Studying individualised transit indicators in the metropolitan area of Granada using a new low-cost information system

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Resumen Given the benefits of an information system about the traffic intensity and about the usage of vehicles, in this paper, a new low-cost information system to monitor the traffic in real-time is proposed.
Current information systems used for data collection and to generate information on the state of the roads have two drawbacks: the first is that they have no ability to identify and target the vehicles detected. The second is their high cost, which makes them expensive to cover the secondary road network, so they are usually located just on main routes. In this paper we propose a system based on scanning bluetooth devices that are near the detection node. This is an unique identifier that allows to know the manufacturer and even distinguish what type of device it is (PC, mobile phone, handsfree, etc).
We intend to collect large amounts of data from passes of bluetooth devices by different nodes (movements or displacements). Thus we could determine the frequency of appearance, calculate speeds between nodes, or calculate the number of devices that pass certain site each day (on both working or non-working days).
Statistics will be obtained and thus several indicators relating to the use of vehicles by the population of the monitored area will be studied.
Palabras clave: DGT, SINECA, traffic, exposure indicators, new technologies, bluetooth, monitoring

1. Introduction

Having a system of information on traffic conditions and the use of roads by vehicles seems key in the current context. With a population increasingly informed, provided with communication devices ubiquitous commonly used about 90 % of the population, obtaining information about the traffic in any of the nearly 20,000 kilometers of roads, would mean to optimally manage a communications network vital for a high percentage of users.

The application of this proposal in the transportation system will involve having an information system on the traffic status.

Our ultimate goal is to have information about traffic flows that occur in a certain area, allowing to optimally manage motion decisions by citizens.

Therefore, various needs from the viewpoint of the transport management have been found:

- A versatile and autonomous data collection and monitoring device is needed.
- It is also necessary to collect traffic data in real time.
- Once the data has been collected, it has to be processed properly.
- And finally, a system that allows sharing data and information with those who make decisions about mobility is needed, both from the institutional and personal points of view.

In this work, a system based on bluetooth (BT) device discovery is proposed. Specifically, it will catch waves emitted by different technological components incorporated on vehicles (handsfree, gps), accessories that the users incorporate to their vehicles, as well as their mobile phones. The main data that is collected is the MAC address of the device BT card. This is an unique identifier for each device, allowing us to identify passing vehicles. From the point of view of data privacy, it is noteworthy that the data collected will not be associated to any user because there is no information that enables the identification of the information we collect with a specific person. Encryption technology unidirectional with nonstandard characters that preclude identifying the MAC of the wireless device is used. Thus, intrusiveness is minimal. A large amount of data related to passing BT devices will be collected, to calculate statistics and to study several indicators about the use of vehicles by the monitored area population.

The rest of the paper is organized as follows: In Section 2 current technologies to monitor the traffic that passes through a certain area is summarized. Section 3 details the goals of this paper. In Section 4, the Intelify device is presented. In Section 5 several analysis and statistics are reported from the data obtained. Finally, we present some conclusions and future work (Section 5).

2. Current technologies

Traffic detection technologies can generally be classified into two groups: intrusive and nonintrusive.

Intrusive detection technologies are installed on/within the roadway, which require lane closures. Using this type of technology is inherently more hazardous and is generally more time consuming, especially for temporary traffic data collection. This technology has a number of drawbacks:

- Installation requires pavement cut.
- Improper installation decreases pavement life.
- Installation and maintenance require lane closure.
- Detection accuracy may decrease when design requires detection of a large variety of vehicle classes.

- Poor pavement condition can dramatically shorten the life span of intrusive sensors.

Non-intrusive technologies are traffic detection sensors that cause minimal disruption to normal traffic operations during installation, operation and maintenance compared to conventional detection methods. They can also be deployed more safely than conventional detection methods and are deployed adjacent to the roadway and require minimal interaction with traffic flow. These are mainly of two types: active (microwave radar, ultrasonic and laser radar), o passive (infrared, acoustic and video image processing).

Figure 1 shows a classification of information systems according to the intrusiveness of the technology.

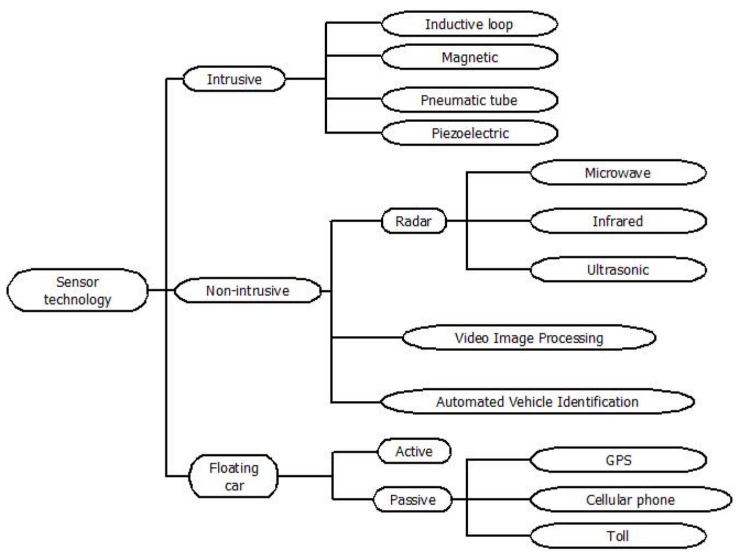

Figure 1. Information systems classification, according to the intrusiveness of the technology.

Main technologies currently used in traffic monitoring include pneumatic tubes, loop detectors, floating vehicles or automatic recognition systems, among others.

Manual counts is the most traditional method. In this case trained observers gather traffic data that cannot be efficiently obtained through automated counts e.g. vehicle occupancy rate, pedestrians and vehicle classifications. The most common equipments used are tally sheet, mechanical count boards and electronic count board systems.

Passive and active infra-red sensors are based on detecting the presence, speed and type of vehicles using the infrared energy radiating from the detection area. The main drawbacks are the performance during bad weather, and limited lane coverage.

Microwave radar can detect moving vehicles and speed (Doppler radar). It records count data, speed and simple vehicle classification and is not affected by weather conditions. *Ultrasonic sensors* devices emit sound waves to detect vehicles by measuring the time for the signal to return to the device. They can be affected by temperature or bad weather.

Pneumatic road tubes are placed across the road lanes to detect vehicles from pressure changes that are produced when a vehicle tyre passes over the tube. The pulse of air that is created is recorded and processes by a counter located on the side of the road. The main drawback of this technology is that it has limited lane coverage and its efficiency is subject to weather, temperature and traffic conditions. This system may also not be efficient in measuring low speed flows. *Piezoelectric sensors* are very similar to pneumatic road tubes, although the principle is to convert mechanical energy into electrical energy. Indeed, mechanical deformation of the piezoelectric material modifies the surface charge density of the material so that a potential difference appears between the electrodes. The amplitude and frequency of the signal is directly proportional to the degree of deformation. This system can be used to measure weight and speed.

Magnetic loops (inductive, magnetic, or video processing based) may be used temporarily or permanently, the latter being the more usual. It is the most conventional technology used to collect traffic data. The loops are embedded in roadways in a square formation that generates a magnetic field. The information is then transmitted to a counting device placed on the side of the road. This has a generally short life expectancy because it can be damaged by heavy vehicles, but is not affected by bad weather conditions. This technology has been widely deployed over the last decades. However, the implementation and maintenance costs can be expensive.

The use of so-called *floating vehicles* consists on a vehicle provided with sensors to collect information while driving on a predefined route. This active device data collection is one of the most popular among operators of roads, used especially for the collection of travel time and for loop detector calibration. Depending on the level of automation in the data collection, the cost can vary.

In some areas, such as electronic toll or transit systems, *automatic vehicle identification systems* (AVI) are also widely used. These sensors are non-exhaustive data sources to identify tags located in vehicles, such as in payment-systems without stopping. The system detects the pass, and the data is sent to the server to be processed to perform an event (pay toll, opening in the fence, etc).

The main disadvantage of these systems is that they are unable to identify vehicles detected, in order to obtain origin/destination matrixes. Just the number of vehicles and their type can be calculated, but does not allow to obtain moves flow, nor to determine whether a certain vehicle passes repeatedly. In addition, its high cost makes it unprofitable covering secundary roads with them, so they are often located on major roads.

Finally, the *automatic recognition* technology has experienced an increase in recent years due to its ability to detect individual vehicles without relying on in-vehicle systems. Video image detection is a good example: video cameras record vehicle numbers, type and speed by means of different video techniques e.g. trip line and tracking. Furthermore, they are used for automatic detection of incidents on the road. That is the main advantage over previous information systems. However, system reliability might not be the best, as the system can be sensitive to meteorological conditions. Moreover, these systems are very costly compared to the previous. Finally, from a privacy point of view, the Spanish Data Protection Agency (Agencia de Protección de Datos) considers the car license plate as a personal data, so that it would require the user consent.

2.1. Commercial products

There are different companies working in the traffic information area using approaches similar to the presented in this work.

- **Bit Carrier** [1] [2]: It offers a traffic management system based in BT to count people and commercial routes (pathsolver). Its technology was implanted in highways managed by Abertis for traffic control and monitoring. Actually it has a 150 devices network in Catalonia, so it allows count the traffic times of 200.000 persons each day.
- **Trafficnow** [3]: Another BT system product. A pilot experience has been implanted in Vigo.
- **Traffax Inc** [4]: It is a company that also has used BT for calculating origin-destination and transport time matrixes.
- **Savari Networks** [5]: It offers the commercial product StreetWAVE for traffic monitoring to know in real time the traffic status.
- **TrafficCast** [6]: They have developed prediction models in different cities based on different technologies, such as cameras, BT and RFID included in the vehicles.

The proposal presented in this work have some common features with the previous approaches, offering similar functionalities with reduced cost.

3. Objectives and expected results

The main objective is building a low-cost system, with a fast implantation and highly reliable. It will provide real-time information about the traffic status, not only to the official organisms and agencies in charge of the traffic controlling, but also to any person who requests it (available as web services).

Several features have been developed:

- *Data collection component*: it includes several sensors to continuously scanning and identify BT devices. It uses a 3G connection to send data the storage server.

- It is enclosed in hermetic boxes, with a power line (220volt).
- *Data processing component*: it stores the obtained data, and offers some tools to serve them (through web services).
- *Information service*: it provides the users the requested information related to the traffic status.

Thus, six devices were installed for data collection. They send obtained data to servers for further data processing. Node locations is detailed in Table 1, and shown in the map on Figure 2. Locations were set according to the suggestions of DGT staff, looking for an adequate place, with a continuous flow of vehicles, and also taking into account the assembly difficulty of the monitoring devices.

Node Id.	Location
1	C/ Julio Verne, 2
2	C/ Calle del Periodista Daniel Saucedo, s/n
3	Plaza del Duque, s/n
4	Autovía de Sierra Nevada, km 119,550
5	Autovía de Sierra Nevada, km 123,250
6	C/ Calle Goleta, 1

Table 1. Node locations.

Additionally, a website has been created, including an information panel allowing different consults about the traffic state on the monitored zone.

We expect collecting a large amount of data corresponding to passing BT devices, to populate a big database and to compute different statistics and indicators on the use of vehicles on the monitored area, driving habits and even the effect of important factors or events (key dates, nonworking days, etc).

Specifically, following statistics will be reported:

- total amount of vehicles detected by every node
- total amount of vehicles detected in working days
- total amount of vehicles detected in non-working days
- number of times each vehicle is detected
- type of path that the vehicles follow
- traffic density by time range and road type
- average speed in the road where two devices where set

Finally, an important event has been analysed, since on November 14th there was a general strike day in Spain, so some conclusions about traffic changes that day would be studied.

4. Data-collecting hardware device

The first step of the study is to choose between several hardware devices to scan for BT devices in range. First test were conducted on a PC with Linux and

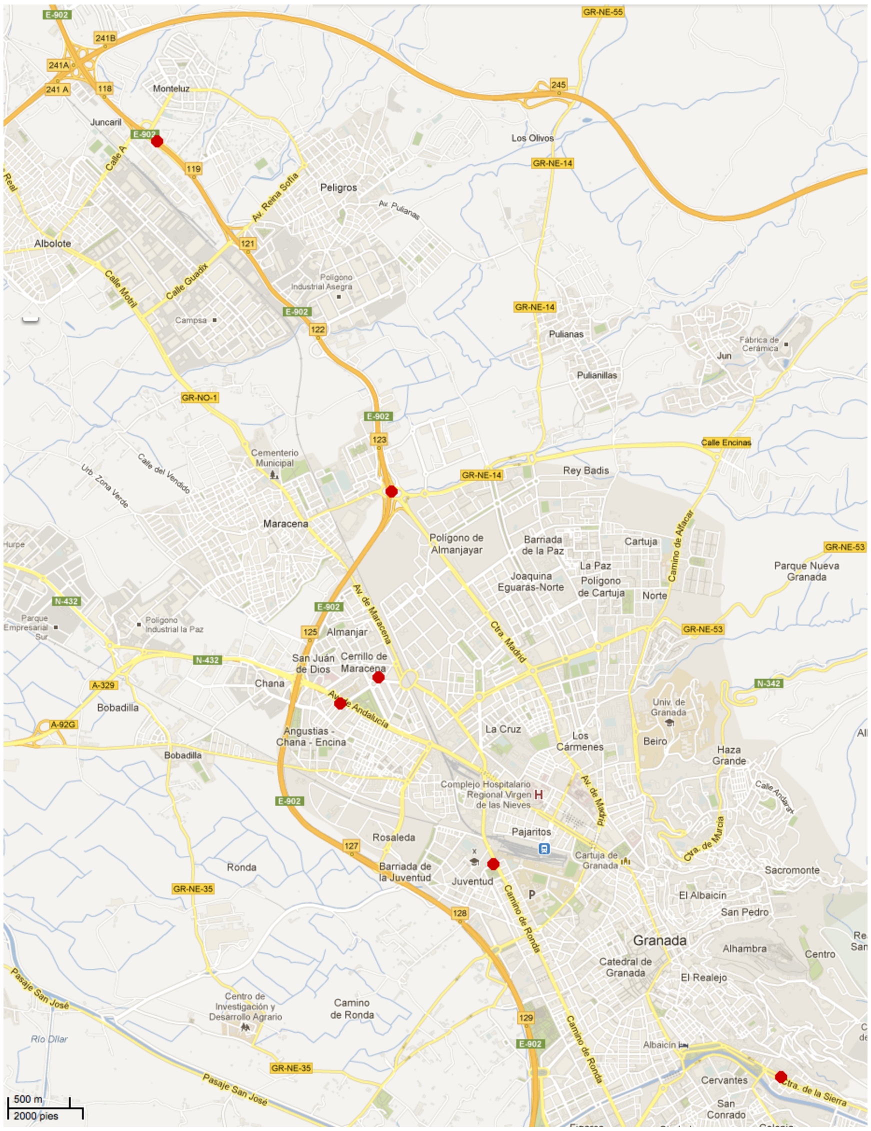

Figure 2. Geographical node locations in the metropolitan area of Granada. Source http://bit.ly/SQdQkH

a BT module. This solution was quickly discarded because of its high size and power consumption were a problem.

Another possible solution studied were using cell phones with Android due to its high autonomy based on low power consumption, high connectivity, highly available development tools and processor been powerful enough.

A prototype application[1] was developed for Android. The application was limited to three task: BT device discovery, BT identification data saving to a text file in the cell phone memory and data sending to a server thorough its 3G connection. The server finally stores the information about the BT devices on a database. Several screenshots of the application running can be seen on Figure 3.

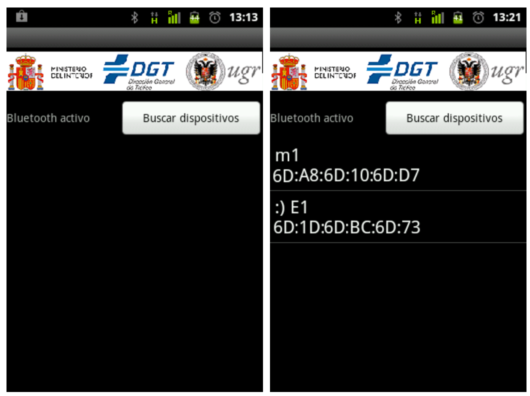

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Figure 3. Screenshots of the Android application that was developed for BT device discovery. a) Application ready for discovery. b) Application while discovering BT devices.

Despite the advantages of the cell phone, the integrated BT devices are low power and small antennas are used because of the power limits. After comparing the detection capability of the cell phone with the PC with and external BT device, the cell phone was discarded.

Thus a third solution was sought with a low power consumption and a high detection range in mind. Finally the Intelify [7] (see Figure 4) was chosen.

Intelify is a hardware detection device based on technology developed by Ciudad 2020 [8,9]. It is an autonomous unit who scan the enviroment and sends the information to a central server for further processing and interpretation. Table 2 shows main features of the device.

Intelify is a small autonomous computer that can be installed in any area to be monitored. It has several sensors that let you discover what is happening in its sorroundings like the flow of people and vehicles.

Technology was developed by Ciudad 2020 and the services offered are based on a net of Intelify devices with the capacity to discover information about the

[1] Application available for download at the address http://bit.ly/VY5kR6

Figure 4. Intelify device with a connected USB 3G dongle.

Dimensions	113x163x30mm
LEDs	Power 3G activity Ethernet activity
Networking	Ethernet Wireless Bluetooth 3G
USB ports	City Analytics Antenna 3G dongle
Other ports	RS-232 VGA
Power	18v - 1200mA external jack - 5.5mm internal jack - 2.1mm
Network connections	Ethernet RJ45 3G USB Modem
Antennas	City Analytics USB antenna wireless antenna
Microphone	noise sensor
Temperature	main board temperature sensor with extrapolation
Box	1.5mm aluminum box external use possible
Operating System	Debian 6.0 Squeeze

Table 2. Main features of the Intelify device.

physical enviroment and help with decision making to any kind of organization based on people flow and behavior.

Valuable information about tourism, trade and mobility can be gathered through the deployment of autonomous devices around a city. A specific example is the service offered in [10]. It offers information about foot traffic through Cordoba city center.

The cost of this solution is 1000 euros per device, including maintenance of remote computer, communications using a 3G telephony service and storage and data management.

Data accuracy is very representative, compared against other technologies. In [11] it was obtained an a priori error estimation of 8,5 % of detections.

5. Data analysis

In this section the analysis of collected data during the monitoring period (November 8 to December 9) to obtain statistics and so study the use of vehicles is carried out.

Specifically, the following subsections report information about the total number of vehicles detected by each node, on weekdays or holidays, information on traffic density by time range on individual movements, and the average speed on a section delimited by two consecutive nodes.

Finally, since November 14 2012 a general strike was held, we will study how the strike affected traffic in the metropolitan area of Granada (Spain), by comparing total number of devices detected that day (November 14), and the following day (November 15).

5.1. Total number of vehicles detected (weekdays and holidays)

The first analysis consisted in calculating the number of devices detected by each node.

Node Id.	N. of devices detected
1	31408
2	45032
3	33165
4	358494
5	297874
6	7872

Table 3. Number of BT devices detected by each node.

In total, 773,845 BT devices have been detected by the six nodes. As shown in Table 3, nodes located in the Sierra Nevada Highway (A44, nodes 4 and 5) have collected a higher number of data, while the node located in a side street (node 6) has detected the smallest number of devices.

5.2. Total vehicles detected on non-working days

To compare the traffic intensity between working and non-working days, the number of pass on holidays and non-working days have been obtained.

Node Id.	N. of devices detected
1	2149
2	2804
3	2832
4	32182
5	24166
6	1269

Table 4. Total number of BT devices detected by each node (only on non-working days).

Table 4 shows how the number of detected devices lowers by all nodes on non-working days, compared to the number of detections on weekdays. Nodes located in the Sierra Nevada Highway still collected much more data than the remainder, due to the traffic this road supports on holidays.

5.3. Traffic density on the road by time range

Traffic density can be calculated taking into account the total number of detected devices by time range.

Figure 5 shows higher density on all nodes, at peak times or out of work and school.

5.4. Total detections by time range

Additionally we can calculate for each node, the number of detected devices by time range, without differentiating whether the device is the same or not (repeated passes). Thus, repeated passes of the same vehicle are counted.

As in the previous case, a greater traffic density can be observed on all nodes, at peak times or out of work and school. (see Figure 6).

5.5. Number of individual vehicles detections

We can take advantage of the proposed system's ability to identify BT devices. Thus, it can be detected whether vehicles pass by different nodes.

Figure 7 shows a large number of vehicles that pass repeated times (up to 10 times) by some of the nodes (mainly those located in the A44). Even it can be seen that nodes 4 and 5 detect about 1,000 vehicles passing more than 25 times repeated. On the other nodes, over 25 repetitions of the same device have been detected only around 120 times.

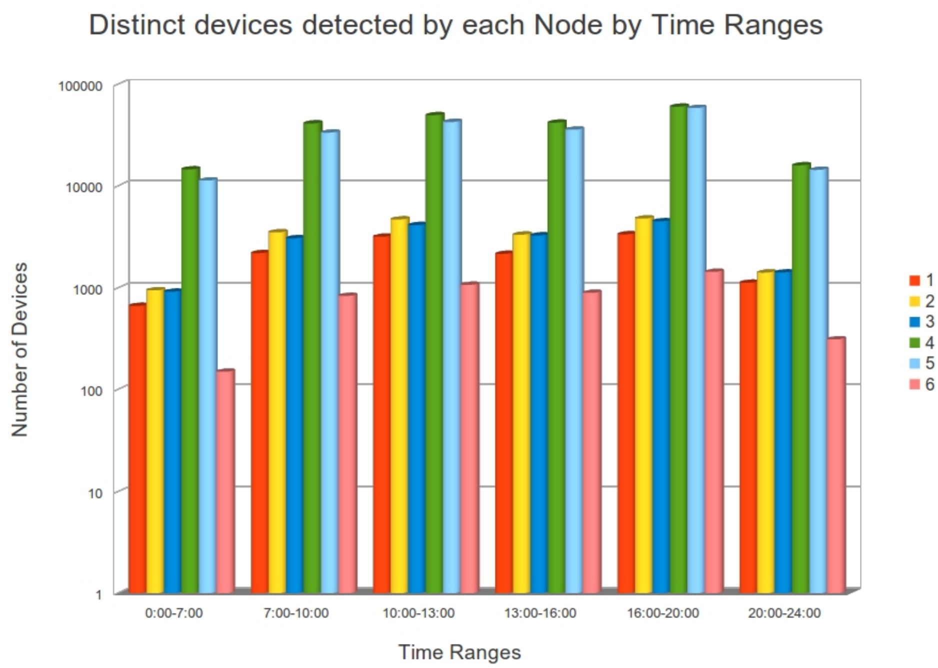

Figure 5. For each node, the total number of different detected devices by time range is shown. Figure is shown in logarithmic scale.

5.6. Complexity of displacement

To study the complexity of displacements, the number of vehicles that have passed through two nodes, 3 nodes and up to 6 nodes were calculated. Table 4 also shows the average number of times that vehicles have passed through 2, 3, 4, 5 or 6 nodes.

The above information is complemented with Figure 8, that shows how many cars pass by only one node, two nodes, three nodes, etc.

As expected, most of the BT devices rarely passed by all nodes, while most of devices pass only by one or two of nodes (their displacements are focused on a small part of the monitored area).

5.7. Effect of Nov-14 strike on zone traffic

Right in the middle of the monitoring period in Spain was held a day of general strike (November 14, 2012), which has been reflected in the number of detected devices (cars) on the nodes.

The effect of the general strike in the traffic of the monitored area has been analyzed and shown in Table 6 as the number of detected devices on November 14 and the very next day.

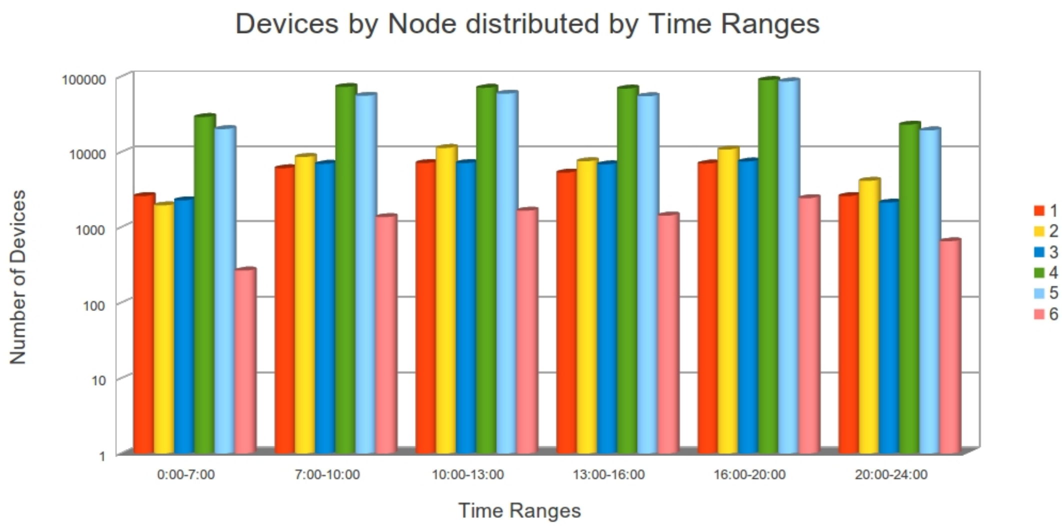

Figure 6. For each of the six nodes, the total number of detected devices by time range is shown. Figure is shown in logarithmic scale.

Table 8 shows a lowest number of detected vehicles the day of the strike that on the following day (working day in which the activity should be normal in the area).

5.8. Analysis of vehicles speed between two consecutive nodes

Finally, taking two consecutive nodes, located on the A44 highway, average speeds in the section bounded by nodes 4 (located at km 119.550) and 5 (located at km 123.250) can be calculated. This highway section where the study takes place is of 3700 meters long. Actually, we can calculate the average speed in the global section, not the speed at which each vehicle has at each instant within the section.

In that section, the speed is limited to 100 km/h. However, although most of the vehicles respect this limit, a lot of cars exceed this limitation.

No. of nodes	No. of devices	Total number of passes	Mean $\pm$ std. dev.
1	72989	165033	2,26 $\pm$ 31,16
2	53947	425667	7,89 $\pm$ 11,48
3	8125	131570	16,19 $\pm$ 24,71
4	1359	39241	28,88 $\pm$ 140,82
5	254	8603	33,87 $\pm$ 59,51
6	61	3731	61,16 $\pm$ 94,78

Table 5. Total number of vehicles that have passed through two nodes, 3 nodes and up to 6 nodes, and average number of times that vehicles have passed through 2, 3, 4, 5 or 6 nodes. In some cases the deviations are high because some devices have a very high number of occurrences for some nodes.

Node	Total number of passes (nov-14)	Total number of passes (nov-15)
2	1841	2722
3	891	1169
4	10807	16942
5	831	4017
6	946	1419

Table 6. Comparison of the number of passes for each node between the general strike day (November 14) and the very next day. Node 1 results are not reported because the hardware device suffered a power supply problem for a couple of days at that time.

Speed range (km/h)	No. of passes
$v \leq 60.0$	1495
$60.0 \leq v \leq 70.0$	2585
$70.0 \leq v \leq 80.0$	7421
$80.0 \leq v \leq 90.0$	16339
$90.0 \leq v \leq 100.0$	20144
$100.0 \leq v \leq 120.0$	14384
$120.0 \leq v \leq 140.0$	5434
$v \geq 140.0$	1326

Table 7. Average speeds (globally) in the section bounded by nodes 4 and 5.

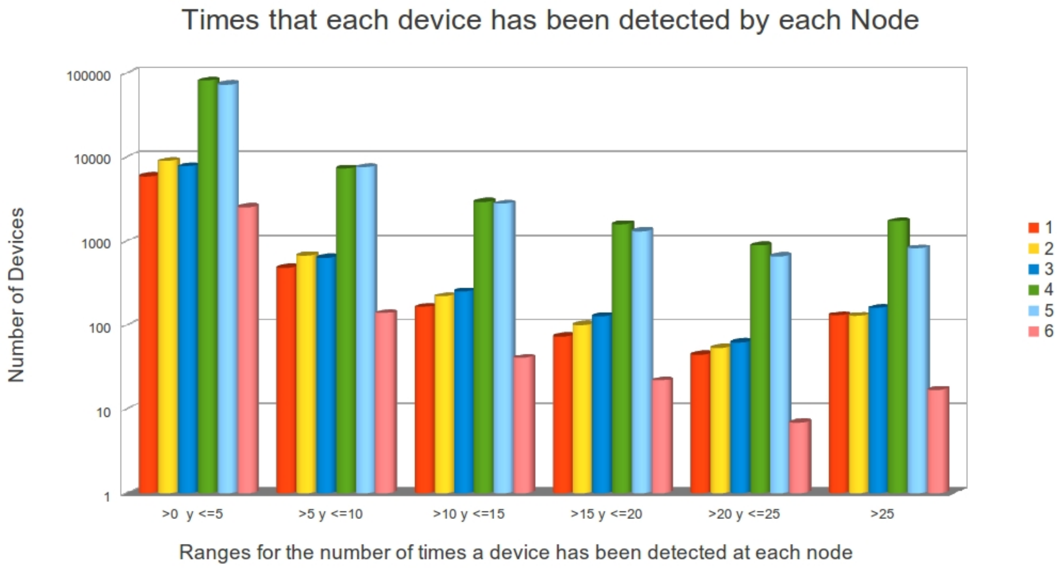

Figure 7. For each of the six nodes, the total number of detected devices N times (repeated occurrences of the same device) are shown. Figure is shown in logarithmic scale.

6. Conclusions and future work

The information systems currently used for collecting data about the road conditions are not able to uniquely identify detected vehicles, and if they do, these information systems have a high cost.

This paper presents a new low-cost information system to monitor traffic on different road types and in real time.

The main goal was getting exposure indicators using a new system based on the BT devices detection using several collecting nodes.

Thus, we are able to monitor the traffic density and car journeys, identifying the vehicles when they move from one nodo to another inside the monitored zone.

Moreover, different hardware solutions have been studied to carry out device detection, and we have rejected some of them for its high prices, for its energy inefficiency or for their short-range for detection.

Also we have taken into account different road types, with different traffic type. Statistical data have also been obtained grouped by days of the week and hours of day.

Several statistics of the collected data have been calculated during the monitoring period (November 8th to December 9th, 2012).

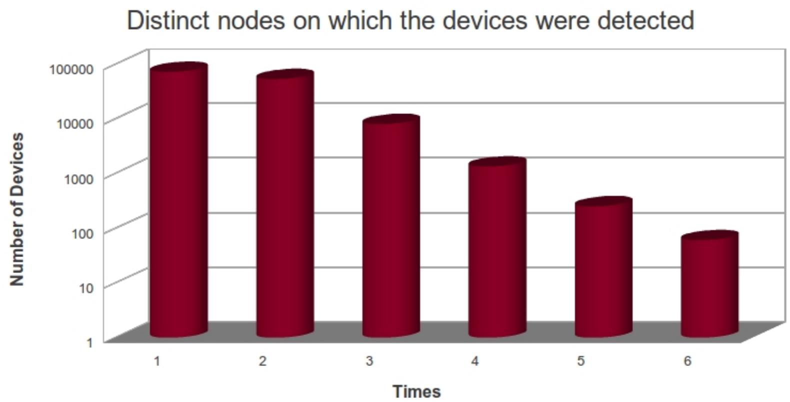

Figure 8. Figure shows how many cars pass by only one node, two nodes, three nodes, etc. Figure is shown in logarithmic scale.

Specifically, the total number of BT detected devices by each node has been analysed, on holidays or working days. We also have analysed the traffic density by time range, and the journeys of the drivers in the monitored zone.

Then, average speed of some journeys has been calculated for a set of drivers that were detected by two consecutive nodes in the highway.

Finally, the power and features of the system have been demostrated. This has been complemented by developing a set of web services for easy access to the data in real time, including different statistics.

Several future research lines have been opened, they are mainly focused on processing the collected data using data mining algorithms [12], evolutionary computation methods [13,14,15], artificial neural networks [16,17,18], machine learning models [19] and statistical methods [20,21,22], which will be included and integrated as web services [23,24] in the system.

Our purpose is to develop in the future a prediction system that helps to make decisions, and able to apply knowledge in applications related to mobility.

It is expected that the development and deployment of these systems will offer a set of information services with added value that are not achieved with current technologies.

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Referencias

1. Falcato Marti Mendez. System and method for monitoring people and/or vehicles in urban environments. *US Patent Application No: 2011/0128,127. Serial no 13/56,068. http://www.google.com/patents/US20110128127*, 2011.
2. BitCarrier. http://www.bitcarrier.com/, 2012.
3. Trafficnow. http://www.trafficnow.eu/es, 2012.
4. Traffax-Inc. http://www.traffaxinc.com/, 2012.
5. Savari-Networks. http://www.savarinetworks.com/index.html, 2012.
6. TrafficCast. http://trafficcast.com/products/, 2012.
7. Blobject. Intelify. Do it social, 2012. http://www.intelify.net.
8. Blobject. CityAnalytics, 2012. http://www.cityanalytics.net/?act=faq.
9. Blobject. Ciudad2020. Blobject S.L., 2012. http://www.cityanalytics.net/?act=nosotros.
10. Blobject. Número de personas, 2012. http://www.numerodepersonas.com.
11. Blobject. CityAnalytics. Estudio estadístico, 2012. http://bit.ly/TtnmLn.
12. Trevor Hastie, Robert Tibshirani, and Jerome Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. *Springer Series in Statistics. Secon Edition. Springer*, 2009.
13. A.E. Eiben and J.E. Smith. Introduction to Evolutionary Computing. *Springer, ISBN 3-540-40184-9*, 2003.
14. Z. Michalewicz and D.B. Fogel. How to Solve It: Modern Heuristics. *Springer-Verlag, 2 edition*, 2004.
15. Yang X. S. Nature-Inspired Metaheuristic Algorithms. *2nd Edition, Luniver Press.*, 2010.
16. P.A. Castillo, M.G. Arenas, J.G. Castellano, M.Cillero, J.J. Merelo, A. Prieto, V. Rivas, and G. Romero. Function approximation with evolved multilayer perceptrons. *Advances in Neural Networks and Applications. Artificial Intelligence Series. Nikos E. Mastorakis Editor. ISBN:960-8052-26-2, pp.195-200, Published by World Scientific and Engineering Society Press*, 2001.
17. Victor M. Rivas, J.J. Merelo, I. Rojas, G. Romero, P.A. Castillo, and J. Carpio. Evolving 2-dimensional fuzzy systems. *Fuzzy Sets and Systems, 138(1):381-398*, 2003.
18. P.A. Castillo, J.J. Merelo, M.G. Arenas, and G. Romero. Comparing evolutionary hybrid systems for design and optimization of multilayer perceptron structure along training parameters. *Information Sciences, 177:2884-2905*, 2007.
19. M.G. Arenas, P.A. Castillo, G. Romero, F. Rateb, and J. J. Merelo. Coevolving multilayer perceptrons along training sets. *In Advances in Soft Computing: 8th Fuzzy Days Proceedings, pages 503-513*, 2005.
20. Jiawei Han and Micheline Kamber. Data Mining : Concepts and Techniques. *2nd edition, Morgan Kaufmann, ISBN 1558609016*, 2006.
21. T. Hill and P. Lewick. STATISTICS Methods and Applications. *StatSoft,Tulsa, Ok*, 2007.
22. R.Nisbet, J. Elder, and G. Miner. Handbook of Statistical Analysis and Data Mining Applications. *Academic Press. ISBN 978-0123747655*, 2009.
23. M. P. Papazoglou and W. Van Den Heuvel. Service oriented architectures: Approaches, technologies and research issues. *VLDB Journal, 16(3):389-415*, 2007.
24. P. Garcia-Sanchez, J.J. Merelo, J.P. Sevilla, P.A. Castillo, M. Martin, and M. Lopez. Plataforma de integración de servicios para la administración basada en BPEL y SOA. *In E. B. Lopez de Roda et al., editor, ACTAS DE LAS III JORNADAS*

EN SERVICIOS WEB Y SOA (JSWEB 2007), pages 111-118. Thomsom Editores Spain S. A., 2007.