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Indice

GIS and Augmented Reality Applied to Field Service Made Available to Digital Multiutilities

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Abstract: Workforce Management is a business sector that can definitely benefit from the use of new technologies. Nevertheless, the innovation process had so far been slowed down by the considerable number of resources operating on field and by the risks involved with equipping them with mobile consumer devices (they would surely end up breaking, loosing, stealing). In the last couple of years, a handful of visionary ICT companies, backed by far-sighted customers, decided to revert the conservative trend and introduce up-to-date technology, thus advancing innovation in the WFM process. As a result, technicians have been provided with mobile consumer devices (iPad, smartphones, ...) and wearables (smart glasses, smartphones, ...). Furthermore, Augmented Reality and GIS capabilities have been integrated in the mobile APP to offer the maximum support possible when on field. Indoor and outdoor positioning and navigation, off-road navigation, shape recognition, drones, and new frontiers such as Microsoft HoloLens, Kinect and Google Tango, are the near future of mobile technology. Beside the revolution undergone by field technologies, sophisticated scheduling Geoalgorithms have been added server side, in order to optimize the agenda of technicians, as well as amazing GIS tools and connectors to main ERPs and CRMs (e.g. SAP, IBM Maximo, Salesforce Dynamics,...). The purpose of the present paper is to outline the

state of the art of the aforementioned technologies applied to WFM and made available to utilities. A case history of Italgas and the project GAStoGO is also included.

KEYWORD: outdoor and indoor positioning, augmented and holographic reality, wayfinding and navigation, LBS and transportation, indoor positioning, mobile devices, wearables, workforce management, iBeacon, indoor navigation, smartglasses.

SUNTO: Il Workforce Management è un settore che può trarre notevoli vantaggi dall'impiego delle nuove tecnologie. Tuttavia, l'elevato numero di risorse in campo e i rischi connessi all'adozione di dispositivi mobili di tipo consumer (che con buona probabilità verranno rotti, persi o sottratti) hanno finora rallentato il processo di innovazione. Negli ultimi due anni alcune lungimiranti società di ICT, supportate da alcuni dei propri clienti, hanno deciso di invertire la tendenza conservatrice puntando su tecnologie moderne e promuovendo l'innovazione dei processi di WFM. I tecnici sono stati dotati di dispositivi mobili di tipo consumer (iPad, smartphone, ...) e di dispositivi wearable (smartglass, smartphone, ...) che si avvalgono di funzionalità di Realtà Aumentata e GIS appositamente integrate nell'APP mobile per offrire il massimo supporto possibile sul campo. Il posizionamento e la navigazione indoor e outdoor, la navigazione off road, il riconoscimento delle forme, i droni e le nuove frontiere aperte da Microsoft HoloLens, Kinect e Google Tango rappresentano il futuro prossimo delle tecnologie mobili. Alla rivoluzione in atto nell'ambito delle tecnologie field si sommano le evoluzioni lato server, quali sofisticati geoalgoritmi di schedulazione per ottimizzare l'agenda dei tecnici, eccezionali strumenti GIS, e connettori per garantire l'integrazione con i principali ERP e CRM (SAP, IBM Maximo, Salesforce Dynamics, ...). Nel presente contributo si descriverà lo stato attuale delle tecnologie menzionate con particolare riferimento alle relative applicazioni in ambito WFM presso le utility. Verranno inoltre analizzati il caso Italgas e il progetto GAStoGO.

PAROLE CHIAVE: posizionamento indoor e outdoor, realtà aumentata e olografica, wayfinding e navigazione, LBS e trasporto, dispositivi mobili, dispositivi wearable, gestione delle risorse sul campo, iBeacon, smartglass.

1 Introduction

In the following paper we present an analysis regarding the state of the art and the progress of the integration of the most recent GIS and Augmented Reality technologies in field service activities.

It will be described how on field operators' mobility is affecting operational processes, and how more and more wearable devices can be used to improve performances, reduce costs and support as much information as available. B2B AR App and indoor navigation's potential will be herein described.

The case history of GAStoGO, software developed by Snam Rete Gas – leading company in Italy in the field of natural gas transportation and dispatch – clearly proves the financial, environmental and operational benefits that can be achieved thanks to a proper integration between new technologies and field service activities.

All consumer devices (phone, watch, camera, ...) currently in use rely on an internal GPS [Amaduzzi 2011], i.e. Global Positioning System receiver[1].

As a result, geographic coordinates are automatically associated to each call, message, activity, photo, etc. and many services, to be later detailed, can be activated.

In consumer applications, it goes without saying, it is the user the one who decides whether to enable georeferencing and make his position available to third parties, as against business applications, where such a procedure is agreed with the company.

For instance, the user can specify whether to associate geographic coordinates to each tweet in the dedicated Twitter settings. In this case, every tweet sent from the profile is geocoded and displayed on a digital map [Amaduzzi, December 2017].

The same applies to all the activities carried out with mobile devices. All Location-Based Services (LBS) we use in our daily lives, e.g. navigation systems, travel planning, devices and nearest restaurant location, etc. are indeed made possible by such a simple and small technology.

[1] The Global Positioning System (GPS for short, in turn abbreviation of NAVSTAR GPS, which stands for Navigation System Time And Ranging Global Positioning System) is a satellite-based positioning system, providing global and continuous coverage, managed by the US Department of Defence.

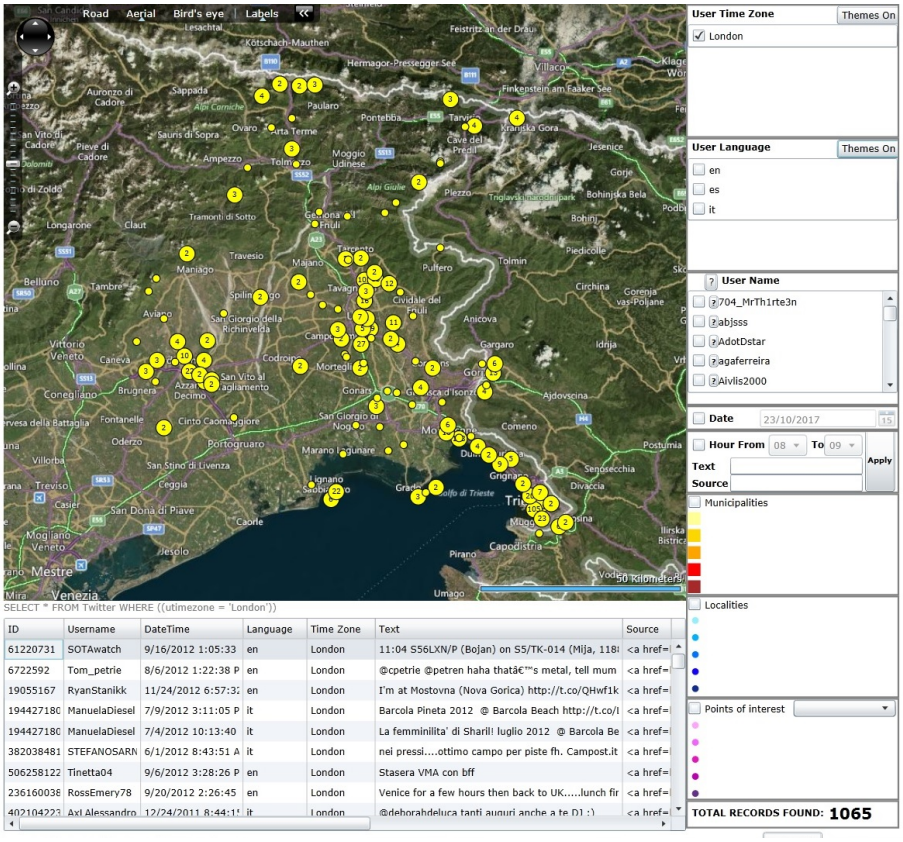

Figura 1. Tweets by tourists from London visiting Friuli Venezia Giulia.

Most companies are designing and implementing LBS APPs. This market will play a strategic role over the coming years, as evidenced by recent acquisitions underway. NOKIA, a leader in the mobile phone and device market, has acquired NAVTEQ, the leading global manufacturer of digital maps. Shortly after, it has, in turn, been acquired by Microsoft. In other words, the main player in the computer world has bought the mobile phone manufacturer owning the world largest producer of digital maps.

An ever-growing number of enterprises are using Workforce Management (WFM) applications to manage their technicians/salesforce on field. Companies need to ensure a constant access to the corporate

Information System by their workforce, in order to share work plan, customer information, technical and administrative documents, etc., and to rely on capabilities such as satellite navigation, Augmented Reality and remote support [Amaduzzi May 2017].

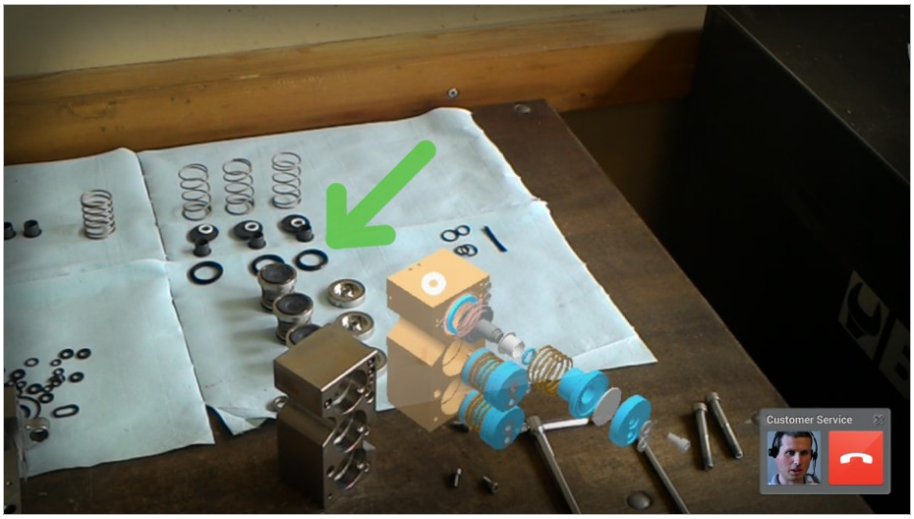

Figura 2. Application interface with Microsoft Hololens smart glasses.

A remarkable project in this respect is GAStoGO, which will be later described. Operators carrying out field activities have understood how technology can simplify and support their tasks. As a result, they are becoming increasingly more proactive and they are advancing a further technological development, namely wearable devices. Relying on such an HW solution, as described in the following paragraphs, users can operate hands-free.

Companies are moving either in the direction of smartwatches (Apple Watch, Microsoft Band, Samsung Gear, ...) or smartglasses (Microsoft HoloLens, Google Glass, Epson Moverio, ODG, RealWear, ...).

2 The Mobile Trend

The infographic below (source Dell) gives an insight into the pervasiveness of mobility.

Figura 3. Mobility trend.

An astonishing fact is that 59% less office space per employee in the last 10 years, working 5 hours form home and by 2020, 30 billion devices will be connected to the Internet.

As you can understand from the aforementioned figures, mobility will be so pervasive that we will, inevitably, end up being its leading actors [Ratti 2016].

Users who were once not deemed capable of relying on field applications, are now ready to make use of new technologies. Supposedly, technicians had difficulties in coming to terms with the applications installed on mobile devices. For this reason, until a few years ago, rugged devices[2] were always preferred to support field activities. Because of their robustness, they ensured durability under the most extreme conditions (rain, sand, very high or very low temperatures, ...) to the detriment of user friendliness and costs.

Experts are gradually understanding that reality is entirely different.

[2] A rugged computer is a computer specifically designed to safely operate in difficult environments and conditions (strong vibrations, extreme temperatures, moisture, dust, ...).

Figura 4. Example of a rugged device.

Regardless of the type of activity carried out during the working day, the chances are pretty good that even operators maintaining gas pipelines, collecting garbage or delivering door-to-door, do use smartphones, tablets and so on in their private lives, e.g. to plan the next holiday or buy a product over the Internet.

A point has now been reached where everyone is able to use mobile devices and applications without a negative impact. After all, using rugged computers with small displays, pens, microscopic keyboards has never been that challenging.

2.1 User Experience

Companies are increasingly making available APPs their customers can use on mobile devices to purchase/book services, track deliveries, monitor the performance of indexes, contact service desks, ...

For these reasons, there has been a significant increase in technological skills and the expectations of users, who are now able to download and

install applications on their smartphones and learn by themselves how to use them.

Users are no longer willing to read a manual before using an application. Interfaces and features must be captivating and intuitive, as otherwise the APP is removed, and a suitable alternative sought after in the APP store.

User experience is, therefore, one of the main points to be considered, both in consumer and business applications.

Until recently, consumer and business applications were regarded as different, both in terms of functions and interface. The broadest possible range of features was included in business applications, sometimes at the expense of their ease of use. As against, special attention was placed in user friendliness when designing consumer applications. However, given the widespread diffusion of mobile devices, it has now become apparent that business and consumer users are virtually identical. As a result, there is a natural convergence between the two typologies of application.

Even in business APPs, the trend is to achieve absolute intuitiveness. Gone are the times when long and challenging training was required. Furthermore, complex applications or multiple menus are no longer developed. Simple, mono-functional APPs, requiring learning times close to zero are now preferred.

2.2 Bring Your Own Device (BYOD)

The mobilization of the activities of business users inevitably ends up causing a rise in the costs incurred by companies in order to provide staff with hardware devices (smartphones, tablets, ...).

Quite often, technicians need a mobile device when operating on field and a PC when they are in the office. In order to reduce costs, a growing number of companies are joining a new trend, known as Bring Your Own Device (BYOD). Resources are basically allowed to use the own mobile device, even when performing field activities. As a result, the company does not bear HW costs and users can rely on a device they already know and handle problem-free.

Nevertheless, the benefits just mentioned are offset by some drawbacks, such as: *security*, *privacy* and *multi-platform use*.

The security problem arises because corporate applications are installed, and corporate data are stored on "private" devices. The security

policies that can possibly be adopted for company devices are completely different from those that can be implemented on consumer devices, on which users are free to install, erase and format their own applications, ... On a company device, any kind of activity outside normal usage can be blocked, and users may be required to use passwords, that would otherwise not be set.

Security issues typically arise when a device is lost or when the user changes company. From a technical point of view, procedures should be implemented to automatically uninstall applications and erase all corporate information from the device.

Several operating systems vendors (Apple, Microsoft, Google) are working on that. Apparently, the latest iOS version is the most suitable for such a combined use, as a clear distinction between private and corporate is achieved.

The issues outlined above also apply to *privacy*. The company cannot control the information stored and is not able to perform any kind of action on applications installed and run on the device for private use.

An additional problem results from BYOD. Companies, undeniably, do not bear the cost of hardware devices. Nevertheless, their staff needs to rely on different device models, in order to ensure a smooth running of business APPs.

In practical terms, this means that all the APPs developed shall be *multi-platform* to allow smooth operation on any device chosen, which obviously results in increased development costs and times.

The most technologically advanced companies have implemented or use multi-platform frameworks.

3 New Technologies Applied to the Mobile

We shall now consider emerging technologies, which we believe to be, in the short time, the most impactful ones, both in the business and the consumer sector.

3.1 Augmented Reality

Augmented Reality is the integration of artificially generated information to the reality observed by users, in order to provide specific and effective support to their activities. The perception of the operating environment is

therefore increased, and the complexity of working activities significantly reduced.

Many are the fields of application: tourism, maintenance and emergency procedures, ...

In practical terms, when the device camera is pointed at an object, the application recognizes it, its position and the direction. The data associated to the object framed are displayed on the monitor, as a result.

For instance, if the object is the Colosseum, the rendering of the building as it appeared in Roman times can be automatically superimposed upon the current image. Meanwhile, a window opens up, featuring a video of the chariot race of the Ben-Hur film.

If the object framed is a manhole, the layers of underground technical networks are displayed as if they were visible, thanks to the enterprise GIS, and the user can interact with them.

In case of indoor settings, where the GPS cannot be used, shapes, marker, or codes (QR, barcode, ...) are recognized instead. The device is able of detecting the exact location and "virtual" information can be superimposed upon those acquired by the camera.

Here are some examples of Augmented Reality applications (OverIT, March 2018):

Figura 5. Automatic recognition of technical objects.

Figura 6. Locations orientation and emergency procedures.

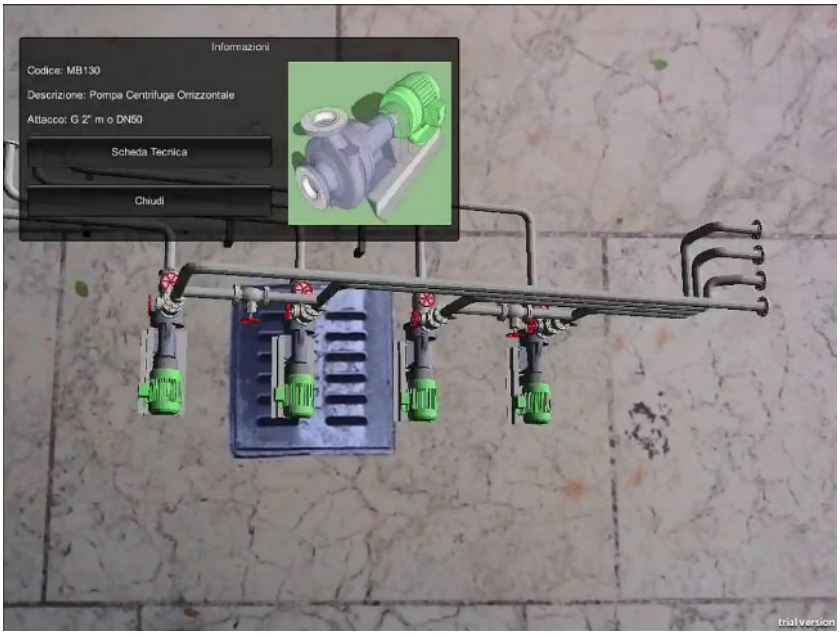

Figura 7. Locating underground utility networks.

3.2 Wearable and Smartglass

The technology described in the previous paragraph is undoubtedly very useful. However, if operators are working within plants, it would be more convenient for them to have their hands free. A tablet or a smartphone, whenever consulted, need to be held and moved to point objects while executing tasks at hand.

Wearable devices worn by operators leaving their hands free are the new frontier. The most appreciated devices by developers and researchers active in this field are smartwatches (iWatch Apple, Samsung Watch, ...) and smart glasses such as Microsoft HoloLens (Microsoft, March 2018), Google Glass, Epson Moverio, ...

In particular, smart glasses are now at the heart of many experimental applications for manufacturing, field service, retail and healthcare. Such devices are real connected PCs, providing the features described in the figure below.

Figura 8. Functional features of Google Glass.

Wearable devices rely on speech-to-text and are able to recognize and track head and eyes movements, which makes them very appealing to the market, provided that SW houses invest in the development of suitable applications.

Figura 9. Smart glasses models on the market.

Gartner expects the revenues of smart glass applications in the coming years at hundreds of millions of dollars. Hence, main system integrators are heavily focusing on such technologies.

3.3 Drone and Data Collection

Drones are the new frontier for the collection of geo-referenced information. Recent technological advancements have led to the creation of high-performance and low-cost RPA (Remote Piloting Aircraft). The benefits of such systems are manifold. Indepth technical expertise is no longer required to pilot them, and the Civil Aviation Authority is currently issuing the first regulation to bring some order to the matter. RPA can take off even in small spaces, support data acquisition systems (cameras, temperature sensors, infrared sensors, LIDAR, ...) and fly over places otherwise inaccessible. Furthermore, they are easy to carry and require low investments.

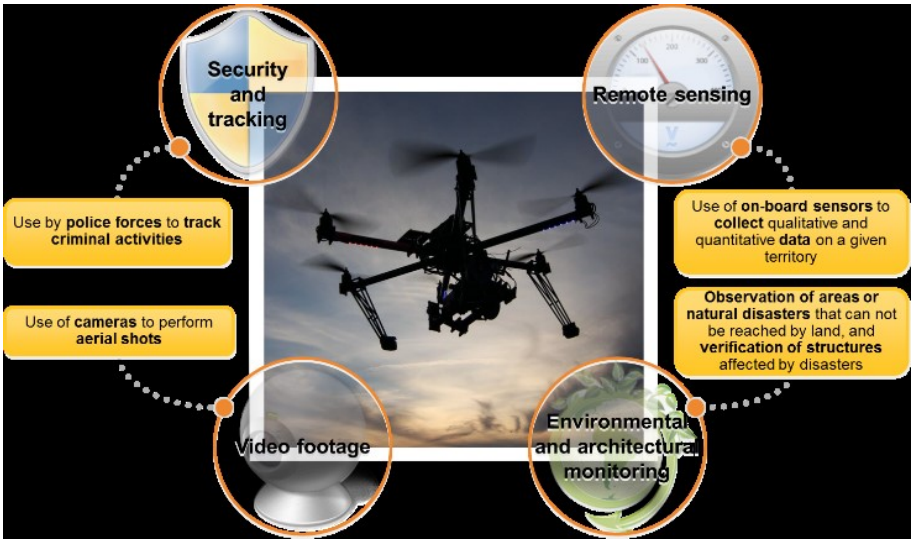

Figura 10. Functional features of drones.

The flight plan prepared by back-office systems can be sent to the drone. A default route, altitude, ... is set, thus making the driving experience easier for the operator.

Figura 11. Definition of the flight plan to be sent to the drone.

Unmanned aircrafts are, therefore, of considerable interest for maintenance and inspection activities. To better understand the benefits of such tools, just consider high voltage towers. Every six months, insulators and other components are subject to checks to ensure they have not been damaged. In order to carry out such an inspection, most companies are forced to send their technicians on top of the towers, as shown in the image below, thus incurring in risks and costs and loosing precious time for the performance of task, which, in most cases, does not require repairs.

Figura 12. High voltage tower inspection.

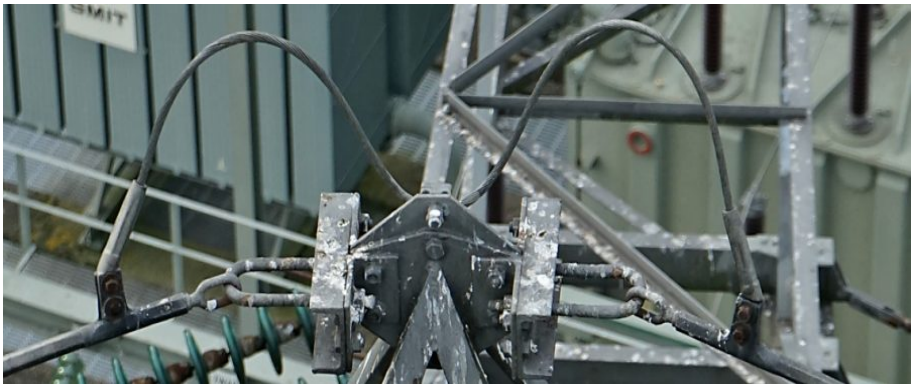

Figura 13. High voltage tower inspection with drone.

Using drones to perform inspections usually carried out by physical operators, allows to capture high-resolution images without any risk, and dramatically reduces the burden in terms of cost and time caused by such an activity.

3.4 From Street View to Indoor Navigation

Virtual journeys to unknown places with Google street view are now commonplace. Such a tool is used both by consumers (e.g. to plan holidays, locate a friend's house, ...) and businesses (e.g. to analyze potential locations for new store/services, ...) and has become a *de facto* standard.

Google collects views thanks to cars or bikes equipped with systems capable of capturing geocoded images and videos, relying on inertial localization systems.

Figura 14. Google car.

Back-office functionalities are available to recreate and publish the street views currently available on the portal.

The new frontier of such a technology is indoor navigation, basically aiming at providing navigation features to users in public buildings (airports, train stations, museums, hospitals, ...).

Two conditions need to be fulfilled in order to make such a service available: the mapping of the building to be navigated and the availability of a technology capable of locating a mobile device within a confined environment.

In order to fulfil the former, an infrastructure has been made available by Google to anyone wishing to load the "internal views" of buildings.

Devices similar to those installed on cars/bikes and able to recognize the interior of a given building are available at affordable prices. Moreover, the platform provided free of charge by Google can also be used to post-process the data collected, to upload them on Google Maps, and navigate within the building in a street-view-like mode.

Figura 15. Indoor navigation.

To learn more about these features, refer to the link in footnote[3] displaying the indoor street view of Milan Central Station.

[3] `https://www.google.it/maps/@45.4859047,9.2045958,3a,75y,44.52h,83.32t/data=!3m5!1e1!3m3!1sblnMCmNuYs_QEoclfllT1A!2e0!3e5`

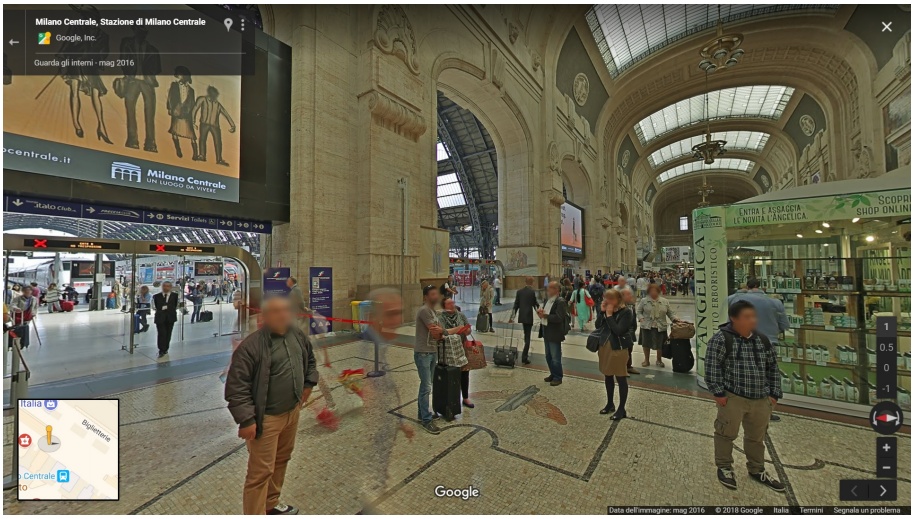

Figura 16. Indoor street view of Milan Central Station.

Google is now committed in increasing the use of this technology, to ensure that as many buildings as possible are uploaded by users, thereby achieving a "de facto" standard.

Fulfilling the latter condition mentioned above is fairly more complex from a technological point of view. As is widely known, GPS receivers work only outdoors since the signal they rely on is directly received from satellites. When indoors, an alternative mode needs to be adopted in order to obtain the position of a mobile device.

One of the technologies mentioned, which appears to be a right mix of cost and feasibility, will be further detailed in the following paragraph.

3.5 iBeacon and Indoor Positioning

iBeacons are low-cost and low-power consumption transmitters. When used correctly, they can locate mobile devices inside a building.

Depending on the configuration set, transmission distance ranges from a few centimeters to 400 meters. Generally, an iBeacon has a lifecycle of a few years, based on signal sending configurations, i.e. the stronger the signal, the less the iBeacon will last. From a technical point of view, calculating the position of a mobile device located in a confined environment where one or more iBeacons are placed is very simple.

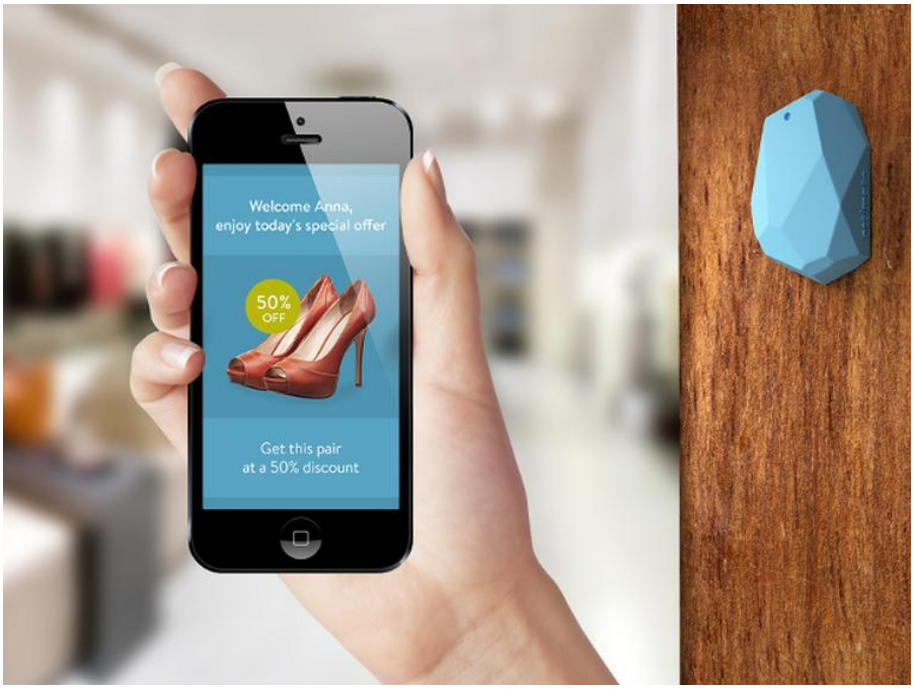

Figura 17. iBeacon device.

An APP receiving the signal of one or more iBeacons can be run on mobile. Relying on simple triangulation algorithms, the position of the device and its distance from the iBeacon are calculated.

At this point, according to the intended use, the APP can:

- Send the device location to an application that, for example, is used to monitor the movement of visitors within a museum;
- Display on mobile device information about the object located near the device;
- Display the indoor street view previously mentioned, and allow a real indoor navigation to guide, for example, a passenger to the gate;
- . . . .

Given these premises, it can easily be understood that managing indoor positioning and, consequently, indoor navigation is very simple.

For navigation purposes, users can benefit from an APP relying on the tools described in the previous paragraph, rather than on a simple two-dimensional mapping of the building.

4 New Technologies and Mobile, the Workforce Management Case

Workforce Management (WFM) tools are used to manage field activities (technical assistance, delivery, sale, ...) in order to dispatch the technicians with the right skills set, at the right time, and to the right place, thus minimizing logistical costs.

Especially when applied to utilities, WFM is the field currently witnessing the emergence of the most innovative mobile technologies, as companies operating in this business segment constantly rely on hundreds of engineers to perform hundreds of thousands of activities every day. Clearly, even minor improvements in terms of service and operational optimization can significantly reduce inefficiencies and save costs. Regulations have been introduced in recent years to define service levels for customers. However, such standards can only be guaranteed through a fine-tuned organization, the main aims being those of optimizing, safely performing and monitoring the operations of back-office and field resources.

Outlined below is Google Maps Coordinates, an affordable infrastructure made available by Google. The following paragraph is dedicated to an important WFM project implemented by the largest Italian utility, namely Italgas, known as GAStoGO.

4.1 Google Maps Coordinate

Google Maps Coordinates (Google, March 2018) is a platform to which users can easily subscribe to manage the field workforce. Supervisors can work more efficiently as they can see how mobile resources are distributed on field in real time and are able to assign tasks directly from their mobile devices. For their part, mobile workers can keep their supervisors informed on the job assigned and increase their efficiency, since they know where their colleagues are located.

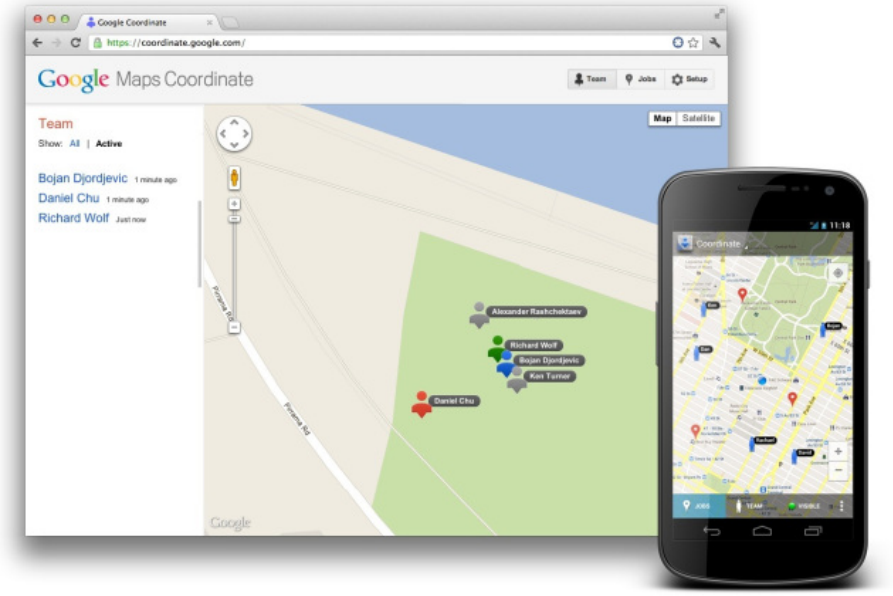

Figura 18. Back-office and mobile interface of Google Maps Coordinates.

No IT infrastructure is needed as Google's cloud platform is complete, back-office is provided via WEB and the APP for mobile devices is available in the Google APP store.

The main back-office functions are aimed at: building a team, managing users, customizing interfaces, developing custom applications, tracking workers in real time, assigning and managing tasks, viewing work status and history, making video conference calls, dispatching works to resource on field, using Google Maps Navigation, taking works in charge, updating work status, contacting the supervisor.

4.2 GAStoGO

Italgas (Snam group) is a leading Italian company in the field of natural gas distribution. It operates a network of over 52,000 kilometers and serves approximately 6 million customers. The company employs 2,500 people, of which approximately 1,300 are workers. Each year, over 2 million appointments with customers, 600,000 maintenance interventions

and 100,000 on-call interventions are managed. Impressive figures like these require great efficiency in scheduling and resource optimization, to achieve continuous improvements in service quality.

GAStoGO (SNAM, March 2018) is the first project in Italy where the iPad, a consumer tool, has been provided to field workers. The use of such a device has been, in our opinion, the key success factor because it proved to be easy to use and drastically reduced the time needed to train operators. In addition, field resources have felt themselves treated in the same way as staff working in the office, thus promoting a democratization process led by technology, which is not usual in organizations of this kind.

Figura 19. GAStoGO project.

GAStoGO is a project implemented in-house by Italgas. An APP was introduced and installed on the iPads of technicians to support them in:

- Recording workplace attendance
- viewing the list of tasks assigned
- Checking the list of the materials needed to perform the activities
- Displaying works on digital maps together with the intervention history
- Feeding the database with technical information and images directly collected on field

- Using FaceTime to share solutions for specific issues in real time
- Relying on an integrated navigation system
- Accessing corporate applications
- Attending training courses provided on *e*-learning platforms.

In the first 2 years of the project, the following goals were achieved:

- Elimination of paper-based documents amounting to at least 500,000 procedures per year, saving at least 5 tons of paper and 12,500 kwh;
- 30% reduction of the daily mileage in less than two years (from 14.9 kilometers per activity to 10.6) and consequent reduction of CO_2 emissions;
- Increase in productivity by 100% (average time of work successfully completed measured in hours work performed daily, increased from 2.1 to 4.2);
- Reduction of the time needed to complete works: from 20 days in 2007 to 0.1 days in 2013;
- Reduction of margins of error due to inaccuracies in the transcription of data;
- Activation of remote training courses to reduce travel times.

5 Conclusions

Given the trends described above, we are no longer talking about a mere testing of prototypes of mobile applications. Rather, applications/projects already have a major impact and can bring significant operational and financial benefits.

For this reason, IT companies are totally focused on mobilizing business processes. Analysts, with Gartner at the forefront, see the mobile market as the most important source of income for the coming years and users are setting no limits to their expectations.

A key factor for the success of the technologies mentioned, which has not been considered in the present paper, is the potential of both consumer and business applications for producing a wealth of textual and multimedia information, that was unimaginable just a few years ago.

The strategic importance of such an issue is further demonstrated by the steps taken by the most important players in the market (Google,

Amazon, Microsoft, ...), currently investing billions of dollars to offer "unlimited" Cloud resources in terms of space and performance.

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