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A mobile business information system for the control of local and remote workforce through reactive and behavior-based monitoring

Sergio Ríos-Aguilar [a,*], Francisco-Javier Lloréns-Montes [b]

[a] Engineering and Architecture Department, Pontifical University of Salamanca, Madrid, Spain
[b] Management Department, University of Granada, Granada, Spain

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ABSTRACT

This study analyzes the viability of using employees' smartphones following the BYOD paradigm as a valid tool to enable firms to control effective presence (primarily of remote labor force). We propose a model for a Mobile Presence Control Information System with which to demonstrate experimentally the viability of unifying three elements that have only been examined individually in previous studies: the consumerization of ITs, the real geolocation capabilities of personal mobile devices that employees can use in the workplace, and the exclusive use of Mobile Web technology to obtain universal location information without the need to install native apps. We also propose a new and specific methodology to analyze the precision and accuracy of the location data obtained by smartphone geolocation services. We developed a prototype of the Information System proposed and demonstrated its validity under different real-use conditions, obtaining valuable information on the accuracy and precision of the location data from real devices (based on iOS and Android) under the conditions of heterogeneous connectivity representative of workplaces. This research enables us to establish a new framework for the requirements needed, on both quantitative and qualitative levels, for the accuracy of the mobile location systems that can be used in Presence Control Information Systems, particularly those related to control of remote labor force.

1. Introduction and definition of the problem

It is now commonly accepted that companies must use Information Systems to gather and organize all information at their disposal to help the company's business strategy to succeed. The increasing competitiveness of current market forces companies to pursue deeper understanding of the cause-effect relationship of their actions on profitability, making it necessary to have specific information that guides their process of improving competitive performance (Bradley & Nola, 1998; D'Aveni, 1994; De Assis Lahoz & Camarotto, 2012).

Performance measurements related to time, quality, and productivity complement financial measurements and permit the introduction of improvements in operational processes. Analyzing the importance of time as a key factor in the performance of task completion, Ballard and Seibold (2004) identified ten dimensions of time in the workplace. Among them, lack of punctuality and absenteeism can be regarded as the most persistent obstacles affecting business competitiveness (Campbell, Ganco, Franco, & Agarwal, 2012).

Early detection, evaluation, and rapid intervention are crucial when managing tardiness and absence in the workplace. These measures help prevent infractions from becoming a serious problem for the competitiveness of companies.

Such detection usually requires investment in Information Technologies, among other tools for the acquisition and implementation of Control, Access, and Presence Systems. These items are often expensive, due not only to the initial costs (equipment for physical identification using card reader technology or biometric identification) but also to maintenance of the equipment and software that form the system's back end, not to mention the possible cost of integration with pre-existing Information Systems (Kauffman, Techatassanasoontorn, & Wang, 2011; Sen, Raghu, & Vinze, 2009).

This kind of system has also proven to be ineffective in extending control to mobile workforce, which in numerous private service sector enterprises may represent a high percentage of the staff, depending on the nature of the business. In this case what is needed is "proof of presence" at places and times established in advance (Kumar & Pandya, 2012).

* Corresponding author.
E-mail addresses: sergio.rios@upsam.es (S. Ríos-Aguilar), fllorens@ugr.es (F.-J. Lloréns-Montes).

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Implementing support for the mobile workplace by introducing Mobile Information Systems (mobile devices and applications engineered for the mobile environment), which enable control of the spatial and temporal dimensions of mobile work, grants not only a competitive advantage but also labor productivity growth to companies (Yuan, Archer, Connelly, & Zheng, 2010).

An analysis of the literature shows see that a variety of research based on large-scale studies demonstrates that location-based queries are already a significant part of the total communication data sent from mobile devices. These results support the idea that such services are already sufficiently familiar to users of mobile devices, making their use easily translatable to the workforce, including both employees present in office and those away from the workplace. (Biancalana, Gasparetti, Micarelli, & Sansonetti, 2013; Ghose, Goldfarb, & Han. 2012; Pan, Nam, Ogara, & Lee, 2013).

Some of the studies reviewed question the validity of the accuracy of the data obtained with location systems based on mobile devices. For example, Pulido Herrera, Kaufmann, Secue, Quirós, and Fabregat (2013) indicate that the global positioning system (GPS) is generally a significant aid but that it is not precise enough to locate a person. They do not, however, study either quantitatively or qualitatively the requirements for accuracy and precision that would be valid for locating a person, particularly for use in an information system for behavior-based control.

The study by Subbu, Gozick, and Dantu (2013), on the other hand, indicates that the GPS system employed in mobile devices is being used widely for locating people on the street, but the authors conclude that the system does not work inside buildings due to the weakness of the signal and to interference, whereas the alternative—WiFi-based mechanisms—are available everywhere. Neither this study nor that of Pulido Herrera et al. (2013), which refers explicitly to the presence of multiple sensors on mobile devices, considers (a) the possibility of integrating data from multiple sensors into the location services of the mobile device, and (b) the quantitative study under real conditions of how combining data provided by different sensors to improve the quality of the position obtained in current smartphones would contribute to this accuracy.

On another order, Song, Kim, Jones, Baker, and Chin (2014) indicate that locating the appropriate mobile application in an app store could become a difficult task for users and that ease of app discoverability is becoming a serious problem, both for users and developers of native applications and for the distribution stores themselves. Their study does not tackle the real possibility of providing location services using web applications instead of native apps, since web applications are universally available and independent of manufacturer or brand and model of smartphone. Heitkötter, Hanschke, and Majchrzak (2013) confirm this universality.

Nayak, Swamy, and Ramaswamy (2013) indicate that the use of location-based applications on mobile devices has increased the risks to individuals' privacy, and that monitoring an individual's location and then integrating the data registered would enable one to reconstruct a profile that violates the fundamental rights of the user. The study by Li, Zhu, Gao, Chen and Ren (2014) explores the danger of exposing a smartphone user's location data and indicates that the current focus is to develop mechanisms that protect privacy in location-based services. The study does not, however, tackle the possibility of permitting users' explicit and nonintrusive use of these services.

With all of the conditions presented, we believe that it is extremely important to study the viability of creating an Information System for the behavior-based control of workforce that enables non-intrusive use of technology for obtaining employees' locations from their own smartphones, regardless of the device's make and model.

For this reason, our study proposes, first, qualitative and quantitative references for the quality of location information required in different environments to control the presence of remote persons, doing this by examining the strictest regulations in effect related to location-based services (primarily emergency services). We also analyze whether it is possible to fulfil the conditions suggested by these references using real smartphone-type devices, by testing the accuracy and precision of the location data obtained using the integrated location services under highly heterogeneous conditions representative of physical work environments.

Finally, we propose an Intelligent Mobile Information System for Presence Control that uses only reactive, terminal-based location technologies in order to make the process of obtaining and delivering the worker's location explicit and non-intrusive through use of a non-native mobile web app that guarantees universal access and contributes considerably to reducing overall costs.

1.1. Opportunities

In the current economic context, it is of vital importance for a business to improve its competitiveness by rationalizing the necessary investment to achieve it. As highlighted above, having a Mobile Information System that permits rational and non-intrusive control of the workforce provides a direct and effective means of achieving such improvement.

Two unique situations have been detected that can allow small and medium-sized enterprises (SMEs) to implement a presence control Information System for both local and remote workforce at very reduced cost and with minimal infrastructure:

(A) The current maturity of mobile location technologies, using different transparent positioning mechanisms (A-GPS, GPS, WiFi and Cell-ID).
(B) The growing BYOD ("Bring Your Own Device") trend, which allows employees to use their own mobile communication devices (smartphones, tablets,...etc.) in the business as a complementary tool that plays a double role as both personal device for private use and provider of access to the company's Information Systems.

This paper builds on these foundations to attempt to ascertain whether it is feasible to implement an Information System for the behavior-based control of workforce that makes non-intrusive use of technology for obtaining the employees locations from their own smartphones, regardless of the device's make and model.

The study first analyzes the viability of using employees' smartphones following the BYOD paradigm as a valid tool for companies to conduct presence control (primarily for remote workforce). It then proposes a Mobile Information System for Presence Control using exclusively terminal-based reactive location technologies, meeting cost minimization and universal access criteria.

Subsequently, the paper proposes qualitative and quantitative references that meet criteria for the location information accuracy required in different business remote workforce control scenarios. Finally, this study discusses the results of testing the accuracy and precision of location data using real devices (iOS and Android) under heterogeneous connectivity conditions and workplace premises

1.2. Granularity in control of the workforce

The use of monitoring technology can often lead to unwanted effects and behavior (Stanton, 2000), and continuous monitoring with mobile location technologies in particular increases such effects (Weckert, 2005). In this context, it is reasonable to expect an Information System designed to avoid these behaviors to use