Improving the service industry with hyper-connectivity: IoT in hospitality

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Abstract

Purpose – Internet of Things (IoT) adoption is a differentiating factor in the hospitality industry which facilitates the integration of the digital and real world. This paper aims to explore academic research and practical applications of IoT in the hospitality domain to help identify opportunities and challenges with implementing the technology for creating competitive advantages and service operations process improvements.

Design/methodology/approach – This paper uses previous works and exemplars to demonstrate the use of IoT in hospitality. Academic indexing websites such as Google Scholar and ScienceDirect are used to search for related terms. Whitepapers, IoT project websites of service providers and media coverage are accessed to collect information. Related work is investigated by classifying into major categories of hospitality.

Findings – Hospitality is one of the leading industries that has adopted IoT to create innovative services, but this topic has not been investigated deeply. A comprehensive study is needed to give guidance to decision-makers and helps to design better services by presenting practical and potential benefits.

Practical implications – The IoT will usher in great opportunities in hospitality by enabling novel applications for customization and personalization of the services. Operational processes will be redefined for efficiency and speed. It will alter the expectations and servicescape; thus, its integration will be vital in terms of competitiveness and success.

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Originality/value – This study provides a comprehensive overview of IoT research and applications in the hospitality domain. It contributes to better understanding of recent trends and potentials. A holistic approach was used instead of focusing on a single sector which enables the consideration of all aspects of the topic. Theoretical support in addition to technical aspects, challenges and concerns are offered to the reader.

Keywords Internet of Things, Hospitality, Sensors, Data acquisition, Smartness

Paper type Research paper

1. Introduction

We are witnessing the fourth industrial revolution where *smartness* is embedded in all applications. It is defined as enhancing the quality of life (customer satisfaction in hospitality context) intelligently, automatically and collaboratively (Alsamhi *et al.*, 2019). Context-awareness and hyper-personalization are among the key characteristics of this trend, which are made possible through intensive and continuous data collection (hyper-connectivity) and real-time processing. The primary source of this data that is derived from internet-connected objects and used to make informed decisions is referred to as the Internet of Things (IoT). Specifically, IoT plays a significant role in the conceptualization and implementation of smart environments by filling the gap between physical and mobile engagement (Gretzel *et al.*, 2018). It provides interconnectivity among people, systems and products (Porter and Heppelmann, 2014) by integrating the digital world with physical infrastructure (cyber-physical systems). IoT enables computers to "observe, identify and understand the world without the limitations of human-entered data" (Ashton, 2009). In fact, IoT should be perceived as an ecosystem, rather than a discrete idea, where objects are interacting, using machine learning (ML) and artificial intelligence (AI) techniques, resulting in meaningful actions and collaboratively creating value.

IoT devices have been adapted rapidly by all domains of industry in the past decade to improve business operational efficiency and reduce costs (Breidbach *et al.*, 2018; Jones, 2008). It is expected that the number of IoT devices connected to the Internet will reach 22.3 billion by 2024 (Cerwall, 2019) and penetrate into all sectors. The hospitality industry possesses the potential to benefit from this trend in numerous ways. Customer satisfaction is the primary focus of the service industry which can be improved with more efficient and personalized service enabled by this emerging technology. Service innovation is the most effective way to attract more customers and increase the market share (Hoffman and Bateson, 2001). The fact that new hospitality customers are demanding highly personalized experiences is shifting the focus to experience-oriented, co-created and demand-based consumption from an always-on service typology (Gretzel *et al.*, 2015).

In this context, IoT can help in many ways. First, understanding the guest's context and predicting his needs is the primary challenge that can be achieved via embedded sensors and intelligence (Xiang and Fesenmaier, 2017). The ability to learn a person's physical location which is possible through IoT wearables and actuators is unique to creating personal and real-time content. Intellectualization describes the smartness in content generation by accounting historical data, preferences, time and context. Second, the existence of pervasive connected devices redefines the interaction with guests and the way services are provided. Third, back of house management can leverage IoT technology to improve business operation efficiency, prevent failures, reduce costs and better use the existing capacity. For instance, because of enabling accessibility anytime and anywhere, remote control and process automation can be easily realized, which can increase the safety, sustain the quality and relieve the employees from routine duties and let them focus on high-value tasks such as unstructured decision-making. Consequently, business analytical applications will work effectively when provided with accurate data collected from devices

and the surrounding environment. In addition, monitoring critical systems using appropriate IoT sensing equipment will enable the opportunity to detect problems before it causes catastrophic failures.

Despite various existing challenges, IoT is becoming an indispensable component of future business in all domains from agriculture to manufacturing (Gardašević *et al.*, 2017) and hospitality is not an exception. IoT integration will be pivotal in terms of customer satisfaction enhancement, gaining competitive advantage and operational efficiency improvement (Breidbach *et al.*, 2018). Thus, we believe that it is important to bring this emerging topic to the attention of practitioners and researchers in hospitality sectors with a comprehensive review including some technical aspects. This paper explores and analyzes IoT applications in the hospitality domain by examining various sectors within it and discussing the opportunities and challenges inherent in the use of IoT. The paper first provides an introduction to IoT in technical terms. It then reviews theoretical support for the use of these devices. Next, existing studies and potential applications by sector are fleshed out followed by the opportunities for using IoT in general. Finally, the paper discusses the challenges that arise with the use of IoT and areas for future research.

2. Methodology

This section explains the method followed while performing the literature review on existing applications and articles. Five subdomains under hospitality were identified including hotels, restaurants, cruise ships, theme parks and event management. Next, the keywords pertaining to the IoT were identified. Hospitality and Computer Science experts in the team corroborated the appropriateness of the selected keywords. A systematic search was conducted using the identified keywords (e.g. "iot + hospitality", "internet of things + hotel") in title, abstract and keywords of peer-reviewed articles. The searches were conducted through two platforms: the academic search engine Google Scholar and the online database ScienceDirect. Full-length journal papers and conference proceedings were included. Articles that were cited in and by the publications identified in the search were also scanned for relevance and inclusion, if deemed appropriate. The authors reviewed all the articles gleaned from the search to validate the reliability.

After a rigorous search for peer-reviewed articles on the topic of IoT applications in hospitality, the researchers discussed and verified the importance of including appropriate trade articles that exemplified pioneer applications in the field that integrates IoT in hospitality and settings. Without including those, this general review would be incomplete. For example, without the use of these supplementary articles, information on the way that Marriott International, the largest hotel brand in the world, currently uses IoT in their properties would not appear in this overview. Accordingly, information regarding the adoptions of IoT and their use in the hospitality industry were collected from e-news coverage and project websites. This paper not only covers the existing work but discusses the potential applications of IoT in all domains. Finally, Gartner was used to collect statistics about the IoT. This article distinguishes itself by giving some background knowledge and implementation challenges. Therefore, some references to other survey papers in this area are provided to offer general information to the reader.

3. Background on Internet of Things

An IoT device consists of mainly three components: processing and storage unit, appropriate sensors and communication interface (Patel and Patel, 2016). However, they are assumed to be resource-constrained in terms of computation capacity. An IoT ecosystem can be described as a network of things which comprises the following three major layers:

(1) data collection (i.e. sensing);
(2) network and technologies (i.e. transport and platforms); and
(3) data processing and applications, as depicted in Figure 1.

Detailed descriptions of these layers are offered:

- *Domain and Sensing*: The primary mission of the sensing layer is to recognize any events in the IoT devices' peripheral environment and collect data from the real world. This layer contains different kinds of IoT devices that use various sensors for IoT applications and solutions (Patel and Patel, 2016). Sensors in IoT devices can be numerous. Some examples are *Motion Sensors* to measure the change in motion together with the orientation of the devices; *Environmental Sensors* to collect different environmental conditions such as light, pressure, temperature, etc.; and *Position sensors to* handle the global position and location-related information such as magnetic sensors and global positioning system (GPS) sensors.
- *Transport and Platforms*: The IoT devices work with special operating systems or platforms which require lower resources than regular operating systems. The integrated network layer uses different types of communication channels and associated transport protocols to transfer data collected at the sensing layer. The physical channel is implemented using diverse communication technologies (e.g. Wi-Fi, cellular network, Bluetooth, Zigbee, etc.) to allow data flow. In the meantime, IoT devices use ecosystem-specific transport or messaging protocols such as Extensible Messaging and Presence Protocol, Message Queuing Telemetry Transport, or Advanced Message Queuing Protocol to format and send the data to the application layer.

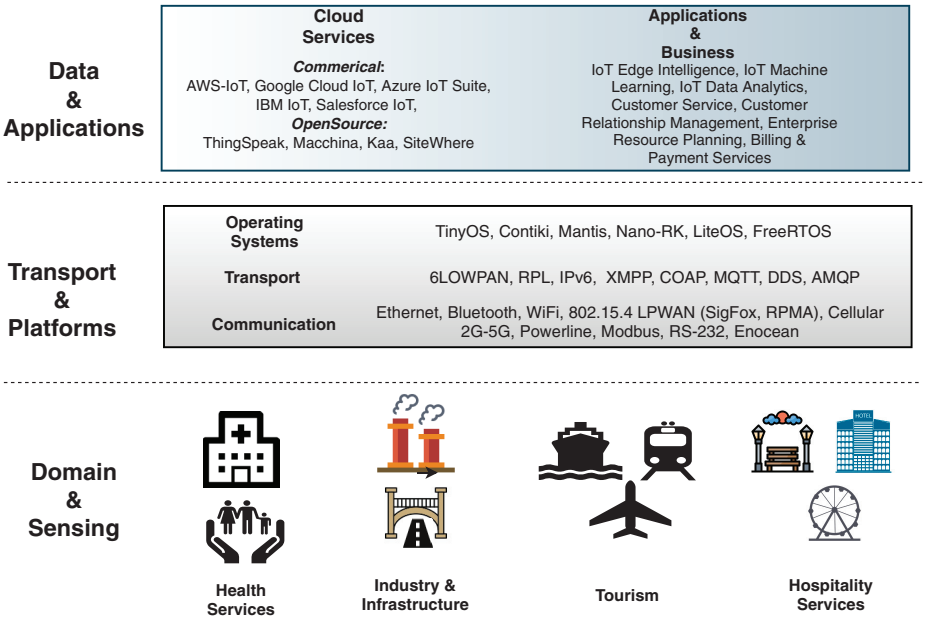

Figure 1.
General view of the IoT ecosystem

- *Data and Applications*: As the IoT devices are resource constrained, data processing is performed generally in the cloud (e.g. AWS IoT, Google IoT, etc.). The aim is making informed decision using ML algorithms based on real and historical data collected from these devices. The results are presented to application layer to produce valuable services. The applications perform various tasks for users, customer relations, etc.

4. Theoretical support for Internet of Things adoption

The hospitality industry relies on service operations or behind the scenes procedures and processes that support and orchestrate the front of house services that are delivered to the customer (Leffingwell, 1917). The service industry is unique in that their offerings are at once tangible and intangible (e.g. food and foodservice), perishable (e.g. hotel room, booking reservation at a restaurant), simultaneously delivered and consumed and distinct in terms of expectations from customer to customer. More recent literature has demonstrated the merits of technology-facilitated value co-creation in these service industries as a way to accommodate these nuances (Breidbach and Maglio, 2016; Huang and Rust, 2018). For example, the IoT leverages big data to assist service providers with anticipating customer wants and needs, personalizing the service experience and executing faster service recovery to provide a holistically better customer experience (Peters *et al.*, 2016; Antons and Breidbach, 2018). This will ultimately lead to the customer being, at least partly, in control of the technologies that will be used to create the service encounter (Jones, 2008). Because future service will be co-created through the IoT and similar innovations, scholars have identified service operations (Jones, 2008) and technological competitive advantage (Bilgihan *et al.*, 2011) process theories to support and explain the phenomenon and its impact on the hospitality industry.

The challenge afforded the hospitality industry is that creating a competitive advantage through innovation management requires the firm to provide a service that is unique, difficult to copy or adopt, value adding and more innovative than competitor's service offerings (Cooper and de Brentani, 1991). Human operations services are typically easy to adopt and copy and are not protected by any legal recourse (Atuahene-Gima, 1996), while technologically supported services (e.g. Kiosks, computers, robots) are often expensive to adopt, typically obsolete in a two-year timeframe and the Return on Investment (ROI) may be difficult to measure. However, operations management theory serves to explain the unique lenses through which innovative technologies may be leveraged to support the hospitality firm.

Jones (2008) identified five primary operation management theories that underpin hospitality IT adoption and implementation. They are as follows:

(1) Theory of Process Choice.
(2) Theory of Swift and Even Flow.
(3) Theory of Lean Manufacturing.
(4) Theory of Performance Frontiers.
(5) Theory of Service Experience.

The Theory of Process Choice discusses the independent and unique processes that are best suited to produce the desired product or service for a specific market based on the capabilities of the firm. According to Jones, this theory is characterized by production lining and decoupling. Production line connotes the process by which operations are reduced to the

sum of their parts and the various tasks that comprise the whole service are outlined step by step. Decoupling connotes the separation of front of house and back of house activities by both physical space and time. The IoT will serve to reduce steps in the process sequence and time it takes for these processes to be complete, as well as recouple some of the activities that have previously been separated because of human limitations.

The Theory of Swift and Even Flow maintains that the faster and more smoothly the service may flow through the process, the more efficient and productive that process is (Schmenner and Swink, 1998). Schmenner and Swink proposed three rules to govern this theory. First, the more randomness a process has, the lower the productivity of the process. Second, the more variability required to execute the process, the lower the productivity. Third, the more opportunities for bottlenecks (or changes in the rate of a process flow), the lower the productivity. Jones (2008) proposed a fourth rule that suggests that for operations with a great deal of instability (like the service industry) the greater the need for prioritization of tasks within the processes (Westbrook, 1994). The IoT and hyper-connectivity will answer the call for a reduction in bottlenecks, instability and variability in service processes as many operations (e.g. order taking in a restaurant, directions in a resort hotel) will be leveraging technological instead of human capital.

The Theory of Lean Manufacturing explains that eliminating waste increases productivity. According to W. Edwards Deming waste may fall into one of seven categories:

(1) inventory;
(2) motion;
(3) over-processing;
(4) overproduction;
(5) waiting;
(6) transport; and
(7) defects.

The application of scientific management principles and quality improvements coupled with the reduction of tasks being performed and elimination of tasks that do not add value all increase productivity according to this theory. The implementation of IoT and interconnected devices has already demonstrated efficacy in the airline and fast-food industries with regard to in-flight meal production and order taking, respectively.

The Theory of Performance Frontiers is used to assess the cumulative capabilities of processes and products to identify peak performance output (Schmenner and Swink, 1998). The first tenet of the theory asserts that improvements to one area lead to improvements across other areas of the process. It also purports that there is a diminishing return on improvement in that the closer the firm gets to its peak asset performance; the more resources must be devoted to create incremental improvements. It also suggests there is a diminishing synergy between assets and operations, the closer the firm gets to its performance frontier, Leveraging the IoT technology to help support the synergy between assets, performance and productivity by means of data mining for areas of improvement will continue to be refined now and in the future.

The Theory of Service Experience describes how service customers are interactive players that respond and react to the service experience. Thus, the theory proposes that a customer service process will be more productive if customer expectations are met or exceeded; if the customer has multiple previous experiences to inform the service encounter; and if customer feedback is applied in real-time and after the fact to improve the process.

Building on this, a co-creative experience whereby the customer helps to craft and personalize the experience helps to satisfy these criteria.

Finally, it is important to understand the opportunities and strengths created through the myriad operation management theories. Accordingly, the way in which these management principles can facilitate a competitive advantage is important to assess. Scholars on competitive advantages generated by IT decisions created a model to explain the process and outcomes. The process begins with the firm making IT decisions (e.g. synergy between the product and the service desired, cost and anticipated benefits) that lead to IT implementation and integration of the system(s). This leads to an evaluation of the capabilities and competencies by which the technology is bound, which then offers the firm a competitive advantage by creating dynamic capabilities. These ultimately result in lower cost, speed, value added, agility, innovation and/or customer service (Bilgihan *et al.*, 2011). The rapid pace at which technologies are innovated and modified indicates that IoT will provide numerous opportunities and as well as present challenges and risks for the hospitality industry (Jones, 2008). These opportunities, challenges and risks are further discussed.

5. Application of Internet of Things in hospitality sectors

IoT devices are used across myriad applications in the hospitality industry. The proliferation in adoption and implementation of this technology is in large part because of the acknowledgement that it offers benefits in terms of improved customer insights and experiences (Bilgihan *et al.*, 2011), asset and facility management (Sklyar and Kharchenko, 2018), safety and security (Rigoli, 2017) and decision-making through data analytics (Aluri, 2015), all of which lead to increased revenue and cost reduction offering an IT competitive advantage (Bilgihan *et al.*, 2011). As strategic management through innovation serves as the foundation for IoT adoption (Bilgihan *et al.*, 2011), this section identifies the applicable areas of utilization of IoT devices and their applications according to the specific segment of the hospitality industry in which they are most useful.

5.1 Hotels

Hotels, a cornerstone of the hospitality industry, rely on information communication technologies as their customers are demanding more technology to keep up with a busy lifestyle and to mimic home comforts. Hotels are well positioned to harvest the benefits of IoT adoption to remediate various issues and propose novel services. Smart rooms are the pioneer examples with advanced features such as automated controls and personalized services. Self-check-in, with the help of a smart lock, is a common application for many hotels now. Bluetooth-only smartlocks can be opened with an app on the phone but cannot be controlled remotely. When a smart room supports Z-wave or Zigbee, it can connect to a network hub, along with any item in the room, such as a TV, curtains, thermostat, phone, light and coffee maker, and can be controlled on a smart tablet by the guest.

The following are some specific examples of IoT in the hotel accommodation sector.

- Marriott and Samsung are working on IoT hotel rooms to deepen personalized room experiences by leveraging mobile and voice-enabled technology (Grass, 2017). Users can communicate with virtual assistants to request services and control the room. Smart mirrors facilitate in-room workouts and are connected to a cloud server with Wi-Fi or Ethernet connection using end-to-end encryption.
- Hilton, on the other hand, developed an application, Fun Finder, that eases the indoor and outdoor navigation through the facilities in the resort and delivers

targeted messages relying on Wi-Fi, beacon and GPS data (Ting, 2016). It sends notifications to guests about the events and special offers suited to his/her preferences by taking into account his/her time and location. The user needs to download the app and answers a pre-arrival survey.

- Employees at the Viceroy L'ermitage hotel are outfitted with Samsung Gear S3 smartwatches installed with a tailored application integrated with hotel management systems to improve communication among staff (Terry, 2018). When a guest requests a service, the appropriate employee is alerted with vibration alert by the task management platform. It allows a manager to assign and track tasks real-time (Draper, 2018).

Hotels also benefit from IoT devices to reduce operational costs and save energy. The Crown Plaza Times Square reduced energy consumption by 24% by using an energy management system (Curcio, 2011). Preventive maintenance is another opportunity that can benefit this industry. Monitoring the system based on real data from actual devices using appropriate sensors such as temperature will prevent unexpected failures (Sklyar and Kharchenko, 2018). Problematic devices can notify the technical team by instant notification: an undetected broken fridge in the kitchen may cause service interruption or food safety problems, smart power outlets with Wi-Fi or Bluetooth communication capability report high electricity usage, humidity sensor detects overflowing bathtub, pressure sensor monitors heating ventilation and air conditioning unit, etc. Assets can also be tracked down by the staff (Liang and Zhang, 2012). For instance, a room service tray left in the hallway can send a signal via a beacon using low-power Bluetooth signal to alert the hotel worker to be picked. Determining minibars that need refilling via barcode and Radio-Frequency Identification (RFID) scanner is another good example to save time. Vacation rentals under the accommodation category are gaining traction with cheaper accommodation offers. They have been adapting technology faster than traditional hotels for booking and communicating with customers. This specific domain would better fit for innovative IoT applications. For instance, the lack of central management is a disadvantage for the property owner to handle the rental process, but a smart lock can help them to overcome this problem, and an occupation sensor is used to understand if the guest is in the house (Huckle *et al.*, 2016).

5.2 Restaurants and cafes

The restaurant industry can benefit from IoT in many ways depending on the business model, location, size and turnover (Sharma, 2019). An integrated restaurant management system that has interfaces for customers, servers, chefs and managers in addition to hardware end-points can collect real-time information and inform efficient sequences of service. Dedicated applications help guests for easy menu selections and remote ordering. Table-side beacons allow servers to pinpoint tables that need assistance, which improves order accuracy and reduces wait times. Managers are empowered to monitor workflow from order placement to kitchen preparation to service. Saeed *et al.* (2016) designed a smart restaurant management system that allows the customer to find an available parking space through infrared proximity sensors in the parking lot, book a table, order a meal using an interactive menu and make payment. It streamlines communication with customers by enabling them to filter meals based on total calorie count or ingredients that may be high in cholesterol or to which they may be allergic. These types of improvements have been shown to increase sales, amount of food ordered and guest satisfaction (Rigling, 2019).

Another crucial opportunity that restaurants can implement in this context is real-time remote measurement and control. First, proactive and preventive maintenance with

continuous control of appliances using sensing devices will prevent disastrous failures at unexpected times. Second, a safer cooking environment that requires constant vigilance is created by automating the regular checks such as food warming stations or freezers which might compromise the food safety (Jamieson, 2019). For example, Taco John's is partnering with SmartSense company to implement automated food temperature monitoring using wireless sensors (Rigoli, 2017). Third, the ability to remotely control the appliances such as measuring warmer temperature or cooking time guarantees quality assurance and consistency especially for chain restaurants. Fourth, it is possible to monitor conditions of the cold supply chain and track delivery status (Lee, 2019). Automated supply chain management is useful for monitoring inventory like the level of drinks consumed in a bar so they can be controlled and refilled.

5.3 Theme parks

Theme parks present exciting opportunities for innovative IoT projects to elevate customer satisfaction (Lai *et al.*, 2016). The challenge lies in the handling of large crowds in a restricted area while meeting their demands satisfactorily. Effective queue management allows visitors to maximize their experience by visiting most of the available attractions. This challenging but crucial task can be achieved by dispersing visitors evenly around the park using customer-worn RFID tags (e.g. Disney's MagicBands) which record their location information and entry time to the park. The operators can also use real-time data from the sensors to improve the efficiency in the park by creating a smart flow. Solmaz *et al.* (2015) has modeled the movement of visitors which can help to manage resources and predict future visitor behavior. This requires the collection of visitor data that is possible by placing sensors in designated areas. It allows park operators to make calculated decisions to create better traffic flow, identify bottlenecks and remove invisible obstacles by analyzing speed patterns of visitors. Safety of children is also a concern in theme parks for which Kim *et al.* (2011) suggested using RFID tags. A wristband on a child sends the location to the parent's mobile application and to park officials.

Disneyland is one of the world's top hospitality providers with almost 100 million visitors each year. Managing the crowd and long waiting times for attractions are the main challenges and concerns. Disney has successfully developed a wearable wristband called MagicBand (Kuang, 2015) in 2014 that interacts with surrounding objects using RFID with a 40-feet communication range. The MagicBand is mailed to people if they register online which streamlines many processes; the arrival to the hotel with shuttle, sending luggage directly from the airport to the accommodation, entrance to the park, hotel check in, payment in stores, etc. (Borkowski *et al.*, 2016). Disney develops a customer-centric business model by offering customized service to visitors. The aim is to create immersive, seamless and personal service for guests. Moreover, they have the chance to collect customer data such as attraction preferences, purchase history, location, etc. which helps to customize marketing messages and to improve operational efficiency such as scheduling 80,000 employees every week.

5.4 Cruise ships

Cruising is a giant industry with millions of travelers every year. Cruise ships can use IoT to streamline their operations. Although the cruise environment is unique, it can inherit some IoT applications from other hospitality domains. For instance, embarking is a check-in process that can be automated using electronic identification devices as the long embarkation process is considered stolen time from the cruiser. Indoor localization techniques may aid visitors in navigating large ships. Room smartization including locks,

televisions, and so on can also be implemented in the same manners as hotels use them. These ships are filled with many attractions so queue management strategies used by theme parks can be applied in this context. Quick payment methods and easy access to attractions using wearable devices will improve their overall success. IoT deployment on the ship will transform the cruise ecosystem from a static to a dynamic environment with smart ships that can create exclusive experiences and attract more people. Smart interactions among stakeholders lead to efficiency and improved profitability by creating exclusive experience and attracting more people (Vafeidou, 2019; Dias *et al.*, 2016).

Carnival, one of the leading companies in the cruise industry, uses IoT in their cruise ships to give a unique experience to its customers (Frizzell, 2019). A quarter-size disc called the OceanMedallion is shipped to guests once they book a trip. This device is used to check in upon embarkation, which takes around 20 s. The same medallion is used to access the cabin, navigate the ship and pay for anything on the cruise. The ship is converted to a smart city that has thousands of interaction points provided by more than 7,000 sensors. It offers numerous functionalities on board such that recommendations are shown on the screen when a visitor passes by any activity, the room is unlocked when the guest approaches the room, food and drink preferences are remembered in restaurants, people can track their children and other members of their groups, and drinks are delivered regardless of location and paid for with the medallion. Crew members are equipped with the required information to deliver the best service.

5.5 Event management

Conferences, fairs, weddings, conventions and any other events require managing large numbers of people quickly, through registration, meal serving with different preferences, effective movement and easy navigation. Attendees, exhibitors and organizers can use IoT to maximize the benefit from their own perspectives. The organizer can send wearable devices such as lanyard and wristband to the registrants in advance to streamline the registration and session check-in process. The same devices can be used to create a venue heatmap by tracking the attendees, which also help with analytics of the event such as popular sections, busy times, average time spent, etc. For a convention, an attendee can perform an effective visit to the trade by only visiting the related stalls. Notifications can be received from the device when the patron is in the proximity of a person that they want to meet or an exhibit they wish to view. The exhibitors can observe the traffic around the booth and identify people with specific or related interests and send them promotions (Yang, 2015).

Across all segments of the hospitality industry, IoT has begun to transform the processes and procedures used to collect data, manage the properties, facilities, human resources and guests, increase safety and security, as well as provide meaningful, targeted information in a timely manner. These functions all aid in lowering costs, increasing speed, adding value, enhanced agility, greater innovation and/or better customer service (Bilgihan *et al.*, 2011). The next section explores how these functions are supported by theory and used to create opportunities for the hospitality organization.

6. Opportunities

The opportunities created by IoT and technology are manifold. Driven by a younger generation of millennial customers who are more tech-savvy and are more apt to using touch-free applications that facilitate co-creation and more personalized services, IoT offers hospitality companies a means by which to accommodate and respond to this growing customer demand (Gretzel *et al.*, 2015). IoT has the potential to create a breakthrough in the hospitality sector by fostering a new wave of service provision (Car *et al.*, 2019; Pelet *et al.*,

2019) that addresses and satisfies the five extant theories that support the creation of a competitive advantage through innovation (Bilgihan *et al.*, 2011; Jones, 2008). In this section, we provide a brief description of opportunities in the hospitality sector that come with the integration of IoT technology.

6.1 Automation

Automation is the ability to fulfill a task without human intervention. It minimizes errors, improves safety, increases productivity and reduces cost (Rigoli, 2017; Borkowski *et al.*, 2016) and is thus supported by the five operation management theories (Jones, 2008). The hospitality sector benefits greatly from automation such as self-check-in and temperature control with the help available IoT devices such as smart locks and thermostats, thereby reducing waste and cost (Sklyar and Kharchenko, 2018) and streamlining processes that alleviate service failures through wasted or extraneous efforts (Jones, 2008). Automation leaves more time for the staff to take care of guests by delegating some tasks to machines and enhancing the service experience through co-creative activities (Bilgihan *et al.*, 2011).

6.2 Hyper-personalization

Personalization is defined by the following characteristics; learning, interaction, empowering, feedback and delight (Langford, 2018). There is a shift from product consumption to service consumption. Customers are looking for and willing to pay more for self-designed products, which add higher value than standardized products (Bitner, 1992). Tailored services can help the provider to increase the revenue and create profound relationships (loyalty) with customers, thus creating a competitive advantage (Bilgihan *et al.*, 2011). These types of services, normally an advantage of small businesses, are now possible for large organizations with the help of IoT devices. The analysis of user's personal data is conducive to providing personalized services in hospitality (Massimo *et al.*, 2017).

6.3 Queue management

Electronic tags and wearable devices can be used to expedite the execution of a process such as embarking to a cruise ship, thus streamlining process choice and ensuring swift and even flow (Jones, 2008). It will both please the customer and increase the total number of guests served in a period (Solmaz *et al.*, 2015), increasing efficiency and reducing costs (Bilgihan *et al.*, 2011). Long lines may result in guests having to wait in line to check in for a conference, get served the food, park your car or use the treadmill, which may result in dissatisfaction (Bilgihan *et al.*, 2011). Reducing waiting time for services and facilities will increase the customer satisfaction (Jones, 2008; Schmenner and Swink, 1998). People can schedule a service and get notification when their turn is approaching (Ghazal *et al.*, 2015). They may also be directed, while waiting for one service, to a queue that has fewer waiting times and may offer a different one. This strategy may be used to add value and customer satisfaction through redirection via the IT (Bilgihan *et al.*, 2011).

6.4 Location-aware services

It is possible to track objects and people using indoor wireless localization, GPS or infrared tags, which enables the interaction with a customer using his location information, to make suggestions to improve the user's experience (Ting, 2016). Detecting the location of customers and crew members helps manage the operations more effectively, streamlining processes through choice, creating a swift and even flow and getting the operation closer to its service frontier (Jones, 2008). Real-time information can be used to assign additional staff

to serve the crowd, employees are directed to the area where people are gathering, and analytics from collected data can help to do better design and staff scheduling (Terry, 2018), all of which serve to create a competitive IT advantage (Bilgihan *et al.*, 2011).

6.5 Asset management and energy savings

Smart lights and temperature control mechanisms can help manage the energy consumption with real-time monitoring, improving the profit margin by reducing dominant factors in cost calculation (Bilgihan *et al.*, 2011; Eskerod *et al.*, 2019; Narraidoo, 2020). The prominent example is adjusting room temperature in hotel rooms using heat and occupancy sensors when the room is empty to save energy (Curcio, 2011) in addition to costs (Bilgihan *et al.*, 2011). Preference of the guest can be incorporated into the equation while he/she is in the room, increasing personalization and adding to the service experience (Jones, 2008). Remote monitoring of amenities and management of inventory including valuable items is also possible through connectivity (Sklyar and Kharchenko, 2018) and remote housekeeping services may be accommodated (Liang and Zhang, 2012), thus ensuring swift and even flow (Jones, 2008). Green hospitality, which aims using less energy, and water is also important for creating a sustainable environment (Lee and Cheng, 2018), which builds on the perceived benefits the hotel provides to the environment, the employees and the guests, resulting in a competitive advantage (Bilgihan *et al.*, 2011).

6.6 Data-driven decision-making

IoT is the key enabler for scientific management (Aluri, 2015) through informed decision-making using the data collected from IoT devices. Collected data is used to take meaningful actions with the interpretation by human or AI applications (Pavlou, 2018). It is easy to collect useful information once the IoT devices are deployed. For instance, it is possible to spot idle facilities or overcrowded areas, and data may be leveraged in real time to alleviate these issues of waiting (Jones, 2008) and bottlenecks (Jones, 2008; Schmenner and Swink, 1998) and increase the swift and even flow of the processes (Jones, 2008).

6.7 Resource and staff scheduling

Efficient task assignments are possible through processing location and availability information of staff and resources (Terry, 2018). The result is efficient utilization of employees and fast service through IT-driven decision-making (Bilgihan *et al.*, 2011). For example, the closest housekeeping members could be notified whenever a guest checks out to prepare the room ready for the next visitor (Draper, 2018), thus bringing the firm closer to their peak performance frontier (Schmenner and Swink, 1998).

6.8 Supply chain management

IoT provides visibility in inventory and supply chain management with precise information (Lee, 2019; Turton, 2019), which speaks directly to the importance and benefits of lean manufacturing, as well as performance frontiers (Jones, 2008). It is valuable to be able to monitor the stock levels dynamically with fluctuating demand to pinpoint optimal levels for operation, reduce costs and deliver more consistent and quality offerings (Bilgihan *et al.*, 2011). Delivery status along with the conditions such as temperature, humidity in a container can be controlled via smart IoT sensors to ensure timely and hassle-free service, thus improving process choice and delivering service through a swift and even flow (Schmenner and Swink, 1998). This information is ideal for any foodservice venue with perishable food and an inventory of beverage, and the data may be used to identify the

optimal, lean manufacturing procedures to reduce excessive or loss of inventory (Jones, 2008).

6.9 Preventive maintenance

As a cost-saving strategy, preventative maintenance aligns seamlessly with creating competitive advantage through innovation (Bilgihan *et al.*, 2011; Jones, 2008). Problems can be detected and solved before they escalate using various sensors and watching for specific symptoms (Sklyar and Kharchenko, 2018), ensuring even flow of processes. Smart outlets can help identify malfunctioning appliances if they drain unusual power, saving costs and preventing the interruption of services, as well as helping scheduling the maintenance team (Jamieson, 2019). Unexpected failures of equipment cause catastrophic shutdown and revenue loss. Timely repair prevents against this and also maximizes the lifetime of assets and saving costs (Bilgihan *et al.*, 2011).

6.10 Marketing

IoT facilitates proactive marketing by using personal information provided by the customer (Ting, 2016). This allows for targeted promotions using push notifications via wireless-enabled beacons to guest devices. These efforts can increase revenue through the synergy created between the customer, the end product and the technology that brings the two together creating personalized customer service (Bilgihan *et al.*, 2011).

6.11 Safety

IoT offers numerous layers of security. It is possible to track valuable items, even children, within a facility using wearable IoT devices (e.g. Disney's MagicBand). Sensors can provide advanced monitoring capability to prevent accidents. Safety of the environment can significantly be increased with sensor deployment (Rigoli, 2017). Security management which is performed by humans most of the time can also be automated to streamlines processes, making them faster and closer to the performance frontier, making the environment safer (Jones, 2008). For instance, the maximum number of people allowed for a specific region can be enforced through automatic counting, allowing a more swift and even flow (Jones, 2008) and preventing fatal errors that often result from human subjective perception.

The opportunities that are afforded from IoT adoption and implementation must be considered on a firm by firm basis, including its infrastructure, its human resources and its financial abilities to support these technologies, as not all firms have the physical infrastructure, technical support staff or cash flow to use these devices and applications (Bilgihan *et al.*, 2011). Ensuring that the benefits afforded by the technology will outweigh the costs in adopting, and installing the technology is paramount for creating a competitive advantage. Careful consideration of the opportunities, as well as the challenges and risks associated with IoT technology adoption are important to consider to identify if the technology with being value adding or a financial burden to the firm (Bilgihan *et al.*, 2011; Jones, 2008). Accordingly, the challenges and risks presented by this technology will be addressed.

7. Adoption challenges and risks

7.1 Privacy and security

Privacy and security are singled out as the most important hurdle preventing the wide adoption of IoT by industry. Attacks on IoT have tripled in 2019 (F-Secure, 2019).

Large numbers of devices deployed exponentially increased the surface of attacks. Face recognition systems and sale terminals are targeted points to receive more attacks (Kansakar *et al.*, 2019). A compromised device could be exploited to access to private guest information and damage the whole system. These devices can be used to establish distributed denial of service attacks and insert ransomware. Hackers attacked the central key management system a hotel in Austria and locked the electronic doors in the entire hotel (Ghoshal, 2017). The hotel had to pay ransom to hackers to resolve the issue.

Considering the severely resource-limited nature of IoT devices, the protection of these devices is challenging to achieve by executing conventional security mechanisms (Usman *et al.*, 2017). For instance, encryption consumes high energy, and most of the devices do not support any encryption scheme at all. Because of the diversity of IoT devices and the associated inner complexities of each device, the conventional security countermeasures (i.e. intrusion detection systems, firewalls, anti-virus software, etc.) are not reliable solutions. Thus, a complete and comprehensive solution for IoT access policy, full protection from vulnerabilities of sensors through side-channels and efficient encryption that considers power-performance is yet to be designed.

Privacy is the biggest concern from the user perspective and is one of the most difficult tasks to achieve when using IoT devices, as personal information is collected to provide personalized service (Sicari *et al.*, 2015). Continuous data collection about a person through location-aware applications may leak information about daily activities, thus collection, communication and storage of this data must be handled with ultimate care. Collected data, if leaked, may be merged with other databases by attackers to gain further information about customers. Only necessary information should be gathered and anonymization techniques should be used when storing to reduce the threat. The service provider should apply strict access control to allow only the authorized people.

7.2 Data management

Data collection and analysis are key to the successful utilization of IoT devices. Hundreds of sensors and devices generate a huge volume of data. Some data requires prompt response while some needs to be analyzed and compared with historical data (Wang and Ranjan, 2015). Velocity and variety of data generation make it harder to process correctly and in a timely manner because of device nature, communication standards and deployed applications. Processing and managing such data to produce valuable services is a challenging task.

Figure 1 offers a brief overview of the services provided by IoT and the used standards and platforms related to data management. It also implicitly represents potential challenges related to data heterogeneity, data management and analysis. The first challenge arises from data heterogeneity, as current IoT infrastructure still lacks the ability to dictate the standards for generated data. For instance, the collected data may have various formats and semantics for different domains. Thus, without proper standardization, interoperability and scalability of IoT applications suffer severely (Razzaque *et al.*, 2015). Setting standards for IoT plays a crucial role and key organizations such as Institute of Electrical and Electronics Engineers, American National Standards Institute and European Committee for Electro-Technical Standardization are actively working to set up global standards for IoT data. The second challenge is the storage of vast amounts of IoT data for later analysis. To overcome this challenge, IoT adapters must use non-traditional data management mechanisms. Moreover, they need to develop particular data mining and ML techniques for more effective data analysis and autonomous decisions in the IoT domain (de Carvalho Silva *et al.*, 2017).

7.3 Adoption

Integration of IoT system requires careful planning for a seamless deployment. There are different phases and aspects of implementation from planning to installation (Ancarani *et al.*, 2019). It is crucial to choose compatible platforms to reduce the integration issues. In some cases, such as cruise ships, it is required to have service interruption for installation. In terms of cost, although device prices are reasonable, downtime, retrofitting, maintenance and personnel training are some additional cost. It is difficult to measure the ROI especially for large-scale deployments. It may be reasonable to observe specific areas to see the improvement. Even though some implementations fail for various reasons such as lack of expertise in the area, a substantial amount of companies who successfully implement the IoT have already seen a return on their investment (Anurag, 2018). The communication of things to the Internet and the cloud services is another point to consider in IoT implementation. Available connectivity options show an enormous variety according to the application environment and the type of IoT infrastructure. For example, for smart room applications, such as a smart appliance, the device may access a Wi-Fi router or a ZigBee router which has various communication range, bandwidth and security features (Naik, 2017). Therefore, IoT adopters in hospitality should decide on communication technology based on availability and expenses. For example, it may be costly to transmit data through a cellular network, and it may also need a constant power supply because of the required transmission power and energy. Thus, without a proper power supply, connectivity is provided with different communication technologies that demand low energy consumption while transmitting data such as LoRA, Sigfox, etc. (de Carvalho Silva *et al.*, 2017).

8. Discussions and conclusion

8.1 Conclusions

IoT is becoming the *de facto* technology in all areas, as it offers many opportunities for customized and personalized service. This article presented recent developments, ideas and potential applications of IoT in different sectors of hospitality. Across all the segments of hospitality including hotels, theme parks, cruise ship industry has begun to benefit from this trend. Even though there are sample cases and implementations around the world, there is still significant room for growth and implementation of this technology. With its continued incorporation into all aspects of the hospitality industry, the ways in which services are provided in terms of standard operating procedures as well as the way in which experiences are facilitated (e.g. co-creation) will continue to alter the servicescape in terms of customer expectations and satisfaction.

8.2 Theoretical implications

As service operations (Jones, 2008) and technological competitive advantage (Bilgihan *et al.*, 2011), process theories were used to support and explain IoT's impact on the hospitality industry, the theoretical and practical implications are nearly inextricably linked. However, this study does demonstrate how the five operation management theories are leveraged to streamline processes (Theory of Process Choice), making them faster and smoother (Theory of Swift and Even Flow), while simultaneously eliminating unnecessary, extraneous or gratuitous steps in the processes (Theory of Lean Manufacturing), ultimately bringing the firm closer and closer to peak performance (Theory of Performance Frontiers), while increasing the experience for the guest through co-creative and personalized processes (Theory of Service Experience) (Jones, 2008; Schmenner and Swink, 1998). All of these operational process improvement measures must be considered and weighed against the

current state of the firm to identify whether or not IoT adoption and implementation would create a strategic advantage for the firm (Bilgihan *et al.*, 2011).

Ultimately, this paper extends the extant theory by highlighting which IoT opportunities (automation, hyper-personalization, queue management, location-aware services, asset management and energy savings, data-driven decision-making, resource and staff scheduling, supply chain management, preventive maintenance, marketing, safety and data sharing) leverage specific operational process theories and increase the likelihood of a competitive advantage through innovation across the various sectors of the hospitality industry. The challenges and risks provide the foundation for evaluating where processes might be hindered, fragmented or interrupted by adopting and implementing the IoT, which may ultimately result in a disadvantage for the firm (Bilgihan *et al.*, 2011). These theories, when evaluated holistically and in tandem, facilitate a comprehensive understanding of how IoT adoption and implementation may or may not create dynamic capabilities and a competitive advantage for the firm.

8.3 Practical implications

The IoT will continue to usher in greater opportunities for customization and personalization of the service experience. Operational processes will continue to be refined and even rewritten for efficiency and speed. For owners, operators and customers, it will alter expectations for costs of goods and services, the speed and agility at which services are expected to be delivered, the value added from the service encounter, the innovative nature of the services and the overall customer services provided (Bilgihan *et al.*, 2011). The IoT will be used for enhancing the customer experience through gained customer insight, improved asset and facility management, innovative product offerings, enhanced safety and security, all of which will increase revenue and decrease costs through streamlined processes and more accurate, timely data (Bilgihan *et al.*, 2011; Jones, 2008). Integration will be pivotal for success in terms of operability and creating a competitive advantage, and co-creative experiences will foster the personalization that will come to be expected of the experience.

While the Corona Virus Disease 2019 pandemic transpired after the review of literature, it would be remiss not to mention its impact on the industry and the subsequent proliferation of use for IoT in the industry. In many ways, the pandemic served as a catalyst for innovation and disruption to standard service processes. For example, the IoT is being used to identify areas of major outbreak to facilitate real-time decision-making with regard to hotel occupancies, dining options (e.g. outdoor dining), special and mega-events (e.g. the Olympics) and cruise line schedules (e.g. No Sail Orders) to name a few. Wearable devices and smartphones are aiding facilities in identifying whether or not social distancing standards are being followed (Chen, 2020). The pandemic has also impelled the use of distance working platforms and chatbots, while information technology and hospitality firms are working conjointly to quickly create emerging technologies including IoT to respond to the changing servicescape and customers' desire for social distance (Panigutti *et al.*, 2020).

8.4 Future research

The use of IoT in Hospitality poses research opportunities and challenges that could be of interest to the research community. The hospitality industry needs to identify safe, effective and integrative ways to create smart ecosystems to help to improve business operations and customer satisfaction. Upcoming technologies such as 5G and blockchain, combined with IoT, may inspire and enable new ideas. Implementation of 5G will improve the connectivity by addressing delay and bandwidth problems and introduce new connected devices such that IoT technologies will be used more in the hospitality industry. While developing

applications and realizing ideas; security, privacy and ethical concerns are important points to consider. Blockchain can bring solutions to existing security problems in IoT communication and provide secure payment methods. Social aspects of IoT implementation such as unemployment and education need further exploration.

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