustrating the potential benefits of the approach. Other application scenarios that the approach may be used for and that provide contributions are the next:

1. Create graphical market analyses at real time about the DAFs based on the combination of contextual data, geo-population, concrete facts georeferenced and other data sources. Notice that the term of market analysis is used here in the most wide sense and going beyond just buying and sell opportunities.
2. Perform analyses based on visual patterns about DAFs in the cities to evaluate different actions such as economic or social investments. Similarly, an adequate

roadmap for cities may be identified with concrete actions that are prioritized according to the data.

3. End-user development of DAFs based on auto-design or auto-consumption as a Self-Service Smart City Service.
4. Creation of visual projections and predictions by means of machine learning algorithms applied to DAFs designed by consumers in order to support decision making.
5. Implement a high level dashboard for intra and inter city DAFS. This dashboard will allow managing, displaying and comparing the behaviour of DAFs from different geographical locations.

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