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Abstract

Ambient Technologies, such as beacons, sensors, and other similar smart devices, can be used in work places such as offices to determine everything from whether an employee is in the building, to where they are located, and whether a booked conference room is actually in use. This is part of a larger smart office strategy involving digital facilities management solutions that respond to modern methods and manners of working, as well as smart building technologies providing digital ecosystems that allow workers empowerment through personalization and automation. This new data-driven environment contributes to energy efficiency, optimized space utilization, enhanced workplace experience and occupants' comfort. However, all of this requires standards for data interoperability and seamless networking. Facilities managers are also now taking on a different role as to how they visualize new smarter office spaces, where it is expected that new environments would support their inhabitants intelligently by promoting easier management, better efficiency, increased productivity, and enabling the buildings to be part of the creation process for design and project development. There are obviously numerous sensitivity issues with respect to gathering, storing, maintaining, and processing of the ambient environment data in terms of user privacy, security, and possibility of potential data misuse. In this chapter, we discuss the new approaches to facilities management in terms of developing smarter office spaces, embedded with devices employing Ambient Intelligence (AmI) . We also articulate cases and examples of ambient technologies implementation.

Keywords (separated by '-'): Ambient technology - Ambient intelligence - AmI - Inoperability - SaaS - Privacy - Strategic design - Co-location - Facilities management - Efficiency - Collaboration

Chapter 12
Twenty-First-Century Smart Facilities Management: Ambient Networking in Intelligent Office Buildings

Alea Fairchild

Abstract Ambient Technologies, such as beacons, sensors, and other similar smart devices, can be used in work places such as offices to determine everything from whether an employee is in the building, to where they are located, and whether a booked conference room is actually in use. This is part of a larger smart office strategy involving digital facilities management solutions that respond to modern methods and manners of working, as well as smart building technologies providing digital ecosystems that allow workers empowerment through personalization and automation. This new data-driven environment contributes to energy efficiency, optimized space utilization, enhanced workplace experience and occupants' comfort. However, all of this requires standards for data interoperability and seamless networking. Facilities managers are also now taking on a different role as to how they visualize new smarter office spaces, where it is expected that new environments would support their inhabitants intelligently by promoting easier management, better efficiency, increased productivity, and enabling the buildings to be part of the creation process for design and project development. There are obviously numerous sensitivity issues with respect to gathering, storing, maintaining, and processing of the ambient environment data in terms of user privacy, security, and possibility of potential data misuse. In this chapter, we discuss the new approaches to facilities management in terms of developing smarter office spaces, embedded with devices employing Ambient Intelligence (AmI) . We also articulate cases and examples of ambient technologies implementation.

Keywords Ambient technology · Ambient intelligence · AmI · Inoperability SaaS · Privacy · Strategic design · Co-location · Facilities management Efficiency · Collaboration

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12.1 Introduction

AQ1 To make office spaces more functional, efficient, and productive, facilities managers are now tasked with finding ways to ensure better usage of the available facilities. This suggests the deployment of technological infrastructures that allow employers and businesses to maximize their investment in, not only the buildings, but also the people who work there. It is recognized that ambient technologies, in the form of smart devices that sense, store, and distribute information, are appropriate tools to aid in these activities. In this section, we first define certain related terms used in discussing the enablement of intelligence in office spaces. Then, we discuss new business approaches related to Ambient Intelligence (AmI) and present the chapter organization.

12.1.1 Smart Buildings, Spaces, and Facilities Management

A smart building can be defined as one that enables integration and control of building systems in terms of efficient facilities management, employee well-being, and employee engagement. Smartness is directly proportional to *awareness*, which may be defined as *the state or ability to perceive, to feel, or to be conscious of events, objects, or sensory patterns* [1].

Smart spaces are workspaces within smart buildings that use technology, and ambient intelligence built within the smart technological devices, that allow for monitoring and measurement of occupancy levels, available vacancies, use of amenities, etc. These spaces are designed for optimal use within the smart buildings. These are triggered by sensors and intelligent devices (such as smart watches, mobile devices, and handheld badges) for the identification of office workers, their status, their relationship with office spaces (i.e., occupancy status), and the relevant courses of action for better utilization of spaces, and at the same time, ensuring workers' well-being.

The reality of smart spaces for users is not just how the relevant data is used, but how the optimization of the space is taken care of. In the later sections of this chapter, we further elaborate on this.

The concept of smart buildings, smart spaces, and Smart Facilities Management (SFM) is driven by the need for energy efficiency, environment functionality, and space optimization. The distinguishing features of smart facilities management include interoperable control systems, use of sensory devices, automated building systems diagnostics, and self-commissioning of building systems (sensors and control systems) [2]. In this context, appropriate management of the device connectivity and networked features allow the required levels of control that result in more efficiency, better comfort, and cost reduction. It can also benefit both the users and the owners of the buildings.

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Buildings facilities include office workspaces including unassigned work areas, workstations with computers connectivity, meeting rooms with various layouts, privacy enhanced soundproof areas for private telephony or web-based conversations, private rooms for solitary work and public areas for either meetings or group work at a large scale.

Office buildings and spaces within buildings do not only facilitate accomplishment of work tasks, they have also the *potential to improve by contributing toward the provision of the optimum working and business environment* [3]. As many functions are carried out in office spaces, optimized utilization of space in office environments has now become vitally important. Office space has always assumed *the role of being the place and the environment where people work, research, team together, create and document information* [4].

Adding "intelligence" to these flexible spaces adds much more than mere knowledge application. It also adds means for enhanced communication as well as provide better working environments that satisfy user actions as people adapt their working behaviors to match their environment. This embedded intelligence is another driver for smart buildings and smart spaces, so that users can find each other in the building, as well as walk into a meeting room that becomes instantly enabled with the right applications and the correct connectivity of devices and data.

However, to achieve the said aims and benefits, there needs to be an understanding of the underlying infrastructure that makes this happen, including standards and interoperability for data exchange.

12.1.2 Ambient Technologies

Ambient technologies can help control the resources that users have access to. They also help to create a more productive and adaptable environment. These technologies work in the background, aiding in the learning how teams may be formed and how they might work together more effectively. This type of technology is still seen as largely experimental; however, users are keen to accept and use them much more than previously anticipated. One example of how smart spaces may be used differently with ambient technologies can be highlighted by the team from Robin which uses meeting room assistants in their smart meeting rooms [5]. Robin is further discussed in the use case section of this chapter.

Technology is making it easier not just to communicate with distant colleagues about work, but also to collaborate and work together. Technologies instill closer personal interactions with distant colleagues. In 2018, it has become much less of a stigma not to be co-located with co-workers. In fact, hot desking, working from home with flexible hours, and smarter working environments are becoming attractive and popular—all this through the use of smart technologies embedded with Ambient Intelligence (AmI) [6].

12.1.3 New Business Models

Mechanisms to use office space more effectively has also evolved over time. Space has now moved from an item of the commodity to a premium article in terms of commercial value. Managing that value is now part of facilities management. This has led to new business models in office space usage, such as Space-as-a-Service (SaaS) that has evolved as a new model of working. The SaaS idea is gaining popularity. Companies like WeWork, Pure House, Krash, and Common are all aware of the millennial desire for convenience, flexibility, and less liability, and have developed successful business models based on the idea of office SaaS. The traditional notions of "private" and "public" space have changed with a more collaborative service economy and technological advancement. Space is being recognized as a profitable commodity that can be leveraged to further business advantage.

Companies such as WeWork lease space wholesale from landlords and then sublet this space, at a margin, in small blocks of floor space, turning real estate into a technology platform for co-working. WeWork currently manages over 3 million square feet of space. They offer its use on a pay-as-you-go basis. Their *unlimited commons* membership option allows people to use WeWork locations anywhere in the world anytime. They provide tenants with the Internet facility, printing services, and separate spaces to relax when taking breaks during working sessions [7]. The co-working location managers handle all services for the use of their facility in terms of actual office management, from payment of utility bills to replenishing the ink in the printer and the coffee in the coffee machines. Managing a facility as a platform in SaaS for a variety of user organizations is a newer but highly successful approach to facilities management.

12.1.4 Chapter Structure

This Chapter looks at the drivers for the need for smarter buildings and smarter spaces; and discusses the rationale for more technologically engaged intelligent facilities management. We first address the technological factors, such as interoperability and standards, that allow the required intelligence to be leveraged. We then discuss the evolution of facilities management as an organizational enabler. The chapter then moves on to discuss ambient technologies and what role they might be able to play in making the buildings and spaces more intelligent and smarter. We examine some of the downsides of this as well, looking at occupants' privacy and sensitivity as well as their being tracked and sensed. Case studies of ambient technology implementations are also discussed before we conclude with final thoughts on where this concept could lead to in future.

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12.2 Interoperability and Standards for SFM

There are numerous technical issues with respect to smart facilities management (SFM). In this section, we briefly discuss the issues of interoperability and standards. For the appropriate use of required smart devices in the smart ambient networks, facilities managers need to first acquire an understanding of the levels of interoperability needed for such networks. Since it can be a huge challenge to seamlessly integrating AmI devices in a technological intelligent environment, a discussion on operability and standards for smooth communication is in order. In this respect, what should be the technological basis of AmI is similar to the layers of the Open Systems Interconnection (OSI) model. In this approach, lower levels of the model aim at the collection of lower level contextual information data with the help of various sensors and other similar devices. The middle and upper layers usually consist of computing nodes (in an edge computing context) with enough computing power to allow for the interpretation of the acquired contextual information and automated decision-making. The computing nodes of the upper levels may provide value-added services such as the collection of statistical data or integration of various business processes.

Sensing is a key function of smart buildings, and therefore, of critical importance for the sensing infrastructure. For this reason, a variety of wireless sensor networks has emerged as enablers for delivering sensor data. A consequence of having hundreds of devices is that these networks can become huge bottlenecks.

In terms of standards, two current standards have become popular for wireless sensor networks in buildings, viz.: VZigBee and 6LowPan. Both standards utilize IEEE 802.15.4 radios and are geared toward low-power wireless networks [8].

Occupancy and vacancy sensors are devices that determine if certain space is unoccupied and, if so then, automatically turn off (or dim) the lights and switch off (or lower) the central heating, thereby saving energy and cost. The sensor devices may also turn the lights on automatically upon detecting the presence of people, providing occupancy convenience and potential security aid. According to the Lawrence Berkeley National Laboratory, occupancy-based strategies can produce average lighting energy savings of around 24% [9].

The precursor to ambient networks in smart buildings was the development of two open communications standards for building automation, viz.: BACnet (for Building Automation) and LonWorks, developed by Echelon Corporation in the US. "Lon" in this case stands for Local Operating Network. The two standards have created possibilities for developing smart building controls and automation [10]. BACnet and LonWorks take different approaches to system integration, as follows:

- BACnet, developed in the mid-1990s, is a communications-only standard developed for a building's mechanical and electrical systems, particularly heating, ventilation, and air conditioning (HVAC). Companies that manufacture such systems are now beginning to make voice-controlled devices. BACnet was specifically designed for building automation systems and was adopted as Standard 16484-5 by the International Organization for Standardization (ISO, Geneva, Switzerland) in January 2003. As of 2018, the BACnet Standard achieved a global market share of over 60 percent, according to the latest analysis by British BSRIA, which also forecasts further growth for the next five years. The

BACnet standard comprises rules for data communication for hardware and software used in building control. It includes 23 virtual object types that together represent much of the functionality a building needs to operate. These virtual objects can be grouped together to represent the functions of real building systems [10]. However, there is a growing need to manage the functionality remotely with better efficiency as building owners are driving the trend to monitor and tweak building functions remotely including lighting, fire safety, security, internal conveyors such as escalators, heating, ventilation, and air-conditioning systems [10].

- Developed in the early 1990s, LonWorks combines a communications standard known as LonTalk, with a piece of hardware called the Neuron Chip. LonWorks is already being actively used in the transportation and utilities industries; and now it is being actively adapted for smart buildings environment. Evidence suggests that LonWorks is installed in more buildings globally than the BACnet standard.

Fortunately, the two standards are not mutually exclusive [10]. Unfortunately, however, even if the systems are based on BACnet or LonWorks or both, manufacturers can still program devices to preclude free-flowing data exchange with another vendors' equipment. LonWorks is a standards technology for many of the global standards organizations including ASHRAE, IEEE, ANSI, and SEMI.

The challenge for applications developers is both the development of industry standards and the integration of APIs, data protocols, and network communication standards. There is also a need for quality middleware. Although the need for middleware is well recognized in the AmI community, current research usually takes a top-down approach focused on the seamless integration of lower level nodes in high-end layers [11]. Given the lack of cooperation between device manufacturers, it would be logical that the integration of devices happens at a higher level in the AmI middleware model. This will be occurring in the Edge Computing aspects of the model which we will discuss below.

IDC, in its November 2017 Futurescape Worldwide IoT Predictions [12], has stated that: *by 2020, IT spend on Edge infrastructure will reach up to 18 percent of the total spend on IoT Infrastructure, driven by deployments of converged IT/IOT systems that reduce the time to value of data collected from their connected devices.* This reduction in time is critical to creating value from the infrastructure, which is part of the new role of facilities management in the current technological age of the Internet of Things (IoT) vision.

12.3 Evolution of Facilities Management (FM)

12.3.1 FM as a Profession

Facilities management has changed as a profession from its original management of physical assets of the building. It is now defined by the International Facilities Management Association (IFMA) as *a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process, and technology* [13]. In the twenty-first century, this has become a profession dealing with state-of-the-art office spaces and developing smart facilities. This is not only managing costs and efficiencies, but also reimagining and measuring the efficiencies of flexible meeting spaces that can be used by individuals and groups to support a wide variety of different tasks.

Facilities management (FM) has played an important role in office space evolution. In the early 1980s, the FM industry developed the concept of service bundling, where companies sought to externalize services as well as soft and hard FM outsourcing. It then moved in the 1990s toward service integration, and then in 2000, toward concepts such as total facility management, sustainability management and now to what we refer to as complete workplace management.

Becker [14] stated that *facilities management is responsible for coordinating all efforts related to planning, designing, and managing buildings and their systems, equipment, and furniture to enhance the organization's ability to compete successfully in a rapidly changing world*. As space as an enabling resource has the potential to facilitate positive change in the organization and provide competitive advantage [15], the objective of facilities managers in any organization is to channel resources to provide the right workplace environment for conducting the core business activities on a cost-effective manner that provides value-for-money.

12.3.2 Evolution of FM for Workspaces

The early approaches to the planning of workspaces were to go big and spacious. This was done in anticipation of an increase in volumes of business and the headcount within organizations. Such approaches have *failed to take into consideration the present requirements of occupants, businesses, and their future requirements* [16]. In terms of both the energy and cost efficiency, space management has become a high priority for most office organizations, mainly due to *the high cost of space, demands for more desirable space, and frequent adjustments required to accommodate the rapid growth or expansion of organizations* [17].

Developing and implementing space standards is one of the key responsibilities of any space management department in any organization as *the development of space standards is a prerequisite to the interior design process* [18]. For facilities management, the efforts toward space management are meant to provide a variety of support services to orchestrate all the organization's functions, putting the efforts toward an integration of primary activities in both strategic and operational levels. This makes facilities management an important element in the process of selecting ambient technologies and making sure that they are implemented in an efficient and profitable manner. For example, Near-Field Communication (NFC) technologies may be combined with IoT networks to create "all access" passes to an office space for ease of facilities management. A user could already be carrying around a wireless device that prepares for the user's arrival as they approach the building. It determines user's credentials, unlocks the front doors if credentials are ok, signs the user in, and starts user's computer before they reach the office. While it is a fact that security is going to be a big issue, there are vulnerabilities that need to be resolved; some such vulnerabilities being the same risks that already exist with the use of key cards [19].

Managing the space effectively requires the use of metrics to determine efficiency and cost savings, such as the energy indices that we discuss in the next section.

12.3.3 Indices for Facilities Energy Management

One new element coming into play for FM is the use of energy indices for buildings' design, selection, and occupancy. Climate Energy Index (CEI) and Building Energy Index (BEI) are both applicable. These were developed as a common basis for comparison of building energy performance and different design strategies in a simple and independent fashion [20]:

- The Climate Energy Index (CEI) provides an indication of the consequences of climate with respect to building performance at an *accepted standard of comfort at a particular geographic location* [20].
- The Building Energy Index (BEI) is designed to be a performance indicator for the overall building design strategy. BEI *comprises the climate related and climate unrelated energy loads, which are, respectively, derived from the CEI and benchmark data for non-space conditioning energy uses. The BEI can be compared directly with simulated or measured energy consumption data of a proposed building to benchmark its energy performance* [20].

A third index has also been developed by CBRE and Maastricht University, called the Green Building Adoption Index (GBAI). Together with the U.S. Green Building Council (USGBC) and CBRE Research, this index shows the growth of ENERGY STAR certified and LEED certified spaces for the 30 largest U.S. office markets, both in aggregate and in individual markets, over the previous 10 years.

It should be noted that the way the ambient technology is selected, measured, and rated in relation to FM is considered part of the evolution of the twenty-first century facilities management and evolving role of facilities managers.

12.4 Ambient Technology Management

12.4.1 Ambient Environments

European Commission Information Society Technology Advisory Group (ISTAG) and Philips organization proposed the Ambient Intelligence (AmI) concept in the late 1990s, and defined it as *eEnvironments that are integrated with sensors and intelligent systems* [21]. To be considered ambient, it was suggested that such environments would have the following characteristics [21]:

- Awareness of the presence of individuals;
- Recognition of individual's identities;
- Awareness of the context (e.g., weather, traffic, news);
- Recognition of activities;
- Adaptation to changing needs of individuals.

In creating these environments, AmI-based devices should be designed to be able to deliver user-specific services automatically and in anticipation of the needs of the inhabitants and visitors, assuming that those visitors can be appropriately categorized and their needs predefined [21].

ISTAG itself did not fully define the specifications for AmI. However, it looked ahead and recognized in advance the need and rapid evolution of the technologies and the markets involved. ISTAG took a more holistic approach and identified what had to happen for the development and realization of AmI in terms of technology, society, and business.

In terms of office space, these ideas can be correctly labeled as ambient facility management (or AmFM) [22]. Although still developing, AmFM allows users to communicate in ways that machines can interpret spoken words and take actions in response. Ambient FM uses tiny sensors, discretely located throughout the surroundings to record our movements and actions, learn our preferences, and then predict our desires and adopt to the required new situation.

Ambient technologies need to be designed to be subtle. Business leaders often talk about *digital disruption,* but the adoption of ambient intelligence seems to be the opposite of being disruptive. Facilities managers will welcome this because it enables more information on patterns of usage and productivity.

The technologies and mechanisms that are enabling efforts toward AmFM include the following:

- Minimal or possibly no user interface, that is the replacement of a computer–screen–and–keyboard combination with machines that respond to voice, touch, movement, and biometrics (e.g., fingerprint and retina recognition);
- Artificial intelligence, that refers to the computer systems that perform tasks that humans would generally do as a routine, such as reading documents, data analysis, decision-making, and language translation;
- Machine learning and machine-to-machine communication, that is the ability of computerized devices to learn and improve the performance of tasks with the use of built-in artificial intelligence;
- Natural language processing, that enables computers to recognize the voice of authenticated users, understand natural language words and phrases, and compose responses [22];
- Edge computing, which improves responsiveness and turnaround time by moving processing from centralized processing centers (most likely in the cloud) to smaller distributed processing centers close to where the information is created, held, or delivered [22];
- Mesh networks (hardware and network), which provide continuous connectivity as computerized device users move from one place of another geographical area.

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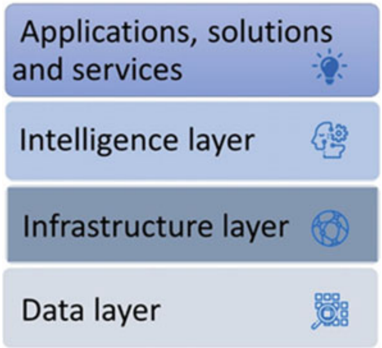

Fig. 12.1 Layered stack for AmI model

Figure 12.1 suggests an AmI model that has the necessary layers of applications, infrastructure (fog computing, mesh networks), and data tools that might be involved in adding intelligence to data being collected in the workplace.

The two middle layers of Fig. 12.1 are most useful to making the data integration work. Indeed, both edge computing and mesh networks are important to be able to make sense of the data being collected. Without these layers, the intelligence aspect of the infrastructure and applications would not be feasible.

Edge computing paradigm helps to reduce the amount of data, that is often transferred to the cloud or a remote data management site, for processing and analysis. It allows the analysis to happen closer to the point where the data is generated. It also improves data security by directing the data to a close and secure collection point for analysis. The edge computing layer is a way to be more efficient with networking resources to mimic centralized capabilities at the edge of the network and support the quick turnaround of results and decision-making.

Mesh networks, often used to provide mobile services, track our movement as we move across physical areas and ensure device connectivity seamlessly. AmI requires flexible and seamless interoperation across and between networks. It is a primary requirement of hardware platforms or de facto standard that exists to permit this interoperability to take place. In a highly functional mesh network, we would not need to reconnect devices to new networks as we move across physical areas; our presence and, more importantly, the presence of the devices, would be detected by a smart network as we come into the range and would be authorized automatically based on either preconfigured authentication or via authentication on the previous network. With mobile phones set to automatically recognize our home and work networks, and with the use of cell networks while we travel across different zones, we get something akin to what we are currently already used to.

Other aspects of AmFM are also being developed, in particular resolving the interoperability-and connectivity-related issues. Some of us may find it easier to send voice instructions to our computers. Others would value smart furnishings that automatically adjust height and support to accommodate a new occupant whose preferences are already known to a building's knowledge base.

Table 12.1 Technologies and levels of intrusion in smart spaces

Activity	Technology used	Level of intrusion
Checking in, Location, presence	Beacons, WiFi, GPS, automated location tracking (location APIs), geofencing, and activity recognition	Medium—requires personal identification and location, as well as some token from the person as to their whereabouts
Conference room availability	Movement sensors, light detection	Light
Personalized environment	Movement detectors, WiFi, smart key	Medium—involves storage and use of personal data

A well-established business enterprise holds a great deal of information about its customers, their preferences, and their personal data. This data could be usefully employed for managing facilities, applications, and resources, to be beneficial to the company. It could also be beneficial to the employees, suppliers, and new perspective customers.

12.4.2 Ambient Technologies in the Smart Office

As evidenced by the existing literature on this topic, it appears that experience with ambient intelligence in workplace conditions could lead to the ability to reduce unpleasant working and living conditions [23], e.g., room temperature adjustments, etc. Even in today's collaborative business environment, individuals are found heads-down in individually assigned work projects than to be engaged in collaborative work. But the type of work also matters, e.g., if the speed and necessary outcomes of a certain piece of work are fast-paced, or level of the job autonomy is low, then the additional demands created by the distractors will highlight the resulting stress caused by the working environment [24]. Some businesses have chosen to address this by changing wall structures, desk heights, and seating options to make the physical environments adapt to the type of work done, e.g., use of ergonomically designed chairs and work desks.

In relation to the questions such as what technologies are in use in smart spaces, and how intrusive are these on workers' productivity, taking into account the cases reported in the existing literature, Table 12.1 provides a summary of our conclusions.

12.5 User Sensitivity to Profiling, Privacy, and Data Sharing

ISTAG in their initial brief in 2000 on AmI [21] stated that *AmI technologies should support the rights to anonymity/privacy/identity of people and organizations, offering, e.g., relevant combinations of biometrics, digital signature, or genetic-based* *methods. Also of fundamental importance is research toward safe and dependable large-scale and complex systems (self-testing, self-repairing, and fault tolerant) to underpin the increasing reliance on ICTs implicit in the AmI landscape*. Information security is, therefore, a reasonable concern in a world of ubiquitous, ambient computing.

Ambient Intelligent (AmI) systems are proactive that can assume responsibility and behave proactively, unlike traditional facilities management where the user is in charge and the systems are passive. The shift from passive systems to what could be regarded as a partnership between humans and intelligent artifacts (e.g., light dimmers) creates a demand for a socially adept system [25] in such a way that intelligent systems should show certain abilities that would be traditionally ascribed to humans [26]. To be able to act proactively to mitigate or eliminate undesired situations while regarding user's specific needs, it is important to allow the Ambient FM systems to be extensible, predictive, and to incorporate decision-making capabilities [26].

The term "proactive computing" was first used by Tennehouse, who suggested the following principles for proactive systems [26]:

- They should be closely connected with their surrounding world.
- They should also deliver results to humans before the user action.
- They must operate autonomously.

The challenges in enabling AmI systems are with respect to the following:

- Ambient systems should be able to manage heterogeneous sources (sensors and appliances) to provide high-level information on the state of the environment and what situations are currently available for users [26].
- The ambient systems should be able to process events for detecting situations that are unwanted in the environment; and predict when these situations might arise and proactively manage these situations in advance.
- The ambient systems should be able to determine the policy of actions to consume appropriate services for adapting the environment ahead of the possible new situations [26].
- The ambient system should have expansive capacities to manipulate and adopt to different situations.

If a system is considered ambient intelligent, it should have the ability to build a trust relationship with the users. The system's ability to communicate rationale on its own behavior is one of the most important abilities that such a system can exhibit to gain trust. These explanations are not just a supplement to an ambient intelligent system, but the core requirement of the design and implementation of such a system. Explanations help both for the reasoning process itself and as a means of communicating with the users [27]. However, there is always a risk that information provided, even under a system of trust, can have the potential to be misused. For example, lighting conditions in the user's surrounding convey rich and sensitive data describing users and their behavior. This information could be hijacked and abused, applied to profile the users and perhaps discriminate against them. That is why web standards and APIs are designed and implemented with privacy and trust in mind. It is challenging and interesting to design, create, and analyze products with privacy in mind, as multiple factors need to be considered.

One of the core issues central to technological aspects of privacy engineering is identifiers. Sometimes software is developed in a way that reveals too much about the user's system. This may be formed from tiny, possibly even innocuous data snippets. It turns out that those may introduce interesting consequences when this data is used as identifiers.

But could this go too far? As shown in a recent New York Times article [28], Amazon has two patents for wristbands that track movement and correct employee actions with vibrations to signal more appropriate movement. The use of the Amazon technology could track the employee by means of emitted ultrasonic pulses and radio transmissions to assess, where an employee's hands were in relation to inventory bins and provide "haptic feedback" to steer the worker toward the correct bin. The aim is to streamline time-consuming tasks, like responding to orders and packaging them for speedy delivery. With guidance from a wristband, workers are able to fill in order forms faster. However, these wristbands should raise employee concerns about the privacy of data and could perhaps add additional surveillance layers to the workplace.

The obligation to define such tracking rests with the employer and/or facilities manager when the person tracked is not an employee of the facility. Electronic monitoring of employees is especially intrusive and can lead to unacceptable levels of workplace surveillance. Any oversight of employees in this manner should be narrowly tailored in time, place, and manner, and it must be transparent to employees. The same can be said for visitors to the facility. Thus, a stated policy should be made clearly known to users when entering the facility, e.g., how and why information and location are tracked by sensors.

Rao et al. [29] suggest that location context control policy gets privileges depending on the classification of users. If the user decides to opt-out, the system might give "fake" information, such as the standard location of the user (their office, perhaps) or the reception area of the facility. This would make the Ambient FM system for that user nonfunctional in that it would not be personalized and the user would receive the standard lighting and air condition package as prescribed by company policy.

Tsai et al. [30] observed users' risk and advantage perception associated with the practice of these apparatuses and privacy restrictions on current location-sharing approaches. Their study involved an online survey and found that although most of their respondents had heard of location-sharing approaches, they did not see the probable value of mentioned approaches. They also found that company rules to manage disclosure of user's place only offers a modicum of privacy.

To illustrate what can be achieved by way of benefits of working with ambient technology in the office, the following section discusses some use cases for ambient technology deployment and how the adopters have addressed user concerns.

12.6 Case Studies in Ambient Technology Usage for FM

We have chosen three cases to illustrate device management, user control, and energy efficiency as core drivers for facilities management. These cases focus on the latest developments in the internet of things and always-on communications. They show how the implementation of data-driven mechanisms can help to increase productivity, enhance occupant happiness and well-being, improve sustainability, and optimize service delivery and operations.

12.6.1 Robin-Powered Conference Room

Robin is a Boston-based start-up that provides a *software layer for office buildings* [5]. In terms of device management, Robin uses iBeacon and BLE (Bluetooth Low Energy) devices to detect the presence of nearby people and things in a conference room context. It can automate conference room bookings for users just by the action of the users walking into a room. And, after the user enters the conference room, Robin gives the user control to update the screens in the room and also gives them control of the nearby devices.

Their web scheduling product allows companies to determine what facilities and items each room has; and the availability or otherwise of these items. Companies like to customize their spaces with respect to products based on their requirements and interests. In this context, Blue Apron names their rooms after exotic spices and fancy cheeses; Casper names their rooms after everyone's favorite meal to wake up to, e.g., breakfast; Foursquare uses their badges as room names, decorated with colors and props. Robin's desk products allow employees to find a place to sit for the day. Employees know as to what is happening around them and are in control of their workspace, as seen in Fig. 12.2.

To get started, users would need to install the Robin software app on their iOS or Android phone so the spaces can properly identify them, and they can identify what information they would want to share with the app. As for the ambient hardware, only beacons are required; each beacon covering a zone of up to 30 m. An accompanying dashboard provides office-wide overview and analytics for the Robin-powered rooms. And, as new connected devices are added to the workplace, Robin can be customized to control them as well, including things such as Chromecast, smart thermostats, lights, and more [5]. Lighting is important for creating mood, as well as for productivity, as discussed in the following case.

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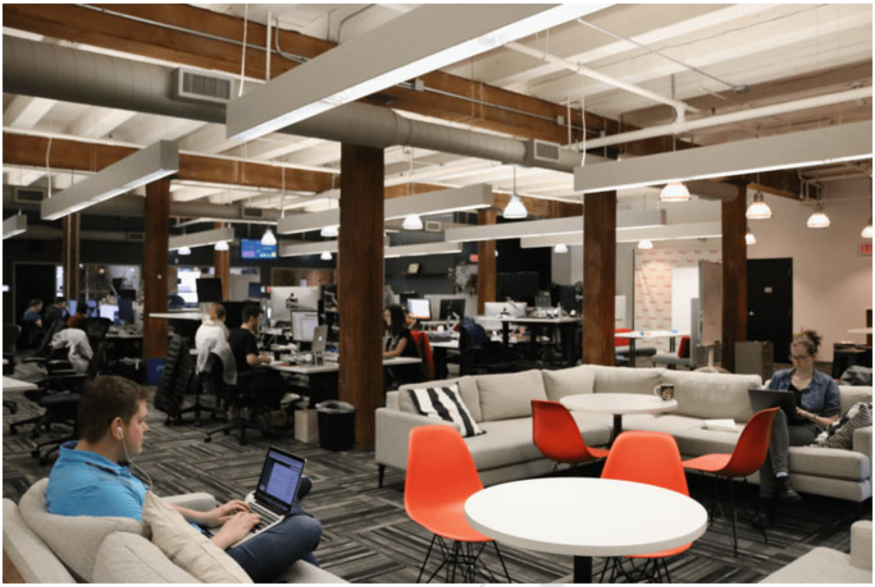

Fig. 12.2 A user-aware workspace with flexible desk scheduling

12.6.2 *Intelligent Lighting with Igor Using PoE*

With the wired Ethernet lighting control opportunities, market leader Philips Lighting has been embedding ZigBee in lights and luminaires and selling it as a service. Users can control lights wirelessly using ZigBee from phones or tablets. Firms such as Igor [31] have focused on Power over Ethernet (PoE) and found that, with the availability of low-cost ultra-miniature LEDs, sensors, and communications protocols, it makes it possible to embed Internet connectivity into every lighting fixture and many low-wattage sensors. By using a standard Ethernet connection and PoE ports, network-enabled PoE devices can provide any user immediate access to building automation control throughout an entire lighting system.

LEDs are used to indicate occupancy, adjust mood, conserve energy, and remotely control the building automation systems. LEDs can expand their role by combining intelligence with movement or ambient light sensors and interconnecting the PoE nodes in a programmable network.

Igor's open PoE platform provides direct API access to setup, control, and real-time data streams from embedded sensors and analytics, delivering a simple dashboard for energy savings, space utilization, security, and more. The intelligent PoE lighting system can increase staff productivity and well-being by optimizing light and temperature to create comfortable and desired work environments.

Central Iowa Power Cooperative (CIPCO), the largest cooperative energy provider in Iowa, distributes power to nearly 300,000 residents [31]. It used its Cedar Rapids office as a showcase for next-generation lighting, using solutions provided by Igor. CIPCO wanted precise control over lighting through a Crestron audio–video control system, using network switches that could provide 48 Power over Ethernet (PoE) ports and deliver 60 watts per port.

Through these mechanisms, CIPCO has successfully managed to reduce lighting energy use by 75 percent in areas where the lighting solutions have been deployed. The company expects this saving to increase to 85% with its smart control strategies, e.g., by using daylight harvesting and occupancy sensors to automatically dim and shut off lights, if not required. As lights are now considered just another IP endpoint, CIPCO can control scheduling and policies through its audio–video control system. CIPCO have now built their "nervous system" in place to support the adoption of ambient intelligence and continued efficiencies [31].

The Igor system also optimizes space utilization by identifying occupied and unoccupied spaces for energy savings, safety, and security. These long-lasting and low-energy LED lights drastically reduce costs and maintenance by identifying high/low use areas. But we should also focus on space usage in other ways, e.g., by space developments by design with the user comfort in mind.

12.6.3 The Edge Office Space in Amsterdam

The Edge is an example of a groundbreaking new office space venture opened in 2015 in Amsterdam [32]. This has inspirational workspaces developed throughout the building as places to reflect, think, collaborate, and innovate. This innovative landmark building in the Zuidas business district of Amsterdam was developed by OVG Real Estate [32]. It is a 40,000 m^2, multi-tenant office building, which embraces leading-edge smart technology to support flexible and activity-based working. It exhibits the highest standards of sustainability and innovative data-driven insights to enable the most efficient facilities management. The architects' concept included intelligent floorplans to enhance employee comfort and efficiency, flexible workspaces, and the use of environmentally friendly materials. Integrated sensors capture data on room occupancy, temperature, and humidity, which the building owners can use to precisely target the delivery of lighting and other resources, such as heating/cooling and cleaning, to maximize energy efficiency. Light levels and cleaning can be reduced in low-occupancy areas resulting in the saving of time, cost, and energy.

The idea that employees use all aspects and areas of the building is fundamental to a smart building design. Open spaces can be located around a vast atrium bathed in natural lighting. As its hub can be a coffee bar and other utility points where meetings and discussions can take place, working at tables in a bar rather than a traditional desk is highly possible.

To enable personalization within the edge environment, personal comfort has been enhanced further with the ability to control and flex the lighting and temperature, even in open-place spaces, via the Philips Personal Control iPhone app, especially designed for use in the edge. The connected lighting system makes it possible for employees to locate colleagues within the building in real time, check on rooms availability, and find their way easily from place to place.

The system also offers building managers rich real-time and historical data on systems' operations and activities. This data gives them the insights they need to create a premier experience for employees, maximize operational efficiency, and reduce the building's CO2 footprint [32].

Designers kept three key objectives in mind when defining the connected lighting system. The system had to seamlessly integrate with the building as a whole, enable customized solutions purpose-built for the unique environment of the edge, and offer smart interfaces that allow individual users of the building to control the environment effortlessly.

The system's 6,500 connected luminaires over 15 floors share data about their status and operations with Philips Envision lighting management software, running in the IT environment. Facility managers can use the software to capture, visualize, and analyze this data, allowing them to track energy consumption and streamline maintenance operations. The expected energy savings at the edge is around €100,000 and €1.5 m in space utilization costs [32].

12.7 Conclusion

Although the drivers for AmI still suffer from resource and energy constraints, there is a movement toward personalized comfort and intelligent design. Offices have been moving away from the idea that time spent at a desk and at a fixed location are measures of productivity. This departure from tradition can be seen from some of the more ambitious innovations at corporate headquarters, e.g., the GooglePlex. With the inclusion of sensors, beacons, WiFi, and other enabling smart technologies embedded with intelligence, companies are now measuring the effectiveness of both the workspaces and employees through the use of ambient intelligence. The company which gives the employees the choice at any given moment to optimize the space effectiveness is going to benefit many times over, in terms of both profitability and worker satisfaction.

With the use of ambient technologies, the role of facilities management has expanded dramatically over the past decade, as businesses start to understand the true impact of smart working and smart environments. Gone are the days when management teams were responsible for little more than checking boxes and ticking off safety requirements. The role is now integrated with enterprise asset management (EAM) processes and energy efficiencies for better reliability and cost savings.

Given its role in the operations of the business, we find that facilities management has become more sensitive to social and cultural changes. The facilities managers now need to ensure that social constraints are effectively balanced with productivity, development, and worker satisfaction. Not an easy task but effective use of appropriate technology is the secret to success.

The nature of ambient technologies and their acceptance into the workplace will further evolve over time and so the employee tracking will become more commonplace. However, this will need a more careful policy on how privacy and security of user information are kept and maintained in the company.

References

1. Gurgen L, Gunalp O, Benazzouz Y, Gallissot M (2013) Self-aware cyber-physical systems and applications in smart buildings and cities. In: Proceedings of the conference on design, automation and test in Europe, pp. 1149–1154. EDA Consortium
2. Armstrong P, Brambley MR, Pratt RG, Chassin DP (2000) Building controls and facilities management in the 21st century, summer study of energy efficiency in buildings. http://aceee.org/files/proceedings/2000/data/
3. Atkin B, Brooks A (2000) Total facilities management. Blackwell Science, UK
4. Hassanain MA (2010) Analysis of factors influencing office workplace planning and design in corporate facilities. J Build Apprais 6(4):183–197
5. Robin (2018). https://robinpowered.com/blog/case-studies/
6. Softdb (2016). What is sound masking and how does it work? https://www.softdb.com/sound-masking/technology/#comfort
7. Grozdanic L (2016) Space as a service: business models that change how we live and work. http://archipreneur.com/space-as-a-service-business-models-that-change-how-we-live-and-work/
8. Weng T, Agarwal Y (2012) From buildings to smart buildings—sensing and actuation to improve energy efficiency. IEEE Design Test Comput. 29(4): 36–44. (Cearley DW (2010) Cloud computing: key initiative overview. Gartner Report)
9. Dilouie C (2017) All about occupancy and vacancy sensors. http://lightingcontrolsassociation.org/2017/08/21/all-about-occupancy-and-vacancy-sensors/
10. Snoonian D (2003) Smart buildings. IEEE Spectr 40(8):18–23
11. Anastasopoulos M, Niebuhr D, Bartelt C, Koch J, Rausch A (2005, October) Towards a reference middleware architecture for ambient intelligence systems. In: ACM conference on object-oriented programming, systems, languages, and applications
12. Corner S (2018, March 31) Edge computing will be key to IoT, say experts. https://www.iothub.com.au/news/edge-computing-will-be-key-to-iot-say-experts-488021
13. IFMA (2018) What is facility management? https://www.ifma.org/about/what-is-facility-management
14. Becker F (1990) The total workplace. Van Nostrand Reinhold, New York
15. Langston C, Lauge-Kristensen R (2002) Strategic management of built facilities. Butterworth-Heinemann, UK
16. McGregor W (2000) The future of workspace management. Facilities 18(3/4):138–143
17. Brauer RL (1992) Facilities planning: the user requirement method, 2nd edn. American Management Association, New York
18. Owen DD (1993) Facilities planning and relocation. RS Means, USA
19. SelectHub (2017) The future of facilities management: AI, robots, and outer space. https://selecthub.com/cmms/future-facilities-management/
20. McLean D, Roderick Y, Quincey R, McEwan D (2011) Climate energy index and building energy index: New indices to assess and benchmark building energy performance. In: Proceedings of the Building Simulation 12th Conference of International Building Performance Simulation Association, Sydney, Australia, vol 1416, p 792799
21. Lee F (2017) Ambient intelligence—the ultimate IoT use cases. https://medium.com/iotforall/ambient-intelligence-the-ultimate-iot-use-cases-5e854485e1e7

22. Karpook D (2018). Ambient intelligence for buildings. https://facilityexecutive.com/2018/02/ambient-intelligence-for-buildings/
23. Veitch JA, Newsham GR (2000) Exercised control, lighting choices, and energy use: an office simulation experiment. J Environ Psychol 20(3): 219–237
24. Veitch JA (2018) How and why to assess workplace design: facilities management supports human resources. Organizational Dynamics
25. Marsh S (1995) Exploring the socially adept agent. In: Proceedings of the first international workshop on decentralized intelligent multi agent systems (DIMAS 1995), p 308
26. Machado A, Lichtnow D, Pernas AM, Wives LK, de Oliveira JPM (2014) A reactive and proactive approach for ambient intelligence. In: ICEIS, vol 2, pp 501–512
27. Cassens J, Kofod-Petersen A (2007) Explanations and case-based reasoning in ambient intelligent systems. In: CaCoA
28. Yeginsu C (2018) If workers slack off, the wristband will know. (And Amazon Has a Patent for It.). Retrieved from the New York Times online from https://www.nytimes.com/2018/02/01/technology/amazon-wristband-tracking-privacy.html
29. Rao J, Pattewar R, Chhallani R (2018) A privacy-preserving approach to secure location-based data. In: Bhalla S, Bhateja V, Chandavale A, Hiwale A, Satapathy S (eds) Intelligent computing and information and communication. Advances in intelligent systems and computing, vol 673. Springer, Singapore
30. Tsai JY, Kelley PG, Cranor LF, Sadeh N (2010) Location-sharing technologies: privacy risks and controls. ISJLP 6:119
31. CIPCO case study (2018). https://www.igor-tech.com/filesimages/Case%20Studies/cipco-case-study.pdf
32. Philips (2018). http://www.lighting.philips.com/main/systems/system-areas/office-and-industry/offices/futureoffice/connectivity/connecting-with-the-future-of-office-design

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