Fraunhofer IAO

FRAUNHOFER INSTITUTE FOR INDUSTRIAL ENGINEERING IAO

Vanessa Borkmann, Dennis Stolze, Christina Bruns

A REPORT FROM THE RESEARCH PROJECT FUTUREHOTEL

FUTUREHOTEL – SMART HOTEL ROOM

DESIGN OF A COGNITIVE HOTEL ENVIRONMENT

FRAUNHOFER VERLAG

FutureHotel

Vanessa Borkmann, Dennis Stolze, Christina Bruns

A REPORT FROM THE RESEARCH PROJECT FUTUREHOTEL

FUTUREHOTEL – SMART HOTEL ROOM

DESIGN OF A COGNITIVE HOTEL ENVIRONMENT

FRAUNHOFER VERLAG

TABLE OF CONTENTS

Preface:

In the interests of legibility, this publication will abstain from the simultaneous usage of male, female, and non-binary terminology. All references to individuals apply simultaneously to all genders via gender-neutral singular »they«.

1 INTRODUCTION

The word »**smart**« is synonymous with clever or intelligent, a characteristic typically attributed to people. If an object is called smart, this is an analogy. A smart object can simulate intelligent behaviour, for example by observing its surroundings via sensors, analysing it with algorithms and appropriately, purposively reacting to it with actuators (López et al. 2011).

In the field of digitalisation, the term is used to describe a technical system solution. For instance, the »smart home« is »the inwardly and outwardly networked household equipped with information and sensor technology« (Bendel 2019). The SmartHome Initiative Deutschland expounds upon the idea of the smart home and includes all intelligently networked buildings or building components, as well as residences or offices: »It is critical that a great deal of routine work is automated, thereby proceeding reliably and precisely« (SmartHome Initiative Deutschland 2019). In summary, smart home solutions »[strive] to improve quality of living, operating and break-in security, and energy efficiency, which has both economic and ecological implications« (Bendel 2019).

The definition of the term »smart« is carried over to the hotel in the context of this report, which serves as a »temporary living space« for the guest.

»The `smart hotel concept´ stands for an interconnected, technical system solution that improves convenience and quality of comfort, security and energy efficiency within a hotel, that exhibits a high degree of automation through digitalisation. The usage of digital data makes a significant contribution to this end.«

Vanessa Borkmann, Head of FutureHotel Research at Fraunhofer IAO, 2019

Smart hotel solutions entail the usage of sensors as well as the networking of all technical components within an entire system. The data are often stored and processed with cloud-based systems, e.g., a hotel (property) management system (PMS). Components of a smart solution are the access to the system data and the interaction with the system via mobile devices. The real-time exchange of data can occur via the internet or radio transmission, with online or offline systems.

A smart hotel solution incorporates the hotel guests and their connectivity. This requires the user to have their own mobile device (see section 3.3.1 BYOD), or that the guest is provided with a device for the duration of their stay. The smartphone now plays an important role in interaction with the hotel guest in the »Smart FutureHotel Room«.

A new dimension of smart solutions involves the networking of all (technical) components within a technical ecosystem. This ecosystem contains sensor technology, biometric authentication in conjunction with mobile devices, the usage of cloud-based services, and not lastly the integration of artificial intelligence and machine learning on the basis of digital data. Advancements in the field of 5G technology, quantum computing and new memory technology will support the further development of the smart hotel solution in the future.
As no hotel is currently known to implement a smart hotel solution that considers the current technical possibilities completely, this report refers to a »future perspective« while still describing a currently feasible, smart hotel room scenario as the »**Smart FutureHotel Room**«.

1.1 INITIAL SITUATION

The FutureHotel Innovation Network at the Fraunhofer IAO, which is currently in its sixth research phase, is the leading think tank and innovation laboratory for the research and development of pioneering hotel solutions. For over ten years the network of experts has been researching areas such as the future hotel room, the current and future needs of guests, the new work environment within the hotel, the use and potential of technology in the hotel industry, digital transformation and innovative concepts (space concepts, usage concepts, business models) for the hotel industry. In addition to the knowledge network of over 26,600 Fraunhofer researchers in various disciplines and industries, the think tank draws on a globally unique, technological body of knowledge from Europe's leading organisation for applied research. Excerpts from the range of FutureHotel research work and findings can be found at www.futurehotel.de.

Smart home solutions are becoming more prevalent, and thus relevant, in our society. Smart home products have already entered consumer markets, and many hotel guests have privately settled on a certain technological standard that is swiftly becoming routine.
At this juncture, the hotel industry is remote from this standard. One reason for this is that smart home solutions cannot automatically be carried over to the hotel industry. Certain conditions must be met, such as security standards, providers with service contracts, and interfaces to hotel-related software products. Currently, there are no system solutions suitable for the hotel industry, solely isolated applications are available.

1 INTRODUCTION

Demand (interest and acceptance) among consumers is also not yet transparent and comprehensible. Smart hotel solutions have not yet been the required standard. It is to be assumed that demand will undergo a rapid increase in the coming years, and guests' demands with it. People used to a certain standard at home, such as in a smart home with voice controls, will not want to miss this while travelling.

Furthermore, smart home solutions can offer the hotelier competitive advantages. Access to and the usage of data will soon be a crucial value for the hotelier in particular. Smart solutions promise advantages in the efficiency of operational processes, savings on expenses, ecological potential, and quality optimisation through more precision due to data-based, real-time decisions. In addition to this, the guest can be offered a seamless travel experience via an interwoven system of smart solutions.

Unfortunately, as of yet there is only very little application-based research on smart solutions for the hotel industry. This report is the result of the need for scientifically grounded, trailblazing insight into the technological possibilities within hotel rooms.

1.2 OBJECTIVE

This report »FutureHotel – Smart Hotel Room« shows the influence of digitalisation and technical networking on the hotel room, and thus illustrates the opportunities and potential that this entails. The report answers the following questions:

- What does »smart« mean in general, and for a hotel room in particular?
- What studies and publications have already been published on this topic?
- What practical examples of smart hotel rooms are currently present on the international hotel market?
- What are the requirements for a smart hotel room?
- What requirements do hotel guests have for their smart hotel room experience?
- How can smart solutions be used to address users' typical »pain points«?
- What are the current technological possibilities for designing a smart hotel room?
- How is the interaction between technology providers and hotel users, and does the supply meet the demand?
- Where are the current obstacles for the implementation of smart solutions?
- What must be noted when implementing a smart hotel room?

1.3 APPROACH AND METHODOLOGY

The content of this report is based on years of comprehensive research in the FutureHotel research network at the Fraunhofer IAO in Stuttgart.

Research results that have been compiled via various key issues, methods, instruments, and with the involvement of numerous international experts since the project commenced in 2008, form the cornerstone for this research report.

In 2008 the FutureHotel network developed and presented the eponymous »Showcase FutureHotel«, a demonstration lab for a smart hotel room in the year 2020. The seemingly futuristic room allowed visitors to experience future technology in an application context.

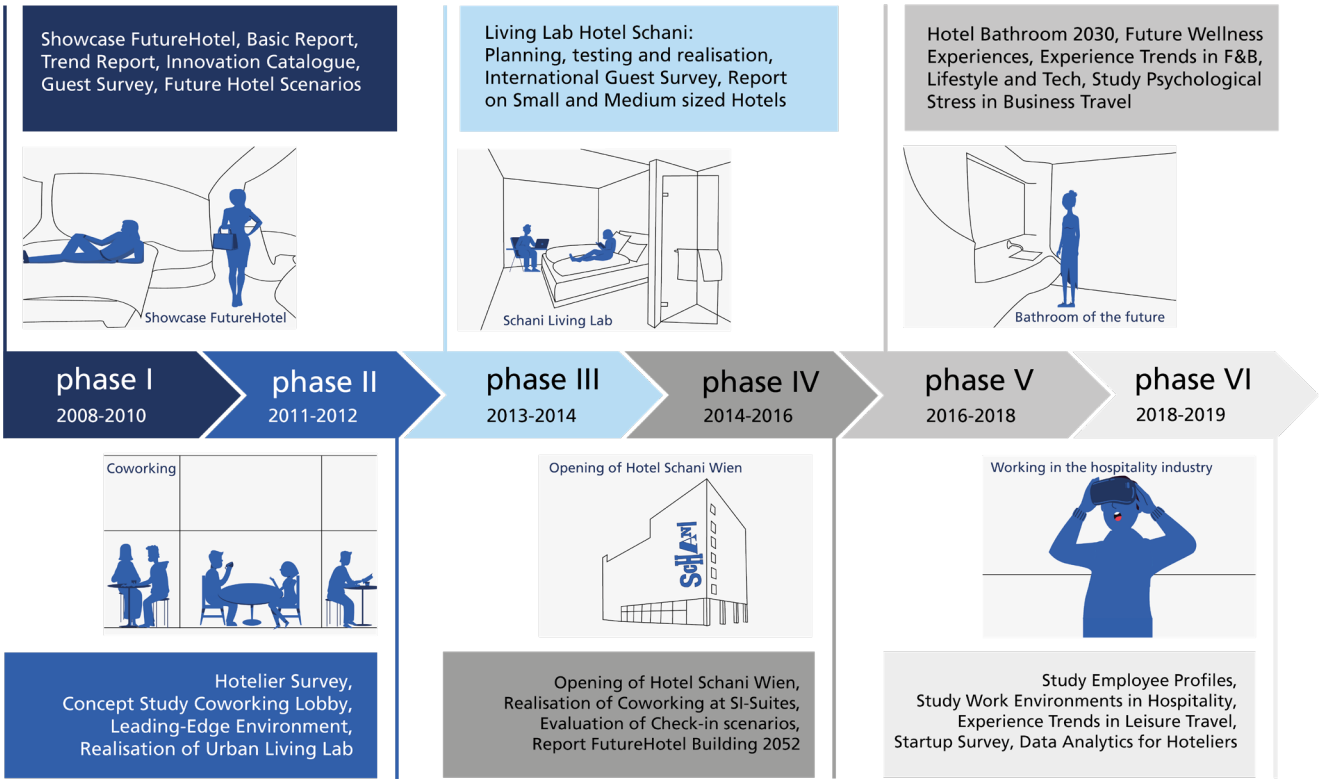

Figure 2: Timeline of project phases and results

This was followed by multiple hotel guest surveys in 2009 (Borkmann et al. 2009), 2013 (Borkmann et al. 2014a), 2014 (Borkmann et al. 2014b), 2015 (Borkmann 2015) and 2017 (Borkmann et al. 2017b), a survey of hoteliers in 2011 (Borkmann et al. 2011) and a Delphi survey among experts in 2015 (Borkmann et al. 2017a). Along with the surveys, the insight from the project is based on numerous workshops with focus groups, industry specialists and experts.

Access to Fraunhofer's own labs, such as the 600 m² hotel lab in Duisburg and the 150 m² Urban Living Lab in Stuttgart, allowed the research team to implement prototypes of innovative approaches and to develop them together with manufacturers and users up to the point of market readiness. One important component of the FutureHotel research is the strong practical reference to years of direct cooperation with hoteliers and their suppliers. Solutions that are ready for application on the market are implemented in partner companies. For example, in 2012 the usage of smartphones at check-in and check-out, as well as usage thereof as a hotel room key were implemented at Hotel Schani in Vienna.

One unpublished report, the guideline ***Leading Edge Hotel Environment*** (Borkmann and Rief 2011), presented spatial solutions for the hotel lobby, the connecting areas, and the hotel room in accordance with the state of research and technology at the time.

In 2016, the study ***FutureHotel Building 2052*** (Borkmann et al. 2016) and the report ***FutureHotel Baderlebnis 2030*** (Borkmann and Rief 2017) were published. Both studies already address pioneering scenarios for the hotel industry.

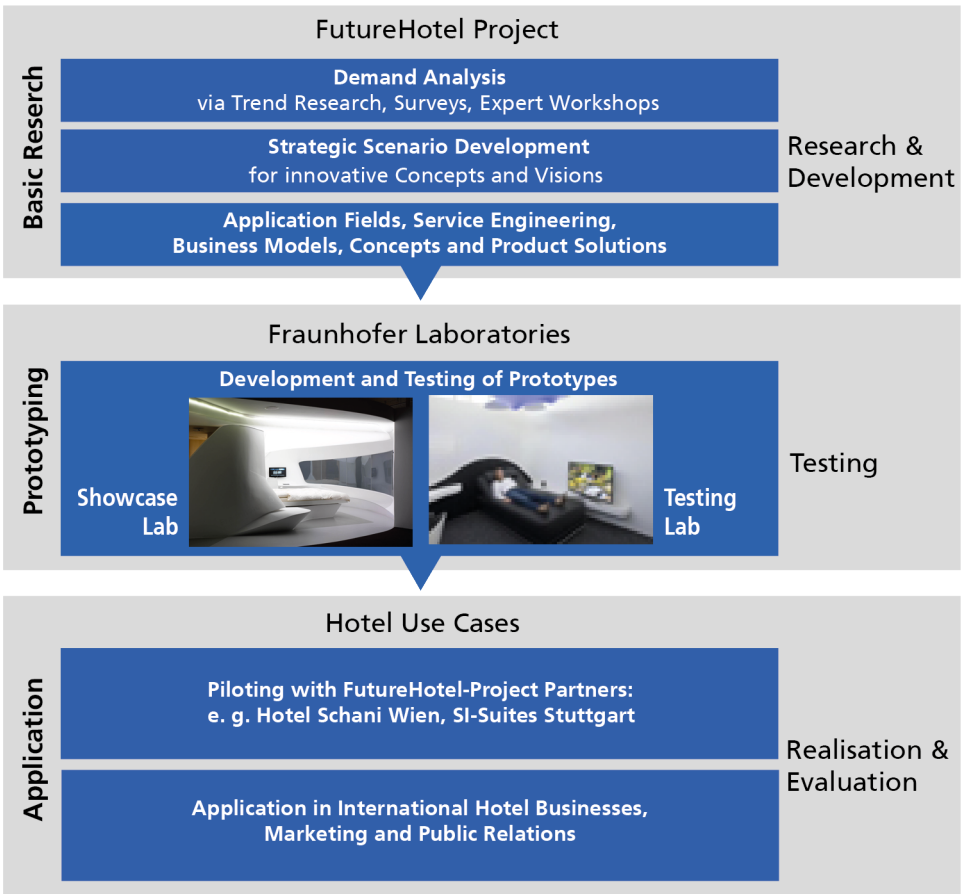

Figure 3: FutureHotel research methods and instruments

A workshop on the topic of the Smart FutureHotel Room was held by the FutureHotel expert group at the company Albrecht Jung GmbH & Co. KG in Schalksmühle in May 2019. The goal of the workshop was to describe a smart hotel experience for the guest and to identify the technical components and solutions (software, hardware, and services) required for a digitalised hotel room, on the basis of currently available technology.

Prior results from over ten years of research on the topic of the Smart FutureHotel Room were presented at the beginning of the workshop. The workshop's focus was on current developments, in particular in the field of smart home solutions. Expert input was presented, and specific topics and questions were compiled in small groups with the World Café method. The expert group of over 30 participants inspected the technical readiness, cost-benefit potential, and opportunities to apply current solutions, as well as the transferability of consumer products for usage in the hotel industry.

2 STATE OF INTERNATIONAL PRACTICE

This chapter presents the international state of practice for smart hotel room solutions. Selected examples will first be presented chronologically, by the year of their respective creation. A graphic illustrates the geographic location of the specific projects. The second part of the chapter is dedicated to the depiction of selected innovation labs, development and demonstration platforms, as well as show rooms pertaining to the smart hotel room.

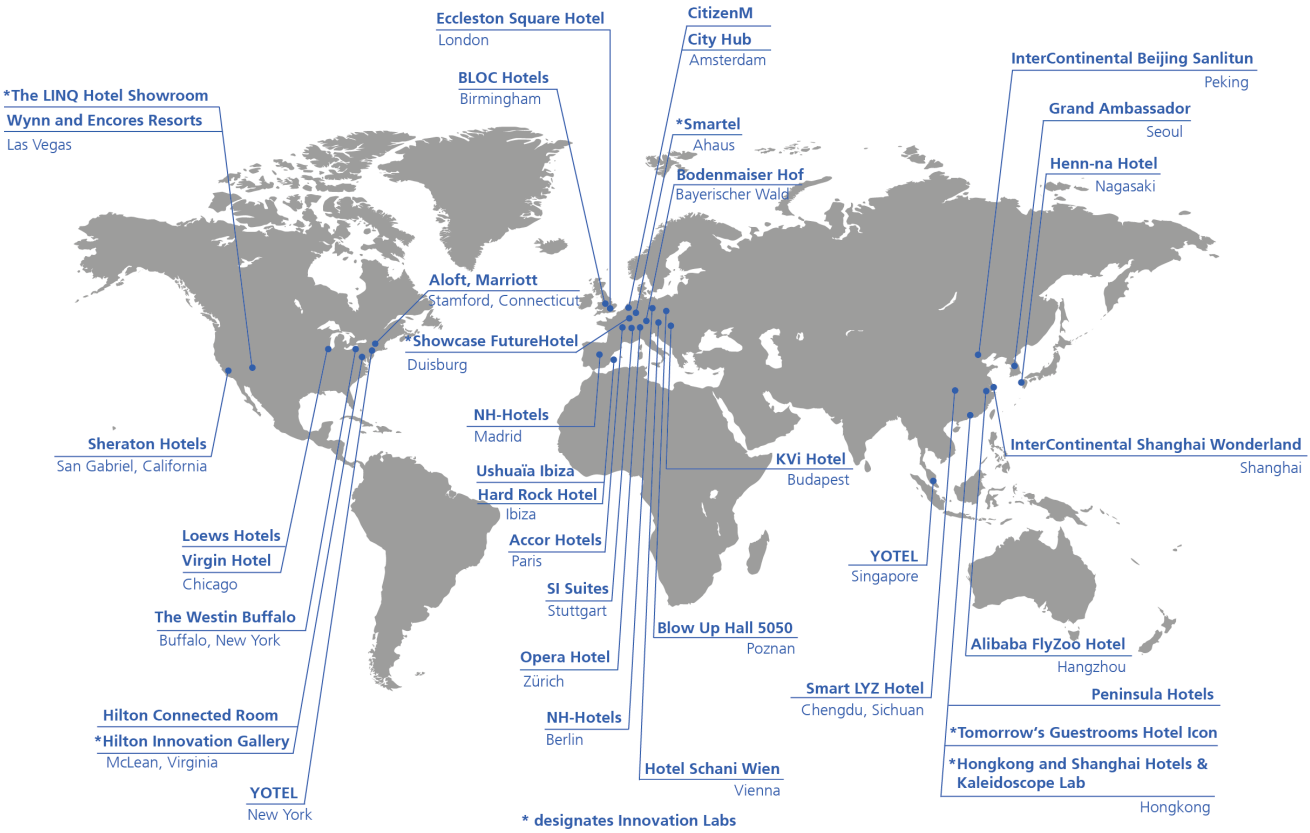

Figure 4: Geographic location of projects

2.1 OVERVIEW OF SMART HOTEL ROOMS IN OPERATIONAL PRACTICE

A list of selected international smart hotel room projects is presented below chronologically by their respective year of creation.

CITIZENM

A partnership between the Dutch hotel chain CitizenM and Philips resulted in the »MoodPad« as early as 2007 (Patel 2007). This is an iPad that can be used to control the ambience of the room. Guests can use the tablet to open and close the blinds, and control the brightness and colour of the lighting in the room (mood lights). Pre-set modes such as Romantic, Relaxation or Party can also be set (CitizenM 2019a). There are currently 19 CitizenM hotels located in Europe, Asia and America. Eleven other hotels are currently being planned. Guests at these hotels can find a MoodPad in all rooms by default (CitizenM 2019a, 2019b).

Figure 5: CitizenM hotel room

BLOW UP HALL 5050

At the Blow Up Hall 5050 Hotel in Poznan, Poland, each guest receives an iPhone. As the rooms do not have numbers, guests can only find and open their room with an iPhone. Furthermore, the smartphone also serves as a virtual concierge and helps the guest find their bearings in the urban factory building (Blow Up Hall 2019).

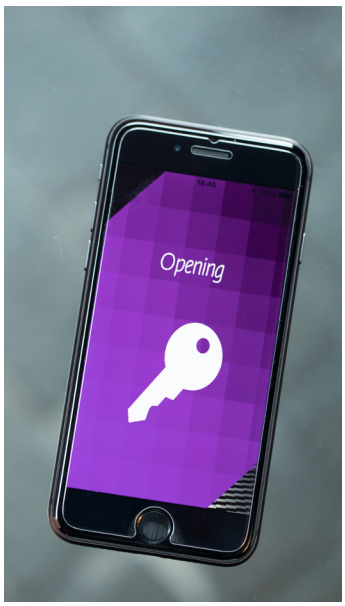

Figure 6: Blow Up Hall 5050

YOTEL

The first Yotels opened in 2007 as airport hotels (YotelAIR) at London's Heathrow and Gatwick Airports. The first city hotel in the centre of Manhattan followed in 2011. Today, 17 Yotels exist worldwide. Numerous new locations being currently planned (Allgemeine Hotel- und Gastronomie-Zeitung 2019). In the rooms (cabins) the guest finds a »techno wall« with Smart TV and customisable mood lighting. The »SmartBed« can be adjusted, allowing the guest to sleep, work, or

watch television on it comfortably (Hochmann 2019). At these hotels the guest selects the desired duration of their stay on an hourly basis. The billing is also hourly (Yotel 2019). Robots are utilised at some Yotels as well. At the Yotel New York, a stationary robot YOBOT securely stores guests' luggage. At the Yotel Singapore, Yoshi and Yolanda deliver towels or other items to the guest's room, while the robot butler YO2D2 developed by Savioke »works« at the Yotel Boston. (Hochmann 2019).

Figure 7: YOTEL Singapur – YOBOTS

Figure 9: YOTEL Singapur – Premium Queen Cabin

Figure 8: YOTEL New York – YOBOT

ECCLESTON SQUARE HOTEL

The Eccleston Square Hotel in London opened in 2011 as »Europe's most high-tech hotel« (Salas 2012). 3D televisions and iPads with a pre-installed app for concierge service were included with each room as early as 2011 (Salas 2012). Now, the room's functions can also be controlled with the in-room tablet. The content of the guest's own device can be displayed on the Smart TV screen via Chromecast. A smart glass wall is installed between the bathroom and bedroom. The hotel provides guests with smartphones so that they can make calls and surf online for free during their stay (Eccleston Square Hotel 2019).

Figure 10: Eccleston Square Hotel room

BLOC HOTELS

The first BLOC Hotel opened in Birmingham in 2011. There are now BLOC Hotels in Birmingham and London's Gatwick Airport. The rooms' concept is inspired by Japanese capsule hotels with the most compact design possible. The guest can check in and open their room door via an app on their own mobile device. In the room, they can control room functions such as lighting (mood lights), temperature, blinds, and television via the app or an in-room tablet (Boutique Hotelier 2013; BLOC Hotels 2019).

Figure 11: Example of a capsule hotel

PENINSULA HOTELS

The flagship of the luxury hotel group The Hongkong and Shanghai Hotels, Limited (HSH), The Peninsula Hong Kong, was extensively renovated and equipped with the latest technology in 2012. The hotel group's own research and technology centre developed the hotel's in-room technology (Hamdi 2019). In 2012 this technology already included in-room tablets on the bed and desk, as well as a wall panel for controlling room functions such as television, music, lighting (mood light), curtains, and room temperature. Menus and hotel services could be accessed via the tablets. In the bathroom, guests found a touch panel with which they could watch television or set the room to spa mode with dimmed lighting and relaxing sounds (PR Newswire 2012).

The rooms currently integrate, among other things, in-room tablets that can be operated in 11 languages, interfaces for the guests' personal devices to play their own media via the multimedia appliances in the room, charging stations next to the bed with all of the common connections, and 4000 internet radio stations (The Hongkong and Shanghai Hotels, Ltd. 2019b, 2019a).

Figure 12: The Peninsula Hotel room

USHUAÏA IBIZA & HARD ROCK HOTEL IBIZA

In 2014 the Palladium Hotel Group introduced the »Very Important Bracelet« (VIB) in its hotels Ushuaïa Ibiza Beach Hotel and Hard Rock Hotel Ibiza on the Spanish island of Ibiza. This bracelet not only gives guests access to their hotel rooms, but also lets them pay for hotel products and services cash-free and, if they wish, access their social media networks through various displays in the hotel and their room. The hotel rooms contain touch screens that connect to the bracelet wirelessly and through which the guest can access information on hotel services and offers. Guests can also use the VIB to use the express check-out option (Ushuaïa Ibiza 2018; Henning 2014).

Figure 13: Ushuaïa Ibiza

Figure 14: Hard Rock Hotel Ibiza

ALOFT HOTELS

In 2014 the Aloft Hotel Cupertino introduced the Butlr robot. At the time, Aloft was managed by Starwood Hotels & Resorts, which became a subsidiary of Marriott International in 2015. The Aloft Hotel Cupertino frequently served the Aloft Hotel Group as a test hotel for innovations in the past. Butlr was specially designed for the service and hospitality industry by the company Savioke (Hospitality Net 2019). Aloft now advertises Butlr's usage as service personnel for bringing the guest towels, care products, and similar items upon request (Aloft Hotels 2019). Access to the guest rooms via the guest's mobile device (mobile key) was first tested at the Aloft Hotel Cupertino before the technology was comprehensively implemented in all (currently 183) Aloft Hotels (Aloft Hotels 2019).

Voice controls of room functions and interaction with a virtual concierge via Alexa Aloft have been possible since 2018. Alexa Aloft is a version of the Amazon Echo that integrates the Alexa software »Alexa for Hospitality« (Aloft Hotels 2019).

Figure 15: Aloft Hotel room /

HOTEL SCHANI WIEN

The second hotel belonging to the Komarek family from Vienna-Ottakring, the Hotel Schani Wien, opened in April 2015. This hotel, with its Viennese charm, is studded with many innovations. As a research partner for the FutureHotel project, the Hotel Schani was one of the first hotels ever to implement custom room selection when booking via the website, mobile check-in, the smartphone room key via a special app, and an integrated coworking space in the hotel lobby.

A total of 135 rooms, among them ten maisonettes and five leading edge rooms, await the guests. The leading edge rooms differ from the standard rooms in their technical amenities. They serve as a test environment for innovative product solutions, such as room controls operated via tablet. The lights or temperature can be regulated directly from the bed. Water and power usage is also measured in order to optimise resource consumption. All 135 rooms are equipped with ultra-high-speed WiFi (200 Mbit) and a 40"-HD flatscreen with screen mirroring option. This allows the guest to connect their smartphone to the television and view pictures or presentations on the large screen. Innovations are part of the Hotel Schani Wien's company philosophy, and that includes cryptocurrencies. Since April 2016 the hotel has accepted Bitcoins at the bar and the hotel shop »Greissler«. The two-way ATM in the lobby was then commissioned in 2017.

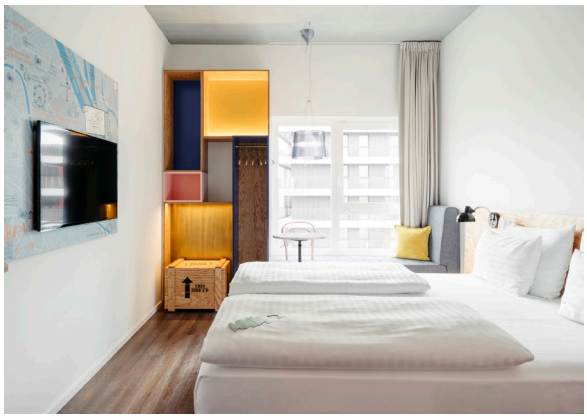

Figure 16: Hotel Schani Wien

Figure 17: TV-Screen Mirroring im Hotel Schani

VIRGIN HOTELS

Richard Branson, CEO of Virgin Airlines, opened the first Virgin Hotel in Chicago in 2015 (Freizeit-Verlag Landsberg GmbH 2015). Via a hotel app, guests can control the room temperature, order room service, communicate with hotel personnel, or speak with other hotel guests (Virgin Hotels 2019a).

Guests who are part of the membership programme »The Know« and share personal information through it benefit from price discounts, upgrades, and a personalised stay at the hotel(Virgin Hotels 2019b).

HENN-NA HOTEL

The Hen-na Hotel at the Huis Ten Bosch theme park in Nagasaki, Japan opened in 2015, with the clear objective of having the majority of services performed by robots. There are currently 12 Hen-na Hotels in Japan (HUIS TEN BOSCH Co 2019). The guest can open their room door with face recognition, and robots are utilised in the areas of front desk service, luggage service, luggage storage, and minor cleaning work such as vacuuming and window cleaning (McMullen 2018).

The room contains a robot module through which information can be accessed, and room functions such as lighting and television can be controlled (Newman 2019). A motion sensor can detect the guest's presence in the room so that electrical appliances are automatically turned off in the guest's absence (McMullen 2018). The »Radiant Panel Air Conditioning System« can detect, via sensors, where a person is in the room and adjust the temperature only in that area (McMullen 2018; HUIS TEN BOSCH Co 2019).

Figure 18: eception at the Hen-na Hotel

CITY HUB

After check-in at the City Hub in Amsterdam, each guest receives a bracelet that they can use to open the door to the sleeping cabin. The bracelet can also open the front door to the hotel. Furthermore, meals can be purchased at the hotel and added to the bill. Functions such as lighting, music, and the room alarm can be controlled via app on the guest's smart device (Wander-Lust 2015; City Hub 2019).

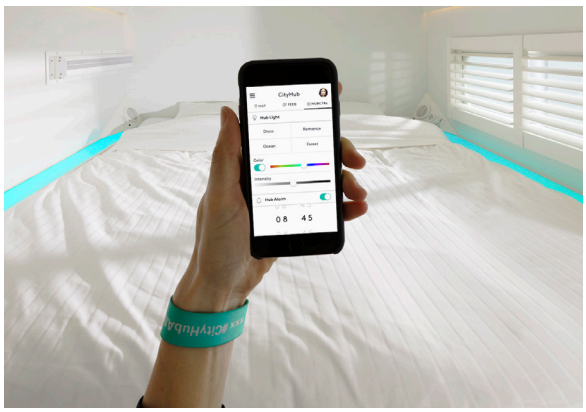

Figure 19: City Hub

BODENMAISER HOF

After extensive renovations at the Bodenmaiser Hof in the Bavarian Forest, modern KNX technology ensures more comfort and energy efficiency. The KNX centrally controls lighting, ventilation, and room temperature. The temperature of an unreserved room can be reduced to a minimum, while it can be increased in a booked room. Once the guest checks in, the room temperature switches to a comfortable level and automatically commences a welcoming scenario. Additional time-dependent, pre-programmed lighting coupled with heating, ventilation, and musical accompaniment awaits the guest in their room. With the »everything off« command, the guest can deactivate all of the lighting when going to bed or leaving the room. The personnel can centrally control all rooms through a visualisation. The guest can also adjust the room temperature or lighting in their room as desired with a regulator and a touch sensor (Hotel Fachzeitung 2018).

Figure 20: Bodenmaiser Hof

WYNN RESORT

Wynn Resorts in Las Vegas and Amazon announced their partnership in December 2016. The goal was to equip all 4748 rooms at the Wynn Resort with Amazon Echo. Along with controlling lighting, curtains, music, and the television, the voice controls were also integrated to answer simple questions about the weather or the news (McQuarrie 2016). In mid-January 2018, 300 rooms had already been equipped with the Alexa tool to regulate room functions via voice controls (Soper 2018). By mid-January 2019 the number of equipped rooms increased to about 70% of the more than 4000 rooms (Prince 2019).

Figure 21: Amazon Echo in a hotel room

OPERA HOTEL

At the Opera Hotel, guests have the option of mobile check-in via smartphone, and can open their room door with their own device. If the guest has booked one of eight »Smart Rooms«, they can control some room functions via Google Home voice controls (Opera Hotel 2019). With an app on their own mobile device they can control room functions, open or close curtains and blinds, or operate the television. Lighting and music in the room can also be adjusted individually. The display mirror in the bathroom presents information like the weather, news, and concierge services (Bataillard 2017).

Figure 22: Smart Room at the Opera Hotel Zürich

GRAND AMBASSADOR

Guests can use their smartphone to scan a QR code and then use the device to control room functions like lighting, curtains, temperature, and the television. In addition, the device can send messages to hotel personnel. These include a »do not disturb« status, a »make up room« request, or an order for additional pillows, shampoo, or towels (Bright 2017).

Figure 23: Scanning of a QR-Code

ACCOR'S »ROOM FOR EVERYONE«

In 2017, Accor developed a hotel room that is fully usable for people with disabilities because of innovative technology and accessible design. This room contains, among other things, an automatic door opening and closing system. LED lighting in the skirting board is activated via motion sensors to guide the guest in case they wake up during the night. In addition, the guest can make use of an alarm service, such as being awoken by the smell of coffee. The room functions can be controlled via a tablet PC (Accor 2018; Mest 2018).

Figure 24: Accor's Smart Room

INTERCONTINENTAL AI-ROOM

In 2017, InterContinental Hotels & Resorts Group (IHG) began a partnership with BaiDu, a Chinese internet search engine provider based in Beijing. In 2018, IHG announced it was commissioning some »AI rooms« in Greater China, in which the guest can use voice controls to regulate various modes such as work or leisure mode, and adjust room settings like lighting and temperature. The BaiDu software can react to indirect instructions, such as »I am going to bed«, by dimming the light and closing the curtains. Guests at the InterContinental Beijing Sanlitun and InterContinental Guangzhou Exhibition Center are supposed to be among the first users of the new smart rooms before they are integrated in hotels across the entire country. The rooms currently only respond to Chinese voice commands (Arlotta 2018).

Figure 25: Example of a voice control system

THE WESTIN BUFFALO

Since 2017, the Westin Buffalo in Buffalo, New York (USA) has been offering guests the opportunity to connect to the room's integrated Amazon Echo via their own Amazon account during their stay. The primary benefit for guests here is that they can access their own data, such as music and preset functions. The hotel offers its own hotel functions via Amazon Echo, such as requesting services, receiving information about the hotel and its offers, and getting recommendations for activities in the surrounding area (Hal Schwartz 2019). A service robot from the company Savioke has been in operation at the Westin Buffalo since 2017, and delivers orders to guests' rooms upon request. (Mroziak 2017).

Figure 26: Service Robot at the Westin Buffalo

HILTON'S CONNECTED ROOM

Hilton presented its development of the Connected Room platform in 2017 (O'Connor 2019). The concept aims to allow the guest to use and control the hotel room in accordance with their personal wishes. With the Hilton Honors app, the guest can set their preferred room temperature and control the lighting and Smart TV with their own device. The self-developed, proprietary app allows for check-in before arrival at the hotel. Furthermore, the guest can use the app's digital map to find their room and open the door via smartphone (Ting 2019). Partnerships between Hilton and streaming services like Netflix and Showtime make it possible for the guests to log into their own account with the respective streaming service through the Hilton Honors app, and thus access their personal content on the Smart TV. If the guest doesn't have their own account, they can still use the streaming service without registering (Perez 2019).

Guests must join the Hilton Loyalty Program in order to use the app. Yet the Connected Room's functions can also be used without the app in that the guest is able to use the remote control to access them via television. (Hilton 2018). After the first beta tests were successfully completed at the Hilton Garden Inn in Memphis, Hilton equipped some other hotels in Memphis, Dallas, and the Washington, D.C. metro area with Connected Rooms (Braunstein 2018). Hilton was already operating more than 1800 Connected Rooms in the USA as of January 2019 (Newsroom.hilton.com 2019). By late 2019, 200 hotels are supposed to be equipped with the technology, with more to follow in 2020 (Ricca 2019).

ALIBABA FLYZOO FUTURE HOTEL

In late 2018 the Alibaba Group's online travel platform Fliggy and other divisions of the Alibaba Group jointly opened the futuristic FlyZoo Hotel in Hangzhou, China. The guest can use the hotel's special app to find and book the desired location and alignment of the room. Check-in via app is also possible. Guests receive access to the room by means of facial recognition. The virtual assistant »Tmall Genie« can be used to operate room functions like lighting, temperature, curtains, television, or music system via voice controls, as well as to order room service or towels. The virtual assistant answers simple questions, such as requesting the WiFi password. Orders are delivered to the room by a robot (Brennan 2019).

Figure 27: Alibaba Logo

INTERCONTINENTAL SHANGHAI WONDERLAND

The InterContinental Shanghai Wonderland Hotel, established in cooperation between InterContinental Hotels & Resorts (IHG) and WeChat, opened in Shanghai in 2018. At this »smart« hotel, the guest can use the WeChat app to book a room, check-in with facial recognition, open the door with a digital key, order room service, operate room functions like lighting, temperature, or curtains, and pay the bill (Liao 2018).

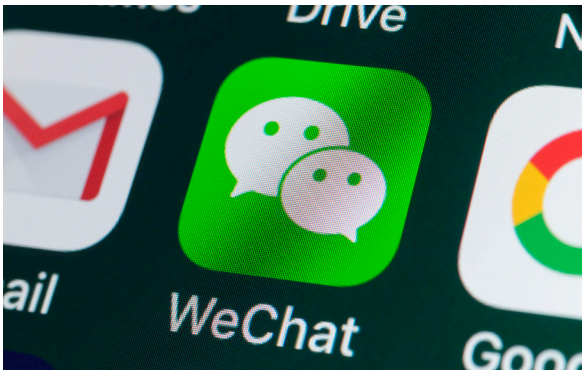

Figure 28: Icon of the WeChat-App

SMARTEL

There are currently two Smartels. The Smartel at The Unbrexit opened in April 2018 and is operated by technology manufacturer Tobit. Software. It employs a minimal staff, as the guest can control their entire stay via smartphone. Namely, guests can use their smartphone to book and pay for their room, open the door, and control the light and television in the room (Tobit Software AG 2019). Guests can also receive recommendations for cafés, bars, restaurants, and leisure activities in the area via the software on their smartphone (Allgemeine Hotel- und Gastronomie-Zeitung 2018). In addition, the software offers solutions for organising housekeeping, the creation and evaluation of digital statistics and communication (Tobit Software AG 2019). The company's latest technology is realised and tested at the Smartel headquarters (Smartel at Tobit.Campus). (Tobit Software AG 2019).

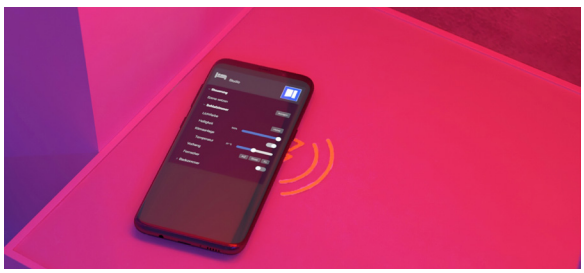

Figure 29: Smart in-room controls at the Smartel

Figure 30: Smartel hotel room

SMART LYZ HOTEL

Shenzhen, China-based AI company Smart LYZ opened the »fully automated« Smart LYZ Hotel in Chengdu, Sichuan, China in early 2017. There is no interaction with human employees if the guest does not desire it. Guests book their room via website, check in with facial recognition, and receive an access code to open their room door or use an app to do so. Guests can also check out via app (Smart LYZ 2018). Robots accompany guests to their rooms and answer their questions. With the app, guests can then order towels from their room (among other things), which the robot then delivers (YellRobot - Robot News 2018). The app can also be used to control the lighting, temperature, closets and curtains in the room (Smart LYZ 2019).

Figure 31: Smart LYZ

KVIHOTEL BUDAPEST

The KViHotel in Budapest, Hungary promises its guests complete control of their stay via app. The guest can book their room, receive access to the hotel, check in and out, and open their room door all via the TMRW app on their personal device. In the room itself, the guest can use the app to control room functions like the temperature, and receive a message when the room has been cleaned. The concierge service for ordering room service or a taxi is also offered through the app (KViHOTEL Budapest 2019). The KViHotel not only uses the guest's smartphone as a room key, but also as a concierge and receptionist, thereby requiring only eight employees for 40 rooms (Brack 2018).

Figure 32: KViHotel Budapest

SI-SUITES

The hotel SI-SUITES in Stuttgart, Germany implements an innovative technological standard in all of its 192 rooms and suites. It has been a close partner of the FutureHotel joint project for years. Hotel manager Thomas Behrendt particularly values future-proofness and investment security. This requires a system that can be successively built upon, which is why a BUS system was introduced as a fundamental measure for digital progress. The constant challenges in this regard are coupling and interlinking relevant interfaces of various systems.

Figure 33: SI-SUITES Hotel Stuttgart

The first steps and implementations for the smart hotel rooms began in 2016, and the aforementioned measures were completed in 2019. For example, the entire building is connected to a weather station, the data of which are used to automatically control the blinds. When a guest checks in, a specific room scenario is triggered: the TV turns on, and the room temperature is increased. During check-out, energy consumption is automatically deactivated (power, heating) and the Bluetooth connection is cut off. All of this is made possible by a strong, 10 gigabyte network running in the background with numerous active and passive components for WiFi, controls and TV units. The lighting at the SI-SUITES is adjusted to specific scenes, e.g., falling asleep comfortably or aiding in waking up in the morning. The bathroom includes an integrated radio, and a display mirror in the more premium room types.

Thomas Behrendt sees a clear trend toward more interlinking in hotels:

»Digital transformation must be seen as a journey, and you cannot expect to just reach an objective – it doesn't work that way.«

Thomas Behrendt,
GM of SI-SUITES Hotels, Stuttgart

NH-HOTELS MOOD ROOMS

In the Mood Rooms at the NH Hotels in Berlin, Germany and Madrid, Spain, the atmosphere in the room can be controlled with a tablet: light, music, curtains, and temperature are adjusted via the touchscreen input. In addition, various modes are offered that can be selected depending on how the room is used (NH Hotel Group 2019).

Figure 34: NH-Hotels Mood Room

LOEWS HOTELS

Loews Hotels currently consist of 29 hotels in the USA and Canada. Since 2019, the hotel chain has been using software from the Dutch company Ireckonu in order to facilitate a personalised hotel stay for the guests. The Ireckonu software Core and IKnowU allow the guest the automatically check in when entering the hotel, operate room functions with voice controls, and personalise their stay on the basis of information from past hotel stays (Airoldi 2019).

ANALYTICAL COMPARISON OF THE PROJECTS

The respective smart features of the preented hotels are illustrated in a table below.

The smart features include the voice assistant, which enables voice control and answers hotel-specific questions or order services; a hotel app that provides access to hotel information, and allows guests to use and book services; a smart in-room device, such as a tablet or smart-phone; voice controls to regulate room functions like lighting, temperature, or TV; digital control options of room functions; the possibility of accessing personal data and accounts via hotel devices, such as when listening to music or streaming; a virtual minibar or shop function; a display mirror; sensors in the room; the usage of service robots; smart room access via a mobile key or biometrics; facial recognition; smart check-in and check-out; and the opportunity to select a specific room.

Hotel brand	Voice assistant	Hotel app	Smart in-room device	Voice controls of room functions	Digital controls of room functions	Access to personal data via hotel devices	Virtual minibar / shop function	Display mirror	Sensors in the room	Usage of robots	Smart room access	Facial recognition	Smart check-in/check-out	Individual room selection
CitizenM-Hotels			X		X									
Blow Up Hall 5050			X								X			
YOTEL					X	X	X			X				
Eccleston Square Hotel			X		X	X								
BLOC Hotel		X	X								X		X	
Peninsula Hotels			X		X	X								
Ushuaïa Ibiza & Hard Rock Hotel Ibiza			X			X					X			
Aloft Hotels	X			X						X	X			
Hotel Schani Wien		X	X		X	X			X	(X)	X		X	X
Virgin Hotels		X			X					X				
Henn-na Hotels	X			X					X	X	X	X	X	
City Hub					X						X			
Bodenmaiser Hof				X	X				X					
Wynn Resort	X			X										
Opera Hotel		X		X	X			X		X	X			
Grand Ambassador		X			X								X	
Accor's »Room for everyone«			X		X				X					
InterContinental AI-Room				X										
Westin Buffalo	X			X		X				X				
Hilton's Connected Room		X			X	X					X			X
Alibaba FlyZoo Future Hotel		X		X						X	X	X	X	X
InterContinental Shanghai Wonderland		X			X							X	X	
Smartel		X			X						X		X	
Smart LYZ Hotel		X			X					X	X	X	X	
KViHotel Budapest		X									X		X	
SI-Suites					X			X	X					X
NH-Hotels Mood Rooms			X		X									
Loews Hotels				X									X	

Table 1: Overview of smart features in the 28 hotel brands worldwide

Common features in smart hotel rooms worldwide:

- Voice controls of room functions (271 hotels)
- Virtual minibar / shop function (217 hotels)
- Usage of robots (215 hotels)
- Smart room access (211 hotels))
- Voice assistant (183 hotels)

These features currently tend to be uncommon in smart hotel rooms:

- Display mirror (2 hotels)
- Individual room selection (6 hotels)
- Facial recognition (15 hotels)
- Hotel app (17 hotels)

Voice controls of room functions, virtual minibar / shop function, usage of robots, smart room access, and voice assistants are particularly prevalent in North America and Asia. In Europe, however, hotel rooms are more frequently equipped with such functions as smart room controls (without voice controls), a smart in-room device, and smart room access.

However, if one looks at the number of hotel brands and not at the total number of hotels operated in the hotel chain, it becomes apparent that there is a greater variety of individual hotel operators who offer smart hotel room features in Europe and Asia than there are in North America..

The overview of the practice projects shows that there are certainly methods for equipping hotel rooms with smart features, although these are not considered a fundamental factor or standard. Chapter 5 further elucidates the obstacles currently facing hotel operators in the implementation of smart solutions. The approaches and measures that help hotel operators implement smart solutions in their facilities are explained in chapter 6. The more hotels which implement required base technology, such as internet and WiFi with sufficient quality and coverage, hotel management systems, and smart building and media technology, and interlink these with each other as well as facilitate access to digital data via mobile devices, the more smart features will take hold and become increasingly prevalent as a result.

2.2 OVERVIEW OF HOTEL INNOVATION LABS

There are individual innovation labs, corporate showrooms, test labs, and development and demonstration platforms for the hotel industry around the world. The following Lab environments were researched with support from Dr. Markus Schuckert, Associate Professor at the School of Hotel & Tourism Management (SHTM) at Hong Kong Polytechnic University. The list makes no claim to be complete. Furthermore, there are numerous labs operated by third-party providers primarily for testing their own technology.

Figure 35: Showcase FutureHotel

Name	Year of creation	Operating company	Project description, topic	Location
Showcase FutureHotel	2008	FutureHotel Projekt, Fraunhofer Instituts für Arbeitswirtschaft und Organisation (IAO)	Vision of a hotel room in the year 2020 Voice controls, robots, sustainability, LED wall and ceiling, display facade, Energy-Bed, SenseFloor, display mirror, aroma steampod, smart check-in and mobile key, etc.	Fraunhofer inHaus Innovationszentrum, Duisburg, Deutschland
Tomorrow`s Guestrooms Hotel Icon	2011	Hong Kong Polytechnic University	Prototypical hotel room for testing design, technology and well-being elements	Kowloon, Hongkong
Urban Living Lab	2012	FutureHotel Projekt, Fraunhofer Institut für Arbeitswirtschaft und Organisation (IAO)	Vision of an urban landscape with profile-based interaction scenarios Highly personalised hotel room and text environment for realization of the check-in process at the Hotel Schani Wien	Zentrum für Virtuelles Engineering, Stuttgart, Deutschland
The LINQ Hotel Showroom	2015	Caesars Entertainment Corporation, Ayla Networks, WeChat	Test room for the CES 2015 Controls of room functions via WeChat app	The LINQ Hotel & Casino Las Vegas, Nevada, USA
Marriott's IoT Guestroom Lab	2017	Marriott, Samsung, Legrand	Personalisable guest rooms: Personalisation via guest profile, voice controls, smart mirror, etc.	Mariott Headquarters, Bethesda, Maryland, USA
Hilton Innovation Gallery	2017	LAB at Rockwell Group, Hilton Hotels & Resorts	Showcase for innovations and design concepts by the Hilton Corporation.	McLean Tyson Corner, Virginia, USA
Hongkong and Shanghai Hotels Forschungs- und Technologiezentrum & Kaleidoscope Lab	Unknown, 2018	The Hongkong and Shanghai Hotels, Stanford Research Institute	Research and Technology Center of the Hongkong and Shanghai Hotels (HSH) Group and Start-up Programme	Aberdeen, Hongkong

Table 2: Hotel Innovation Labs and Showcases

Figure 36: Showcase FutureHotel

SHOWCASE FUTUREHOTEL

The testing environment for the hotel of the future offers a demonstration platform for the constructed vision of a hotel room in the year 2020. It was opened in 2008 at the inHaus Zentrum in Duisburg by the FutureHotel Project, under the management of the Fraunhofer Institute for Industrial Engineering. Here, the guest was able to check in with their smartphone and enter their room with assistance from biometric access controls. The room contained an LED membrane ceiling and wall, as well as OLEDs (organic light emitting diodes) as flexible, transparent surface lighting and display surface. Via a glass display facade, the guest could enjoy a virtual view or films. There was also a television, which the guest could use to watch television as well as order hotel services or operate the room controls. Voice-operated room controls were also possible.

The »SenseFloor« detected the guest's position in the room to create movement profiles and control room functions, such as automatically opening sliding glass doors. The bathroom mirror included an integrated display, speaker, and LED lighting in order to provide the guest with entertainment in the bathroom as well.

In order to facilitate a personalised stay for the guest, they could input a personal profile that stores, among other things, the preferred room temperature and lighting scenarios. The respective aspects in the room adjusted themselves in accordance with the guest's preferences.

Additional extras in the FutureHotel Showcase were the »EnergyBed«, a swinging bed that ensured relaxation through its pendulum-like movements, and the »FutureSpa« with a prototypical whirlpool, a display mirror, an aroma steampod for customised aroma experiences, an infrared-based sauna, and adjustable relaxation lighting.

Robots were also utilised. The centrally stacked minibar robot could be summoned via the virtual minibar, and delivered the desired products directly to the room. Service and cleaning robots were also used. Energy efficiency and facility management were supported by monitoring of energy consumption, innovative materials, and product life cycles.

TOMORROW`S GUESTROOMS

The ***Tomorrow's Guestrooms*** comprise three prototype rooms on the tenth floor of the Hotel Icon, which can be used for research purposes. The Hotel Icon is a boutique hotel with 286 5-star rooms opened on the mainland side in Kowloon, Hong Kong in 2011. The hotel is owned by the Hong Kong Polytechnic University. It is independently operated and connected to the ***School of Hotel and Tourism Management*** as a specialty area for hotel and tourism management (King und Tang 2019). The ***Tomorrow`s Guestrooms*** are used both for sociological consumer research as well as for practical testing of technology and products for the hotel industry. Since 2013, companies and the Hotel and Tourism Department have had the opportunity to conduct design and application studies. The studies encompass a range of practice tests with regard to various technical products, such as audiovisual systems and entertainment electronics, lighting and lighting controls, as well as other smart hotel applications. Various air filters and air conditioning systems are also tested alongside a variety of furniture and accessories. Furthermore, the platform offers faculty and students the opportunity to perform their own studies while ensuring practice-based instruction and research. Research with the ***Tomorrow's Guestrooms*** is divided into the categories of design, technology, and well-being, all under the umbrella concept of »soft renovation«. The ultimate goal is to support the hotel industry with the development of new products, service offers, and industry standards (Tse 2013).

Figure 37: Tomorrow's Guestroom

Figure 38: Hotel room lab at the Urban Living Lab

URBAN LIVING LAB

The Center for Virtual Engineering's Urban Living Lab in Stuttgart, Germany, opened in 2012. Here, scientists from the Fraunhofer IAO research innovative, technology-supported interaction concepts for the development and sale of products and services in an urban environment. For this purpose nuanced, ideal human-technology interaction scenarios are created and made real - for the user's professional and private life - on the basis of an integrated user profile control (Spath et al. 2013).

Depending on the user profile, the lab visitor equipped with mobile devices such as a smartphone or smartwatch receives customised information and service offers. The variously configured interactions take place at various spotlights in the urban landscape and can be used for preference-based services in hotels, among other purposes. These spotlights are equipped with innovative display technology as well as control and configuration elements that offer the lab users a ground-breaking experience through the city of the future (Spath et al. 2013). The hotel room lab at the Urban Living Lab focuses on researching smart interaction concepts, with the inclusion of all spatial and medial components within the room. Guests receive personalised displays on the television, access to their respective audiovisual content they brought with them, or access to lighting moods with a matching sound and air conditioning profile. The lab serves as a pilot platform for innovations shortly before they are implemented in hotel practice.

THE LINQ HOTEL – SHOWROOM

The Caesars Entertainment Corporation cooperated with Ayla Networks, a provider of Internet of Things (IoT) platforms, and the messenger WeChat as part of the 2015 International Consumers Electronics Show (CES) in Las Vegas. During the convention, they presented their vision of a hotel room of the future in some of the LINQ Hotel suites in Las Vegas, which could be controlled via smartphone. Visitors could download the WeChat app via a QR code in the room, which would then allow them to control such functions as lighting, temperature, blinds, and curtains. A variety of room scenarios could also be selected (Wallstreet-Online.de 2015).

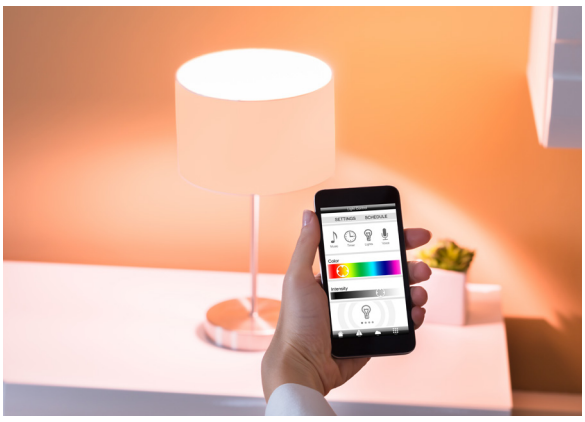

Figure 39: LINQ Showroom for the CES 2015

MARRIOTT'S IOT GUESTROOM LAB

In cooperation with Samsung and Legrand, Marriott's Innovation Lab developed two model hotel rooms in late 2017. The rooms are supposed to be customisable and adapt to a guest's specific needs. For example, while showering the water temperature automatically adjusts to the temperature saved in the guest profile. Room functions such as lighting and room temperature can be controlled with voice controls via a virtual assistant (Marriott International 2017). Guests can use a »smart mirror« to assist them with their morning yoga routines and display their favourite artwork in a digital picture frame. Sensors detect the guest waking up in the night, and a red light automatically turns on to show the way to the bathroom (Ting 2017).

At the same time, Marriott introduced another innovation: the »smart shower doors«. While showering, guests can use their finger to write or paint on the shower doors, and then send the message or picture via e-mail (Caswell 2017).

HILTON INNOVATION GALLERY

The Hilton Innovation Gallery in McLean, Virginia, USA was drafted by the LAB at Rockwell Group and opened in 2017. The gallery serves as a showcase for innovations and design concepts by the Hilton Corporation. This is where Hilton tests and presents new products designed by itself or by potential collaboration partners under various conditions and in different environments. Along with a show kitchen and an innovative meeting space, guests can try out innovations in rooms based on typical Hilton guest rooms via virtual reality. Another highlight is the »Dark Room«, which is used for situational experiments (Rockwell Group 2019; Dorris 2018).

HONGKONG AND SHANGHAI HOTELS RESEARCH AND TECHNOLOGY CENTRE & KALEIDOSCOPE LAB

At the internal Research and Technology Centre of the luxury hotel group Hongkong and Shanghai Hotels, Limited (HSH) in Aberdeen, Hong Kong, 26 engineers and information scientists are currently developing and testing innovative technology for their hotels' rooms. The HSH's own Research and Technology Centre develops and tests technology that the rooms in the 10 Peninsula Hotels will be equipped with. This is also where the functionality of the technology already used at the hotels is simultaneously and remotely monitored and maintained (The Hongkong and Shanghai Hotels, Ltd. 2019b).

Figure 40: Work in a lab

In 2018 the HSH Group, in cooperation with SRI International (Stanford Research Institute), developed and initiated the »Kaleidoscope Lab« programme, which allows start-ups to implement and test their innovative ideas for the hotel industry in a real environment over the span of a 12-week programme (The Hongkong and Shanghai Hotels, Ltd. 06.06.2019). The programme is supported by such partners as Samsung and the Hong Kong Science and Technology Park (Hamdi 2019).

In January 2019, ASA Innovation & Technology and Neoma were selected from among 70 applicants and named the two winning start-ups. ASA won for Airluna, an air-purifying lamp that measures room air quality and eliminates toxins from the air with ozone catalyst oxidation (OCO) technology. Neoma won with its AI platform that automatically sends information and recommended actions concerning a guest to hotel staff in order to customise personal contact via the usage of technology (The Hongkong and Shanghai Hotels, Ltd. 23.01.2019).

The winner start-ups were technically assisted in the implementation of their concepts at the HSH Group's Research and Technology Centre. They were then given the opportunity to test their products in the hotels The Peninsula Hong Kong and The Peninsula Beijing, and form a pilot or commercial contract with the Group (Hamdi 2019). The next round of the Kaleidoscope Lab Programme is supposed to commence in late 2019 (The Hongkong and Shanghai Hotels, Ltd. 06.06.2019).

3 BASIC CONDITIONS FOR SMART HOTEL EXPERIENCES

The guest room is one of the most important touchpoints between the hotel and the guest. It is embedded in a spatial and technological environment or ecosystem. The stay inside the guest room is composed of a sequence of experiences that might be developed dramaturgically. Because the guest spends the majority of their time in their room while at the hotel, this space is particularly significant for the guest's experience. Furthermore, according to empirical studies, the hotel room is one of the most important aspects for selecting and booking a hotel.

This chapter describes how the travel experience can be personalised and customised with assistance from currently available, digital tools and methods. This includes handling guest data and the analysis thereof, as well as the possibility of individual room selection by the guest. In addition, concepts and solutions for technological integration in the Smart FutureHotel Room, such as the Internet of Things (IoT), Bring Your Own Device (BYOD), and artificial intelligence (AI) applications such as voice controls, sensor technology, and biometrics are described. It is also explained how the safety factor in the Smart FutureHotel Room will change in that new security aspects that must be considered by hotel operators are arising, but also how higher security standards can be ensured. The chapter concludes by addressing the contribution that the usage of technology and software in the hotel room can make for more sustainability and accessibility.

3.1 SEAMLESS TRAVEL EXPERIENCE – THE SMART GUEST JOURNEY

The experience of being in the hotel room while staying at a hotel is not a singular event. It is part of an overall experience that can be illustrated along a process chain, namely the guest journey (see Figure 43). The basis for a **seamless travel experience** is a smart technological ecosystem. The goal is a seamlessly interconnected linking of the various events in order to offer the guest a smart guest journey.

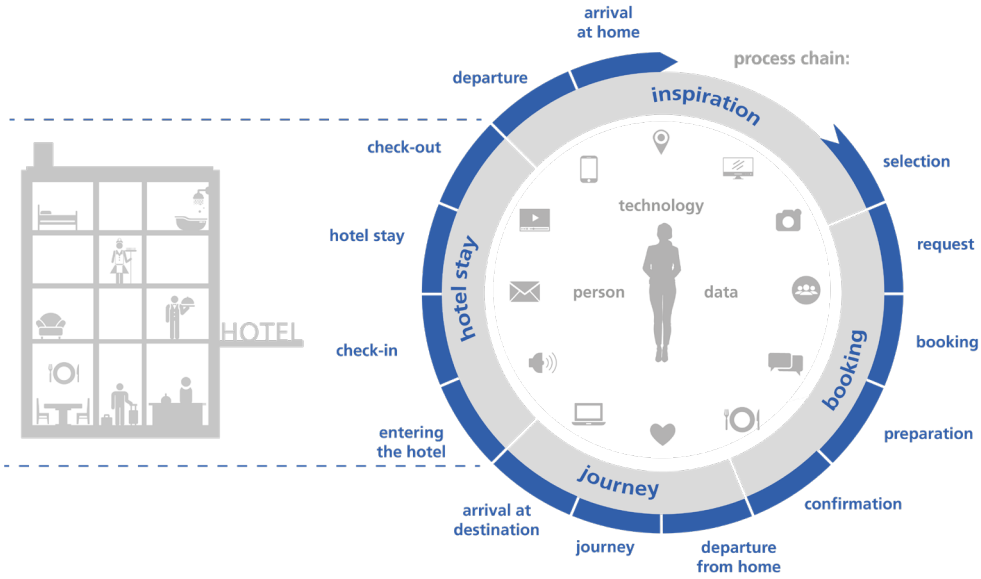

Figure 41: The FutureHotel process chain of a guest journey

Before the guest begins their actual stay at the hotel, their trip starts with selecting the hotel, the booking request, booking, and confirmation by the hotel. Digital tools can already make this process more personalised and needs-based than is the case with most hotels. In order to make full use of the means available today, hotels can direct targeted, personalised, and scheduled advertisements to potential gusts with self-learning algorithms, or adjust their offers in accordance with guests' interests. **Dynamic Pricing** means that prices are dynamically adjusted with consideration of various factors such as demand, consumer behaviour, the season, and the competitive environment, so that each guest pays a different price, thereby maximising profits (Kietzmann et al. 2018).

Further steps of the guest's journey include preparation for the trip, departing from home, arriving at the destination and entering the hotel. These steps can also be personalised and situationally adjusted, such as with assistance from data analysis processes. After booking the hotel, arrival options can automatically be offered for booking. The guest may also input their own plans for arrival. If it is known when and how the guest will arrive, a personal greeting can be planned at the right time and, for example, adapt accordingly to flight delays. A guest who is known to have travelled a long distance can be offered the hotel's wellness service before arrival by automatically sending the following message to their mobile device: »We know that you have had a long and stressful trip, but you're almost here and we are expecting you. How would you like a massage after dinner? We have set aside an appointment at 7:30 p.m., and we just need your quick confirmation«.

At the hotel itself, the guest's trip includes entry into the hotel, check-in, staying at the hotel, check-out, and ultimately departure and the trip home. The hotel's digital processes are integrated into all of these steps, allowing the hotel to make the guest's experience as convenient as possible. Instead of a personal welcome that can be entirely customised with the guest profile (see chapter 3.2.1) depending on the situation, the guest can always check in via their smartphone and thus gain access to the hotel room. Possible upgrades and the hotel's current offers are presented to the guest in a user-friendly manner as needed, e.g., on their device. After check-in, the mobile device automatically connects to the hotel WiFi for the duration of the guest's stay. The guest also has unlimited access to the WiFi and 5G network in the corridors and lift. The entire hotel contains conveniences for the guest such as digital building navigation, such as how to get to their room or voice-controlled lift operation.

The guest no longer brings just their portable luggage, but also their virtual data luggage (see chapter 3.2.1). The more access they grant the hotel, the more personalised the overall experience can become for the guest.

One significant aspect during the stay at the hotel is the options for on-site mobility for business travellers and private travellers. Travellers highly value the opportunity to obtain, book online, and pay for mobility offers directly through and within the hotel.

»Sixt works as a partner for hotels around the world to ensure mobility for travellers at the place of accommodation in order to facilitate stress-free travel. The car-sharing offers provide a sensible solution for synergetically meeting the needs of hotel guests and the local residents.«

Melanie Lang, Director Customer Excitement & Quality Management, Sixt SE

.

At the end of the hotel stay, check-out via the guest's device including automatic digital billing is accelerated and can be performed anywhere. The guest is thus no longer required to queue for this process. The guest's departure and trip home can also be made seamless through smart processes, for example by automatically providing transportation to the airport so that the guest need only confirm this on their smartphone or via voice input. After departure, the guest can decide themselves whether their data will remain available to the hotel and saved for a future visit, or if they will all be deleted.

3.2 CUSTOMISATION AND PERSONALISATION

Guests appreciate **personalised offers** and will require corresponding service in the form of upgrades, offers, and personal touches as a given, such as a bar of their favourite chocolate in their room. The most important aspects of customer experience, according to an international PwC poll among 15,000 people, are efficiency, convenience, competent and friendly service, and a simple payment system. Furthermore, up-to-date technology, personalisation, and unique experiences are considered important (Clarke and Kinghorn 2018).

The physical environment and service should be adaptable, and should be geared toward individual needs instead of general ones. Because a guest's needs can change during their stay at the hotel, these aspects should not only be customised to the specific person, but also to the respective situation. There will thus no longer be an offer »for everyone«, but rather only »for me«, whereby convenience, comfort, acceptance, and satisfaction, among others, will increase. Personalisation of the service means offering exactly the service that the guest would like to receive, and offering this service in the exact manner that the guest would like to receive it (Kazandzhieva et al. 2017). Travel provider TUI sends customers of the Robinson brand customised offers through automated campaigns in combination with predictive analytics, thereby achieving distinctively better results.

»Uniform communication through all channels and originators that is tailored to the customer, such as pre- and post-stay campaigns, provides the guest with a seamless travel experience along the customer journey.«

Jessica Bruns,

Head of CRM Robinson

The concept of personalisation or customisation is not to be understood in such a way that each guest is treated in a unique way. Rather, it is about reacting successfully to a guest's wishes and needs, which are categorised or classified on the basis of known, comparable wishes and needs of other guests. To this end users are categorised on the basis of such characteristics as travel purpose, age, and sex. The allocation into categories serves to allow for operation by known patterns. This digital process facilitates an automated and standardised reaction to behaviours and needs.

The individual does not play a significant role. The priority here is efficient processes and sequences. Successful classification of needs based on analytical logic results in faster and tailored reactions to the individual. Predictive services are not a futuristic dream, but rather refer to analytical documentation and simultaneous prediction of human behaviour. In this sense, individuality means human wishfulness.

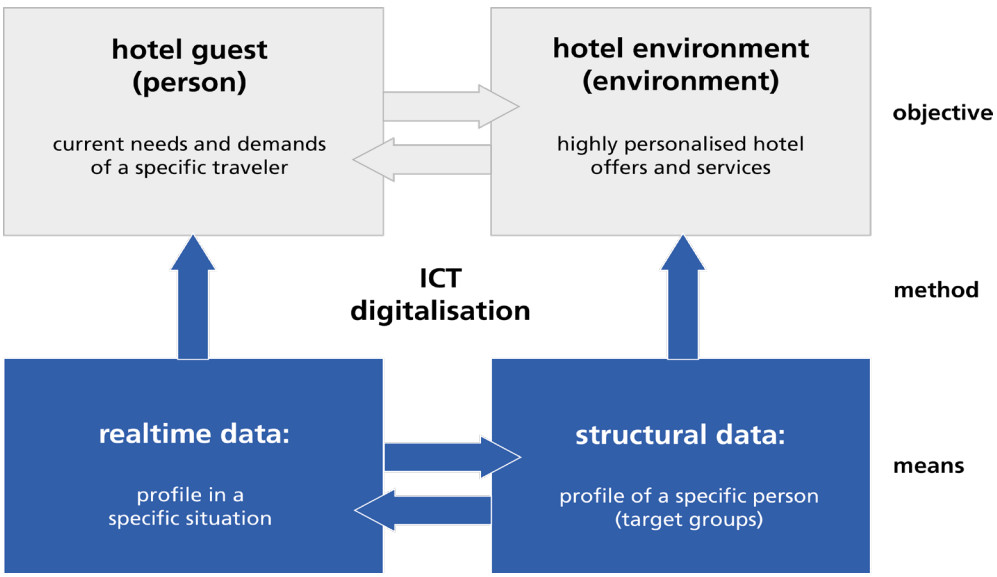

Figure 42:
Fit Model of the hotel guest and the environment and the influence of digitalisation

The **Person-Environment Fit Model** according to (French and Caplan 1972) refers to the match of individual and environment, and is based on the assumption that an ideal fit leads to optimal satisfaction (see Figure 44). Data and algorithms can become a key (enabler) for a successful guest-hotel fit (matching). The current needs and requirements of the hotel guest are identified in order to ensure personalised hotel offers and services. Both structure data in the form of profiles of specific travel types or target demographics, as well as real-time data of the specific traveller, are considered (Edwards et al. 1998).

With information acquired from a variety of data, the hotel can offer what are known as »**predictive services**«. These services are developed for and offered to the guest without the guest having to ask for or worry about them. These predictive offers are developed on the basis of data. For example, such a service may involve summoning the lift to the respective floor once the guest leaves their hotel room, reducing the wait time. Guests' wishes and requests can be predicted on the basis of available data.

3.2.1 DATA AND DATA ANALYTICS

Many hotels already collect data on their guests. Hotel operators can use smart technology to compile detailed user data on their guests and evaluate them, while also offering them improved, customised accommodations and service (Kazandzhieva et al. 2017). User data can be divided into four categories: personal data, interaction data, behaviour-based data, and attitude-based data (Writer 2019).

Personal data can include information that directly refers to the customer's identity, such as core data. These data include, for example, first name and surname, address, date of birth, or telephone number. When combined, these data can quickly indicate the individual's identity.

In addition, **online user behaviour** can be used to indirectly infer the user's identity via cookies (text information stored on a user's computer and that can be re-read by the respective website), IP addresses, characteristics such as the device or browser used to visit the website, and the screen resolution. .

Interaction data are information about how the customer interacts with a company (online). This includes behaviour on the website (which functions are used?), and interaction with social media (which posts are read or »liked«?) or customer service (which offers are requested?).

Behaviour-based data are all data that can actively be observed. In a hotel this is the place where the guest stays, the activity they perform, or their vital data. These data can be obtained from various sensors, which are described further in chapter 3.3.4. But the usage of the hotel's offers via the hotel app for controlling room actions (lighting, air conditioning, sound, etc.) and for ordering room service can also be included in this category.

Attitude-based data refer to the customer's perception of the company. These data can be obtained from customer feedback as well as emotion analyses (Writer 2019).

Data that do not directly refer to the guest, such as the weather forecast or information on upcoming events in the vicinity of the hotel, can also be documented and saved by the hotel in order to personalise the guest's stay.

However, data are not only compiled by the hotel. Many data nowadays are compiled or generated, saved and managed by the guest themselves. The guest no longer travels with their real luggage alone, but also brings their »**virtual luggage**« on their trip. This consists of data uploaded to the internet (virtual data cloud) or on their own mobile device. These data may be files, programs, games, contacts, social media accounts, music, films, or other digital information such as health data that the guest can access via their personal technical devices or the internet. Data constantly generated by the omnipresent usage of mobile devices can provide indications of the guest's emotions, well-being, desires, and needs.

If one considers the type of information spread, one can differentiate between the existing or structural data and the real-time data. **Existing or structural data** are information retrieved or otherwise compiled for (potential) later use. This is contrary to **real-time data**, which are processed and used immediately upon retrieval.

The collection and storage of customer data in the European Union is regulated by the **General Data Protection Regulation (GDPR)**. This means, for example, that customer data can only be processed for one or more specific purposes with the respective individual's consent (The European Parliament and the council of the European Union 2016).

Ideally, the guest can decide while booking, or during check-in at the latest, which data or which user profile they provide to the hotel so that their stay can be optimally personalised. A study published by Amadeus in 2019 in which 7,500 international travellers were surveyed showed that guests are willing to share personal information. 47% of those surveyed stated that they would disclose their data if they receive something in return, and 30% stated that they would disclose their data to receive **personalised travel recommendations**. Subjects of a hotel guest study conducted by Fraunhofer in 2013 said that they considered information on restaurants, sights, and leisure activities to be desirable. Current information on arrival and departure, such as train delays, was also deemed desirable on average (Borkmann et al. 2014a).

A **guest profile** set up and maintained by the guest, which is available to the respective hotel for a specific amount of time as needed, is one way to implement this transfer of data. Basic settings saved in the guest profile from previous hotel stays can automatically be retrieved and need not be requested again. For example, guests can include the aspects listed in Table 3 in their guest profile.

Entities	Profile settings
Travel context	Leisure/business, activities within the hotel or environment, travel and mobility data, type of check-in (personal or automatic at terminal).
Meals (F&B)	Preferences, allergies, meal times, single/shared table, special requests, special beverages/dishes for the virtual minibar or room (e.g. diet, lactose-free or vegetarian products).
Activities	Coworking space, meeting room, wellness offers, excursions, events.
Infotainment	Type and sequence of television/radio station, additional multimedia equipment such as 3D TV, video game consoles, tablet PC, charging infrastructure.
Room	Location in the hotel (e.g. not too high in case of fear of heights) and room amenities (e.g. bed, sofa, bath with sauna, beverage caddy, office caddy), room temperature, colour of lighting.
Bed	Number and type of pillows/blankets, additional amenity characteristics such as sensor mat for vital functions, heating blanket.
Bath	Open or closed bath, amenities (shower, tub or both), type and number of towels, additional bath accessories, additional wellness components.
Service	Desired room cleaning, type of services (e.g. more personal or anonymous) and reduced to the basics (privacy), offers and information suiting the duration of accommodation and specific travel context (upon request), alarm times, additional services (e.g. luggage service, pick-up service upon arrival, personal travel agent, purchase and delivery of groceries to home before returning home).

Table 3:
Possible content of a guest profile

A lot of information is compiled per guest based on data from a variety of sources – such as the guest profile, portable smart devices such as »**wearables**« and other sensors. These large data quantities (»**Big Data**«) are a valuable commodity for the hotel industry, as they form the basis for smart data analysis. Processing of these data requires a technical network of hardware and software components that links all data sources together and facilitates an exchange thereof.

With »**cloud computing**« the memory space, the computing power, the application software, or other computing resources are provided as a service via an external server (Microsoft Corporation 2019). Data are transmitted to an external server with high computing power via the internet, where they are analysed with help from software applications. However, it is not enough for the hotel to collect all available information about the guest, the data must also be utilized.

Artificial intelligence (AI) methods may prove to be a very useful tool in creating a meaningful and useable guest profile. With help from algorithms based on **machine learning** or **artificial neural network** methods, the compiled data can be automatically evaluated with »**data analytics**« and the corresponding action recommendations and instructions can be imparted to the personnel or connected systems. Furthermore, such software can compensate for the lack of information through **pattern recognition**, which means that guests are assigned a **guest profile** on the basis of available information, and conclusions can thereby be drawn concerning further likely preferences. This method is also known as »**cognitive computing**«, as the computers are thereby able to partially simulate human thought and draw appropriate conclusions from the data. The IT and consultation firm IBM defines cognitive computing as »an advanced form of artificial intelligence that uses various types of AI, including machine learning algorithms and deep learning networks, which become stronger and more intelligent over time« (IBM 2019). This method can be used to offer the guest »**predictive services**«, which can quickly react to a guest's personal needs. For example, sensors can notify of a need for new towels or hygiene products, or if the guest is waking up and will thus want their breakfast shortly. Such systems can thus be particularly beneficial for an optimal **hotel-guest fit**.

»**Predictive analytics**« can help predict guests' wishes and requests. This is a process that entails usage of data analyses, such as statistical and analytical methods. The goal is the creation of a model that can predict future events and behaviour (Nyce 2007).

If the guests' wishes and requests can be predicted, the desired experience can then be predicted as a »**predictive experience**«. Experiences can be individually staged, or access to attractive experience can be simplified. Because the experiences are highly personalised and geared toward a specific, desired effect, the guest receives a sort of experience guarantee.

3.2.2 INDIVIDUAL HOTEL ROOM SELECTION AND ATTRIBUTE-BASED BOOKING

Two ways to facilitate an experience precisely tailored to the guest's ideas are **individual hotel room selection** and **attribute-based bookin**g. While booking the room, the guest can select the specific room, location, design, and amenities. The room can then ideally be viewed in advance with a **3D 360-degree panorama view or virtual reality**, including the desired design and space elements such as pictures, coffee maker, or Smart TV. According to a FutureHotel guest survey, nearly 85% of travellers can imagine choosing from differently designed and equipped hotel rooms within a hotel, depending on their needs in the future (Borkmann et al. 2014a).

As the results of the guest survey show (see Figure 45), guests have high standards with regard to individual aspects of the hotel room, such as the bed, the view, the bathroom, and the room controls (Borkmann et al. 2014a). International guests also state, with 3.69 out of 5 points, that the design and interior amenities of the room are very important to them, as well as the location of the room itself with 3.4 out of 5 points. (Borkmann 2015). It is all the more remarkable that in most hotels, it is only possible to select the room category but not the design, view or floor that the guest desires. However, based on the numbers, it can be assumed that the guest would be willing to pay more for the specific room that they wish to book.

Criteria for Selecting a Hotel Room

How important are the following criteria to you when choosing your very own hotel room?
Please rate the following topics

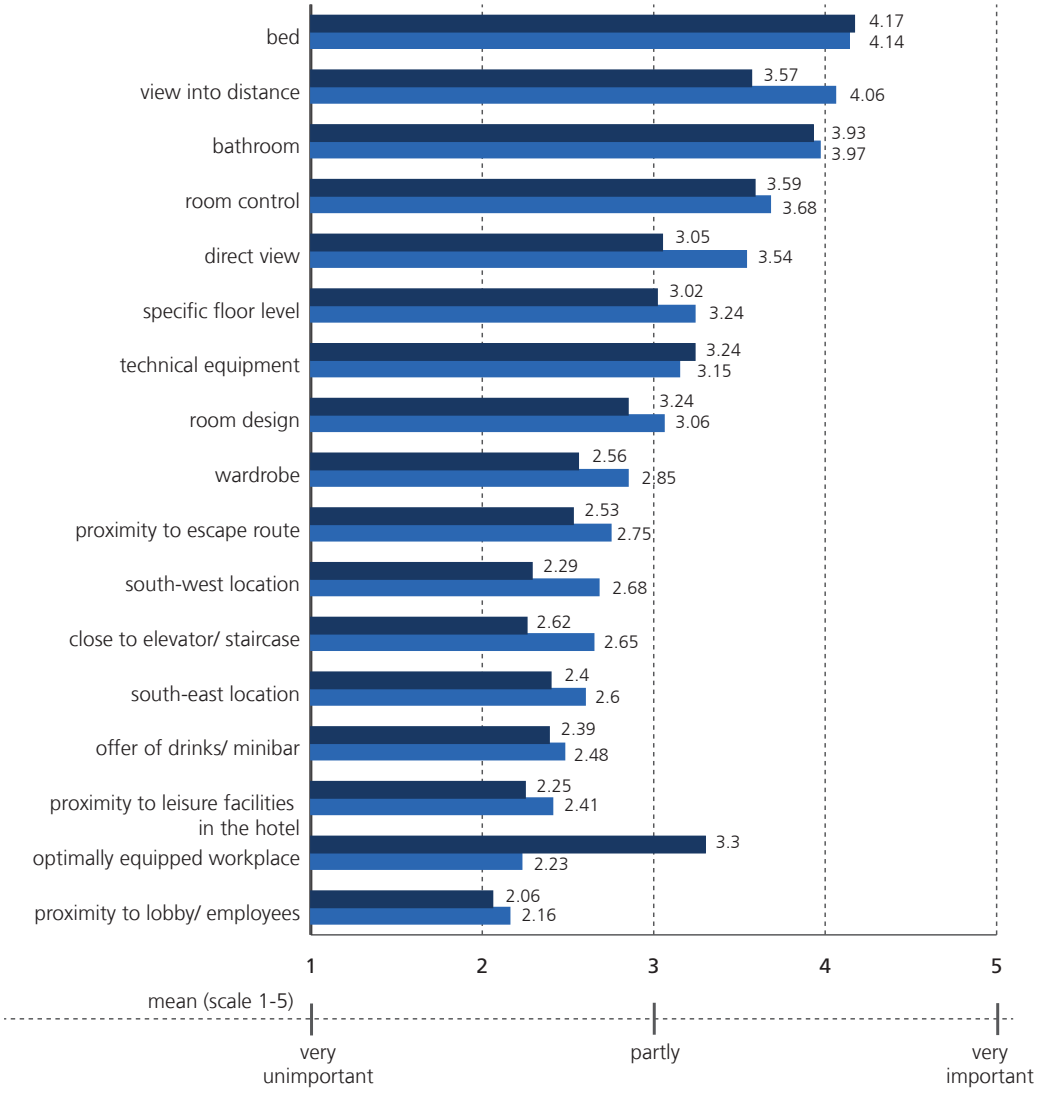

Figure 43: Criteria for selecting a hotel room

Travel service provider TUI uses digitalisation to provide customers with individual, customised offers on activities at the travel destination and services in the hotel. The provider is moving away from standardised services toward continuously more customised ones. TUI-Blue and Robinson guests, for example, have the opportunity to select their hotel room instead of just choosing between the garden and ocean view. TUI Magic Life should also begin using this feature in 2020.

»The customer appreciates the option to select their room and is prepared to pay for this service. Market research has shown us how important a suitable room is for many guests: one would like a room close to the pool, another would like one far from the lift, and another the other way around – we make all of that possible.«

Sarah Pfening,
Manager Customer Strategy, TUI Hotels & Resorts

As part of an international guest survey, Amadeus discovered that 56% of Europeans, 67% of Americans, and even 75% of Asians are interested in personalising their hotel room or have done so in the past (Amadeus IT Group SA 2019).

Guests who took part in a FutureHotel survey with 3,380 participants in 2013 stated that they would prefer to select their hotel room with **photos and text** (3.95 of 5 points for business travellers, 4.11 of 5 points for private travellers). Interest in a **virtual tour** was almost exactly as great, with 3.63 of 5 points for business travellers and 4.03 of 5 points for private travellers (Borkmann et al. 2014a). In a study from the year 2019, 72% of the 7,500 international travellers who were surveyed expressed interest in viewing their hotel room in advance with **augmented reality apps** (Amadeus IT Group SA 2019). Furthermore, 61% of those surveyed expressed the wish for price adjustments according to the extras that they have booked, meaning they only pay for what they receive, and they only receive what they want (Amadeus IT Group SA 2019). This reveals the guest's desire for an **optimised and personalised buying experience**.

Mr. Gerhardt, do you see any potential for the hotel industry in the analysis of behaviour-based data?

»There is still much discussion surrounding BYOD (Bring Your Own Device). 95% of 14- to 49-year-olds are smartphone users, and bring their device with them to the hotel. We logically concluded that the personalisation of hotel accommodation is becoming an irreversible trend. Hotel operators' interest in directly evaluating behaviour-based data during the guest's stay is increasing rapidly. This means that offers can always be made to the guest if they are desired by the guest. Once the guest sees added value for themselves, they are willing to disclose personal information. The data that can be evaluated during the guest's stay via smartphone usage are the key for being able to personalise their accommodation. It also comes down to analysing behaviour-based data and offering a wide range of offers to the guest. This trend is already quite advanced in the field of E-commerce, although it is quite complicated for the hotel industry during the guest's stay because of the frequently fragmented technology and the abundance of data accrued in a very short amount of time. Yet that is precisely why personalisation through the analysis of behaviour-based data holds so much potential for hotel operators.«

Figure 44:
Frank Gerhardt,
CEO of VINN GmbH

How can the hotel industry use compiled data appropriately?

»Theoretically, hotels are sitting on a giant data set. This stems from a range of digitalisation tools that are already available or will soon be on the market. Start-ups in particular have extraordinary ideas that often cover a small sub-area. This creates new island solutions. It is thus about interlinking all technology together on one software platform, regardless of the manufacturer. To this end, the various data must be cleaned and compiled. Only then can correlations be made that result in a real added value. These added values may concern offers, convenience and safety for the guest, profitability for the operator, or energy efficiency of the building. The offering of services via message to the guest's smartphone on the basis of known preferences is only the most obvious form of this.«

What should hotel operators consider when implementing a smart hotel room?

»The network design or infrastructure as an information highway that must be prioritised and regulated should be the top priority. Network specialists who are familiar with the hotel-specific idiosyncrasies for all of the technology should be involved early on. All of the hotel operator's preferred technology providers should have open interfaces for their solutions and provide them free of charge as standard APIs as needed. The hotel operator can integrate this technology step-by-step and within the limits of their budget, and connect it to the software platform. With regard to the contracts, the hotel operator should also ensure that operation is ensured in accordance with the General Data Protection Regulation. All data accrued in the hotel must be usable for the hotel operator's own ends.«

INTERVIEW WITH FRANK GERHARDT, CEO OF VINN GMBH

What is your company doing to keep abreast of technological innovations for hotel customers?

»As partners of the FutureHotel joint research project, we are aware of the requirements and technology of the future. In the group we are working with hotel operators to develop innovative concepts and solutions. We are currently working on our own VINN FutureLab in Krefeld, Germany. The showroom is being planned, developed, and constructed like a real hotel project, with assistance from building information modelling (BIM) among other things. The lab will also be useful as a (cost) simulation for entire hotel projects in order to determine the usage of innovative products compared to conventional products, such as the orbital shower versus a conventional shower, or air conditioning controls via notification of the guest's presence with a wearable versus conventional air conditioning controls. The lab will be open for technology from all third parties who would like to connect to our software platform.«

3.3 SMART TECHNOLOGY

»Smart technology should enhance the emotional hotel experience, and not be in the forefront.«

Bruno Marti,
Chief Brand Officer at 25hours Hotels

The Smart FutureHotel Room contains state-of-the-art technology in order to achieve an **optimised guest experience** and **efficiently configure operative processes**. All of the devices in the room can communicate with each other as they are connected wirelessly through WiFi or radio connection (see chapter 3.3.1). The **smart devices that the guest has brought with them** (see chapter 3.3.1), such as their smartphone or wearable, become part of the hotel room and serve as a room key, a control device for room functions, and as a means of communication between the hotel personnel and the guest. The guest can access their own data via screens and speakers in the room through wireless connections. **Voice controls** simplify operation of the functions in the Smart FutureHotel Room and **integrated sensors and biometric systems** ensure a personalized stay, safety, and convenience.

»Smart building technology is defined by the guest unconsciously acknowledging it while also appreciating it.«

Stefan Löhr,
Senior Product Manager International Markets & Business Development at Albrecht JUNG GmbH & Co. KG

Perhaps the most important aspect of the smart hotel room is its look and feel, or its **aesthetic and usability**. Because only a hotel room that is visually appealing and in which the smart components can be organically integrated into everyday life can simultaneously be a room in which the guest feels comfortable (Plewe et al. 2015). The smart hotel room should entail usage of »**ambient intelligence**« that clearly simplifies the guest's everyday life and naturally supports them as needed (Brucker 2013).

»Technological progress, regardless of the field, will only be taken for granted by the guest when the technology has also become prevalent in household use.«

Bruno Marti,
Chief Brand Officer at 25hours Hotels

The hotel room innovations presented in Figure 45 have been described in the report FutureHotel Leading Edge Environment from 2011 already (Borkmann and Rief 2011), but are not yet standard in the hotel industry. The technical innovations that will supplement these design characteristics in the future are described below.

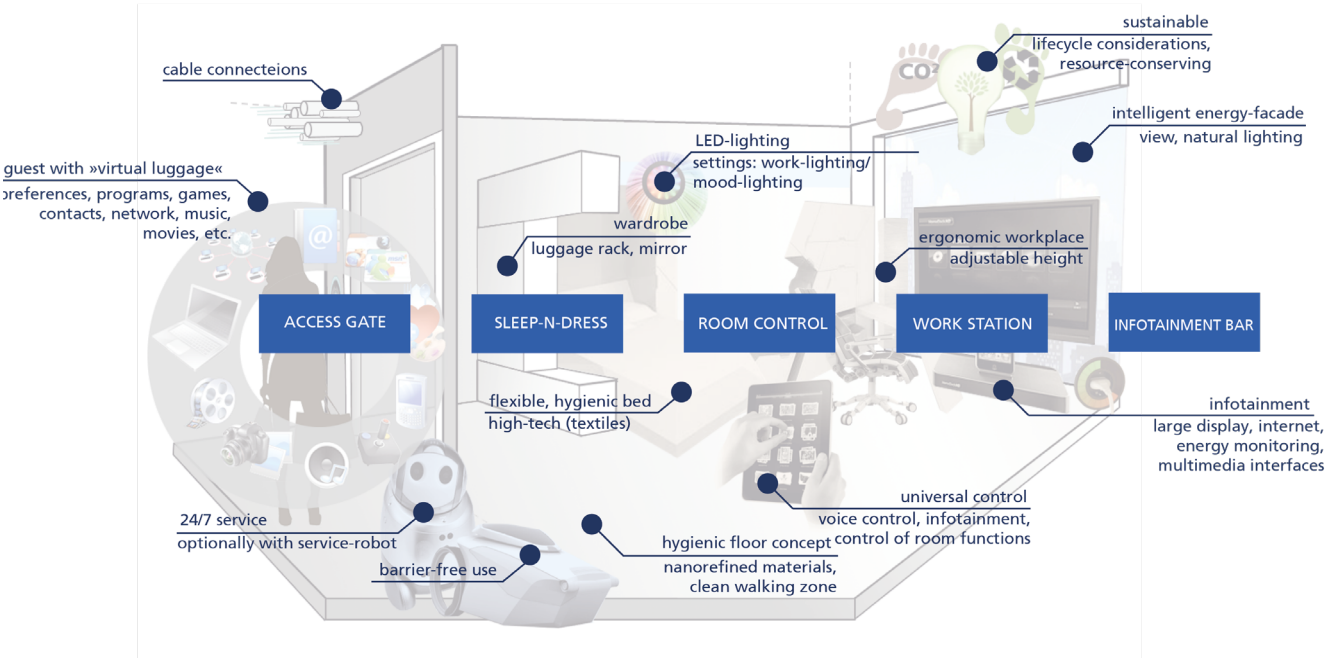

Figure 45: Technical innovations in a Smart FutureHotel Room

The basis for the usage of smart technology is a **reliable and fast internet connection** in the entire hotel. Access to the internet / WiFi is especially important according to a 2013 FutureHotel survey of 3,380 participants. Business travellers considered free WiFi in the hotel to be very important with 4.19 out of 5 points, and 3.68 out of 5 points for private travellers (Borkmann et al. 2014a). Despite the importance of reliable internet access in the hotel, this aspect appears far from being implemented in all German hotels, because almost every other internet user is unsatisfied with the quality of the internet in German hotels. Furthermore, 37% of the 1,004 Germans who were surveyed are unsatisfied with WiFi access (Bitkom 2019b). Advanced technology now makes it possible to optimally illuminate even large buildings with WiFi. For example, since 2018 the company Signify has been offering an internet connection (»LiFi«) via the room lighting, in which the connection is established via light waves (Signify Holding 2019).

3.3.1 SMART OBJECTS AND THE INTERNET OF THINGS (IOT)

The term »**ubiquitous computing**« describes how a user uses not just one specific device for a certain purpose, but rather uses various devices simultaneously and routinely without necessarily consciously perceiving the individual usage thereof (Pipek 2014). »The computer thus disappears from the users' perception as a result of its omnipresence, and the focus transitions from explicit to implicit usage of information technology« (Pipek 2014). For example, users consciously or unconsciously interact with various smart objects in their environment at the same time, such as the music system, the personal virtual assistant, and the smart coffee maker.

A **smart object** can collect information on the current situation from sensors, have this information evaluated by central software, and react to it purposefully and appropriately with assistance from actuators. Various objects can also form a smart system, which has these characteristics as a whole (López et al. 2011). A **smart system** is formed by the **Internet of Things (IoT)**, in that items are connected to the internet (Borkmann et al. 2016). These items are then capable of independently communicating with each other, generally via a **microprocess-controlled digital network** (Siepermann 2018)

IoT is used for »**providing information on automatic orders up to alert and emergency functions**« (Siepermann 2018). With sensors, status information can be transmitted via the device itself and through the environment, for example in order to request replacement lighting. Furthermore, user data can be evaluated and/or further processed so that the user's desires and needs can be derived from the analysis of daily rhythms and habits (Neumann 2016). IoT devices can also regularly perform **self-maintenance**. This means that the device is able to repair itself or independently request assistance to minimise the need for technicians in case of malfunction. Other possible areas of application for IoT in the hotel are staff safety, wayfinding through the

hotel, tracking goods, device localisation or asset tracking, condition monitoring, and location tracking of the guest in the hotel.

A **smart device** is a sub-group of smart objects and refers to electronic mobile devices that are interlinked wirelessly and via different sensors, such as smartphones. »Smart devices are connected via the Internet of Things (IoT) and communicate with other smart devices via wireless protocols like Bluetooth Low Energy (BLE), WiFi, Near Field Communication (NFC), or mobile telephone system (DATACOM Buchverlag GmbH 2019).

Virtual objects in the IoT are digital representations of real objects (Nitti et al. 2016). These are software objects, such as those in computer games or virtual representations of a room. A smart objects describes real items as well as virtual smart objects that are used to retrieve, process, and store data, and which can interact with the user or other smart objects.

Hardware components like speakers, microphones, screens, and cameras offer the necessary interfaces between smart objects and users. These should be deliberately integrated into a cognitive environment in order to prevent the formation of any »dead angles«. All produced data are centrally compiled and analysed. Measures that serve as a reaction to the data analysis are transmitted to the corresponding actuators.

Cooperation and interaction of the smart objects is coordinated via a »room manager« in the form of a central platform. This is where data are compiled, sorted, processed, and analysed, and where orders are issued to be carried out by the smart objects. Information on the situational context and past interactions (interaction history) can be stored in a knowledge database at any time and are processed according to certain rules. The situational context information includes the current room status (e.g. number of people present), the status of each room zone (e.g. the presence of people in the bathroom), and a description of the status of any given device (e.g. lights in the bathroom are off, TV is on). The interaction history contains all interactions between the user and devices that the user has initiated, such as triggering the motion sensor or turning on the bathroom light. The **interaction history** serves as the trigger for actions of specific room components, and the situational context determines the type of the next action to be taken (Leonidis et al. 2013).

This platform is the requirement for a »digital ecosystem«, which is required for a Smart FutureHotel Room. A digital ecosystem is derived from the biological ecosystem and is similarly robust and self-organised. It also has scalable architectures that can automatically solve complex and dynamic problems (Briscoe and Wilde 2006). For example, the provider ThingOS offers such a platform. This combines access to all smart devices, sensors, and actuators on site and thus

facilitates interoperability. ThingOS supports the Bluetooth Low Energy technology MESH, which is able to connect a great number of low-energy devices in a Bluetooth network, and is thus a useful networking tool for smart home and smart hotel systems (ThingOS GmbH 2019; BLE-MESH.com 2019).

3.3.2 BRING YOUR OWN DEVICE (BYOD)

73% of Germans cannot imagine life without a **smartphone** (Bitkom 2019c). In 2018, 57 million Germans used a smartphone (Haas 2018). The smart mobile phone thus accompanies eight out of ten Germans in everyday life, including on trips and in their hotel room. A remarkable 95% of people aged 14 to 49 years old use smartphones, and smartphones are now an integral component of this age group (Tenzer 2019).

Smartphones are not only used for telephone calls like earlier mobile phones were. 90% of smartphone users use their device to take photos or videos, 79% to search for things online, and nearly 70% to listen to music, read messages, or use social media. 64% use navigation and map services on their smartphone and nearly half use the smartphone for banking and shopping. 20% use it for dating services (Haas 2018). For most people the smartphone is the **most important travel companion**, even more important than their toothbrush, deodorant, and driving licence (Egencia 2016). A survey by Hotels.com of 9,200 travellers from 31 countries revealed that most people state that their mobile telephone is more important to them than a beloved one while travelling (Hotels.com 2016).

Modern travellers also take their personal **laptop, tablet PC, or smartwatch** with them. Almost three quarters of Americans (U.S.) have a desktop PC or laptop, and around half have a tablet PC and E-reader (Pew Research Center 2019). According to a 2018 SevenOne media study with 2,464 participants in Germany, 88% of participants used a smartphone, 70% a laptop, 48% a tablet PC, and 20% an E-reader (SevenOne Media 2018).

In 2017, 17% of the 1,231 Germans who were surveyed have a »**wearable**« within their home, namely a technical device that is worn directly on the body, such as a fitness bracelet, intelligent sportswear, a smartwatch, hearables, or smart glasses. 12% of 2,464 survey participants even wore such a device themselves (SevenOne Media 2018). According to a PricewaterhouseCoopers (PwC) survey of the same year, every other American possessed a wearable. 45% of owners of a wearable had a fitness armband (Pricewaterhouse Coopers (PwC) 2017). One quarter of the American population currently uses a wearable at least once per month. Half of this group uses a smartwatch (Wurmser 2019).

Some hotels and hotel chains are providing their guests with **in-room smartphones or tablets** with which the guest can access information about or book hotel services, and control functions like the lighting and temperature in the room. The guest can also receive information on current events within and around the hotel through the device. Special providers are currently providing hotels with in-room smartphones for guests to use for free, but store and use the user data in turn. The advantage is that the guest has all of the apps and relevant telephone numbers on hand, the device is handier than a tablet PC, and it can also be used for personal uses like making phone calls. The guest's own smartphone does not necessarily need to be used parallel to this, as is the case with in-room tablets.

»Guests bring all sorts of personal devices themselves, so they do not need more of them in the hotel.«

Bruno Marti,
Chief Brand Officer at 25hours Hotels

The converse approach, in which the hotel allows for the guest's devices to integrate into the hotel's digital network, is called **Bring Your Own Device (BYOD)**. As most guests bring their own mobile devices with them, they can use their own personal devices instead of devices offered by the hotel. This means that the guest has a very intuitive option for controlling the functions in the hotel room, as the guest is not forced to learn to operate a new device or switch between multiple devices.

The wireless connection between the personal device and the multimedia system in the hotel room is also more convenient for the guest, because they can acess their own media via the hotel hardware. For example they can listen to their own music via the built-in speakers and watch their own media on the television. Furthermore, BYOD is advantageous when it comes to hygiene, because hotel control devices require cleaning after being used by a number of guests, while a guest's personal device is only used by the guests themselves.

»In the urban hotel industry in particular, easy operation is the most important aspect because the guest is only staying for one night and has no time to learn.«

Bruno Marti,
Chief Brand Officer at 25hours Hotels

In addition to smartphones, tablet PCs, and wearables, **virtual assistants and personal robots** will also accompany guests to the hotel in the future. These can perform some of the services that are otherwise performed by hotel staff. Communication between the personal and hotel assistants and service robots could be possible in order to ensure optimal care (Borkmann et al. 2016).

3.3.3 VOICE CONTROL AND CONVERSATIONAL AI

Although technology and automation possibilities are becoming ever more prevalent, the guest still highly values **personal contact** with hotel staff. Over 70% of guests consider it important to be received personally by an employee when arriving at the hotel (Borkmann et al. 2014a; Clarke and Kinghorn 2018). Especially when it comes to more complex interactions, such as requesting recommendations or directions, only about 30% prefer technology over personal contact with hotel employees (Amadeus IT Group SA 2019). One possible reason for this is that the currently available technology is not yet sufficient for being superior to direct human contact.

Yet, the guest certainly has a general interest in smart technology in the hotel: 75% of international guests who were surveyed said that they are interested in staying in a hotel room equipped with smart systems, and 64% said they would like access to a voice assistant like Alexa or Google Home while there (Amadeus IT Group SA 2019). Technology should thus make processes more seamless, but not completely replace people. For example, AI can help hotel staff by providing them with helpful information on the guest, with which the staff can customise their personal interactions with the guest. Technology should be used in such a way that it improves service by aiding in personal communication between the guest and hotel personnel. The goal is to increase the level of conversation to the extent that it is optimally efficient and personalised, thereby making interactions shorter and more satisfactory. Because there is a continuous lack of professional staff in the hotel industry, efficient usage of time by the available hotel personnel is prudent (Handelsblatt GmbH 2019).

Simple requests, such as stating the breakfast hours, can however be easily taken care of with chatbots or virtual assistants that use machine-based **natural language processing (NLP)** methods that do not require any interaction with personnel.

Chatbots are programmes that the user can use to communicate via an instant messenger, such as WhatsApp, Telegram, or Facebook Messenger. A well-programmed chatbot knows who it is speaking with, and can thus require certain things as given. For example, the guest can write, »Could I please have a beverage delivered to my room?« and the chatbot does not need to ask for the room number to send off the beverage to the right room. Furthermore, the chatbot can respond to many user requests simultaneously. As no system is perfect, the guest should immediately be directed to hotel staff in the event of a request that cannot be answered by the bot. The advantage of a chatbot is that guests can receive information in their native language 24 hours a day with very little effort. This equals a lighter workload for the hotel staff.

A **virtual assistant** that the guest can interact with through voice holds potential as a convenience factor for the guest. The guest can effortlessly obtain all of the information that they would otherwise have to request from hotel staff (e.g. via phone or at reception) or use the search engine on their smartphone or tablet for. Setting the room functions by voice command is also easier than using switches or solid panels that are not immediately available. Wherever the guest is in the room, the virtual assistant is ready to respond to the guest. Some guests may bring their own voice assistants on trips in the form of their mobile devices.

The hotel should therefore provide an interface to enable the guest to use its own virtual assistant to control room functions. Also the guests' assistant can as serve as an interface between the guest and the hotel room functions while maintaining the user-specific configurations of the guest. If the guest does not have an own virtual assistant, the hotel should provide the guest with one. A voice assistant in the hotel industry should be fluent in all languages in order to be able to communicate with each guest in their respective native language. Operation should be intuitive and provide a way to turn off voice controls, such as with a »voice off« button. Ideally, the guest should be able to tell immediately upon entering the room that it can be voice-controlled.

3.3.4 SENSOR TECHNOLOGY AND BIOMETRICS

Sensors and biometric processes are indispensable aspects of a Smart FutureHotel Room. **Microphones** provide the necessary **audio data** to analyse the language spoken by the guest with a voice recognition software, such as that from Google (Google Cloud 2019). Microphones are also mandatory for operating a **virtual assistant and voice controls**. They must thus be positioned in the room in such a way that the guest is detected from every angle of the room.

Analysis of speech speed, pitch, and volume of the voice in combination with other data allows for **affective computing**, whereby the guest's current **emotional state** is determined. »Affective computing – the idea of developing systems that automatically detect and can themselves simulate human emotions and feelings – shall help make machines not only intelligent, but also empathetic« (Maier 2017). To better assess emotions, the Smart FutureHotel Room will contain cameras to take pictures or videos that record the **guest's facial expressions** and gestures, whereby the facial expressions are often more meaningful and easier to analyse than gestures. These data are analysed and provide indications of the guest's current mood. Other emotional indicators are physiological data, such as pulse, movement patterns, and galvanic skin response. These can be measured with the guest's wearables (Maier 2017). Detecting the guest's emotional state offers the advantage of being able to individually address their current needs in order to achieve a better guest-hotel fit.

The guest's video, image, audio, and physiological data can help improve hotel security. **Biometric data** can be used to securely identify the guest and ensure or prevent access to the room or personal data accordingly. »Biometrics is the science of establishing the identity of an individual based on the physical, chemical or behavioural attributes of the person« (Jain et al. 2008). Biometric data can vary in nature. Behaviour-based biometric characteristics may be the gait or signature, while chemical traits may be bodily scent or DNA information (Jain et al. 2008). Fingerprint recognition, iris recognition, and facial recognition are currently the most common methods for securely identifying people (Digitale Gesellschaft 2019).

Presence and motion sensors can detect the presence and absence of the guest in the room. Contrary to presence sensors, motion sensors detect walking movements down to the smallest motions. If nobody is in the room, devices can be turned off in order to save power. However, this information can be conveyed to other parties, such as the cleaning personnel so that they can tell whether the room is free to make up without disturbing the guest. Sensors that detect spillage and pressure can be installed in the bathroom floor, for example, to detect if the guest has slipped and fallen so that help can be sent right away.

3.3.5 XR TECHNOLOGY

XR technology like Virtual Reality (VR) and Augmented Reality (AR) have become increasingly popular in recent years. According to the International Data Corporation (IDC), the predicted expenses for AR and VR applications in the year 2019 are 16.8 billion USD, and 160 billion USD in 2023 (International Data Corporation (IDC) 2019).

The term **Mixed Reality (MR**) refers to the spectrum between reality and virtuality. VR and AR can also be categorised in this spectrum. This in turn is categorised into **immersive and holographic technology**. Immersive technology gives the user the feeling of being immersed in another world, as though they were really there. Holographic technology integrates digital information into the real world, as though this information were really there (Microsoft 2018). XR technology holds great potential for positively influencing the guest's experience before and during their stay at the hotel.

Virtual reality (VR) describes applications in which the user finds themselves in a virtual world and can interact with it. The level of immersion in the virtual world can be very high with VR applications, to the extent that the real world is almost entirely faded out. For this experience the user requires a pair of VR glasses at the very least. Depending on the application, other aids are required for acting within and interacting with the virtual environment, such as sensors for detecting the position of the user's individual body parts within the space (sensor gloves, controllers, sensor suits, sensor mats, etc.). The level of immersion can be enhanced if the user's hands or even their entire body are part of the virtual world (Albrand 2017).

VR glasses can also be used to watch **360° videos** (interactive CGI landscapes). This means that the viewer is not interacting with the virtual environment, but rather is consuming it as a viewer who can only change their line of vision but not their position (Albrand 2017).

VR can be used in a variety of ways in the hotel industry to create fun or fear, to learn, to discover places that are not accessible, or to meet people who are far away or deceased. Memories, enhancements, reductions in size, or flashbacks can be experienced as desired. With VR games, the guest is offered entertainment and experiences worth remembering. Yet applications specifically tailored to the hotel can also be of use. With VR, the guest can visit the hotel and the rooms before booking, and look for the room that they like most. The guest can also take a city tour through VR in their hotel room if the weather is poor, and travel to other eras in time to watch history unfold. This means that the guest is not restricted to the city where they currently are, but instead can visit various interesting cities all around the world. VR applications can aid in training hotel staff. For example, new cleaning staff can learn through visualisation how the individual work steps in the respective situation should be performed.

Augmented Reality (AR) is the enhancement of the real world with virtual content (Albrand 2017). The real environment is »expanded by a computer-assisted, virtual perception« (Borkmann et al. 2016). Usage of AR applications requires a medium for integrating the additional information into the user's field of vision, usually in the form of text, images, videos, or animations. Such a medium may be a smartphone, tablet, head-up display, holographic system, or augmented reality glasses. The areas of application for this technology are diverse and range from games (e.g. Pokémon Go), educational information (e.g. city tours with text information on buildings), and everyday gadgets (e.g. navigation and warnings on the windscreen of a car) to professional applications (e.g. placing virtual furniture in an actual room) (Khora VR 2019).

IThere are almost no limits to the usage of AR in the hotel. For example, specific context-based information, graphics, texts, displays, or sound can be presented in the hotel room. This is done via the smartphone or other media right when the guest is located at a certain point in the room or finds themselves in a certain situation. This means that the guest can receive additional information, such as on artworks in the room, provided by the speakers within the room or the guest's own smartphone **(soundscaping)**. This may include the artist's biography or a video about the process of making it, in the viewer's native language. Other possibilities are information on the functionality of various technical appliances in the room, or the view from the window. Functions like »**shop the hotel**« can also be supported by AR. This concept was developed as part of the FutureHotel Project in 2008 and allows the guest to learn the price of an item in the hotel room by targeting it with their smartphone or AR glasses, and then purchasing it by clicking on a virtual button and having it sent directly to their home. This function can also be performed with QR codes.

By projecting **3D mappings** onto the surfaces of the rooms, the design and atmosphere in the room can be changed in real-time. This means that the guest can also be provided with information without them having to use a smartphone or smart glasses (Borkmann et al. 2016).

In the hotel industry, the overlapping of additional information in specific situations can be made accessible to certain users, such as for paintings, simulating behaviour in an emergency situation or experiencing alternative situations, planning and developing environments (e.g. testing other materials indoors, trying on glasses or clothing with AR, testing products in 3D/on site). »**Virtual Collocation**« makes it possible for people to jointly immerse themselves in a situation via »**virtual windows**«, even though they are in different locations. This facilitates virtual cooperation and virtual togetherness, such as dinner with the family.

Very good three-dimensional visualisation and animation are required to generate the content of VR and AR applications. However, once these applications have been implemented, AR and VR can help turn the hotel room into an »experience imparting centre« where journeys of experience begin. Stories can be experienced within the room and told outside of it, such as if the guest posts videos from the room to social networks.

The term »**storytelling**« is used to describe which story a company tells in a certain area, space, or situation (intentional or unintentional). Storytelling can be defined as the »sharing of events with words, images, sounds and/or experiences. Sometimes with improvisation or embellishment« (SAPIENT CORPORATION 2019a). A story is always going to be told, but it is up to the company to decide what that story will be.

»**Storyscaping**« goes one step further and integrates the guest into the story interactively, so that it can be experienced. The story being told is not only found in certain spaces or situations, but rather pervades the entire brand. Storyscaping can be defined as »creating landscapes of emotional & transactional experiences, where each connection inspires engagement with another, so the brand becomes part of the consumer's story« (SAPIENT CORPORATION 2019b). Storyscaping is a very promising strategy in marketing for reaching customers on an emotional level. »By using Storyscaping, brands can move beyond making ads and into creating worlds where their story becomes part of the consumer's story. This is where enduring, dynamic relationships are built between consumers and brands« (Legorburu and McColl 2019).

»The hotel will be an important networking function in the physical world while taking on a strong presence in the virtual world – from both a social and an infrastructural standpoint. The hotel experience will increasingly be tailored to the individual guest.«

Vanessa Borkmann, Head of FutureHotel Research
at Fraunhofer IAO, 2019

In order to tell a story that has a long-term, positive impact on the guest experience and thus achieve a marketing effect, content must be actively generated and constantly evaluated.

3.4 SECURITY AND DIGITAL ETHICS

Smart systems can increase the standard of security within the hotel. At the same time, new data protection requirements are coming into effect and there are questions on the topic of digital ethics.

NFC allows for certain access permissions to be stored in the personnel's access key (e.g. smartphone, wearables). Entries to the room, including the time of entry and person who had access, can thereby be traced and master keys are no longer required. Furthermore, the usage of **biometric security systems,** such as with fingerprint or voice recognition, can also increase the level of security in the hotel, especially with their access restrictions for certain parts of the hotel such as the wellness area. Integrated **radio frequency identification chips (RFID chips)** in furniture protect against theft, because it can immediately be detected when an object is removed from the room (Borkmann und Rief 2011). It can also differentiate between a misplaced and a stolen object (Plewe et al. 2015).

Because BYOD, sensors in the room, guest profiles, and other sources provide the hotel with a lot of **personal data**, the guest expects hotel management to fulfil their obligation of ensuring the security of these data. Data are a precious commodity nowadays, and **cyber attacks** on hotel companies are becoming more common, causing immense damage. One prominent example is the hacker attack on the Marriott Group (Axel Springer SE 2018) or the Choice Hotels data leak (Tageskarte GmbH & Co. KG 2019).

Unsecured WiFi networks in hotels pose a threat to guest data (Czycholl 2019). Careful treatment of guest data by hotels is the foundation for a trust-based business relationship between guest and hotel operator.

In addition to guests' physical safety, **data protection, cybersecurity**, and personal rights are important issues in the hotel industry (Borkmann et al. 2011). Measures such as firewalls, separate systems for guests and hotel management and data encryption can help ensure that guest profiles and customer data remain as closed off from third-party access as possible (Borkmann and Rief 2011). One way to securely manage data and regulate access is the **blockchain**. One advantage of the blockchain over the central storage of data is that data are redundantly distributed and it is nearly impossible to change them in the blockchain, thereby making them (almost) counterfeit-proof. The data are also nearly impossible to destroy. Blockchains are suitable for storing very high quantities of data and exchanging them almost in real-time. The uneditability of the data in the chain allow for the comprehensible and secure conducting of transactions. The blockchain's potential for storing and managing patient data is

already known in the health care industry (Talin 2019). It could also be used to manage guest data. For example, through blockchains it could be possible for the guest to provide the hotel with the data they create through their profile and personal devices for the duration of their stay, and then automatically revoke this access after checking out. Booking can also be conducted through the blockchain via a »**smart contract**«.

In order to dismantle guests' mistrust in the security of their data, the **hotel should inform them of security measures**. For example, the voice assistant can provide information on what happens with the personal data that the guest provides, how they are protected, and when they are deleted. Tours or information sessions for interested guests may also help dispel concerns and fears. Usage of an independent, closed system that does not communicate with the outside world is particularly secure.

For IoT systems in particular, it is recommended that the security requirements of hardware and software are considered when developing and configuring the system (**security by design**).

According to Dr. Robert Paffen, Risk Consulting Leader at PwC Europe and PwC Deutschland, **digital ethics** ensure that technology is developed and used in accordance with high ethical standards: »... that they do not discriminate, that they secure data protection and privacy, and contribute to human well-being« (Weyer 2019).

One PwC study showed that the decision-makers who were polled see the management level as responsible for digital ethics, and primarily see the influence thereof in areas such as working with sensitive information like employee or customer data (85%) and IT security (78%). Over half of the people polled also agree that digital ethics influence corporate culture (62%) and strategic decisions (59%) (Weyer 2019).

A Digital Ethics Committee has already been established in the German federal government. »Yet this does not by any means relieve companies of the responsibility to create their own rules and standards for handling digitalisation responsibly« (Weyer 2019).

3.5 SUSTAINABILITY AND ACCESSIBILITY

Further aspects facilitated by smart systems within the hotel are sustainability and accessibility. The importance of both of these topics for hotel operators and guests will increase in the future, as people are becoming increasingly aware of the reality of climate change and travellers are becoming ever older due to demographic shift, thereby necessitating greater accessibility (Bundesministerium für Wirtschaft und Energie 2019).

Sustainable economic activity is a strong trend, and it is becoming increasingly worthwhile for the hotel industry to follow it. Because climate conservation is becoming more important to people, they also opt for the more **climate-friendly** alternative while travelling. Around 60% of business travellers and 55% of private travellers stated in 2014 that, in the future, they can imagine preferring hotels with a particularly energy-efficient standard and that act in an environmentally friendly manner (Borkmann et al. 2014b). Furthermore, sustainable economic activity can help s**ave resources and costs.** This also concerns wellness components that normally demand high energy consumption.

»Smart innovations can raise the sauna experience to a new level: interaction and operation via smartphone app or voice controls allow for remote control of the sauna or polysensory adjustment of it to the guest's own disposition.
For hotel operators, the digital interface of the sauna makes it possible to integrate them into central building systems, and thus not only keeps them easy to monitor, but also easy to operate them as needed. This saves work time as well as lots in energy expenses.«

Phillip Rock,
CEO of KLAFS GmbH & Co. KG

Among other things, smart systems can be installed to save power by turning off all electronic appliances once it is detected that there is nobody in the room. Furthermore, sensors can collect real-time data on the temperature, humidity, and air quality and evaluate them so that the room's climate can be optimally regulated (Plewe et al. 2015). Simplified digital communication between the guest and cleaning staff can minimise unnecessary cleaning processes, thereby saving on resources and personnel. Some other aspects are described in this report as well.

Smart systems can break down barriers, such as by automatically opening the room door when the guest is approaching in a wheelchair, the voice assistant guiding a blind guest through the hotel and their room, and light signals in the room notifying a hearing-impaired guest that a video call is incoming, someone is at the door, or there is an alarm in the hotel. Innovative, smart gadgets can help significantly simplify the lives of people with physical disabilities. This is illustrated by visually impaired Microsoft employee Saqib Shaikh, who, through an app on his smart blindness glasses with an integrated speaker in the frames, receives information on his surroundings so that he is able to better orient himself in everyday life. For example, with a built-in camera in the glasses and the »Seeing AI« app from Microsoft, the number, sex, and facial expressions of people present can be analised in real-time. Saqib thus obtains the acoustic information, such as whether he is receiving undivided attention or if he should wait briefly before beginning his presentation. The smart device can also read texts aloud to him and warn of obstacles lying in his path (Microsoft 2016).

People without physical disabilities can also benefit from smart gadgets. For example, a translation tool can help break down language barriers. The little headphone picks up the language being spoken via a microphone, detects the language, and interprets it into the user's ear in their native language, thereby facilitating a conversation between people in their respective native languages.

.

4 THE GUEST EXPERIENCE IN THE SMART FUTUREHOTEL ROOM

The scenario of a »Smart FutureHotel Room« describes a guest's experience in a hotel room that is preset to suit the guest's needs, and can be adjusted according to the situation. This is facilitated by state-of-the-art technology, namely technical components that are currently on the market.

The guest's stay at the hotel room is an important experience component in the FutureHotel guest journey that has already been presented (see Figure 41). The guest's fundamental requirements are taken from the digital guest profile and used to preconfigure the room. Current, situation-specific guest requirements are determined by sensors in the hotel room, and then fulfilled in a personalised manner. Information and communication processes geared toward the guest are improved with the usage of technology. Convenience of use and comfort in the hotel room are increasing. At the same time, service processes are becoming highly efficient and resource-friendly.

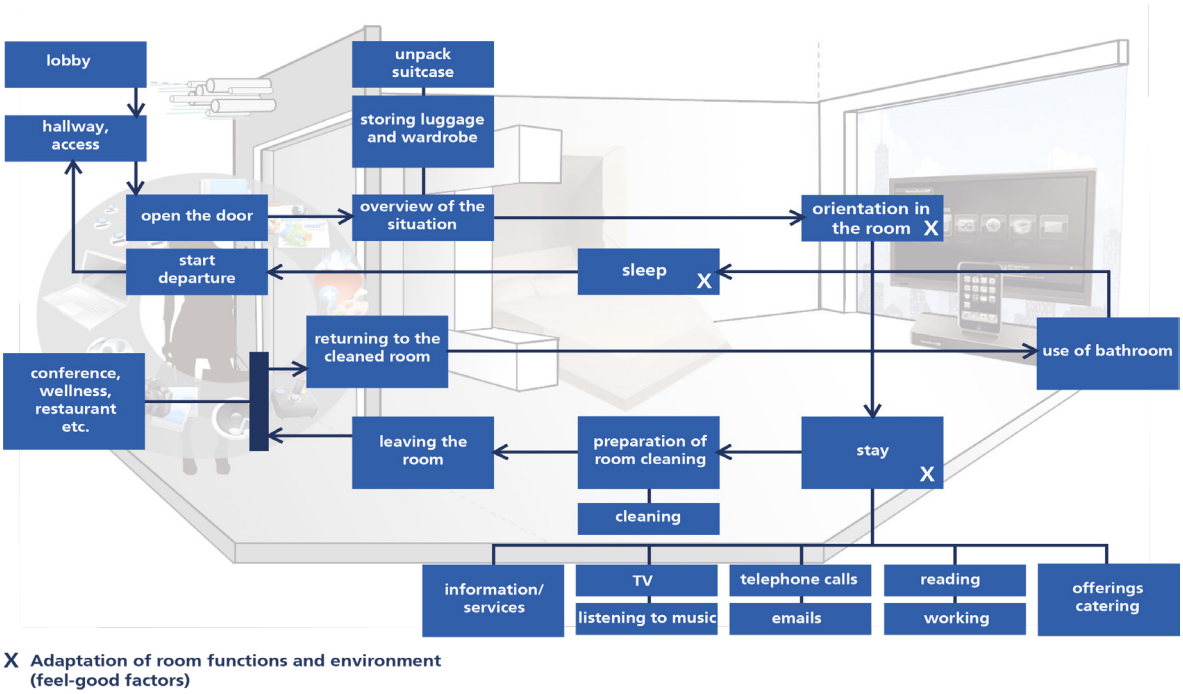

Figure 46: The guest journey of the Smart FutureHotel Room

This chapter covers a guest's model smart stay, starting with the path to their hotel room and ending with check-out. Implementation-related technology is specified and the benefits of smart solutions for guests and staff alike are presented.

4.1 THE PATH TO THE ROOM

The guest has arrived at the hotel room. They have been personally greeted by an employee and their smartphone has automatically connected to the hotel WiFi. They have already installed the hotel app on their phone on the way to the hotel, as they received a notice to do so on their phone including a link to the PWA. As the guest would like to receive the best possible personalisation during their stay, they give the hotel full access to their data for the duration of their stay, namely their guest profile, their virtual luggage in the form of music, films, calendar of dates, personal virtual assistant, etc., as well as the self-logged real-time data that the guest's smartphone and wearables generate. The guest was able to check in with the hotel app without issue.

The path to their room is displayed with the app on their smartphone. Their luggage is transported next to them on a luggage robot. When the guest enters the lift, a song from their favourite playlist begins playing. The lift travels to the right floor unprompted, and informs the guest as they leave that their room is to the left. Before reaching their room and before they are able to pull their smartphone out from their pocket to access the mobile key, the door opens automatically.

4.1.1 THE HOTEL APP

The hotel app is the central node for communication between hotel and guest. Yet downloading a hotel app is a tiring process for the guest, and it can cause a build-up of many different apps on frequent travellers' devices. Only if the guest obtains actual added value from it will they download and use the app. The **Progressive Web App (PWA)** promises more usability. As opposed to traditional (native) apps, this has the advantage of the guest not downloading from the app store, but rather obtaining the app from a website. The icon can be dragged onto their home screen so that the PWA is then usable offline like a traditional app (Brandstetter 2018). One disadvantage of the PWA is that some functions are not supported by all browsers. With Safari (iOS), for example, PWAs cannot, or at least only to a limited extend, use Bluetooth and NFC.

Some hotels are already using their own hotel apps (PWA or native app). A survey of over 63,000 North American hotel guests conducted by J.D. Power revealed that only 19% of those surveyed downloaded the hotel's own app, although doing so did make them much more satisfied with their stay and loyal to the hotel brand (Powder, J.D. 2017). For instance, the all-inclusive club brand TUI Magic Life offers its guests the possibility to specify their dinner every day with the »Magic APPetite« function on the app, thereby allowing for digital influence over a real experience (TUI Group 2019).

» The constant growth of our app adds an increased convenience factor for the guest. For example, while in their hotel room they can easily book a dinner reservation at a restaurant, their favourite workout course, or a day bed.«

Lisa Krause,
Marketing Manager, TUI Blue

Numerous third-party providers offer »white label apps«, which can be tailored to suit the corporate design of the respective hotel. Among other things, these apps integrate functions such as loyalty programmes, mobile booking, recommendations for activities around the hotel, informational videos on using the room's functions and appliances, mobile room keys, communication platforms between hotel employees and the guest, check-in, check-out, mobile payment, feedback requests, and room service. Quickly taking care of check-in is highly important to 91% of business travellers and 85% of private travellers (Borkmann et al. 2014a). Mobile keys and self-check-in can greatly reduce waiting times at reception, as employees have to spend significantly less time on tasks like inputting guest data into the system and creating room keys. This time can be used for personal interactions with the guest, like informing them of spa offers in the hotel or providing them with information on sights in the area.

Some apps already offer an interface to the traditional property management systems (PMS). The hotel app also allows the guest to control Smart FutureHotel Room functions like lighting, temperature, and Smart TV. However, the currently available apps have not yet been integrated into the entire smart hotel ecosystem. There is still a general lack of interfaces and solutions for the complete interlinking of all systems. Furthermore, not nearly all processes and products have yet been digitalised.

Functions available to the guest in the Smart FutureHotel Room via the app and room infotainment system are explained below.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Usage of a hotel PWA	App is not downloaded, rather opens up in a browser Hotel information is centrally available on the app on the user's own device Guest can control room functions with their personal device	No procurement costs for mobile devices to control room functions and communication between staff and guest (e.g. in-room tablets) Personnel can use the app and obtain additional authorisations (access to rooms and staff areas)	Software: Hotel PWA

Table 4: Benefits for guest and staff/ company by using a hotel app

4.1.2 OPENING THE ROOM DOOR

There are a number of ways to open the hotel room door without requiring a key or key card that has to be carried around and can be lost or stolen.

It is possible to detect the guest's position in the hotel with »**geo-fencing**«, and to automatically open the door when the guest approaches it. The technical prerequisite for automatically opening the door, alongside the smart door lock connected to the hotel system via a wireless connection or the internet, is (for example) a motorised engine that opens the door. At the same time this system allows for accessible entry for persons in wheelchairs. Usage of geo-fencing requires the guest to disclose the location of their mobile device so that it can be determined where the guest is. This technology can also detect whether the guest is in the room or not, and the electrical appliances can be turned off if the guest is absent. Geo-fencing can also be used to illuminate a path along the corridor to the guest's room, to play the guest's favourite music wherever they are, and to automatically have the lift go to the right floor. The room can predictively prepare for the guest's arrival by adjusting the temperature and humidity to the guest's preferences. **Mobile keys** provide another method for opening the door. This means that the guest's own mobile device serves as the key. With near-field communication (NFC), data can be exchanged across short distances. This is already installed in most smartphones by default, and is the technology used for contact-free payment, among other things. The guest's device, where the mobile key is

default, and is the technology used for contact-free payment, among other things. The guest's device, where the mobile key is stored in the wallet or hotel app, is held up to the NFC reader to open the room door (Borkmann and Rief 2011). A QR code scanner on the door can also be used. The guest then receives a **QR code** during check-in that unlocks the room door for the duration of their stay.

The door can be opened without any devices by i**nputting a PIN** or using **biometric sensors**. For example, the door can be equipped with a **fingerprint** sensor or a camera for i**ris or facial recognition** (Hohl 2016). Acoustic signals, such as the guest's **voice**, can be recorded through a microphone and analysed to ensure access to the room (DATAKONTEXT GmbH 2011). The usage of biometric data as an access authorisation is thus more secure than using tokens or passwords, as they cannot be stolen, lost, or disclosed to others. They are also counterfeit-proof up to a certain degree, and depending on the characteristic used.

All of the areas available to the guest can be made accessible for them with these access options. With the app the guest can determine if and when the room shall be opened or closed to staff, e.g. for cleaning.

Access control systems potentially increase security for the guest, as it can always be determined who is in which room at any time. A good basis in the **security concept** as well as **secure interfaces** must be ensured in order to implement this in practice. (Borkmann and Rief 2011).

In the survey released in 2019, 70% of the 7,500 international travellers surveyed by Amadeus stated that they are interested in being able to use an app or their mobile phone to open the hotel room door (Amadeus IT Group SA 2019). This number is remarkable because in the FutureHotel guest survey in 2013, depending on age and hotel type, only 4-8% of the 3,380 people surveyed from the German-speaking world expressed the wish for access via NFC smartphone, and even fewer for access via app or QR code. Every tenth individual surveyed approved of access via fingerprint or number code on the door lock, although around 60% of the people surveyed still preferred access with a plastic key card (Borkmann et al. 2014a). According to a current study by Bitkom with 1,004 participants from Germany, 31% of those surveyed would use the option to open and lock their hotel room door with an app on their smartphone (Bitkom 2019a). These results allow one to conclude that interest in the use of smart technology to open the hotel room door is strongly growing in the German-speaking world, although it remains relatively low when compared internationally.

»We see the technological trend in the smart door, which is equipped with facial recognition and an integrated fingerprint scanner for authenticating and regulating access authorisation for guests and staff. We offer the hotel operator all components from one source.«

Mario Virgolini,

Solution Management, JW/ BOS

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Opening the room door with personal device	No additional physical key	No additional physical key	Smart door locks: NFC PIN input QR code reader Automatic door opening: Geo-fencing
Opening the room door with biometrics	No additional physical key No device necessary Cannot be stolen, lost, or forgotten	No additional physical key Access authorisation can be issued and withdrawn centrally	Smart door locks: Fingerprint recognition Iris recognition Facial recognition Voice recognition
Access authorisation	Limited issuance of access authorisations	Transparency for guest and management of who was in the room at what time	Software: Connection to PMS and building management system (e.g. BUS system or smart home solution)

Table 5: Benefits for guest and staff/company when opening the room door

4.2 ENTERING THE ROOM

IArriving at the room, the light automatically turns on. The luggage robot moves into the room past the guest, who follows it. The known voice of the guest's own personal virtual assistant (PVA) greets them in their native language. The guest looks around the room, takes their luggage from the luggage robot, lets the robot leave, and begins setting up. The guest places their smartphone in the slot in the mirror next to the door, where it begins charging. The guest's mood is determined to be neutral and balanced based on their movement patterns, pulse, and facial expression. The voice assistant asks whether the guest would like a brief introduction to the room functions, and the guest accepts. While the voice assistant explains the various parts of the room, the guest's attention is drawn to respective parts of the room through changes in the lighting. The respective devices being explained are visibly activated and deactivated, or perform the actions being described.

4.2.1 CONTROLLING ROOM FUNCTIONS

Modern lighting solutions are integrated into the Smart FutureHotel. **Lighting trends** are gravitating away from visible lights and toward built-in, customisable LED lighting. The various room parameters in the Smart FutureHotel Room automatically adjust to the guest's needs, although the guest can always adjust them individually as well. **Integrated control electronics and data networking** fulfil the technical requirements for this (Borkmann und Rief 2011). A FutureHotel survey of 2,590 hotel guests from the German-speaking world shows that guests desire the possibility of individual controls of the temperature and ventilation (4.2 out of 5 points on the scale) and lighting (3.6 out of 5 points) (Borkmann et al. 2014b). In this regard it is important to guests that the **controls are intuitive** (4 out of 5 points) and **hygienic** (3.5 out of 5 points) (Borkmann et al. 2014b), which supports the option of controls via voice command or the guest's personal device. A current Bitkom study reports that 39% of the 1,004 Germans surveyed would use an app or voice recognition to control lighting, temperature, and music in the hotel room (Bitkom 2019a).

»The smart door is a system component for room controls: presence sensors integrated into the door can be used to control the air conditioning, temperature, and lighting depending on the number of people in the room.«

Mario Virgolini,
Solution Management, JW/ BOS

Other methods for controlling room functions are labelled or marked switches, touch panels on the wall, and in-room tablets. The disadvantage of switches is that they are not suitable for selecting and adapting complex room control scenarios that consider a number of room parameters, for example. Touch panels on the wall are suitable for individual, progressive settings of the room functions, but cannot be controlled from everywhere in the room and are thus less convenient than a mobile device. Compared to a guest's personal device, the disadvantage of an in-room tablet, which some hotels provide for their guests, is that they must be purchased and regularly have to be maintained and cleaned, which costs time and money. Furthermore, in-room tablets require a slot space that is scarce in most hotel rooms. They also force the guest to switch between their personal device and the hotel's device. Controls with a PWA on a personal device and with voice controls are thus a sensible option.

In the Smart FutureHotel Room, the guest can make use of various lighting scenes. For example, if the guest points the control device at a corner of the room, they can change the atmosphere of that part of the room by altering the light intensity, warmth, and colour as they please. By selecting a certain **room scenario**, the music and temperature in the room change in addition to the lighting. The hotel can preset such scenarios, but the guest's entirely individual settings that they have saved in their guest profile can also be used in the Smart FutureHotel Room. As far as the authors are aware, however, there is not yet a technical solution for this on the market

The division of the room into different **climate zones** allows the guest to, for example, set the ideal sleeping temperature around the bed (e.g. with cooling surfaces on the blanket or an adjustable mattress). But not only the room ambience, but also other room functions like the blinds, music, multimedia device, or coffee maker can be centrally controlled via the guest's device or through voice controls. Controls via facial expression, gestures, or emotions (known as **emotion control**) will also be conceivable in the future. If the guest does not opt for a certain scenario, the room functions adapt automatically. Real-time data on the current activity in the room and vital values, upcoming appointments, alarm times, and the outdoor temperature and time of day are also considered in order to create an optimal room ambience.

The room is thus also implicitly controlled in accordance with the **guest's needs**. The information from the guest's own **wearables** (computer systems that can be worn on the body, such as smart watches or fitness armbands), or implants in the future, can be used to **control the room**. The room temperature can be adjusted according to the guest's measured body temperature. An increased pulse may indicate that the guest is emotionally agitated. Quiet, peaceful music, almost imperceptible and calming aromas, or dimming of the lights can counteract the stress. The hotel room holds great potential for improving physical health, especially when it comes to alleviating stress and providing relaxation – two aspects for which there is a growing social need (Borkmann 2018).

The digital platform of the smart hotel/hotel system can be operated via a variety of channels, such as voice controls through integrated interfaces in the room, voice controls via the guest's personal mobile devices, switches, or interacting with the display or a mobile device or a device integrated into the room itself. This platform constitutes a central hub and connects all devices, sensors, and platforms that communicate with each other through IoT technology in the smart hotel room. The individual components can be connected to the smart hotel system via **WiFi, wireless, or BUS systems.** With regard to smart homes, there is already a range of solutions that will not be explained in detail here. In order to ensure a seamless stay in the room, corresponding **interfaces** are required for connecting the real environment with the guest's virtual luggage, such as connections for their devices, broadband internet connection, and internet-compatible hotel devices for retrieving the preconfigured data (Borkmann and Rief 2011).

Figure 47: Example of a smart room control interface

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Central operation of building technology and media technology (e.g. lighting, temperature, blinds, music, multimedia devices, coffee maker)	Complete control over room functions Room conditions for promoting well-being and health Situationally adjusted room atmosphere and mood	Resource efficiency with presence sensor Remote control over functionality of system components Control of and access to remote as well as adjusted to environmental conditions (e.g. weather) Centralised and automatic maintenance	Smart hotel system: WiFi, wireless systems or BUS technology with interface to PMS Controls: Via hotel app on personal device, voice controls, switch, touch panel, in-room tablet

Table 6: Benefits for guest and staff/company with room function controls

4.2.2 GREETING IN THE ROOM VIA VOICE ASSISTANT

The guest brings their virtual luggage with them into the hotel room along with their mobile devices, and thus their »personal virtual assistant« (PVA) as well. If the guest does not have their own PVA, they can use the hotel's virtual concierge directly, which otherwise connects to the PVA. This is then configured by the hotel according to its mood, character, and other aspects, and represents the hotel's identity. When the guest is addressed, whether the greeting is brief or longer, and which options are suggested to the guest, can be adjusted as needed. A demonstration of the hotel room's functions can be conducted live, although it is also possible via video or an augmented reality application in which the guest is shown the functions once they point their smartphone at the corresponding item in the room. Furthermore, the guest can be given the opportunity to visit the room from home through virtual reality, allowing them to try out the functions in advance. This option may provide the initial impetus for making the first booking, or additional bookings. Technologically, usage of a voice assistant requires the corresponding software such as Alexa, Cortana, or Siri, if the guest does not bring this themselves. It is important that the demo is only offered upon first entering the hotel room, and not every time the guest re-enters the room thereafter. It must also be determined whether the guest has already seen the demo during their last stay at the hotel. In this case, only new additions that have been integrated since the guest's last stay should be shown, or the guest should be asked if they would like to see the demo again as a refresher.

Microphones integrated into the room can detect the guest's needs in the entire hotel room, including the bathroom. Speakers for voice output must also be conveniently positioned so that the PVA can be easily understood from any location in the room. Sensors that determine the guest's position in the room and cameras that provide the necessary data for analysing the guest's emotions and activities help personalise the interactions. For example, only those speakers that are close to the guest can reproduce the voice of the PVA in order to facilitate localisation of the voice in the room. All desired usage scenarios should be defined in the planning phase and determine the selection of the hardware components, such as sensors, screens, and speakers, or a modular architecture/installation method should facilitate future replacement of the components.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Personal virtual assistant welcomes the guest and introduces them to room functions	Introduction to room functions If guest brings their own PVA, usage is familiar to them If guest has no PVA, the hotel PVA provides an experience factor	Guest is familiar with room functions, and thus - relies less on assistance from hotel staff - is more satisfied	Software: voice assistant (PVA, chatbots/ conversational AI) Software for position and emotion analysis Presentation of the room is pre-programmed (or video presentation, augmented reality application or VR application must be prepared) Hardware: Sensors (proximity and motion sensors, microphones), speakers, screen(s)

Table 7: Benefits for guest and staff/company with voice assistant greeting in the room

4.2.3 UNPACKING AND SETTLING INTO THE ROOM

A luggage robot that transports luggage provides the guest with extra convenience, as the guest no longer has to carry their luggage themselves. The transport robot is integrated into the smart hotel system, and receives its tasks either automatically or directly from hotel staff. The guest can order the luggage robot to their room before checking out. The robot moves around the hotel like an autonomous car. It moves to different floors by taking the lift, which automatically brings it to the right level. Service robots can generally reduce the hotel staff's workload, increase efficiency, and simultaneously provide the guests with a source of excitement (Ivanov et al. 2017).

Multiple storage surfaces in the Smart FutureHotel Room have i**nduction charging stations,** meaning that an empty battery will be a thing of the past. Charging via **magnetic resonance** is also possible, and promises the guest even more convenience because the device that has to be charged not only does not need a charger, but it does not even have to be lined up with a charging area because it only has to be placed in the immediate proximity of the charging source in order to charge. Multiple devices can also be charged at the same time (IDG Business Media GmbH 2010).

Initial solutions make it possible to c**harge mobile devices from a distance** because the power source transmits an electrical charge to the connected device within an entire area, such as the hotel room. Compatible devices such as smartphones, tablets, wearables, and IoT devices can be charged with **OTA (over the air)** technology, in which radio waves are converted into direct current (Powercast Corp. 2019; Energous 2019). However, with this type of charging it must be noted that the negative impact of radio waves on human beings is not yet fully known and, for example, the International Agency for Research on Cancer (IARC) states it is possible that radio waves aid in the formation of some types of tumours (Hardell 2017).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Smart luggage robot	Luggage is transported Interaction with robots becomes an experience	Cleaning staff can also use luggage robots to transport laundry or perform similar tasks	Luggage robot with interface to smart hotel system and GPS
Automatic, wireless charging of mobile devices	The mobile device charges automatically once it is placed on a certain surface	Fewer problems with guests who cannot control their room because of an empty battery	Charging surfaces that are built into various surfaces in the room Charging via: Induction Magnetic resonance Beacon technology

Table 8: Benefits for guest and staff/company when unpacking and settling into the room

4.3 ORIENTATION IN THE ROOM

When looking into the room the guest notices that the items they have booked, like plants and artworks, have been placed in the room. They also find a water boiler, ginger tee, and a lemon instead of the usual coffee maker. The guest had not ordered this, but their preference for ginger tee with lemon in the morning had been noted from their orders on past trips and automatically included in their guest profile. The view from the smart facade shows the guest information on the port city that can be seen from above. As the voice assistant previously informed the guest, the hotel app can convert the facade into an opaque display. As the guest is no longer certain how to change the information being displayed from building names to historical information, they read the usage information directly on the facade with the help of their smartphone.

4.3.1 AMENITIES AND EXTRAS IN THE HOTEL ROOM

By accessing the information in the guest profile, the hotel is able to surprise the guest with a personalised courtesy in order to increase the guest's satisfaction and loyalty. Everything can be personalised, from the shampoo and beverages on offer to the colour of the towels. Offers customised to suit the customer increase customer satisfaction and trust in the company, contrary to »one-size-fits-all« offers. This in turn promotes customer loyalty (Ball et al. 2006).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Small, personalised courtesies in the room	Guest feels valued	Guest is satisfied, loyalty increases	(Automatic) analysis of guest profile (Automatic) request to staff that small items be prepared and brought to the room

Table 9: Benefits for guest and staff/company with amenities and extras in the hotel room

4.3.2 THE SMART DISPLAY FACADE

A display facade that can be either transparent or opaque and that can display information is already technically feasible today. With nanotechnology, materials can exhibit »smart« properties, for example by changing shape or colour when the temperature changes or when power is flowing through them (Borkmann and Rief 2011). This could be used in the Smart FutureHotel to save power, among other things, for example by stabilising the room temperature by dimming the window panes.

With augmented reality, the guest can view helpful information about the view from the hotel room on their smartphone. This could include information on the building's architecture, usage, or public events that are taking place at the time. This information changes depending on the time of day and the guest's own interests.

According to a current survey by Bitkom, 60% of the 1,004 Germans surveyed would use an augmented reality smartphone app to discover novel worlds of experience (Bitkom 2019a).

In place of a smart facade, most smart hotel rooms currently only have smart TVs with large-scale displays. This state of technology generally corresponds to the standard in households, and will rarely leave a guest astonished.

Projections are a conceivable alternative to displays. In the future guests will likely bring their own projectors with them, which will be integrated into their smart device by default. They then require an open wall or window space in the hotel room to function as a display replacement. This will result in the disappearance of the traditional television as a hotel room product, although the function will remain the same (see chapter 4.4.2).

Radio Frequency Identification (RFID) is used to automatically identify and localise objects and lifeforms contact-free. In the hotel context, for example, it can be used to protect valuable appliances or furniture against theft. The guest's NFC-compatible mobile phone allows them to directly read the operating and product information on the devices or furniture, which renders complicated user manuals redundant (Borkmann and Rief 2011)This technology can also make the »shop the hotel« function accessible to the guest. This means that the guest can purchase the products that they got to try out while staying at the hotel, whenever they want. The product can be delivered the exact same day that the guest arrives at home.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Smart display facade / virtual window	View is overlapped with information Can be converted into large display as desired		Nanotechnology for changing the nature of the facade Augmented reality app and content
Reading product and operating information via smartphone	No complicated and unhygienic operating manuals required	Theft protection	RFID chips in devices and furniture NFC-compatible reader (e.g. guest's smartphone)
Shop-the-hotel function	Guest can test products before purchasing them at the hotel	More income through additional sales	RFID chips in devices and furniture NFC-compatible reader (e.g. guest's smartphone)

Table 10: Benefits for guest and staff/company with smart display facade

4.4 INTERACTING WITH THE INFOTAINMENT SYSTEM

The guest activates their PVA and asks what's new at the hotel and what offers are available today. After the PVA has responded to the guest, it also offers the guest information on activities outside of the hotel. As the guest would like to go get something to eat later today, they ask the PVA to recommend a restaurant. The assistant suggests a small seafood restaurant that perfectly suits the guest's preferences. The PVA reserves a spot at the restaurant that evening and notes the appointment on the guest's personal calendar.

The guest controls the infotainment system by using their smartphone as a remote control. From the virtual minibar, the guest orders a glass of lemonade and some fruit and then checks the local weather forecast, which is displayed on the system in their native language.

Next, the guest would like to call their family to let them know that they have arrived safely. The guest gives the voice command, »call home«, and then selects the video call option when the PVA offers the choice. The guest can now see their family on the large display and speak with them. The camera follows the guest through the room as they move while speaking, so that they are always shown from the front when possible. During this call, a service robot delivers the beverage and fruit that were ordered

4.4.1 THE CONCIERGE SERVICE

The PVA has access to the guest's personal data (if the guest has disclosed them) and the hotel's PMS data, so that it can take on the role of personal assistant and virtual concierge. The PVA thus forms an interface between the guest, hotel staff, and room functions. With the personal guest data, the concierge service can be tailored to the guest and provide recommendations that really interest the guest.

With **augmented hospitality services**, the guest can also receive information and services tailored for them and the situation in a user-friendly way and in real-time. This makes it possible to offer the guest unprecedented service quality. The service point used to always be a fixed location, but with the addition of online components, service can now be offered virtually practically anywhere. The term »augmented hospitality service« as introduced by Vanessa Borkmann means that real situations and online service overlap with one another and likely entail greater acceptance, conversion (profit), and satisfaction. One example of application is that the guest would like to leave the hotel in poor weather conditions, and receives a push notification on their smartphone or a note appears on the door that they can borrow an umbrella at the help desk.

In a survey of 750 travellers from the USA, China, Great Britain, France, and Germany, the participants from European countries stated that they mostly approve of a customised recommendation of nearby activities among the available AI services at the hotel (MAZARS 2018). In order to achieve this level of personalisation, access to information databases and online sources is required. For example, the hotel can ask hotel staff or the neighbourhood what secret tips they would like to recommend to guests. These tips can then be divided into various categories, and suggested depending on the guest's known interests. If the right recommendation for the guest is not available, interest-based internet searches can help (for example, musical taste and the booked hotel category can provide a clue as to which bar or restaurant matches the guest's interests). Depending on the guest's interests, multimodal mobility services are also offered: with an E-scooter to the nearby metro stop and then a short walk or a ride in a car form the hotel's car-sharing pool to the destination. The guest can also be notified of the availability of parking at the hotel or nearby via real-time data.

»Innovative mobility offers, such as electric cars, E-scooters and sharing services are attractive to travellers and support carefree mobility at the destination.«

Kathrin Stauber,
Senior Executive Customer Journey Management, Sixt SE

The PVA thus refers to the available services in the hotel when appropriate. For example, depending on the guest's mood and activity, it could refer to the menu at the hotel restaurant or the spa service at an appropriate moment. The PVA also makes it possible to order from the virtual minibar at any time.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Personalised recommendations and information	Receives information that really interests them and suggestions that really match their interests and needs	Increase of sales of hotel offers, as they are suggested by the hotel based on interests	Software for offer adjustment Analysis of guest interests and identification of suitable offer selection

Table 11: Benefits for guest and staff/company with the concierge service

4.4.2 USING THE INFOTAINMENT SYSTEM

Hotel guests rate the importance of the television with 4 out of 5 points, and entertainment electronics with 4.3 out of 5 points, and expect a certain standard (Borkmann et al. 2014b). The importance of free internet access via the television is rated equally as high, with an average of 4 out of 5 points (Borkmann et al. 2014b). As guests privately own increasingly better, smart, and high-resolution televisions, it can be assumed that the guests' standards for this technology in hotels is increasing. They no longer expect a television with a good resolution and selection of channels, but rather appliances that perform functions such as shared screens, access to personal data and services, and on-demand TV. After turning on the device with their smartphone, the guest has access to their own data, music, apps, and streaming services. The guest can also access the internet and make (video) calls. The infotainment system is connected to the Property Management System (PMS) and thus facilitates services such as contacting hotel staff via message or call, an overview of the selection in the virtual minibar, and a current overview of the bill. Table reservations in the hotel restaurant, bookings of spa applications, a virtual tour through the hotel, live images/streams from the hotel bar, and the display of the current resource consumption are other possible functions of the infotainment system (Borkmann and Rief 2011).

The »**virtual minibar**« is open for the guest round-the-clock. The complete selection from the minibar can be seen via the infotainment system. The order is made via voice control, touch function on the display, or selection on the smartphone. The costs are automatically and precisely **charged** via a central system. The usage of **service robots** and virtual minibars can reduce the staff workload and simultaneously facilitate expanded and service available at all times. By abstaining from minibars in the hotel rooms, employees are no longer required to examine, clean, and fill all of the minibars in the hotel rooms (Borkmann and Rief 2011). This also **saves energy**, because minibars can comprise up to 10% of a hotel's energy consumption (The Bottomline 2009).

A connection can be made via the guest's preferred internet calling app via voice command or the interface (e.g. the guest's smartphone). Audio and images to be transmitted can be recorded by the guest's personal smartphone or may come from the integrated cameras and microphones in the room. For example, one option is the integration of **cameras** at multiple locations in the room that can also be used to recognise individuals (face ID) and analyse emotions. The guest is recorded from these various perspectives and they are able to transmit whatever picture they design or select to always transmit whatever picture shows them from the front. The guest's voice can be forwarded by the **microphones** integrated into the room, which are also used for voice controls. The conversation partner's picture can also be transmitted onto the guest's personal smartphone display as well as onto the l**arge-format screen** in the room, and the voice is emitted from the **speakers** in the smartphone or the **boxes** integrated into the room.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Content mirroring from smartphone on entertainment system	Personal access to streaming platform and social media can be used to watch movies, listen to music, and communicate with people	Only the interface and internet-compatible display need be provided by the hotel, but not access to movies, music, or video calling	WLAN interface Internet-compatible large-format display
Access to hotel service via infotainment system	Guest has a simple overview of all hotel offers and can book them directly	A good depiction of the available offers can increase sales of additional offers (such as the spa application, orders from the virtual minibar)	WLAN interface Internet-compatible large-format display

Table 12: Benefits for guest and staff/company through usage of the infotainment system

4.5 USAGE OF THE BATHROOM

During the conversation the guest gets up and goes to the bathroom. The light automatically turns on and the video call image is transferred to the display mirror. The audio is now transferred to the speaker in the bathroom. In order to maintain the guest's privacy, the conversation partner still only see the empty hotel room and no images are transmitted from the bathroom. Shortly thereafter the guest says goodbye to their family, ends the video call connection via voice command, and takes a shower. The water turns on automatically once they have fully stepped into the shower, and it immediately is set to the right temperature. The guest turns on their favourite music via voice command. The water temperature, pressure, and intensity are set to the guest's preferences and can also be changed via voice command. The guest also tries out a message function, for which jets of water shoot out from the wall and massage the guest's back. A number displaying water consumption is shown on the mirror and is going up. The guest decides to keep consumption low and finishes showering.

Figure 48: Bathroom at Beyond by Geisel, München

4.5.1 THE SHOWER EXPERIENCE IN THE HYGIENIC BATHROOM

On average, guests rate the importance of the bathroom with 4.3 out of 5 points (Borkmann et al. 2014b), although they are not willing to pay extra for the desired minimum standard of convenience and hygiene (Borkmann et al. 2009).

The guest can take advantage of **barrier-free** usage of all components in the smart bathroom. The »**health light**« with UV lighting, heating lamps, and light therapy offer the guest special moments of comfort. **Contact-free, digital fittings** can save water, and usage of the bathroom is more hygienic overall. **Autonomous hygiene** via legionella rinse and UV lighting will be implemented in the bathroom of the future.

The »**FutureHotel Baderlebnis 2030**« report, released in 2017, presented further visions of components in a smart bathroom. This includes a smart shower experience, for example, in which water is emitted as needed from various nozzles above and to the side of the guest, and which are aimed right at the guest. The amount of water used as well as the pressure with which it hits the guest are adjustable. There are also various shower scenarios that can either be triggered automatically with a needs-based analysis or which can be set, such as a massage, relaxation, or waking-up scene (Borkmann and Rief 2017).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Convenience and hygiene in the bathroom	Accessible operation Moments of comfort	Easy to clean	UV lamps Legionella rinse Non-contact fittings
Smart showering experience	Comfort Conserves resources – clean conscience	Saving water	Special shower cabinet with nozzles on the top and sides that can be controlled separately

Table 13: Benefits for guest and staff/company through usage of the bathroom

4.5.2 THE DISPLAY MIRROR WITH RESOURCE DISPLAY

In order to act **sustainably**, the hotel can use water recycling, water-saving toilets, and heat recovery. Cleanliness and hygiene are the most important aspects in the bathroom for guests, with 4.9 out of 5 points (Borkmann et al. 2014b). That is why the smart hotel room exhibits **high-tech nanomaterials** that are self-cleaning or slip-resistant, or independently combat the formation of mould and reproduction of bacteria (Borkmann and Rief 2011). Information such as the weather report or upcoming appointments can be displayed, and films can be watched, on the **display mirror**.

Various measures will be taken to reduce resource consumption. The shower system can reduce water consumption via optimal water output through nozzles distributed around the shower, and used water can be treated and recycled (Borkmann and Rief 2017). Guests can also be actively involved in the water saving process. For example, while showering, the amount of water or energy consumed can be displayed, and the guest can see a comparison of their **current resource consumptio**n with that of other hotel guests, or with consumption during the guest's last shower. This can be done in a playful manner, like a competition with other guests. Guests can thus be actively involved in a sustainable concept. Additional information, such as current energy and water consumption, CO2 footprint, the resulting amount of waste, and the cost of cleaning the room in the time since check-in, can be made visible. This could be done with a **real-time feedback system**, for instance. The guest's choice of an eco-friendly manner of arrival can also be included and rewarded (Borkmann and Rief 2011).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Display mirror can be used as a smart display	Convenience through ability to use all functions of the infotainment system in the bathroom		Display mirror with touch function and interface to infotainment system in the room LED lighting Speaker
Reducing resource consumption	Clean conscience	Saves on costs	Smart metering technology Energy monitoring with feedback system Water preparation unit

Table 14: Benefits for guest and staff/company through usage of the display mirror with resource display

4.6 THE WORKING SITUATION

Freshly showered and revitalised, the guest sits down on the chair with their laptop to check e-mails and work on a presentation that they need at a business meeting tomorrow. Their laptop connects to the infotainment system if they wish, so the screen of their laptop is shown on the display wall. The laptop is automatically charged on the coffee table. The temperature in the room becomes almost imperceptibly cooler and the light a little brighter. Quiet music that the guest usually listens to while working automatically turns on. There is a knock at the door. The guest says, »Come in«, and the room door opens for a hotel employee to enter with documents that the guest had printed by the hotel's co-working service. Once the second person is in the room, the picture shown on the display changes to a neutral image. Once the employee has left the room and the guest is finished with their work, their PVA reminds them that their table at the restaurant is reserved one hour from now. The guest decides to take a walk around the area first, and leaves the room. Once they leave the room, a vacuum robot comes out from under the bed and begins vacuuming the floor.

4.6.1 THE CONTENT DISPLAY AND PRIVACY SETTINGS

The transfer of one screen onto another screen is called »**content mirroring**«, and WiFi is one way to facilitate it. To do this, the laptop is simply connected to the WiFi network and requires no other wiring.

As described in section 4.2.3 there are various means for wirelessly charging mobile devices. However, because not all laptops can be charged wirelessly, outlets should be provided in the typical work areas such as the desk and bed, and should also be easily accessible.

It is especially important to business travellers that they can work as efficiently and comfortably as possible in the hotel room. Individually adjustable **room scenarios** (see 4.2.1) can turn the room from a cosy relaxation area into a workspace for optimal concentration or creativity by changing the lighting, temperature, and acoustics.

The smart system in the Smart FutureHotel Room detects that there is a second person in the room and takes corresponding measures that help protect the guest's privacy. Once the guest is no longer alone, none of the guest's private information is disclosed or displayed by the system. All visible displays show neutral pictures, and audio files cease playing unless the guest explicitly authorises the disclosure of the information.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Smart workplace	Working in the hotel is made easier		Outlets within reach Induction charging surface Comfortable seating LED lighting
Content Mirroring	Working in the hotel is made easier		Display or projector that projects an image onto the wall with an interface WiFi

Table 15: Benefits for guest and staff/company with content display and privacy settings

4.6.2 ABSENCE OF THE GUEST

When leaving the room, the smart home/hotel system switches into **energy saving mode** and turns off all devices in the room (Borkmann and Rief 2011). Only the vacuum robot comes out from under the bed and begins vacuuming the room.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Energy saving mode when guest is absent	Detects whether guest is in room or not – no disruptions	Saves on costs and energy	Sensors for detecting presence and people Vacuum robot

Table 16: Benefits for guest and staff/company when guest is absent

4.7 SLEEPING AT NIGHT AND WAKING UP IN THE MORNING

When the guest returns to their hotel room late in the evening, they immediately lie down in bed. They turn on a movie, but quickly fall asleep, completely forgetting to set an alarm for the next day. Thankfully the PVA knows their appointments and habits, and the alarm is set automatically.

The screen showing the movie automatically turns off once sensors have detected that the guest has fallen asleep. The anti-snoring system detects when the guest begins to snore and raises the headboard of the bed somewhat so that the guest can breathe freely again. After a while the CO2 content in the room increases, and so a window opens automatically to ensure the ventilation of fresh air in the room.

The guest is gently woken up the next morning with a simulated sunrise and birds chirping. The voice assistant informs the guest of their upcoming appointments, the weather forecast, and current news while the guest goes through their morning routine.

Before the guest leaves the room, the assistant asks whether the room service should come by today and whether there are any special requests or preferences to be noted. If the guest only wishes to make little use of the cleaning service, they could receive Bonus points from the loyalty program of the hotel that can be used for any extra (Borkmann and Rief 2011). The guest pulls up a list on their smartphone and checks off the boxes for »New towels« and »Clean the toilet«. The guest also enters the time frame during which the cleaning should be performed. They can also order their desired breakfast via the hotel app before even leaving the room.

4.7.1 THE SPACIAL SITUATION

The hotel room should be a place of refuge and relaxation. With 4.6 out of 5 points, it is very important to guests that they are **not exposed to any disturbing noises** (Borkmann et al. 2014b). For example, these noises may be caused by the air conditioning, the refrigerator, or other electrical appliances, or may come from the hallway, street, or neighbouring room. The Smart FutureHotel Room should be soundproofed and regularly examines the integrated devices for noise emission. The volume in the room can be measured via the integrated microphones. If it gets loud outside during the night, the motors in the windows shut them automatically. According to the survey of our hotel guests, they rate the importance of openable windows with 4.3 out of 5 points (Borkmann et al. 2014b). Along with outside noises, sensors in the Smart FutureHotel Room detect CO2 content and **unpleasant smells**. Corresponding measures are taken as needed, such as **automatic ventilation or notification of cleaning staff**. Guests

who were surveyed rate the importance of no unpleasant smells in the hotel room with 4.7 out of 5 points (Borkmann et al. 2014b).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Window automatically closes in case of noise	Prevents disturbing noises		Microphones in the room Software for measuring volume and analysing the type of sound and origin thereof Centrally controlled motors in the windows
Window opens automatically when fresh air is required	Sufficient oxygen supply		Sensors for measuring CO2 content and indications of bad smells (e.g. detecting ethane, propane or acetone)

Table 17: Benefits for guest and staff/company when sleeping at night and waking up in the morning

4.7.2 THE BED

Guests rate **the bed** as very important, with 4.7 out of 5 points (Borkmann et al. 2014b). Every other guest would pay extra for a bed that is ideally equipped to suit their standards (Borkmann et al. 2009). As the guest spends a significant portion of their stay in bed, either to sleep or to watch television, to work or to eat, it is worthwhile for hotel operators to pay particular attention to the bed as a room element.

As described in section 3.2.2, the guest can select the pillows that they would like while booking the Smart FutureHotel Room (e.g. face-down sleeping pillow, side sleeping pillow, foot pillow, various sizes and firmness levels). The guest can automatically adjust the mattress's firmness. This requires a special **mattress**, for example one that can change its firmness through the intake and release of air in small air cushions within the mattress, or through dynamic foams that change firmness via small amounts of thermal energy. There is already a variety of providers of such mattresses. The mattress is connected to the smart ecosystem of the Smart FutureHotel Room,

Figure 49: Sleeping area at Beyond by Geisel, München

and the preferred **mattress firmness** specified in the guest profile is automatically set. Individual changes can be made as desired via the hotel app or voice control.

The bed's height is adjustable for accessibility, and offers other electrical setting possibilities (e.g. adjustable backrest) for reading, working, and relaxing. The bed also contains a **massage unit** and a **sensor mat** that monitors vital functions.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Mattress adjusts level of firmness to the guest's preferences	Guest has restful sleep		Mattress that can be integrated into the smart hotel room system and its firmness can be adjusted via: -Air cushion -Dynamic foam
Bed's backrest is adjustable	Guest can adjust the bed to suit their needs		Flexible slatted frame and remote control-compatible electrical motor in the bed's backrest
Bed integrates a massage function	Relaxation and moments of comfort		Massage mat in the bed
Bed detects sleeping phases and events, like snoring or waking up in the night	The alarm can go off during an optimal sleeping phase so that the guest is more well-rested Snoring is detected and countermeasures can be taken Sleeping rhythms can be observed and pathological patterns can be recognised early		Sensor mat that records movements, sounds, and pressure distribution Software that analyses the data

Table 18: Benefits for guest and staff/company with the bed

4.7.3 WAKING UP

The **alarm sets itself automatically** in that information, such as appointments in the guest's calendar, the typically required amount of time between waking up and leaving the house, and the required travel time including typical traffic, ensure punctual arrival for the appointment.

Sensors in the bed can document the guest's sleeping phase so that the alarm scenario can begin at the right moment within a certain time frame around the calculated alarm time. If parameters change, such as a road closure on the way to the workplace, the alarm time changes dynamically. A sunrise can be simulated with the display facade and the LED lighting in the room. The alarm procedure preferences set in the guest profile can be individually considered. Regardless of whether the guest requires shrill sounds and bright light, or would like to wake up gently and slowly with a simulated sunrise, or requires a coffee or some peace and quiet in the morning before getting out of bed, the suitable scenario is created in the Smart FutureHotel Room.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Alarm sets itself automatically	Optimal alarm time is automatically developed, guest does not worry about oversleeping or having too little time in the morning	Staff must make fewer wake-up calls	Software for determining optimal alarm time (time frame) under consideration of relevant factors
Alarm scenario begins at optimal time and is tailored to the guest	Guest is awoken while in a phase of light sleep and is not jolted awake from deep sleep – this makes waking up easier		Movement sensors for determining the phase of sleep, e.g. -App in guest mobile phone that guest places in bed for this purpose -Sensor mat in bed -LED room light (centrally controlled and connected to Smart FutureHotel Room system) -Speaker

Table 19: Benefits for guest and staff/company with the alarm

4.7.4 ORDERING ROOM SERVICE

If the guest only selects specific services that are to be performed in the room, this can save resources. The selection of a desired time frame in which the cleaning is to take place provides more convenience for the guest.

The individual **breakfast request** can be pre-ordered based on the guest profile, so that everything is ready for the guest in the restaurant. The **guest's preferences and intolerances** are considered, so that a guest on a vegan diet is exclusively offered vegan meals to choose from, and non-vegan alternatives are only provided upon request.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Selection of the required cleaning services by the guest	Guest can receive bonuses by making use of few services	Usage of resources can be planned in advance	Software as well as input and output medium for communication between guest and staff
Guest can select the time frame in which the room is to be cleaned	Self-determination and comfort for the guest		Software as well as input and output medium for communication between guest and staff

Table 20: Benefits for guest and staff/company with room service

4.8 CLEANING THE ROOM

While the guest attends appointments in the morning, the room is cleaned. The hotel employees can use their mobile devices to read, in their native language, which tasks have yet to be completed so that the list can be easily and intuitively worked through. The cleaning staff can also tell whether a guest is still in their room so as not to disturb them. A robot accompanies the housekeeping chores and transports cleaning agents and bedding materials right to the rooms where they are needed, and where the staff is currently working.

When the guest returns to their room, they notice that the room has been cleaned as per their wishes, although the soap in the bathroom is almost all used up. With their hotel app, the guest confirms the room cleaning and states that they are satisfied. The guest tells the voice assistant

that they need new soap, which is brought to their room by a service robot a short time later. Soon thereafter, the personal virtual assistant asks the guest how satisfied they are with the service at the hotel. The guest says that they are very satisfied.

4.8.1 PROCESS AND PLANNING OF THE ROOM CLEANING

A **plan for the order** of rooms to be cleaned and the **tasks to be performed** is automatically created for each employee, and updated as circumstances change in real-time, thereby optimising processes within the hotel. General cleaning and maintenance cycles are also recorded in the system so that orders for incomplete tasks are punctually and automatically send to the responsible employee. With the integrated translation systems, the staff can view **information in their native language**, such as the usage of cleaning agents, cleaning steps, or the guest's special requests (Borkmann and Rief 2011). According to a Bitkom survey, 69% of the 1,004 Germans surveyed would like to use technology with which the hotel service automatically detects whether the guest is in their room as not to disturb them (Bitkom 2019a).

A housekeeping robot accompanies the housekeeping chores and helps by transporting materials, such as bedding. A vacuum robot is either available in every room and vacuums once the guest has left the room, or accompanies the housekeepers. Exoskeletons that help employees with physically demanding work, such as making the beds, are also conceivable in the future.

Generally, the materials used in the room are as **antibacterial, non-soiling, and easy to clean as possible. UV light** can be used to kill off bacteria and germs in the interest of hygiene (automatically in some areas, such as on fittings, door handles, etc.). Ultraviolet light is used to disinfect water, air, and surfaces. Microbes are neutralised in a fraction of a second. One currently common way to use UV light is water preparation. The germ count can be reliably and severely reduced without the addition of chemicals that impact the taste, scent, and pH value of the water (Borkmann and Rief 2011).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Staff receives an automatically generated, digital list of services to be performed in native language		Seamless and customisable procedures Fewer misunderstandings caused by language barrier	Interconnected software that can collect, organise, and allocate tasks Translation programme
Robots bring materials and cleaning agents where they are required		Fewer personnel expenses Saves time	Housekeeping service robot
Materials are antibacterial, non-soiling and easy to clean	Better hygiene in the room	Saves time, requires fewer cleaning materials	High-tech materials

Table 21: Benefits for guest and staff/company with room cleaning

4.8.2 RETURNING TO A CLEAN ROOM

Back in the cleaned room, the guest is able to provide **feedback on the room cleaning**. The guest confirms the cleaning if they are satisfied.

The smart hotel room asks for feedback **at an appropriate location and in appropriate situations.** It makes sure to ask the guest for feedback in moments when they are in a good mood as opposed to when they are agitated or tense. A person's mood changes throughout the day, thereby necessitating real-time data in this regard.

If the guest expresses a complaint, the hotel staff should respond to this quickly and appropriately. Research results show that good complaint management can even result in a guest being more satisfied than if they had no complaint to begin with. 97% of 2,590 hotel operators surveyed in 2012 said that a quick reaction to online guest reviews is one of the most important actions their hotel can take (Borkmann et al. 2011).

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Confirmation of room cleaning	Guest can state if everything was completed to their satisfaction or not Partial service can be reordered if necessary	Direct feedback	Hotel App
Feedback request (e.g. on room cleaning)	Guest feels like they are taken seriously	Hotel receives important information in order to evaluate service quality	PVA

Table 22: Benefits for guest and staff/ company when returning to cleaned room

4.9 LEAVING THE ROOM UPON DEPARTURE

Because the guest is flying back home this afternoon, the PVA asks them whether a ride to the airport should be ordered. The guest accepts, and a taxi is ordered for the early afternoon. One hour before leaving, the PVA reminds the guest of their time of departure and asks for feedback on their stay. The guest is also asked whether they would like to speak with their guest experience manager over the phone or in person.

Shortly before leaving, the luggage robot comes to the room to pick up the guest's luggage. When leaving the hotel the guest is automatically checked out and they receive the bill in an e-mail on their smartphone while in the taxi. In the taxi the guest receives a suggestion for a social media post in the form of a brief text, tweet, or image focusing on the positively reviewed aspects in the feedback, and the guest need only say »ok« or click to upload the post to their profile on one or more social media platforms. Furthermore, as a thank-you and incentive for returning, the guest receives a discount coupon for their next stay at the hotel. An additional message informs them that all of their personal data in the hotel system have now been deleted.

4.9.1 BEFORE DEPARTURE

If the guest discloses the required information on flight times, etc., the departure can be planned automatically. A mobile service partner organises the appropriate mobility solution at the right time, be it a driving service, E-bike, E-scooter, or carpool, and the guest is informed of the service. The costs are added onto the hotel bill if desired. The guest is reminded of their departure at the corresponding time, and a luggage robot helps transport the luggage from the room to the desired means of transportation.

Because guest feedback is a valuable resource for evaluating service quality in the hotel, this will constantly be requested in the right situation in the Smart FutureHotel Room, and general feedback will be requested at the end of the stay. This makes it possible for as many guests as possible to express their opinion without being annoyed because too many questions have to be answered at once. The feedback can be given in conversation with the PVA or via the hotel app.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Automatic organisation of transportation	Less work for the guest	Increased guest satisfaction	PVA (microphone and speaker), Wi-Fi, software
Luggage robot brings luggage from room to means of transportation	Service and convenience	Increased guest satisfaction	Luggage robot: connection to Smart FutureHotel System, GPS
Guest feedback request via voice input or app	Opinion is appreciated	Help with evaluation of the service – the more feedback, the more meaningful	PVA (microphone and speaker), Wi-Fi, software

Table 23: Benefits for guest and staff/company before departure

4.9.2 SMART CHECK-OUT PROCESS AND POST-CHECK-OUT

When leaving the hotel, the guest can easily check out via one-click in the hotel app. Once it is clear that the guest has ended their stay, for example because they are sitting in the taxi on the way to the airport, an automatic check-out is also possible. The bill is digitally sent to the guest.

Marketing via social media is imperative in a good marketing concept these days. In a Bitkom survey, nearly half of the 103 executive managers and chairpeople of tourism companies who were surveyed said that social media like Facebook and Twitter are important to very important for advertising and marketing their company. This is also confirmed by a survey of 803 internet users, one third of whom say that they get inspiration for new travel destinations from the internet. Nearly half say that the internet is imperative for travel planning (Bitkom 2016).

Guests often have their own social media accounts where they regularly make posts. According to a survey of 2,000 participants, Germans spend an average of 150 minutes per day using social media platforms like YouTube, Facebook, Instagram, Pinterest, Twitter, or Snapchat. Millennials, namely people born between the early 1980s and late 1990s, even spend over five hours per day using these platforms (Pricewaterhouse Coopers (PwC) 2018). In order to increase the number of guests who talk about their own hotel, posts can be generated and suggested to the guest. This suggestion should be customised in that the aspects that were rated positively in the guest feedback and which are pertinent to the booking of a hotel are emphasised. Furthermore, the guest can be asked whether they would like to add matching holiday photos to the post. A reward can be given for making the post, such as in the form of a discount coupon for the next reservation at the hotel. Such an incentive for booking the hotel again can be presented to the guest in a variety of ways: as a gift card for an activity, food, room extras, a discount coupon, or the offer to better personalise their next stay.

After leaving the hotel, the room is immediately open to housekeeping staff. Following the cleaning, the vacuum robot sucks up the remaining crumbs off the floor. All personal data and settings in the guest room are deleted upon check-out and set to neutral. With the guest's consent, personal settings, preferences, environmental parameters, etc., are saved to the guest profile in order to make their next stay even more personalised.

Smart process	Benefits for guest	Benefits for staff/ company	Technology used
Automated check-out	No waiting, swift and seamless process	Less time spent on check-out	Hotel App
Customisable social media post	Guest can easily make post without effort	Marketing for the hotel	Software: Evaluation of feedback – generation of a post, possibly access to guest photos and selection of a suitable motif
Automatic room neutralisation upon check-out	Data security	No staff work required to reset settings	Vacuum robot Central reset and deletion option for the room

Table 24: Benefits for guest and staff/company during check-out

5 OBSTACLES TO IMPLEMENTING SMART SOLUTIONS

Although there are currently many possible ways to implement a smart hotel room, smart solutions in this field are only sporadically encountered in practice (see chapter 2). Many realisations are test or pilot projects. The required technical infrastructures and technology have not yet been taken up as basic requirements in the hotels' planning guidelines. There may be various reasons for this stemming from either the hotel's, guests', or manufacturers' scope of responsibility. Possible obstacles are described below.

5.1 UNCERTAINTY OF HOTEL OPERATORS

Hotel operators' reticent attitude toward innovations can have a variety of reasons, such as lack of knowledge of the **benefit and profitability of innovations**. Hotel operators who have no knowledge of the **cost-benefit ratio** of the innovations generally are also unaware of the long-term potential benefits and possible synergy effects. This deficit can stem from a **lack of personal experienc**e with digital transformation processes or **lacking digital competence**. The entire industry is also marked by a lack of **empirical experience** and communication of important tips among hotel operators. The courage to change things is often missing entirely. A lack of certainty about the future development of technology creates insecurity. Services from technology start-ups enjoy little trust if the future of a young company is not secure.

Technological innovations entail a certain **dependency on the manufacturers** for hotel operators. Every new technological standard simultaneously means a limitation of the possible future components within the hotel's own technical ecosystem. **Lacking reliability and functionality of technology** can make hotel operators feel wary. High **costs of acquisition** for technology that has just arrived on the market are another reason why hotel operators idle in hesitation.

The economy of the hotel industry has been promoting growth and profits for years. The pressure to innovate in the industry is currently low as a result. This may change due to developments in the labour market (lack of qualified professionals), persistent predatory competition, and the demand to develop sustainable, resource-friendly, and environmentally friendly solutions. Not lastly, it is **uncertainty at the onset** of one's own digital transformation that stands in the way of the will to act: where does one begin, what does a strategic digitalisation process in one's own company look like?

5.2 LACK OF AVAILABLE MARKET-READY SOLUTIONS

One significant impediment to the implementation of smart solutions in hotels lies in the fact that many of the solutions have not yet reached the necessary **product- and market-readiness**. The potential of artificial intelligence has been extensively communicated, yet the technology has not been sufficiently developed for many application cases

The need to be able to draw back on a **manufacturer's market-ready complete or system solutions** has been expressed by hotel operators a number of times (see FutureHotel Workshop).

> **»The greatest pain factor for most of us hotel operators is that providers promote isolated solutions and think in terms of interfaces and software solutions, instead of thinking in general terms with regard to the guest.«**
>
> Bruno Marti,
> Chief Brand Officer at 25hours Hotels

For system solutions that connect multiple manufacturers together, there is not only a lack of interfaces but also mainly a central contact for technical support. In general, the development of the required **interfaces** for combining solutions from multiple manufacturers is frequently an obstacle for implementation.

The implementation of partial solutions of a smart hotel room in individual hotels or hotel chains is generally not entirely transferable to other hotels. The main reason for this is the **lack of uniform standards**. This results in the existence of many special solutions that are solely geared toward one's own metrics and methods. These non-standardised applications thus also subject the guest to the unpleasantness of having to always go through a specific learning process before an application can be used intuitively. Furthermore, the lack of standards can result in the inability to use all of the data in the guest's »virtual luggage« (Kansakar et al. 2018).

This prevents the i**mplementation of consistent digital process chains** that justify the usage of individual investments through synergy effects. It is also required that the developers of **hotel management systems (PMS)** quickly react to hotel operators' new needs and manage new requirements for smart systems. If the requirements are not implemented in the PMS, this consequentially prevents the implementation of innovative solutions.

In addition to this, **high-quality hardware is scarcely offered**, while predominantly cheap components with unimpressive quality are more common. Smart technology is typically integrated into the room with an inconspicuous design and is only noticed when it does not function seamlessly (Clarke and Kinghorn 2018).

The required **network coverage** is another obstacle to the implementation of smart, online-based systems. At the same time, there is a **lack of adequate offline systems** available on the market.

Too few **manufacturer-neutral informational events** on the acquisition and benefits of technical ecosystems are offered to hotel operators and their employees. After the products have been acquired, there is still a need for **introductory training** for employees and continuous training throughout the entire usage period. Procedural innovations and the integration of new technology not only require processes of change among employees, but also correspondingly **informative and explanatory communication** geared toward the guests. Lack of communication can quickly result in the user declining new solutions.

5.3 LACK OF PLANNING AND TEAM COMMUNICATION

The planning and implementation of innovation projects are crucial to the projects' successes. Faulty planning can lead to unnecessary expenses and frustration. A **uniform digitalisation strategy** means a complex undertaking in which many responsible parties work closely together. A lack of planning can be caused by **communication deficits between the responsible parties**, thus resulting in planning errors. Involving technical planners early on in the planning stage is sensible in order to integrate their requirements and technical expertise and consider them in the planning. **Budget requirements should be transparent early on** so that there is no planning or development beyond the bounds of the available financial means and there are no disappointments in the end or suspension of the project. The **usability competence of the involved planners and designers** must also be considered in the planning phase. Especially with regard to technical solutions in the field of service environments, the success of the solution not only depends on the technical realisation per se, but also on usability and the user experience. Eliminating such errors down the road can be costly and entail great effort.

Further obstacles preventing good planning include **unclear budget responsibility or uncertain areas of accountability**, as well as conflicts of interest between real estate owners, investors, hotel operators and planners. Hotel operators are generally not able to act independently, and so multiple parties are responsible for successful implementation. In the planning phase these include financial service providers and investors, project developers, and real estate specialists; in the realisation phase these include technical experts, market providers, or third-party companies who later become active service providers.

»For most operators, the problem is not the lack of interest in new concepts or ideas, but rather the possibilities of integration into existing real estate or software processes.«

Bruno Marti,
Chief Brand Officer at 25hours Hotels

The requirements of **existing real estate compared to new structures** impact the possible implementations. Structural requirements differ in this regard, and influence the potential solution.

»One special requirement that affects many hotel operators equally is retrofitting and digitalisation within an existing property. The new standards and product selection should thus be carefully considered and strategic in nature.«

Thomas Behrendt,
GM of SI-SUITES Hotels, Stuttgart

5.4 INSUFFICIENT AND VARYING REQUIREMENTS FOR IMPLEMENTATION

First and foremost, companies differ in the **financial budgets available** to them. When implementing innovative hotel room solutions, not only the question of what is needed or desired and whether and to what extent the solutions are profitable in the long term arises, but also which financing options are available to the company (e.g. leasing or purchase).

In terms of **scalability** of innovative solutions, hotel chains are in a more favourable starting position than individual hotels. This results in a better negotiating basis for hotel chains and possible bulk discounts from which individual hotels often cannot profit.

Some of the basic requirements for the implementation of smart hotel rooms are missing entirely. For German providers in particular, the scarce coverage of many regions with **high-speed internet and mobile networks** is an obstacle for the implementation of smart solutions in one's own company. In addition, the WiFi connection in the hotels is often insufficient for smart solutions.

The **legal situation in matters of digitalisation is country-specific**, and sometimes even state-specific in Germany. The legal foundations are difficult to understand and they also vary. Examples of this are locally regulated installation and importing requirements. Political conditions concerning the **disclosure and usage rights of data** vary in different countries, and are regulated in Europe by the General Data Protection Regulation (GDPR). Along with legal obstacles, **ethical doubts** concerning the treatment of privacy, personal data, and data security may be frightening. The thought of perhaps receiving negative press in the public eye can result in reticence. Because a smart hotel room depends on access to and usage of data, the security of that data is an elementary requirement for the required trust from users in the hotel company and smart solutions.

The majority of hotel operators **focus first on marketing, sales, and distribution** when it comes to their digital strategies. Comprehensive digital solutions for guests' actual stays in the hotel environment have scarcely been implemented by most hotel operators.

When integrating highly innovative solutions from young companies or start-ups, hotel operators take on the risk that the provider will not persist in the market, meaning there will be no more support or there will be security gaps as a result of no upgrades.

5.5 UNCERTAINTY AND LACK OF ACCEPTANCE AMONG GUESTS

If the **available technology cannot be used intuitively**, it will either not be used at all or guests will be annoyed and frustrated, and will then avoid it. This explains why hotel operators often wait and see which solutions have proven themselves in other hotels.

Guest feedback is often not enough to gain an overall picture of guest satisfaction with all of the room's factors. Either an insufficient number of guests provide feedback, or the satisfaction questionnaires do not go into enough detail on the needs situation. Many hotels do not make stringent use of the feedback to determine needs for action and measures. One reason for this is that deficits are not communicated to the decision-makers so as not to shed a negative light on the staff. Possible optimisations fall too short as a result. A lot of hotels are insufficiently aware of their guests' **need for innovative solutions**. Information on novel solutions cannot generally be derived from the guest feedback, as the guest is unaware of the innovations and thus cannot review them, or there is no explicit demand due to the lack of knowledge about the theoretical possibility thereof.

Because the guest is only beginning to discover the merits of new technology, t**hey do not feel it is missing in the hotel room** as a basic function or fundamental satisfaction characteristic. This explains guests' currently low demand for smart technology in the hotel room. For example, in Germany there is **scepticism of artificial intelligence**. According to an Ipsos study with 18,000 international participants, only 21% of Germans trust artificial intelligence, while 50% have no trust in it. Only Canadians are more sceptical, of whom 55% say they have no trust in AI. On the other hand, 70% of Chinese participants say that they trust AI (Colledge and Martyn 2018). This scepticism is partially attributable to the idea that the line between currently available AI and so-called »superintelligence«, which appears threatening, is thinner than it actually is. The current media reporting on »**data leaks**« and violations of user privacy reinforce this scepticism. One exemplary report in this regard is »Datenleak: Millionen Passwörter im Netz veröffentlicht« about passwords leaked online (ZEIT ONLINE GmbH 2019) or the report »Amazon schickt Alexa-Gespräche an Heimarbeiter in Polen« about Amazon sending Alexa conversations to third parties Poland (Fuest 2019).

5.6 INSUFFICIENT REQUIREMENTS FOR THE MANUFACTURERS

The implementation of system solutions for individual manufacturers is made difficult by the **lack of uniform standards**. This **results in fragmented technology**. Many manufacturers offer a variety of **(isolated) solutions** that are based on a range of technology and are not compatible with each other. The manufacturers develop the products although it is often uncertain who is responsible for the **costs and expenses of the required interfaces** to other potential system components. In the first stage it is easier for the manufacturers to only develop and offer small, self-contained parts (silo applications) or proprietary solutions within a potential smart ecosystem.

For manufacturers themselves, the evaluation of usage of their products is an important aspect of **quality assurance**. The evaluation of solutions after their implementation in hotel operations has not yet been standardised. Many manufacturers are scarcely aware of the strengths and weaknesses of the products from the perspective of different users while in operation. Positive and negative feedback is a factor for joint learning and fact-based development.

Additional potential obstacles for the development of the required smart products in the Smart FutureHotel Room include responsible parties failing to convey important information, such as requirements, to technical planners and manufacturers.

There is a fundamental lack of networking or connection between PMS and smart home technology, and between building / media technology and the channels used for marketing, sales and distribution, facility management, and employee and guest communication. Only when all of these components are interconnected does the synergy effect set in, which is a great step toward digital transformation in the hotel industry.

6 RECOMMENDED ACTIONS FOR PRACTICE

The basis for corresponding projects is the hotel operators' knowledge that smart technology holds potential, such as an improved guest experience, increased employee satisfaction, and economic and ecological improvement of operative processes. A study of 2,590 hotel operators by the Fraunhofer IAO shows that the success factors »hotel performance«, »guest satisfaction«, and »hotel operator satisfaction« correlate with the degree of »trendsetting«, i.e. they depend on the early implementation of innovative ideas for practice (Borkmann et al. 2011). Specific recommended actions for practice are elucidated below.

6.1 INITIAL SITUATION, MANAGEMENT OF NEEDS AND REQUIREMENTS

A smart hotel room is necessarily embedded into a smart hotel environment. The concept of »digital from A-Z« must be implemented in the entire hotel, and not limited to isolated solutions.

The usage of new technology should not be taken lightly or used purely as a marketing tactic, but rather should be integrated into a cohesive digital concept. A company that would like to implement its own **digital strategy** should first answer the following questions:

- Needs and benefit analysis: what is required and sensible? Whom should it benefit?
- Budget: what is financially feasible? How much budget is available?
- Technological possibilities: what can be implemented?

UIn order to get an overview of the technological possibilities, the needs situation, and experience from the industry, there are a variety of resources to use as sources of information. According to a survey of hotel operators, they primarily refer to trend reports, conversations with experts, and organised innovation and network meetings. But also visiting other hotels, targeted market research and surveys, personal conversations with hotel guests, feedback from online guest forums, employee conversations, the creation of a testing environment or model room, as well as the development of future scenarios with external experts number among the preferred actions (Borkmann et al. 2011).

6.2 INITIAL PROJECT PLANNING AND DETERMINATION OF REALISATION PARTNERS

Consulting experts is advised during the initial project planning. When **determining the project partners**, including designers, architects, consultants, technical planners, technology manufacturers, hard-/software providers, and vendors, the selection should be made carefully as knowledge exchange among partners at a later stage in a project usually entails great expense and effort. In the phase leading up to planning, it is important to define the objectives and develop the suitable scenario for the specific operation. The following questions must be answered:

- **Level of standardisation:** Is a standard solution sufficient, or is an individually adjusted or self-developed solution required?
- **Conditions:** What requirements (structural, legal, financial, technological – e.g. data transfer rate) must be fulfilled?
- **Financial expense:** What budget is required for acquisition? What ongoing costs are to be expected? Is it possible to save costs by means of technology?
- **Selection process:** What solution is appropriate for the specific requirements? Which provider has the right solution? What references are available? What are the differences between quotes from different manufacturers? Is sufficient information provided, are workshops or online demos offered? Is free test usage offered?
- **Contract situation:** How are the special conditions of the contract, e.g. duration (automatic contract duration, cancellation term), hidden costs (setup, interfaces), inclusive services (training and support offers), penalties and special right of cancellation?
- **System administration:** How is a smart system managed and how are updates integrated? With a large number of sensors in particular, this consideration is important as each sensor poses a potential security risk because it serves as an entrance point into the system for hackers.

6.3 GRADUAL IMPLEMENTATION IN OPERATIONS

Before innovations are comprehensively implemented in the entire hotel, these should be tested first. Innovative ideas are ideally implemented and evaluated as a small solution and test case to start with. This allows for **the early detection and elimination of defects, and the avoidance of high costs and frustration**. Potential improvements can be identified and addressed in the next phase of implementation. Digitalisation offers a multitude of new solutions and possibilities. Due to changes to the companies, tried-and-true solutions must be done away with as well. This demands bold decisions, as sometimes there is little empirical experience with innovations.

»Hardly any industry is as ideally suited for modular construction as the hospitality industry. The reproducibility of the guest rooms offers great potential for industrialising the building process.«

Stefan Löhr,
Senior Product Manager International Markets
& Business Development at Albrecht JUNG GmbH & Co. KG

The success of innovative solutions often depends on not taking a multi-pronged approach, but rather being completely open to new concepts. A multi-pronged method generally contradicts the achievement of an acceptable business case (scenario for assessing an investment) and return on investment (economic figure for measuring profits) with new solutions.

Below is an incomplete list of ways to test the implementation of a smart hotel room or smart individual solutions in the room early on:

Digital planning and construction with building information monitoring (BIM) offers the possibility of virtually planning the construction of a building with inclusion of all relevant technical areas. This facilitates the transparent configuration of planning for all parties involved. With this, »Schedules, costs, and risks [...] can be documented more easily, earlier, and more precisely, and monitored seamlessly« (BMVI 2019). The digital model of the building is called the **digital twin**.

A mock-up room is a model room that can be equipped with new technology in order to test it. The room can be used not only by guests, but also by hotel staff such as housekeeping and

technicians in order to scope out as many potential problems as possible. This model room does not have to exist in real life, but can rather be a digital twin of the planned room (**virtual model room**) that one can visit and test via virtual reality.

Throughout the course of implementation, it is recommended that a detailed schedule be created and the respective responsibilities precisely defined. Regular and efficient communication between the responsible parties helps avoid misunderstandings or clear them up early on. This is aided by **digital collaboration tools**.

New solutions generally entail **changes to employees' work processes**. One important success factor is the early involvement of employees and making them acquainted with the changes. Employees who are impressed and excited by the amenities of the smart hotel reflect this enthusiasm outwardly as well. **Training and workshops** help teach the personnel how to work with the new hardware and software professionally so that they can **make full use of its potential and assist the guest** in case of any difficulties.

6.4 INVOLVEMENT OF PERSONNEL

The usage of technology and digitalisation can relieve the staff's workload while also creating new tasks. A detailed examination of **the effect of innovations on operative processes** is recommended for a seamless process.

»The integration of smart, interlinked building technology must neither overwhelm the guest with regard to its use nor prevent housekeeping from performing their tasks.«

Stefan Löhr,

Senior Product Manager International Markets
& Business Developmentat Albrecht JUNG GmbH & Co. KG

For example, preparation of the room is changed by the implementation of attribute-based booking. Alongside thorough cleaning, the personnel are required to adapt the room's amenities to the next guest and place the reserved extras in the room.

Figure 50: Digital switches from Jung GmbH & Co. KG

The usage of AI technology in particular can trigger feelings of **uncertainty and fear** among hotel guests. In matters of digitalisation the model of »**reverse mentoring**« can be employed, meaning that young employees (digital natives) assist older colleagues and managers as mentors, and provide an important perspective on decisions concerning the usage of technology. However, it must be considered that young people lack the experience to assess the consequences thereof for the company.

Staff should be able to answer questions competently. Open communication is an important measure for acceptance by guests and employees alike. Building tours or informational events can be offered for interested guests. The hotel staff should undergo **regular training sessions** in order to be competent in matters of **working with technology**, such as **data security and legal parameters**. Furthermore, the staff requires reliable access to **support function**s when needed.

6.5 EVALUATION AND TESTING

With regard to innovation projects, a **test phase for pre- and post-evaluation** of the solutions via neutral institutions such as agencies or research institutes, should be offered by the manufacturers. This means that feedback on suggested improvements is considered in the innovation process from the start. Test phases can take place throughout the course of product development, but also after a certain operating phase if feedback can be obtained from guests and employees during actual operation. A specific request and evaluation of the feedback provides valuable insight into which components of the smart hotel room are well received and which aspects are worth improving. Measures for improvement are drawn up and implemented on this basis. In order to be able to react quickly to negative feedback, a **truthful flow of information** between the guest and staff is important.

6.6 MARKETING THE INNOVATIVE SOLUTION

Innovative concepts can be beneficial to the public, increase awareness, and entice new, interested guests and potential employees. Targeted **marketing** for opening a smart hotel room is advantageous to the hotel operator and their realisation partners.

It is also prudent to include the new offers in **communication with guests**. The potential guest should already have been made aware of the benefits and convenience aspects of the smart hotel room before their bookings, thereby gaining new incentive to make a reservation.

Unique features can be integrated into the marketing. Possible advantages that smart functions entail include VR tours for explaining and booking the room features and the room design, or room demonstrations with a 3D 360° panoramic view.

The respective content for this **communication strategy** must be developed by agencies. These should be coordinated through various communication channels and continuously updated. The effort that this entails cannot be underestimated.

Along with guests, **employees** must also be involved in the communication of innovative solutions. Employees serve as an interface between the guest and technology, and thus have a special responsibility to convey the unique features even if some guests are initially sceptical of unknown solutions.

7 OUTLOOK

Are the smart solutions described here the apex of digital development in the hotel room? In an age when technology is advancing at an unprecedented rate, there will soon be new possibilities and solutions that will make staying at a hotel even more convenient and customised for the guest.

When this report discusses a smart hotel room, it must be ensured that this is embedded in a smart ecosystem that concerns the entire hotel. In order to live up to new technical possibilities, guest's needs, and the operative requirements, this smart ecosystem will have to continuously evolve. Even now we are aware of the next technological stages of development that entail new prospects for configuring the smart hotel.

The technological future is »**cognitive**«. The word »cognitive« describes the natural interaction of a computer system with a human, shaped and facilitated by the system's ability to learn and draw logical conclusions (Sommer 2017).

New stages of development can be achieved in the application area of »predictive services« and »predictive travel experiences« in the future. AI technology is facing increased demand. This includes »**Conversational AI**«, with which (for example) virtual assistants can be spoken with to control functions in the hotel room. In addition to interaction via voice, facial expression, or gestures, operation will be possible with thought alone. **Brain-Computer Interfaces (BCI)** allow for the measurement and analysis of brain activities and the conversion thereof into control signals (Borkmann et al. 2016). This technology has been developed to the point that speech can be interpreted from brain waves, in which the signals are fed into a virtual voice apparatus. In the future this will allow people who have lost their capacity for speech to communicate with a virtual assistant (Pluta 2019). The user could hence »think« their commands in the future and no longer have to speak them aloud. One solution for this is offered by Facebook-owned start-up ***Ctrl-Labs***, which hopes to make it possible to control appliances by thought. To do this, the start-up uses an armband to receive neural signals on the path to the muscles, and then transmit the corresponding commands to the device to be operated (Spiegel Online 2019). **Human-Computer Interaction (HCI)** via minimal body language is already possible through radio waves, such as with Google's interaction sensor Soli (Google ATAP 2019). »Virtual regulators and dials will allow this technology to control nearly all technical devices and objects. This will be supported by small implants, for example, or one's own smart devices« (Borkmann and Rief 2011).

The cognitive future also entails the scenario that doors are no longer opened via NFC on one's mobile device, but rather via implants in the guest's arm that are equipped with an RFID or NFC chip. Access is thus made more seamless and secure. The chip will also facilitate personal authentication and payment. As early as 2017, some Swedes had implants with NFC chips inserted under their skin, enabling them to pay for them in the bus, for example (Potor 2017). The company ***I am Robot*** from Dortmund offers NFC implants including surgery by a piercer. The chip can open doors, share information, read emergency information, and perform many other functions (Sven Becker – I am ROBOT 2019).

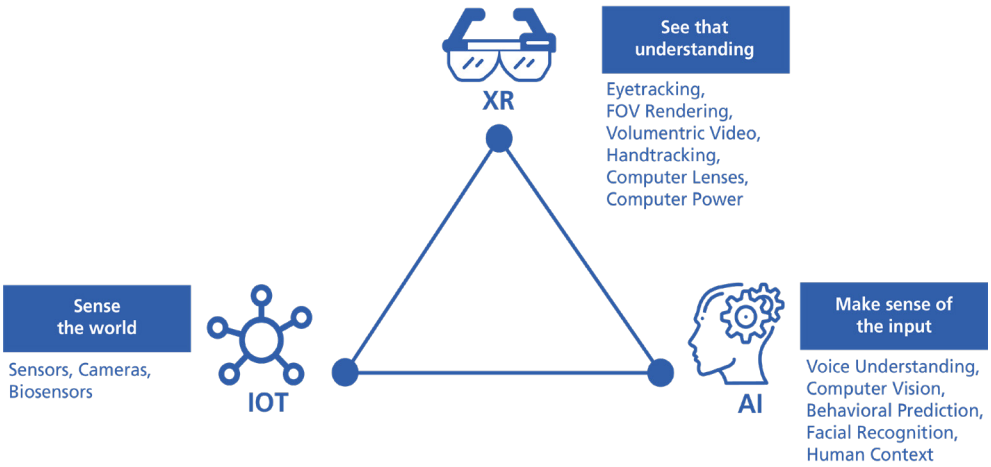

Figure 51:
The super intelligence of tomorrow (Khora VR 2019)

In Figure 51, Danish company Khora presents an image of the **super-human of tomorrow**. This means that IoT uses sensors to record the world while XR provides access to the digital world, which is in turn curated into a personal experience by AI assistants. The guest of the future will continue to change along with their entire environment with help from technology like XR, AI, and IoT. Through the interaction and linking of the various components, the super-human's cognitive ability will expand, their perception will be qualitatively and quantitatively improved, and their knowledge will be enhanced.

Through wearables, smart glasses, and other technological tools, the guest's reality will continuously expand. Along with the perceived reality of the space, the virtual reality will become ever more present and digitally augment the analogue world. Smart glasses provide information about the hotel or the communication partner during an interaction. A hearable translates in realtime when hotel employee and guest's communicate, both in their native language. »Augmented reality will become the human-environment interface of the future. It will become increasingly difficult to differentiate between real and virtual information. The difference between reality and virtuality will be relative. In many cases, both realms will be connected« (Borkmann et al. 2016).

8 EPILOGUE

This report presents the current technical possibilities. The journey to a smart hotel room requires self-reflection and a critical approach to the technical possibilities for each hotel company individually. The implementation of measures must be planned a long time in advance.

The usage of additional technology can quickly result in increased energy consumption, and thus more expenses. Furthermore, in addition to the costs of procurement are those for maintenance and upkeep. On the other hand, innovations can aid in saving on resources and potentially additional income. For example, hotel operators can take advantage of marketing effects facilitated by the use of smart technology and demand higher room prices, promote extra sales, and reduce the costs of personnel.

Smart hotel rooms will not be implemented as the first step in a company's digital transformation. When considered on its own, it hardly constitutes a business case. Yet if the necessary conditions are met and the infrastructure is in place in the hotel, the step toward a smart hotel room is a small one, and the potential benefits are promising.

The FutureHotel research project is a leading-edge think tank in the field of trend research for the hotel industry. We offer a direct partnership with hotels interested in solutions for configuring their own business in an innovative and trailblazing manner. We are always available for a personal diglogue, and look forward to hearing from you.

9 GLOSSARY

Amenities: »Amenities are additional functions that increase the value of a property / offer. This could be a swimming pool or a shopping centre, for example« (Borkmann and Rief 2017).

Ambient Intelligence: »A smart, digitalised environment that can interact with and appropriately react to the person, e.g. via integrated sensors« (Borkmann et al. 2016).

Big Data: »Refers to continuously growing, large quantities of data. Their complexity prevents them from being evaluated by traditional data processing tools« (Borkmann et al. 2016).

Brain-Computer-Interface (BCI): »Movement impulses in the brain, such as electronic activities, are recorded, analysed, and converted into control signals. For example, devices can be controlled by one's own thoughts with this technology« (Borkmann et al. 2016).

Building Information Modeling (BIM): »BIM describes a software based on a 3D model. All relevant building and product data are automatically stored, linked, and synchronised. Effects of changes, including on other areas, are visualised in a virtual building model and, for example, adjust themselves accordingly« (Borkmann et al. 2016).

Cloud Computing: »Cloud computing« means that computing resources like memory, databases, or software are provided via the internet (Microsoft Corporation 2019).

Cognitive Computing: »Cognitive computer systems are able to learn to think like people. With cognitive intelligence, they acquaint themselves with the learning content, draw conclusions, and provide predictions and advice. At the same time, the high computational output of computers is also available« (Borkmann et al. 2016).

Head-Up Display: A transparent display that shows additional information. For example, these are used for car windscreens so that the driver can always keep an eye on their current speed and navigation while driving (Hoffmann 2016).

Hearables: »Smart« headphones that contain functions in addition to listening to music. For instance, they can track the wearer's activities through sensors and visualise them on the wearer's smartphone via a wireless connection (Hearables.de 2019).

Holographic System: A system that allows for the free generation of a 3D projection in the room. The DeepFrame makes this possible, for example (REALFICTION 2019).

Infotainment: »As a portmanteau of the words 'information' and 'entertainment', infotainment is the conveyance of information and knowledge through multimedia« (Borkmann et al. 2016).

Intelligent Sportswear: Clothing that, for example, measures muscle activity and visualises it in real-time via an app on the wearer's smartphone in order to ensure optimal exercise (itwissen.info 2019b).

Predictive Service: »Predictive service reacts to a hotel guest's personal needs. Using databases and algorithms, the guest's behaviour, needs, and wishes can be predicted. A customised service, possibly via the telepathy in the future, is possible. Sensors also independently detect changes in the product inventory and automatically send out new orders« (Borkmann et al. 2016).

Seamless Travel Experience: The seamless travel experience is a continuous, smooth experience for the traveller. This experience is distinguished by the fact that there are no disruptions to the desired user experience, such as those that could arise from changing between various interaction partners, end devices, or applications.

Smart Contracts: These are contracts based on computer protocols and blockchain technology. They are self-performing once the contract condition directly written in the code between the buyer and seller has verifiably been fulfilled (e.g. receipt of payment) (Schiller 2019).

Smart Devices: »Smart devices are electronic appliances that are used for processing information and for communication. With sensors, they allow for mobile, wireless, and interconnected use. Smartphones, data glasses, or tablets« (Borkmann et al. 2016).

Smart Glasses: Also known as data glasses. They serve to project images directly onto the retina via glass prisms, thereby adding information to the user's field of vision without blocking their view of their actual surroundings. This in turn facilitates augmented or mixed reality (itwissen.info 2019a).

Superintelligence: A superintelligence is an intellect that is superior to the human brain in every discipline, including scientific creativity, general wisdom, and social skills (Bostrom 1997).

Wallet: A wallet in this context is a digital collection folder in which, for example, debit/credit/prepaid cards, gift cards, boarding passes, coupons, and customer cards can be stored. Access authorisations (mobile keys) can also be stored and accessed here (Apple Inc. 2019).

10 INDEXES

10.1 INDEX OF FIGURES

10.2 INDEX OF TABLES

10.3 BIBLIOGRAPHY

Accor (Hg.) (2018): Hospitality trends in 2018. Group.accor.com. Online verfügbar unter https://group.accor.com/en/Actualites/2018/02/08/hospitality-trends-2018, zuletzt aktualisiert am 02.08.2018, zuletzt geprüft am 26.08.2019.

Airoldi (2019): Loews Hotels Will Personalize Guest Experiences with Ireckonu. Hg. v. Business Travel News. Businesstravelnews.com. Online verfügbar unter https://www.businesstravelnews.com/Lodging/Loews-Hotels-Partners-Will-Personalize-Guest-Experiences-with-Ireckonu, zuletzt aktualisiert am 06.05.2019, zuletzt geprüft am 03.09.2019.

Albrand, Carolin (2017): Virtual Reality und 360°-Videos. Der Zuschauer wird zum Augenzeugen. Hg. v. SÜDWESTRUNDFUNK Anstalt des öffentlichen Rechts. ARD.de. Online verfügbar unter http://www.ard.de/home/ard/Was_ist_Virtual_Reality/3364362/index.html, zuletzt aktualisiert am 2017, zuletzt geprüft am 14.08.2019.

Allgemeine Hotel- und Gastronomie-Zeitung (Hg.) (2018): Vom Ratshotel zum Smartel. Die Software-Firma Tobit hat ein Bestandshotel übernommen und voll durchdigitalisiert. Ahgz.de. Online verfügbar unter https://www.ahgz.de/news/technik-konzept-vom-ratshotel-zum-smartel,200012248032.html, zuletzt aktualisiert am 11.06.2018, zuletzt geprüft am 16.09.2019.

Allgemeine Hotel- und Gastronomie-Zeitung (Hg.) (2019): Themenseite: Yotel. Ahgz.de. Online verfügbar unter https://www.ahgz.de/thema/yotel, zuletzt aktualisiert am 2019, zuletzt geprüft am 03.09.2019.

Aloft Hotels (Hg.) (2019): Aloft Hotels. Aloft-hotels.marriott.com. Online verfügbar unter https://aloft-hotels.marriott.com, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.08.2019.

Amadeus IT Group SA (2019): Drivers of Change in Hospitality. Unter Mitarbeit von Amadeus, InterContinental Hotels Group (IHG), Cornell's Center of Hospitality Research, Foresight Factory. Online verfügbar unter https://amadeus.com/en/insights/white-paper/drivers-of-change-in-hospitality, zuletzt geprüft am 23.09.2019.

Apple Inc. (Hg.) (2019): Wallet auf dem iPhone oder iPod touch verwenden. Apple.com. Online verfügbar unter https://support.apple.com/de-de/HT204003, zuletzt aktualisiert am 2019, zuletzt geprüft am 23.09.2019.

Arlotta, C. J. (2018): IHG, Baidu collaborate on AI rooms in Greater China. Hg. v. Hotel Business. Hotelbusiness.com. Online verfügbar unter ttps://www.hotelbusiness.com/ihg-baidu-collaborate-on-ai-rooms-in-greater-china/, zuletzt aktualisiert am 21.08.2018, zuletzt geprüft am 10.09.2019.

Axel Springer SE (Hg.) (2018): Massiver Hackerangriff auf Marriott-Konzern. Welt.de. Online verfügbar unter https://www.welt.de/newsticker/news1/article184742436/Datenschutz-Massiver-Hackerangriff-auf-Marriott-Konzern.html, zuletzt aktualisiert am 30.11.2018, zuletzt geprüft am 23-09.2019.

Ball, Dwayne; Coelho, Pedro S.; Vilares, Manuel J. (2006): Service personalization and loyalty. In: Journal of Services Marketing 20 (6), S. 391–403. DOI: 10.1108/08876040610691284.

Bataillard, Roger (2017): Smart Rooms. Hg. v. Seesicht. Seesichtmagazin.ch. Online verfügbar unter https://seesichtmagazin.ch/aktuelles/smart-rooms, zuletzt aktualisiert am 12.05.2017, zuletzt geprüft am 27.08.2019.

Bendel, Oliver (2019): Definition: Smart Home. Hg. v. Gabler Wirtschaftslexikon. Wirtschaftslexikon.gabler.de. Online verfügbar unter https://wirtschaftslexikon.gabler.de/definition/smart-home-54137/version-368820, zuletzt aktualisiert am 2019, zuletzt geprüft am 24.06.2019.

Bitkom (2016): Social Media ist wichtig im Tourismus-Marketing. Berlin. Paulsen, Nina; Kinne, Lisa. Online verfügbar unter https://www.bitkom.org/Presse/Presseinformation/Social-Media-ist-wichtig-im-Tourismus-Marketing.html, zuletzt geprüft am 17.07.2019.

Bitkom (2019a): 8 digitale Technologien, die den Urlaub noch besser machen. Berlin. Paulsen, Nina; Kinne, Lisa. Online verfügbar unter https://www.bitkom.org/Presse/Presseinformation/8-digitale-Technologien-die-den-Urlaub-noch-besser-machen, zuletzt geprüft am 17.07.2019.

Bitkom (2019b): Deutsche Hotels haben bei Internet und WLAN Nachholbedarf. Berlin. Paulsen, Nina; Kinne, Lisa. Online verfügbar unter https://www.bitkom.org/Presse/Presseinformation/Deutsche-Hotels-haben-bei-Internet-und-WLAN-Nachholbedarf, zuletzt geprüft am 17.07.2019.

Bitkom (2019c): Smartphone-Markt wächst um 3 Prozent auf 34 Milliarden Euro. Pauly, Bastian; Kriegeskotte, Nick. Online verfügbar unter https://www.bitkom.org/Presse/Presseinformation/Smartphone-Markt-waechst-um-3-Prozent-auf-34-Milliarden-Euro, zuletzt geprüft am 12.08.2019.

BLE-MESH.com (Hg.) (2019): BLE-MESH.com. Connecting the things. BLE-MESH.com. Online verfügbar unter http://ble-mesh.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

BLOC Hotels (Hg.) (2019): Rooms. Blochotels.com. Online verfügbar unter https://www.blochotels.com/rooms#1, zuletzt geprüft am 10.09.2019.

Blow UpHall (Hg.) (2019): blow up hall. innovations. blowuphall5050.com. Online verfügbar unter http://www.blowuphall5050.com/hotel-en, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.08.2019.

BMVI (2019): Digitales Planen und Bauen. Stufenplan zur Einführung von Building Information Modeling (BIM). Hg. v. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). Online verfügbar unter https://www.bmvi.de/SharedDocs/DE/Artikel/DG/digitales-bauen.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 19.08.2019.

Borkmann, Vanessa (2015): FutureHotel international hotel guest survey. Study as part of the FutureHotel research project ; a survey on innovative solutions conducted with hotel guests from selected international markets. Stuttgart: Fraunhofer-Verl. Online verfügbar unter http://www.bookshop.fraunhofer.de/buch/242269.

Borkmann, Vanessa (2018): Entwicklung eines Modells zur Ermittlung psychischer Beanspruchung am Beispiel von Reisenden bei geschäftlich bedingten Hotelaufenthalten. Unter Mitarbeit von Dieter Spath und Hans-Jörg Bullinger. Hg. v. Fraunhofer Verlag. Institut für Arbeitswissenschaft und Technologiemanagement IAT der Universität Stuttgart, Stuttgart Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO, Stuttgart. Online verfügbar unter https://elib.uni-stuttgart.de/bitstream/11682/10259/5/Borkmann_Dissertation.pdf, zuletzt geprüft am 13.08.2019.

Borkmann, Vanessa; Klein, Sascha; Lambertus, Janina (2016): FutureHotel Building 2052. Visionen und Lösungen für das Hotelgebäude der Zukunft. Stuttgart: Fraunhofer Verlag. Online verfügbar unter http://publica.fraunhofer.de/dokumente/N-393607.html.

Borkmann, Vanessa; Rief, Stefan (2011): Leading-Edge Hotelumgebung 2012. FutureHotel - Leitfaden. Unter Mitarbeit von FutureHotel-Projektpartner der Forschungsphase 2010-2012. Stuttgart: Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO.

Borkmann, Vanessa; Rief, Stefan (2017): FutureHotel Baderlebnis 2030. Visionen und Lösungen für das Hotelbad der Zukunft : Studie aus dem Forschungsprojekt Futurehotel. Stuttgart: Fraunhofer Verlag. Online verfügbar unter http://shop.iao.fraunhofer.de/details.php?id=699.

Borkmann, Vanessa; Rief, Stefan; Iber, Benjamin (2014a): FutureHotel Gastbefragung 2013: Ergebnisband DACH-Markt. Studie aus dem Forschungsprojekt FutureHotel ; eine Erhebung zu innovativen Lösungen für die Hotelgäste der Hotellerie im Dach-Markt. 1. Aufl. Stuttgart: Fraunhofer-Verlag. Online verfügbar unter http://publica.fraunhofer.de/dokumente/N-272393.html.

Borkmann, Vanessa; Rief, Stefan; Regler, S. (2009): Gaststudie FutureHotel. Auswertung der Hotelgastbefragung 2009. Internes Dokument: Fraunhofer Verlag.

Borkmann, Vanessa; Rief, Stefan; Strunck, Stefan (2017a): Der Alpentourismus der Zukunft. Trends - Ideen - Chancen. Unter Mitarbeit von Jamie Niederer. Innsbruck, Wien: Haymon Verlag.

Borkmann, Vanessa; Rief, Stefan; Strunck, Stefan (2017b): FutureHotel Spa- und Wellness Erlebnisse. Studie aus dem Forschungsprojekt FutureHotel: Ergebnisse der Gast- und Hoteliersbefragung zum Wellnesserlebnis im Hotel. Stuttgart: Fraunhofer Verlag.

Borkmann, Vanessa; Rief, Stefan; Wagner, Stefanie (2014b): FutureHotel Small Medium. Situation und Perspektive der Individualhotellerie des 1 - 3 Sterne Segments im deutschsprachigen Raum ; Impulse und Handlungsempfehlungen für die Praxis ; Studie aus dem Forschungsprojekt FutureHotel. 1. Aufl. Stuttgart: Fraunhofer-Verl. Online verfügbar unter http://www.bookshop.fraunhofer.de/buch/241307.

Borkmann, Vanessa; Rief, Stefan; Weber, Clara (2011): FutureHotel Hoteliersbefragung. Eine Erhebung zu innovativen Lösungen für die Hotellerie: Status Quo und zukünftige Entwicklungen. Stuttgart: Fraunhofer Verl. Online verfügbar unter http://www.bookshop.fraunhofer.de/buch/236591.

Bostrom, Nick (1997): How long before Superintelligence? Hg. v. Oxfrord Future of Humanity Institute, University of Oxford. Online verfügbar unter https://nickbostrom.com/superintelligence.html, zuletzt aktualisiert am 12.03.2008, zuletzt geprüft am 23.09.2019.

Boutique Hotelier (Hg.) (2013): EXCLUSIVE: Bloc plans to open 10 hotels in five years. Boutiquehotelier.com. Online verfügbar unter https://www.boutiquehotelier.com/exclusive-bloc-plans-to-open-10-hotels-in-five-years/, zuletzt aktualisiert am 10.12.2013, zuletzt geprüft am 10.09.2019.

Brack, Andrea (2018): Budapest: Dieses Hotel kommt (fast) ohne Personal aus. Hg. v. Madsack Vertical GmbH & Co. KG. Reisereporter.de. Online verfügbar unter https://www.reisereporter.de/artikel/3459-budapest-smartphone-hotel-dieses-hotel-kommt-fast ohne-personal-aus, zuletzt aktualisiert am 18.03.2018, zuletzt geprüft am 17.09.2019.

Brandstetter, Jonas (2018): Progressive Web Apps: Was ist das? Einfach erklärt. Hg. v. CHIP Digital GmbH. Chip.de. Online verfügbar unter https://praxistipps.chip.de progressive-web-apps-was-ist-das-einfach-erklaert_98066, zuletzt geprüft am 25.06.2019.

Braunstein, Leslie (2018): Hilton Rolls Out Mobile-Centric »Connected Room« Technology. Hg. v. Urban Land Institute (ULI). Urbanland.uli.org. Online verfügbar unter https://urbanland.uli.org/industry-sectors/hilton-rolls-mobile-centric-connected-room-technology/, zuletzt aktualisiert am 18.01.2018, zuletzt geprüft am 16.09.2019.

Brennan, Tom (2019): Introducing Alibaba's Flyzoo Future Hotel. Hg. v. Alizila - News from Alibaba Group. Alizila.com. Online verfügbar unter https://www.alizila.com introducing-alibabas-flyzoo-future-hotel/, zuletzt aktualisiert am 11.03.2019, zuletzt geprüft am 06.09.2019.

Bright, Craig (2017): Grand Ambassador Seoul introduces 25 Smart Rooms. Hg. v. Business Traveller. Businesstraveller.com. Online verfügbar unter https://www.businesstraveller.com/business-travel/2017/07/12/grand-ambassador-seoul-introduces-15-internet-things-smart-rooms/, zuletzt aktualisiert am 12.07.2017, zuletzt geprüft am 26.08.2019.

Briscoe, G.; Wilde, P. De (2006): Digital Ecosystems: Evolving Service-Oriented Architectures. Online verfügbar unter http://arxiv.org/pdf/0712.4102v6.

Brucker, Bettina (2013): Ambient Intelligence. Was ist das denn? Hg. v. Haufe-Lexware GmbH & Co. KG. Haufe.de. Online verfügbar unter https://www.haufe.de/arbeitsschutz/sicherheit/was-ist-denn-ambient-intelligence_96_163380.html, zuletzt aktualisiert am 12.02.2013, zuletzt geprüft am 23.09.2019.

Bundesministerium für Wirtschaft und Energie (Hg.) (2019): Eckpunkte der Bundesregierung Orientierungsrahmen für eine nationale Tourismusstrategie. Kabinettsbeschluss der Bundesregierung vom 30.04.2019.

Caswell, Mark (2017): Marriott creates 'smart' shower door. Hg. v. Business Traveller. Businesstraveller.com. Online verfügbar unter https://www.businesstraveller.com/business-travel/2017/12/04/marriott-creates-smart-shower-door/, zuletzt aktualisiert am 04.12.2017, zuletzt geprüft am 26.08.2019.

CitizenM (Hg.) (2019a): citizenM says: the most fun you'll have in 14 sq m. CitizenM.com. Online verfügbar unter https://www.citizenm.com/content/innovative-rooms, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.08.2019.

CitizenM (Hg.) (2019b): portfolio & rollout. Meet the best hotels in the world's best cities CitizenM.com. Online verfügbar unter https://www.citizenm.com/company/portfolio-and-roll-out, zuletzt aktualisiert am 2019, zuletzt geprüft am 23.09.2019.

City Hub (Hg.) (2019): City Hub Amsterdam. Your Key to Amsterdam. Cityhub.com. Online verfügbar unter https://cityhub.com/amsterdam/, zuletzt geprüft am 10.09.2019.

Clarke, David; Kinghorn, Ron (2018): Experience is everything: Here's how to get its right. Hg. v. Jennifer Meritt. Pricewaterhouse Coopers (PwC). Online verfügbar unter https://www.pwc.com/us/en/advisory-services/publications/consumer-intelligence-series/pwc-consumer-intelligence-series-customer-experience.pdf, zuletzt geprüft am 19.07.2019.

Colledge, Mike; Martyn, Chris (2018): Entrepreneurialism. Ipsos.com. Online verfügbar unter https://www.ipsos.com/sites/default/files/ct/news/documents/2018-10/entrepreneurialism-2018-global-report.pdf, zuletzt geprüft am 19.07.2019.

Czycholl, Harald (2019): Vorsicht Digitalgefahr! Hg. v. Axel Springer SE. Welt.de. Online verfügbar unter https://www.welt.de/print/die_welt/reise/article196447237/Vorsicht-Digitalgefahr.html, zuletzt aktualisiert am 06.07.2019, zuletzt geprüft am 23.08.29019.

DATACOM Buchverlag GmbH (Hg.) (2019): Smart Device. itwissen.info. Online verfügbar unter https://www.itwissen.info/Smart-Device-smart-device.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

DATAKONTEXT GmbH (Hg.) (2011): Stimmanalyse (Sprechererkennung). SecuPedia.info. Online verfügbar unter https://www.secupedia.info/w/index.php?title=Stimmanalyse_(Sprechererkennung)&oldid=12594, zuletzt aktualisiert am 04.09.2011, zuletzt geprüft am 13.08.2019.

Digitale Gesellschaft (2019): Biometrische Verfahren. Hg. v. Bundesamt für Sicherheit in der Informationstechnik. BSI.bund.de. Online verfügbar unter https://www.bsi.bund.de/DE/Themen/DigitaleGesellschaft/Biometrie/BiometrischeVerfahren/biometrischeverfahren_node.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 02.07.2019.

Dorris, Jesse (2018): The LAB at Rockwell Group Builds a Future for Hilton. Hg. v. Sandow. Interiordesign.net. Online verfügbar unter https://interiordesign.net/projects/14456-the-lab-at-rockwell-group-builds-a-future-for-hilton/, zuletzt aktualisiert am 22.02.2018, zuletzt geprüft am 10.09.2019.

Eccleston Square Hotel (Hg.) (2019): Eccleston Square Hotel. Ecclestonsquarehotel.com. Online verfügbar unter https://www.ecclestonsquarehotel.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.08.2019.

Edwards, Jeffrey R.; Caplan, Robert; van Harrison, R. (1998): Person-environment fit theory. In: Theories of organizational stress 28 (67).

Egencia (2016): Expedia/Egencia study reveals the smartphone as the »Most Indispensable« travel companion. Hg. v. L. L.C. Egencia. Egencia.com. Online verfügbar unter https://www.egencia.com/public/us/expediaegencia-study-reveals-the-smartphone-as-the-most-indispensable-travel-companion, zuletzt aktualisiert am 06.02.2016, zuletzt geprüft am 24.06.2019.

Energous (Hg.) (2019): Wireless Charging 2.0. Energous.com. Online verfügbar unter https://www.energous.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 18.09.2019.

Freizeit-Verlag Landsberg GmbH (Hg.) (2015): Erstes Virgin Hotel eröffnet in Kürze. Hotellerie International. Tophotel.de. Online verfügbar unter https://www.tophotel.de/erstes-virgin-hotel-eroeffnet-in-kuerze-8908/, zuletzt aktualisiert am 08.01.2015, zuletzt geprüft am 10.09.2019.

French, John R. P.; Caplan, Robert D. (1972): Organization stress and individual strain. In: A. J. Marrow (Hg.): The failure of success. New York: Amacom, S. 30–66.

Fuest, Benedikt (2019): Amazon schickt Alexa-Gespräche an Heimarbeiter in Polen. Hg. v. Axel Springer SE. Welt.de. Online verfügbar unter https://www.welt.de/wirtschaft/article197916397/Alexa-Amazon-laesst-Mitschnitte-von-Zeitarbeitern-in-Polen-auswerten.html, zuletzt aktualisiert am 05.08.2019, zuletzt geprüft am 05.08.2019.

Google ATAP (Hg.) (2019): Soli. Online verfügbar unter https://atap.google.com/soli/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Google Cloud (Hg.) (2019): Translation. Dynamisch zwischen Sprachen übersetzen – mithilfe der ML-basierten Technologie von Google. Cloud.google.com. Online verfügbar unter https://cloud.google.com/translate/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Haas, Markus (2018): Smartphone-Markt: Konjunktur und Trends. Hg. v. Bitkom-Präsidium. Bitkom.org. Berlin. Online verfügbar unter https://www.bitkom.org/sites/default/files/file/import/Bitkom-Pressekonferenz-Smartphone-Markt-22-02-2018-Praesentation-final.pdf, zuletzt aktualisiert am 22.02.2018, zuletzt geprüft am 23.09.2019.

Hal Schwartz, Eric (2019): Westin Buffalo Becomes First Hotel Offering Smart Speakers Linked to Guests' Personal Alexa Accounts. Hg. v. Voicebot.ai. Voicebot.ai. Online verfügbar unter https://voicebot.ai/2019/07/08/westin-buffalo-becomes-first-hotel-offering-smart-speakers-linked-to-guests-personal-alexa-accounts/, zuletzt aktualisiert am 08.07.2019, zuletzt geprüft am 17.09.2019.

Hamdi, Raini (2019): Peninsula's Personalization Plans Include Reducing Size of Hotels. Hg. v. Skift. Skift.com. Online verfügbar unter https://skift.com/2019/04/16/peninsulas-personalization-plans-include-reducing-size-of-hotels/, zuletzt aktualisiert am 16.04.2019, zuletzt geprüft am 16.09.2019.

Handelsblatt GmbH (Hg.) (2019): Viele Lehrstellen unbesetzt. Hotels leiden unter Azubi Mangel. Wiwo.de. Online verfügbar unter https://www.wiwo.de/unternehmen/dienstleister/viele-lehrstellen-unbesetzt-hotels-leiden-unter-azubi-mangel/24336322.html, zuletzt aktualisiert am 18.05.2019, zuletzt geprüft am 06.08.2019.

Hardell, Lennart (2017): World Health Organization, radiofrequency radiation and health - a hard nut to crack (Review). In: International journal of oncology 51 (2), S. 405–413. DOI: 10.3892/ijo.2017.4046.

Hearables.de (2019): Hearables. Was sind Hearables? Hg. v. Hörgeräte Collofong & Speckert GbR. Hearables.de. Online verfügbar unter https://www.hearables.de/, zuletzt aktualisiert am 2019, zuletzt geprüft am 23.09.2019.

Henning, Carsten (2014): Social Media Hotels: Bezahlen per Armband. Very Important Bracelets ersetzen auch Schlüsselkarten im Ushuaïa Ibiza Beach Hotel und neuen Hard Rock Hotel auf Ibiza. Hg. v. Hospitality Leaders. Hottelling.net. Online verfügbar unter https://hottelling.net/social-media-hotels-bezahlen-per-armband-very-important-bracelets-ersetzen-auch-schlusselkarten-im-ushuaia-ibiza-beach-hotel-und-neuen-hard-rock-hotel-auf-ibiza/, zuletzt aktualisiert am 30.04.2014, zuletzt geprüft am 17.09.2019.

Hilton (Hg.) (2018): The Inside Story of Hilton's New High-Tech Hotel Rooms. And What It Will Mean For Travelers. Newsroom.hilton.com. Online verfügbar unter https://newsroom.hilton.com/brand-communications/news/the-who-what-and-why-behind-hiltons-new-hightech-hotel-room-concept-and-what-it-will-mean-for-travelers, zuletzt aktualisiert am 26.07.2018, zuletzt geprüft am 26.08.2019.

Hochmann, David (2019): Robot Butlers Are Taking Over Hotels (Good News: No Tipping Required). Hg. v. Forbes Magazine. Forbes.com. Online verfügbar unter https://www.forbes.com/sites/davidhochman/2018/02/23/robot-butlers-are-taking-over-hotels-good-news-no-tipping-required/#7639e6677636, zuletzt aktualisiert am 23.02.2019, zuletzt geprüft am 03.09.2019.

Hoffmann, Lucas (2016): Informationen aus der Windschutzscheibe. 5 Head-up-Displays zum Nachrüsten im Test. Hg. v. Motor Presse Stuttgart GmbH & Co.KG. Auto-motor-und-sport.de. Online verfügbar unter https://www.auto-motor-und-sport.de/test/head-up-displays/, zuletzt aktualisiert am 27.10.2016, zuletzt geprüft am 16.09.2019.

Hohl, Peter (2016): Zutrittskontrolle. Hg. v. DATAKONTEXT GmbH. SecuPedia.info. Online verfügbar unter https://www.secupedia.info/w/index.php?title=Zutrittskontrolle&oldid=20392, zuletzt aktualisiert am 12.08.2016, zuletzt geprüft am 13.08.2019.

Hospitality Net (Hg.) (2019): #MeetBotlr: Aloft Hotels Recruits Robot to Join Team in Cupertino. Hotel Industry's First Robotic Butler Reports for Duty at Aloft Cupertino in Silicon Valley. Hospitalitynet.org. Online verfügbar unter https://www.hospitalitynet.org/news/4066528.html, zuletzt aktualisiert am 13.08.2019, zuletzt geprüft am 27.08.2019.

Hotel Fachzeitung (Hg.) (2018): Bodenmaiser Hof: Wellnesshotel mit Gebäudeautomation Hotelfachzeitung.com. Online verfügbar unter https://www.hotelfachzeitung.com hoteltechnik/23-elektrotechnik/619-bodenmaiser-hof-wellnesshotel-mit gebaeudeautomation.html, zuletzt aktualisiert am 09.02.2018, zuletzt geprüft am 17.09.2019.

Hotels.com (2016): Mobile Travel Tracker Study Finds Travelers Prefer Their Device More than Their Loved One. Hg. v. Hotels.com L.P. Hotels.com. Online verfügbar unter http://press.hotels.com/us/hotels-com-mobile-travel-tracker-study-finds-travelers-prefer-their-device-more-than-their-loved-one/, zuletzt geprüft am 24.06.2019.

HUIS TEN BOSCH Co,.Ltd. (Hg.) (2019): Brand Concept. Unter Mitarbeit von HIS Hotel Group, Hen-na Hole Group Site. h-n-h.jp. Online verfügbar unter www.h-n-h.jp/en/concept, zuletzt aktualisiert am 2019, zuletzt geprüft am 03.09.2019.

IBM (Hg.) (2019): Künstliche Intelligenz für intelligentere Cybersicherheit. Kognitive Sicherheit mit Watson. ibm.com. Online verfügbar unter https://www.ibm.com/de-de/security/cognitive, zuletzt aktualisiert am 2019, zuletzt geprüft am 17.07.2019.

IDG Business Media GmbH (Hg.) (2010): Fujitsu: Kabelloses Laden von Handy & Co ab 2012 Magnetische Resonanz versorgt mehrere Geräte gleichzeitig mit Strom. Tecchannel.de. Online verfügbar unter https://www.tecchannel.de/a/fujitsu-kabelloses-laden-von-handy-und-co-ab-2012,2031064, zuletzt aktualisiert am 14.09.2010, zuletzt geprüft am 23.09.2019.

International Data Corporation (IDC) (2019): Commercial and Public Sector Investments Will Drive Worldwide AR/VR Spending to $160 Billion in 2023, According to a New IDC Spending Guide. Shirer, Michael; Torchia, Marcus. Online verfügbar unter https://www.idc.com/getdoc.jsp?containerId=prUS45123819, zuletzt geprüft am 14.08.2019.

itwissen.info (2019a): Smart Glasses. Hg. v. DATACOM Buchverlag GmbH. itwissen.info. Online verfügbar unter https://www.itwissen.info/smart-glasses-Datenbrille.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.06.2019.

itwissen.info (2019b): Smart Textiles. Hg. v. DATACOM Buchverlag GmbH. itwissen.info. Online verfügbar unter https://www.itwissen.info/smart-textiles-Intelligente-Textilien.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 02.08.2019.

Ivanov, Stanisklavn Hristov; Webster, Craig; Berezina, Katerina (2017): Adoptionofrobotsandserviceautomationby tourismandhospitalitycompanies. In: Revista Turismo & Desenvolvimento (27/28), S. 1501–1517. Online verfügbar unter https://ssrn.com/abstract=2964308, zuletzt geprüft am 19.08.2019.

Jain, Anil K.; Flynn, Patrick; Ross, Arun A. (2008): Handbook of Biometrics. Boston, MA: Springer Science+Business Media LLC. Online verfügbar unter http://site.ebrary com/lib/alltitles/docDetail.action?docID=10211006.

Kansakar, Prasanna; Munir, Arslan; Shabani, Neda (2018): Technology in Hospitality Industry: Prospects and Challenges. Kansas State University, Manhattan, Kansas, USA. Online verfügbar unter https://arxiv.org/pdf/1709.00105.pdf, zuletzt geprüft am 19.07.2019.

Kazandzhieva, Velina; Ilieva, Galina; Filipova, Hristina (2017): The Impact of Technological Innovations on Hospitality Service. Conference: Contemporary tourism - traditions and innovations. Sofia University "St. Kliment Ohridski". Online verfügbar unter https://www.researchgate.net/publication/317290270_THE_IMPACT_OF_TECHNOLOGICAL_INNOVATIONS_ON_HOSPITALITY_SERVICE, zuletzt geprüft am 19.08.2019.

Khora VR (Hg.) (2019): The Internet of Experiences. Kopenhagen.

Kietzmann, Jan; Paschen, Jeannette; Treen, Emily (2018): Artificial Intelligence in Advertising. In: JAR 58 (3), S. 263–267. DOI: 10.2501/JAR-2018-035.

King, B.; Tang, C. M. F. (2019): Training hotels in Asia: an exploration of alternative models. In: Journal of Hospitality & Tourism Education, S. 1–12.

KViHOTEL Budapest (Hg.) (2019): Welcome to the first 360 smart hotel of the World. invented for the traveller of tomorrow, where everything is controlled by your smartphone. KVihotelbudapest.com. Online verfügbar unter https://www.kvihotelbudapest.com/#anchor, zuletzt aktualisiert am 2019, zuletzt geprüft am 17.09.2019.

Legorburu, Gaston; McColl, Darren (2019): Storyscaping. the book. Hg. v. SAPIENT CORPORATION. Storyscaping.com. Online verfügbar unter https://www.storyscaping.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Leonidis, Asterios; Korozi, Maria; Margetis, George; Grammenos, Dimitris; Stephanidis, Constantine (2013): An Intelligent Hotel Room. In: David Hutchison, Takeo Kanade, Josef Kittler, Jon M. Kleinberg, Friedemann Mattern, John C. Mitchell et al. (Hg.): Ambient Intelligence, Bd. 8309. Cham: Springer International Publishing (Lecture Notes in Computer Science), S. 241–246.

Liao, Shannon (2018): A WeChat-powered hotel in China lets you check in, enter your room, and get breakfast through your phone. It opened its doors today. Hg. v. The Verge. Theverge.com. Online verfügbar unter https://www.theverge.com/2018/11/21/18106975/wechat-powered-hotel-china-phone-check-in-room-number-breakfast, zuletzt aktualisiert am 21.11.2018, zuletzt geprüft am 10.09.2019.

López, Tomás Sánchez; Ranasinghe, Damith Chinthana; Patkai, Bela; McFarlane, Duncan (2011): Taxonomy, technology and applications of smart objects. In: Inf Syst Front 13 (2), S. 281–300. DOI: 10.1007/s10796-009-9218-4.

Maier, Marco (2017): Wie funktioniert Affective Computing? Hg. v. DIGITALE WELT. Digitaleweltmagazin.de. Online verfügbar unter https://digitaleweltmagazin.de/2017/06/19/wie-funktioniert-affective-computing/, zuletzt aktualisiert am 19.06.2017, zuletzt geprüft am 02.07.2019.

Marriott International (2017): Marriott International Teams with Samsung and Legrand to Unveil Hospitality Industry's IoT Hotel Room of the Future, Enabling the Company to Deepen Personalized Guest Experience. Bethesda, MD, USA. DeLollis, Barbara; Yoo, Daniel; Henderson, Kate. Online verfügbar unter https://news.marriott.com/2017/11/marriott-international-teams-samsung-legrand-unveil-hospitality-industrys-iot-hotel-room-future-enabling-company-deepen-personalized-guest-experience/, zuletzt geprüft am 26.08.2019.

MAZARS (Hg.) (2018): Artificial Intelligence. A Game Changer in the Hospitality Industry. Unter Mitarbeit von Cédric Haasler, Isabelle Massa, Simon Beillevaire, Anton Lissorugues und Marc Atallah. Online verfügbar unter https://www.mazars.com/content/download/945401/49211039/version//file/Mazars_2018_AI_in_Hospitality_Study.pdf, zuletzt geprüft am 19.07.2019.

McMullen, Melanie (2018): The New Approach to Hospitality: A Hotel Run by Robots. Hg. v. IoT Solution Provider. Iotsolutionprovider.com. Online verfügbar unter https://www iotsolutionprovider.com/smart-building/the-new-approach-to-hospitality-a-hotel-run by-robots, zuletzt aktualisiert am 16.01.2018, zuletzt geprüft am 03.09.2019.

McQuarrie, Laura (2016): Wynn Resort's High-Tech Hotel Rooms are Equipped with Amazon Echo. Hg. v. Trend Hunter Inc. Trendhunter.com. Online verfügbar unter https:// www.trendhunter.com/trends/hightech-hotel, zuletzt aktualisiert am 24.12.2016, zuletzt geprüft am 10.09.2019.

Mest, Elliott (2018): AccorHotels details new Smart Room concept. Hg. v. Hotelmanagement. net. Hotelmanagement.net. Online verfügbar unter https://www.hotelmanagement. net/operate/accorhotels-details-new-smart-room-concept, zuletzt aktualisiert am 16.01.2018, zuletzt geprüft am 10.09.2019.

Microsoft (2016): Seeing AI 2016 Prototype. A Microsoft research project. Video. Online verfügbar unter https://www.youtube.com/watch?v=R2mC-NUAmMk, zuletzt geprüft am 06.08.2019.

Microsoft (Hg.) (2018): What is mixed reality? Online verfügbar unter https://docs.microsoft com/en-us/windows/mixed-reality/mixed-reality, zuletzt geprüft am 14.08.2019.

Microsoft Corporation (Hg.) (2019): Was ist Cloud Computing? Leitfaden für Einsteiger. Azure microsoft.com. Online verfügbar unter https://azure.microsoft.com/de-de/overview what-is-cloud-computing/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Mroziak, Michael (2017): Programmed to deliver: Westin Buffalo introduces robot butler. Hg. v. WBFO. News.wbfo.org. Online verfügbar unter https://news.wbfo.org/post/ programmed-deliver-westin-buffalo-introduces-robot-butler, zuletzt aktualisiert am 30.05.2017, zuletzt geprüft am 17.09.2019.

Neumann, Detlev (2016): Internet der Dinge. Eine kurze Definition mit 4 Beispielen. Hg. v. Digitaler Mittelstand. Digitaler-mittelstand.de. Online verfügbar unter https:// digitaler-mittelstand.de/trends/ratgeber/internet-der-dinge-eine-kurze-definition-mit-4-beispielen-20287, zuletzt geprüft am 24.06.2019.

Newman, Peter (2019): The Henn na Hotel in Japan is firing most of its robotic workforce and hiring humans instead — highlighting the limits of automation. Hg. v. Business Insider. Businessinsider.com. Online verfügbar unter https://www.businessinsider. com/henn-na-hotel-fires-robots-hires-humans-2019-1?IR=T, zuletzt aktualisiert am 17.01.2019, zuletzt geprüft am 03.09.2019.

Newsroom.hilton.com (Hg.) (2019): Hilton's High-Tech Connected Room Brings Personalized In Room Streaming to Guests with Netflix. The new feature is the latest enhancement to Hilton's industry leading mobile-centric room and enables guests to stream their favorite Netflix series and movies on in-room TVs. Hilton. Online verfügbar unter https://newsroom.hilton.com/brand-communications/news/hiltons-hightech-connected-room-brings-personalized-inroom-streaming-to-guests-with-netflix, zuletzt aktualisiert am 24.01.2019, zuletzt geprüft am 26.08.2019.

NH Hotel Group (Hg.) (2019): Entdecken Sie den neuen Mood Room™ von NH Hotels. Das Zimmer, das sich so transformiert, wie Sie es wollen, wann Sie es wollen und besser, als Sie es sich je vorgestellt haben. NH-hotels.de. Online verfügbar unter https://www.nh-hotels.de/highlights/mood-rooms, zuletzt geprüft am 26.08.2019.

Nitti, Michele; Pilloni, Virginia; Colistra, Giuseppe; Atzori, Luigi (2016): The Virtual Object as a Major Element of the Internet of Things: A Survey. In: IEEE Commun. Surv. Tutorials 18 (2), S. 1228–1240. DOI: 10.1109/COMST.2015.2498304.

Nyce, Charles (2007): Predictive Analytics. White Paper. Hg. v. AICPCU/IIA. American Institute for CPCU/ Insurance Institute of America. Malvern, PA, USA. Online verfügbar unter https://www.the-digital-insurer.com/wp-content/uploads/2013/12/78-Predictive-Modeling-White-Paper.pdf, zuletzt geprüft am 19.08.2019.

O'Connor, Shelby (2019): Smart-Room and AI Technology are Gaining Popularity. Hg. v. Hotelier Magazine. Hoteliermagazine.com. Online verfügbar unter https://www.hoteliermagazine.com/smart-room-and-ai-technology-are-gaining-popularity/, zuletzt aktualisiert am 06.09.2019, zuletzt geprüft am 16.09.2019.

Opera Hotel (Hg.) (2019): Unsere Smart Rooms. Zurücklehnen, entspannen, traumhaft schlafen Operahotel.ch. Online verfügbar unter https://www.operahotel.ch/smart-room/, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.08.2019.

Patel, Nilay (2007): Philips and citizenM build a modular high-tech hotel. Hg. v. Verizon Media. Engadget.com. Online verfügbar unter https://www.engadget.com/2007/10/23/philips-and-citizenm-build-a-modular-high-tech-hotel/, zuletzt aktualisiert am 23.10.2007, zuletzt geprüft am 27.08.2019.

Perez, Sarah (2019): Hilton and Netflix partner on in-room streaming, controlled through Hilton's own app. Hg. v. Verizon Media. Techcrunch.com/. Online verfügbar unter https://techcrunch.com/2019/01/24/hilton-and-netflix-partner-on-in-room-streaming-controlled-through-hiltons-own-app/, zuletzt aktualisiert am 24.01.2019, zuletzt geprüft am 10.09.2019.

Pew Research Center (2019): Mobile Fact Sheet. Hg. v. Pew Research Center. Pewinternet.org. Online verfügbar unter https://www.pewinternet.org/fact-sheet/mobile/, zuletzt geprüft am 24.06.2019.

Pipek, Volkmar (2014): Ubiquitous Computing. Unter Mitarbeit von Matthias Betz. Hg. v. Enzyklopädie der Wirtschaftsinformatik Online-Lexikon. Lehrstuhl für Wirtschaftsinformatik (insb. Prozesse und Systeme), Universität Potsdam. Online verfügbar unter http://www.enzyklopaedie-der-wirtschaftsinformatik.de/lexikon/technologien-methoden/Rechnernetz/Ubiquitous-Computing/index.html, zuletzt aktualisiert am 26.09.2014, zuletzt geprüft am 23.09.2019.

Plewe, Daniela Alina; Ong, Rui An; Röcker, Carsten (2015): Ambient and Aesthetic Intelligence for High-End Hospitality. In: Fiona Fui-Hoon Nah und Chuan-Hoo Tan (Hg.): HCI in Business, Bd. 9191. Cham: Springer International Publishing (Lecture Notes in Computer Science), S. 739–747.

Pluta, Werner (2019): Forscher erzeugen Sprache aus Hirnströmen. Hg. v. Golem Media GmbH. Golem.de. Online verfügbar unter https://www.golem.de/news/sprachsynthese-forscher-erzeugen-sprache-aus-hirnstroemen-1904-140962.html, zuletzt aktualisiert am 30.04.2019, zuletzt geprüft am 28.06.2019.

Potor, Marinela (2017): In Schweden nutzen Fahrgäste Implantate statt Fahrkarten. Hg. v. BASIC thinking GmbH. Mobilitymag.de. Online verfügbar unter https://mobilitymag.de/implantate-fahrkarten/, zuletzt aktualisiert am 03.07.2017, zuletzt geprüft am 23.09.2019.

Powder, J.D. (2017): »Enjoy Your Stay—and Have You Downloaded Our App?«. Costa Mesa, California, USA. Effler, Geno. Online verfügbar unter https://www.jdpower.com/business/press-releases/jd-power-2017-north-america-hotel-guest-satisfaction-index-study, zuletzt geprüft am 19.08.2019.

Powercast Corp. (Hg.) (2019): The Company. Powercastco.com. Online verfügbar unter https://www.powercastco.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 18.09.2019.

PR Newswire (Hg.) (2012): The Peninsula Hotels Revitalizes Its Brand with New Global Marketing Campaign, Flagship Renovation and Pioneering New Guestroom Technology. 'Peninsula Moments' showcases hotels and destinations in a glamorous new light; The Peninsula Hong Kong unveils dramatic new interior design and technology concept. PRNewswire.com. Online verfügbar unter https://www.prnewswire.com/news-releases/the-peninsula-hotels-revitalizes-its-brand-with-new-global-marketing-campaign-flagship-renovation-and-pioneering-new-guestroom-technology-168687046.html, zuletzt aktualisiert am 06.09.2012, zuletzt geprüft am 16.09.2019.

Pricewaterhouse Coopers (PwC) (2017): New year, new you. pwc Holiday outlook wrap-up Health and Fitness. Hg. v. Pricewaterhouse Coopers (PwC). Pwc.com. Online verfügbar unter https://www.pwc.com/us/en/consumermarkets/assets/pwc-holiday-outlook-wrap-up-health-and-fitness.pdf, zuletzt geprüft am 24.06.2019.

Pricewaterhouse Coopers (PwC) (Hg.) (2018): Zwischen Entertainer und Werber. Wie Influencer unser Kaufverhalten beeinflussen. Pwc.com. Online verfügbar unter https://www.pwc.de/de/handel-und-konsumguter/pwc-zwischen-entertainer-und-werber.pdfhttps://www.pwc.de/de/handel-und-konsumguter/pwc-zwischen-entertainer-und-werber.pdf, zuletzt aktualisiert am 12.2018, zuletzt geprüft am 23.09.2019.

Prince, Todd (2019): Las Vegas Strip resorts slow to welcome Alexa, Google Home Hub. Hg. v. Las Vegas Review-Journal. Reviewjournal.com. Online verfügbar unter https://www.reviewjournal.com/business/casinos-gaming/las-vegas-strip-resorts-slow-to-welcome-alexa-google-home-hub-1599678/, zuletzt aktualisiert am 18.02.2019, zuletzt geprüft am 10.09.2019.

REALFICTION (Hg.) (2019): DeepFrame. Realfiction.com. Online verfügbar unter https://www.realfiction.com/solutions/deepframe, zuletzt aktualisiert am 2019, zuletzt geprüft am 16.09.2019.

Ricca, Stephanie (2019): Hilton exec: Revenue managers must think like customers. Hg. v. Hotel News Now. Hotelnewsnow.com. Nashville, USA. Online verfügbar unter www.hotelnewsnow.com/Articles/298013/Hilton-exec-Revenue-managers-must-think-like-customers, zuletzt aktualisiert am 09.09.2019, zuletzt geprüft am 16.09.2019.

Rockwell Group (Hg.) (2019): Hilton Innovation Gallery. Rockwellgroup.com. Online verfügbar unter https://www.rockwellgroup.com/projects/hilton-innovation-gallery, zuletzt geprüft am 10.09.2019.

Roelstraete, Dieter (2019): Hans Eijkelboom. Hg. v. Dokumenta 14. Documenta14.de. Online verfügbar unter https://www.documenta14.de/en/artists/13568/hans-eijkelboom, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Salas, Nathalie (2012): Meet the owners: Olivia Byrne of Eccleston Square Hotel, London, UK. Hg. v. Boutique Hitel News. Boutiquehotelnews.com. Online verfügbar unter https://www.boutiquehotelnews.com/home/features/2012/8/27/meet-the-owners-olivia-byrne-of-the-eccleston-square-hotel,-london,-uk/, zuletzt aktualisiert am 27.08.2012, zuletzt geprüft am 27.08.2019.

SAPIENT CORPORATION (Hg.) (2019a): 03 Harnessing the Power of Experience. Storyscaping.com. Online verfügbar unter https://www.storyscaping.com/educators/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

SAPIENT CORPORATION (Hg.) (2019b): 04 Moving from Storytelling to Storyscaping. Storyscaping.com. Online verfügbar unter https://www.storyscaping.com/educators/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Schiller, Kai (2019): Was sind Smart Contracts? Definition und Erklärung. Hg. v. haftungsbeschränkt (Lunikn Pro UG). Online verfügbar unter https://blockchainwelt.de/smart-contracts-vertrag-blockchain/, zuletzt aktualisiert am 20.09.2019, zuletzt geprüft am 23.09.2019.

Siepermann, Markus (2018): Internet der Dinge. Hg. v. Gabler Wirtschaftslexikon. Online verfügbar unter https://wirtschaftslexikon.gabler.de/definition/internet-der-dinge-53187/version-276282, zuletzt aktualisiert am 2018, zuletzt geprüft am 24.06.2019.

Signify Holding (Hg.) (2019): Broadband data through light. Signify.com. Online verfügbar unter https://www.signify.com/global/innovation, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Smart LYZ (Hg.) (2018): CNN: China's first fully automated Hotel. smartlyz.com. Online verfügbar unter https://www.smartlyz.com/news/2018-07-30-7091435452, zuletzt aktualisiert am 30.07.2018, zuletzt geprüft am 17.09.2019.

Smart LYZ (Hg.) (2019): Smart Accommodation - Erleben Sie eine andere Reise. smartlyz.com. Online verfügbar unter https://www.smartlyz.com/, zuletzt aktualisiert am 2019, zuletzt geprüft am 17.09.2019.

SmartHome Initiative Deutschland (Hg.) (2019): Was ist ein SmartHome? Smarthome-deutschland.de. Online verfügbar unter https://www.smarthome-deutschland.de/initiative/ziele-und-hintergruende.html, zuletzt aktualisiert am 2019, zuletzt geprüft am 02.08.2019.

Sommer, Peter (2017): Artificial Intelligence, Machine Learning and Cognitive Computing. Hg. v. IBM. ibm.com. Online verfügbar unter https://www.ibm.com/blogs/nordic-msp/artificial-intelligence-machine-learning-cognitive-computing/, zuletzt aktualisiert am 20.11.2017, zuletzt geprüft am 23.09.2019.

Soper, Taylor (2018): Testing Alexa in a hotel room: We used Amazon's voice assistant inside a swanky Las Vegas suite. Hg. v. Geek Wire. Geekwire.com. Online verfügbar unter https://www.geekwire.com/2018/testing-alexa-hotel-room-used-amazons-voice-assistant-inside-swanky-las-vegas-suite/, zuletzt aktualisiert am 10.01.2018, zuletzt geprüft am 10.09.2018.

Spath, Dieter; Bauer, Wilhelm; Borkmann, Vanessa (2013): Zentrum für virtuelles Engineering ZVE. Haus der Wissensarbeit. Stuttgart: Fraunhofer Verl. Online verfügbar unter http://www.bookshop.fraunhofer.de/buch//239662.

Spiegel Online (Hg.) (2019): Facebook kauft Start-up für Gedankensteuerung. Spiegel.de. Online verfügbar unter https://www.spiegel.de/wirtschaft/unternehmen/facebook-kauft-start-up-ctrl-labs-fuer-geraete-steuerung-mit-gedanken-a-1288279.html, zuletzt aktualisiert am 24.09.2019, zuletzt geprüft am 25.09.2019.

Sven Becker – I am ROBOT (Hg.) (2019): I am ROBOT. Iamrobot.de. Online verfügbar unter https://iamrobot.de/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Tageskarte GmbH & Co. KG (Hg.) (2019): Datenleck: Bis zu 700.000 Daten von Choice-Hotel Gästen betroffen. Tageskarte.io. Online verfügbar unter https://www.tageskarte.io/hotellerie/detail/datenleck-bis-zu-700000-daten-von-choice-hotel-gaesten-betroffen.html, zuletzt aktualisiert am 22.08.2019, zuletzt geprüft am 23.08.2019.

Talin, Benjamin (2019): Blockchain – Möglichkeiten und Anwendungen der Technologie Blockchain und Smart Contracts haben grosse Potentiale und viele Anwendungsmöglichkeiten. Hg. v. Morethandigital.info. Morethandigital.info. Online verfügbar unter https://morethandigital.info/blockchain-moeglichkeiten und-anwendungen-der-technologie/, zuletzt aktualisiert am 05.01.2019, zuletzt geprüft am 23.09.2019.

Tenzer, F. (2019): Anzahl der Smartphone-Nutzer in Deutschland in den Jahren 2009 bis 2018 (in Millionen). Hg. v. Statista. Statista.com. Online verfügbar unter https://de.statista.com/statistik/daten/studie/198959/umfrage/anzahl-der-smartphonenutzer-in-deutschland-seit-2010/, zuletzt aktualisiert am 2019, zuletzt geprüft am 27.06.2019.

The Bottomline (2009). In: The Journal of Hospitality Finacial and Technology Professionals (24).

The European Parliament and the Council of the European Union (2016): General Data Protection Regulation. GDPR, vom 2016/679. In: Official Journal of the European Union (L 119/1). Online verfügbar unter https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679, zuletzt geprüft am 19.07.2019.

The Hongkong and Shanghai Hotels, Ltd. (Hg.) (2019a): heritage meets Innovation. 150 years of innovation and looking to the future. Hshgroup.com. Online verfügbar unter https://www.hshgroup.com/en/about/kaleidoscope-lab, zuletzt aktualisiert am 2019, zuletzt geprüft am 16.09.2019.

The Hongkong and Shanghai Hotels, Ltd. (Hg.) (2019b): Research & Technology. Innovative in-room technology with a personal touch. Hshgroup.com. Online verfügbar unter https://www.hshgroup.com/en/About/Research-and-Technology, zuletzt aktualisiert am 2019, zuletzt geprüft am 16.09.2019.

The Hongkong and Shanghai Hotels, Ltd. (23.01.2019): The Hongkong and Shanghai Hotels announces winners of its exclusive luxury hospitality tech start-up programme. Hongkong. Mulholland, Lynne; Lau, Lilian; Osborne, Sally, 8/F, St. George's Building, 2 Ice House Street, Central, Hong Kong. Online verfügbar unter https://www.hshgroup.com/en/media/press-releases/2019/announces-winners-of-its-exclusive-luxury-hospitality-tech-start-up-programme, zuletzt geprüft am 23.09.2019.

The Hongkong and Shanghai Hotels, Ltd. (06.06.2019): Kaleidoscope Lab wins Innovation Award. Hongkong. Mulholland, Lynne; Lau, Lilian; Osborne, Sally, 8/F, St. George's Building, 2 Ice House Street, Central, Hong Kong. Online verfügbar unter https://www.hshgroup.com/-/media/Files/HSH/Press-Releases/2019/HSH-press-release---Kaleidoscope-wins-Innovation-Award---EN.ashx, zuletzt geprüft am 16.09.2019.

ThingOS GmbH (Hg.) (2019): ThingOS – The Smart Things Integrator. ThingOS is One of the First to Support BLE MESH. Thingos.io. Online verfügbar unter https://thingos.io/, zuletzt aktualisiert am 2019, zuletzt geprüft am 25.09.2019.

Ting, Deanna (2017): Hilton and Marriott Turn to the Internet of Things to Transform the Hotel Room Experience. Hg. v. Skift. Skift.com. Online verfügbar unter https://skift.com/2017/11/14/hilton-and-marriott-turn-to-the-internet-of-things-to-transform-the-hotel-room-experience/, zuletzt aktualisiert am 14.11.2017, zuletzt geprüft am 26.08.2019.

Ting, Deanna (2019): Hilton CEO: »We're Not Trying to Compete With Google, Amazon and Apple«. Hg. v. Skift. Skift.com. Online verfügbar unter https://skift.com/2019/02/04/hilton-ceo-were-not-trying-to-compete-with-google-amazon-and-apple/, zuletzt aktualisiert am 04.02.2019, zuletzt geprüft am 10.09.2019.

Tobit Software AG (Hg.) (2019): Dein smartel. Smartel.com. Online verfügbar unter https://smartel.com, zuletzt aktualisiert am 2019, zuletzt geprüft am 26.08.2019.

Tse, Tony S. M. (2013): The Marketing Role of the Internet in Launching a Hotel: The Case of Hotel ICON. In: Journal of Hospitality Marketing & Management (22 (8)), S. 895–908. Online verfügbar unter https://doi.org/10.1080/19368623.2013.734224, zuletzt geprüft am 10.09.2019.

TUI Group (2019): Guten APPetit: TUI Magic Life Gäste wählen ihre Lieblingsgerichte künftig per App. TUI ermöglicht Urlaubern Mitbestimmung am Buffet der All-Inclusive-Clubs. Hamburg. Kreye, Natascha. Online verfügbar unter https://www.tuigroup.com/de-de/medien/presseinformationen/ag-meldungen/2019/2019-05-28-guten-appetit, zuletzt geprüft am 19.08.2019.

Ushuaïa Ibiza (Hg.) (2018): Ushuaïa Ibiza – eine Innovationsschmiede. Theushuaiaexperience.com. Online verfügbar unter https://www.theushuaiaexperience.com/de/blog/ushuaia-ibiza-eine-innovationsschmiede/, zuletzt aktualisiert am 17.04.2018, zuletzt geprüft am 17.09.2019.

Virgin Hotels (Hg.) (2019a): About the App. Virginhotels.com. Online verfügbar unter https://virginhotels.com/about-the-app/, zuletzt aktualisiert am 2019, zuletzt geprüft am 10.09.2019.

Virgin Hotels (Hg.) (2019b): The Know. Virginhotels.com. Online verfügbar unter https://virginhotels.com/the-know/, zuletzt aktualisiert am 2019, zuletzt geprüft am 10.09.2019.

Wallstreet-Online.de (Hg.) (2015): Caesars Entertainment Collaborates With WeChat and Ayla Networks to Showcase Hotel Rooms of the Future During *International CES 2015. Wallstreet-Online.de. Online verfügbar unter https://www.wallstreet-online.de/nachricht/7282106-caesars-entertainment-collaborates-with-wechat-and-ayla-networks-to-showcase-hotel-rooms-of-the-future-during-international-ces-2015, zuletzt aktualisiert am 06.01.2015, zuletzt geprüft am 26.08.2019.

Wander-Lust (Hg.) (2015): Now open » City Hub Amsterdam. Wander-lust.nl. Online verfügbar unter https://www.wander-lust.nl/now-open-city-hub-amsterdam/, zuletzt aktualisiert am 02.11.2015, zuletzt geprüft am 10.09.2019.

Weyer, Franziska (2019): Unternehmen fehlt umfassende Strategie zur digitalen Ethik. Hg. v. Pricewaterhouse Coopers (PwC). Pwc.com. Düsseldorf. Online verfügbar unter https://www.pwc.de/de/pressemitteilungen/2019/unternehmen-fehlt-umfassende-strategie-zur-digitalen-ethik.html, zuletzt aktualisiert am 04.08.2019, zuletzt geprüft am 25.09.2019.

Writer, Staff (2019): What Is Customer Data? Definition, Types, Collection, Validation and Analysis. Hg. v. MarTech Advisor. Martechadvisor.com. Online verfügbar unter https://www.martechadvisor.com/articles/data-management/customer-data-definition-types-collection-validation-analysis-martech101/, zuletzt aktualisiert am 2019, zuletzt geprüft am 19.07.2019.

Wurmser, Yoram (2019): Wearables 2019. Advanced Wearables Pick Up Pace as Fitness Trackers Slow. Hg. v. eMarketer. Emarketer.com. Online verfügbar unter https://www.emarketer.com/content/wearables-2019, zuletzt aktualisiert am 2019, zuletzt geprüft am 24.06.2019.

YellRobot - Robot News (Hg.) (2018): Smart LYZ Hotel in Chengdu is Completely Automated. Yellrobot.com. Online verfügbar unter https://yellrobot.com/automated-hotel-robot-china-smart-lyz/, zuletzt aktualisiert am 24.10.2018, zuletzt geprüft am 17.09.2019.

Yotel (Hg.) (2019): Our Brands. Yotel.com. Online verfügbar unter https://www.yotel.com/en about-yotel/brands, zuletzt aktualisiert am 2019, zuletzt geprüft am 03.09.2019.

ZEIT ONLINE GmbH (Hg.) (2019): Datenleak: Millionen Passwörter im Netz veröffentlicht. Zeit.de. Online verfügbar unter https://www.zeit.de/digital/datenschutz/2019-01/datenleak-email-passwoerter-internet-it-sicherheit, zuletzt aktualisiert am 17.01.2019, zuletzt geprüft am 05.08.2019.

11 IMPRINT

Authors:
Prof. Dr.-Ing. Vanessa Borkmann
Dennis Stolze
Christina Bruns

Contact:
Fraunhofer Institute for Industrial Engineering IAO
Nobelstraße 12, 70569 Stuttgart, Germany

www.iao.fraunhofer.de/en
www.futurehotel.de/en

URL: http://www.iao.fraunhofer.de, www.futurehotel.de
Bibliographic information from the German National Library. The German National Library indexes this publication in the German National Bibliography; detailed bibliographic information is available online at http://dnb.d-nb.de.

ISBN: 978-3-8396-1549-2

FRAUNHOFER Verlag
Fraunhofer-Informationszentrum Raum und Bau IRB
Nobelstraße 12, 70569 Stuttgart, Germany
Phone: 0711/970-27 03, Telefax: 0711/970-25 99
E-Mail: verlag@fraunhofer.de, URL: http://verlag.fraunhofer.de

The study »FutureHotel – Smart Hotel Room« presents the scenario of a technologically possible hotel room experience in the year 2020.

The report initially discusses the current state of practice by listing worldwide projects on smart hotel rooms and innovation laboratories. The technological, social and ecological determinants are presented to provide a framework for smart hotel experiences.

A detailed depiction of a smart guest journey shows the opportunities for individualisation and personalisation as well as the application potential of smart technologies in the hotel. The effects on security, sustainability and accessibility are backlit.

The main part is dedicated to the experience of a smart hotel room from a guest´s perspective. Technological use cases, the benefits for guest and hotelier alike, and the technical requirements and possible technical solutions for the entire accommodation experience are listed.

The focus then shifts to the implementation of smart solutions. Current obstacles are listed, and specific recommendations for action are addressed.

The study offers hoteliers, as well as their planners and consultants, concrete assistance in strategically developing their future actions and realising a scientifically proven solution for their own smart hotel rooms.

The study was funded and supported by the following partners of the research project FutureHotel:

ISBN 978-3-8396-1549-2