Vehicular traffic estimation through bluetooth detection
the open-source way

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Abstract. We present a traffic monitoring prototype powered by a raspberry-pi that leverages on techniques such as the detection of signals as Bluetooth. Namely, signals spread by vehicles passing on the roadway are revealed by the battery powered boxes installed on the roadside.
The entire system is proudly powered by only free and open source softwares, at the probe side upon a healthy OS level orchestrated by the Debian OS runs the bluetooth inquiring tool while at the server side the traces are gathered and analyzed by a python back-end developed with the web2py web framework.
Given the growing and serious issue as the traffic jam and the continued reduction of the budget that municipalities have to deal with a sane and open source system for monitoring the traffic trends could be a starting point not only for cutting the expenditure down but also to develop an homogeneous monitoring infrastructure.

1 Introduction

The aim of developing our prototype based on signals as bluetooth stems from an interest of proposing an open source solution in the field of monitoring vehicular traffic. Moreover the idea is that the same solution can be applied by different municipalities without any significant effort in customizing and adapting the source code for their particular requirements. Nowadays the bluetooth technology is available on several vehicular fleets, it is a matter of fact, it is widely used as the main in-car short range point-to-point communication standard for info-entertainment and phone headset. Its adoption in new vehicles is growing, as a result we expect that the number of cars monitored will increase in the following years. This positive growth can only strengthen the use of this technology. In particular, based on empirical tests carried out in the city of Bolzano, the number of cars detected are at least the 25% of the total traffic flow, with an average of 30%, and peak of 43%. This figures are proof that it is possible and worthwhile to predict the traffic trends with this approach. In

addition, by detecting bluetooth signals the system is not only able to project an estimation of the total number of cars passing through the monitored area but also to compute the travel time that a vehicle took to pass through two different places monitored by the probes. Namely, the former is an estimation chart generated as a function of the percentage of cars equipped with bluetooth while the later can provide input data for the so called in the Intelligent Transportation System (ITS) domain origin/destination matrix, which is used by traffic engineers to feed complex traffic simulation models that compute the traffic flows distribution over the entire road-network.

2 Infrastructure overview

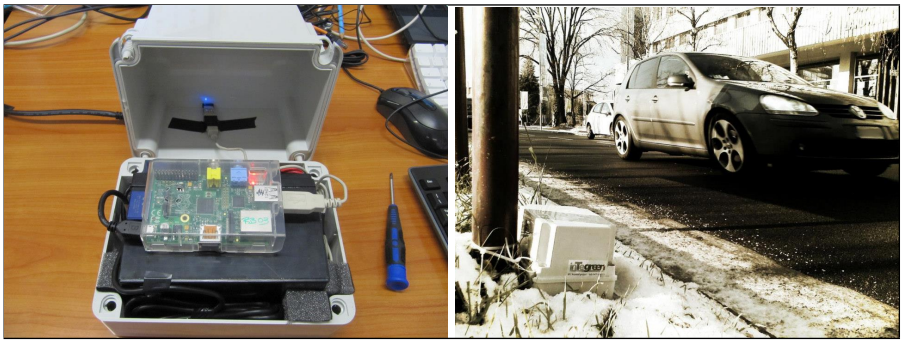

Fig. 1. The white box containing a raspberry-pi battery powered

The probe infrastructure is practically divided into the hardware and the software domains respectively. The hardware is represented by a tiny board called raspberry-pi, a computer that has got a lot of research and industrial attention lately not only for its significant features, it owns an arm processor with hdmi port, but also for the very low price, only 25$ for the entire board (cpu and ram included). Moreover, attached to the board is placed an usb bluetooth dongle which acts as the real physical detector. Finally, a probe is powered by a 12V 9Ah battery which gives to the board more than one day of life time.

The second domain, involves two sets of free and open source softwares, one concerning the applications running on the probe prototype while the others concerning the applications used at the server side for analyzing the data gathered. On the probe side, on the custom debian running onto the raspberry-pi called raspbian we installed Bluelog, the application initially developed by Tom Nardy has been adapted to the project by the author of this paper. It represents the core application by inquiring seamless for new bluetooth devices in the monitoring area, when it found any new device it store in a permanent manner the mac address of the device detected coupled with the timestamp. On the server side,

a toolchain of softwares has been developed to fulfill the gathering and analysis tasks, in addition in order to output not only numerical estimations but also an easy to understand charts regarding the vehicular trends we developed a web application. This latter is written with the web2py python web framework and is in charged to deliver the data, in the json format, to the client side application, written in javascript with the Flot library, that draws the chart. The python web application is running at *http://traffic.integreen-life.bz.it* while the source code is available here *https://github.com/ilvalle/vtraffic*

3 A first experiment

The experiment we have carried on has the aim to understand the impact of the traffic congestion on the travel time while passing from two points monitored by our probes, which are 3km far away from one another. Along, the path there are 4 traffic lights both of them working on demand. Namely, they are always green apart from when a pedestrian or a cyclist requests to cross the road. In normal traffic conditions, the average time is about 3m and a half, in common traffic conditions, the average increases up to 5 or even 9 minutes in particular cases. In order to draw the charts shown in Figure 2 we have set up an open source web application in which it has been shown as the most descriptive point the most frequent travel time for each time frame of 15 minutes. As a result of this approach we have been able to remove all the outlier from our distribution. The chart not only highlights very well a typical situation in which in the late afternoon the travel time increases but also that on Friday December, 14th the traffic has grown more than usual, with a peak over 9 minutes. Without delving

Fig. 2. A comparison between 7^{th} and 14^{th} December, 2012

into the details of the several thoughts that came after that figures, however it is worth to notice that on the referred, it was the day before December 8th that is a public holiday in Italy during which tourists use to spend the long weekend in the town of Bolzano.

4 The potential alternatives

The potential alternatives in this field are more expensive and highly invasive than the one proposed here. Without delving into the details, a common approach to obtain an origin/destination matrix is to use expensive cameras that read cars plate whereas a common approach to count the number of cars passing through a place is to install in the roadway few sensors. In addition several issues are encountered in deploy probes along the roadside, these issue not only delay the installation time due to official requests but also increase drastically the cost of the deployment itself. For example a classic constraint regards the electrical connectivity which has to be provided, otherwise the installation of the probes is bound on only specific places. For this premises our prototype is not only an autonomous probe battery powered but also a small entity easy to deploy, gather or replace.

5 The INTEGREEN project

The INTEGREEN project[1] is a demonstrative LIFE+ Environment Policy and Governance project realized on a local scale - the city of Bolzano. The main objective is to realize a demonstrative system for the municipal mobility management centre of the city of Bolzano that aims to provide the public authorities with distributed correlated traffic/environmental information for the adoption of eco-friendly traffic management policies. In order to achieve this, the INTEGREEN system will integrate on the one hand traffic and environmental dynamic data sources provided by vehicles and on the other hand environmental static data sensed by the environmental stations network of the city. Moreover, on the base of the validated INTEGREEN framework, the project aims at studying and demonstrating the quantitative impact on the urban environment of specific traffic policies, including novel strategies.

6 Lessons learnt

Any single thing is important, it does not matter their complexity, even the simplest thing can irreparably compromise an entire set of test. As a matter of facts the system is affected by several different variables which not only concern the software but also the boxing and deployment as well. During the development we have always kept in mind that all the different variables were related one to

[1] http://www.integreen-life.bz.it

each other, as a chain. This has been the real and most significant thing we have learnt during our tests. The chain as a whole is more important rather than the single things independently, to some extent all of them are important, and have the same fundamental role in the whole experiment. As a matter of fact, the free software approach has leveraged us from writing, testing and debugging code since it was already made productive by different people all around the world. The probes code relies on software written by an open-source community, this has allowed us to put all our effort in the deployment and analysis activities. Without the possibility to rely on that code we would never have been able to reach our achievements.

7 Conclusions and Future Works

Being part of the Free Software and Open technology area at the TIS innovation park in the city of Bolzano we are glad to make and share our R&D prototypes as open source. Moreover, thanks to the open source software we used we got a speedup in the development of this prototype that allows us in being able of deploying the first test in less than a week of work. The experiment we have started and presented in Section 3 is basically focused on the Christmas market which is held every year in the historically centre of the city of Bolzano. The main drawback of this huge event is the growing vehicular traffic which dramatically expands the travel time in the whole town. As a result of a first test deployment of our prototypes on a test route we have been able to gather some interesting data about the amount of traffic we have got in the city. Future works will work on two different work packages. The first one will be to improve the analysis part while the other one will be on the probe side to improve the life-time of the probe itself through the use of a new DC-DC adapter.