Pervasive Technologies for Smart Workplaces: A Workplace Efficiency Solution for Office Design and Building Management from an Occupier's Perspective

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Abstract. Corporate Real Estate (CRE) Management and office design are increasingly considered as a strategic resource for developing businesses and competitive advantage. Measuring the added value of CRE, as well as managing smart workplaces are an issue for academics and professionals. We consider that pervasive technologies offer potential for increasing workplace efficiency on a long-term basis. In order to gain insight of workplace and building management in practice from an occupier's perspective, Colliers International France designed its Paris office as a "living lab". We implemented a work environment based on desk-sharing and a set of activity-based workspaces. We also deployed Schneider Electric's WorkPlace Efficiency (WPE) solution aimed at monitoring the occupancy rate of our building as well as at supporting the effective use of shared office resources and employees' wellbeing. The paper presents our experience of this solution in the context of our Paris office and discusses its potential for building smart and sustainable workplaces.

Keywords. Office Design, Real Estate, Pervasive Technologies, Smart Building, Worlplace

1 Introduction

Corporate Real Estate (CRE) Management and office design are increasingly considered as a strategic resource for developing businesses and competitive advantage. Rather than a way of reducing costs, real estate decisions address challenges such as productivity, employees' wellbeing, innovation and flexibility. In this context, building and managing smart workplaces are an issue for both, academics and professionals. In order to meet these demands, an increasing number of companies choose to, fully or partially, implement "activity-based" workplace (ABW) environments. These

office solutions are aimed at better supporting the "new ways of working", that is to say work practices as they actually take place in modern organizations. Indeed, in today's "knowledge-intensive firms", work is "increasingly characterized by a temporary constellation of collaborators" [3] as people work in projects. It is also technology-dependent and thus distributed and distributable across time and space. Knowledge workers are likely to work anywhere, anytime and face growing requirements for cooperation and coordination of tasks and activities [6].

The concept of ABW appears complex and ambiguous [4]. ABW relies on the idea that space should fit the needs of employees' specific activities and the company's strategic goals in order to provide a basis for an effective CRE Management [1]. The activity-based office first emerged in the 1980's [13] [14]. The spread of Information and Communication Technologies (ICT) in the last two decades, as well as the low occupancy rate of offices [2] further supported this trend. As CRE managers are increasingly considering both financial and indirect benefits in real estate decisions (functional, strategic value), the focus in measuring CRE management effectiveness is moving towards a cost benefit ratio [5] [1]. Nonetheless, research on whether or not these office solutions truly increase productivity and employees' satisfaction show mixed results [12].

In the main, the idea of ABW is translated by architects, office planners and consultants into specific building and office layout (for instance activity-based workstations and workspaces such as "project rooms" for team work, non-reservable closed offices for individual concentration work or unplanned meetings) as well as into change management programs. The design and implementation of ABW involves a major transformation of work practices and habits [7], including behaviours and interactions with technology.

While ABW may be a good starting point for building smart workplaces, it raises questions related to the effective use of shared office resources such as space but also energy. In order to build flexible workplaces that truly fit organizations' needs and are able to adapt to corporate growth and restructuring, there is a need to both design and manage ABW. We think that pervasive technologies offer great potential in order to measure, manage and increase workplace efficiency on a long-term basis. In what follows, we present Colliers International France as well as our office in Paris. We use our building as a "living lab" in order to gain insight on flexible working and activity-based work environments. Then, we introduce a solution based on Radio Frequency Identification (RFID) technology, the WorkPlace Efficiency Solution (WPE), aimed at monitoring the occupancy rate of our building as well as at supporting the effective use of shared office resources. The solution was developed and implemented in partnership with Schneider Electric, a global specialist in energy management and energy efficiency. The post-occupancy evaluation of Colliers Paris of-

fice (Section 4) provided background and incentive for monitoring WPE performance and analysing the data over a ten-month period (January to October 2014). We conclude with a discussion on the implications of this solution for building and managing smart and sustainable workplaces and buildings.

2 Colliers International France

Colliers International France is a global independent Real Estate and Workplace Consulting and Project Management company. We help our clients to implement high performing flexible work environments, like ABW, and to reduce occupancy costs. In order to do so, we rely on a wide range of expertise (real estate and workplace consultants, architects, space planners, construction engineers) which allows us to address the different functional layers of buildings [9] in a coordinated manner. As Leamen [9] contends buildings are complex systems which are organized in functional layers, each setting constrains that influence characteristics on a smaller scale. Thus location, geographical characteristics, urban infrastructure may have an impact on size, shape, orientation, and accessibility of buildings, which in turn set the context for building services, like for instance heating, lighting, ventilation and for office design and layout (workstations, meeting rooms).

In our view, design and build processes (planning, architecture and build, interior design) require a systematic and an integrated approach to the building as a whole. This means considering and "aligning" a number of potentially conflicting perspectives on the system, those of the professionals or the stakeholders involved in the different stages of the project (architects, engineers, end-users, property developers, real estate and workplace consultants). The design of smart and sustainable workplaces is that of a building, but also that of the practical conditions of building management on a long-term basis from an occupier's perspective.

In order to gain a deeper understanding of workplace and building management in practice, our Paris office is organized as a "living lab". The design team was entirely composed of Colliers International France professionals and implemented a flexible work environment based on desk-sharing and a set of activity-based workspaces. Figure 1 provides a view of some of the workspaces available in our Paris office.

Fig. 1. Different types of workstations and workspaces in Colliers International France.

In addition to office design and related issues ("ways of working", users' support in understanding and using space), we also implemented an indoor location-sensing system based on RFID technology. The system was designed by Schneider Electric and is aimed at providing us with data on the use of shared spatial resources such as meeting rooms, "bubbles" and the different kind of workstations.

The following section presents the system as well as its intended use and actual use.

3 The Workplace Efficiency Solution by Schneider Electric

Schneider Electric's WorkPlace Efficiency (WPE) is a solution designed to manage comfort and occupancy as well as to provide services to users in large office buildings. Colliers International France implemented the WPE occupancy monitoring system which connects a network of sensors with anonymous RFID tags inserted into employees badge holders. The tags transmit information to the sensors via radio which allows a real-time occupancy monitoring of the different spaces ("bubbles", meeting rooms, workspaces). Figure 2 shows the location of sensors on a standard floor of Colliers office as well as an employee badge holder.

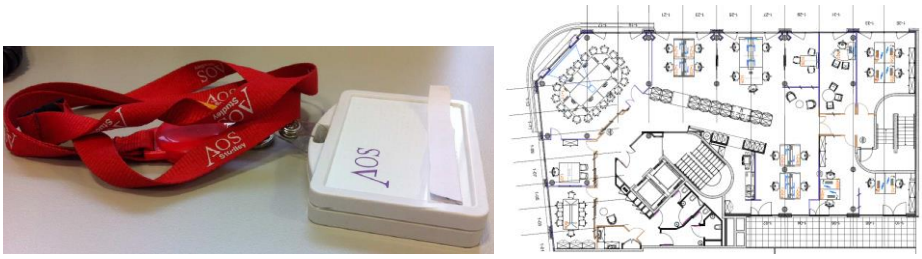

Fig. 2. An employee badge holder and a standard floor plan

The data transmitted by the tags includes the user category (for instance employee, trainee or visitor) as well as the detection zone (which are numbered and associated to different types of workstations or given workspaces). The WPE provides data on the actual use of different workspaces. Thus, Colliers is able to measure the frequency rate of a given workspace (time of use/availability) and its occupancy rate (occupation/capacity).

4 The Post-Occupancy Evaluation of our Building

In 2013, two years after designing its office, Colliers International France launched a post-occupancy evaluation (POE) of its building-in-use [11] [15]. The aim of the project was to provide feedback on the designed environment (occupants satisfaction, perceived comfort, workspaces "fitness" to users' needs, building's technical performance) as well as to define a set of requirements for improving workplace efficiency. By developing knowledge on the results of design decisions, the project was also expected to eventually inform the practices of Colliers building-related professionals.

The initial phase of the project extended over a six-month period and included several field studies: a) an online survey of employees' satisfaction of their office and perceived workplace efficiency was carried out by an independent provider ; b) focus groups with user representatives; c) real-time observations of workspaces occupancy over a two-week period. The online survey questionnaire (a) included questions on employees' activities and satisfaction with physical features of their workplace (such as available workspaces and furniture, air quality, noise level, lighting) and facility services (mail, IT service, reception areas, access). The focus groups (b) gathered user representatives and experts from various disciplines (architects, workplace and change management consultants etc.) and aimed to generate ideas on improving employees' comfort, as well as the workplace efficiency as a support for productivity and innovation. Finally, real-time observations of workspaces' occupancy (c) were carried out four times per day during two weeks. A group of surveyors walked through the building and recorded manually whether workstations and meeting areas

were “used” (when a user is physically present), “in use” (when a user is not physically present but the workstation appears as occupied) or “unoccupied” (empty desk or space) by users. The survey provided data on peak, average and minimum occupancy rates as well as a map of most used areas in the building.

The results yielded by these studies suggested that concentration work as well as informal, un-planned meetings were insufficiently supported by the environment both in terms of workspaces availability and technical performance (noise level, air conditioning, air quality, etc.).

In this context, the WPE solution occupancy data highlighted workspaces occupancy trends over several months. The analysis sought to further develop post-occupancy evaluation (POE) diagnosis and to eventually provide a basis for recurring evaluation and continuous improvement of Colliers activity-based office. We analysed the data of the Schneider Electric WPE system over a ten-month period (January to October 2014). We specifically focused on the use of shared workspaces such as the non-reservable closed offices, called “bubbles”, the meeting rooms and the cafeteria. The WPE solution reports the maximum number of users that occupied a given workspace (“room”) per unit of time (1/4 of an hour, hour, day, week, and month). “Rooms” include workspaces with identified functional characteristics (“bubble”, meeting rooms, and informal meeting areas, individual enclosed offices) as well as open spaces where different types of workstations (“benches”, boxes) are available. The reports systematically feature rooms’ capacity (number of seats) against the number of detected users.

The occupancy data reports were generated per hour, per day and per month. The analysis considered all user categories. In parallel, meetings rooms booking system provided additional information on the number of reservations of a given room per hour. Booking system data was compared to the frequency of occupation.

5 Implementation in an Activity Based Workplace

The ABW’s underlying principles imply that employees choose their location according to their needs and preferences. While teams and services each have a dedicated area, people can potentially choose to work anywhere in the building. ABW is thus supposed to provide the means for an efficient management of peaks and troughs in user demand. Furthermore, functional characteristics of space are designed to match employees’ needs (concentration, interaction, cooperation). For instance, open space meeting areas should support serendipitous interactions and trigger knowledge-sharing and workplace learning. In this context, the WPE system’s data allows us to

make hypothesis on the users' needs as well as on the current workspace "suitability" for employees' activities.

The figures 3 and 4 below display the occupancy of the cafeteria and one of the bubbles from January to October 2014. During observations and focus groups, the cafeteria was reported (b; c) to be regularly used outside lunch hour (figure 2) for planned and un-planned meetings. Analysis of WPE data on an hourly basis shows that cafeteria was occupied by a maximum of 45 users from 10:00 to 11:00 over a ten-month-period. Only 7 to 8 users were detected from 15:00 to 17:00.

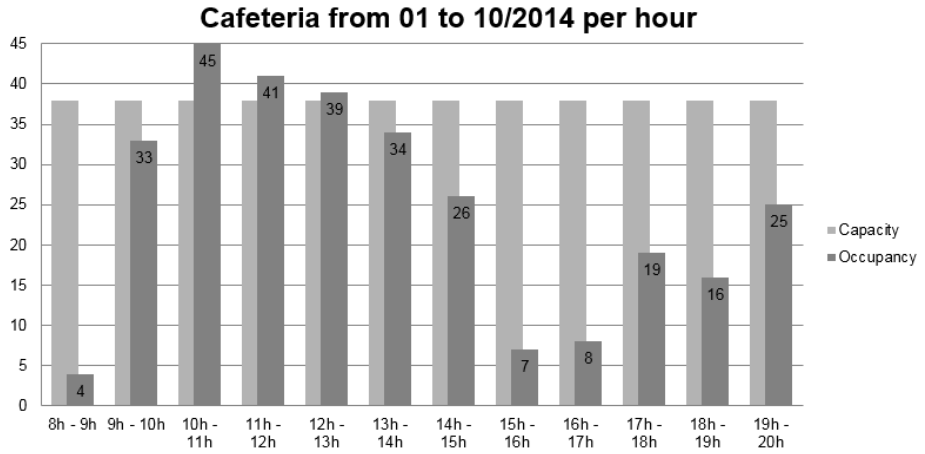

Fig. 3. Occupancy of the Cafeteria from June to October 2014

Since occupancy refers to the maximum number of tags detected per hour of a working day over a five-month period, WPE reports highlight peaks values. From a design perspective, trough levels appear as important as peaks. Early afternoon occupancy of the cafeteria (from 15:00 to 17:00) was of a maximum eight users over several months. This neither confirm nor contradict the idea that cafeteria supports planned and unplanned meetings as reported by user representatives. Additional data is needed in order to draw meaningful conclusions on the average occupancy rate of a given space. In our case, observational study (d) tends to confirm cafeteria's "extended" use. This allows us to interpret the maximum observed as referring to a recurrent phenomenon, potentially related to a type of activity (planned or unplanned meetings of at least two people).

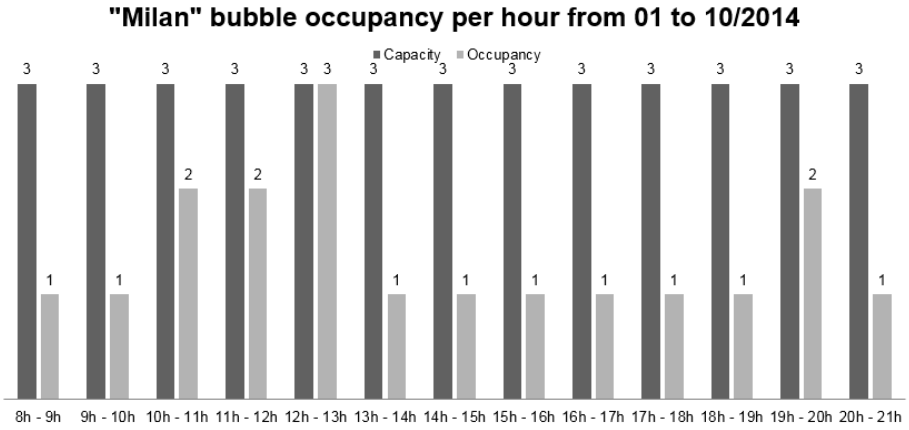

Fig. 4. Occupancy per hour of the “Milan” bubble from June to October 2014

We also found that “bubbles” (fig. 4) were frequently used by only one person over a day-long period, while their intended purpose is to support both concentration work and cooperation (2 to 3 users). Figure 4 shows the occupancy of the “Milan” bubble. The maximum of occupiers detected by the system nine hours per day, over the ten-month period considered, is of one user. Likewise, monthly reports over the same period highlight a maximum of one occupier six months out of ten. WPE data suggests that “bubbles” are under-occupied since peak occupancy levels detected rarely reach its maximum capacity.

Meeting rooms also appear as intensely used but under-occupied (1 to 4 users). The figures below display the frequency of occupancy of a meeting room compared with the number of reservations made by users via Outlook or directly on the reservation screen. Frequency of occupancy refers to the number of times the room was effectively occupied by one or several users. According to the number of occupiers considered (one, two or more) when defining “effective occupancy”, there is a clear variation in results.

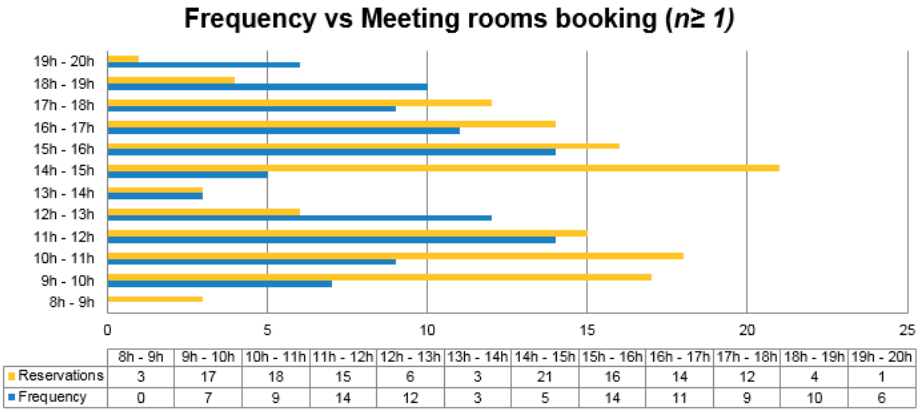

Fig. 5. The frequency of occupancy of a meeting room versus the number of reservations

For instance, if we assume a meeting room is regarded as occupied when at least one user is actually present, results (figure 5) highlight that occupancy exceeds reservations at noon (12:00 to 13:00) and at the end of the day (18:00 to 20:00). However, when occupancy involves at least two users, there is a considerable gap between the number of reservations and actual use (figure 6). This implies that a significant proportion of the reservations do not translate into actual use. This observation also suggests that meeting rooms are potentially "misused" since frequency of occupancy decreases when at least two occupiers are considered.

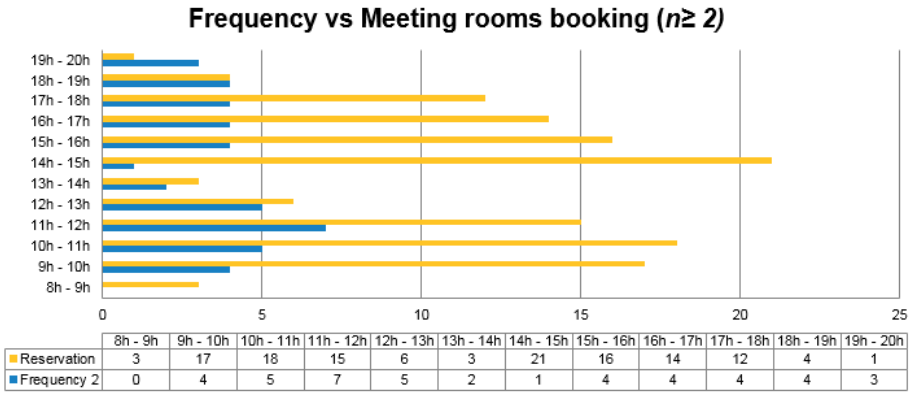

Fig. 6. The frequency of occupancy of a meeting room versus the number of reservations

ABW is expected to provide an extensive supply of shared collaborative spaces such as meeting rooms or bubbles in order to increase employee comfort and effectively support collaboration. In the case of Colliers International France, bookable meeting

rooms are intended for a group of at least three users since bubbles also support planned and unplanned meetings for up to 3 people. In spite of this, both WPE reports and the observations we have conducted highlight a difference between intended and current use of workspaces by employees. This is a challenge for practitioners in further adapting ABW to users' needs.

6 Discussion and Future Work

In 2015, we redesigned our Paris office. The WPE provided a basis for both deepening our understanding of ABW use and identifying issues to be further investigated. While pervasive technologies' potential for building energy management has been widely acknowledged by academics and professionals [8][10], most of the POE studies still rely on questionnaire surveys, face-to-face interviews or facilitated work sessions with user representatives [10]. Be that as it may, as an increasing number of companies are trying to provide functionally supportive or "activity-based" workplaces, developing our knowledge of building-in-use is essential in ensuring the "adaptability" of workplaces to changing organizational needs.

So far, our results suggest that there is a gap between intended and actual use of shared workspaces and point at the need to better support concentration activities. The study also shows that successful implementation of a WPE solution is predicated upon a better understanding of the solution potential among the design and facility management professional communities.

A situated approach in understanding work practices, would greatly improve design process and could also contribute to develop the use of WPE. As a cafeteria is not intended for planned and unplanned meetings, just as informal meeting areas are not only for individual work, its "extended" use could be considered as "misuse" by designers and project managers. Yet in practice, having a meeting in the cafeteria, instead of in a meeting room, might be of value for users. It allows them to be seen and eventually heard by others. In other words, "misuse" could be considered as much as a resource for building mutual awareness as an inappropriate behaviour.

The use of WPE solution, in our experience, throws up several issues related to its acceptance by employees. While monitoring workspace utilization provides valuable input for design and has proven to be an effective "medium" for user involvement during workshops, further investigation is needed in order to assess and to deal with workplace "fitness" to employees' needs. Furthermore, the WPE system guarantees the anonymity of employees. Nevertheless, our experience shows that it can be perceived by users as a way of monitoring people rather than the use of space. In order to improve the acceptance of the system by employees, we recently introduced remova-

ble badge holders. Users are now able to separate their badges (by swiping it out) from the RFID badge holders and potentially swap with someone else's badge holder (within the same user category). A mobile application was also presented to employees. The application provides services such as a meeting room finder based on real-time occupancy data, a 3D building navigator designed to help users find their way in the building, as well as a comfort remote control. Additional third-party services are available, like transportation time estimation, carpark load information, restaurant information, company news etc. The recent developments of the WPE solution offer new opportunities for employees to actively engage with the system and thus develop their understanding of its possibilities and practical relevance. This is both an opportunity and a challenge for the design of pervasive technologies and smart workplaces. We are currently looking to develop the use of existing data pertaining to sustainability issues such as energy efficiency.

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