**INTERNET OF THINGS –GROUP 4**

# PUBLIC TRANSPORTATION OPTIMIZATION

**PHASE 3**

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Nowadays, passenger counting operations are often developed on surveys, throughout the territory and using manual procedures: even though these may be capable of providing highly accurate values, which can be taken as a reference point in analysing the precision of the automatic systems, the manual procedures are not usually homogeneous in surveys, since they inevitably depend on the operator who performs them and may also be influenced by the time of the day – early morning versus the last hours of the day – and by a repetitive task.

On the other hand, the APC (Automatic Passenger Counting) systems, can be much more appropriate and of greater interest, as related to this short analysis. It is important to underline that – even though most of them are still at a development stage – the passenger counting technologies available on the market are various and the issues of different kinds; the combinations of technologies are such that no solution can be considered to date better than others or economically preferable a priori; every solution should be analysed in detail for applying it thereafter to the actual conditions of the public transport system or company.

This article is intended to shortly examine the different solutions of passenger counting technologies and to provide some suggestions as related to the management of data, in order to outline a general framework which may facilitate a more justifiable, customised choice of an automatic counting system.

## Tools and technologies

In order to count people on buses, tramways, metros and trains, the two main following procedures can be summarised:

1. Counting independently from the ticket (for buses, tramways, trains): a. monitoring of single passengers, usually by technologies on-board the vehicle; b. monitoring of the overall load on the vehicle, with technologies applied to the suspensions/air springs or on the ground
2. Counting related to the ticket (for metros, trains), sometimes also recognised as ERF (Electronic Registering Fare boxes) solutions.

In the former case, the counting can be based either on the detection or attempted detection of the single passengers or indirectly, usually by ascertaining the weight of the vehicle under the passenger compartment or on the infrastructure, that is normally the road pavement.

As usual, the cost of the system needs to be contained, and this is related not only to the type of technology but also to the relevant hardware-software combination.

The ‘1a’ type solutions – frequently obtained by using a double sensor – can be frequently more expensive than the ‘1b’ ones; this is essentially due to the need for developing appropriate counting stations: for instance, in a 12m, 3-door bus, six sensors and two dedicated stations may be usually required.

Counting independently from the ticket has to be carried out by means of appropriate sensors, which may detect the passage of people through gates, usually the doors of buses, tramways and trains. Some manufacturers of APC technologies supply equipment which can perform such function; a widespread solution is based upon the use of infrared sensors, which act as active switches; in case of passive switches, pyro electric sensors can be used.

In some of them, only infrared (IR) ray switches are used, in other ones, double sensors (e.g. active and pyro electric IR) are used to enhance the reliability of the counting.

As far as this topic is concerned, the manufacturers declare accuracy in passenger counting with an error contained between 5 and 10% on the total amount of passengers which are actually present. However, the class '1a' counting systems are frequently still at experimentation stage and would be worth further investigation both as related to the CAN integration and in the assessment of the counting reliability.

In the '1b' cases, counting can be developed indirectly, on the basis of the load on-board or by monitoring the weight directly by means of plate sensors; a further alternative, analysed further on, is the detection of the vehicle load on the ground.

In the former case, the number of people can be detected by assuming the average weight of a person: the counting is performed by load sensors either on the ground or on the suspensions: various types are available and are nowadays experimented in other contexts as well. The main disadvantage linked to this kind of counting is the variability of the dynamic load on the shock absorbers, besides the lack of important actual field experimentation documented in the literature.

**infrared sensors**

The infra-red detectors can be divided into two main categories, namely:
» Sensors of the active type, consisting of a transmitter and a receiver; they create a punctual ray and operate as on/off detection

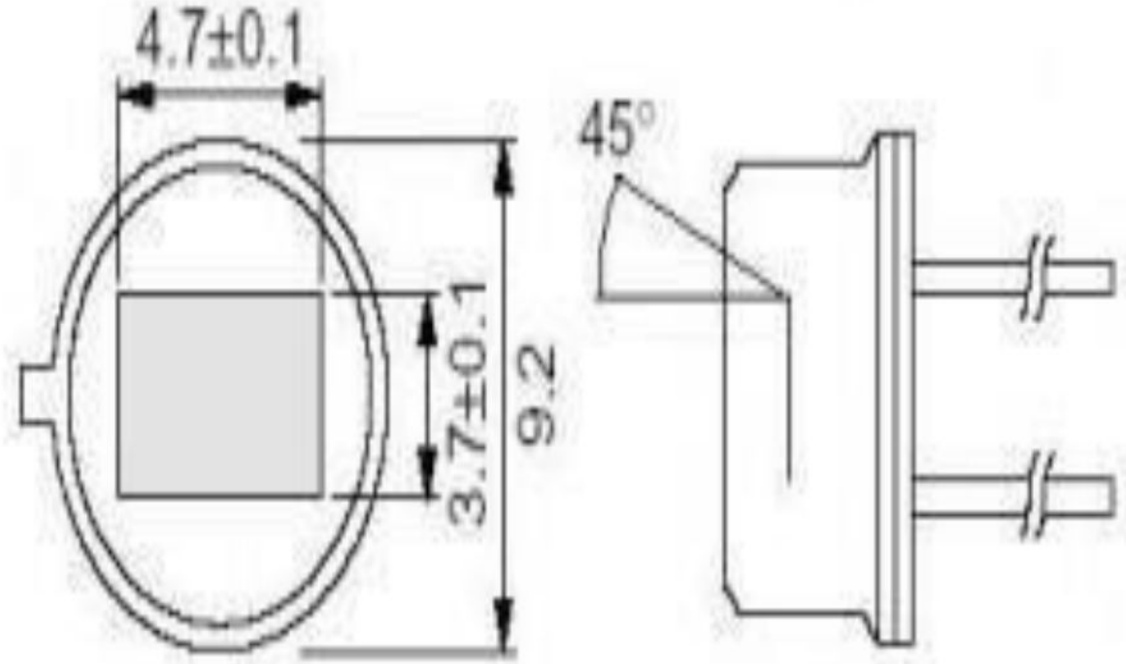
» Sensors of the passive type, which divide the sole infra-red ray into bundles, thus creating an area of volumetric detection.

In the first case, the infra-red emitters are generally set parallel to one another so that the LED interruption occurs in the direction of crossing and the entry direction can thus be discriminated from the exit one: because of their 'bar' configuration, this type of infra-red sensor is also defined as 'barrier sensors'

A weak point in this automatic counting solution – which, amongst other things, can also be easily found in commerce – is the need of installing more than one sensor per door, with a consequent cost increasing. In order to prevent the infra-red ray from being avoided by a passenger and evaluate the crossing direction, a minimum amount of two sensors is to be installed on every gate, but the number of LED's may increase remarkably if the gates are larger than 2m.

The use of passive components generates a less punctual ray (the LED is replaced by emitters which generate ‘widened’ infra-red bundles), composed by two parallel arrays whose arrangement allows diversifying the two typologies of signal reflection, whether the passengers are entering or leaving the vehicle.

The issues relevant to the number of sensors to be utilised and – subsequently – to their cost cannot be overlooked because, as in the case of the active systems, more than one sensor per door is to be applied to detect the passage direction. As mentioned above, the electronic device used by the passive infrared-red sensors is pyro electric i.e. it ‘reacts’ to the sudden temperature variations or – better – to the infra-red radiation emitted by a human body; this typically emits a frequency included in the range between 7 and 14 μm.



Solutions with sole passive components are often utilised to detect the motion in surveillance systems of large-sized internal or external environments; adapting them to automatic counting is not difficult, but – if the coverage bundle emitted by the sensor is too large, the counter may be erroneous.

The application of passive infra-red sensors, conceived for the sole detection of people, and which can be modified with the support of a counting device, is often rather expensive. The market provides even solutions that – in order to count the entries and exits with the greatest accuracy – use a sensor which contains both a passive and an active component.

**Python Script for Interfacing IR Sensor with Raspberry Pi. IR Proximity Sensor using Raspberry Pi.**

```
import RPi.GPIO as GPIO
import time



sensor = 16   buzzer =
18
```

```
GPIO.setmode(GPIO.BOARD)
GPIO.setup(sensor,GPIO.IN)
GPIO.setup(buzzer,GPIO.OUT)


GPIO.output(buzzer,False)
print "IR Sensor Ready....."
print " "


try:        while True:        if
GPIO.input(sensor):
GPIO.output(buzzer,True)        print
"Object Detected"        while
GPIO.input(sensor):
        time.sleep(0.2)
else:
        GPIO.output(buzzer,False)
```

```
    except KeyboardInterrupt:
GPIO.cleanup()
```

**Treadle mat sensors**

Treadle mats – placed on the steps of a bus, a tram or a train – register passengers as they step on a mat. This solution relevant to the APC technologies is produced by several companies operating in the transport industry: the counting system uses treadle mats located in proximity of the vehicle gates, typically on the access steps.

The metal structure can be covered by a layer of rubber and attached to the steps by means of purposely-allocated attachment structures, or simply glued by means of high seal adhesives; the latter solution is less frequently applied because it may deteriorate rather quickly.

Their installation generally does not call for special care; it must nevertheless be considered that the edge of the mat is not active, i.e. it does not commute the switch; subsequently, the position of the mat is to be studied and experimented so that the metal plate deforms every time a person transits on it, in order not to obtain wrong data due to missing detection.

if the public transport line equipped with this kind of APC is always very crowded, the errors can be relevant and – in such cases – the use of different means, such as passive IR sensors, may be preferable, or the access to the vehicle and exit from it can be managed by other instruments – such as turnstiles – to have a 'Main components linked to an APC system and errors

The analyser is an essential component for the connection between sensors and servers – be they on-board or remote – of an APC system: it determines the number of passengers in in-feed and out-feed on the basis of the signals transmitted by the sensors.

As visible in, the analyser is connected to the following essential functional units:

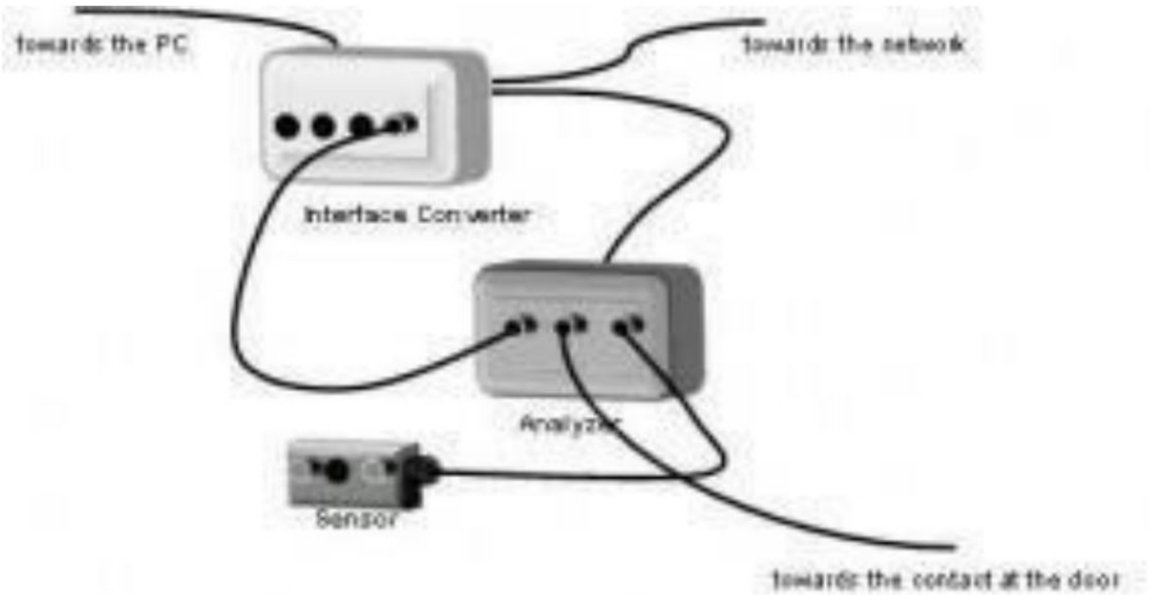
» Power supply (24V dc)

» Micro-control based signal processing

» Sensor interface

» Data bus interface2

» Modem for radio transmission of the data.




Last but not least, the significance of the appropriate electrical insulation of the analyser, cables and all the components connected to the APC system should not be overlooked, mainly in the case of passive infra-red systems, which are particularly sensitive to both the electromagnetic sensors and the heat.

In general, the analysers have one, two or four connections per sensor and either one or two connections per door contact; subsequently, an analyser can be connected to a maximum amount of two door sensors: this is an important factor to be evaluated when designing and programming the whole system. The transmission of data between analyser and sensor is regulated by a microcontroller.

It is important to keep into account the errors in passenger counting; an objective judgement in passenger counting, should consider namely:

» The error on the total number of passengers »

The error on passengers in in-feed and out-feed »

The unbalance error.

The unbalance error describes the absolute errors and – therefore – it is particularly important in comparing the different installations and the APC systems.

The field experience accrued in several years and many applications ensures the following values for the rough data (i.e. the ones considered before processing) of the passenger counting system:

» Passenger error ≤ 5%

» Passenger error in in-feed ≤ 10% »

Passenger error in out-feed ≤ 10%.

**serial read using the Python REPL**

```
>>> import serial
>>> import time
>>> ser = serial.Serial('COM4',9600)
>>> time.sleep(2)
>>> b = ser.readline()
>>> b
b'409\r\n'
>>> type(b)
<class 'bytes'>
```

```
>>> str_rn = b.decode()
>>> str_rn
'409\r\n'
>>> type(str)
<class 'str'>
>>> f = float(str)
>>> f 409.0
>>> type(f)
<class 'float'>
>>> ser.close()
>>> exit()
```

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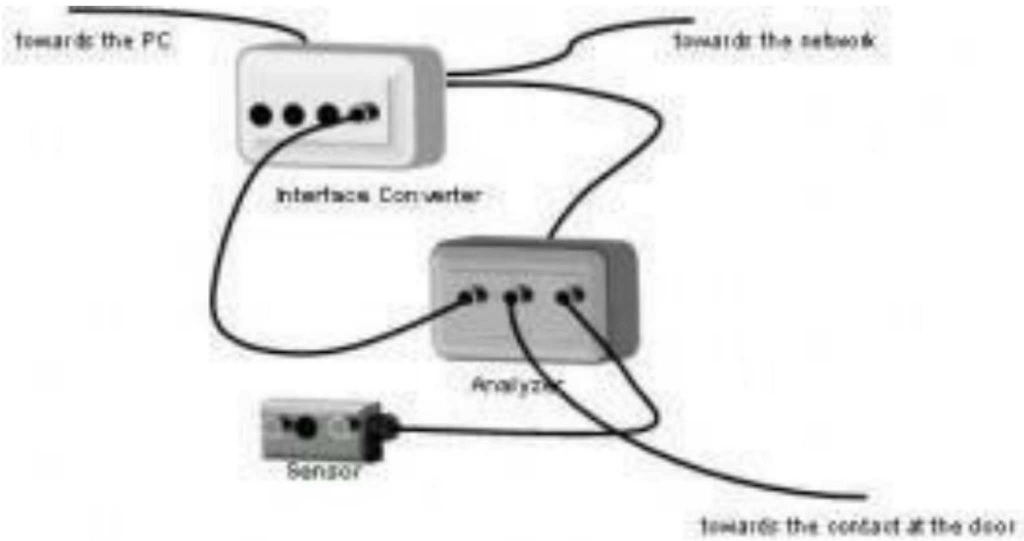


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