

THE INTERNET OF THINGS IN A HOTEL CONTEXT

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Abstract

Even though it may seem futuristic, but the Internet of Things (IoT) has become a reality. The Internet of Things is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and the connectivity which enables these objects to connect and exchange data. Connecting things changes everything. It is, therefore, important for hotels to make the most of it, yet many people still struggle to fully understand what it is, and how it can help. This technology is changing the way products and services deliver value, and it also has the potential to redefine the guest experience by solving real-time guest queries and rendering hyper-personalized recommendations.

Key Words: *digitalization, Internet of Things, hotel, hospitality*

JEL classification: *L83, Z32*

Introduction

Within the period of the tourism expansion (Dimitrov & Koteski, 2017), the use of the Internet and other information communication technologies has led to a new era of the tourism industry (Ristova & Angelkova-Petkova, 2018), including the hospitality industry. Guest experience nowadays is what evaluates the hotel in this era, and for guests, the Internet of Things (herein after referred to as IoT) in their accommodations makes for a more comfortable and customized stay, therefore the hospitality has realized the potential impact of the IoT research, with many hotels conducting research in IoT to implement their proprietary solutions. This research contributes to the literature in several ways and drawing upon theoretical and practical

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considerations, it lays a foundation for the adoption of IoT in practice. First, the paper explores the convergence of IoT and IoT in hospitality in the context of the literature, value attributes and researchers' offerings. Second, it provides an overview of the numerous ranges of practical examples of how the hospitality industry has already incorporated IoT into their businesses, gaining a number of crucial benefits. Third, since IoT turn all those practical examples into "smart" objects, a discussion intends to elaborate what being "smart" means for the hospitality industry, why the IoT technology is becoming so important, and what the various plus points are.

Literature review

IoT started in 1998, and the term IoT was originally coined by Kevin Ashton in 1999 during his work at Procter & Gamble (Car et al., 2019). During that time, Ashton was working in supply chain optimization and wanted to attract senior management's attention to a new exciting technology called RFID. Because in the 1999, the Internet was the hottest new trend and according to him, somehow it made sense, he called his presentation "the Internet of Things". During his speech he stated (Ashton, 2009):

"Today computers, and, therefore, the Internet, are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,024 terabytes) of data available on the Internet were first captured and created by human beings by typing, pressing a record button, taking a digital picture or scanning a bar code. The problem is, people have limited time, attention, and accuracy. All of which means they are not very good at capturing data about things in the real world. If we had computers that knew everything there was to know about things, using data they gathered without any help from us, we would be able to track and count everything and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling and whether they were fresh or past their best."

To Ashton, IoT was the technology that empowers computers to sense the physical world without human intervention. But since his initial pioneer vision has evolved even further, IoT now has a larger functionality. Not only does it empower computers to sense the physical world, but it also actuates an object in the physical world without human intervention. IoT

provides a platform where it can mediate interactions among objects also without human intervention. IoT is an expansion of Mark Weiser's vision of ubiquitous computing (Ubicomp), which aims to produce a global network that supports Ubicomp and context awareness among devices (Shammar & Zahary, 2019). IoT is a network that can connect with anything, anytime and anyplace by technologies of RFID (Radio Frequency Identification), WSN (Wireless Sensor Network) and 3G/4G/5G mobile communication, according to an agreed protocol, in order to identify, locate, track, monitor and manage smart objects (Mingjun et al., 2012). Simply stated, IoT consists of any device with an on/off switch connected to the Internet, it is a giant network of connected 'things' which also includes people.

For the definition of IoT from researchers and academics, several definitions or visions from different perspectives have been stated. Gil et al. (2016) have summarized several in their paper such as from the viewpoint of services provided by things, IoT means *"a world where things can automatically communicate with computers and each other providing services to the benefit of the human kind"* (Furness, 2008). From the viewpoint of connectivity, IoT means *"from anytime, anyplace connectivity for anyone, we will now have connectivity for anything"* (International Telecommunication Union, 2005). From the viewpoint of communication, IoT refers to *"a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols"* (European Technology Platform on Smart Systems Integration, 2008). Finally, from the viewpoint of networking, IoT is the Internet evolved *"from a network of interconnected computers to a network of interconnected objects"* (de Saint-Exupery, 2009).

Others, including the European Commission Information Society (de Saint-Exupery, 2009), define IoT as *"things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"* or *"interconnected objects having an active role in what might be called the future Internet"*. The "things" that make up IoT can be anything and any physical object can be transformed into an IoT device if it can be connected to the Internet to be controlled or communicate information. These 'things' could be objects of all shapes and sizes – from smart microwaves to wearable fitness devices as well as parts of the automobile that has built-in sensors to alert the driver when tire pressure is low, etc. Morgan (2014)

predicts that in the near future: anything that can be connected, will be connected.

IoT refers to billions of physical devices around the world, but generally a PC or a smartphone aren't considered an IoT device. In the post-smartphone-era, digitally connected "non-phone" devices, popularly known as IoT, communicate autonomously between themselves over defined wireless communication protocols (Oskam & Boswijk, 2016; Rong et al., 2015; Gretzel et al., 2015). For businesses, this is an opportunity to optimize to previously unprecedented levels. In the broadest sense, the term IoT encompasses everything connected to the Internet, but it is increasingly being used to define objects that "talk" to each other. Glória et al. (2017) explain that IoT has the ability to transform a simple physical device into a smart one, using embedded technology and computational power. Using the sensors and actuators available to guarantee the features of the device, it is possible to share that information between devices and put them to work together to improve the user experience. This will contribute to a bigger explosion coming from things connected to the Web that were not connected before, did not exist, or now use their connection as a core feature. Since there have been attempts to define what IoT is and means since the term was first coined, a summary (Table 1) will be presented from the application perspective, the technological perspective and the industry context by researchers and academics.

Table 1: *Various digitalization definitions*

Author(s)	Definition
Vermesan et al. (2009)	<i>[...] as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network"</i>
Aggarwal and Lal Das (2012) Abu-Elkheir et al. (2013)	<i>[...] it a dynamic and global network infrastructure, in which intelligent things (objects), subsystems and individual physical and virtual entities, are identifiable, autonomous, and self-configurable"</i>
Rose et al. (2015)	<i>[...] broadly to the extension of network connectivity and computing capability to objects, devices, sensors, and items not ordinarily considered to be computers. These "smart objects" require minimal human intervention to generate, exchange, and consume data; they often feature connectivity</i>

Author(s)	Definition
	<i>to remote data collection, analysis, and management capabilities"</i>
Ng and Wakenshaw (2017)	<i>[...] as a system of uniquely identifiable and connected constituents (termed as Internet-connected constituents) capable of virtual representation and virtual accessibility leading to an Internet-like structure for remote locating, sensing, and/or operating the constituents with real-time data/information flows between them, thus resulting in the system as a whole being able to be augmented to achieve a greater variety of outcomes in a dynamic and agile manner"</i>
Sethi and Sarangi (2017)	<i>[...] is defined as a paradigm in which objects equipped with sensors, actuators, and processors communicate with each other to serve a meaningful purpose."</i>

Source: Authors' research

Despite the excitement of defining the IoT at the global level, there is no single standard and universally accepted definition for the term (Rose et al., 2015). As we see, many different groups, including academicians, researchers, practitioners, innovators, developers and corporate people that have tried to define the term, yet the initial use of definition has been attributed to Kevin Ashton, an expert on digital innovation (Madakam et al., 2015). The exact definition of IoT is still in the formation phase and to an extent it depends on the researchers' points of view (Li et al., 2015; Perera et al., 2014; Bandyopadhyay & Sen, 2011).

As for the hospitality industry, there has been a little empirical research on IoT deployment. Even though IoT as a technology concept has been around for nearly a decade (Atzori et al., 2010), the opportunity for viable deployment in the hospitality industry is a more recent phenomenon, particularly in relation to the usage of IoT to generate the data for analytics and optimization purposes (Nadkarni et al., 2019).

Yet, the boom in IoT will boom the future of the hospitality industry, it will get the competitive edge in the market through the interconnection of devices (sensors, actuators, identification tags, mobile etc.) through the Internet (Kansakar et al., 2017). Therefore, every guest that will check into an IoT enabled hotel property can avail a huge cache of services. The vast jump of applying IoT if taken by hotels can offer luxury that will make guests' experience memorable. Additionally, with the implementation of IoT into the hotel, comfort being key, check in and out including personalized setting-up will provide extreme prestige. In the hospitality

industry, IoT provides easier operability towards automation and real-time data. For hotels, it is crucial for aiding customers with end-to-end IoT solutions for first-class personalized services and better guest experience, because of guest's perspectives, IoT in hospitality plays a vital role for a comfortable and customized stay.

Regarding the potential of IoT to transform the hospitality industry, Li et al. (2013) discuss several IT applications that are applicable to the hospitality industry, considering that IoT has potential of use for "real-time customer service, customer information identification, service guidance, route planning and customer expense recording", among other non-specified applications. Since the hospitality industry is counted mainly on the utmost service standards and their executions with intangible characteristics, it is no wonder that the innovative technology IoT will begin its influence to seek the customer's satisfaction, cost saving, and business profit. Hecht et al. (2014) discuss the need for hotels to include in their business model the transformation of reality resulting from the advent of ubiquitous computing/IoT, concluding that there is an opportunity for increased income by re-engineering their operating models and their physical and logic connectivity models, through the creation of services to their usual customers, for local residents and for transient visitors. Wei et al. (2013) have seen the benefit of IoT in nutrition, where they present an IoT based solution for hotels to provide meals adequate to their guests' nutritional needs. With the proposed solution, it is possible for a guest to define a meal based on his/her own nutritional needs, both in type and in quantity.

Even if there is no universally agreed definition of IoT in hospitality, everybody is trying to interpret and define IoT according to his/her specific needs, concerns and backgrounds (Atzori et al., 2010; Singh et al., 2014), so IoT in the hospitality industry is best defined as: *"an Internet extension with a growing network of digital devices and machines for enhanced guest experience, innovate processes and optimized revenue"*.

IoT applications in the hospitality industry

The hospitality industry has been relatively slow in adopting the IoT technology and yet represents a very important factor in the industry, enabling new ways of doing business (Car et al., 2019). Many industries can potentially benefit from IoT, but the hospitality industry leads the way when it comes to IoT technology, because IoT is a new technological

paradigm that connects anything and anyone at any time and any place, giving rise to innovative new applications and services (Lu et al., 2018). From saving energy and costs to delivering a more personalized experience for guests and optimization of processes, to numerous systems used for inventory control, energy use, locking systems, safety and security and tracking customer behavior, the IoT applications in the hospitality industry are many. Table 2 illustrates several applications with examples of IoT in the hospitality industry.

Table 2: *Various digitalization definitions*

Application	Example
Hyper personalized hotel rooms	<i>Marriott International</i> has teamed with two IT companies, Samsung and Legrand, to develop a smart hotel room. <i>Marriott's</i> Innovation Lab came up with a value proposition that has the potential to elevate the guest experience, create more efficient hotel room design and construction, and contribute to <i>Marriott's</i> global sustainability efforts and goals. <i>Hilton</i> is taking an in-house development approach whereby they are creating their own technologies, most of which can be accessed through the <i>Hilton</i> app. The brand had been working on its "Connected Room" concept, and it has been put into beta testing in a handful of hotels. <i>Marriott's</i> "Internet of Things" room and <i>Hilton's</i> "Connected room" include customers' integrated experience with access to their own data and information, accessible voice and mobile-optimized controls, and improved personalized service.
Intelligent hotel room	Constantly monitors the activity and location of people and objects within it, and uses this information to control technology in anticipation of the guests' needs. This room delivers "intelligent" and personalized services to the guests. <i>Avaya Intelligent Hotel Room</i> provides a template covering hotel brand reinforcement, security controls, messaging to hotel guests, stunning presentation and access to hotel services, easy hotel and external communications, and room environmental controls.
Location-based information	<i>Marriott</i> hotels triggered location-based notifications for guests depending on proximity to related offers, while other examples cover parents' ability to track their children's location in a large resort. <i>Hotel Fontainebleau Miami</i> uses location-based data to upsell guests through pre-arrival and checkout offers, enabling the resort to optimize room revenue by inviting guests to arrive early or stay late for an additional fee.

Application	Example
Voice-controlled customer service	In 2018, <i>Alexa for Hospitality</i> was introduced designed to improve the customer experience within hotels. Guests will be able to ask Alexa for information, to contact services, use it as in-room telephone and also to play music and radio over iHeartRadio and TuneIn. As <i>Marriott</i> is Amazon's launch partner on the new platform, the new Alexa experience is presented in <i>Marriott Hotels, Westin Hotels & Resorts, St. Regis Hotels & Resorts, Aloft Hotels, and Autograph Collection Hotels</i> .
Predictive repairs and maintenance	Allows the hotel to use sensor data to identify wasteful trends and alert maintenance staff before a given issue escalates into a much more costly one. Rather than waiting for a component to break down before being serviced or replaced, IoT technologies enable the technical staff to predict maintenance needs based on system usage, prevent system failures and reduce the costs of operating a faulty system.
Keyless mobile access	<i>Starwood Hotels</i> provides keyless entry to members of the chain's loyalty program with a simple gesture of guest smartphones.
Mobile ubiquity	<i>Starwood</i> and <i>Hilton hotels</i> offer an option of checking in via a mobile gadget instead of spending time at the front desk.
Interact lighting	Manage the lighting of hotels to save cost and to adapt it to the guests' preferences. <i>Interact Hospitality</i> delivers real-time operational transparency for an enhanced guest experience while improving staff efficiency and saving energy. They are integrating LED lighting, sensors, HVAC and Property management systems.
Smart mirror	<i>Electric Mirror</i> introduced the <i>Savvy Smart Mirror</i> featuring voice activation and activation on the touch. <i>Savvy Smart Mirror</i> offers guests the opportunity to talk to him and ask him for room service, or for the hotel's swimming pool hours. Also, the TV can measure room temperature. The first hotel to use <i>Savvy Smart Mirror</i> will be <i>Sinclair Hotel</i> , a member of the <i>Marriott's Autograph Collection</i> in Fort Worth, Texas where in 2018 over 150 mirrors were installed in the guest room bathrooms. <i>Starwood Hotels</i> have integrated tablet features into a "smart mirror" in several locations since 2016.
Sensors	Sensors help monitor the activities on going inside and outside the hotel and with them, the information flow within the network is closely monitored and adopted by applications to work seamlessly. Every room at <i>Hotel 1000</i> in Seattle has a heat-detecting sensor that ensures snoozing guests are not disturbed.

Application	Example
Energy management	Usage of HVAC systems runs more efficiently and saves significantly their energy consumption and costs. The <i>Conrad Hotel</i> , located in Chicago, saved more than 450,000 kWh/year by installing automated HVAC controllers, infrared motion detectors, and wireless door switches. These technologies let Conrad staff manage the temperature of its 352 HVAC units when rooms are unoccupied.
Android robot controller	Robot control system that works on mobiles, wearables and full-fledged computers. <i>Henn-na hotel</i> in Japan introduced the first robotic hotel with fully automated customer services. In-room robots allow a series of sensors inside the property that help the hotel to save energy and reduce waste. Robot concierge at the <i>Hilton hotel</i> connected to a cognitive system with machine learning abilities that can, on one hand, provide hotel and travel related recommendations to hotel guests, and on the other hand, learn and improve its database via interaction with guests. The <i>Yotel hotel</i> in New York has a "Yobot" that handles and stores customers' luggage. The "Botlr" is a service robot in the <i>Aloft Cupertino hotel</i> in California that delivers towels to you at the pool, and snacks and toiletries to your room.
Beacon technology and augmented reality	Beacons are special augmented reality technologies that use low-energy Bluetooth connections to communicate with smartphones and tablets. <i>James Pocket Assistant</i> application in <i>James Hotels</i> , located in Chicago, Miami, and New York City was realized and designed to act as an e-concierge. The application allows guests access to special offers, view maps, contact the hotel, and request services.

Source: Authors research after Lee, (2019); Ting (2017); Leonidis et al. (2013); Alias (2019); Nadkarni et al. (2019); Terry (2016); Perez (2018); Eskerod et al. (2019); Jeong (2016); Car et al. (2019); Eisenack (2018); Ristova & Dimitrov (2019); Yick et al. (2008); Berelowitz (2016); King & Berry (2017); Lofaro (2017); Buhalis & Leung (2018); Kabadayi et al. (2019); Hospitality Technology (2015).

IoT has come a long way in recent years. The continued implementation in the hospitality industry will lead to a drastic increase in hotel's productivity and customer satisfaction, enabling the creation of positive relationship with them.

Why IoT is the "smart" solution for the hospitality industry

The incorporation of IoT technology in the hospitality industry qualifies hotels as smart buildings which are important facets of smart cities (Mohanty et al., 2016). Since IoT generally supports "providing information and analysis as well as automation and control" (Buhalis & Amaranggana, 2013), it can turn the technology into "smart" objects, which are capable of both sending and receiving data and communicating with each other. This can improve data collection, increase levels of automation and allow for multiple devices to be controlled or monitored from a single control point, such as a remote control, phone or tablet. A smart hotel is an intelligent hotel with a range of information technologies working together to let the guests have an honorable and convenient vacation environment (Wu & Cheng, 2018). In other words, a smart hotel that has fully embraced IoT offers its guests have an opportunity to create bespoke experiences based upon their personal requirements. This comes from the basic premise of IoT as a service, which is the ability for smart hotels to be able to provide guests with immediate access to futuristic technologies within their rooms. The authors list several reasons why IoT technology should be embraced by the hospitality industry and become the smart choice.

1. *Higher levels of personalization and satisfaction.* Because smart services are pro-active, they can prevent unpleasant surprises which provides guests with value and satisfaction. Being offered exactly what they need, whenever and wherever they need it, in a seamless experience, not only increases guest's satisfaction with a service provider, but also their likelihood to remain loyal to that provider in the long run (Kabadayi et al., 2019). It only makes sense for hotels to follow and satisfy the guest's need by enabling them to personally enhance their quality of stay in the hotel. Nowadays, mobile applications have shifted from being a novelty to becoming an essential part of the consumer experience, with the capabilities of offering personalized information for guests, two-way sharing, context awareness based on smartphone sensors, or communication with other machines (Dickinson et al., 2014). Hotel Lugano Dante in Lugano, Switzerland uses HGRM-Happy Guest Relationship Management system which functions as a meta-platform that combines several hotel operating systems, one of which the guest's intranet site MyPage. In the pre-arrival stage, guests receive an invitation upon confirmation to access their personalized guest website (MyPage). From this point onwards, they are given a choice of whether or not they desire to personalize their stay. In case they do, they can independently manage their MyPage website to

communicate with the hotel, virtually meet the team and engage with hotel employees, manage details of their stay and select personal preferences (Neuhofer et al., 2015).

2. *Sustainable hotel rooms.* The context of sustainable development should mean equal attention should be paid to the environment and tourism (Dimitrov, 2018), in this case, hospitality. By cutting energy consumption, hotels can go along with green trends by using automation that IoT offers. Crowne Plaza hotel in Copenhagen, Denmark has become neutral in terms of CO2 emission, the entire energy used in it originates from renewable sources (e.g. bicycles propelled by the power of the muscles of the guests working out in the hotel fitness club) (Jaremen, et al., 2016).
3. *Advanced security of guest, staff and hotel property.* Smart hotels promise personalization upon the collected guest data that they have gathered for years such as names, addresses, emails, credit card and passport numbers and now even more personal information. Knowing the IoT vulnerabilities, Ross (2017) writes about the introduction of a multi-layered, multifaceted approach to security where in addition hotels can install firewalls to shield the sensors on IoT devices, also to separate the guest network traffic from business network traffic using software-defined architectures and multi-WAN firewalls. Following a multi-layered approach to IoT security also means securing all devices that connect with other devices through the Internet, rather than just the obvious ones. Authenticating devices and encrypting data should be a standard procedure as well.
4. *Easy property management systems.* PMS is a perfect example of an IoT tool that can be deployed to help achieve the goal of the hotel. With IoT, PMS can play a significant role in improving guests' outcomes with focused planning, targeted technological integration, and professional development. As a cloud-based property management system, Oracle OPERA PMS integrates several functionalities into a single platform. Besides property management functionality, OPERA PMS include integrated channel and rate management with group travel functionality to handle more complex requests. With comprehensive guest profiling capability, it allows to keep track of guests' preferences, has advanced rate and room availability restrictions, as well as enhanced rate-management capability, includes an intelligent accommodation management tool, and it is also equipped with a mobile version to allow staff to check-in guests via any smartphone or tablet (Oracle, n.d.).

Conclusion

With the rapid development of the Internet of Things, new applications and research are booming. The hospitality industry has clearly realized the potential impact of the Internet of Things, and as we see, many hotels have already conducted their research about IoT and implement it in their proprietary solutions. Because the hospitality industry is a highly competitive industry, one might say it is a necessity to implement the Internet of Things application in order to provide the guests with personalized services to improve the guest's experience. Even though, a lack of definitions is noted in terms of Internet of Things implementation in the hospitality industry, it is obvious that practical implementations are numerous, and things are changing fast. IoT has raised the bar in terms of the guest's expectations, from enabling automatic check-ins and checkouts to hotel rooms and helping guests locate their travel destination to monitoring the nutrition diet of guest. So, it is up to today's hoteliers to understand, know and use IoT applications in the daily hotel environment and be able to evaluate, recommend and acquire these applications to improve guests' satisfaction, operational efficiency, productivity, customer service and revenue. The hotels which eventually adopt some of these new IoT applications are going to be able to increase brand visibility, gain operational efficiency and enhance the guests' experience.

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