Big Data in Real Time for the Management of Tourist Destinations: The TOURETHOS Platform Technological Model

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Abstract Big data is one of the main existing promises for improving the management of tourist destinations. The acquisition of large amounts of data from different sources, their consolidation and exploitation by means of artificial intelligence algorithms will allow the achievement of various objectives for destination management, such as understanding tourist flows, an increase and better distribution of tourist spending, improving the quality of life of residents and achieving better sustainability. Additional benefits could even be obtained if this big data were to be managed in real time. To achieve these objectives, it is necessary to have high quality and reliable data sources. This article describes a technological platform called Tourethos, which allows active collaboration between different stakeholders to collect data on the movements of tourists in the territory based on their connections to Wi-Fi networks in the area. This data source has interesting and valuable characteristics: it is relatively simple to collect, it can be easily anonymized and it offers a sufficient level of precision to draw valuable conclusions for the management of tourist destinations in real time.

Keywords Big data · Software architecture · Smart destination

1 Introduction

In general, there is an expectation that big data will help improve the management of tourist destinations (Ardito et al., 2019). Obtaining massive data from different sources, consolidating it and exploiting it by means of artificial intelligence algorithms will make it possible to achieve various goals for improving destination

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management. For example, improving the flow of tourists, enabling a better distribution and an increase of spending, improving the quality of life of residents and increasing sustainability. Big data is considered one of the foundations of smart tourist destinations (Shafiee et al., 2021).

There are numerous definitions and characteristics of big data. But an analysis of them allows us to summarize its differential characteristics into two main ones: volume and variety (Xu et al., 2020). In other words, we can say that we have big data when we consolidate different data sources, some of which are massive ones. Numerous data sources are mentioned in the literature to create big data, such as social networks, tourist movements captured based on their phones or their spending, and online traces in the search and booking process (Li et al., 2018), among many others.

An alternative that allows to complement the previous sources is the monitoring of the movements of tourists in the destination based on the Wi-Fi points to which they connect. This article describes a technological platform called Tourethos, which has been developed within the international Welcome2 project. This platform allows active collaboration between different participants, public administrations and private companies, to collect connection data to a series of Wi-Fi hotspots, as well as other additional functionalities that are part of the strategy of a smart tourist destination: the cross-selling of products and the creation of destination intelligence in real time based on the collected data.

2 Literature Review

Smart Tourist Destination. The concept of Smart Tourist Destinations (STD) is usually based on that of smart cities (Gretzel, 2018). A smart city is a city that is able to improve the quality of life of its residents while making the city more competitive (Boes et al., 2015). One of the main authors in the field of smart cities, Cohen (2014), mentions six dimensions that characterize them: smart governance, smart environment, smart mobility, smart economy, smart people and smart life.

Based on this, an STD can be defined as a destination that leverages on technology to improve the sustainability of the tourism that takes place at the destination, to improve the quality of life of residents of the destination, and that promotes accessibility and integrates visitors with residents. An STD must consider multiple domains and perspectives. For example, Bulchand-Gidumal (2022) proposes an integrated model for STD development based on Cohen's (2014) model for smart cities. Bulchand-Gidumal's (2022) model consists of 18 dimensions grouped into 6 main domains: smart economy, smart sustainability, smart residents, smart mobility, smart tourists and smart governance.

Definition of big data. The term big data usually refers to two concepts. On the one hand, to the data, to the databases that build big data and that must present some differential characteristics to be qualified as such. On the other hand, big data platforms, that is, flexible and scalable software that processes and analyzes the data,

usually with artificial intelligence techniques, and that makes it possible to explain and predict the behavior of a population or the operation of an infrastructure, among many others.

There are several definitions of big data in the literature. These definitions usually mention different characteristics that allow qualifying big data. Attributes beginning with the letter 'v' are sometimes mentioned. Among others, volume, variety, velocity, variation, validity and value are cited (Kitchin, 2013). Among all of them, we believe that it is possible to summarize the differential features of big data into two: volume and variety (Xu et al., 2020). These two features implicitly include many of the other ones often mentioned. For example, volume is usually associated with a high velocity of data generation.

In terms of what distinguishes big data platforms, it is the computational load required to process this data. Big data belongs to the group computational problems whose resolution time is exponential to the size of the problem. From this point of view, what determines whether software is big data is the architecture that supports the processing of the data. The software must be able to adapt to changes in data growth, depending on the processing requirements. At present, there are already architectures (e.g., Lambda) and computing paradigms (e.g., Map Reduce) that are adapted to this type of need.

Big data sources. The review by Li et al. (2018) classifies big data sources in tourism into three main categories: user-generated content (UGC), device data, and transaction data. UGC is found on social media, which in turn includes social networks, review sites such as TripAdvisor, and blogs. Device data, on the other hand, comes from users' cell phones, which leave traces of their movements at the destination, and from other traces derived from Bluetooth and Wi-Fi connections (Lee et al., 2023; Xu et al., 2020), either from the cell phones themselves or from other types of devices. This last type of connection is the focus of this article. Finally, transaction data refers to the operations that the user performs online, both before and during the trip, such as searches, bookings and purchases.

Other data sources can be added to these three. First of all, the data that can be obtained through classical research methodologies (for example, interviews, questionnaires and focus groups) and that can help to qualify the previous sources. Second, the databases of public administrations (for example, urban planning permits or vehicles in circulation), of companies operating in the tourism sector (for example, customer consumption in hotels), and open databases that may exist.

3 Objective

It has been suggested in the literature that mobile phones can be one of the sources of big data, since these devices leave a trace when they connect to Wi-Fi points, Bluetooth devices, and the antennas that provide the cellular signal. In the specific case of Wi-Fi points, in a geographical area, each point usually belongs to a different

business operating in that area, which makes the collection and integration of data almost impossible. The objective of this contribution is to describe the technological architecture of a system designed to create a common Wi-Fi network in a territory in order to integrate the information generated by the devices in the territories when connected to this common Wi-Fi network.

4 The Welcome2 Project and the TOURETHOS Platform

As described above, there are different data sources that can be part of the big data of an STD. One of these sources that has not yet received much attention, either from an academic or a business point of view, is the acquisition of data on the flow of tourists in the destination based on their connections to existing Wi-Fi points while at the destination (Lee et al., 2023). The Welcome2 project, officially called *MAC2/1.1b/374: Welcome2, Destination Intelligence: A Strategy to Analyze Tourist Behavior in Tourist Destinations*, was developed to take advantage of this opportunity. This project obtained funding in the MAC call for territorial cooperation between Madeira, the Azores and the Canary Islands, as well as a number of third countries: Cape Verde, Senegal and Mauritania.

The Welcome2 project is part of the joint smart tourism strategy of three municipalities in the Canary Islands: Mogán, Teguise and Granadilla de Abona, whose main objective is to generate intelligence through digital technologies. The three African territories admitted to the MAC projects also participate in this project: Cape Verde, Senegal and Mauritania. In turn, the project was born thanks to the encouragement and support of the consulting firm EPC, specialized in innovation for the public sector and the network economy. Finally, in addition to the three municipalities mentioned above, there are a number of partners involved in the project. The Fundación Canaria Universitaria de La Palmas is involved in the development of the platform. On the business side, different orgnaizations are part of the project: the Lanzarote Tourism Federation; the Federation of Hospitality and Tourism of Las Palmas (FEHT); the Business Association of El Médano (ASEC El Médano); the Operational Nucleus of Information Societies (NOSI) of Cape Verde; the Agence de l'Informatique de l'Etat (ADIE) and the Senegal Office of Organization and Method (BOM) of Senegal; and the General Directorate of Information and Communication Technologies (DGTICS) and the National Tourist Office (ONT) of Mauritania.

Finally, the scientific part of the project is led by the University of Las Palmas de Gran Canaria, with the collaboration of the Piaget University of Cape Verde, the Faculty of Sciences and Techniques of the Cheikh Anta Diop University of Senegal, the Assane Seck University of Ziguinchor of Senegal and the University of Nouakchott Al Aasriya of Mauritania.

For the development of the Welcome2 project, a technological platform called Tourethos (*tourism* + *ethos*, behavior in Greek) has been created. This technological platform allows the collaboration between the different municipalities to implement

an intelligence strategy in the destination. In turn, it allows the development of a public–private cooperation strategy with companies that provide tourist services.

4.1 Description of the TOURETHOS Platform

The Tourethos architecture consists of sensors that collect data about the presence of a tourist in an area. The hardware of these sensors is a Wi-Fi access point. This Wi-Fi access point is installed on top of the Internet access that the establishments (e.g., accommodations, restaurants, cafes, hairdressers, stores) in the tourist area already have and creates a Wi-Fi network that has the same network identifier for all the access points in the area, thus allowing the tourist's device to connect directly to the Wi-Fi network when entering a new establishment. For example, a tourist may connect to the network created by the project when they arrive at the destination, in the first establishment they go to, as could be the hotel in which they will stay. Later, while moving around the destination, their device would automatically connect to the Wi-Fi network at the restaurant they may go to or in a store they may enter, without having to perform any validation operation. Given the project in which the action is framed, in each tourist destination in which the points are installed a different Wi-Fi network identification will be generated, with names such as Welcome2Mogán, Welcome2Teguise and so on.

In a pilot phase, 200 access points were deployed in each territory, using the existing internet connections of shops, hotels, restaurants and tourist offices. With more than 1,000 devices deployed, the first functionality offered by the platform is device control. This is, remote monitoring and diagnosis. For example, devices need to be monitored to know how long they have been running and if they are online or offline. It must also be possible to update the firmware of the devices to guarantee security. To this end, the Tourethos platform includes a management tool (Fig. 1) in which all the access points that are deployed in the territory are registered. With this tool, each territory has an inventory of all devices with their serial number, model, brand and installed firmware version. In addition, it is possible to remotely update the firmware or manage the captive portal that is displayed to users when they connect.

At the locations where the Wi-Fi access points are installed, two subnets connected to the Internet Service Provider's (ISP) router are created: a corporate subnet and a guest subnet. This separates network traffic into corporate and guest traffic, allowing businesses to achieve greater security. This allows organizations to offer Wi-Fi to their customers without compromising the security of internal traffic because the corporate subnet cannot be accessed from the guest subnet. This configuration prevents corporate traffic from being seen by guests. In addition to improving security, it also improves network speed and performance by reducing network congestion and load (Fig. 2).

As already mentioned, the main characteristic of the deployment of these access points in the territory is that they all offer the same SSID, that is, they all have a Wi-Fi network with the same name. It is enough for the user to connect to one of the access

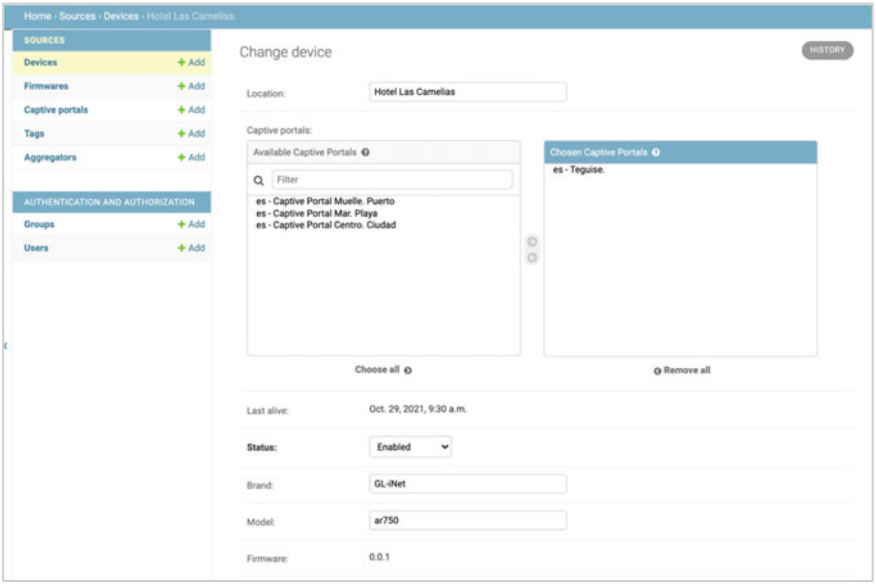

Fig. 1 Device control in the Tourethos platform

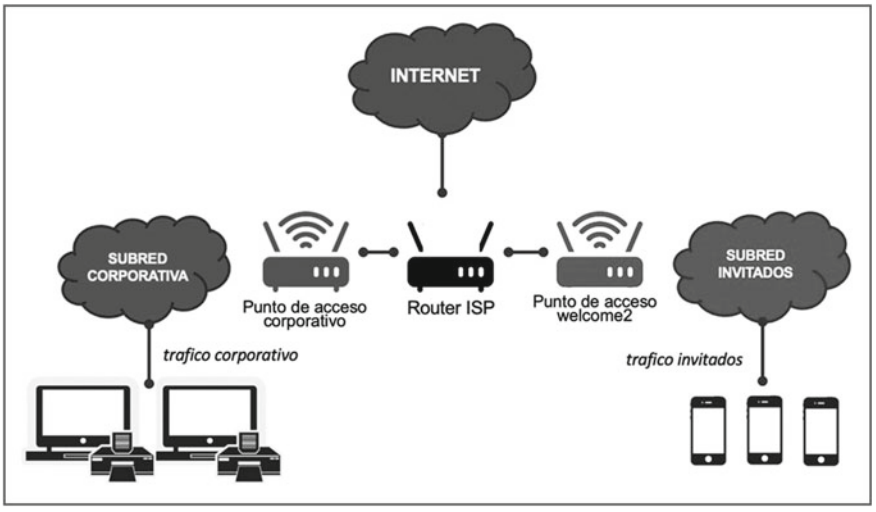

Fig. 2 Installation of Wi-Fi access points on ISP routers

points in order to have automatic access to any of the other access points. This is due to the fact that when a device has the Wi-Fi connection enabled, it will automatically connect to a network with an SSID that it has already connected to before. In this way, it is possible to offer a Wi-Fi service to tourists and citizens, taking advantage of the internet connections that the businesses have already contracted. Many authors point out the importance of free Wi-Fi access in a tourist destination (Magasic & Gretzel, 2020; Noorhaiza et al., 2017).

In the access points a software is installed to monitor the connections: *tourethos-monitor*. This possibility of installing software in the access point is one of the advantages of the operating system that the installed devices include by default (OpenWrt). In addition, it allows access to the MAC addresses of the connecting device, through which a user can be uniquely identified. The function of *tourethos-monitor* is to generate a message (event) and send it to a cloud server when a user connects to the access point. This message contains the time, the MAC address of the connected device and the geographic location in the form of a label from which the geographic coordinates can be obtained. The *tourethos-sensor* module is in charge of this functionality. The events generated by the sensor are sent to the cloud, where a service, *tourethos-datahub*, records them. *Tourethos-datahub* is a fully managed service that can send both real-time and batch data streams for processing.

This process of integrating data from different devices, while keeping the data conceptually separated on the platform and, when appropriate, between different platforms, is one of the strengths of the system and one is of great importance. In this way, each participant in the project can be offered a data analysis tailored to their needs, while respecting the confidentiality and use of the data. The different businesses participating in the project will have access to a dashboard that will allow them to see the (anonymous) behavior of those who have connected to the point/points of their establishment/establishments. In addition, they will have access to aggregated data on the behavior of other businesses so that they can make comparisons. For example, the total time the person spends in the establishment or the rate of repeat customers.

In turn, and in the same way, the tourist offices participating in the project will have a control panel that will allow them to observe the behavior of tourists in the destination, from routes in it to other data derived from questions that can be asked to tourists connected to the network. Where appropriate, it will be possible to make aggregate comparisons regarding the behavior in other destinations of the project.

In Tourethos, data is stored redundantly and protected against unauthorized access. Each of the countries involved in the project has its own set of restrictions regarding data storage and access. For example, in the case of Senegal there is the restriction that the data can only be stored in the country's own data centers. The configuration of the project respects this type of restrictions.

Tourethos data storage services can be deployed independently, so that each territory has the possibility of storing data in compliance with current legislation. In other words, each territory has the power to deploy an independent storage service so that it can autonomously protect its own data, without prejudice to the fact that they can also cooperate to have a shared data infrastructure.

However, there may be scenarios in which these data may be used by third parties other than the organizations that collect them. In fact, in the Welcome2 project, the transnational research network ACODE is formed by the aforementioned University of Las Palmas de Gran Canaria, University of Piaget, Cheikh Anta Diop University, Assane Seck University of Ziguinchor and University of Nouakchott Al Aasriya. One of the commitments of this research network is the sharing of data with the aim of carrying out joint publications in scientific journals.

To this end, a component was added to the Tourethos architecture that allows the aggregation of data from the territories. This component allows consolidated data to be analyzed in research papers. In this way, the Tourethos platform also becomes a vehicle for collaborative research, involving the territories themselves in research that can contribute to better management of their destinations. This functionality is specified in the management environment of the Tourethos platform through an operation that allows the sharing of data with other organizations. One of the characteristics of this functionality is that what data is shared and for how long is under control.

5 Results and Discussion

The implementation and development process of STD presents many challenges for destinations. The STD concept is complex and involves multiple dimensions and domains. This project touches on several of these dimensions. First and foremost, as mentioned above, and following Bulchand-Gidumal's (2022) model, it touches the IT and data dimension. Indeed, the data sources for big data are multiple and diverse, and the richer and more diverse they are, the more valuable and interesting information can be obtained from their processing.

So far, connections to Wi-Fi hotspots have been mentioned in the literature as a possible source of data (Li et al., 2018), although they have not been studied in detail. The main reason is that in an area, each Wi-Fi access point usually belongs to a different network, so obtaining joint information from these connections would be extremely difficult. This project proposes the creation of a common Wi-Fi network at the destination that, by analogy with cellular networks and antennas, allows devices to connect to the different points of the network in a seamless manner, without user intervention.

Compared to a typical situation, the proposal is very advantageous for tourists, since it allows them to connect to Wi-Fi networks in a similar way as they do with the mobile phone network. In this sense, it must be taken into account that a certain part of the tourists who go to the destinations participating in the project (Canary Islands, Cape Verde, Senegal, Mauritania) come from areas where there is no international roaming agreement. Tourists arriving in the Canary Islands from the European Union have access to this international roaming, but those arriving from the United Kingdom after Brexit or from third countries such as Russia or Asian countries do not. This situation extends to all international tourists arriving in Cape Verde, Senegal and

Mauritania. Therefore, for these tourists, the smooth use of this Wi-Fi network can be extremely convenient.

For the companies participating in the project, the main advantage is that they will have access to real-time information on what tourists are doing at the destination. All companies that participate in the project and therefore contribute data to the platform will have access to processed and anonymized information on the behavior of tourists. For example, where tourists come from when they arrive at a particular establishment, what their next visits are, or what kind of consumption they make at the destination. In addition, in the connection to the Wi-Fi network a welcome webpage is shown, in which a cross-selling of products can take place.

From the point of view of the participating universities, the project represents a qualified data source with valuable characteristics. First, it has not been discussed in the literature. Secondly, it allows to obtain data in a simple and anonymous way, which has not been possible until now. As we know, data is generally owned by the companies that generate it, and therefore access to data based on mobile phone movements or purchasing behavior has been possible, but extremely expensive. In this case, data that is generated in a distributed way in each company, is then consolidated anonymously and can be exploited at the research level by universities.

In short, and as can be verified, what the project allows is the cooperation between different stakeholders operating in the destination in a distributed way, generating data sources of great value and interest to understand the behavior of tourists and, based on this, to offer them products and services better adapted to their interests. Thus, and although we have already commented that this project is mainly oriented towards the IT and data dimension of the model of STD presented, we see that it also affects other dimensions: Marketing and promotion. Facilities and experiences, Sustainable tourism economy and Support services.

Even the generation and development of the type of data proposed in this project will allow the development of actions that would be part of the Entrepreneurship and innovation dimension, by having data on tourist behavior that will subsequently allow the development of new actions in this area.

One aspect that has been particularly relevant in the development of the project is that of privacy. To this aim, the user agreements that are presented to tourists have been thoroughly analyzed, taking into account the specificities of the participating countries. In addition, all the necessary precautions have been taken to mask the data stored in the databases, so that it is possible to have a profile of the movements of a tourist in the destination, but without being possible to follow the reverse path of identifying the tourist starting from these data on movements and connections.

As mentioned above, the proposed solution has been experimentally tested in a pilot study based on the development of both sensors and services for public administrations, tourism companies and academia. Collaterally, it has been possible to provide universal Wi-Fi access to tourists in destinations where it has been implemented. The user experience is that of feeling at home, with Wi-Fi access always available wherever they are.

This research shows a new source of data that can be used by tourism stakeholders (destinations, researchers, businesses) in order to better understand the behavior of tourists while at the destination.

6 Conclusions

In the process of developing smart tourist destinations, a key issue is the availability of high quality and diverse data sources for the creation of destination big data. So far, different data sources have been mentioned in the literature. One of them is device related, although in general it is more associated with the use of mobile phones or GPS devices. In this manuscript, the Welcom2 project is presented in which data is generated through the connections of tourists to the Wi-Fi hotspots available in the destination thanks to the Welcome2 project and the TOURETHOS platform. The project and the platform are developing a common Wi-Fi network for all the establishments in the destination. This allows tourists to connect continuously and frictionless to every participating Wi-Fi hotspot. At the same time, data is generated and consolidated in the destination's big data database. In addition, with the presented platform, this data can be exploited in real time. What has been developed in this project is a first pilot that will be strengthened in the coming years with the integration of other types of data already available in the different destinations, with the aim of better understanding the behavior of the tourist and thus improving the management of the destination, moving towards the concept of smart tourist destinations.

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