Ranking the Challenges of Hotel 4.0: Priorities according to the Experience of Implementing Innovative Water and Electricity Monitoring Technologies

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Abstract. Industry 4.0, known as "the Fourth Industrial Revolution", has been blowing among different industries and changing the paradigms of doing businesses. Although all industries are under the influence of emerging technologies, the rate of success and cause of failure of transition processes are still not clear, and interest researchers. The challenges of technology transfer, technology management, and technology implementation are not new, but the fourth revolution has its own characteristics and dilemmas in practice and Hotel 4.0 is not an exception. This paper, discusses the challenges of implementing innovative Water and Electricity Monitoring Technology in Hotel industry, and the final ranking model helps understand the priorities of the challenges. The challenges could be seen in both service provider and client sides. Moreover, the main challenges were prioritized and ranked using Analytical Hierarchy Process (AHP) technique. Although the level of consistency, questions the accuracy of the weights, but the ranking of challenges could show the main concerns and importance of potential dilemmas which should be taken into account. This could help have a better understanding of future challenges, decide for strategies to improve the system, and increase the readiness. The work is based on interviews and brainstorming sessions with a group of technicians involved in the projects and information elicited from real cases in Europe..

Keywords: Hotel 4.0, Innovative Monitoring Technologies, I4.0 Readiness, Analytical Hierarchy Process (AHP).

1 Introduction

The trend of 4.0 is now beyond "Manufacturing" but could be seen everywhere including in the Tourism industry. Hotel 4.0 presents the future generation of the hotels while the hotels could be seen as an Intelligent Cyber-physical System. To make this dream happens, there are many aspects but technology is the core pillar. The transition process to shift to Hotel 4.0 is not always successful and the potential challenges are important to be recognized and considered in advance. In this paper, the experience of Optishower, to Implement Innovative Water and Electricity Monitoring Technologies

in hotels, is used to extract, categorize and rank the main challenges. The result is a combination of different Decision Process techniques including brainstorming, Delphi and Analytical Hierarchy process (AHP).

Optishower is a tech-based solution, offering an innovative platform for the hospitality sector with a very disrupting idea that incorporates elements from tech to social behavior. Optishower is a combination of hardware and software directly implemented in hotel infrastructure and interacting with managers and guests. The hardware package includes water metering sensors installed on measuring spots, e.g. rooms, kitchen and laundry entrances. Moreover, various communication technologies are applied including Wi-Fi and ZigBee modules. Additionally, the consumption of water and electricity is presented to hotel manager/associates via web dashboard. This dashboard consists of different modules that give detailed information to the hotel manager about historical consumption, savings real time and online monitoring of water and energy consumptions in the infrastructure of the hotel for all rooms, and any other monitoring spots such as kitchen, laundry, swimming pool, and chillers. The dashboard has been designed to be used with a different level of authorities and access for Managers, Financial Agents, Maintenance, and staff.

Although Optishower was successfully implemented in different European countries, still the probability of project failure is high. That's why dealing with challenges parallel with technological issues is part of the concern of the team. It is important to deal with implementation dilemma. The challenges could be general ones, pointed by previous researchers or some specific problems of this technology. The aim of this work is to document the difficulties and, later by employing ranking technique, to try to find the importance of the system and lower the probability of the failure. It is important to have a comprehensive picture of potential barriers ahead and evaluate the readiness of hotels, before starting the project. This will help develop an appropriate strategy and select the right solutions. Solutions are chosen according to the result of readiness evaluation. It could affect the business model, types of technology, the learning process for hotel staff, operational plan, etc. In this paper, the main barriers from previous project experiences were extracted through interviewing different groups involved in the project while Delphi was used to finalize the list. Afterwards they were ranked by using AHP technique to understand their priorities and importance. The results could be generalized to other innovative technologies in different industries and help techno-companies start projects with a wider perspective and better understanding of potential challenges ahead.

The rest of the paper is organized as follows: Section II provides a brief literature survey on challenges of implementing new technologies in hotel industries. Section III categorizes the challenges and describes each of them briefly. Section IV deals with the problem of ranking and prioritizing the challenges. The results and discussion are provided in section V, and the paper ends in a conclusion and future works.

2 Literature Survey

Examining information technology (IT) capabilities for implementation on United State hotels including all hotel sectors from luxurious hotels to economy ones has been studied by [1] to understand their similarities and differences in strategy. The study confirmed that there was no governmental strategic priority for hotel guest service improvement based on information technology. References [2, 3] reviewed the existing research works on the implementation of quality programs in hotel industries located in Ireland. The paper identified service quality, empowerment and implementation of management strategies as the key performance indices of hotel's quality. The relationship between hotel front office systems and the hotel guests has been studied by [4] through considering the quality, information technology infrastructure, technology acceptance by guests and perceived value. Reference [5] considered the implementation of customer relationship management (CRM) in 128 medium and small size hotels in Spain. The paper evaluated the main success factors of CRM implementation through organizational factors such as employee training, organizational motivation raising, and top management support. They also investigated that the technology investment is necessary to increase CRM, but it is not sufficient. The impact of hotel property attributes on adoption of radio frequency identification (RFID) for hotel sector has been investigated by [6]. The results of this paper showed that property size and chain affiliation, education level and age of IT decision-makers have significant impact on RFID technology adoption. For instance, they indicate that those larger hotels are more likely to adopt RFID technology. The possible barriers of implementing environmental technologies in the hotel industry in Hong Kong has been addressed by [7] through several interviews in managerial levels of hotels. The paper categorized barriers into three internal, external and product-related ones, and addressed some potential solutions to them. Reference [8] addressed managerial and theoretical extension of technology acceptance model based on evaluating the additional antecedent beliefs and predicted the attitude of tourists' behavior facing self-service technologies in the hotel environment. The paper also analyzed the trust impact on guests' behavioral intention for experiencing self-service in hospitality context, and showed trust has significant impact on tourist's attitude. The key factors of CRM based on both customer-centered management, employee support and organizational culture have been addressed in [9]. Reference [10] focused on the implementation of RFID used in hotel's locking technology to understand the adoption process and its theoretical implication. Possible barriers of applying information technology in hotels with the potential strategies as a solution have been addressed in [11]. This research categorized the barriers into three different stages; I) pre-implementation, II) implementation and III) post-implementation based on collected data from series of semi-structured interviews from chief information officers, hotel managers and IT managers.

Investigating existing conducted research works shows that the literature suffers lack of a study addressing the potential challenges in implementing an innovative water and electricity monitoring technologies. This paper is going to point out challenges that happened in a real case study and during the implementation of Optishower water and electricity monitoring in several hotels in Europe.

3 Challenges

To have a list of challenges, we must consider both service provider and client sides. Some challenges are based on the context and the place of implementation which could be different from one case to the other. We are trying to extract the main dilemmas common among different case studies. Needless to say, that some difficulties were from the service provider side including technical problems and calibration among others which mainly deal with the technology itself. It should be noted that because of page limitation, the challenges are explained briefly.

3.1 Service Provider Challenges

3.1.1. Water Consumption Measurement

Water consumption can be measured in different I) intrusive and II) non-intrusive ways; I) Intrusive way uses sensors like hall-effect sensors and hydroelectric generators through cutting the water pipeline and installing the sensor in the right location.
II) Water consumption measurement via use of acceleration sensor or ultrasound modules can be categorized as non-intrusive type of measurement because they do not need any water pipeline cut and they can be installed in restricted areas. This technology is more expensive and more difficult to code. However, using non-intrusive technology can pass "Intrusive installation" and "Old and Worn-out Water Pipelines" challenges.

Intrusive Installation: In our experience, hall-effect water flow sensor was used because they were cheaper, easy to code and their accuracy was acceptable for the measurement. However, because of their intrusive technology for installation, we faced some problems. For instance, in one hotel there was no access to the water pipeline inside the rooms and we had to cut-off the water pipeline on the whole floor. This kind of actions are very risky for hotel managers, especially when the hotel rooms are fully booked. In another hotel there was only ten-centimeter space for installation that was totally impossible for the job to be done.

Hotel Renovation: Because of renovation in some hotels, even the hotel technicians do not know which pipe goes to which room, and it takes a lot of time to figure out how the system works. Depending on whether the hotel accept the responsibilities or not, the issue can be considered as service provider challenges.

Old and Worn-out Water Pipelines: Most of the water pipes and main valves were open for years and require significant efforts to close them for maintenance and installation. In addition, flow meter installation needs to be done by certified plumbers who are paid on an hourly basis and the complex pipelines increases the installation costs, while in some cases plumbers do not take the responsibility of the process. Moreover, in many cases, there is no piping map available for the building which makes the work even more time-consuming and inefficient.

3.1.2 Electricity Consumption Measurement

Insufficient space in room electricity box: The electricity box which is located in each room entrance can be a good place for installing the electricity measurement unit. However, in our experience sometimes the box was too small and there was not enough space for installation. There might be some military grade or expensive sensors with smaller size to fit those boxes but they are not affordable for the company and this kind of applications.
Hotel Renovation: Similar to the challenges of water measurement, lack of knowledge about new electricity wiring system in renovated hotels is considerable. For each room in the hotel we needed to find the main wire that provided the electricity for the whole room electric devices. The problem was that the main electricity wire in the division box was going to the main hall of the room and the bathroom of the adjacent room. This was very time consuming when trying to find the right wire and an extra module was needed to check the electricity in the main hall and the bathroom separately.

3.1.3. Data Transfer Technology

There are different existing data transfer technologies such as Wi-Fi, Z-Wave and Zigbee. Among those mentioned technologies, Wi-Fi data transfer through Node MCU modules with ESP8266 Wi-Fi chipset is very popular, inexpensive, with lots of available libraries and source codes on the web. In addition, Wi-Fi infrastructure are always available in any hospitality areas. However, based on our experience there are some challenges regarding the use of ESP8266 or similar technologies that can be noted as follows:

Need for Power Supply: Most of the Wi-Fi data transfer technologies have high rate of consumption and it is not affordable to use battery to provide their power supply. There are some existing methodologies to reduce the consumption of the module by switching between transmission mode and deep sleep mode. Our experience shows, this was not reliable enough to be used in our case. For example, sometimes the modules went to deep sleep mode and never came back or sometimes it began to restart in the middle of data transmission for unknown reasons. The other problem was that in case of providing power supply for water consumption metering and transmission, in most cases there was no accessible power line near the place where water flow sensors were needed to be installed.
The following challenges are solved during our experience. However, we explain them briefly to be considered in the design procedure and reduce the cost of facing this types of challenges.

Hotel's Wi-Fi Infrastructure: When you use Wi-Fi as a data transfer technology at least you need one router nearby, to be used and to connect your Wi-Fi modules to the cloud. Most of the hotels, according to our experience, use captive login to provide free Wi-Fi for their guests and it is hard to ask them for SSID and Password.

Power Outage: Having a power outage in long time monitoring is inevitable. In case of having short power outage, we implement a simple auto-reset circuit to refresh our Wi-Fi modules and make them reconnect to the internet.

No Internet Situation: Without internet, data cannot be sent to the cloud-based server. In case of having no internet situation, the best solution is to design a mechanism to store the data in a memory and send them to the cloud-based server when the internet is available.

3.1.4. Marketing

Hotel management will provide needs through trusted supply networks. They prefer to keep few suppliers in order to reduce diversion in after sale services which will always limit various marketing ways for new product developers. New players must deal with hotel suppliers rather than hotel managers.

3.2 Client challenges

Infrastructure: Energy and water projects strongly depend on infrastructure and many challenges could be counted in this regard; the main ones are listed here. Challenges in water distribution include various types of water counters and pipe sizes, no map for water distribution and no accessibility to pipelines. The main challenge in electricity distribution is the lack of map for the electricity grid. There are more challenges in Wi-Fi connection and accessibility.

Security: Data security for any IoT project has always been a challenge. There are many easy ways to breach IoT sensors and the risk of data disclosure is irreparable.

Safety: Implementing new solutions/products in hotels always jeopardizes hotel safety, and introducing new software/hardware requires pilot durations. Insurance companies may never accept the risks of installation and hotel managers should accept all the risks. One important challenge is to convince hotel managers that risk is under control & can be handled if new solution/ Technology is implemented.

System adaptation: To introduce new solution/product to a hotel, we should have integrated and synchronize both systems. Normally, there is a need for new API to adapt new software data transfer and data registration to the existing data management system which is currently working in the hotel.

Decision process: It is always difficult to find the right decision maker in a hotel. When it comes to any change, hotel managers, marketing and maintenance directors, as well as ICT managers, are engaged to check the feasibility. Sometimes board and financial managers are also involved due to the financial or/and side effects of the project. This means, the decision process for a new product or technological solution in a hotel is complicated and requires approval from different departments when the steps, responsibilities or authorities are not clear.

End user intervention: Hotel clients may intervene in any new product/solution while the hotel owner has no control over them. Vandalism or stealing stuffs in hotel rooms are two examples.

Economic Feasibility: Many times, the economic feasibility of a new technology/solution is not clear to a hotel manager and there is a need for feasibility study or pilot duration to evaluate the product.

Technology Resistance: There is always resistance against new technologies and behavior change. In hotels, it will be even worse. Hotel guests are persuading a place to get rid of limitations and restrictions while technology could bring them back.

4 Ranking and Weighting the Challenges

In this section, the main aim is to rank the challenges and to know their weights. It will help have a better picture of challenges we will face in the implementation process and the resources which should be allocated in advance. Although all potential problems must be considered in any implementation strategy, for sure the level of importance is not equal and the priority of each challenge to deal with is significant to be known. To do the Analytical Hierarchy Process (AHP), a well-known managerial decision-making process algorithm, is employed. As we have to have the final decision of the group of experts regarding the comparison of challenges, a brainstorming meeting was organized and people who were involved in several projects with enough experiences exchanged thoughts to answer the main questions and fill related tables. The first step was to develop a conceptual model in which we were trying to merge some criteria to reduce the complexity of the system and accordingly the possible errors in weighing process. In AHP, the number of criteria is important and adding to the number of criteria, will dramatically increase the complexity and the risk of inconsistency. To avoid this problem, some challenges having some similarities were merged. For instance, both water and electricity consumption measurement challenges could be merged to represent the consumption measurement challenge. In fig.1 the final model which represents the challenges could be seen.

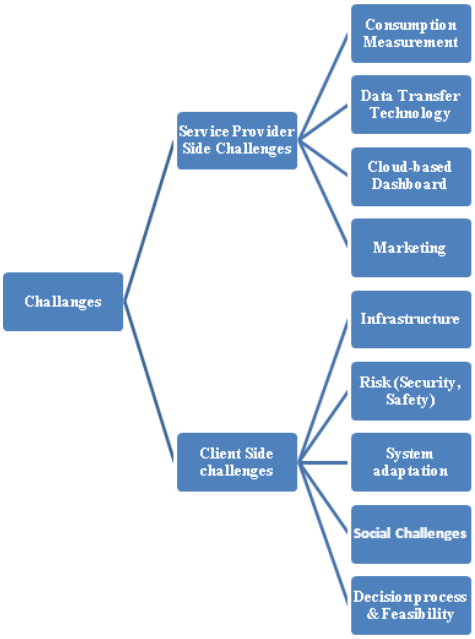

Fig. 1. Conceptual Model for AHP

To start the process of AHP, Pairwise Comparison scale adopted from Saaty [12] is used: Pairwise Comparison Set = [Extreme Importance, Very strong to extremely, Very strong Importance, Strongly to very strong, Strong Importance, Moderately to Strong, Moderate Importance, Equally to Moderately, Equal Importance]. Equivalent Numeric Rating for AHP Scale of Importance for comparison pair = [9, 8, 7, 6, 5, 4, 3, 2, 1]. Reciprocal (decimal) Rating for AHP Scale of Importance for comparison pair = [1/9 (0.111), 1/8 (0.125), 1/7 (0.143), 1/6(0.167), 1/5(0.200), 1/4(0.250), 1/3(0.333), 1/2(0.500), 1 (1.000)]. Tables 1 and 2 represent the pairwise comparison matrix of criteria for challenges on both service provider & client sides respectively. These two tables are the final results of the brainstorming session. Although the opinions were not the same, ultimately, consensus was made to have the final tables.

Table 1. Pairwise comparison matrix of criteria for Service Provider Side Challenges

Service Provider Side Challenges	*Consumption Measurement*	*Data Transfer Technology*	*Cloud-based Dashboard*	*Marketing*
Consumption Measurement	1	6	2	5
Data Transfer Technology	0.143	1	0.2	5
Cloud-based Dashboard	0.5	5	1	7
Marketing	0.2	0.2	0.143	1

Table 2. Pairwise comparison matrix of criteria Client-Side challenges

Client-Side challenges	*Infrastructure*	*Risk (Security, Safety)*	*System adaptation*	*Social Challenges*	*Decision process & Feasibility*
Infrastructure	1	3	0.25	9	5
Risk (Security, Safety)	0.33	1	6	9	7
System adaptation	4	0.17	1	4	1
Social Challenges	0.11	0.11	0.25	1	0.2
Decision process & Feasibility	0.2	0.14	1	5	1

By following the process of "approximate method" in AHP (ref), the final result for the priorities of the criteria for the challenge are calculated and shown in table 3 and table 4.

Table 3. Priorities of Service Provider Side Challenges

Service Provider Side Challenges	*Consumption Measurement*	*Data Transfer Technology*	*Cloud-based Dashboard*	*Marketing*	*Priority*
Consumption Measurement	1	7	2	5	0.487
Data Transfer Technology	0.143	1	0.2	5	0.123
Cloud-based Dashboard	0.5	5	1	7	0.335
Marketing	0.2	0.2	0.143	1	0.056

Table 4. Priorities of Client-Side challenges

Client-Side challenges	*Infrastructure*	*Risk (Security, Safety)*	*System adaptation*	*Social Challenges*	*Decision process & Feasibility*	*Priority*
Infrastructure	1	3	0.25	9	5	0.31

Risk (Security, Safety)	0.33	1	6	9	7	0.36
System adaptation	4	0.17	1	4	1	0.22
Social Challenges	0.11	0.11	0.25	1	0.2	0.03
Decision process & Feasibility	0.2	0.14	1	5	1	0.09

As it can be seen, the main challenge in Service Provider Side is consumption measurement following by cloud-based dashboard challenge while in client side, infrastructure and risk (security, safety) are considered as the main dilemmas followed by system adaptation.

One of the main concerns in AHP process is consistency. This is the way to make sure the judgments made by experts are consistent. The decision makers are using pairwise comparison and the criteria are compared with each other one by one, so some inconsistency is expected, and it is important to make sure the level of inconsistency is acceptable. To explain what inconsistency means, imagine that criterion A is two times as much important as B, and B is two times as much important as C. We are expecting A to be four times as much important as C, while the decision maker can choose any other numbers. Higher deviation from "four" means higher level of inconsistency. To calculate the inconsistency, the main process which is introduced by Saaty [12] was followed as follows. λ_{max} for both Service Provider Side and client-side challenge are calculated by the process which could be seen in Table 5 and Table 6.

Table 5. Priorities as factors and weighed coLumns of Service Provider Side Challenges

Service Provider Side Challenges	***Consumption Measurement***	***Data Transfer Technology***	***Cloud-based Dashboard***	***Marketing***	***Weighted sum***	***Priority***	***Weighted sum/ Priority***
Consumption Measurement	0.49	0.86	0.67	0.28	2.30	0.49	4.71
Data Transfer Technology	0.07	0.12	0.07	0.28	0.54	0.12	4.37
Cloud-based Dashboard	0.24	0.61	0.33	0.39	1.58	0.33	4.72
Marketing	0.10	0.02	0.05	0.06	0.23	0.06	4.06
Total							17.86
Divide Total by 4 to obtain λ_{max}							4.47

Table 6. Priorities as factors and weighed columns of Client-Side challenges

Client-Side challenges	*Infrastructure*	*Risk (Security, Safety)*	*System adaptation*	*Social Challenges*	*Decision process & Feasi-*	*Weighted sum*	*Priority*	*Weighted sum/ Priority*
Infrastructure	0.31	1.08	0.05	0.22	0.43	2.11	0.31	6.76
Risk (Security, Safety)	0.10	0.36	1.29	0.22	0.61	2.59	0.36	7.17
System adaptation	1.25	0.06	0.22	0.10	0.09	4.70	0.22	21.80
Social Challenges	0.03	0.04	0.05	0.02	0.02	0.17	0.02	6.89
Decision process & Feasibility	0.06	0.05	0.22	0.12	0.09	0.54	0.09	6.22
Total								48.82
Divide Total by 5 to obtain $\lambda_{\max}$ =								9.76

Now the Consistency Index can be calculated using (1) when N is 4 for service provider side and five for client-side challenge.

$$CI = \left(\lambda_{\max} - n\right) / \left(n - 1\right) \tag{1}$$

And finally, the Consistency ratio will be calculated using (2) while RI is the consistency index of a randomly generated comparison matrix. The RI index is the average of consistency Index of 500 randomly filled-in matrices [12]. Table 8 shows the RI index according to the number of criteria.

Table 7. Consistency indices for a randomly generated matrix [13, 14]

N	3	4	5	6
RI	0.58	0.9	1.12	1.24

$$CR = CI \,/\, RI \tag{2}$$

Table 8. Consistency result for Service provider and client sides challenge

fa	$\lambda_{\max}$	*n*	*CI*	*RI*	*RI*

Service Provider Side Challenges	***4.47***	***4***	***0.16***	***0.9***	***0.17***
Client-Side challenges	***9.76***	***5***	***1.19***	***1.12***	***1.06***

Unfortunately, CR is bigger than 0.10. For values smaller than 0.10, it could be assumed that Judgment matrix is reasonably consistent. This means that the expert matrix for pairwise comparison was not acceptable and in order to have accurate data, it should be revised.

5 Discussion and Conclusion

This paper targeted an important subject of Technology Implementation challenges while trying to share the experiences from real projects. Industry 4.0 is a new paradigm and it's more than hard and soft technology but prosperous implementation strategy. To make sure successful transition process in organizations and companies are deployed and adopted this new trend, it is important to know the dilemmas and challenges in advance. Although the focus of this paper was Innovative Water and Electricity Monitoring Technologies in Hotel Industry, many factors could be the same in other industries and for other types of technology. Through interviews with the technical and commercial people involved in the projects, different challenges were identified and introduced while it was finalized by using Delphi Technique. The challenges were categorized either as service provider side or client-side challenge. Then AHP process was used to understand the weight of challenges. Although the final result was not satisfactory, due to the level of inconsistency, and the final weights were not accurate, but the ranking was interesting. Most probably the variety of the background of the contributors was the reason for deviation and low level of inconsistency. In Service provider side the main challenge is measurement system which is a technological challenge followed by cloud base dashboard. The result shows that marketing is not a big issue to deal with as compared with technology. In client side, the risk is the most important concern, which makes sense in hotel industry. They are sensitive and any risk in the safety or security could cause an irrecoverable cost. Infrastructure ranks the second and the existing situation of infrastructure and their potential problems even in 4-/5-star hotels were not expected. System adaptation stands third and most hotels suggest negotiations with a third party who is in charge of running and maintaining existing ICT systems in the Hotel. Also, communication between technical staff responsible for infrastructure and the ICT department caused some problems. They had different mindsets and different approaches. Social challenges in fourth place were more a concern of luxury hotels. This means that the gamification and the rewarding strategy does not work properly unless the hotel uses the technology align with their sustainability approach and green strategy. Contrary to our expectation, feasibility and decision process issues were in the last place. This clearly shows that the main challenges are not economic but either related to the technology or adaptation. The project is still going on

and more hotels in different countries are using this technology. The future works' concentration is on two areas. First to improve the current result by using other weighing techniques and to improve the judgment matrix accordingly. Second, by introducing "I4.0 Readiness model" at micro level to understand the readiness of the hotels that would like to start transition strategy to be known as Tourism 4.0 Leaders. It is crucial to have a better understanding of the potential future challenges and plan appropriate customized implementation strategy according to the situation of each hotel. This could also help understand the difference between the countries or better say ecosystems as all Interviewees confirmed that their experiences in different European countries were not the same.

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