the 21th Scientific
Forum on Research in
Hajj, umrah and visits

Under the Patronage of

Custodian of the Two Holy Mosques

King Salman bin Abdulaziz Al Saud

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Umm Al-Qura Universty

The 21st Scientific Forum for Hajj, Umrah and Madinah Visit Research

The Scientific Bulletin

English Part

Scientific Papers

Preface

Under the Patronage of The Custodian of the Two-Holy Mosques King Salman Bin Abdulaziz Al-Saud, Hajj Research Institute in Umm Al-Qura University organizes the 21st Scientific Forum on Hajj and Umrah Research themed with "Digital Transformation in Hajj and Umrah". The forum is organized annually and alternately between Makkah in Umm Al-Qura University and Madinah. The forum is considered as an annual scientific event where specialists, scientists and stake holders working in Hajj and Umrah eco-system meet to discuss scientific issues, solutions and technology advancements that can enhance services and operations to Pilgrims and Visitors .

The 21st version of the Scientific forum announced the Call-For-Paper to all interested scientists in Saudi Universities and research institutes and officials in governmental, private, and non-profit organizations to submit papers during the present year (1443H-2022) covering the tracks namely: 1. Governance of Digital Transformation in Hajj and Umrah, 2. Application of Digital Transformation to Enhance Pilgrims Services and 3. Application of Digital Transformation to Develop Decision Support and service Provisioning .

The forum's scientific committee received about 200 submissions from more than 40 Academic, Governmental, Private and Non-Profit institutions in the kingdom. The committee reviewed the submissions with the help of specialists and experts in different sub-domains and selected 88 submissions as Scientific Papers and Poster Papers. This proceeding includes 34 Scientific Paper classified into 3 tracks while the remaining poster papers can be found in the forum website including work papers.

The scientific committee would like to thank authors for their submissions, reviewers for their voluntary work in manuscripts' evaluation. We greatly appreciate your contribution and time, which not only assisted us in reaching our decision, but also enables the committee to disseminate the right decision in selecting the highest qualified papers.

The committee would like also to extend its appreciation to H.E. Minister of Education and H.E. President of Umm Al-Qura University and Dean of Hajj Research Institute for their continuous support.

Scientific Committee of the 21st Scientific Forum of Hajj,
Umrah and Madinah Visit Research

The Scientific Committee of the 21st Scientific Forum of Hajj, Umrah and Madinah Visit Research

The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research – Umm Al-Qura University

6 – **7** Shaban 1443 / **9** – **10** March 2022

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First Theme

Governance of Digital Transformation in the Hajj and Umrah System

The Influence of Strategic Orientation to Digitalization on Strategic Decision-Making Effectiveness

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أثر التوجه الاستراتيجي نحو الرقمنة على فعالية اتخاذ القرارات الاستراتيجية: دراسة الشركات ذات الصلة بخدمات الحج والعمرة في المملكة العربية السعودية

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الملخص

الهدف من الدراسة: تهدف الدراسة إلى تحليل التأثير الوسيط لكل من العقلانية والتسييس في عمليات اتخاذ القرارات الاستراتيجية على العلاقة ما بين التوجه الاستراتيجي نحو الرقمنة وكلا من جودة وفعالية اتخاذ القرارات الاستراتيجية. وقد تم اختبار نموذج البحث باستخدام تصميم نمذجة المعادلة الهيكلية بناءً على بيانات مسح من الشركات ذات الصلة بخدمة قطاع الحج والعمرة في المملكة العربية السعودية. وقد أظهرت نتائج الدراسة أن التوجه الاستراتيجي نحو الرقمنة في الشركات ذات الصلة بخدمة قطاع الحج والعمرة في المملكة العربية السعودية له تأثير بشكل إيجابي على العقلانية في عمليات صنع القرارات الاستراتيجية في تلك الشركات، والتي بدورها تؤثر بشكل إيجابي جودة وفعالية اتخاذ القرارات الاستراتيجية في تلك الشركات. علاوة على ذلك، فقد أظهرت نتائج الدراسة أن التوجه الاستراتيجي نحو الرقمنة في الشركات له أثر سلبي على التسييس في عمليات صنع القرارات الاستراتيجية في تلك الشركات، والذي بدوره يؤثر بشكل إيجابي جودة وفعالية اتخاذ القرارات الاستراتيجية. وقد كشفت نتائج هذه الدراسة أن الرقمنة تعد بمثابة المفتاح للشركات ذات الصلة بخدمة قطاع الحج والعمرة في المملكة العربية السعودية لتكون قادرة على تقديم خدماتها بجودة عالية ومميزة والذي بدوره سوف يساهم في خلق قيمة تنافسية لهذه الشركات من خلال استغلال التقنيات الرقمية المتاحة، وبالطبع فإن هذا لا يقتصر على تحسين كفاءة التشغيل في هذه الشركات، ولكنه يساهم أيضا في تلبية توقعات العملاء في هذا القطاع. وبالتالي، تدرك هذه الشركات في هذا القطاع الهام قيمة فرص الرقمنة فيما يتعلق بتحسين نتائج أعمالها من خلال اتخاذ قرارات استراتيجية عالية الجودة وفعالة؛ ومع ذلك، يمثل تطبيق واستغلال هذا القرار تحديًا كبيرا لهذه الشركات. وبالتالي تساهم هذه الدراسة في هذا الحقل المعرفي من خلال توفير رؤى تجريبية في سياق الرقمنة ونتائج عمليات اتخاذ القرار الاستراتيجي في الشركات ذات الصلة بخدمة قطاع الحج والعمرة في المملكة العربية السعودية.

الكلمات الدالة: العقلانية، التسييس، التوجه نحو الرقمنة، فعالية القرارات الاستراتيجية.

Abstract

Purpose – This study aims to analyse the mediating effect of the two factors of strategic decision-making process (rationality and politicization) of strategic orientation to digitalization and strategic decision-making effectiveness.

Design/methodology/approach –The research model was tested using a structural equation modeling design based on survey data from 175 companies engaged in serving the Hajj and Umrah sector in the Kingdom of Saudi Arabia. This sector is classified as being highly digitalized.

Results – The results showed that the strategic orientation towards digitalization has a positive and direct effect on strategic decision-making effectiveness and has direct effect on politicization; and it has a positive and direct effect on procedural rationality. Moreover, the results revealed that procedural rationality has a positive and direct effect on strategic decision-making effectiveness. Though, the politicization has not effect to strategic decision-making effectiveness.

Conclusions – The findings of this study have revealed that digitalization is key for companies related to serving the Hajj and Umrah sector in Saudi Arabia to enable them, to provide high quality services and create competitive value through exploitation of digital technologies, not only to improve operation efficiency, but also to meet customers' expectations in this sector. Thus, these companies perceive the opportunities of digitalization regarding the improvement of their business outcomes through making quality and effective strategic decisions. However, application and exploitation of such a decision, remains challenging. This study contributes to the existing body of knowledge by providing empirical insights in the context of digitalization and the outcomes of the strategic decision which is bound to improve effectiveness of companies related to serving the Hajj and Umrah sector in the Kingdom of Saudi Arabia.

Keywords: Rationality, Politicization, Digitalization, Strategic Decision-making effectiveness.

1. Introduction

The increase of competition, the globalization of markets, the greater transparency required by corporate governance and regulatory and technological influences are pushing companies to develop strategies and systems to manage their operations, their strategy and decision-making more effectively throughout the organization, in order to maintain their market share and profitability. Technological innovations and digital changes now allow companies to achieve tangible improvement in their results due to the transversal integration of these technologies within their structures. A recent research by Kindermann, B., et al., (2020) revealed that the digital technologies are strategically fundamental for value creation within IT business alignment and digital orientation. The ability to employ digital technologies for business innovation and to change the traditional techniques and practices used to conceptualize goals, manage operations and control results. The strategic orientation towards digitalization focuses on the fusion of information technology (IT) practices with strategic decision-making. Nevertheless, it exist many organizations that suffer by difficulties to adopt technologies and to benefit from its added value. Therefore, trans-functional effect of digitalization on decision support should be integrated with specialized competencies and skills. This merge of IT-competencies allow the organization which occurred several difficulties to follow digitalization and numeric innovation with the required speed. A concept

delineating a strategic orientation towards digitalization to clarify the correlation that exists between IT transformation and strategic decision-making effectiveness through analyzing of determinants and factors which affect more the competitive advantage across corporate, Kohli, R., and Melville, N.P., (2019); McKenny et al. (2018).

In this study, we seek about the following axes that will deal with the available technologies allowing the integration of best practices for strategic decision-making: What are the advantages? What are the criteria for success? What are the threats to avoid? More specifically, we will deal with: (1) Similarities and differences between digital transformation standards that promote and slow down integration. (2) The latest trends and system developments in Industry 4.0. (3) The different levels and objectives of integration and how these vary according to the stages of the project. (4) The potential for optimizing risk management, traceability of non-conformities, performance improvement and strategic planning during integration based on digital. (5) Key factors for the successful planning and implementation of an integrated technological system that helps in decision-making. (6) The politicization and procedural rationality as a mediator factors that affect strategic decision-making effectiveness and firm value. The fundamental role of digital technology appears in many organizational activities through the employment and implementation of support systems and ICT technology. We validate the research model and its construct based on 175 companies which provide service to Umrah and Hajj sector in Saudi Arabia. The confirmation of study hypothesis have been established through two techniques of analysis, the first method is a principal component analysis (PCA) and the second method is a structural equation modeling (SEM) that helps to estimate variables and define causal relationships between constructs. Moreover, the research model allowed explaining the influence of strategic orientation to digitalization on strategic decision-making effectiveness in Umrah and Hajj sector.

2. Conceptual background

Several studies have focused on strategic orientation and characterize it with digitalization through measuring its impact on firm effectiveness. The ultimate purpose of digitalization in making decision strategy is the assembly of many actors which present a suitable system that support any organization change Furthermore, this study provides insights to explain how the strategic decision-making effectiveness can be affected by the politicization and procedural rationality by considering the strategic orientation towards digitalization demands of decision-making processes.

Several studies of strategic orientation to digitalization have focused on the firm value creation (e.g. Nambisan, S., et al., (2019) Raissi, N., (2017)), paying attention to the practices used to optimize strategic decision-making. According to Bouncken, R., and al., (2021b), this research extends the recent literature on the strategic orientation to digitalization by shifting the debate on the impact of strategic decision-making effectiveness.

By conceptualize on theory of organizational changes and IT-Based strategy the study recognizes that the capability of the firm to digitalize the information in the objective to support strategic decision-making effectiveness influences. Also, in Figure 1, this study categorizes the construct and estimated relationships in the conceptual model, which this study debates in the following sections.

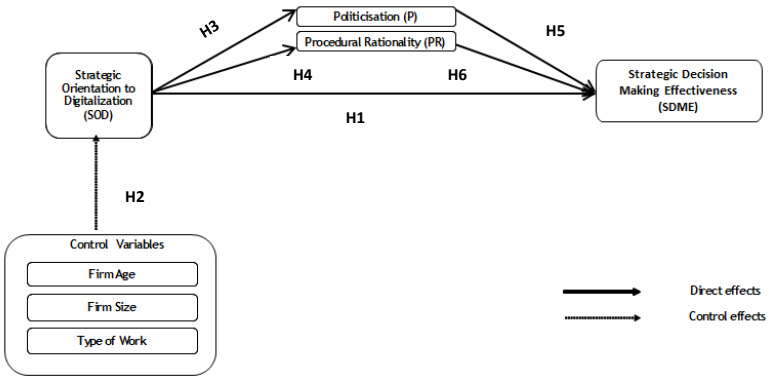

Figure 1. Research Model

2.1. Strategic orientation to digitalization

The global market has increasingly focused on innovation and differentiation. In fact, most companies aim to understand exchanges between stakeholders through cooperation and open dialogue. The challenge is to integrate the responsiveness of the culture into an integrated digitalization and IT into the organizational structure, in order to adapt to new requirements as well as internal and external conditions. Until now, the existing IT standards in terms of software and application at work take first and foremost the internal activities of the company (Kohli, R., and Melville, N.P., (2019); Raissi, N., & Matoussi, H., (2020)). However, as the strategic orientation to digitalization standard that emphasizes privilege is given to decision makers and corporate strategy processes. The transversal relationship is labelled with the learning organization through digitalization. It is in order to emphasize that digital innovation and transformation initiatives develops business strategies and provides competitive advantage, as well as the continuous improvement of competencies to meet dynamic and innovative demands and challenges. An integrated digital techniques and tools will require continuous reconstruction, updating and innovation in the different areas of management and especially in top management, Quinton et al., (2018).Thus, this study argued that:

Hypothesis 1. The strategic orientation to digitalization has a positive and direct effect to strategic decision-making effectiveness.

Hypothesis 2. The strategic orientation to digitalization has a high and positive sensitivity to firm age, firm size and type of work.

Hypothesis 3. The strategic orientation to digitalization has a negative and direct effect to politicisation.

Hypothesis 4. The strategic orientation to digitalization has a positive and direct effect to procedural rationality.

2.2. Politicisation

Scholars have discussed and defined politicization in different ways, however, most definitions confirm that politicization is related with the attempts by the decision-making team members to affect decision-making so as to satisfy and serving their own interests, rather than those of the firm (Allen et al., 1979; Elbanna, Thanos, & Papadakis, 2014; Thanos et al., 2017). In their attempts to impact on the strategic decision outcomes and protect their own interests, decision-makers in organizations often coalition formation and engage in political behaviors, for example, manipulation, secret

communication, hindering decisions on resource allocation, also restrict and distort information flow, and distract decision-makers' attention from their organizational goals and divert it towards their own self-interests (Dean and Sharfman, 1996, Elbanna, 2006, Pettigrew, 2014). Previous studies have been linked politicization in the strategic decision- making process to continual interruptions, discontinuities, and resistance (Papadakis et al., 1998). Therefore, politicization has been blamed for undermining effectiveness and speed in strategic decision- making, because it restricts and distorts the flow of accurate information which is needed for effective strategic decision-making (Dean & Sharfman, 1996). Existing studies in the literature showed that mostly large organizations broadly identify a negative relationship between politicization and organisations outcomes (Bouquet & Birkinshaw, 2008; Geppert, Becker-Ritterspach, & Mudambi, 2016). However, the influence of politicisation on small and medium-sized enterprise strategic decision-making has received little attention, existing evidences in the literature have shown the negative impact of politicization on the speed and effectiveness of small and medium-sized enterprise strategic decisions- making process (Elbanna, Di Benedetto, & Gherib, 2015). Moreover, previous studies that studies on the relationships between business digitalization and decision-making effectiveness suggest that politicization might negatively impact the development of strategies based-digitalization as well as performance outcomes in organizations (Francioni, Musso, & Cioppi, 2015; Thanos et al., 2017). Therefore, this study argued that:

Hypothesis 5. The politicization has a negative and direct effect on strategic decision-making effectiveness

2.3. Procedural rationality

Strategic decision-making processes are those processes (procedural rationality and politicization) followed by decision-makers to reach important decisions that include the arrangement and the configuration of resources (Dean & Sharfman, 1996; Elbanna, Thanos, & Jansen, 2020; Papadakis, Thanos, & Barwise, 2010). Thus, procedural rationality links to the systematic and methodical way of collection and analysis of relevant data and information from the external and internal environment, the number of alternative solutions simultaneously considered, and the extent to which quantitative analyses are used (Dean & Sharfman, 1996). Therefore, from the perspective of procedural rationality, strategic decision-making involves a systematic and methodical process of collecting and analyzing data so as to make a decision (Samba, Tabesh, Thanos, & Papadakis, 2020; Miller, 2008).

Prior studies showed that some small and medium-sized enterprises using procedural rationality despite that many resources required to process the external and internal environment information (Crick & Spence, 2005). Strategic decision-making in the organizations about digitalization involves the collection and analysis of all possible information about decision-making effectiveness, the availability of partners and the competitive environment (Oviatt & McDougall, 2005a). Therefore, the more strategic decision-making effectiveness based on procedural rationality, the shorter it takes to reach a decision because digitalization is well integrated and it correlated positively with procedural rationality (Vermeulen & Barkema, 2002).

For this reason, increasing procedural rationality in strategic decision-making may help small and medium-sized enterprises to respond on time to opportunity in competitive markets (Baum & Wally, 2003). Then, this study presented that: Hypothesis 6. The procedural rationality has a positive and direct effect to strategic decision-making effectiveness.

2.4. Strategic Decision-Making Effectiveness

Strategic decision-making effectiveness is based on extremely complex processes since of resource arrangement and their configuration related to firm-specific advantages and their improved performance (Calabretta, Gemser, & Wijnberg, 2017). Previous studies identified two essential models of strategic decision-making effectiveness which are procedural rationality and politicization. The rationality model refers to the extent to which decision-makers follow a systematic and methodical process in reaching carefully thought-out goals (Schwenk, 1995). Moreover, the strategic decision-making effectiveness issued by processes (procedural rationality and politicization) followed by decision-makers to reach important decisions that include the arrangement and the configuration of resources (Dean & Sharfman, 1996; Elbanna, Thanos, & Jansen, 2020; Papadakis, Thanos, & Barwise, 2010). Strategic decision-making effectiveness related to digitalization as a function not only of entrepreneurial behaviour but also of strategic decisions (Nummela, Saarenketo, Jokela, & Loane, 2014), which include the question about the time taken on orientation to digitalization. Furthermore, strategic decision-making effectiveness determined by the extent of information processing, and consequently the speed of reaching a decision to digitalization (Andersen & Buvik, 2002). Consequently, strategic decision-making processes should differentiate between the pace of digitalization of small and medium-sized enterprises (Casillas & Acedo, 2013). In other words, it should distinguish between small and medium-sized enterprises time taken between the starting of the firm and its orientation to digitalization.

As noted by Casillas and Acedo (2013) "studies on the speed of digitalization could be significantly advanced by using essentially process-based determinants" (p. 24). Then, this study assumed that the strategic orientation to digitalization may be has a lower effect in small and medium-sized enterprises that adopt more politicization to reach the strategic decision-making effectiveness.

3. Methods

3.1. Research design and sampling

The purpose of this research is to explain the methodology applied in order to approve a relevant, reliable and valid model construct and items that will confirm the correlation between strategic orientation to digitalization and strategic decision-making through politicization and procedural rationality. Furthermore, to determine the sample of research, the researchers have used a questionnaire delivered to 175 companies which provide a service to Umrah and Hajj sector in Saudi Arabia.

The study by questionnaire was directed in two sections, the first section about demographic data, and the second part is devoted to analyze the impact of each variables and factors that appear in our conceptual model. Then, to specify a measure a model criteria, we chose the "Likert scale" with 7 levels. According to Evrard and al. (2009); YIN, R. K. (2017), the Likert scale revealed as a best instrument used to measure the opinions and attitudes of respondents. The instrument for data collection is a questionnaire which used a scale that provides opinions on the same subject, and the subject chooses between seven possible answers (from Strongly disagree to Strongly agree). Likewise, in this section, the researchers treated questions coding which presented items of each construct that forms the research model and prepares the data to be analyzed by software (SPSS and SmartPLS).

3.2. Measures

This study employed well established measures of variables, which had been widely used and tested in the literature and had acceptable validity and reliability levels. Analytically:

Independent variable

Strategic orientation to digitalization is an independent variable. Digitalization refers to how information technology or digital technologies can be used to promote the existing business processes (Verhoef et al., 2019). To measure strategic orientation to digitalization, the scale of Lu and Ramamurthy (2011) was adapted, because in previous studies, this scale has been shown to have good reliability and validity indicators. Developing a clear vision regarding how information technology contributes to business value; integrating business strategic planning and information technology planning; enabling functional area and general management's ability to understand value of information technology investments; we constantly keep current with new information technology innovations; we are capable of and continue to experiment with new information technology as necessary; we have a climate that is supportive of trying out new ways of using information technology; we constantly seek new ways to enhance the effectiveness of information technology use. Also, the study included 9 items based on several questions as a scale measure.

Dependent variable

Strategic decision-making effectiveness is a dependent variable. It is measured by a four-item scale taken from (Jansen et al., 2013), scaled on seven-point Likert scales. The study included 10 items of which are reformulated in questions presented as follow: (1) *To what extent have the strategic decisions contributed to the turnover growth of your firm*; (2) *To what extent have the strategic decisions contributed to the profit growth of your firm*; (3) *To what extent is the decision-making team were satisfied with the decision*; and (4) *To what extent has the decision led to the expected result*.

Mediating variables

Procedural rationality and politicization are mediating variables. Procedural Rationality (Cronbach alpha = 0.76) was measured based on Dean and Sharfman's (1996) scale. This scale has been widely used in the literature (e.g., Ji & Dimitratos, 2013; Thywissen et al., 2018). It assesses the decision-making process in regard to key strategic orientation to digitalization in the firm in terms of searching for relevant information; analyzing relevant information; the importance of quantitative techniques in making decisions; how analytical the decision-making process is; and, how effective are the decision-makers in taking account of relevant information. Likewise, the study adopted 3 items for politicization and 5 items for procedural rationality.

Control variable

- Firm age influences the pace of firm growth and internationalization (Consistent with Ronkko et al., 2013). Therefore, firm age was used as a control variable.
- Firm size was measured in logarithmic form and was represented by the number of employees (e.g. Heavey et al., 2009; Karami & Tang, 2021).

- Type of work: Drawing on the work of De Clercq et al. (2015), we distinguished between manufacturing and service firms.

3.3. Analysis procedure

This section is intended to clarify how the data collected have been analyzed. It permits the researchers later to integrate data into SPSS software and to make easy the modelling of our research. The statistic validation supports us to use the data analysis and to do exploratory factor analysis (EFA) for measures scales (Items) validation. Therefore, the analysis of the sample used exploratory factor analysis and confirmatory factor analysis (CFA) that offered many structural relations path and gave rise to diverse results within Structural Equation Model (SEM) that analyzed by SmartPLS.

4. Results and discussion

4.1 Descriptive Statistics

The sample of study incorporates 175 companies which provide service to Umrah and Hajj sector in Saudi Arabia. The respondents presented 5 service divided into 8.6% accommodation; 12% hotel; 6.9% public services; 64% tawaffah; and 8.6% transport. The analysis is initiated by measuring the perception of managers to the real added value of digitalization on their strategic decision-making effectiveness.

The results show a diversity of answers and explain the degree of IT integration. The researchers find that the ratio of the number of computers to the number of employees exceeds 70%, of the percentage of digitized operations and procedures out of the total transactions is around 65%; the percentage of services provided electronically out of total services exceed 66%; the number of computer programs used is around 6; the number of websites is one per company; and the number of electronic systems and applications is around 3 per organization. Also, the companies oriented to digitalization since 10 years as an average mean. The descriptive analysis provides a few information about the model tested in our research.

Table 1. The sample description (Service)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Accommodation	15	8.6	8.6	8.6
	Hotel	21	12.0	12.0	20.6
	Public services	12	6.9	6.9	27.4
	Tawaffah	112	64.0	64.0	91.4
	Transport	15	8.6	8.6	100.0
	Total	175	100.0	100.0	

4.2. Validity of Measurement Scale

The analysis used the exploratory factor analysis (EFA) to validate the measurement scales that is defined by 4 constructs and 27 items. The study begins by testing the reliability and the validity of politicization and procedural rationality as mediator variables within 3 items and 5 items successively; the strategic orientation digitalization as an exogenous variable (9 items); and the strategic decision-making effectiveness as an endogenous variable with 10 items. The items were to approve the model constructs and their dimensions within item's coherence. The measures validation was done

using statistical tests have been done; the reliability test with Cronbach's Alpha, the approval data via normality test (Skewness and Kurtosis coefficients); KMO and Bartlett's Test and finally with Total Explained Variance (TVE) indicator. In addition, the validation of items applied through Principal Component Analysis (PCA). Table 2 below shows exploratory factor analysis for measurement scales presented the results obtained after reliability and validity tests.

Table 2. Exploratory factor analysis for measurement scales

Variables	Code	N of Items retained	Cronbach's Alpha	KMO and Bartlett's Test		Total Variance Explained (Cumulative %)
				Kaiser-Meyer-Olkin Measure	Bartlett's Test (Sig.)	
Politicization	P	3	0.802			
Procedural Rationality	PRO	5	0.869			
Strategic Orientation Digitalization	SOD	9	0.919	0.756	0.000	45.197
Strategic Decision Making Effectiveness	SDME	10	0.806			

The main results presented the validation of all items and the reliability test with Cronbach's Alpha calculated revealed that all values exceed the threshold 80%. It exists a high consistency between items for all constructs. The variables tested approve internally coherence and have satisfactory reliability coefficient. Furthermore, the items validity via normality test (Skewness and Kurtosis coefficients) confirmed that all values seem between -1 and +1 (Hair et al., (2017)); the normality distribution approved and items have been retained. Likewise, the validation of measurement scales required to calculate the representative of each item (loading) with factors through Total Variance Explained (TVE) indicator. Moreover, the results of KMO test and Bartlett's test are statistically significant with successively value of more than 75.6%; and a p-value for constructs is acceptable with (P-value = 0.000) that reflect a high significance. Also, the variance analysis explained that all items validated and factors exceed 45% for the 4 tested latent variables.

4.3. Confirmatory Factor Analysis

The test of model after validity of measurement scale have been established by testing items with their constructs, and evaluating measurements model by calculating the following indicators: Cronbach's Alpha, Jöreskog's Rhos and Average variance extracted (AVE). The findings of 4 constructs that characterize the estimated model (independent and dependent variables) are shown in table 3 below:

Table 3. The reliability and validity of constructs

Constructs	Code	N of Items	Cronbach's Alpha	Jöreskog's Rhos	Average Variance Extracted (AVE)
Politicisation	P	3	0.801	0.866	0.690
Procedural Rationality	PRO	5	0.869	0.906	0.659
Strategic Orientation Digitalization	SOD	9	0.918	0.932	0.606
Strategic Decision Making Effectiveness	SDME	4	0.853	0.902	0.697

The analysis of initial items given after statistical evaluation of 21 items which defined 4 latent variables. The items retained presented as follows: 3 items of politicization, 5 items of procedural rationality, 9 items of strategic orientation

digitalization, and 4 items of strategic decision-making effectiveness which showed all the dimensions of estimated model. Furthermore, calculating reflective measurement models started firstly by reliability and validity tests of items with their latent variables. The results revealed that the Cronbach's indicator is more than 0.8 and seem between [0.801; 0.918]; it appears as an acceptable items consistency of each constructs (the reliability of internal consistency is significantly higher). The second criterion tested is Jöreskog's Rhos; its value is more than 86.6%, which significantly exceeds the threshold of 0.6. These statistical indicators reflected that the internal coherence of 21 items is approved and that exist a high consistency between items and constructs. The significant values of tested criterion validated items as a research model measurement scales. Accordingly, the valuation of validity required to test the convergent and the discriminant validities. The authors Fornell, C., & Larcker, D.F., (1981) cited by Hair, J. F., and al., (2017) argued that the Average Variance Extracted (AVE) as a criterion of convergent validity should be calculated to validate the measurement scales; it is necessary to has a value higher than 0.5. The study approved this level and the AVE values are more than 60.6% which indicate acceptable convergent validity. The results revealed that latent variable is able to represent more than 50% of the variance of its indicators on average (Hair, J.F., and al., (2019); Götz, O., et al., 2009). Then, the discriminant validity should be tested with two measures; the Fornell–Larcker criterion in table 4 and the Heterotrait-Monotrait Ratio (HTMT) in table 5.

Table 4. Fornell-Larcker Criterion (Discriminant validity)

	Co Age	Co Size	Politicisation	Procedural Rationality	Strategic Decision-Making Effectiveness	Strategic Orientation to Digitalization	Type of Work
Co Age	1.000						
Co Size	0.021	1.000					
P	-0.086	-0.065	**0.831**				
PRO	-0.051	-0.205	0.072	**0.812**			
SDME	-0.020	-0.189	0.038	0.911	**0.835**		
SOD	-0.108	-0.309	0.204	0.339	0.309	**0.778**	
Type of Work	-0.167	-0.008	0.087	-0.020	-0.052	-0.054	1.000

The test of discriminant validity demonstrates that the values of AVE of each construct should be more than the squared correlation coefficients with other latent variable, Hair et al., (2019). The results indicate that AVE values of the tested latent variables approved this criterion and showed as follows: the value of politicization is 0.831, procedural rationality is 0.821, and strategic decision-making effectiveness is 0.835, while that of strategic orientation to digitalization is 0.778. The findings revealed that the self AVE of each construct is higher than other variables except in procedural rationality, (Hair, et al., 2017; Götz, O., et al., 2009; Chin, W.W., 1998).

Table 5. The Heterotrait-Monotrait Ratio (HTMT) (Discriminant validity)

	Co Age	Co Size	Politicization	Procedural Rationality	Strategic Decision-Making Effectiveness	Strategic Orientation to Digitalization	Type of Work
Co Age							

Co Size	0.021					
P	0.098	0.058				
PRO	0.091	0.222	0.124			
SDME	0.087	0.202	0.100	**1.046**		
SOD	0.119	0.311	0.192	0.376	0.337	
Type of Work	0.167	0.008	0.094	0.034	0.055	0.095

Moreover, the assessment of discriminant validity of HTMT criterion required a HTMT value to be less than 0.90, and the discriminant validity should be approved through the test within two reflective constructs, Henseler, J., et al., (2016) cited by Hair, J.F., and al., (2019). Consequently, the variables tested by bootstrapping Heterotrait-Monotrait Ratio showed a statistical significance. Also, the formative constructs are confirmed except the constructs with value marked in bold (PRO and SDME: (1.046)) which designated discriminant validity problems with threshold HTMT ratio 0.9. Furthermore, the valuation of structural model required multicollinearity test which measures the correlation of manifest variables. The multicollinearity calculated by variance inflation factor (VIF). The findings presented that VIF values is more than 1 and less than 2. Also, the inner VIF values of structural model showed as follows: SOD --->P(1.000); SOD--->PRO (1.000); SOD--->SDME(1.173); P--->SDME (1.044); PRO--->SDME (1.130). Based on the previous values, the multicollinearity of formative indicators approved and statistical significant. It is necessary after multicollinearity test to measure R Square of endogenous construct which specified substantial if its value around 0.67, moderate, if the value reaches 0.33, and weak, if the value is 0.19; Hair, J.F., and al., (2019). In our case, the R2 approve the model's predictive accuracy and the structural model is statistical significant; and the coefficient showed as follows: Strategic Decision-Making Effectiveness (R2 = 0.831). Additionally, the estimated value of path coefficients via structural model required assessing the sign, magnitude, and significance (applied bootstrapping routine). Likewise, the path coefficients tested to examine the causality between model constructs in the SEM approach, Tenenhaus, M., et al., (2005), cited by Hair, J.F., and al., (2019). It appears in Table 6 that exists 4 significant causalities presented as follows: (1) Co Size -> Strategic orientation to Digitalization; (2) Procedural Rationality -> Strategic Decision-Making Effectiveness; (3) Strategic orientation to Digitalization -> Politicisation; (4) Strategic orientation to Digitalization -> Procedural Rationality.

Table 6. The estimates of path coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Co Age -> Strategic orientation to Digitalization	-0.114	-0.115	0.076	1.505	0.133
Co Size -> Strategic orientation to Digitalization	-0.307	-0.312	0.062	4.933	0.000*
Politicisation -> Strategic Decision-Making Effectiveness	-0.029	-0.029	0.036	0.802	0.423
Procedural Rationality -> Strategic Decision-Making Effectiveness	0.911	0.912	0.037	24.887	0.000*
Strategic orientation to Digitalization -> Politicisation	0.204	0.215	0.092	2.209	0.028*
Strategic orientation to Digitalization -> Procedural Rationality	0.339	0.343	0.098	3.457	0.001*
Strategic orientation to Digitalization -> Strategic Decision-Making Effectiveness	0.006	0.003	0.047	0.122	0.903

Type of Work -> Strategic orientation to Digitalization	-0.075	-0.071	0.065	1.162	0.246

* p < .05

At this phase, the results of affective and reflective constructs evaluation and the structural model fit have been tested via SmartPLS 3 presented significant values in comparison with critical threshold. The findings showed that SRMR indicator of Common Factor Model and Composite Model revealed a statistical significant within p-value (<5%). The SRMR criterion defined as the difference between the observed correlation and the predicted correlation, Henseler, J., et al. (2014); Hu, Li-tze & Bentlerb, P. M., (1999) cited in Hair, J.F., and al., (2019). Consequently, the results of this study showed that the SRMR criterion is around 0.08 and it is has an acceptable fit (0.089 > 0.08). Additionally, the Bentler-Bonett index or normed fit index (NFI) required to validate the quality of global model that the value reaches 0.9, (Hair, J.F., and al., (2019)). In this case, the critical level has not been reached, it is around 0.419; this level is moderate and the indicator has not an acceptable value to explain the quality of model. In general, to confirm the robustness of model fit, the calculation of a indicative criterion has been applied as follows: dULS (2.386) < bootstrapped HI 95% of dULS, dG (7.077) < bootstrapped HI 95% of dG, Chi-Square (2772.482/ p-value = 0.000) and the rms Theta (0.213 --> (close to zero)). Therefore, the structural model characterizes the data very well. Based on Table 7 it is revealed that revealed the total effects of relationship between latent variables, the findings presented a statistical significance at the critical threshold of 5% (p-value < 0.05).

Table 7. Total effects

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Co Age -> Politicization	-0.023	-0.024	0.019	1.207	0.228
Co Age -> Procedural Rationality	-0.039	-0.039	0.027	1.428	0.154
Co Age -> Strategic Decision-Making Effectiveness	-0.035	-0.035	0.025	1.422	0.156
Co Age -> Strategic orientation to Digitalization	-0.114	-0.115	0.076	1.505	0.133
Co Size -> Politicization	-0.063	-0.068	0.034	1.858	0.064
Co Size -> Procedural Rationality	-0.104	-0.108	0.040	2.580	0.010*
Co Size -> Strategic Decision-Making Effectiveness	-0.095	-0.098	0.039	2.411	0.016*
Co Size -> Strategic orientation to Digitalization	-0.307	-0.312	0.062	4.933	0.000*
Politicization -> Strategic Decision-Making Effectiveness	-0.029	-0.029	0.036	0.802	0.423
Procedural Rationality -> Strategic Decision-Making Effectiveness	0.911	0.912	0.037	24.887	0.000*
Strategic orientation to Digitalization -> Politicization	0.204	0.215	0.092	2.209	0.028*
Strategic orientation to Digitalization -> Procedural Rationality	0.339	0.343	0.098	3.457	0.001*
Strategic orientation to Digitalization -> Strategic Decision-Making Effectiveness	0.309	0.310	0.096	3.204	0.001*
Type of Work -> Politicization	-0.015	-0.015	0.016	0.978	0.329
Type of Work -> Procedural Rationality	-0.026	-0.025	0.024	1.058	0.291

Type of Work -> Strategic Decision-Making Effectiveness	-0.023	-0.023	0.022	1.055	0.292
Type of Work -> Strategic orientation to Digitalization	-0.075	-0.071	0.065	1.162	0.246

* p < .05

Finally, the correlation between constructs confirmed a statistical significance at critical threshold of 5% (p-value < 0.05). Moreover, based on total effects outcome, the first relationship is between company size as a control variable and Procedural Rationality; Strategic Decision-Making Effectiveness and Strategic orientation to Digitalization; it revealed that exist a statistical significance and the p-values of constructs under than 5% (p-value < 0.05). The second path is between Procedural Rationality -> Strategic Decision-Making Effectiveness; the relationships presented a statistical significance at the critical threshold 5 % (p-value < 0.05). Third path is between Strategic orientation to Digitalization -> Politicization; Procedural Rationality and Strategic Decision-Making Effectiveness. These results revealed that exist a positive and direct relationship between Strategic orientation to Digitalization and Strategic Decision-Making Effectiveness. For more specifications, the structural model with estimated parameters clarifies the causal relationships between constructs as shown in Figure 2.

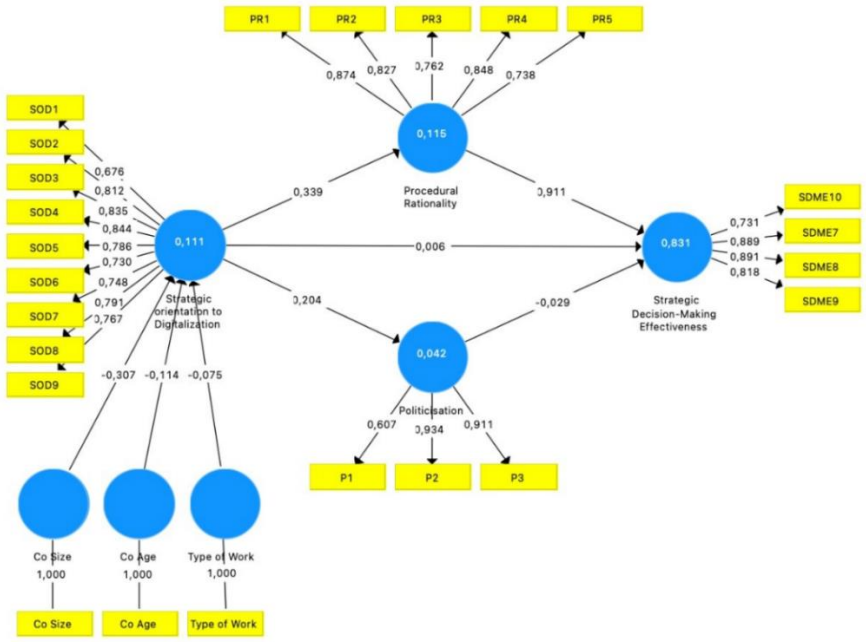

Figure 2. The structural model with estimated parameters

4.4. Hypothesis testing results

The findings approved and accepted along this analysis section allow confirming or rejecting the hypotheses in the conceptual part of this study. The researchers can therefore argue that the results revealed an acceptable fit of structural model. Based on the coefficients like: NFI, R2 which are close to the acceptable threshold; (NFI = 0.419; R2 = 0.831). Moreover, the SRMR criterion is equal to 0.089 > 0.08; the f2 values varying between 0.044 (small) and 4.342 (large); Chi-

Square (2772.482 / p-value = 0.000) and the rms Theta (0.213 -> (close to zero)). Certainly, the causality analysis of constructs gave the opportunity to test 6 relationships (direct and indirect) between constructs.

Table 8. The significance analysis of the Direct and Indirect Effects

	Hypotheses	Path	Direct (DE)/Indirect effects (IDE)/NR	t-values	p-values	Outcome	Hθ validation
H1	The strategic orientation to digitalization has a positive and direct effect to strategic decision-making effectiveness.	SOD -> SDME	DE	3.204	0.001	Yes	Accepted
H2	The strategic orientation to digitalization has a high and positive sensitivity to firm age, firm size and type of work.	SOD -> Co Size	DE	4.933	0.000	Yes (Only with Co Size)	Accepted (only with Co Size)
H3	The strategic orientation to digitalization has a negative and direct effect to politicization.	SOD -> P	DE	0.277	0.782	Yes	Accepted (with one criteria)
H4	The strategic orientation to digitalization has a positive and direct effect to procedural rationality.	SOD -> PRO	DE	3.457	0.001	Yes	Accepted
H5	The politicization has a negative and direct effect to strategic decision-making effectiveness	P -> SDME	NR (no relationship)	0.802	0.423	No (Neither direct nor indirect)	Rejected
H6	The procedural rationality has a positive and direct effect to strategic decision-making effectiveness.	PRO -> SDME	DE	24.887	0.000	Yes	Accepted

Note: * $p < .05$, estimated using the latent variable scores of the constructs.

The results of study showed that the strategic orientation towards digitalization has a positive and direct effect on strategic decision-making effectiveness. This relationship aligned with the studies of Elbanna, and al., (2020); Raissi, N., & Matoussi, H., (2020); Kohli, R., and Melville, N.P., (2019); Quinton et al., (2018) and Calabretta, & al., (2017). The second hypothesis has been accepted only with company size. The idea was to propose that the strategic orientation towards digitalization has a high and positive sensitivity to firm age, firm size and type of work. This result comes in line with the finding of research of Raissi, N., & Matoussi, H., (2020); Kohli, R., and Melville, N.P., (2019); and Quinton et al., (2018). Hypothesis three which argued that the strategic orientation towards digitalization has a negative and direct effect to politicisation has been approved with one criterion. It exist a direct effect and positive relationship between constructs that is why this purpose has not been aligned to studies of Raissi, N., & Matoussi, H., (2020); Kohli, R., and Melville, N.P., (2019); and Quinton et al., (2018). Thus, the hypothesis four which revealed that strategic orientation to digitalization has a positive and direct effect to procedural rationality has been confirmed. This result coherent with researches of Raissi, N.,

& Matoussi, H., (2020); Kohli, R., and Melville, N.P., (2019); and Quinton et al., (2018). The fifth hypothesis claimed that politicisation has a negative and direct effect to strategic decision-making effectiveness has not been approved. The results do not aligned with studies of Thanos et al., (2017); Geppert & al., (2016); Elbanna, Di Benedetto, & Gherib, (2015); Francioni, and al., (2015); Elbanna, and al., (2014); Pettigrew, (2014). Finally, the sixth hypothesis which suggests that the procedural rationality has a positive and direct effect on strategic decision-making effectiveness has been accepted and this result showed a consistency with the studies of Elbanna, and al., (2020); Samba, and al., (2020).

5. Conclusions and recommendations

This study revealed that the findings of this research will help to give our main problematic an answer: Do strategic decision-making effectiveness differentiate with digitalization of small and medium-sized enterprises? According to the theory of organizational information processing (Daft & Lengel, 1986; Tushman & Nadler, 1978) and the Resource-Based View of the firm (Barney, 1991; Wernerfelt, 1984), in his study argues that procedural rationality as a key strategic decision-making process, increase the demand for information processing when small and medium-sized enterprises consider digitalization, which has a positive effect on strategic orientation to digitalization. Theory of organizational information processing theory postulates that firms gather, share and analyse information in trying to support the decision-making process (Tushman & Nadler, 1978). This may propose that requirements of information processing based on a great extent on the processes of decision-making in the organization. Furthermore, the Resource-Based View posits that firms possess various resources, and thus, their strategies are based on different resource bundles types (Barney, 1991). The Resource-Based View reports that small and medium-sized enterprises possess limited or little resources compared to larger companies, thus, it may limit to some extent its abilities, their organize processes and in turn their competition (Terziovski, 2010). Therefore, the need of digitalization of strategic decision-making processes may have implications for strategic decision-making in small and medium-sized enterprises, whereby littler resources are dedicated to information processing. This study examines procedural rationality and politicization as two strategic decision-making processes. Procedural rationality is linked to the use of systematic and comprehensive analytical methods while problem-solving and making strategic decisions (Deligianni, Dimitratos, Petrou, & Aharoni, 2016). While, politicization is linked to political behavior that brings in coalition formation, interruptions, and resistance between decision-makers during the strategic decision-making process (Papadakis, Lioukas, & Chambers, 1998; Thanos, Dimitratos, & Sapouna, 2017). To investigate the relationship between strategic decision-making of small and medium-sized enterprises and the digitalization, this study has worked on as a sample of 175 small and medium-sized enterprises from the Kingdom of Saudi Arabia which provides service to Umrah and Hajj sector. We selected the Kingdom of Saudi Arabia as our research setting because the Kingdom of Saudi Arabia is one of the big Middle East countries and one of the strongest economies in this region with many small and medium-sized enterprises and comparatively few local opportunities for growth (Brouthers, Nakos, Hadjimarcou, & Brouthers, 2009). Due to these characteristics, this study is likely to have theoretical and empirical implications that could be applied to many similar countries in the Middle East and other parts of the world. This study contributes to the theory of organizational information processing and digitalization, the literature on the digitalization of strategic decision-making in small and medium-sized enterprises, and the literature on the pace of small and medium-sized enterprises digitalization. By integrating the theory of organizational

information processing and the Resource-Based View, this study finds out that the digitalization requirements of strategic decision-making processes impact strategic decision-making speed and effectiveness in small and medium-sized enterprises. Such theorizing contributes to the literature on strategic decision-making in small and medium-sized enterprises because it recognizes that digitalization requirements should be in line with the firm's capacity to deal with information, a condition not examined before (Acedo & Jones, 2007; Li, Qian, 2015). Furthermore, this study provides insights into the way that strategic decision-making effectiveness underlies the pace of digitalization by considering the information processing demands of strategic decision-making processes. Previous studies of digitalization have focused on the entrepreneur (e.g. Acedo & Jones, 2007; Hagen & Zucchella, 2014), paying little attention to the process of reaching this strategic decision. According to that view, this study extends the current literature on the pace of digitalization by shifting the debate on the effects of strategic decision-making processes. By building on theory of organizational information processing and Resource-Based View, the study recognizes that the capacity of the firm orientated to digitalization to support strategic decision-making effectiveness.

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Second Theme

Applying Digital Transformation to Improve Pilgrims' Services

Secure E-voting System for Measuring the Quality of Services in Hajj

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نظام تصويت إلكتروني آمن لقياس جودة الخدمات في الحج

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الملخص

الحج هو حدث إسلامي عالمي يقام في مكة المكرمة بالمملكة العربية السعودية حيث يستقطب أكثر من ثلاثة ملايين حاج سنويًا. مع تزايد عدد الحجاج ، يزداد الطلب على تحسين جودة الخدمات التي تقدم أثناء الحج أيضًا. يؤدي تحسين جودة الخدمات إلى جعل الحج آمنًا ومريحًا وهو الهدف الرئيسي لمنظمي الحج. يسمح قياس جودة الخدمات لمنظمي الحج بتحسين رضا الحجاج ، وتحديد نقاط القوة والضعف في الخدمات المقدمة . يعد نظام التصويت الإلكتروني أحد أكثر الأساليب شيوعًا لقياس جودة الخدمات. ومع ظهور الجريمة السيبرانية ،أصبحت هناك حاجة لتطوير نظام تصويت آمن يعتمد أدوات تقنية متقدمة مثل سلسلة الكتل . ونظام سلسة الكتل (Blockchain) هو دفتر رقمي آمن وغير قابل للتغيير وله مجموعة واسعة من التطبيقات ، مثل الصيانة الهندسية وسلسلة التوريد وأنظمة التصويت الإلكتروني. لذلك في هذه الورقة ، نقدم نظام التصويت الإلكتروني الآمن القائم على Blockchain وهو يهدف إلى قياس جودة الخدمات ورضا الحجاج خلال فترة الحج. فهو لديه قابلية استخدام عالية ؛ حيث ان نماذج التصويت ونتائجها أكثر قابلية للقراءة وأسهل في الاستخدام والفهم. علاوة على ذلك ، فإنه يضمن قائمة بخصائص الأمان مثل الأهلية والإنصاف والنزاهة وخصوصية التصويت.

Abstract

Hajj is an International Islamic event held in Makkah, Saudi Arabia. It attracts more than three million pilgrims annually. With the increasing number of pilgrims, the demand for improving the quality of services during Hajj has increased. Improving the quality of services to make Hajj safe and comfortable is the main objective of Hajj organizers. Measuring the quality of services allows Hajj organizers to enhance pilgrims' satisfaction and identify the strengths and weaknesses of their services. The e-voting system is one of the most popular methods for measuring the quality of services. However, with the rise of cybercrime, appears the need to develop a secure e-voting system. Blockchain is a secure, distributed, immutable, and digital ledger with a wide range of applications. These applications include engineering maintenance, supply chain, and e-voting systems. In this paper, the researcher presents a blockchain-based e-voting system that aims

to measure the quality of services and the satisfaction level of pilgrims during the Hajj period. This system has high usability; the voting forms and results are more readable and easier to use and understand. Moreover, it guarantees a list of security features such as eligibility, fairness, integrity, and voting privacy.

keywords: E-voting system, Blockchain, Service quality, Pilgrims' satisfactions, Hajj, and Data visualization.

1. Introduction

Hajj is an Islamic event in the Kingdom of Saudi Arabia across a specified geographical area that includes Makkah's sacred mosque, Arafat, Muzdalifah, and Mina. According to the hegira calendar, it is performed during the period from the 8th to the 13th day of the 12th month (Dhul-Hijja) (Eid 2012). It is expected that within the coming ten years, the total number of pilgrims anticipated to visit this Holy city is likely to exceed 10 million (Alharthi and Gutub 2017). With the increasing number of pilgrims, the demand for improving the quality of services during Hajj also increases. Improving the quality of services makes Hajj safe and comfortable, which is the main objective of the Ministry of Hajj.

The Ministry of Hajj supervises and monitors many service providers for pilgrims. Service providers such as Umrah service agents must investigate and evaluate their strengths and shortcomings, compare themselves to their rivals, and prepare plans for future growth and progress (Othman et al. 2020). Service quality assessment is one of the essential measuring methods for service providers to understand the pilgrims' requirements and wants by assessing their experiences and satisfaction with the services they get (Ghotbabadi et al., 2015).

The e-voting system is one of the most popular methods for measuring the quality of services. E-voting systems have several benefits, such as facilitating the electoral process; there is no longer any chance for wasting of resources. The voter will not wait a long time to cast his vote in addition to the ease of counting the votes and announcing the result (Pawlak et al., 2018). Moreover, it reduces crowding in electoral commissions, especially in the current circumstances (Covid-19), by making all steps of the electoral stage, whether candidacy, election, or assignment, electronic. This will avoid crowding in front of the electoral stations and limit the spread of the virus. However, with the rise of cybercrime, there is a need to develop a secure e-voting system. Blockchain technology has recently attracted more attention as a decentralized and distributed public ledger in a peer-to-peer network. A linked block architecture is used in this technology. A reliable consensus method is set up to synchronize data updates, allowing the development of a tamper-proof digital platform for storing and sharing data (Abuidris et al., 2019). The four key features of the blockchain are as follows: (i) The ledger can be found in various places: There is no single point of failure in the distributed ledger's upkeeping. (ii) The ability to add new transactions to the ledger is distributed. (iii) Any proposed" new block" to the ledger must refer to the prior version of the block, forming an immutable chain that gives the blockchain its name and prohibits tampering with previous entries' integrity. (iv) Before a proposed new block of entries becomes a permanent part of the ledger, a majority of the network nodes must agree (Hjalmarsson et al., 2018).

Ethereum is a blockchain platform with its cryptocurrency named Ether (ETH) and Solidity programming language. Ethereum is a decentralized public ledger that may be used to verify and record transactions (Bosri et al., 2019). Users of this platform can create, publish, monetize, and use other apps on the platform, and they can pay with Ether, the network's cryptocurrency. Miners do the Ethereum platform execution. Miners mine the transactions between a contract participant

and a contract for a fee. The charge is calculated using the transaction cost as defined by the execution environment, expressed in an abstract quantity known as gas. A participant chooses the price he or she is prepared to pay for a unit of gas and pays for the transaction. The miner then deducts the cost of the actual gas utilized from the amount received as pay for mining the transaction and returns the remainder (Marescotti et al. 2018).

The smart contract is a software that executes on the Ethereum blockchain. It's a set of code (its functions) stored on the Ethereum blockchain at a single address (Vijayalakshmi and Vimal, 2019). As a smart contract is a kind of Ethereum account, it has a balance and can send transactions via the network. But, they are not managed by a user; rather, they are deployed on a network and run according to a set of instructions. User accounts can then engage with a smart contract by sending transactions instructing the smart contract to perform a function. Smart contracts, like regular contracts, can set rules and have them enforced automatically via the code. Ethereum Smart contract has a wide range of applications, such as engineering maintenance, supply chain, and e-voting systems (Omar et al., 2021).

A blockchain-based e-voting system has grown in importance as a means of solving some of the problems that arise with e-voting. Voting systems powered by Blockchain technology. This system has been proposed as the next generation of modern e-voting systems. Since the blockchain's immutable characteristic has made it a distributed ballot box. Governments are encouraged to implement intelligent and sustainable voting systems and integrate sustainability information into voting systems using blockchain technology. It guarantees that all parties have transparent access to accurate information about voting (Taş and Tanrıöver 2020). Recently, many e-voting systems such as Follow My Vote (FMV), Tivi, Open Vote Network (OVN) (McCorry et al. 2017), BitCongress, and Verify-Your-Vote (VYV) (Chaieb and Yousfi 2018) have been widely used. These systems rely on blockchain technology to guarantee the security of the system.

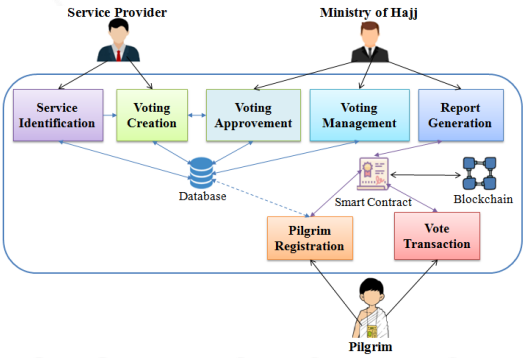

Figure 1. Secure e-voting system (SVS) Architecture

This paper introduces a blockchain-based e-voting system aiming to measure the quality of services and the satisfaction level of pilgrims during the Hajj period. The researchers proposed a list of metrics to evaluate service quality and pilgrim satisfaction. Our system has high usability; the voting forms and results are more readable and easier to use and understand. Moreover, it guarantees a list of security features such as eligibility, fairness, integrity, and voting privacy. The rest of the paper is organized as follows: a full description of the system architecture is explained in Section 2. The report generation model is illustrated in Section 3. The experimental results are discussed in Section 4. Finally, conclusions are presented in Section 5.

2. Secure e-voting system (SVS) Architecture

This section provides a description of the proposed secure electronic voting system (SVS) that aims to measure the quality of services and the level of satisfaction of pilgrims during the Hajj period. The SVS has three actors named (Service Providers, the Ministry of Hajj, and Pilgrims). ***Service providers*** are the institutions that support the services to pilgrims, such as health, hotels, transportation, food, and other services. They are also responsible for creating a page on the SVS application to familiarize pilgrims with these services and benefit from them. In addition, they generate the election forms to be submitted to the pilgrims later to vote. ***The Ministry of Hajj*** is responsible for managing the electoral life cycle from its inception when proposed by the service provider until its end in the reporting stage on the quality of service and the extent of pilgrims' satisfaction with Hajj services. Finally, ***pilgrims*** are eligible to register on the SVS application, load the election ballots, and cast their votes. Since all transactions executed in the blockchain will be charged (Marescotti et al. 2018). SVS reduces the cost by minimizing the number of accesses to the blockchain. Generally, SVS consists of seven components and two types of storage (such as a database and a blockchain) as shown in Figure 1. Database storage is used to store general information (such as form content, election times, and less secure information about pilgrims). Therefore, it is accessed through five components called service identification, voting creation, voting approval, voting management, and pilgrims' registration. At the same time, blockchain storage is used to save private data (such as voter 's votes, usernames, and passwords). So it is accessed through three components called voting transaction, pilgrim registration, and report generation. The description of each element is as follows:

- ***Service Identification:*** In this component, the service provider creates a page in the SVS Application that contains all the information related to the service, such as the definition, purpose, usage, and benefits.
- ***Voting Creation:*** The service provider creates a voting form by adding a list of questions about the service. For each question, voting options are scaled from 1 to R, where R is the number of options. In this paper, the researcher assumes that the number of options equals 4 (R = 4), and they are classified as follows: not satisfied, slightly satisfied, satisfied, and extremely satisfied. For example, if the pilgrim is asked about the transportation services comfort level, the previous four options will appear to him. The pilgrim chooses the answer that expresses his opinion. Noting that the question option is a radio button, the pilgrim can't select more than one answer, as shown in Figure 2.
- ***Voting Approvement:*** After the service providers define the service and build the voting form. SVS allows the Ministry of Hajj to accept, reject, modify or add questions to the election form.
- ***Voting Management:*** The Ministry of Hajj is responsible for determining the period during which service providers can create a voting form. It also specifies when pilgrims are allowed to fill out the election form and express their opinion. Figure 3 provides an example of an election management form. In order to reduce the cost of this system, these data and election forms are stored in databases.
- ***Pilgrim Registration:*** Only pilgrims are eligible to cast their votes. They log into SVS via biometric authentication such as fingerprint or face recognition (Wayman et al., 2005). Then SVS verifies the login authority by examining the data stored in the blockchain. If he/she is authorized, the voting form will be

displayed. Other pilgrims' information such as his/her mobile, nationality, e-mails, and so on are optional to save in the database.

- ***Vote Transaction***: In this component, pilgrims fill out the voting form, and the data is stored on the blockchain since it is immutable.
- ***Report Generation:*** This component retrieves the data from the blockchain, and then it generates reports about three metrics: service quality measurement, pilgrim satisfaction, strength and weaknesses of the service. In the next section, the researcher explains how these metrics are evaluated and the content of the smart contract in detail.

SVS guarantees a list of security features such as eligibility, fairness, integrity, and voting privacy. Only pilgrims are eligible to access the system and cast their votes. SVS provides the fairness features by hiding other pilgrim's choices that may affect voters' choices. SVS supports consistency and accuracy by saving the blockchain's voting data. SVS does not support a link between the pilgrim and his/her choices to achieve vote privacy.

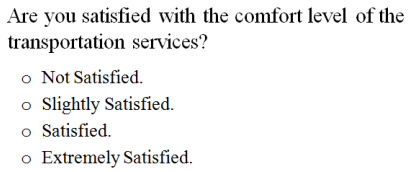

Figure 2. an example of transport service question

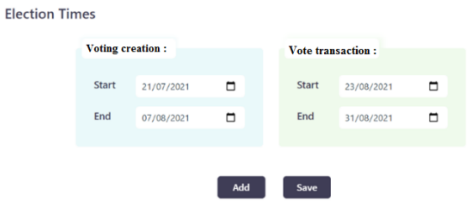

Figure 3. an example of an election management form.

Table 1. Summary of the symbols that are used in the SVS.

Symbol	Description
S	Number of Services
s_i	Represents the ith service
n_i	Number of questions for si
N	Number of Questions for all services
Q_{ik}	Represents the Question k of service i
r_{jk}	represents the response of pilgrim index j and question k
R	Number or responses options
P	Number of pilgrims
SScore	SScore The service score
QScore	QScore The question score
PScore	PScore The pilgrim satisfaction score

3. Report generation model

In this section, the researcher proposed three metrics called Service Score (SSCore), Pilgrim Stratification Score (PScore), and Question Score (QScore) that are used to measure service quality, pilgrim satisfaction, and service strengths and weaknesses, respectively. Table 1 shows the variables that are used in the SVS model.

The first metric, $PScore_{ij}$ for si and pilgrim j, is evaluated by the summation of the responses r_{jk} to all questions ni times 100 divided by the number of questions n_i times the number of responses options R. After that, the researcher categorizes the pilgrims into four categories named not satisfied, slightly satisfied, satisfied, extremely satisfied. The percentage of pilgrims in each category is calculated by using algorithm 1.

$$\text{PScore}_{ij} = \sum_{k=1}^{n_i} r_{jk} \times 100/(\text{R} \times n_i)$$

The second metric, $QScore_{ik}$ for s_i and question k, is evaluated by summerizing the responses r_{jk} of all pilgrim P times 100 divided by the number of pilgrim P times the number of responses options R. The question Q_{ik} is considered a strength of the service if the $QScore_{ik}$ is greater than or equal 50 % and a weakness point otherwise.

$$\text{QScore}_{ik} = \sum_{k=1}^{P} r_{jk} \times 100/(\text{R} \times \text{P})$$

If $QScore_{ik} \geq 50$ then Q_{ik} is a strength point, Else Q_{ik} is a weakness point

The third metric, $SScore_i$ for s_i, has three ways to calculate its value. First, it is calculated by the summation all pilgrims responses r_{jk} to all questions n_i times 100 divided by the product of the number of questions n_i times the number of responses options R times the number of pilgrims P. Second it is evaluated by summation of $PScore_{ij}$ for all pilgrims divided by the number of pilgrims P. Third it is evaluated by summation of $QScore_{ik}$ for all questions divided by the number of questions n_i. After calculating the $SScore_i$ metric, the level of service quality is determined by the measurement shown in Table 2.

$$\text{SScore}_i = \sum_{j=1}^{P} \sum_{k=1}^{n_i} r_{jk} \times 100/(\text{R} \times n_i \times \text{P})$$

$$\text{SScore}_i = \sum_{j=1}^{P} \text{PScore}_{ij} /\text{P}$$

$$\text{SScore}_i = \sum_{k=1}^{n_i} \text{QScore}_{ik} /n_i$$

Algorithm 1: Pilgrim satisfaction category

Input: $PScore_i$, P
Output: The percentage of the number of Pilgrims in each satisfaction category
$CategoryPercentage = [0, 0, 0, 0]$ /* Note that: index 0 for not satisfied category, index 1 for slightly satisfied category, index 2 for satisfied category, and index 3 for extremely satisfied category */
for $j = 0$ *to* P - 1 do
    if $PScore_i[j] \leq 25$ then
        $CategoryPercentage[0] = CategoryPercentage[0] + 1$
    end
    else if $PScore_i[j] \geq 26$ *and* $PScore_i[j] \leq 50$ then
        $CategoryPercentage[1] = CategoryPercentage[1] + 1$
    end
    else if $PScore_i[j] \geq 51$ *and* $PScore_i[j] \leq 75$ then
        $CategoryPercentage[2] = CategoryPercentage[2] + 1$
    end
    else
        $CategoryPercentage[3] = CategoryPercentage[3] + 1$
    end
end
$CategoryPercentage = CategoryPercentage \times 100/P$
return ($CategoryPercentage$)

Table 2: SVS levels of service quality and pilgrim satisfaction

Scores	Level
Up to 25 %	Services are not meeting pilgrim expectations.
26 – 50 %	Services are meeting pilgrim expectations.
51- 75 %	Services are surpassing pilgrim expectations.
76 – 100 %	Services are amazing pilgrim expectations.

Ethereum smart contracts have data fields, named storage, and program code, named functions (Marescotti et al., 2018). Because storage is expensive, the researcher must only store the data fields required for the voting process, like Services, Questions, and Pilgrims. Services contain the attributes such as ID, name, and number of questions. Questions contain the attributes such as service ID, name, and votes count that are incremented by one for each vote for that question. Pilgrims contain attributes such as national ID, name, and ethereum Address to validate if the sender of the vote is the indicated voter. And also the state is used to determine if he voted or not to prevent him from voting more than once .

SVS smart contract has the following functions: add a service, add a question, add pilgrims, view results, and finally, the core function is the responsibility for casting pilgrims vote. Note that not all functions need a gas fee to carry out (Cryptomarketpool, 2022). Gas is required only for transactions that write to the blockchain, such as adding a service, adding a question, adding pilgrims, and casting pilgrims' vote functions. You do not have to pay a gas cost if you are accessing a contract to view data such as view results. The Remix IDE tool is used to write Solidity contracts straight from the web browser. Also, it has modules for testing, debugging, deploying smart contracts, and much more (Remix's 2019).

4. Experimental results

To validate this system and measure its level of performance, the researcher implemented it using the Python language. Moreover, to ensure practicality, the researcher generated a randomly generated 10000 Pilgrims. The distribution of PScore of N services is normal distribution, as shown in Figure 4. The dataset consists of 36 questions; 12 questions, 10 questions, 8 questions, and six questions related to the hotel, transport, restaurant, and health service, respectively. The

questions' responses are scaled between 1 and 4 and are coded as one is Not Satisfied, two is Slightly Satisfied, three is satisfied, and four is extremely satisfied. Table 3 shows the parameter values that have been used in this experiment:

Table 3. Summary of the parameter values have been used in our experiment

Symbol	value	symbol	Value
S =	4 services	N =	36 questions
s_1 =	Hotel service	n_1 =	12 questions
s_2 =	Transport service	n_2 =	10 questions
s_3 =	Restaurant service	n_3 =	8 questions
s_4 =	Health care service	n_4 =	6 questions
P =	10000 Pilgrims	R =	4 Responses

Figure 4. The PScore of N servies Distribution

Figure 5 shows the service quality of the four services. The SScore of the health care s_4 and transport services s_2 obtained satisfaction of 87.5% and 76.4%, respectively. According to these satisfaction levels reported in Table 2, these services win the pilgrims' expectations. While the SScore of restaurant service s_3 was evaluated with 59.1%, which is surpassing the pilgrims' expectations. Finally, the SScore value of hotel service s_1 is 47.9%, meaning that this service meets the pilgrims' expectations. If the system administrator presses on the service name, more details about this service will be displayed, such as the pilgrims' satisfaction score and the service strength and weakness as shown in Figures 6 A and B.

Figure 6 (A) shows the Pilgrim satisfaction of the restaurant's service. 17.04% of the pilgrims are Slightly Satisfied, whereas 81.7 % of the pilgrim are satisfied, and 1.26 % of the pilgrim are Extremely Satisfied. It is clear that restaurant's service is surpassing pilgrim expectations. Figure 6 (B) views the strength and weaknesses points of the restaurant's service. This service has more points of strengths than points of weakness. Five strengths were achieved (bathroom cleanliness, general cleanliness, ease of dealing with staff, food and drink quality). Compared to three weak points (adequate sound system, food arriving on time, and restaurant menu), it showcases the breadth of the restaurant's effectiveness in serving pilgrims.

Figure 7 shows that the Pilgrims' satisfaction with the restaurant service. For example, in bathroom cleanliness responses to Question Q_{31}, 32.17% of the pilgrims are Slightly Satisfied, whereas 33.98 % of the pilgrim are satisfied, and 33.85% of

the pilgrim are extremely satisfied. Overall, Q_{31} is a strength point of the restaurant service. Restaurant menu Question Q_{38},50.27 % of the pilgrims are not Satisfied, whereas 49.73% of the pilgrim are Slightly Satisfied. Overall, Q_{38} is a weak point of the restaurant service.

Figure 5. The service quality of four services

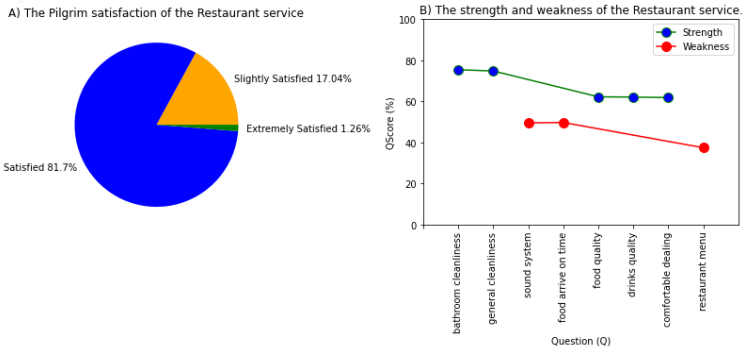

Figure 6. A) The Pilgrim satisfaction B) The strength and weakness of the Restaurant service.

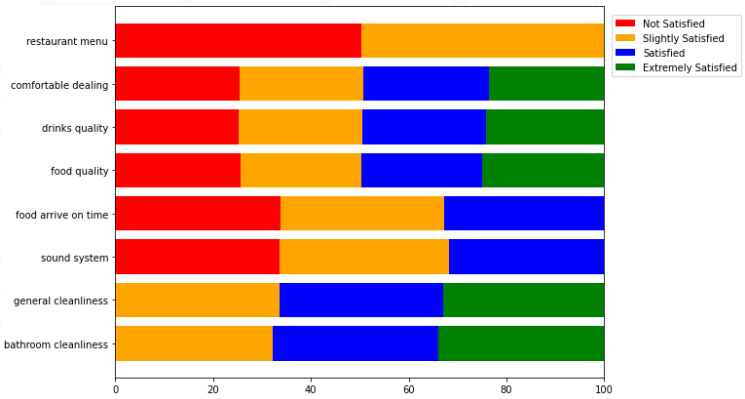

Figure 7. The Pilgrim satisfaction of the Restaurant service Questions

5. Conclusion

In this paper, the researcher presented a secure electronic voting system (SVS) which aimed to measure the quality of services, the level of satisfaction of pilgrims and identify the strengths and weaknesses of services during the Hajj period. SVS guarantees a list of security features such as eligibility, fairness, integrity, and voting privacy. Also, it has high usability and it is economically feasible. Since all transactions executed in the blockchain will be charged, SVS reduces the cost by minimizing the number of accesses to the blockchain. The voting transaction, pilgrim registration, and report generation components access the blockchain, but other components access the database. Finally, to validate and measure SVS performance, the researcher generates a random dataset and analyze its results.

6. Recommendations

The researcher recommends developing a secure and fast electronic voting system to transparently collect pilgrims' opinions about Hajj and Umrah services. In addition, the researchers recommend saving these votes in the blockchain, as it is immutable

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Automating the Entry of Visitors to Holy Mosques Using Barcode Scanning Technology Towards Preventive Support for Measures During the COVID-19 Pandemic

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أتمتة دخول الزوار إلى المساجد المقدسة باستخدام تكنولوجيا ماسح الباركود نحو دعم وقائي للتدابير خلال جائحة COVID-19

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الملخص

في ظل الأوضاع الراهنة وما يعانيه العالم من جائحة فايروس كوفيد-١٩ وتبعاتها، وما تقدمه المملكة العربية السعودية من جهود حثيثة لمواجهة هذا الفيروس وتخفف من آثار هذه الجائحة، يجب على العقول البشرية أن تستنبط أفكارا إبداعية تقلل من التدخل البشري وتحقق التباعد للحد من تفشي الفايروس وخصوصاً في الحرمين الشريفين مزار المسلمين وقبلتهم التي تستقبل عشرات الملايين من المصلين والمعتمرين والحجيج من جميع أنحاء العالم، وهذه الأعداد الغفيرة لابد أن تكون هناك طرق لاستقبالهم وتنظيم دخولهم مما يستوجب مزيداً من العناية لينعموا بأداء الشعائر في بيئة آمنة، وكذلك دون تعريض البلاد ومواطنيها لهذا الخطر الداهم باستحداث طرق رقمية يتم من خلالها تنظيم الحشود. هذه الورقة العلمية تهدف إلى تحويل الإجراءات العادية إلى منتجات رقمية من خلال تطوير نظام يعمل على تنظيم دخول الحشود للحرمين من خلال بوابات رقمية تسمح للمصرح لهم فقط بالدخول من خلال تقنية مسح الباركود للتصاريح المستخرجة من تطبيقي "توكلنا" و"اعتمرنا" بالإضافة لقياس درجة الحرارة من خلال الأشعة تحت الحمراء، حيث توضح الدراسة "الوضع الحالي" باستخدام النمذجة المرئية لعملية وجود الموظفين على مدار 24 ساعة خلال الأسبوع للتأكد يدويا من صحة التصاريح، ثم يتم توضيح "الوضع المستقبلي" المقترح وكيف يساهم في تيسير عملية تفويج الحشود بسلاسة، عن طريق أتمتة العملية ؛ وذلك لتقليل التكلفة من خلال الإفراج عن الموظفين والإعفاء من رواتبهم وزيادة سرعة عملية مصادقة الدخول بتصريح ساري المفعول و قياس درجة الحرارة للتقليل من دخول غير المصرح لهم به .من ثم تقييم أداء الوضع المستقبلي من خلال استخدام استوديو بيزاجي بعمل على رسم نموذج مبدئي.

Abstract

Under the current circumstances around the world, people are suffering from the crisis of COVID-19 pandemic and its consequences. Saudi Arabia is actively working to mitigate the effects of this pandemic and reduce the spread of the virus. The two Holy Mosques receive tens of millions of Muslim worshipers and pilgrims from all over the world. Furthermore, these large numbers must have ways to receive them and organize their entrance, which requires more concentration to perform rituals in a safe environment. From this point of view, the purpose of this paper is to transform the ordinary procedure into digital products by developing an automated system that regulates the entrance of crowds to the two Holy Mosques s through digital gateways. Those digital gateways allow only authorized people to enter through QR code scanning for permits extracted from "Tawakalna" and "Etmarna" applications and infrared temperature detection. The study will clarify the "As-Is" business process using business process modelling notations of the employees' presence 24/7 to confirm the validity of the permits manually, and then describe the proposed "To-Be" business process that contributes to facilitating the crowd visitors' entrance smoothly by automating the process ;hence ,reducing the cost through releasing employees , freeing from their salaries , increasing the speed of the validation of the entrance process with valid permit and measure temperature to reduce unauthorized entry. Finally, implement and simulate the "To-Be" business process using the automation feature in Bizagi Studio.

Keywords: COVID-19, crowd entrance, QR-code, access system, temperature detection, thermal detection, infrared, validation process

1 .Introduction

Regarding the spread of COVID-19 pandemic has swept the whole globe in all nations. When it comes to the two Holy Mosques, procedures must be strict and doubled. After a period of lockdown at the peak of COVID-19, the pandemic became stable; it became possible to visit the Holy Mosques only by booking an appointment through the "Eatmarna" app and getting a permit for entrance. The permit was checked manually by the employees at the entrance gates. This causes crowds at the gates, expands the waiting time, and makes the infection likely to occur. In Addition, this paper's idea was to automate the entrance process to the two holy mosques through digital gates.

These gates can scan the QR code on the permit exported from the "Eatmarna" application to allow an authorized visitor entrance. Then, while the subjects were investigated, the thermal detection was an additional process visitors passed through. Therefore, the proposed solution was to reduce entrance procedures in one checking phase. In the upcoming sections, the research has covered a literature review followed by process models for the current and proposed system and analysis for each. The proposed system aspires to solve the crowd problem and facilitate the entrance.

2. Literature review

This section presents an overview of crowds' entrance. Moreover, it reviews recent studies about QR Code scanning systems for different purposes, especially access gate systems. Then, it explores related studies that aim to detect the temperature of people using many measurement devices, in addition to the issues related to the current method of regulated holy mosques' visitors. Finally, interview details are displayed.

2.1 Crowds Entrance

Disney theme parks deal with crowds by increasing capacity of space, virtual queuing, reservation system, using the app and social media to inform visitors about crowding level, hiring more employees, and the park closure in case of rampant overcrowding. One more solution to regulate the queue entrance is to validate the reservation by touching the guest's MagicBand or RFID ticket to a reader at the entrance gate [1]. Another study is to manage the crowd of all Philippines Light Rail Transit (LRT1) stations and trains intelligently by using the Smart Crowd Control Management System to overcome the deterioration. Researchers used several desktop and tablet applications to measure the crowd density of passengers at LRT 1 stations waiting area. As a result, The System claimed to be acceptable for accuracy, suitability, and security.[2]

2.2 QR code scanning

Giving consumers a comprehensive report can help them better understand the food quality that encourages them to improve their food environment at home [3]. An Elegant Shopping using Smart Trolley is another study that aims to improve the operational efficiency of the payment method by saving time in billing and reducing the number of staff required. After choosing a product, the system will scan its barcode, and then the updated billing is sent to the stores' server. As well as the customer can view billing information on his mobile with the help of RS232 protocol [4]. Smart Attendance System Using QR Scanner was used in some organizations and big classes at universities. The system scans the QR code to detect employees' and students' attendance [5],[6]. QR code-based smart security door system was developed with Raspberry Pi processor to increase security control to appoint an authorized individual, to keep track of the pupils' attendance and to prevent illegal activity inside the laboratories [7].

The Implementation of the Intelligent Automated Gate System (IAGS) with QR Code is a study that aims to create and deploy a security gate system with a medium level of protection for small businesses. The QR code reader was used to pass cards from employees to check user authorization and send a real-time email notification if any unwanted activity was detected. Using the system leads to no need for human intervention, increases the company's security, improves a company's performance, and minimizes the cost for small companies that install a security gate system [8].

In Malaysia, researchers apply a new mode of access to the gated system. The homeowner is responsible for having a valid QR code for the guests to access the gated residential area by scanning their QR code when they arrive at the community gate. The system builds using IoT architecture and the BCRYPT algorithm to encrypt QR codes [9]. Another study using a QR code-based access control system to facilitate and secure booking a room and check-in process. Accessing the room without any human intervention in hotels using a QR code key; reduces human interaction for a hotel staying during COVID-19 crisis. The Hotel Management System (HMS) builds on Raspberry Pi® platforms incorporated into an access control server with three major components: a central server, a black box, and door QR readers [10].

From a perspective of various self-service technologies (SSTs), a self-check-in kiosk (SSK). The Encrypted quick response (EQR) scheme provides a single key for hotel check-in and access control to the room [11]. The QR-Code Based Barrier Gate Opening System (Q-BaGOS) is developed and installed in mobiles with Android. The system is used as a key using a web server, Arduino Uno, and QR code scanner to open and close the barrier gate [12].

2.3 Temperature Detection

Infrared (IR) in thermal detection systems (ITDS) is often used to mitigate the risk of virus spread at workplaces. An experiment was made to compare four temperature devices: IR tympanic and the forehead digital contact probe, IR laser thermometer, thermal Imaging Camera, and iButton.

The devices experimented in actual and simulated environmental circumstances. It turned to state that thermal imaging camera was affected by the environmental temperature, an employee must rest from 2 to 9 minutes to adapt to indoor temperature [13]. In addition, another experiment in a hospital compares the sensitivity of manual fever check (MFC) and infrared thermal scanning Cameras (ITSC).

A nine-month period came up with that MFC detected about ten times more patients than ITSC. ITSC is easily affected by the outside temperature [14]. A descriptive study was conducted to study the usefulness of thermal screening at international airports for early detection of suspected cases of COVID-19 and to measure the fever detection rate in passengers screened. As a result of the study, thermal screening of passengers at international airports has a limited role in the early detection of suspected cases of infectious diseases like COVID-19 and has a minimum impact on the course of the pandemic [15].

The risk of manual temperature scanning has led to designing and developing a "low-cost humanoid robot (HR) with thermal temperature scanner". Opening the gate is a decision depends on the stored temperature data, voice alarm with SMS alert by a robot detected as a further step if the scanned data found abnormal [16].

Thermal Detection Swing Gate Turnstile with QR Code Application" scans the quick response (QR) code to ensure employees' information instead of the manual method. The project contains turnstile hardware that can detect people's temperature with a web CAM even in a large group to allow their entrance if they don't have a fever [17] .

3 .Methodology (Materials and methods)

In this work the researchers follow the Business Process Management (BPM) [24] as follows: As s Process Discovery and Design, Process Analysis, Process Redesign (To Be Model), Process Automation and Moniotring.

3.1 Permit Validation Process (As-Is) Model Design

To model the As- Is process, an interview to collect data with the deputy of the general president of the two holy mosques for Inspection and crowd management. Eng.Osama AlHijily, had given the researchers some helpful information about the current entering process and how employees are suffering from manual checking of permits. His opinion about this research is that he was corroborator with the idea of the barrier gates while entering Al-Haram still with permits; therefore, he suggests studying the feasibility versus cost in case no more permits are needed [18].

The As-Is validation process was built by Bizagi studio. The current validation process as in Figure 1 specifies four roles: Holy mosques visitors, Eetmarna application, the employees, and thermal detection camera system.

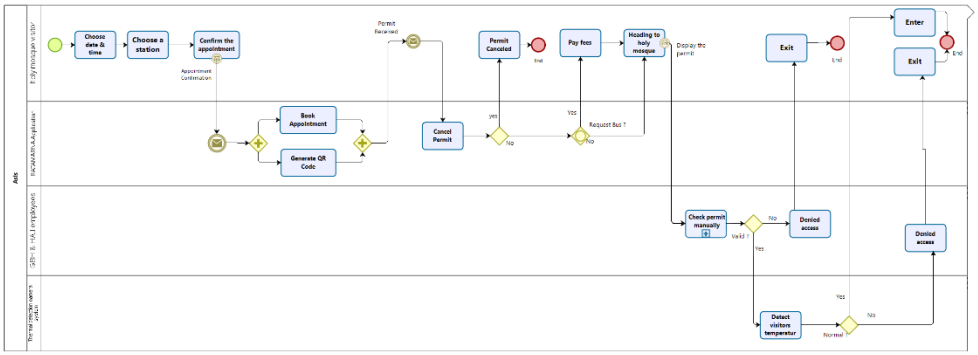

Figure1 as-is permit validation process

3.1.1 Holy mosques visitors: This role represents the visitors that came from the insides and outside Saudi Arabia in order to do religious practices. The functions that can be achieved by this role are using the smartphone and registering in the Eetmarna application, the visitors can choose a preferred date, book an appointment in a certain appropriate period of time.They can change the date and time if needed, making payment process if a bus is assigned and hence entering holy mosques only if the temperature is normal and the permit is valid, otherwise will be prohibited>

3.1.2 Eetmarna application: This role represents the medium between the visitors and entering the Holy mosques and managing the following processes: generating a one-time QR code for each person after booking confirmation, providing a changing date feature if requested and providing bus registration if requested.

3.1.3 HAJ employees: This role is responsible for checking manually for the existence of QR codes associated with each visitor. The checking process is associated with a sub-process that starts with permit verification if the employee checks the date and time. After that, the permit is checked, and the sub-process comes to its end .

3.1.4 Thermal detection camera system: This system is responsible for checking the existence of abnormal temperature for every visitor by using a thermal detection camera system.

3.2 As-Is Permit Validation Process Analysis

Following is a detailed anylysi of the As is process.

3.2.1 Value-Added Analysis: This step is important before re-designing the "To-Be" business model because it helps in recognizing the problems that could be associated with each process. It takes every process apart and classifies it as value-adding VA, business value-adding BVA, or non-value-adding NVA. Table 1 displays the value-added analysis for the validation process.

Table 1. Value-added analysis for validation process description.

Step	Performer	Classification
Choose date and time	Visitor	BVA
Choose a station	Visitor	BVA
Confirm the appointment	Visitor	BVA

Book appointment	Eatmarna application	VA
Generate QR code	Eatmarna application	BVA
Cancel permit	Eatmarna application	VA
Permit cancelled	Visitor	NVA
Pay fees	Visitor	VA
Heading to holy mosque	Visitor	BVA
Check permit manually	Employee	NVA
Denied access	Employee	BVA
Exit	Visitor	BVA
Check time	Employee	BVA
Check date	Employee	BVA
Detect visitors' temperature	Employee	BVA
Enter	Visitor	VA
Denied access	Employee	BVA
Exit	Visitor	BVA

3.2.2 Root Cause Analysis: this is another step to analyze possible causes, where repeated ones could be the roots. Figuring out the root cause will detect the significant area for improving the "As-Is" business model. Figure 2 shows that the enormous gaps are employees' lack, manual checking, and infringement visitors.

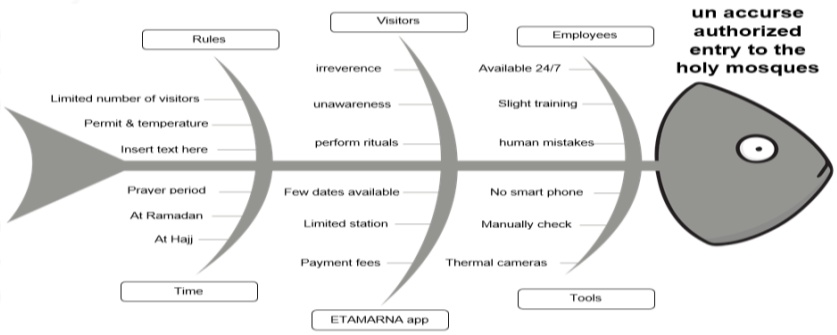

Figure 2. Cause-effect (fishbone) diagram for As-Is process

3.2.3 Quantitative Flow Analysis. Table 2 displays the approximate cycle time for each activity in the validation process and the total period.

Table 2. This is a table. Quantitative Flow Analysis for As-Is process -approximate.

Activity	Cycle Time [18]
Choose date and time	1 minute
Choose a station	30 seconds
Confirm the appointment	30 seconds
Book appointment	10 seconds
Generate QR code	10 seconds
Cancel permit	10 seconds
Permit cancelled	10 seconds

Pay fees	2 minutes
Check permit manually	4 minutes
Denied access	3 minutes
Exit	2 minutes
Detect visitors' temperature	2 minutes
Enter	2 minutes
Total	**17:40 ~ 18:00 minutes**

3.3 To-be permit validation Process Design

In the following subsections the researchers first introduce the challenges of the current model, then propose the recommendation for improvements.

3.3.1 Disadvantages/Challenges of the current model

Performing the permit checking manually has resulted in accumulation of crowds at the gates that led to increasing the waiting time and thus decreased visitors' satisfaction and exhausting the employees due to the huge number of visitors per day. Moreover, as described in the As-Is business process model, in the sub-process of 'checking permits manually', visitors should display the permit to the employee so the employee can detect whether the date and time are valid or not. This causes more time, which in turn is not desirable and it would be inefficient sometimes because doing this manually makes the mistakes possible. Some manual processes that are undertaken by humans are committed to errors due to the dynamism of human nature, unlike a machine that follows a set of instructions [19]. When it comes to the cost, hiring employees to work 24/7 required pay salary which can be decreased if replaced with the QR system. Moreover, in the situation of COVID-19 employee is more likely to get infected by this epidemic due to direct contact with the visitor to check the permit.

3.3.2 Recommendations of Improvements on the Process "To-Be"

After the As-Is process is understood, the objectives of the improvement step are to solve time problems, performance perfections, and accuracy issues and take advantage of the possible improvement opportunities. The improvement in the processes is focused on increasing visitors' satisfaction by reducing the time required to enter holy mosques and providing an accurate temperature detection method. The proposed solution is by providing digital gates that are integrated with QR reader technology. In addition, using an infrared sensor is more accurate to detect the high in human temperature.

3.3.3 Re-design the To-Be Permit Validation Process

The main process in the previous system is done manually, which affects many aspects of the process evaluation such as time, accuracy, quality, and cost. Consequently, to implement a more efficient system and overcome these kinds of challenges, a new automation business process model is re-designed.

Therefore, according to the proposed process improvements, we have replaced the " HAJ Employees " role with the "QR system" role. Also, we have removed the "Thermal Detection Camera System" and merged its processes with the "QR system" role, as shown in Figure 3.

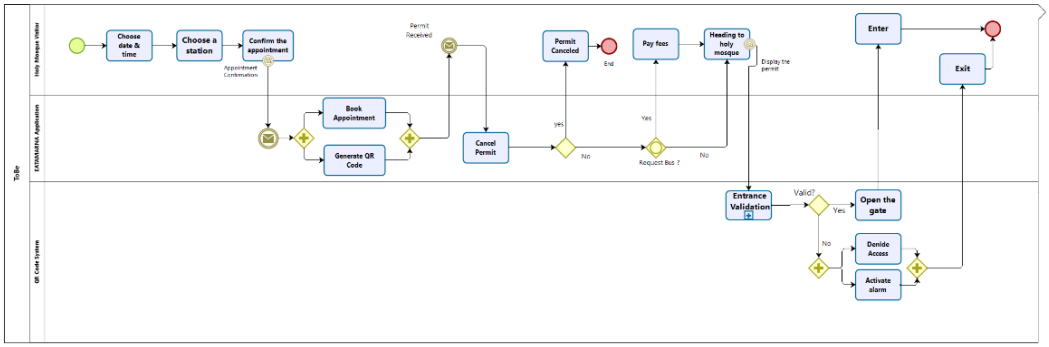

Figure 3. "To-Be" permit validation proces

The sub-process of the "Entrance Validation" has two processes; the system should read the QR code as well as the temperature. This process is done in parallel as shown in Figure 4. Also, the system in the sub-process of "Read QR code" will scan the date and time and check if they are valid or not. Scanning the date and time is done in parallel as well, See Figure 4. The last sub-process is for "Check temperature with infrared sensor". Visitors should pass their wrist towards the sensor so the sensor can detect the temperature level to decide whether it is abnormal "high-degree" or not. See Figure 4.

3.4 To-be permit validation Process Automation and Monitoring

Simulation was used to test the significance of the results. As-Is model and To-Be suggested model were both simulated to assess and compare the findings regarding the different performance measures. We used the Bizagi Studio which follows the BPSim (Business Process Simulation) standard in this study [20], which allows simulating business processes designed in BPMN and assists in the validation of the process, throughput time, and required resources. Simulation has the potential to predict probable judgments tangibly and understandably before making them in the real world. Overall, it makes it easier for decisions to be made by analyzing and constructing different scenarios for each task. To keep the processes running accurately, Bizagi Studio Simulation evaluated the processes based on four steps include process validation, time, resource, and calendar analysis.

3.4.1 Validation process: These processes were utilized to detect the missing tasks, gateways, and error messages that appeared in each process [21]. The number of tokens: According to Bizagi recommendations, we defied 1000 token instances to get reliable outcomes [22]. The gateway conditions: During the execution time of the process model, each gateway branch has a different probability. This project has multiple gateways, which are:

- Canceled the permit: it is assumed that 10% of visitors cancel the permit, and the rest don't want to cancel.
- Request a bus; it is assumed that 70% of visitors request a bus service, and the rest don't want to.
- Valid entrance: it is assumed that 80% of visitors have a valid entrance; they have the right to enter the Holy Mosques after the process of validating their permit and checking their temperature, and the rest can't get in.

3.4.2 Time analysis: The most affected measure from the re-engineering is time. Each task takes significantly less time, and there may be some tasks are no longer required because it assigned to be performed by the QR code system. Besides that, Table 3 shows tasks in the To-Be model; how long does each task take to implement.

Table 3. Simulation results of time analysis

Scenario Information						
Name	Scenario 1					
Time unit	Minutes					
Duration	030,00:00:00					
Name	Type	Instance Completed	Instance started	Min.time	Max.time	Avg.time
To Be	Process	1,000	1,000	2 m 30s	1 h 5m	59m 11s
Message Intermediate	Intermediate event	1,000	1,000			
Parallel Gateway	Gateway	188	188			
None End	End event	916				
Parallel Gateway	Gateway	1,000	1,000			
Valid?	Gateway	916	916			
Parallel Gateway	Gateway	188	188			
None Start	Start event	1,000				
Request Bus?	Gateway	916	916			
End	End event	84				
Exclusive Gateway	Gateway	1,000	1,000			
Permit Received	Intermediate event	1,000	1,000			
Parallel Gateway	Gateway	1,000	1,000			
Open the gate	Task	728	728	5s	5s	5s
Entrance Validation	Task	916	916	30s	30s	30s
Cancel Permit	Task	1,000	1,000	10s	10s	10s

3.4.3 Resource analysis: Resources planning helps to ensure that all resources are meeting the desired cost-benefit and use time effectively. By comparing As-Is and To-Be models, the resources were reduced due to eliminating the HAJ employees and the thermal detection camera system. And replace them with digital gateways using a QR code system and digital infrared thermometer, this aids in improving the quality of the tasks, reducing process time, and lowering associated expenses.

3.4.4 Calendar analysis: In the As-Is model, the resources which are employees are affected by breaks and shifts. These time factors will change the performance of the whole process and may reduce the visitor's satisfaction. Consequently, to get an accurate performance, the availability of digital gateways in the To-Be model has been assigned 24/7.

4. Results and Discussion

After the re-engineering of the process, the results of the time analysis of processes were utilized to track the process' efficiency, where there was a difference in time before and after BPR implementation according to time analysis. To calculate the change for any quantity over time must use a mathematical formula. The Percentage Change is the one that has been used in this case. A percentage change is a simple mathematical formula that determines the rate of change over time, with a positive result indicating an increase and a negative value indicating a decrease [23]. Percentage Change =

$(A - B) / B$, Where A denotes the entire amount of time spent in the To-Be model, and B is the total amount of time spent in the As-Is model. Time Percentage Change = -0.11104069146 .As mentioned before, when the change value is negative, it indicates that the amount of time spent is decreasing. In a nutshell, the re-engineered process takes 11 percent less time than the As-Is module. Table 3 above shows in detail the simulation results of time analysis of the To-Be Model.

5. Simulation

For more clarification, the team decided to design a video clip representing three cases for different visitors. The system within the gate will check and ensure the validation of the permit and temperature, a decision is made to open the gate. Figure 4 shows a visitor with a valid permit and normal temperature, a green light turned on, and the gate will open.

Figure 4. valid permit + normal temperature

Where Figure 5 display case 2, a visitor with a valid permit and up-normal temperature and Figure 6 shows case 3, a visitor with a non-valid permit. The red light and alarm will turn on in the last two cases, and the gate will remain closed.

Figure 5. Valid permit + up-normal temperature

Figure 6. Non-valid permit

6. Conclusions

In conclusion, this paper analyzes the current visitor's entrance validation process to the Holy Mosque and determines the improvement that can be adopted on the process through the Bizagi Platform. Therefore, this paper aims to implement digital gateways as one factor that ensures visitors' safety from covid-19 and secures their prevention. It provides them with quick entrance through the gates to avoid the crowd. The result of this paper indicates the benefits of the re-engineering improvement of the digital gateways, such as reducing the cost through releasing employees and freeing from their salaries and increasing the speed of the validation entrance process with valid permit and temperature to reduce unauthorized entry. In general, time was decreased by eleventh percent overall after re-engineering, proving the process model's improved performance and efficiency. The main limitation in the implementation of the simulation process; is the difficulty of evaluating the resource analysis due to a lack of information related to resourcing which is the numbers of the digital gateways needed because. Indeed, this requires accurate information from reliable sources such as the Ministry of Hajj and Umrah that cannot be obtained at this short time.

7. Recommendations

Through the discussion of the results in this paper, the researchers recommend the adaption of digital gateways in the Holy Mosques in Makkah and Madinah that regulates the entrance of crowds to the two Holy Mosques. In addition, the researchers recommend performing a feasibility study to determine the number of gates that need to be placed around the Holy Mosques, total cost, and effectiveness.

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The Use of Digitization and Digital Transformation in Crowd Management During HAJJ Seasn: A Case Study

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استخدام الرقمنة و التحول الرقمي في إدارة الحشود في الحج : دراسة حالة

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الملخص

يتم تعريف الحشود على أنها تجمع العديد من الأشخاص في مكان واحد وفي وقت محدد لتحقيق هدف معين. تتطلب هذه الحشود إدارة شاملة للحفاظ على السلامة وتقليل الكوارث. يعتبر الحج من أكبر التجمعات البشرية على مستوى العالم ، حيث يؤدى المسلمون بمختلف أجناسهم فريضة الحج في مكان واحد في وقت محدد ، وهو يكون بداية شهر ذي الحجة . تولي المملكة العربية السعودية اهتماما كبيرا لتنظيم الحجاج ومراقبة تقدمهم. ووضعت إدارة الحشود ضمن أولويات وزارة الحج والعمرة للوصول إلى أفضل الحلول لإدارة الحشود. ولا تزال تسعى جاهدة لتحسين خدمات الحج والعمرة من خلال استخدام الرقمنة والتحول الرقمي ومواكبة تطلعات رؤية 2030. وفي هذا الصدد ، تهدف هذه الورقة إلى دراسة كيفية زيادة كفاءة عملية مراقبة تدفق الحجاج و الاستجابة للطوارئ باستخدام سوار الحج إضافة الى كاميرات المراقبة. يحتوي سوار الحج على جهاز استشعار لمراقبة العمليات الحيوية في جسم الحاج ، كما أنه مزود بباركود يمثل الحالة الصحية للحاج ، ويتم تمثيل هذه الحالات بألوان على الخرائط في مركز مراقبة الحجاج. لذلك ، سيساعد هذا في التنبؤ بحالات الطوارئ وتعزيز وقت الاستجابة لها. تم إجراء عمليات المحاكاة لتحليل الوقت في الوضع قبل التحسين وبعد التحسين. أظهرت نتائج المحاكاة تحسنًا ملحوظًا في زمن الاستجابة والتحكم في الحشود بعد تحسين النموذج باستخدام سوار الحج.

Abstract

Crowds are defined as gathering of many people in one place and at a specific time to perform a particular act. These crowds require comprehensive management procedure to maintain safety and reduce disasters. The Kingdom of Saudi Arabia gives great attention to organizing pilgrims. It places crowd management among the priorities of the Ministry of Hajj and Umrah. It is still striving to improve Hajj and Umrah services by using digitization and keeping pace with the aspirations of 2030 Vision. In this regard, this paper aims to study how to increase the efficiency of monitoring the flow

of pilgrims and speed up the emergency responses using the Hajj bracelet, in addition to surveillance cameras. The Hajj bracelet contains a sensor to monitor the vital sign processes in the pilgrim's body, and it is also equipped with a barcode that shows the health status of the pilgrim. The health status is represented by colors on maps at the Pilgrims Control Center. So, this will help to predict emergencies and shorten the response time to them. Simulations were conducted for time analysis of the two models As-is and To-be. The simulation results showed a significant improvement in response time and crowd management and control.

Keywords: Crowd management, Business Process Management (BPM), Hajj season, Bracelet Technology.

1. Introduction

Hajj is the fifth pillar of Islam, in which Muslims come at a specific time each year to Makkah. Hajj is considered one of the most significant events in which a gathering of more than two million people takes place in the same place [1] [2].The Ministry of Hajj and Umrah organizes the arrival of pilgrims and specifies their numbers. It is concerned with securing and facilitating the movement of pilgrims to the holy sites and developing plans to manage these large crowds and prevent accidents. Saudi Arabia's government priority in hajj is planning and managing the crowd; therefore, they try every year to use technology and innovative solution to serve crowd management [3].

This paper presents a suggested model for improving crowd management plans. This is done by using a smart bracelet that the pilgrim puts on their hand and measures the pilgrim's health condition. In an emergency, the bracelet will send an alert that will appear on the maps of the control and monitoring center, which speeds up the possibility of detecting emergencies in the crowd instead of relying only on surveillance cameras. It will also facilitate sending ambulance teams to the pilgrim's site and transferring him to a designated place to follow up on his condition, thus reducing emergency response time.

Business Process Management (BPM) primary goal is to enhance and improve business processes [4]. This paper uses BPM approaches to enhance time in the crowd management process in hajj.

This solution was modeled and simulated using Bizagi Studio. An (As- is) model has been built to show how the pilgrims are currently monitored. Then a (To- be) model has been created to show how crowd control and management will be improved after adding the surveillance cameras and the hajj bracelet. After that, a time analysis simulation was done on the two models to compare and see the enhancement in the crowd management process. This solution helps to manage the crowd.

Literature Review

This paper contributes as a case study in the integration of the rituals of Tawaf and Saee during Hajj. The aim of the study is to simulate and validate real Hajj data in different crowd Circumstances, and to assess to what extent capacity and behavioral aspects contribute to crowding and crowding within the Grand Mosque area. The study used ExtendSim a discrete event simulation tool; As a tool for modeling and simulating integrated Tawaf and Saee rituals in normal situations and evacuation situations. After validation of the models, various scenarios were developed to study and evaluate the effect of changes in the distributions of pilgrims. The results showed that the distribution of groups of pilgrims

according to capacity achieves super results, in addition to the awareness of the exits and paths of evacuation, together with training, and scheduling, considering the physical agility of pilgrims, among the decisive factors that can ensure the completion of the evacuation in the minimum time. Finally, the study recommends the necessity of ~~the~~ gradual distribution of pilgrims and applies better planning of the schedule with regard to the arrival and departure of the Grand Mosque [5].

The emergence of digital technologies has helped researchers to explore and suggest modern methods and techniques and to develop control strategies for better crowd management. This study provides a survey of advanced techniques that were used to manage crowds during past Hajj events. Among these technologies are wireless, computer vision, spatial computing, data analytics, mobile applications, immersive technologies, and audience modeling and simulation. This study also includes a summary of previous research papers (from 2007 to 2020) and articles discussing the techniques. The papers have been classified into two categories based on whether the techniques proposed by the researchers were only theoretical and/or implemented for Hajj crowd management. Although advanced technologies provide several solutions to address crowd management issues, this study suggests integration of additive effective technology such as data analysis that can help discover useful information with the help of data mining, text analytics, and data visualization[3].

Similarly, this paper provides a broad overview of recent technological developments in the field planning techniques and collective monitoring. Two highly crowded case studies (Hajj and crowded scenarios in India) are presented. Three main crowd data collection techniques are discussed (i.e., vision, RF, and web/social media). Crowd models and simulations can be useful in planning crowded events and in anticipating anomalies in real-time crowd management systems. Moreover, it can help design and develop improved crowd control measures. Crowd management systems can help avoid crowd disasters through real-time crowd data collection and rapid data analysis to provide timely decision support. Furthermore, the collected data can be used to improve crowd modeling and simulation. Future research trends: Recognize and track multiple visitors. Crowd density measurement. Analyze crowd behavior, detect anomalies, and generate conclusions from crowd scenarios, etc.[6]. Crowd management is an important area of influence on many people. The study of crowds in terms of monitoring, tracking, and studying behavior, and the study suggests providing the solution through a system that can detect internal and external threats, as it contains external sensors to sense temperature, toxic air, and fires, whereas the internal sensors can be used to sense heartbeat, high body pressure and movement. The hand to detect the stampede through a bracelet on the wrist of the hand [7].

A large number of visitors to public and holy places such as the Two Holy Mosques (Saudi Arabia) and railway stations in Mumbai (India) as well as gatherings for sporting events and managing these crowds is very necessary to avoid the occurrence of congestion disasters. This study suggests relying on the Internet of Things through the applications on mobile devices with a simple smart interface that is suitable for all ages and linked to a sensor system to track visitors' progress and collect information about crowds [8].

The Crowds in Mekkah to perform Hajj may lead to a stampede or human suffocation, most of the pilgrims are not familiar with the entrances and exits to perform Hajj. So this study proposes a solution to improve crowd management in Hajj by developing a pilgrim management application used by Hajj campaigns to help managing pilgrims at Hajj sites. This

application PTS Pilgrim Tracing System is for Android 4.8 and higher systems, to enable campaign agents to provide care for pilgrims during the pilgrimage journey and help them track pilgrims and send alerts in case the pilgrim is away from his companions one kilometer. It also facilitates the lost pilgrim to find the right way using offline maps [9].

This research [10] aims to manage crowds during the stoning ritual (Rami Al-Jamarat) to ensure the safety of pilgrims. The paper presents a crowd management system and alarm system using image analysis and classification, through deep learning techniques, and convolutional neural network (CNN). The CNN model is trained on the image data and then classifies the crowding into five categories: very crowded, crowded, semi-crowded, light crowded, and normal. This system was developed using Python for the CNN algorithm, SQL for algorithmic development, and Java to obtain simulation results to implement crowd-level detection algorithms. As a result, the accuracy for the first attempt with the first convolutional layer with 32 filters was very poor by 55%. The result of the accuracy of the second attempt after adding a second convolutional layer with 64 filters was 97%. The accuracy improved to 98% after using the dropout fraction by 0.5 to prevent over fitting, and this is an acceptable accuracy.

This research [11] solves the problem of reporting emergencies, difficulty locating families or friends, and difficulty finding places using mobile technologies. This will serve crowd management, location-based services, and people tracking. This paper uses RFID technology and a location-aware mobile solution to follow the movement of pilgrims through smartphones. Each pilgrim will have an RFID tag, and the RFID reader placed in different locations in the Hajj areas. The data from the RFID reader is sent to the processing control center to process the real-time data of the pilgrims' locations. This process helps in crowd management. Also, there is a mobile app to use the services based on location as sending emergency requests, finding the location of other people, receiving alerts, etc. The system was not completed until the publishing date of this paper because of the time and effort needed to develop the app and aggregate the RFID readings and represent the data on the map.

In another study presented a new system architecture for real-time crowd recognition for smart cities and smart buildings. this architecture is based on the Internet of Things with the help of artificial intelligence. The described system proposes a privacy-conscious platform that enables the application of artificial intelligence mechanisms to assess the behavior of the masses in buildings that use Perceptible effects of Wi-Fi. This system was implemented in two buildings, an airport and a market with the aim of validating and evaluating the solution in real world situations. The results of applying three different AI classifiers to assess audiences in both publications are described. The three analyzed mechanisms showed good performance. In future work, this system intends to include other classification techniques, to assess which provides the best performance for positioning tasks[12].

This paper provides a comprehensive review of crowd studies, from crowd detection to crowd control to crowd management, where a systematic discussion of crowd management steps, including crowd detection, was presented, and several new methods were reviewed, followed by clarification of both direct and indirect methods of crowd monitoring and tracking monitoring. Crowd management systems cannot be treated as separate processes but instead should be viewed as a single system of different integrated phases. A common misconception of crowd control and management was clarified, and a crowd management model was clearly superior. Furthermore, it is highly recommended to combine two or more technologies, and hybrid technologies have been shown to increase accuracy, enhance performance, and

increase encounter defects. An effective crowd management system depends on efficient crowd detection and control. The primary purpose of this review is to establish a comprehensive understanding of crowd-related processes. Furthermore, it aims to find research gaps to overcome the limitations of using stand-alone techniques in each process and to provide support for the future work of other researchers [13].

Nandakumar et al. In [14] discussed a series of video-based strategies for gaining real-world crowd insights and managing dense crowds in urban settings. For the low crowd, the people detection model is employed, whereas, for huge crowd, regression-based counting is used.

2. Methodology (Materials and methods)

The main purpose of this research is to examine the effectiveness of adding sensors by using maps and cameras for crowd management improvement. To achieve this research aim, a well-established procedure, inspired by the Business Process Management lifecycle (BPM), is used to create a systematic plan and strategy for identifying, analyzing, re-designing, measuring, controlling, and monitoring business processes to consistently enhance their performance and maximize organizational value. The (BPM) lifecycle mainly consists of six steps which are, respectively:

process identification, process discovery, process analysis, process redesign, process implementation, and process monitoring and control [15], [16]. However, in this work, the researchers will depend on the simulation technique to analyze and compare the responsiveness to crowd management during the adoption of the sensors.

Thus, the two last steps of (BPM), that are concentrated on real-life implementation of the proposed solution, will not be taking into consideration. Figure 1 depicts the five-step procedure for achieving the goal of this study, which includes process identification, process discovery, process analysis, process redesign, and process simulation. In the next sections, we'll go through each stage in further depth.

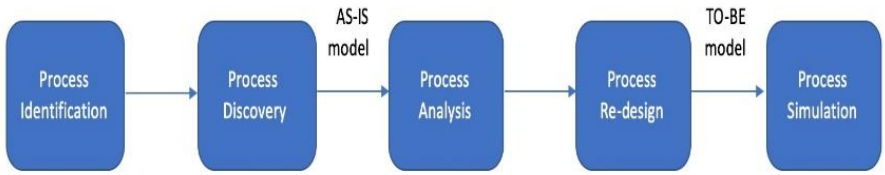

Figure 1. Research Method

In this paper, a new feature has been added to the Hajj bracelet technology to contribute to the service of crowd management by reducing the time spent in controlling crowds and accelerating the process of responding to various emergency situations.

Hajj Bracelet

A unique technical service that contributes to improving the pilgrim's journey and facilite the pilgrims' movements during the performance of the rituals. This technique is a bracelet in the form of a watch that is placed around the wrist of the pilgrim's hand. This bracelet is linked to the profile (identity card) of the pilgrim's condition, in addition to a sensor that measures vital signs (temperature / heart rate).

This bracelet offers many features such as providing complete information about the pilgrim, follow-up and monitoring of health status data, and services for requesting emergency medical or security assistance, and determining his location, which contributes to quick access to the place and assistance and other services. Hence, this bracelet contributes to providing high quality services to pilgrims.This technology works through free internet services distributed in the places where the pilgrims are. This contributes to facilitating the performance of data processing, as each bracelet carries an ID indicating the health status of the pilgrim. Accordingly, the fences are treated as any multiple IDs and, therefore, when one sees a certain number of IDs in an area, this indicates the presence of crowding, as this shows the number of crowds and emergency health cases on the map with expressive colors in the control room, and, therefore, it helps to ease monitoring congestion and following up the process of pilgrims' progress with ease. In addition to fasiliting responding and dealing with crowds based on the appropriate plan for the type of crowd.

A. Process Identification

This step aims to define the current business process, to fully comprehend the process and related challenges, including its sub-activities, functions, processes, and stakeholders. As well, it serves as a basis for the next steps (i.e., process discovery, analysis, and redesign). In this case study, the researchers have taken the information and collected it from the official website of the Ministry of Hajj and Umrah, and they also asked questions to some people who are working to achieve the process of organizing pilgrims and Umrah.

This is done to understand crowd management and how to respond to different situations. When the researchers are collecting information and when they ask the people working to organize pilgrims, they concentrated on the workflow of the process, its sub-tasks, duration ~~time~~ of each task, main roles, and stakeholders. Based on the results, it appears that there is one main role in the crowd management process: which is the selection of crowd area, and three subsidiary stakeholders, namely: the Ministry of Hajj and Umrah, Ministry of Interior Affairs, and Ministry of Defense.

B. Process Discovery (As Is) Model

In this step, the textual description of the process will be translated into graphical representation for better understanding and analysis, which in turn facilitates the identification of related issues. The main outcomes of this step is the AS-IS model. Based on the information collected and the employees the researchers asked the AS-IS model for the current crowd management process is modeled as it is represented in Figure 2.

in addition, for more simulation purposes, the researchers assigned the duration time (i.e., processing and response time) gathered from the information for each sub-task of the process. As it is represented, the process will start when the crowd area been selected, using the radios provided with the pilgrims' organizers, which they have been determined if the crowd is normal that doesn't need to be interfered with and this will be the end of the process, or a heavy crowd that needs ~~from~~ Ministry of Interior Affairs to intervene through crowd breakdown. This can be by closing paths, or controlling tracks. This process may need The Ministry of Defense to intervene, through transfer status if there are any injuries, or just crowd area disintegration.

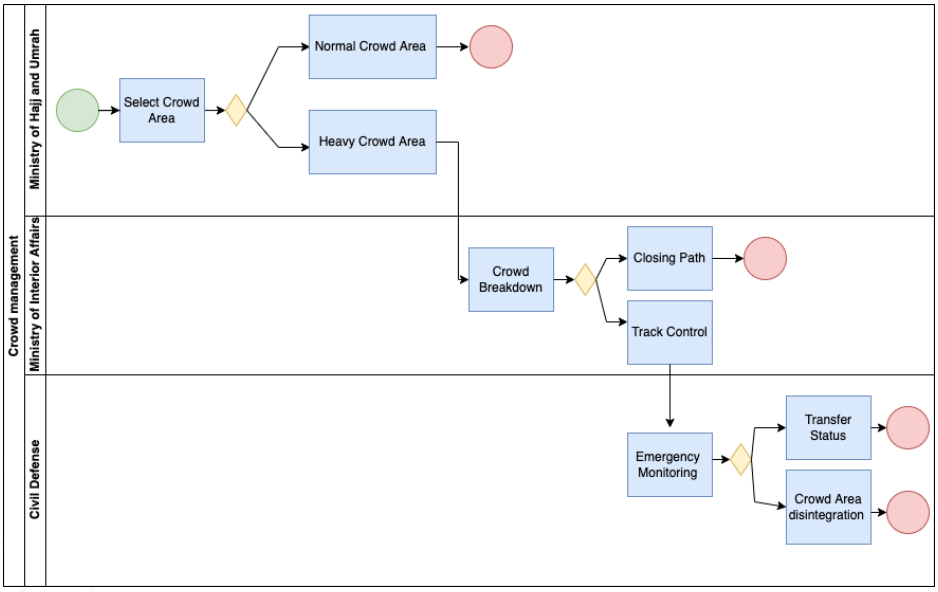

Figure 2. Crowd management process (AS-IS) model

C. Process analysis

In this stage, the current performance of the process is evaluated. Here, the time scale was relied upon because it is the most important part of crowd control operations. The focus is on cycle time for crowd management operations. The process cycle time refers to the average time taken to complete the process.

According to the website of the Ministry of Hajj and Umrah, and depending on the employees who were asked, the operations are carried out through surveillance cameras and determine if the crowding area is normal or there is a need to break up the crowd, and there may be a need to close the tracks or intervene to transfer infected cases.

D. Process redesign

This step, is the stage of improvement of the existing system. An improvement has been suggested that contributes to reducing the problem. This proposal is to add a new technology in addition to the cameras used to monitor crowds. It is a bracelet on the pilgrim's wrist. This bracelet is attached to maps in the control center and carries a barcode that represents the health status of the pilgrim, and whether this pilgrim has chronic diseases.

In addition to a sensor to monitor the vital signs in the human body (temperature, heart rate), and they are represented on the linked maps by colors, where the blue color indicates that the pilgrim is in good health and the seventies emergency cases. The To-Be model represents the process of crowd control, where the new technology is added, and it shows its role in emergencies so that the health status of the injured can be known directly by scanning the barcode and access his health information, and thus deal with it in an appropriate way.

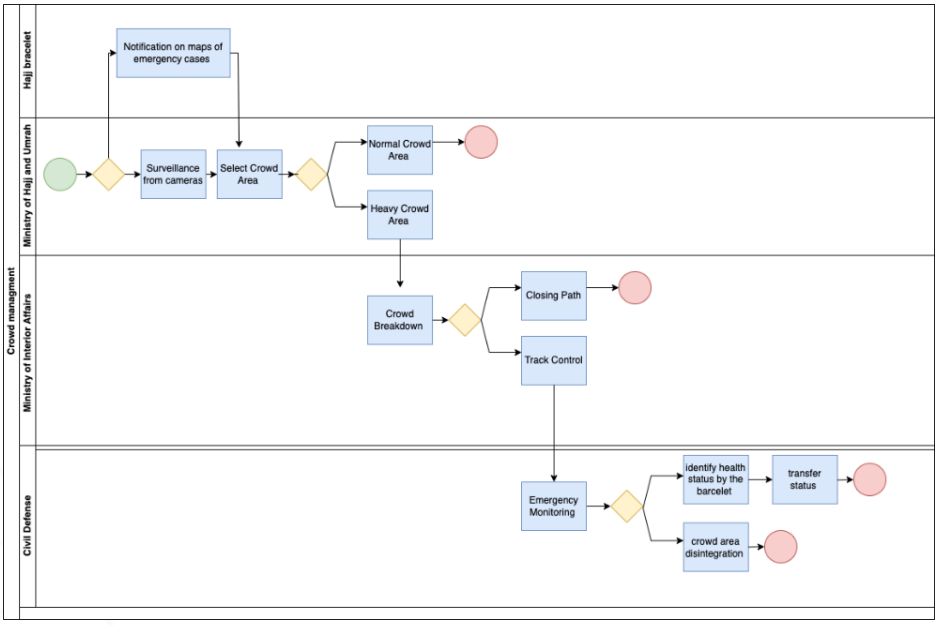

Figure 3. Crowd management process (To-Be) model

E. Simulation result

By comparing the two cases, the addition of this new technology instead of the manually methods as what it is happen in (as-is) model, to reduce the time taken for the process by approximately 30 days. The change that's shown 30 days we calculate by change on (To-Be model - As-Is model) which is equal approximately (51 days - 81 days) = 30 days. If we want to calculate the time that we saved with this addition by a percentage, we can calculate it as follows:(Original Number-New Number/ Original Number*100) in which the Original Number present the total time of the process in (As-Is) model, and New Number present the total time of the process in (To-Be) model. Time percentage change= 37%, the simulation results of the As-Is model showed that the mean time by minutes is 117243.On the other hand, the simulation results in Table To-Be indicate that the average time by minute is 73529.

Table 1. The Difference of Simulation Results From (As-is) Model to (To-Be) Model.

The Model	Total Time
AS-IS Model	117243 minutes
To-Be Model	73529 minutes
Differences	30 days

[1] from source [22].

3. Results and Discussion

This research examined the effectiveness of sensors adoption in the crowd management processes. – The goal of this research was to find an answer to the following question: Is there a difference between the average time spent performing the selected crowd area process using the radios provided with the pilgrims' organizers and the average time spent after

incorporating the sensors into the process? To answer this question, (BPM) has been followed as it is a well-defined methodology for (BPR). Moreover, this study applied the Bizagi simulation tool to analyze the cycle time of crowd management process in terms of two situations: the AS-IS and the TO-BE model. The simulation results indicated a significant impact of the usage of the sensors on the bracelet on the time performance of the crowd management process. It effectively shortened the entire cycle time of the process by around 30 workdays. This result complies with the situation of managing pilgrims that approve the efficiency of usage of sensors numerous advantages for crowd management environment, such as increased managing efficiency, and saving employees' efforts. This study found that automating the repetitive tasks of a human workforce saves time and money.

4. Conclusions

This paper presented a proposed solution for the crowd control management process by adding new technology to surveillance cameras. This technology is a bracelet on the wrist of the pilgrim connected to maps in the control center, and the bracelet carries a barcode representing the health status of the pilgrim and a sensor for vital signs (heat/heartbeat), where emergency cases are represented on the map in expressive colors for the cases of pilgrims. This, in turn, leads to a reduction in the time required for the process. This technique has also made possible to predict emergency situations, as indicated by the simulation results through two models of As-Is and To-Be for the crowd management process. Time has been saved by 37%. The researchers recommend evaluating the effect of the Hajj bracelet technique on the quality of crowd control operations.

5. Recommendations

Based on the simulation and results presented in this paper, the researchers recommend the use of Hajj bracelet, in addition to surveillance cameras to increase the efficiency of monitoring the flow of pilgrims and speed up the emergency response. For sustainable results in performance, it is recommended to study the operation of the bracelet with long-life energy.

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Social Media Monitoring for Enhancing Hajj Pilgrimage Experience

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مراقبة وسائل التواصل الاجتماعي لتعزيز تجربة الحج

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الملخص

في كل عام، يأتي الحجاج المسلمون من جميع أنحاء العالم لأداء فريضة الحج في مكة المكرمة. خلال شعائر الحج، يتم تلقي أنواع مختلفة من التغذية الراجعة التي تعد مصدرًا رئيسيًا للمعرفة لتحسين تجربة الحج في السنوات القادمة. ومؤخراً، أصبحت منصات وسائط التواصل الاجتماعي، مثل تويتر مصدراً معرفيًا رئيسيًا للعديد من المنظمات لاستقراء آراء الناس حول منتج محدد أو خدمة معينة. وبالمثل، فإن نسبة عالية من الحجاج يعبرون عن مشاعرهم وآرائهم وتفاعلاتهم حول تجربة الحج من خلال وسائط التواصل الاجتماعي. في هذه الورقة، سوف يسلط فريق البحث الضوء على تجربة الحجاج حول خدمات الحج المقدمة. يقدم ArHajj-21، وهي مجموعة بيانات عربية للحج على تويتر تم نشرها خلال موسم حج 2021. تعد ArHajj-21 أول مجموعة بيانات عربية تغطي احداث الحج على تويتر وهي متاحة للجمهور حيث تتضمن حوالي 200 ألف تغريدة إلى جانب شبكات الانتشار بما في ذلك كل من إعادة التغريدات والتغريدات ذات العلاقة (مثل سلاسل الردود) للمجموعة الفرعية الأكثر شيوعًا. تم تصميم ArHajj-21 لتسهيل البحوث المتعلقة بالحج في مجموعة متنوعة من المجالات، بما في ذلك الحوسبة الاجتماعية، وتعلم الآلة، ومعالجة اللغة الطبيعية، واسترجاع المعلومات. بالإضافة إلى ذلك، سوف يستخدم فريق البحث بعضًا من أحدث تقنيات تعلم الآلة غير الخاضعة للإشراف مثل التجميع ونمذجة الموضوع لاستخراج أنماط ذات معنى لصانعي القرار. تهدف هذه الدراسة إلى تعزيز تجربة الحج بما يتماشى مع رؤية المملكة العربية السعودية 2030.

Abstract

Every year, Muslim pilgrims come from all over the world to perform Hajj in Makkaha. Different feedback types have been received during Hajj rituals, which are key knowledge sources for developing the pilgrimage experience in the following years. Recently, social media platforms, such as Twitter, have become a major source of knowledge for many organizations to obtain opinions about a particular product or service. Similarly, a high percentage of pilgrims express their feelings, opinions, and views about the Hajj experience. In this paper the researchers will highlight the analysis of the pilgrimage experience about the Hajj services provided. The researchers present ArHajj-21, an Arabic Hajj Twitter dataset that was produced during the Hajj 2021 season. ArHajj-21 is the first publicly available Arabic Twitter dataset covering Hajj activities that include about 200K tweets alongside the propagation networks. These include retweets and

conversational threads (i.e., threads of replies) for the most popular subsets. ArHajj-21 was designed to facilitate Hajj related research in various areas, including social computing, machine learning, natural language processing, and information retrieval. In addition, the researchers will use some of the state-of-the-art unsupervised machine learning techniques such as clustering and topic modelling to extract meaningful patterns for decision-makers. The study enhances the pilgrimage experience in line with Saudi Arabia's vision 2030.

Keywords: Unsupervised learning, Document clustering, Topic modelling, Hajj evaluation

1. Introduction

Monitoring social media is significant for the use of Semantic Analysis in social media (SASM). Social media monitoring is a helpful process to turn unstructured data into meaningful and valuable information. Social media monitoring is an act that involves monitoring and tracking broadcast media, web resources, and social media to examine stakeholders' perspectives in many settings. The massive amount of information available through social platforms is a valuable source of open intelligence, and social media platforms provide direct communication with the target audience. Unlike traditional journalism, the author's perspective and mood give another layer to social media data. The varied length of source documents, for example, a collection of several tweets and blogs alongside content diversity, further complicate social media document analysis. Such systems are essential because, over the last decade, semantic text analysis in social media monitoring has become a major source of business intelligence to help discover and anticipate behavior and respond to customers. It may also give improved intelligent visual display and reporting to decision-makers to increase awareness, communication, planning, issue solving, or prevention.

Twitter[1] is a widely used social media platforms all over the world. Around 326 million individuals use Twitter on a monthly basis, according to recent statistics[2]. Each day, around 500 million tweets are sent, which equal to 5787 tweets every second. Users can send a short message or tweet in 34 different languages, including Arabic and English. Users commonly use Twitter to voice their thoughts about government projects, social issues, religious matters, and various other topics. However, due to the massive volume of tweets generated each day, manually processing each tweet to discover the topic of public discussion is challenging. Moreover, users utilize a variety of social media features, such as hashtags, to communicate and exchange their thoughts on the same subject. Such challenges complicate the effort of categorizing semantically consistent tweets.

Different natural language processing (NLP) techniques, including topic modeling and clustering, can be used to digest and analyze these short messages, providing the followers with information that help to infer pilgrims' interests, follow new hajj-related stories, and discover emerging hajj issues. Clustering is a technique that divides documents into a certain number of groups based on their similarity to predefined criteria. Any clustering algorithm's purpose is to increase similarity inside the cluster while minimizing similarity between clusters. Various models have been proposed for using standard clustering approaches (e.g., k-means) with short texts, such as tweets [1], [2]. These approaches often begin by extracting features from the text, which are then represented as a term frequency-inverse document frequency matrix

[1] https://www.twitter.com/

[2] https://blog.hootsuite.com/twitter-statistics/

(TF-IDF). Recent advances in the field of deep learning have resulted in the proposal of a semantically richer representation of documents known as Word Embeddings [3], [4]. Compared to the TF-IDF feature matrix, the usage of word embeddings has resulted in significant improvements in various NLP applications, including document categorization. Clustering methods are applied to the extracted features following feature extraction. The difficulty of document clustering has captivated the scientific community for several decades. Efforts have been continuously to create a semantically relevant grouping of texts.

Besides documents clustering, topic modelling is an unsupervised learning approach for identifying latent themes or topics in a corpus of documents. It is identified latent themes that characterize a collection of documents, and a theme is a collection of commonly occurring words. Different topic modelling techniques have also been developed to analyze short texts from a variety of domains. The Latent Dirichlet Allocation (LDA) and Latent Semantic Indexing (LSI) are two of the most commonly used approaches [5], [6]. Many algorithms based on LDA have been used to model textual contents in various fields, including crisis detection [7], [8].

Furthermore, numerous recent techniques have used the Dirichlet Mixture Model (GSDMM) to cluster short text [9]. Despite the wealth of NLP approaches published in the literature, evaluating tweets presents numerous issues [10], [11], including massive noise and irregular tweeting behaviors of users restrict researchers from fully using the information contained in tweets.

To the best of our knowledge, no previous work has studied how to use social media with a focus on textual-based posts to evaluate the Hajj experience. It has been noticed that the majority of previous work in the domain of document clustering is limited to the English language. This article aims to fill in the gaps generated by clustering algorithms on a corpus of Arabic-language hajj-related tweets. Various experiments have been conducted utilizing various representations of the tweet's textual contents.

The various features of tweets are represented using a TF-IDF matrix, a vector representation utilizing Word2Vec embeddings, and a Doc2Vec representation. Additionally, other topic modelling methodologies, such as LDA and GSDMM, were examined. As a result, the researchers evaluate the effectiveness of the aforementioned methodologies using short texts from a hajj-related dataset (ArHajj-21). Using two internal validity indices, we evaluate the efficacy of topic modelling and clustering (i.e., assessing the goodness of a clustering structure without external information).

2. Aims of Research

This research has carried several aims, as follows:

1. Collecting a large number of Arabic tweets that are related to Hajj 2021.
2. Improving Arabic short text clustering performance.
3. Applying different text feature representation techniques to improve the documents clustering performance.
4. Applying state-of-the-art topic modelling approaches in order to discover meaningful patterns from hajj-related tweets.
5. Comparing the performance for the suggested methodology without manual efforts.

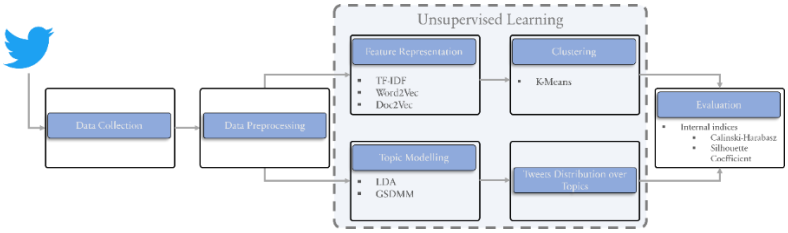

Figure 1 Workflow of the proposed methodology.

3. Methodology

This section explains the approach for clustering hajj-related Arabic tweets that have been proposed. The methodology comprises many phases, as shown in Figure 1, including extracting data, pre-processing, feature representation, clustering, topic modelling and evaluation. First, the data were collected from Twitter. Due to the presence of noise in the raw text, it must be preprocessed. As a result, numerous preprocessing procedures are performed on the tweet text following data extraction. Following that, different features such as TF-IDF, word embeddings, and document embeddings are extracted. The extracted features are then exposed to a clustering model. Besides, topic modelling techniques were described.

3.1. Dataset Collection

During this stage, we started collecting Arabic tweets mentioning a Hajj pilgrimage on a specific date frame (the date of the Hajj season). In this paper, we looked at tweets about Hajj from July 15 to July 30, 2021, in the Arabic language. We gathered the tweets based on hajj-related keywords, such as "الحج", "عرفة", "مزدلفة", "الجمرات". Since the rituals of Hajj have a religious connection to many Muslims around the world, especially the Arabic-speaking countries, the corpus should contain tweets in a variety of dialects. We collected around 200 thousand Arabic tweets posted during the period of interest. The researchers crawled the tweets based on Hajj-related keywords using the Twitter API[3].

3.1.1. Dataset Pre-possessing

Pre-processing is a critical step in almost any NLP task. A tweet contains a variety of viewpoints on the data it represents. The obtained JSON object for each tweet contains a number of properties. The researchers have kept the following elements for this study: tweet ID, tweet text, creation time, and user ID. Tweets that have not been pre-processed are highly unstructured and contain unnecessary features. To address these issues, tweet pre-processing is carried out in a series of steps, as follows:

Before Preprocessing

After Preprocessing

Figure 2 AraHajj-2021 visulaization

1. Unnecessary white space has been eliminated from a tweet together with duplicated letters.

[3] https://developer.twitter.com/

2. URLs and usernames were also deleted from the tweet.
3. Non-Arabic letters were removed: Tweets including English alphabets and patterns, such as '@',' RT ', and 'via'. that are not in Arabic have been eliminated.
4. Elimination of punctuation and diacritics: In the Arabic language, diacritics are important to understand the pronunciation of a word better. However, it is not essential for the written content, so punctuation and diacritics have been excluded.
5. Elimination of Emojis: Emojis are used to communicate a writer's feelings. Emojis were deleted because they lacked the necessary information.
6. Stopwords Removal: Stopwords are commonly used words in a language, and these terms are of secondary or tertiary relevance in tasks involving natural language processing. As a result, they can be excluded from the corpus for dimensionality reduction. 343 Arabic stopwords were excised from the corpus in this work.
7. Tokenisation and normalisation: The researchers used Stanford segmenter to perform the tokenisation and normalisation of the tweets.

Figure 2 illustrates the sample of the data before and after preprocessing phase. After finishing preprocessing stage, the total number of words after preprocessing were 57,637 from 17,259 unique words.

3.2. Feature representation

This study has investigated and reported many features, including the term frequency-inverse, document frequency matrix and word and document embeddings, as shown in the following sections.

3.3.1. Term Frequency-Inverse document frequency matrix

From the pre-processed text, a TF-IDF matrix including unigram and bigram words was constructed.

3.3.2. Word embeddings

The word embeddings have demonstrated outstanding performance of different types of learning problems. The term "Word Embeddings" refers to the representation of words in vector space. The words are represented so that they are close to one another in the vector space when used in the same context. The Word2Vec model is widely used for learning word embeddings. The Word2Vec model is composed of two layers: an input layer and an output layer. After cleaning and tokenizing the text, the researchers used Word2Vec to construct vectors from the documents' tokens. This procedure is divided into two stages. To begin, the researchers trained a Word2Vec model on the tokens created before. Second, they created a vector for each document based on the vectors of its words. The Gensim library was used to train Word2Vec models.

3.3.3. Document embeddings

The vector representation of a document is called document embedding. A document may include many sentences. Doc2Vec is a more a comprehensive implementation of the Word2Vec paradigm. Its objective is to generate a numerical representation of any document, regardless of its length. Also, with word vectors, a Doc2Vec model incorporates a vector Document ID that is distinct across documents. A document vector is simultaneously trained when training word vectors. After training, the document vector contains the document's numeric representation.

The Genism Doc2Vec[4] component was used to train a Doc2Vec model. The model has been trained on the ArHajj-21 tweets dataset. During the Doc2Vec model's training, the number of dimensions was adjusted to 300 and the context window size to 40. The dimensions and size of the context window were determined after a series of experiments.

3.3. Clustering

The researchers employ one of the most well-known clustering methods, K-Means [12], in conjunction with three distinct feature representations: TF-IDF, Word2Vec, and Doc2Vec. K-Means is a frequently used technique for iterative clustering. The method requires an input of the number of clusters K.

The researchers evaluated feature vectors of various sizes: 100, 200, 500, and 1000 most frequently occurring words after preprocessing. The researchers discovered that the four variants had fairly comparable outcomes. As a result, we use the 100 most common terms as the number of features in this study for TF-IDF, Word2Vec and Doc2Vec, with a "K" (i.e., number of clusters) ranging from 5 to 50. In this paper, the K-Means algorithm was employed using the sklearn library[5].

3.4. Topic Modeling

Topic Modeling is another unsupervised machine learning technique that relies mainly on the statistical features of the data in order to identify "topics" that define a collection of documents.

Topic modelling techniques employ statistical techniques to extract topics from a collection of texts, and each topic is specified as a distribution of words. Topic modelling can also be used for clustering by providing a probability distribution for each document over various topics. Indeed, clustering and topic modelling techniques have been employed to solve clustering problems. The researchers implemented state-of-the-art topic model approaches for short text clustering, including LDA and GSDMM.

1. Latent Dirichlet Allocation (LDA) [13] is a probabilistic generative model that characterises a set of observations as a mixture of multiple categories. An observation is a document containing various themes, and a mixture of word distributions presents each theme. The probability that a document is part of the topic-based terms used in that document can be computed using these distributions. LDA learns distributions using a Bayesian approach: a set of themes, word probabilities, and so on.
2. GSDMM is a collapsed Gibbs Sampling technique used to short text for the Dirichlet Multinomial Mixture model (DMM). DMM is a probabilistic generative model for documents that are predicated on two assumptions regarding the generating process [14]. First, documents are created by a mixture model, and then the mixture components and clusters have a one-to-one connection. Thus, GSDMM assumes that each document is associated with a single topic, which is reasonable for specific short texts. For a set of topics, this method organises documents and derives topic structures from the data. If the number of topics is set to a large amount, the model will automatically discover the range of topics.

[4] https://radimrehurek.com/gensim/models/doc2vec.html

[5] https://scikit-learn.org/stable/

4. Experiments

A series of experiments have been carried out to evaluate the proposed methodology on the ArHajj-2021 dataset. In this section, the researchers presented the evaluation metrics used in these experiments. Then, the overall results for the proposed methodology are presented. Finally, the researchers analyse the performance and discuss the main findings on the performance of clustering algorithms.

4.1. Evaluation metrics

In the case of absence of ground truth labels as in this research, the researchers employed internal indices that included the Calinski-Harabasz (CH) and Silhouette Coefficient (SC) [15], [16] for evaluation of clustering performance. Multiple studies have shown that the CH index is useful for selecting the optimal number of clusters [17]. However, SC is a well-known statistic that shows how successfully each element has been classified. The fundamentals of internal indices are then explained.

- **Calinski-Harabasz criterion (CH):** It is also called the Variance Ratio Criterion. A larger CH value means the clusters in the model are well-described. CH_k is defined as the ratio of the average inter-cluster dispersion matrix (B_k) to the average intra-cluster dispersion matrix (W_k), as follows:

$$CH_k = \frac{B_k}{W_k} \times \frac{n-k}{k-1} \tag{1}$$

where n denotes the total number of points and k denotes the number of clusters. The B_k value is defined as:

$$B_k = \sum_{i}^{k} n_i \cdot dist^2(c_i - c) \tag{2}$$

where n_i denotes the number of elements in a cluster C_i, c_i denotes the cluster's centre, and c denotes the entire dataset's centre. W_k is a distance measure between clusters and is defined as:

$$W_k = \sum_{i}^{k} \sum_{x \in C_i} dist^2(c_i, c) \tag{3}$$

where x is a C_i cluster point? Importantly, B_k is maximised and W_k is minimised to achieve well enough and dense clusters. As a result, the largest value of CH reflects a partition that is adequate for the dataset.

- **The Silhouette Coefficient (SC)** quantifies the distance between clusters. Each point is assigned a width based on its membership in a cluster. After that, the widths are averaged across all observations for each k. SC values are in the range $[-1, 1]$, with -1 indicating low clustering quality or poorly defined clusters and 1 indicating excellent clustering quality. The SC_k the value defines, as follows:

$$SC_k = \frac{1}{n} \times \sum_{i}^{n} \frac{b_i - a_i}{\max(a_i, b_i)} \quad (4)$$

where n is the total number of elements in a cluster, a_i denotes the average distance between element i and all other elements in the same cluster, and b_i denotes the average distance among element i and all other elements in the neighbouring cluster.

Overall, a higher clustering quality of an algorithm often results in improved prediction performance for machine learning tasks, such as clustering. As a consequence, the researchers aim to uncover the algorithms that maximise the overall quality of clustering. They also plot and evaluate the trained representations' t-Distributed Stochastic Neighbour Embedding (t-SNE) [18] and Uniform Manifold Approximation and Projection (UMAP) [19] mappings for visual validation.

4.2. Results and Discussions

The researchers conduct experiments on SC and CH to evaluate the clustering and topic modelling techniques. The CH and SC results presented in Table 1 are for the k-means algorithm with TF-IDF, Word2Vec, and Doc2Vec and topic modelling approaches using LDA and GSDMM, respectively, for example, 5, 10, 20, and 50 clusters/topics ("k").

Note, CH and SC measure clusters/topics on three facets: the similarity of tweets inside a cluster (cohesion) and the dissimilarity of tweets from other clusters. The number of clusters is subjective and depends on the method used for measuring similarities and parameters used for partitioning. In this paper, we tested different numbers of clusters/topics to show the varying performance across feature types with k-means and topic modelling.

Table 1 Overall evaluation results using SC and CH scores over a different number of clusters

SC				
Model	5 clusters	10 clusters	20 clusters	50 clusters
TF-IDF	0.0022	0.0032	0.0039	0.0051
Word2Vec	0.5307	0.5182	0.5232	0.4679
Doc2Vec	0.2173	0.1943	0.1745	0.1642
LDA	0.6509	0.5686	0.4299	0.3834
GSDMM	**0.9841**	0.9817	0.9810	0.9833
CH				
TF-IDF	1999	1897	1802	1791
Word2Vec	6600	12271	24304	52791
Doc2Vec	735	641	448	329
LDA	4344	1655	492	169
GSDMM	**150139**	59377	25024	20843

The results indicate that the GSDMM topic model approach produced the best results for Arabic hajj-related tweets when evaluated using SC and CH scores. However, Word2Vedc outperformed GSDMM in terms of CH metric when the cluster size is set to 50. Word2Vec representation achieved the best results in comparison to TF-IDF and Doc2Vec models.

Another interesting finding is that the LDA topic modelling decreases performance when increasing the number of topics because LDA works better for content-rich documents.

The visualizations of t-SNE and UMAP mappings in Figure 3 demonstrate that GSDMM leads to increased cluster reparability. The final visualization is based on intriguing insights gained from the outperforming model using the GSDMM technique, as illustrated in Figures 4 and 5. Figure 4 shows the top words (as bubbles) from each topic compared to the total number of tweets for that topic. As an illustrative example, Figure 5 highlights the most important terms in Topic 4 related to the food issue during Hajj.

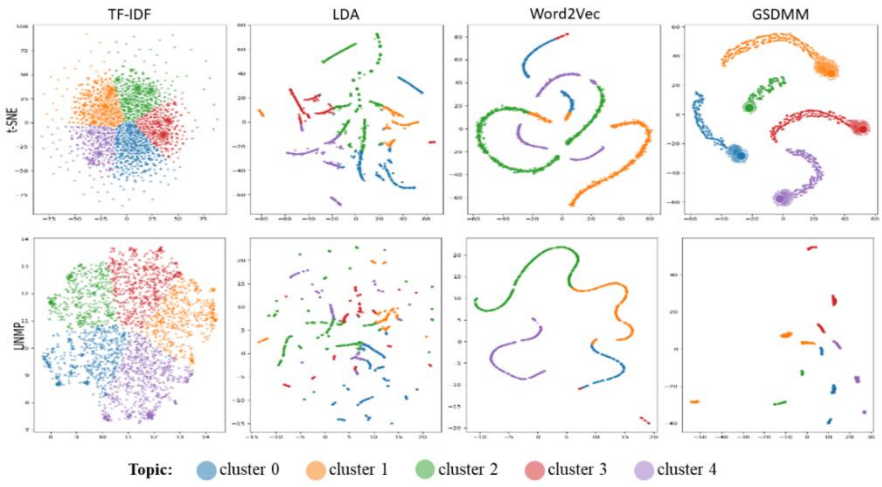

Figure 3 Visualisations using t-SNE and UMAP of representations derived using TF-IDF, LDA, Word2Vec, and GSDMM, and colouring depending on the representations' clustering into five clusters.

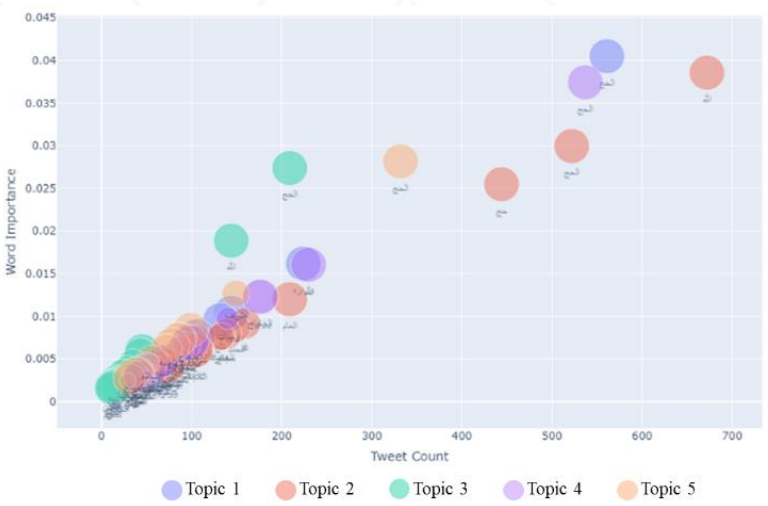

Figure 4 Ratio word importance over tweet count based on GDMM topic distribution

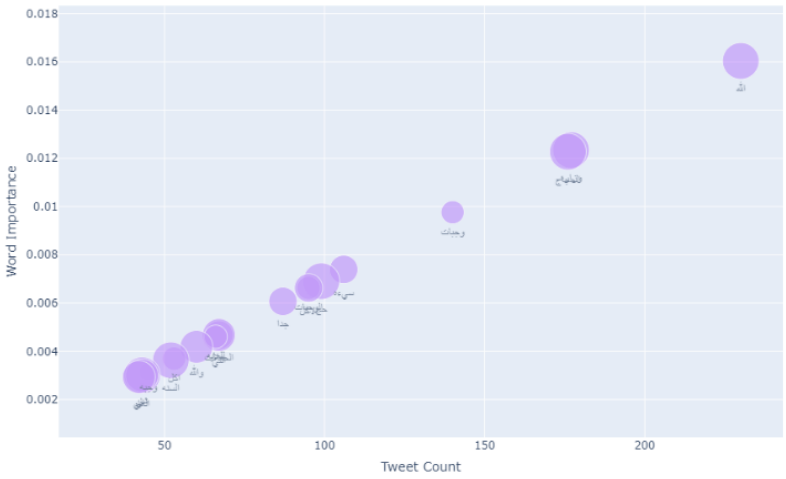

Figure 5 Ratio word importance over tweet count based on GDMM topic distribution as in Topic 4

5. Conclusions and Future Work

This study has conducted a comprehensive evaluation of various unsupervised learning approaches on Arabic Hajj-related tweets, including topic modelling methods and document clustering method. The researchers established k-means clustering algorithms using TF-IDF, Word2Vec, and Doc2Vec document vectorisations, as well as LDA and GSDMM. Two internal metrics were used to assess performance, including the Calinski-Harabasz index and the Silhouette Coefficient. The results demonstrated that short text topic modelling outperformed clustering strategies using a variety of alternative feature representations. Additionally, it was discovered that the word embedding-based feature representation is more beneficial than the document embedding-based feature representation. Overall, this study shows the feasibility of using topic modelling and clustering to Arabic Hajj-related tweets.

Numerous further works on this study are planned. First, the concept of employing domain-specific word embeddings may be implemented in light of various Arabic dialects. Second, strategies for clustering based on deep learning will be investigated and integrated into the present framework. Thirdly, the researchers intend to evaluate different cutting-edge contextualized embedding-based methodologies. Finally, the researchers intend to build an interactive dashboard or online application to visualize and analyze the findings of the analytical component.

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Measuring Water Level in Zamzam Dispensers in the Two Holy Mosques Using IoT Technology

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قياس مستوى الماء في حافظات ماء زمزم في الحرمين الشريفين باستخدام تقنية إنترنت الأشياء

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الملخص

تأتي سقيا ماء زمزم على رأس الخدمات الجليلة التي تقدمها حكومة المملكة لزوار الحرمين الشريفين، إذ يتم توفير ماء زمزم عبر عدة طرق فعالة وتليق بشرف المكان، حيث يقوم بتلك الخدمة وغيرها فرق ذات تأهيل عالي من مختلف القطاعات التي تسعى جاهدة لخدمة الحرمين الشريفين، ونظراً للدور المهم للتقنيات الحديثة في تحسين جودة وكفاءة الخدمات والعمليات بما في ذلك سقيا زمزم، فإن هذه الورقة تعرض نظاماً للارتقاء بفاعلية استخدام الحافظات البلاستيكية لماء زمزم والتي لاتزال تستخدم على نطاق واسع في الحرمين الشريفين منذ عقود ، ويضيف الحل المقترح لتلك الحافظات بعض المزايا التي تهدف إلى تحسين جودة وكفاءة العمليات، وتقليل التكلفة التشغيلية، ففي المرحلة الحالية من العمل، قام فريق البحث بتطوير مكونات إضافية للحافظات الحالية من أجل الوصول لنتائج سريعة بأرخص تكلفة وأقل جهد، حيث يراقب النظام الحالي مستوى المياه داخل الحافظات من خلال جهاز استشعار قادر على قياس مستوى الماء لإعطاء تنبيهات للأشخاص المسؤولين عن ضرورة إعادة التعبئة، وتم تطوير الوحدة الخلفية للنظام وفق نهج "الحوسبة دون خوادم" حيث يتم إرسال بيانات المستشعر إلى سحابة للمعالجة والتخزين والاسترجاع، كما تم تطوير لوحة المراقبة على تطبيق الجوال متعدد المنصات على نظامي أندرويد و آي أو إس حيث يمكن للمستخدمين استعراض الحالة المحدثة لكل حافظة مياه، وتقدم الورقة عرضًا عمليًا للنظام الذي أنشأه فريق البحث لهذا الغرض باستخدام تقنية إنترنت الأشياء والحوسبة السحابية .

الكلمات الدالة: التحول الرقمي ، إنترنت الأشياء، سقيا زمزم ، الحرمين الشريفين.

Abstract

Providing Zamzam water through several efficient and decent ways comes at the top of the great services that the Saudi government provides to the visitors of the Two Holy Mosques. That service and many others are delivered by highly qualified teams of different sectors who strive to undertake the great mission of Custodian of the Two Holy Mosques. Indeed, modern technology plays a vital role in enhancing the quality and efficiency of services and operations including Zamzam water providing. This paper presents a solution that constitutes a significant upgrade for the current portable plastic dispensers that have effectively served the purpose for decades.

The proposed solution operates the smart dispensers with minimal cost and little effort. The current system monitors the water level inside the dispenser to give alerts to the people in charge of refilling the dispensers. A sensor device that is capable of detecting the level of water is developed. The system backend is developed in a serverless design approach where sensor data is sent to a cloud for processing, storage and retrieval. The dashboard is developed on a cross-platform mobile application on Android and IOS where an updated status of each water dispenser is displayed to users. The paper presents a practical demonstration for the system that we built for that purpose adopting IoT technology and cloud computing.

1. Introduction

The increasing adoption of technology at the two Holy Mosques will have a significant impact on enhancing the efficiency of operations done by the different sectors. The services related to providing Zamzam water are on top of those operations. Zamzam water is provided through different channels: from the different size bottles to a well-established water pipe network throughout the Holy Mosque. In this work, we target the portable plastic water dispensers that are handled manually during filling, level checking, and Cleaning.

A problem that encounters the personnel who are in charge of taking care of those dispensers is checking the level of water and replacing them with a full dispenser without affecting the quality of service. Therefore, we propose an IoT solution that enables checking water levels automatically and remotely. This work aims at solving the problem of manual operations to handle the portable dispensers of Zamzam water in the two Holy Mosques by utilizing IoT technology. Particularly, the refill process is targeted in this work. Instead of performing the process manually by personnel who need to check the water level on-site, the researchers enable personnel to check the water level remotely. The main contribution is the development of an IoT solution with non-invasive sensing, and with a simple dashboard on a mobile app to facilitate personnel work.

2. Research methodology

To develop an effective solution to the problem of manual inspection of water level in the portable dispenser, we should take into consideration reducing the need for changes in the current process. That is very important in order to enhance the user experience and to achieve smooth adoption of technology. Also, for cost-effectiveness, it is very important to leverage the current assets and reduce the number of modifications on them, which will have a direct impact on cost and scalability. Therefore, it is fundamental to understand the status quo of both: the process and the "thing" to be monitored

by proposed IoT solution. Looking at the process of water level check, currently, the portable dispensers in the Two Holy Mosques are inspected manually by having the personnel visit each dispenser on-site to check the water level inside. That personnel has the long experience that allows them to make good estimates about when to go into the inspection process based on time (of the day, week, or season) and place. This part of the operation motivates us to enable remote monitoring for the water level to eliminate the need for manual inspection.

Moreover, the Zamzam water that is contained in the dispensers is regularly subject to a multitude of strict tests in advanced laboratories to ensure maintaining the highest quality of drinking water. If we decide to use any invasive sensing method, obviously that will not be welcomed by the operational team because it will be questioned whether it is safe to the drinking water if such electronic components are mounted inside the dispenser. Hence, that motivates adopting a non-invasive sensing approach in this work.

Another part of the operations is the cleaning and sanitization of the empty dispensers. That is, each dispenser is subjected to regular cleaning and sanitization process that implies exposing the dispenser to a considerable amount of movement and humidity, which are both, generally, not friendly conditions for electronics. Based on this process, the researchers are motivated to avoid placing electronic parts in the external body of a dispenser as much as possible. Rather, electronic parts can be placed in the base as shown in Figure 1.

Figure 1: Showing the main parts of the water dispenser.

The aforementioned motivations resulted in the decision of the sensing device to be external to the dispenser body and mounted on the base. For the microcontroller, the researchers selected the ESP32 module that is equipped with a built-in WiFi module [espressif, n.d.]. For the non-invasive sensing, we used a weight sensor [sparkfun1, n.d.] that is mounted on the base. For efficient power consumption, the device is configured to enter deep sleep mode after data transmission. When active, the device (1) connects to the wireless network, (2) connects to the cloud, (3) sends sensor data, and finally, (4) disconnects from the wireless network to enter deep sleep mode.

To avoid making any changes to the dispenser or the base, the researchers added another base that is placed on top of the original base, where the dispenser becomes in complete contact with the new base.

This new base consists of two layers of hard material (wood in this prototype) sandwiching the weight sensor in between as illustrated in Figure 2(a). That way, the force of the dispenser weight is totally detected by the sensor. The sensing device board accommodating the microcontroller module with a sensor interface circuit (HX711) [sparkfun2, n.d.] is shown in figure 2(b). The complete setup is shown in Figure 2(c).

(a) (b) (c)

Figure 2: The dispenser with the sensing device.

The weight sensor that is used in this work can measure up to 50 kg. The dispenser stands steadily on a set of small legs, one of them is the sensor itself, in addition to small wooden pieces that we use to balance the dispenser and to avoid wobbling. Therefore, the weight of the dispenser is distributed over those legs including the sensor, and, hence, the sensor measures only a fraction of the dispenser weight. In fact, measuring the fraction of the weight is not a problem since we can still measure how much water is consumed by measuring the relative weight. As long as the sensor measurements are clean (not noisy), then we can easily determine the water level inside the dispenser. In the current demonstration, when there is 100% of water, the sensor measures 4.8 kg, and when there is 0%, it measures 0 kg (the weight of the dispenser body is subtracted in the microcontroller). In order to find the relationship between weight and water level, the researchers collected data at different levels of water. That data is plotted in Figure 3, which shows a linear relationship.

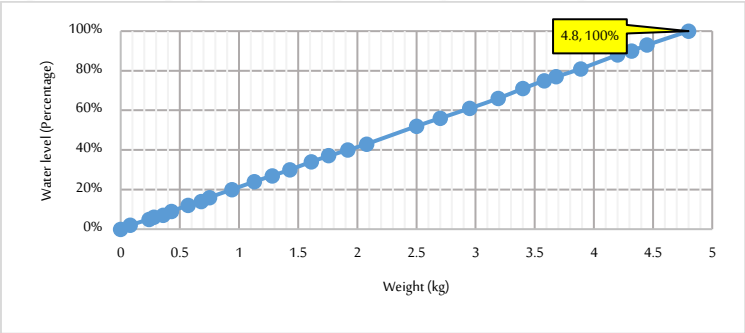


Figure 3: The relationship between weight measurement and water level

The researchers built the backend using a serverless approach utilizing the native cloud services of Amazon Web Services (AWS) [AWS, n.d.] as illustrated in Figure 4. The communication protocol between the device and the cloud is the MQTT

protocol, which is an efficient protocol for IoT applications. In order to establish a connection between the sensing device and the MQTT broker, a certificate was issued by AWS, then coded to the ESP32 embedded software to authenticate the devices when exchanging data with the cloud. Then, the cloud MQTT broker subscribes to the topic that the devices publish to. In the heart of the serverless architecture, there is the Lambda function that handles data and manages the different cloud services in this system. Whenever data is received from some device, the IoT service calls the Lambda function that, in turn, writes data to the database.

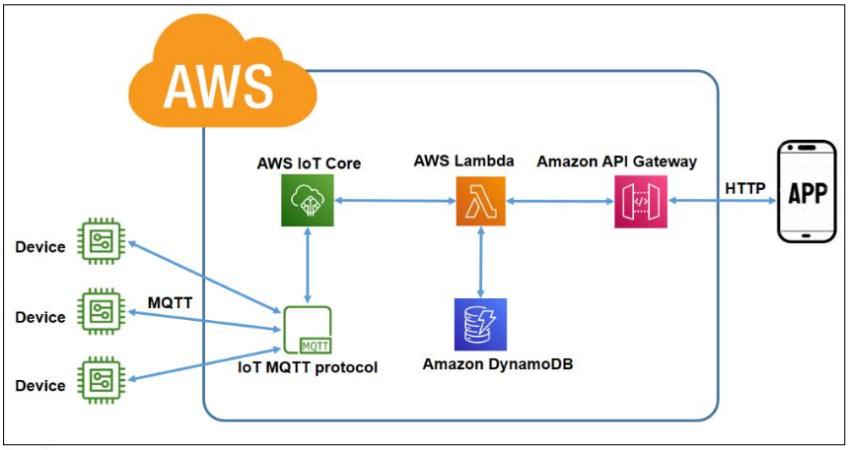


Figure 4: The cloud-based system backend.

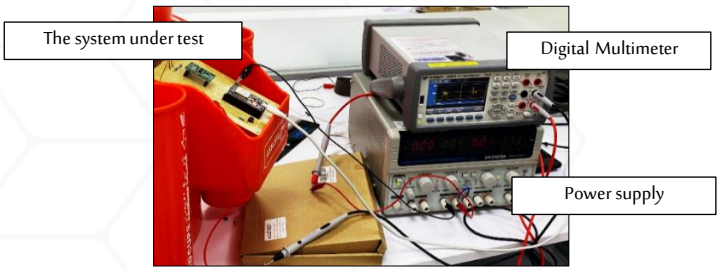
The researchers developed the dashboard on a mobile application using the Flutter framework [Flutter, n.d.]. For this stage, the application is run on a software emulator on a PC, not on a real mobile device. For simplified user interface design, each dispenser data is displayed in a color-coded box as shown in Figure 5, where blue color indicates water level above 50% the orange color is for warning that the level is between 50% and 10%, and the red color indicates almost empty dispenser of less than 10% of water. Data are sorted such that a lower level of water is on top (most important for the user) and a higher level of water at the bottom (least important). For each dispenser, the system shows three pieces of information about the dispenser (shown in the app from right to left):

1. **Dispenser ID (رقم الحافظة):** A unique identifier assigned to each dispenser by the system administrator.
2. **Filling Date (تاريخ التعبئة):** This is the date when the dispenser is filled the last time. This information is useful in case if it is desired to set an expiry date to refill the dispenser even if it is not empty yet. Therefore, the personnel will be able to know how many days have passed since the last filling. At the current stage of this work, the filling date is set manually from the cloud. In the example illustrated in this paper, we set that date to 2021-10-29 for all dispensers, which means they are all filled with water at that date. In the future, the researchers should implement some mechanism to make it easier for users to set the filling date through the app .
3. **Water Level (مستوى الماء).** This is the main information about the dispenser, which indicates the water level in percentage. This value affects the color of each row as explained above.

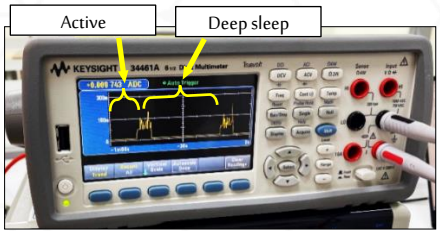
3. Results and discussion

The researchers ran the system and established a link starting from the device up to the mobile application going through the cloud. The device power consumption is observed during active mode and sleep mode. The test setup of the device is shown in Figure 6. The power consumption of the device is measured using a digital multimeter. The power cycle is observed as designed: 30 seconds in deep sleep followed by active mode operations that takes around 6 seconds. The power measurement results are listed in Table 1. The power level at the sleep mode is around 41% of the overall average power level, and around 10% of the active mode level. The complete system test is carried out by filling the dispenser with water then allowing it to be emptied gradually over time by draining water through the drinking faucet. At the same time, the dashboard is being observed to check the update in level measurement. The device at that experiment is arbitrarily assigned the ID of 78. The dashboard shows live update of the water level drop as expected. Figure 7 shows screenshots of the initial and the last states of the experiment for Device 78.

Figure 5: The dashboard mobile app designed for this system as displayed on the device emulator.



(a)



(b)

Figure 6: The test setup of the sensing device showing the power level on multimeter screen during active and sleep mode.

Table 1: Power test results of the sensing device

Variable	Value
Voltage Supply	3.3 V
Device Current Consumption during Deep Sleep	94 µA
Device Maximum Current while sending data through WIFI	1100 µA
Device Current Consumption (Average)	230 µA
Deep Sleep Duration	30 Seconds

Figure 7: Water level at the beginning and the end of the test.

4. Summary and conclusion

An IoT system for monitoring the level of water inside Zamzam water dispensers is developed. A non-invasive sensor device is developed to detect levels employing a weight sensor. The system backend is developed in a serverless design approach where sensor data is sent to a cloud using MQTT for processing, storage and retrieval. The dashboard is developed on a cross-platform mobile application on Android and IOS where an updated status of each water dispenser is displayed to users. Test results show the efficiency of the sleep-active power cycle in reducing power consumption to around 25% on average, around 10% in sleep mode, both concerning the power level at the active mode. The work demonstrates the great potential of utilizing IoT technology in enhancing the efficiency of operations of handling Zamzam water dispensers. This system is also useful in the time of pandemics such as COVID-19 because it allows for doing many tasks remotely from the office instead of doing them on-site, so the person will not need to go to the dispenser's locations to check water level manually. Also, if the water level data is made available to the public so that people can figure out whether a dispenser is empty or not, that will reduce the chance of unnecessary touching of empty ones. In future work, the system should be tested on a larger scale and demonstrated in the field.

5. Recommendations

1. The work demonstrates the great potentialities of utilizing IoT technology in enhancing the efficiency of operations of handling Zamzam water dispensers.

2. Non-invasive sensing should be applied in drinking water applications in general and in Zamzam water in particular .
3. The Serverless approach for backend design is highly efficient in terms of cost and development time.
4. More technology solutions should be developed targeting the Two Holy Mosques, Hajj, and Umrah applications .

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An RFID-Based Framework for Enhancing the Process of Pilgrims Housing and Grouping

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إطار عمل قائم على RFID لتعزيز عملية إسكان الحجاج وتجمعاتهم

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الملخص

تقدم هذه الدراسة إطارًا قائمًا على RFID بوصفه وسيلة لحل مشكلة توصيل أمتعة الحجاج من منطقة الاستقبال في الفنادق أو أي مكان آخر من أماكن الإقامة إلى الغرف الخاصة بهم خلال إقامتهم في موسم الحج. في هذه الدراسة ، تمت صياغة عملية نقل الأمتعة الشاملة في إطار عمل (Framework) مبني على تقنية ال RFID بوصفه اسلوبا تقنيا موصى به. علاوة على ذلك، يتم تقديم نموذج بيانات قائم على الرسم البياني (Graph) للتعامل مع جميع المعلومات المطلوبة لهذا النظام، بما في ذلك معلومات الأمتعة والحجاج ، بالإضافة إلى تفاصيل الإقامة والنقل. ويستطيع النظام المقترح الحصول على جميع معلومات تتبع الأمتعة عبر النظام المقترح باستخدام مخطط البيانات والاستعلامات في نظام Neo4j لإنشاء قواعد البيانات.

Abstract

This study introduces an RFID-based framework as a solution for delivering pilgrims' luggage from the reception or luggage area in hotels or any other kind of accommodations to the pilgrims' rooms. In the proposed solution, an overall luggage transportation process is modelled in the recommended RFID-based framework. Furthermore, a graph-based data model is introduced to deal with all required information of this system, including luggage and pilgrims' information, as well as accommodation and transportation details. Additionally, all luggage tracking information can be gained through the proposed system using Neo4j cypher queries.

1. Introduction

Hajj is the fifth pillar of Islam, and it is the obligation that every Muslim must perform at least once in a lifetime. Therefore, one may find that most Muslims from all corners of the earth are eagerly looking forward to performing this obligation even once in a lifetime, according to the Lord's guidance for Muslims. This has led to the Saudi ~~Arabia~~ government to devote all its financial and technical capabilities to serve the guests of the Most Merciful, as it is the incubator of the holy sites and cities (Makkah and Madinah). In fact, all pilgrims usually move between these two Holy Cities.

This requires the availability of effective and creative logistical services to ensure their smooth and easy movement, and this is something that the government of the custodian of The Two Holy Mosques has been emphasizing on. In implementation of those directives, the efforts of all sectors concerned with Hajj were focused on focusing on all the ways that would reduce and speed up the grouping of pilgrims from one region to another and from one city to the next, with the fastest and most modern methods.

One of these methods is the use of the latest technologies in the field of grouping and housing. In this work, the researchers consider the use of RFID as a modern technology to expedite and ease grouping for pilgrims, especially at this time when people are suffering from the spread of the new Corona virus, in which governments seek to provide their services as quickly and prevent crowdedness as far as possible. The solution consists of creating an RFID reader at the side entrances of hotels in which the pilgrims will live (especially those that consist of more than 500 rooms). All the information of the pilgrims are stored in the recommended RFID card, including the name of the pilgrim and his nationality, as well as the Tawaf manager responsible for the campaign, the name and location of the hotel.

These RFID-based stickers are provided to the pilgrims by their hajj agencies before arriving in Makkah. These stickers are provided for pilgrims before sufficient period with enough explanation about the mechanism of using these stickers in their luggage. When the buses arrive loaded with large numbers of pilgrims coming from the city or vice versa, they head to the main entrances to their hotels and carry the luggage to the side gate that has the RFID reader. When the luggage is passed over the reader, all the information about the owner of that baggage, the room and the floor in which he lives will appear. Thus, it is easy to sort it out after that by the specialized staff and send to the pilgrims' rooms, each according to the information recorded in its slide. After completing the procedures for entering the hotel, the pilgrim goes to his room, where he will find his luggage waiting in his room safely.

The Problem

In this article, the researchers discuss the difficulties in the speed of transportation of pilgrims' luggage from the reception area in hotels to the guest rooms. This problem is clearly evident when the process of grouping pilgrims is repeated, and buses are pushed with pilgrims and luggage in the lobby area of the hotels throughout the day. This problem is further complicated in hotels with a huge capacity, i.e., has a capacity of more than 500 rooms, as the buses drop the luggage with the pilgrims and go to bring more of them.

The proposed Solution

The proposed solution in this work is based on placing a sticker on each piece of the pilgrims' luggage so that each sticker contains a chip that works with the RFID system. So all the information about the pilgrim or guest can be stored. The

stored information may include the identification number, name, nationality, contact number, arrival time and destination, room number and any other relevant information. This process requires preparation and logistical coordination between accommodation hotels, in both of the two Holy Cities; Madinah and Makkah, with the pilgrims responsible for their campaigns. When the buses transporting pilgrims arrive at the destination, the luggage is dropped off at the side of the hotel instead of the main lobby area.

A specialized reader for reading RFID tags must be there to read the information in each RFID tag of the guests' baggage. Thus it can be sorted and delivered to the guest rooms without any problem and without causing any confusion or crowding in the reception area of the hotels. This would accelerate the process of housing the pilgrims in their rooms with all ease and speed, especially with the outbreak of the Corona COVID-19 epidemic, which requires implementing physical distancing between pilgrims and the speed of their service.

About RFID

The first invention of the Radio Frequency Identification technology was in the year 1948, when it was used in World War II by the British as it relies on radio waves to transmit information from distances, but it was not used commercially until the year 1980 AD [1]. The RFID technology does not require direct connection between chips and a reader, which is one of the known problems in the barcode technology that is currently used in most places. This particular feature (not contacting or directing between the sticker and the reader) is the one that gives the technology of the RFID its paramount importance in the process of pilgrims' grouping.

The Component of RFID Ecosystem

At work, RFID ecosystem is proposed for tackling the issue of tracking pilgrims luggage in their journey during Hajj season. The RFID system consists of several components, namely, the RFID chips (tags), the RFID antenna, the RFID reader, the central server, the database, the web application and the information visualization devices. The following figure (Figure 1) demonstrates major components of the overall proposed RFID framework.

Figure 1: The main component of RFID ecosystem

The first component is the RFID chips (tags). These chips can be fixed to any surface that we want to store its information. The cost of these chips is high in contrast to the barcode used these days [2]. In general, there are two main types of RFID chips, namely, active chips and passive chips. The Active chip contains a battery inside, which enables the tag to transmit waves at high frequencies and over long distances. This tags are considered the most expensive. On the other hand, the passive chips are those that do not contain any battery inside and they depend on the information reader to transmit information. The passive tag along with the system's antenna, sends activated radio waves, which, in turn, operates the passive chips to extract information from them. This type of RFID tags is considered the cheapest type [3] and [4].

Furthermore, the second component of the RFID ecosystem is the antenna. The antenna is normally fixed on the top of the RFID reader to pick up the signals coming from the chip, and send the activated waves to operate it [4]. Additionally, the third component is the RFID reader. The reader is utilized to read information coming from RFID tags and analyse their content. It, then, sends the captured information to the central computer, in which the associated information systems that use pilgrims' information for storing, analysis and retrieving the correct and accurate information about the luggage so that it can be directed to its desired destination without any complications. As it can be seen the following section.

The proposed RFID Framework

In this section, the researchers discuss how the recommended RFID-based framework can be implemented to serve the issue of luggage transmitting in al Hajj season. The following figure (Figure 2) illustrates the overall framework, including all luggage transmitting processes involved. The whole process starts when a new pilgrims group arrives at one of national ports in the Kingdom of Saudi Arabia, which can be either an airport or harbor. A new smart pilgrim identification card is given to every new pilgrim in the arrived group at the port. A RFID chip (tag) is issued, programmed and linked to every pilgrim, and installed (attached) to their luggage.

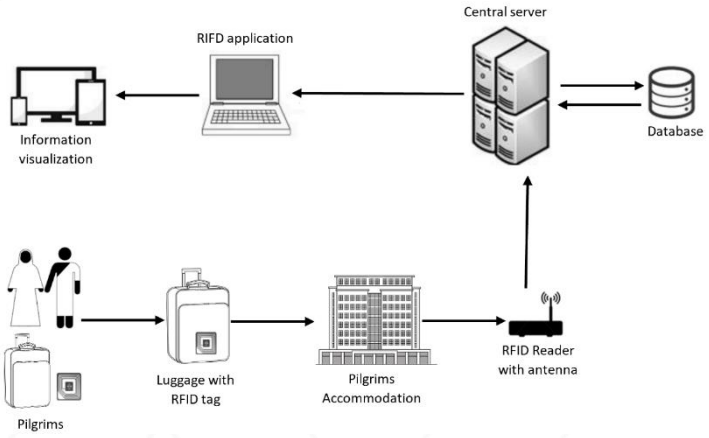

Figure 2: The overall RFID framework

The journey of luggage starts from the pilgrims' group arrival port to their accommodation in Makkah or in Al Madina. Traditionally, the process of transporting of pilgrim groups and their luggage is performed by local buses between cities. If an exceptional case occurs and some bags were lost or delayed, it would be easy to find out their correct destination ~~of~~ using the attached RFID tags on them. When the bus of the pilgrims group arrived at their accommodation, they can easily directed to their previously allocated rooms, without the need to wait for their luggage to be loaded from the bus at the accommodation entrance, lobby or even luggage lounge (area). As a result, this practice may reduce an expected crowd at accommodate entrance and lobby when group arrival.

Every bag of the luggage is detected by the RFID antenna when it is placed inside the range of the antenna. The RFID reader, then, reads and serializes the stored information on the tag. The scanned information are transmitted into RFID server, which might be a local centralized server or even a cloud-based server. The associated RFID system receives the

serialized information and stores it into the system database. A step of data processing or reformatting is applied to ensure the accuracy and completeness of the detected information. In the same time, the detected tag with its information can be accessible by the accommodation workers, using any smart devices compatible with the overall RFID web-based application. Thus, the accommodation workers are able to know which room this bag belongs to. Consequently, this bag is directed and transmitted by the workers to the correct floor and room without any difficulty or delay.

RFID Luggage States Modelling

State-Machine diagram can be used to demonstrate conceptually all possible states of luggage journey from the boarder port to the pilgrim's room in their accommodation. The following State-Machine diagram is constructed to illustrate the luggage states during the overall transmitting process.

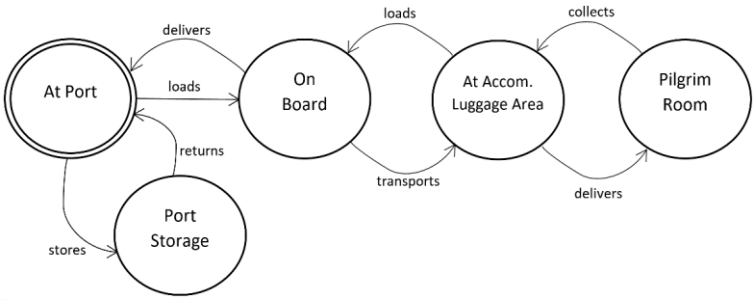

Figure 3: The conceptual representation of the proposed RFID framework

According to the Figure 3 above, there are five main states; namely, at port, port storage, on board, at accommodation luggage area and pilgrim room. The at port state is considered an initial and final state in the same time, as at the beginning all new tags are activated at this state after attaching them on the top of arrival bags. The RFID reader at that port then detects the activated tags and all associated information is serialized and stored in the backend database of the system with a timestamp. After loading luggage into a bus of the group, the state of every loaded bag is changed into on board state with an associated timestamp. This state remains until all bags arrive at the luggage area in the group accommodation in the city of Makkah or al Madina. Then the RFID reader at the accommodation detects luggage tags and transmit their data to the hotel/ accommodation system to be compared and checked. The status of these bags are then changed to at accommodation luggage area. After completing the pilgrims' check-in process, the accommodation workers, then, collect luggage from the luggage area and deliver them to the target pilgrim room using RIFD readers and their smart devices. It is worth mentioning that when returning ~~back~~ to Figure 3 above, there is a hidden iteration (loop) between the three states (on board, at accommodation luggage area and at pilgrim's room). This iteration can cover the transportation of pilgrims group between the two Holy cities during their journey. Additionally, the State machine diagram (Figure 3) also covers the returning journey from accommodation to the departure ports.

Conceptual RFID Data Schema

There are two kinds of entities in the proposed RFID ecosystem: (1) static entities, which are used for representing data about static entities in the system, such as, pilgrims' personal information and groups, locations of accommodations and

other. Typically these data are not temporal and never changed expansionary. (2) dynamic entities, which are used for tracking every individual object within the RFID framework, such as, luggage status or even the pilgrims themselves.

The data stored in this kind of entities are considered temporal, as different timestamps associated with all luggage movements and states are recorded into the database.

The proposed data model consists of six main entities, namely, the pilgrim, accommodation, transportation, port, luggage, and system _reader. The pilgrim entity holds all personal information about a pilgrim, including id, name, nationality, age, al Hajj group, contact number, rfid_tag_id and so on. The luggage entity holds associated information about the pilgrim luggage, including basic details, such as, tag_id, type, color, shape and more. The accommodation entity holds all associated information regarding all registered accommodations in al Hajj season, including, id, name, type, address, GPS location and more. In addition to this, the transportation entity holds information about every vehicle or train that participates in transmitting pilgrim groups between cities and during al Hajj days, including, vehicle_id, type, capacity and more. The port entity holds basic information about arrival and departure ports that the pilgrim used to come to the Kingdom of Saudi Arabia and to travel out from it. They include information like port_id, type, address, city, arrival date, departure date and more. Moreover, there are three main relationships between these entities in the proposed data model, namely, housing, trip, and owning relationship. The housing relationship is utilized to link pilgrim's entity and accommodation one, whereas the trip relationship is used to connect pilgrim entity to transportation one, and the owning relationship is used for linking pilgrim and luggage entity in the data model.

Graph-based Data Model

In this research, the commonly- known graph-based data model is adopted to refine the conceptual RFID data schema. In the domain of computer science a graph database can be defined as a database that utilizes graph structures for semantic queries with nodes, vertices, and properties to express and stores data in a computer software system. It is considered a type of NoSQL databases that are not restricted to a predefined relational database schema. There are various graph databases available nowadays, such as OrientDB, Virtuoso, Neo4j, Nebula Graph and others.

In this study, the Neo4j graph database is used as a representation of the backend graph data based on the proposed RFID framework. It is an open-source java and Scala-based native graph database. It implements the property graph as its data model physical representation for storing data. The following snapshot of the Neo4j cyphers are used for creating nodes and relationships of the proposed graph data model:

```
// Create the core nodes of the graph data model
CREATE(n:Pilgrim{name:'Pilgrim'}), (m:Accommodation{name:'Accomodation'}),
(k:Transportation{name:'Transportation'}),
(u:Luggage{name:'Luggage'}),(s:Port{name:'Port'}), (r:Reader{name:'Reader'})
// Creating the 'Owning' relationship between two graph nodes
MATCH
  (a:Pilgrim),
  (b:Luggage)
WHERE a.name = 'Pilgrim' AND b.name = 'Luggage'
CREATE (a)-[r:RELTYPE {name:'Owning'}]->(b)
RETURN type(r), r.name
```

The following Figure (Figure 4) demonstrates the generated graph data model after executing the above Neo4j cyphers.

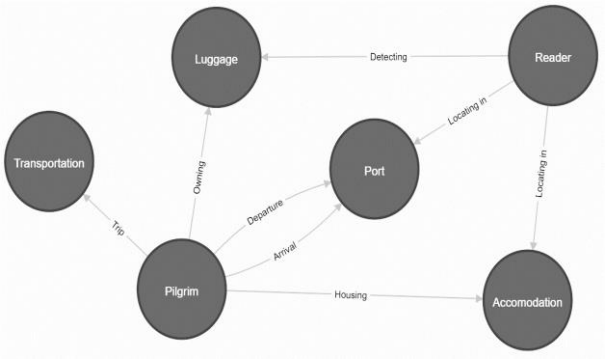

Figure 4: The Graph-based data model of the proposed RFID system

Tracking Luggage

The Neo4j cypher language can also provide graph queries that allow users to inquire about and retrieve data from the graph database in such an easy and efficient way. In the proposed framework, all what the end-users need is to answer question like "which room must I deliver this bag to?" The graph database can answer this question very easily using the following cypher statement:

```
// a nested query for finding a room of a detected bag
MATCH(u:Reader)-[:Detecting]->(n:Luggage)
WHERE EXISTS {
        MATCH(m:Pilgrim)-[:Owning]->(n)
        WHERE m.rfid_tag_id = n.tag_id
        WHERE EXISTS {
                MATCH(m:Pilgrim)-[:Housing]->(k:Accomodation)
                WHERE m.id = k.guest_id
                    } }
RETURN k.room_no // return the room number of pilgrim
```

Features of the Proposed RFID framework

One of the main advantages of the proposed system is the ability of sending and capturing information. As it can transmit all critical information about the arrived luggage at the hotel lobby, in a fast way, without the need for touching any surface. This is considered a great advantage, especially during the current period as the world has suffered and is still suffering from the widespread of the Corona virus (COVID-19) pandemic. People are still trying to find safe and modern ways to accomplish their jobs with minimum surfaces contact to prevent the spread of the virus as much as possible [4].

The second main advantage is the accuracy of transmitting information without errors. As it is found that dealing with RFID-based information enables establishments to complete their tasks in a quick manner and without significant errors and without the need to complete missing data, as all required data are previously stored in the tags [2].

The third advantage of the proposed RFID framework is its ability to provide rapid customer services with a professional and high quality manner [2]. As such it is considered one of the modern systems that enables people who work in al Hajj season to complete their tasks with limited touching of surfaces? This can help Saudi Arabia in al hajj season to pass this period in which people are suffering from the spread of the Corona (COVID-19) epidemic [4].

2. Discussion

A brief comparison, including the similarity and differences between the proposed framework and the related ones those applied to various services in the Hajj season is presented in this section. In [5], for instance, critical success factors for introducing a suitable crowd management architecture of Hajj was discussed. This work suggested using modern technological solutions for tracking and monitoring crowds that empowered with adequate number of sensors and various biometric identification methods in the Hajj season. Unlike the promising objectives of our introduced framework, the RFID technology that is connected via the mobile 3G network was presented in [5] to be utilized as an alternative for using traditional wristbands for tracking and identification of pilgrims.

Besides, a Service Oriented Architecture (SOA) based positioning system that tackles the problem of food distribution and food cart locating in overcrowded region was introduced and discussed in [6]. The case of the region of Mena in the Hajj season was carefully considered in that work. The optimization positioning algorithm was utilized for determining the least waiting time for providing services with the shortest distance and lowest cost and the maximum profit for the service providers. The proposed work in this article shares the same objectives of the discussed work in [6] with a different context. As this RFID-based framework targets enhancing the pilgrims housing and grouping by providing shortest amount of time to deliver luggage to pilgrims' rooms.

Furthermore, another common recurring issue in the Hajj season was discussed in [7] and [8], which is the problem of losing the pilgrims' official identification documents during the events of Hajj. The work adopted similar technology utilizing the promising framework of this article and ~~they~~ introduced a version of an RFID-Based Pilgrim Identification System (PIS). Their current architectural design - consists of 4 major components, namely, passive RFID wristbands and readers, database and terminal PC. Indeed, there is one major difference between this PIS system and the suggested framework in this study from the technological perspective.

Unlike this framework that is based on the graph database, the PIS system utilized traditional relational backend database system for sorting out and manipulating the collected RFID-based pilgrims' data. It is worth mentioning that both systems collect, store and manipulate similar information of pilgrims, including, personal information, medical condition details, and the associated Hajj campaign information.

3. Conclusion

This scientific paper presents a vision for solving the problem of the accumulation of pilgrims and their luggage in the lobby of hotels, which are closed places by nature. It prevents the transmission of infection between those present in those places, which is what the government of the Kingdom of Saudi Arabia seeks to avoid, especially with the spread of the Corona pandemic. As well as this scientific paper seeks to focus on the benefits of the RFID system especially the process of completing the task quickly and without touching the surfaces. The proposed RFID-based framework consists of a number of components, including RFIDs reader devices distributed across all registered accommodations and ports that are involved in Hajj season. A graph-based data model is also introduced for storing, querying and tracking pilgrims' luggage during their journey in al Hajj season. The widely known Neo4j database system is also utilized as a realization of the proposed conceptual design of the recommended RFID framework.

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Airport Smart Gates System with Face Recognition Technology for Pilgrims

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البوابات الذكية بتقنية فحص الوجه للحجاج

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الملخص

موسم الحج هو أهم موسم لدى جميع المسلمين حيث يأتي الحجاج من جميع أنحاء العالم لأداء هذا الفريضة العظيمة. وقد شكل هذا التدفق والزخم عبئًا كبيرًا على المطارات القريبة من مكة المكرمة ، مثل مطار الملك عبد العزيز في جدة ومطار الأمير محمد بن عبد العزيز في المدينة المنورة. ، وقد أدى هذا الاقبال علي هذين المطارين إلى مزيد من الضغط والعمل لموظفي المطارات كما أدى إلى زيادة مدة الانتظار للحجاج لاستكمال إجراءات الدخول. لذلك فإن أتمتة إجراءات الدخول ستؤدي إلى تقليل وقت الانتظار وزيادة سرعة العمليات الروتينية للإجراءات بشكل كبير. لذا فإن هذه الورقة تهدف بشكل أساسي إلى اقتراح اعتماد البوابات الذكية بتقنية التعرف على الوجه في مطار الملك عبد العزيز بجدة. حيث يتم استخدام وجه الحاج كمعرف بيولوجي مما يسهل ويسرع إجراءات دخول الحجاج. ومن خلال نتائج المحاكاة اتضح أن العملية المقترحة تحسن سرعة الإجراءات بنسبة 80٪ بكل كفاءة وجودة.

Abstract

Hajj season is the most important season for all Muslims where pilgrims come from all over the world to perform this profound ritual. This influx and momentum create a immense burden on airports near Makkah; such as the King Abdelaziz Airport in Jeddah and Prince Muhammad bin Abdelaziz Airport in Medina. The overcrowding, consequently insert an overwhelming pressure on passport checkpoints and exacerbate the waiting time for the completion of the entry procedures for pilgrims. Automating the entry procedures at the checkpoints will surely reduce waiting time and increase the speed of operations significantly. This paper mainly aims to propose the adoption of smart gates with facial recognition technology at King Abdulaziz Airport in Jeddah. In this proposal, the pilgrim face is used as a biometric identifier which will facilitate and expedite the entry procedures for pilgrims. Through simulation results, it has been proven that the proposed process improves the speed of procedures by 80% with all efficiency and quality.

Keywords: Face Recognition, Gates System, Hajj, Smart Airports, Smart Gates.

1. Introduction

Hajj is an essential pillar of the Islamic religion. This ritual has a great importance for all Muslims for which they flock to Makkah annually with the aim of performing the Hajj. In 2019, the number of pilgrims reached nearly to 2.5 million. In addition, one of the main objectives of the Vision 2030 is to increase the capacity of the Hajj season to accommodate 5 million pilgrims. Since the majority of pilgrims arrive in Saudi Arabia by air, it is essential to adopt improvements at airports procedures to acclimate to this surge in the number of arrivals. In recent years, a new term for technologically advanced airports has emerged smart airports. According to [1] the Smart Airport concept is the future of airports operation, and it may dramatically change the industry towards modern technology adaptation. The majority of smart airports are using automatic personal identification technologies based on biometric characteristics in susceptible checkpoints. The more tractable biometric characteristics have been found are facial recognition, fingerprints, hand geometry, handwriting, voice, retinal, and vein [2]. Therefore, airport controls, procedures, and processes may all be improved using biometric scanners to give a more seamless service to passengers. These services eventually improve passenger comfort strengthen security concerns and reducing human mistakes. Considering the large number of pilgrims arriving for a short period such as the Hajj season, the long waiting period for the completion of entry procedures at airports gets one of the biggest obstacles faced by pilgrims and airport officials. The current process in use for pilgrims' entry is based on lengthy, multi-stage and manual procedures. In this research, we make improvements to the process of entering pilgrims in order to speed up the procedures and reduce the waiting time. The proposed business process is mainly based on replacing manual procedures with smart gates that work with facial recognition technology. Through these gates the identity of the pilgrim can be matched personally and automatically as the face of the pilgrim is scanned, recognized and matched with his/her photo in the passport. In the next section, the relevant literature is presented. In the third section, the current process is explained and analyzed in detail. In the fourth section, the proposed process is presented. The simulation results for the two processes and the difference between them in terms of speed are presented in the fifth section, the system has been modeled into a three-dimensional model in the sixth section and the work is concluded with the results and discussion.

1.1. Literature review

In this section the researchers will explain the term facial recognition technology. Then, we will mention some of the applications that use facial recognition. Also, we will manifest a number of studies related to face identification technology at airports. All this information was collected from a number of research papers up to 20 papers.

1.1.1. Facial Recognition

Facial recognition technology (FRT) builds a "template" of the target's facial image and compares it to pictures of previously photographed faces (known). These photographs of the suspects have been discovered in a number of places, including driver's license databases and government identity documents or may be on social media [3].

1.1.2 General Applications of Facial Recognition Technology

The first Application of Facial Recognition Technology is in the attendance field where the current paper/manual attendance system has many challenges. In [4] paper the authors presented an attendance management system based on face recognition technology to get individual attendance of students by using Eigen face method. In another research,

attendance facial recognition system is based on the Raspberry Pi hardware, Python and they used PHP for the website. The accuracy of the system has reached 95% [5]. Another application used in Japan, they use the commercial product NeoFace which uses the Ticket ID System to recognize faces of ticket owners.

The accuracy of this system was 90% [6]. Facenet, due to the Corona pandemic a sophisticated deep network-based facial recognition chosen by [5] as a solution. The accuracy of this system has reached 95.25% of the Yale and to 96% on the ORL databases for both masked and unmasked faces [6]. In another field, to enhance conventional security system, [7] proposed a system using the Raspberry Pi model. The PIR sensor first detects a human presence at the entrance. Then, the recognition result indicates whether or not to open the door. There is a similar method used by [8]. However, they differ in the proposed solution by employing the Local Binary Pattern (LBP) technique. As a result, this method achieved an accuracy of 80%. Furthermore, other research proposed analysis based on LBPH Algorithm. This algorithm turns image to grayscale and separates it into pixels. [9]. The last application in this section is about how to ensure high-level security and to prevent ATM robberies. The accuracy of this system was estimated by 80% [10].

1.1.3. Related Work

In Finland [11], facial recognition systems (FRS) are used in the airport. Where the passenger must glance in the mirror. Then, the camera behind that mirror will take and the technology will compare it with the photo in the passport. In the Netherlands at Schiphol airport [12], data was obtained from real passengers to assess the quality of facial recognition. As a result, the verification rates were greater than 99%, and the False Accept Rate were less than 0.1%. On the other hand, [13] take an overview to comprehend the functionality, security, enjoyment, ease-of-use, usefulness, and intention features of smart entry service (SES), all of these aspects were also researched by [14].

Furthermore, the second study derived a model called structural equation model (SEM) to motivate the user to repeatedly use a biometric security system. While the research papers [15], [16] search about the concept of automated border control (ABC) systems. Both focus on identifying the optimal model that can be used to recognize the face in e-gates. [15] examined the non-idealities of ABC systems and provided two solutions (invariant 2D face recognition system models and face databases). A research was done in Finland with the goal of distributing free boarding passes to first-class travelers. The early findings were 85 %, which did not meet the acceptance rate. However, the results were encouraging [17].

From Egypt [18] discuss and analyze the smart technologies that were introduced at Cairo International Airport. It was a qualitative research paper. Another study looked at the issue of re-authenticating travelers at several checkpoints. This paper offered a method for automating re-authentication by segmenting faces and clothes, then combining and matching their features [19]. In order to enhance China's airport security checkpoints' manual security, identity verification procedure. [20] Presented a two-step procedure.

First, self-service centralized passenger identification and boarding pass verification. The result shows that a portion of the manual verification can be replaced by the intelligent verification system. In [21] paper discussed the user's distrust of e-gates. The researchers recommend that before focusing on the traveler's bodily attributes, work to establish a trust link between the traveler's passport and document reader.

2. Methodology (Materials and methods)

2.1. The current procedure of the outsider pilgrims at international airport in Saudi Arabia

The journey of receiving pilgrims begins with the plane landing either at King Abdelaziz International Airport (KAIA) in Jeddah or at King Muhammad bin Abdelaziz International Airport in Madinah. Due to the large number of the pilgrims' landing at King Abdulaziz International Airport in Jeddah, this research has focused on explaining the process at this airport. All pilgrims should be processed at the Hajj and Umrah Terminal. The pilgrims' Terminal at King Abdulaziz International Airport in Jeddah is considered as one of the largest airport terminals around the world, with an estimated area of about 5 million square feet (465,000 m²) and a capacity for about 50,000 pilgrims. It includes about 200 passport stamping platforms operated by thousands of employees from dozens of government sectors.

2.1.1 The entry procedures for outsider pilgrims to Saudi Arabia (as is)

The entry procedures for pilgrims to enter the Kingdom of Saudi Arabia begins with filling out the pilgrim card, which must be clearly and accurately filled followed by standing in a long queue in front of the passport control. Upon reaching the passport officer, the pilgrim performs several procedures, which are: handing over the passport and the pilgrim card, check and retrieve the information from NIC (National Information System), matching the fingerprints of his four fingers to each of his right and left hands, then matching the fingerprints of the two thumbs together, then looking at the camera to take a photograph of the pilgrim then save them into NIC. Thus, the pilgrim finished the entry procedures and heads to the baggage claim area and completes the series of procedures. In this project, we chose the process of entering the pilgrims into the Kingdom of Saudi Arabia, using the Bizagi program. Then we will analyze, design, and test it to improve the process of entering the pilgrims by making it faster and easier. Figure 1 shows the as - is process of entry procedures for outsider pilgrims to the Kingdom of Saudi Arabia.

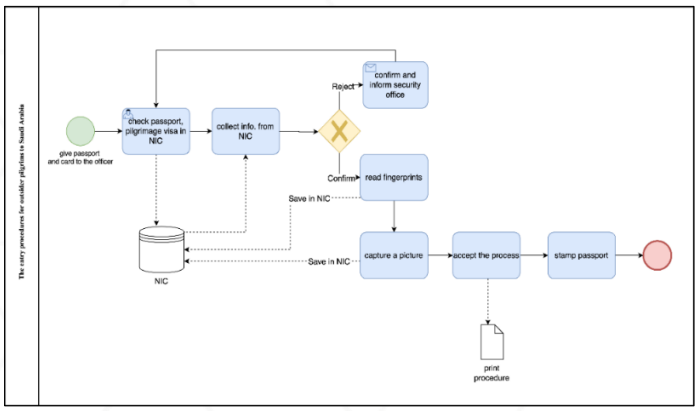

Figure 1. The entry procedure for outsider pilgrims process as-is model

2.2 As-is business process analysis

The as-is model is analyzed to understand the processes and enhance the efficiency and effectiveness of its operations. Two techniques are used to capture and record manual processes, locate the causes of delays, identify opportunities for improvement, and analyze the actions of pilgrims and passport staff.

2.2.1 Value-Added analysis of the business process

The first technique is value-added analysis, which examines individual process steps to separate those that add value to the user from those that do not. Table 1 demonstrates our qualitative analysis of the entry procedures for outsider pilgrims to Saudi Arabia. Where abbreviations in classification column refer to: Value-adding (VA), Business value-adding (BVA) and Non-value-adding (NVA).

Table 1. Value-Added analysis of the current business process

Step	Performer	Classification
Get the pilgrim identification document (passport and visa)	Passport Officer	VA
Check identification document information		BVA
Collect pilgrim information from NIC		VA
Accord identification document information with the existed information from NIC		VA
Terminate the procedure and direct the pilgrim to the terminal officer if the information does not match.		NVA
Read fingerprints if the information matches		VA
Capture a photo of the pilgrim		VA
Accept the process and print the end of procedure verification		VA
stamp passport		BVA

2.2.2 Quantitative Analysis of the business process:

The second technique is a quantitative analysis applied to strengthen our mathematical vision of the system by presenting a numerical value of the processes for outsider pilgrims. Table 2 displays the processing and waiting time of the activities in the current procedure of entering the pilgrims into the Kingdom of Saudi Arabia.

Table 2. The quantitative analysis of the current business process

Activities	Waiting time	Processing time
Check the pilgrim's passport and visa in NIC	22.5 sec	45 sec
Collect information from NIC	3 sec	6 sec
Accord passport information with NIC information	45 sec	90 sec
Read fingerprints of pilgrim	90 sec	180 sec
Capture a photo of pilgrim	60 sec	120 sec
Accept the process	2.5 sec	5 sec
stamp passport	10 sec	20 sec

- Cycle Time (CT) = 45 +6+ 90+ (180* 0.95) + (0*0.05) +120+5+ 20= 457 sec
- Processing Time = 22.5 +3+ 45+ (90* 0.95) + (0*0.05) +60+2.5+10= 228.5 sec
- Cycle Time Efficiency = Theoretical Cycle Time / CT = 228.5 /457= 0.5 sec

2.3 Redesigning the business process of the entry procedure for outsider pilgrims to the of Saudi Arabia

2.3.1 Challenges of the current model

The challenges of the current situation include problems with manual operations and errors in the recognition of pilgrims' fingerprints, which lead to delays in walking and duplication of effort for staff and pilgrims themselves. The overall process of entering pilgrims is still very long, owing to slow passport checkpoint procedures. Improving and speeding up processes in passport management will improve procedures in general.

2.3.2 To - be business process model

This paper presented a smart gate to assist pilgrims in entering and verifying their data and pilgrimage visas. The process starts with scanning the pilgrim's passport and pilgrimage visa, checking the validation of information in NIC. If the verification succeeds, match the pilgrim's face in front of the camera with the scanned face in the passport. If not matched, a pilgrim will be directed to the security office. Then after verification of identity, a picture of the pilgrim's face will be captured and the gate will open. Finally, the officer will stamp the passport. Figure 2 shows the redesigned process of the entry procedures for outsider/international pilgrims to Saudi Arabia.

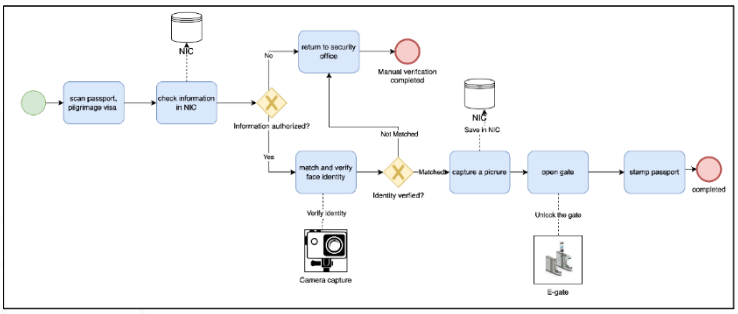

Figure 2. To-be model of the entry procedure for outsider pilgrim's process

2.4 Simulation

The simulation process was performed using Bizagi studio for both as-is and to-be models. The results showed the time analysis for both models with the average time spent in the process. The average time estimated for the as-is model is 6m 25s and 1m 25s for the to-be model. Figure 3 shows the simulation of the as-is model and presents the time analysis of the as-is process. Simulation process of the redesign business process using face recognition and smart gate for the time analysis of the to-be process in Bizagi shows an average time estimate of 1m 25s.

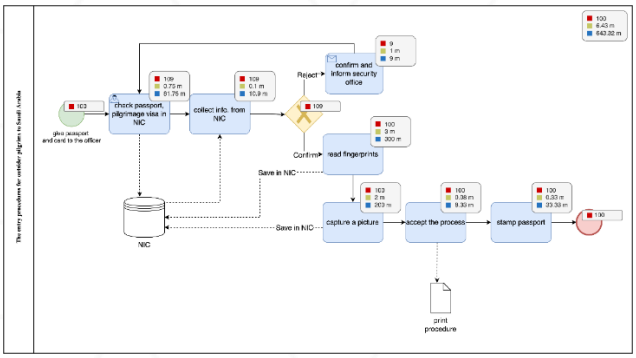

Figure 3. Simulated the as is process and the time analysis of the as-is process

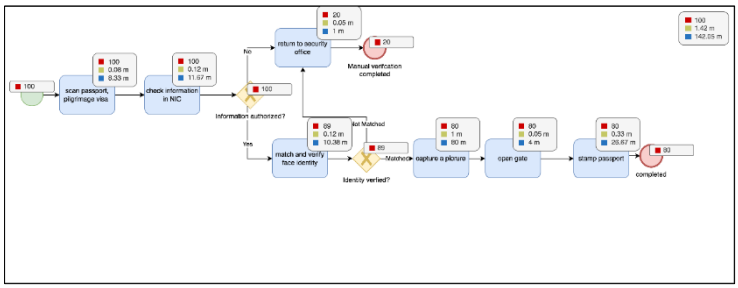

Figure 4. Simulated the to be process and the time analysis of the to-be process

2.5 Modeling

The proposed solution has been modeled into a 3D model using clara.io website to get a clear visualization. As shown in Figure 5, the model suggests the presence of two smart gates, with a traditional passport control gate in the middle. In the case of a technological failure or verification error, the traditional gate in the middle will service the two smart gates. However, the smart gates are in charge of all entry processes and identity verification for pilgrims.

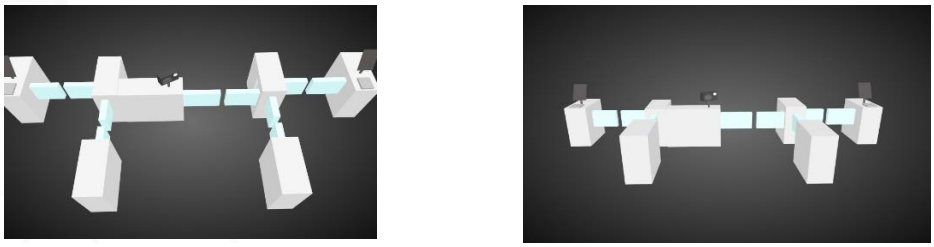

Figure 5. 3D model of the proposed solution

2.5.1 The possible scenarios at gates

Figure 6 describes the first possibility when the identity of the pilgrim is verified without any errors, so the gate is open and the pilgrim is allowed to cross, the second possibility is when the identity is not verified, the pilgrim is transferred to the traditional gate to be verified manually and the last possibility is when there is a technical error in the smart gate, the pilgrims are transferred to the traditional gate directly.

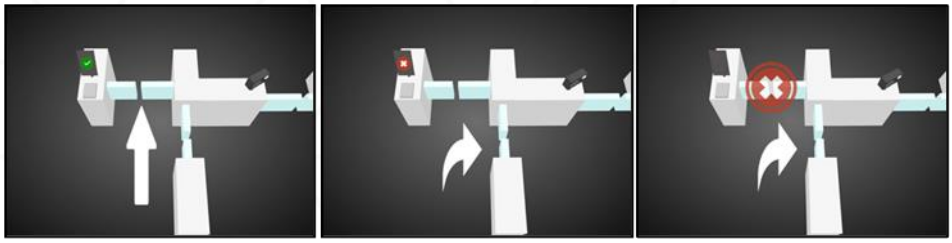

Figure 6. The possible scenarios

3. Results and Discussion

The output from the simulation shows that the improvements implemented in the redesign phase helped achieve an incredible speed of the procedure. The addition of facial recognition technology has transformed long and tedious manual

processes into a quick procedure that does not exceed two minutes to complete. The average time for the current process was 6 minutes and 25 seconds, while the average time for the proposed process was only 1 minute and 25 seconds. By applying the percentage equation below:

Percentage = (x - y) / x *100

Where:

x: Current Average Time y: Proposed Average Time

We found that the improvement percentage in terms of time compared to the current process is 80%. These changes will be reflected in the level of pilgrims' satisfaction and the efficiency of the system.

4. Conclusions

This paper studies the current business process of pilgrims entering the Kingdom of Saudi Arabia through the Hajj ports at the airports and proposed improvements that can be applied to it. The proposed (to–be) aims to replace all procedures for entering pilgrims, that are done manually, with smart gates at the airport with face recognition technology. We can conclude that using the smarts gates with a face recognition system will help manage and speed up the process. The outcomes of implementing the proposed (to-be) model in Bizagi demonstrated significant improvement in terms of time compared to the current process by 80%.

5. Recommendations

As described throughout the results of this paper; we recommend the adoption of smart gates with face recognition technology at King Abdulaziz Airport in Jeddah. In this proposal, the pilgrim face is used as a biometric identifier which will facilitate and expedite the entry procedures for pilgrims.

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Digital Transformation in Hajj Crowd Management

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التحول الرقمي في إدارة الحشود للحج

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الملخص

يعتبر الحج من التحديات اللوجستية الكبرى التى تواجه المملكة و التى فى نفس الوقت تطمح للتوسع في إتاحة الفرصة للمزيد من المسلمين كل عام لاداء هذه الفريضة. فبدون استخدام التقنيات الحديثة تعتبر هذه المهمة من المستحيلات حيث أصبح التحول الرقمي فى مراحل التخطيط و التشغيل و المراقبة من الضروريات. فى هذه الورقة يلخص فريق البحث مخرجات مسح ادبي قام به لتلخيص تجارب استخدام التقنيات الحديثة مثل الرؤية بالحاسب و الاتصالات اللاسلكية الحديثة و الحوسبة المكانية و تقنيات الواقع الافتراضى و تحليل البيانات الضخمة, و المحاكاة و النمذجة و التطبيقات الذكية المستخدمة و المقترحة فى إدارة الحشود داخل منظومة الحج. كما تهدف الورقة إلى إظهار و عرض التقنيات الحديثة التى من الممكن أن تساعد متخذى القرار و المحتصين فى إدارة الحشود من جعل حركة الحشود فى الحج أكثر أمانا و كفاءة لتحقيق رؤية المملكة 2030 باستضافة المزيد من الحجاج و المعتمرين.

الكلمات الدالة: التحول الرقمي، النمذجة والمحاكاة، التقنيات المتقدمة، الرؤية بالحاسب، إدارة الحشود، سلامة الحشود.

Abstract

Hajj is a significant logistical challenge for Hajj organizers in Saudi Arabia. At the same time, the government is planning to expand the pilgrimage opportunity to even more Muslims. Indeed, without the use of advanced technologies, this mission might be impossible to achieve. The digital transformation for Hajj's planning, operational, monitoring, and analysis phases has become a necessity. This paper summaries the existing technology usage in Hajj Crowd Management. The researchers surveyed scientific articles discussing the implementation or suggestions of different technologies, including Computer Vision, Advanced Wireless Networking, Spatial Computing, Immersive Technologies, Big Data Analytics, Simulation and Modeling, Social Media Analytics, and Mobile Applications that can be useful for digital transformation in crowd management during Hajj. This paper aims to present all the work from different technologies

to increase the awareness of technology to authorities and decision-makers and improve Hajj's safety and efficiency to eventually achieve Saudi Arabia's vision 2030.

Keywords: Digital transformation, Modelling and Simulation, Technologies, Computer Vision, Crowd Management, Safety

1. Introduction

The religion of Islam has five main pillars, the fifth of which is a pilgrimage, or Hajj. Hajj entails a visit by Muslim pilgrims to Makkah, the holy city, during the month of Zulhijah. Hajj pilgrims are required to perform several religious rituals with certain constraints regarding space and time. While there may be some relaxation in the time constraints, the rituals must be performed between the eighth and twelfth day of Zulhijah. Further, the rituals are mandated to take place at five sacred sites, which are mapped out in Figure 1.

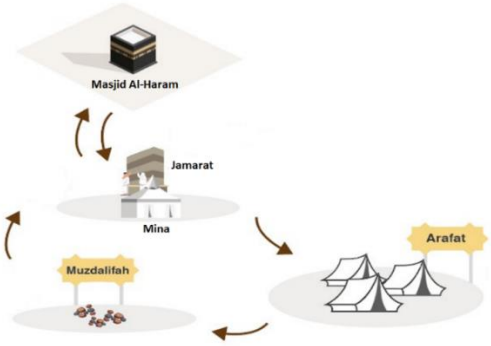


FIGURE 1. Places Used in Hajj: Masjid Al Haram, Mina, Muzdalifah, Arafat, and Jamarat.

Naturally, Hajj attracts a massive number of people from all over the world every year. Most of the pilgrims are first-time guests of the city and require direct guidance to fulfill the space and time requirements of the rituals. The primary responsibility for the organizing, implementing, and managing of Hajj lies with the Ministry of Hajj and Umrah, with support from local administration and private coordinators. The Ministry strives to make the pilgrims' arrival, stay, and departure as smooth and comfortable as possible. Given that the crowd of visitors is both massive and heterogenous, the management of such event is incredibly challenging[1][2][3].

To make Spatio-temporal rituals of Hajj smooth where millions of pilgrims need to move from one place to another within the given time, organizers are constantly in search of improved techniques and solutions for crowd control. Inventive strategies are advanced and adopted every year, which make use of modern technological developments. The purpose of this submission is to provide a review of the various areas of technology used for managing the event of Hajj and catering to the significantly large crowd of visitors. The technological areas are classified into Wireless, Computer Vision, Spatial Computing, Immersive Technologies, Mobile Application, Social Media, Big Data Analytics, Simulation, and Crowd Modelling that can be valuable to adapt digital transformation in crowd management. The paper also reviews the result of the work that has been successfully implemented in Hajj. Moreover, the paper provides a discussion and recommendation on the various aspects of the technologies discussed.

2. Taxonomy

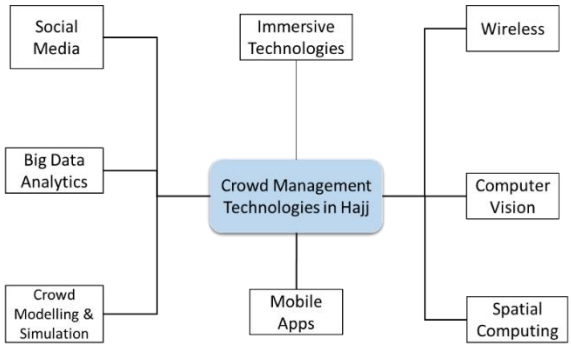


FIGURE 2. Taxonomy of Technologies used for Hajj

The following are the classification of the areas of technology that are utilized for managing the crowd during the Hajj event. Figure 2 elucidates the taxonomy of the various technologies used during Hajj.

a) **Immersive Technologies** create a virtual world that mimics the real world through devices that can be worn in the form of virtual, augmented, or mixed reality.

b) **Wireless Technology** enables devices to be connected for data transfer over a platform without any physical connection. Such technologies include Wireless Fidelity (Wi-Fi), Bluetooth Low Energy (BLE), and Radio Frequency Identification (RFID). RFID can be used in various services like tracking, medical care, transportation, etc.

c) **Computer Vision** uses artificial intelligence to process visual data in the form of videos and images of crowds.

d) **Spatial Computing** deals with scheduling visitors' movements and evacuation procedures in the case of an emergency. It is particularly used in Mina, which houses over 3 million guests for the week of Hajj.

e) **Social Media** platforms are used both by pilgrims to share their experiences during the pilgrimage and by the coordinators to circulate important information about the event.

f) **Mobile Applications** offer various services pertaining to Hajj. The most popular apps in this context are discussed in the next section

g) **Big Data Analytics** deals with the storage and processing of vast volumes of data, which are generated during the Hajj pilgrimage.

h) **Crowd Modelling and Simulation** entail the simulation of the motions observed in the large masses of people and vehicles that gather during Hajj to fully comprehend the trends and tendencies and in turn, be able to predict the future flow of the crowds or traffic [4].

3. Recent Technologies in Hajj

The papers presented in this article worked steadily to support the different phases of Hajj through the implementation of technological advancements in the areas highlighted in the preceding section. Like any other event, the annual event of Hajj can also be split into three phases, as shown in Figure 3.

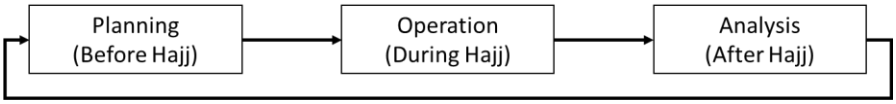


FIGURE 3: Three Phases of Hajj Events

A. Planning Phase

The planning phase generally takes place before the event where authorities do the planning of the event such as camp assignment, scheduling of pilgrims movement, allowed roads for transportation, evacuation. The planning phase work has focused on spatial Computing, big data analytics, crowd modeling and simulation, and wireless technologies.

A1 Spatial Computing

In collaboration with the Ministry of Hajj and Umrah, the authors formulated a scheduling algorithm called Tafweej. This step was intended to help pilgrims move between the sacred areas of Mecca (via trains between Mina, Muzdalifah, and Arafat and walking between Mina and Jamarat). This algorithm, which has been used in Hajj for the last three years, takes into account various factors like the capacity of trains, stations, and roads, train timings and routes, together with camp locations at the start and end of the journey [5]. Fig 3a shows the output of the crowd scheduling algorithm of Al-Shobian road between Mina and Jamarat for days 9,10, 11, 12, and 13, along with the usage and road's capacity.

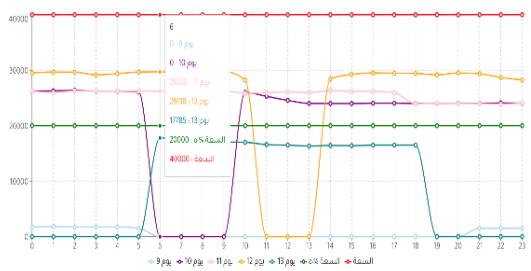
The proposal of Felemban et al. [6] was implemented in 2019 and revolved around train movement in Mashaer sites. It optimized the transportation of pilgrims by enabling the planning of movement to align with train schedules, capacity, station location, camp-to-station transport, and other factors. Fig 3b shows the analysis of the train scheduling algorithm between Arafat and Muzdalifah of Arafat Station 1, showing the number of pilgrims scheduled per hour.

Emad et al. [7] addressed the issue of planning for evacuation through multimodal transportation, as well as the comprehensive tracking of bus services during Hajj by migrating the GPS data of buses to a Cassandra cluster (a NoSQL DBMS) for better scalability and efficiency. Presto was availed for big data aggregation to run distributed SQL analytical queries on HDFS. Fig 3c shows big data architecture designed to store, index, and analyze GPS data of 20000 buses.

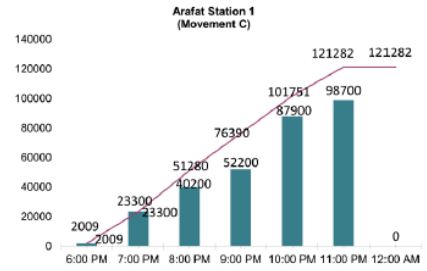
A Spatio-Temporal Service Model was proposed by Bilal et al. [8] and was tested to identify and predict anomalies in crowd movement. This framework compares real-time data about crowd mobility with past data to identify safe paths and exits and flag any deviations.

The Crowd-separated Allocation of Routes, Exits, and Shelters (CARES) approach was presented by Yang et al. [9], which allocates different evacuation routes and destination shelters to different groups of pilgrims and prevents collision among groups traveling in opposite directions. It is a much faster and safer evacuation design than the current approach of evacuation to the nearest exit or shelter (NES). Fig 3d shows the evacuation work to be in the state of preparedness in case of any disaster.

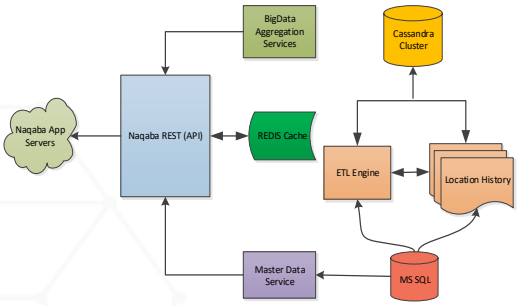
The system allows the selection of the evacuation area, shelter area, and the number of evacuees, and it shows the total time and path to evacuate them.



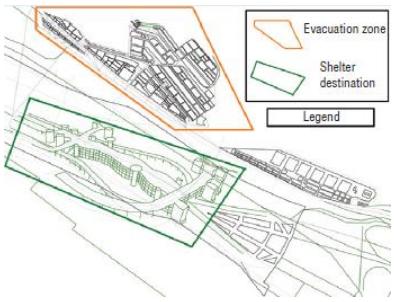
a) The output of the Crowd Scheduling between Mina- Jamarat



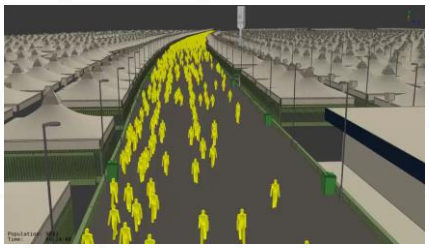
b) Number of pilgrims per hour in Arafat Station 1



c) High-level architecture of Big Data Platform for Naqaba



d) Evacuation zone and shelter destination (Jamarat complex) in area of interests



e) Crowd Simulation of Mina Area

f) Knowledge Evaluation Tool

FIGURE 3: Technologies used in Hajj in Planning Phase: a) shows the analysis of the schedule Mina – Jamarata, b) Train Scheduling comparison between actual and schedule number of pilgrims per hour of Arafat Station 1 (Movement C), c) high-level overview of big data framework to analyze bus data, d) interface of the evacuation work to evacuate the pilgrims from Mina camps, e) Crowd Simulation of Mina Area and f) Knowledge evaluation tool to evaluate crowd managers. Emad et al. [10] presented a low-cost framework to build a 3D model of Mina, Makkah using sensors and multiple technologies. The proposed infrastructure can be used for digital twin in the upcoming Hajj to monitor the output of multiple sensors such as crowd flow and temperature.

A2 Big Data

Faizan et al. also devised a system in which the Amazon EC2 server is used to manage multimedia content and routing services [11], [12], [13], and vast volumes of geographically tagged multimedia content are stored permanently in the Amazon S3 database. Such data are assembled from smartphones, social media platforms, vehicle sensors, PostgreSQL

with PostGIS as space-time and relational databases, and DynamoDB as NoSQL data. Expired sessions of personal diaries and historical app usage data are stored on DynamoDB.

A3 Crowd Modelling and Simulation

Rahman et al. [14] presented a GPU-based model to steer agents along correct paths while avoiding obstacles during the performance of Hajj rituals. CPUs are not equipped to graphically render such a vast number of agents quickly and hence slow down the simulation. This makes the use of GPU in such simulations advantageous.

Emad et al.[15] offered several scenario simulations on ~~the~~ crowd flow at Mina and Masjid Al-Haram, which would enable the organizers to determine the highest volume of pilgrims who can simultaneously perform the rites with safety and efficiency. Fig 3e shows the simulation of pilgrims in Mina street 204 based on the output of the scheduled data.

A4 Wireless

A Priority-based Routing Framework for Flying Adhoc Networks (PRoFFAN) [16] was proposed by Emad et al. to quickly deliver crucial multimedia data from the UAV to control centres by reducing the response time of the FANET application. This framework is intended to improve crowd management and ensure a smooth and safe flow of the crowd.

A5 Knowledge Management

Emad et al. [17] develop a tool that can train and evaluate crowd managers to gain mindset, skillset, and toolset to understand the crowd's flow and help them make decisions in real-life crowd scenarios. Fig 3f shows the result of the tool that is used to train and evaluate crowd managers.

B. Operation Phase

The operation phase is during the actual event, i.e. 8th -12th Zulhijah. In this phase, the work focuses on mobile app development, immersive technology, social media, spatial computing, big data analytics, and computer vision.

B1 Mobile Applications and Immersive Technology

The app introduced by Ahmad et al. [18] relies on GPS to display various types of audio-visual, image, and text content shared in the past by other pilgrims regarding a particular site as the user enters that site. This app educates pilgrims about the religious significance of each area they visit and keeps them well-informed. The Perform Hajj and Umrah app developed by Ahmad et al. [1] [2] offers pilgrims several services based on their location, including navigation to the desired area, guidance about the area they are currently in, a Hajj messenger facility, lost and found services, and a function that tells them whether they are inside or outside the boundaries of the holy site where they need to perform a ritual. The following apps have been developed to facilitate the carious stakeholders of Hajj:

- Perform Hajj and Umrah [1][2], used in Hajj 2014, Smart Hajj, used in 2015
- Manasikana, used in 2016-21[6]
- Tafweej, used in 2019-21[7]

[6] https://play.google.com/store/apps/details?id=com.hajj.manasikana&hl=en&gl=US

[7] https://play.google.com/store/apps/details?id=com.tafweejapp

These apps provide a multitude of services, including information about sacred sites, navigation, weather prediction, prayer times and qibla finder, tracking of friends, and many other types of guidance about Hajj.

Figure 4 a-c shows the screenshot of the mobile applications developed for pilgrims and group leaders. Fig 4a is the screenshot of the Manasikana mobile application, and it is now the official application of the Ministry of Hajj and Umrah. Fig 4b is the screen of the Smart Hajj application that was developed in 2015. Along with a mobile application for pilgrim's relatives and friends. Fig 4c is the screenshot of the Tafweej mobile application given to every group leader to monitor their movement during Hajj.

a) Manasikana Mobile App

b) Smart Hajj Mobile App

c) Tafweej Mobile App

FIGURE4: Technologies used in Hajj in Operation Phase: a) Manasikana App- Official App of Ministry of Haj and Umrah, Saudi Arabia, b) Smart Hajj App developed by GIS TIC Center, Umm Al-Qura and c) Tafweej App developed by Tafweej Unit, Ministry of Haj and Umrah, Saudi Arabia.

Yet another app, by Faizan et al. [11], uses a cloud-based multimedia routing application to track visitors through their phone GPS and offer them guidance through multimedia content as they navigate to their destination. Fig 5a shows the screenshot of the multimedia routing application that visualizes live events from the point of interest.

Another app designed by Faizan et al. [19] aids visitors in identifying the most optimum path to arrive at a particular site to perform a ritual. A data collection framework is used, which lets users upload details of any accidents or obstacles that they are aware of on the various routes. Using this uploaded information, the app calculates the smoothest and quickest way to get from one location to another in Makkah during Hajj.

B2 Social Media

The pilgrims constantly update their social media with their varied Hajj experiences through text and photos. They also communicate directly with their friends and family through these platforms. Hajj authorities also use social media groups and pages to make announcements regarding Hajj events. Social media has thus become a crucial source of live information regarding Hajj.

The Hajj Geo-Social Network (HGSN) developed by Akhlaq [20] is very helpful in disseminating useful information among the heterogeneous crowd of Hajj pilgrims. This network uses the graph theory to mobilize the social media data of pilgrims with many connections or with a high grasp of the language. The linguistically diverse subnets of HGSN are bridged using a second network layer of the multilingual hub. By tracking pilgrims with a high linguistic capacity, information can be quickly spread through the network. A data collection structure formulated by Ahmad et al. [21] substantiates the quality of mobile app sensory data about various Hajj activities, merges it with the personal information and content of individual pilgrims as uploaded on different social media platforms, and provides a messenger service for Hajj pilgrims to blog about and discuss their experiences.

The structure calibrates the information according to the context of each user and supports them with tailored services. Bilal et al. [22] addressed the need to coordinate shared transport by introducing a social network platform that links people belonging to a Community of Common Interest (CoCI). The application allows users to group for shared intra-city transportation with the aid of multimedia content. This network was debuted in Hajj 2015 and enabled users to form groups to avail shared transport within Mecca.

B3 Spatial Computing

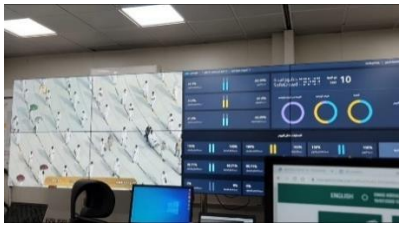
An event as massive as Hajj will have unpredictable and uncontrollable factors, which means that schedules cannot be immutable. The solution given by Faizan et al. [23], used in 2019, enabled local authorities to request changes in the original schedule through an interactive algorithm that processed such requisitions and promptly generated a fresh schedule to suit the new circumstances. The solution was particularly effective in ensuring the smooth course of the stoning ritual at Jamarat. Fig 5b shows the interface of the rescheduling tool that shows the current capacity of the road, and it can be used to reschedule the group in case of emergencies such as heavy rain or any other condition.

B4 Big Data

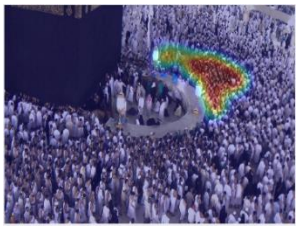
Of the millions of pilgrims attending Hajj every year, a significant proportion uses smartphones or other devices to stay connected to each other, communicate with the world, and access various services. An enormous amount of data are generated from this Internet of Things (IoT) platform, which needs to be analyzed to comprehend individual and group behavior tendencies, which would support organizers in event and crowd management.

a) Multimedia Routing to see live multimedia updates along with navigation.

b) Rescheduling after selection of fauj to change the time based on preferences.



c) Multi-Level Dashboard to Monitor Mobility Progress during Hajj 1441-2020



d) shows the congested regions in Mataf during Tawaf

FIGURE 5: Technologies used in Hajj in **Operation Phase** for Monitoring: a) Screenshot of Dashboard used in Ministry of Haj and Umrah, b) Congestion Detection in Mataf, and c) Rescheduling and Monitoring of crowd schedule and d) multimedia routing to see live updates with navigation.

In collaboration with the relevant Ministry, Felemban et al. [24] formulated a dashboard to coordinate the movement of pilgrims to and from the various sacred sites. The framework gathers data from two-way radio communications and a mobile app used by group leaders to input arrival and departure times. This dashboard was implemented in Hajj 2020 and proved to be very useful in coordinating pilgrims' movement to ensure a smooth flow[24]. Fig 5c shows the dashboard of the Ministry control room that shows the live movement of groups movement in Hajj.

The Amazon EC2 server [25] is utilized to store huge volumes of multimedia/sensory data collected from smartphones and vehicle sensors, along with the Hadoop Distributed File System (HDFS) as a NoSQL database accompanied by in-memory and relational databases.

To address the requests of users to arrange for shared transportation or locate specific group members in the crowd, the system utilizes Spatial Hadoop, Apache Geode, and Postgres as NoSQL in-memory and relational DBMS.

As per the proposal of Ahmad et al. [2], [26], a cloud-based server using Amazon EC2 server is used to process sensory data from the smartphones of visitors, Amazon S3 is used to store big data that has been analyzed, PostgreSQL database is used to store space-related data of the user or places of interest near the user, and the NoSQL database DynamoDB is used to store and recover any volume of data through the Map-Reduce approach. The Amazon S3 data is mainly used to address Hajj-related transactional and analytical queries.

Shahbaz et al. [27] designed a solution that uses RabbitMQ Server to store and recover data gathered from wearable devices used by pilgrims. For in-memory data storage and indexing, this solution used Elasticsear; for historical data storage, it used MongoDB, and for archiving, it used HDFS. The intent was to use geo-clustering visualization to generate a map of crowd movements.

B5 Computer Vision

A system designed by Emad et al. and Sultan et al. [28][29] has been proven to accurately identify Masjid al-Haram's overcrowding. The system splits videos of crowd movement in the area into several overlapping fragments of the same period. Trajectories are extracted via the particle advection approach from each video fragment. Oscillation maps from

these trajectories help to detect areas where overcrowding is potentially becoming critical. Fig 5d displays the work to detect congestion in Mataf using computer vision techniques.

C. Analysis

In the analysis phase, i.e, after the event to prepare the report or to take the feedback. The analysis phase is to analyze the event and gather the information that can use to improve upcoming events. The author used a web-based portal to consolidate the feedback from group leaders about the scheduling survey in Hajj 2019 and 2021[8]. Fig 6 shows the comparison of schedule and actual group movement between Mina and Arafat. They analyzed Hajj's movement based on zones and companies and identified the groups that didn't follow the schedules.

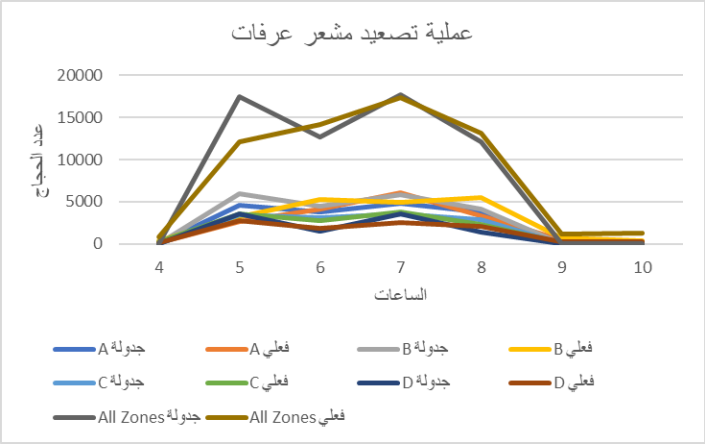


FIGURE 6: Analysis of Schedule and Actual movement for different zones between Mina-Arafat in Hajj 1442

4. Summary of Additional Research Work in Hajj

This section provides a summary of the various technologies for crowd management that have been put forward during Hajj events in previous years, following the taxonomy set out in section-2.

Technology	Description	Reference
Spatial Computing	The authors suggested the use of a decision support framework in the form of a scheduling tool and a real-time video-based counting system	Haase et al. [30]
Spatial Computing	Authors came up with a web-based system that used GPS and GIS to enable authorities to monitor the pedestrian movement during the Tawaf ritual and take the correct decisions to prevent congestion in the area using information collected and processed by the system	Koshak et al. [31]
Spatial Computing	A scheduling model was proposed [8] that addressed various space, time, and religious constraints to resolve congestion issues in Hajj transportation.	Charnes et al. [32]
Crowd Modelling and Simulation	Prof G. Keith modeled crowd dynamics on large public assemblies in complex spaces, particularly for the Jamarat bridge	Keith Still [33]
Crowd Modelling and Simulation	The cellular automata discrete system was designed using a microsimulation model with the comprehensive portrayal of individual agents for the Mataf area.	Abdelghany et al. [34]

[8] https://tafweej.haj.gov.sa/

Crowd Modelling and Simulation	Build a model for the crowd dynamics during Tawaf using the simulation software SimWalk to ease the congestion.	Zainuddin et al. [35] and Sarmady et al. [36].
Crowd Modelling and Simulation	The authors applied queue theory to create a crowd and traffic mobility simulation, which was later used in trials for solutions regarding machine-assisted movements for mobility-impaired visitors.	Tunasar [37]
Crowd Modelling and Simulation	Proposed a high-density crowd model that represents agents with diverse ages, gender, and behavioral characteristics. Also presented the Right of Way model, which considers asymmetric rather than symmetric interactions between agents in large crowds	Curtis et al. [38][39].
Crowd Modelling and Simulation	The authors formulated a model designed on agent proxemics, i.e. the effect of agents' personal space on crowd dynamics.	Manenti et al. [40]
Crowd Modelling and Simulation	Proposed an improved queue system for Tawaf by considering the effect of density and service speed on the crowd flow at Masjid Al-Haram through a four-factor full factorial experiment and improved service time in the model significantly.	Haghighati et al. [41]
Immersive Technologies	To prepare the pilgrims' for the Hajj[9] experience, the concept of a game-like experiencing the pilgrimage in cyberspace through a VR simulator is being introduced, which would offer training as well as information to new pilgrims, particularly about the performances of the Tawaf and Umrah rituals [24].	D. Schlosser [42]
Immersive Technologies	Other Applications offer true-to-life VR excursions to sacred sites, as well as guidance.	like Muslim 3D [43], Labbaik [44], & [45][46]
Immersive Technologies	Pilgrims who used the VR-based Hajj mobile app developed by the authors gave very positive feedback regarding the experience and help.	Nassr et al. [47]
Immersive Technologies	To navigate Hajj, be contacted by the organizers and get other types of guidance on demand.	A. Owaidah [48][49]
Immersive Technologies	Introduced an app that offers pilgrims real-time views and descriptions of the sites they are interested in.	Taileb et al. [50]
Immersive Technologies	It helps pilgrims to identify, locate, and learn about various holy sites in Mecca, and even offers guidance regarding ritual performance.	Hajj AR[10]
Immersive Technologies	Al Jazeera has an AR-based guidance segment that gives pilgrims detailed information in on-screen text floating above the sacred site when the device camera is pointed towards it.	Al Jazeera [51]
Mobile Applications	It would be no exaggeration to say that almost every aspect of a pilgrim's Hajj experience is supported by some mobile app or others in many languages. Whether it be currency conversion, prayer timings, and Qibla, translation to and from Arabic, ritual instructions, weather predictions, or navigation to places of interest, pilgrims can find an app to help them. These apps are designed to use mobile phone sensors to collect the user's data, which are then processed to be helped in the required manner. They contribute greatly in resolving the challenges faced by Hajj pilgrims individually and as a crowd.	[45] [52] [53] [54] [55].
Wireless Technology	Enables users to interact with each other using their mobile devices to support crowd management by gathering sensory data	Mohamed et al. [56]
Wireless Technology	Proposed another efficient IoT system for crowd management that can forecast potential obstacles through route monitoring	Nasser et al. [57]

[9] https://www.arabnews.com/node/1536656/saudi-arabia

[10] http://ipay.mobily.com.sa/store/web/portalone/Hajj+AR?mid=8861820519

Wireless Technology	The authors formulated another IoT framework for avoiding overcrowding and possible stampede scenario.	Islam et al. [58]
Wireless Technology	Stampede prediction and prevention, using proof and deployment simulation. Multiple IoT firms have introduced several novel products and solutions using LTE-M or NB-IoT connectivity, which has the scalability to allow many devices to be deployed at once in congested areas while creating no performance or connectivity issues [51][52].	Yamin et al. [59]
Computer Vision	The computer vision techniques can be used to calculate the number of pilgrims in a certain congested area like Mataaf, using a series of photographs	B. Yogameena [60]
Computer Vision	Extracted still images from videos of crowds moving through the Haram area, from which information regarding crowd density and direction could be processed	Saqib et al. [61]
Computer Vision	A framework that could process video frames, remove the background, and calculate with 95% accuracy the number of people where Sultan et al. [56] estimates the density of the crowd, identifying congestions, and recognizing patterns in crowd movement	Arif et al. [62] and Sultab et al. [63]
Computer Vision	The system used background removal and edge detection tools to separate foreground features, which were then corrected for perspective distortion through pixel size normalization.	Hussain et al. [64]

5. Discussion

Based on the experience of past Hajj events and the existing studies on crowd management at Hajj, the researchers have classified the entire Hajj event into three phases, as shown in Figure 2. Figures 3, 4, 5, and 6 show the output of some of the work done in Hajj's planning, operation, and analysis phase. The researchers found that most of the successfully implemented works are done in Saudi Arabia compared to other counties where it is primarily theoretical except for mobile applications.

Saudi authorities are making a great effort to make the Hajj smooth, but things can be improved further using advanced technology and scientific methods. There is still a big gap between the technology provider and actual needs, such as a situational-awareness dashboard required to monitor the crowd analytics using computer vision in real-time and predict the hazardous situations. There is also a lack of research or scientific content for local hajj crowd management. Moreover, there must be training and reliable tools to evaluate the crowd managers using advanced technology.

Most of the research has mainly focused on the planning and operation phase compared to the analysis phase. In this era of data analysis, the researchers recommend focusing on the analysis phase that helps to analyze the data of previous Hajj such as bus movement data and pilgrims' movement data to identify the bottleneck and shortage. This type of analysis helps to improve the upcoming Hajj events and detects the camps where authorities can safely increase the number of pilgrims in Mashaer as per vision 2030.

Conclusion and Future Works

It is an enormous challenge to manage the millions of pilgrims from diverse backgrounds who visit Makkah every year for Hajj purpose. The heterogeneity of the visitors makes it essential to have adaptive services to smoothen the process of Hajj ritual performance. The organizers are supported in this daunting task by researchers who are investigating modern methods and technologies to improve the Hajj experience for pilgrims. In this paper, the researchers provide a list of the modern technologies and solutions used during past Hajj events for maximizing and securing the safety of pilgrims. While

the solutions provided by advanced technologies have proved effective in greatly facilitating digital transformation in crowd management, the researchers suggest that added effective technology like Data Analysis, Advanced Simulation, Metaverse, and Artificial Intelligence should be integrated with the Hajj organization. The data analysis techniques can be beneficial to identify the shortcoming of previous events and help authorities improve upcoming Hajj events.

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MAAD: A Mobile Advisory Application for Digititalizing Hajj and Umrah Experience

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معاد: تطبيق استشاري للهاتف المحمول لرقمنة تجربة الحج والعمرة

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الملخص

تحسين تجربة الحج والعمرة هو الهدف الرئيسي الثالث لبرنامج "ضيوف الرحمن" ، وهو أحد برامج تحقيق رؤية 2030. نظرا لأهمية موسم الحج والعمرة فقد تم اقتراح العديد من التطبيقات والأبحاث بهدف تحسين جودة الخدمات المقدمة للحجاج والزوار وتذليل الصعوبات التي يواجهها الحجاج مثل الازدحام والضياع وعدم توفر الخدمات الصحية. إلا أن البحث في الأدبيات يظهر أن العديد من هذه التطبيقات تفتقر إلى الشمولية في نوعية الخدمات المقدمة التي يحتاجها الحاج في مكان واحد. وبالتالي فقد يضطر الحجاج إلى تنزيل أكثر من برنامج على أجهزتهم مما قد يتسبب في تشتيت انتباههم أو نسيان كيفية استخدامها. وبالتالي، قرر فريق البحث تطوير معاد ، وهو تطبيق استشاري للهاتف المحمول لرقمنة تجربة الحج والعمرة ، وذلك باستخدام مفاهيم هندسة البرمجيات و الذكاء الاصطناعي.

الكلمات الدالة: الحج و العمرة ، الحاج، تطبيق محمول، الذكاء الاصطناعي .

Abstract

Enhancing the experience of Hajj and Umrah for pilgrims is the third key objective of "Doyof Al Rahman Program", which is one of the realization programs of the Vision 2030. Due to the importance of Hajj and Umrah season, many applications and research have been proposed to enhance the quality of the provided services and to reduce the difficulties that pilgrims face, such as crowding, loss and the shortage of health services. However, investigating the literature shows that many of these applications lack comprehensiveness in terms of provided services that a pilgrim needs in one place. Consequently, the pilgrims may have to download more than one program on their devices, which may cause distraction

or lead him to forget how to use them. Thus, the researchers decided to develop MAAD, a mobile advisory application for digitalizing Hajj and Umrah experience, using software engineering and AI concepts.

Keywords: Hajj and Umrah, Pilgrim, Mobile Application, Artificial Intelligence.

1. Introduction

In light of the development taking place in the Kingdom of Saudi Arabia (KSA)and its tendancy to accomplishing the vision of 2030, the Kingdom focuses on utilizing technology in all fields such as education, entertainment, medicine, and religious field. Indeed, enhancing the experience of Hajj and Umrah is the third key objective of "Doyof Al Rahman Program". This program is one of the realization programs of Vision 2030 [1]. The kingdom also provided a role model of utilizing technology to facilitate the life of the citizens and the residents during the Covid-19 pandemic. Experiencing the improvement in the quality of provided services motivated the researchers to Bthink about the importance of utilizing technology towards facilitating the experience of Muslims coming from all over the world to perform Hajj and Umrah. Thus, the researchers decided to develop Maad, a mobile advisory application for digitalizing Hajj and Umrah experience, using software engineering and AI concepts.

Due to the importance of Hajj and Umrah season, many applications and research have been proposed to enhance the quality of the provided services and reduce the difficulties that pilgrims face, such as crowding, loss and the shortage of health services. However, investigating the literature shows that many of these applications lack of comprehensiveness in terms of the provided services that a pilgrim needs in one place. Consequently, the pilgrims may have to download more than one program on their devices, which may cause distraction or lead the pilgrim to forget how to use them.

2. Literature Review

2.1. Related Work

The researchers have conducted an extensive literature review and noticed a shortage in published literature compared to the importance of Hajj and Umrah events. About 16 applications were found, which were listed from reference [2] to reference [17], these references are similar in their functions to what the researchers are proposing. Thus, the researchers conducted a comparative study to highlight the differences and similarities between Maad, the application proposed, and these applications. The findings are shown in Table1. In this table, the first column shows the name of the application. The "Target" column shows the targeted user by the application. The "Application Type" column shows how the application function and whether it collects input data from the user or not. Thus, the application type could be either interactive or informative. The "Output Type" column indicates whether the application is dedicated to serve a specific user thus meet individual requirements "Personalized" or act as a "General" application for all users. The "Location-based services" column indicates whether the application provides location-based services or not. The "Health and Well-being" column indicates whether the application provides health and well-being services or not. The "Hajj permit and proofs" column indicates whether the application considers saving the proofs and permits for the user. The "Hajj and Umrah guides" column indicates if the application contains instructions on how to perform Hajj and Umrah or not. The "Languages" column shows the languages supported by the application. The "Awareness services" column shows if the

application notifies the pilgrim about crowded places and the weather conditions ~~or not~~. The "Feedback type" column shows whether the application provides visual or audible output.

By investigating the content of each application, the researchers found that most related applications are اعتمرنا Eatmarna [2], بطاقة شعائر الذكية Shaaer Smart Card [3], مناسكنا Manasikana [4] and المطوف Mutawef [5]. With regard to the current applications that aim to serve the pilgrims, there is no system available that serves two different targets (pilgrim, campaign owner) simultaneously, meaning that these systems either provide services related to the pilgrim or the campaign owner. Applications such as اعتمرنا Eatmarna [2], بطاقة شعائر الذكية Shaaer Smart Card [3], مناسكنا Manasikana [4] and المطوف Mutawef [5] focus on serving the pilgrim only, while EatmarnaBusiness [6] application focuses on serving the campaign owner only. The researchers think separating the services provided to pilgrims and to campaign owners into different applications affects their efficiency since the pilgrim and the campaign to which she/he belongs are closely related and need to interact continuously. This is what the researchers aim to provide in this suggested application, to enable both the pilgrim and the campaign owner or any other stakeholder to get benefit from the application simultaneously.

Regarding the applications that provide location-based services, they often provide general information such as clarifying the locations of the important places for pilgrims, help centers, health centers, security assistance centers and WC, provided by المطوف Mutawef [5] application, مناسكنا Manasikana [4] and the بطاقة شعائر الذكية Shaaer Smart Card [3]. However, they do not provide personalized services such as determining the location of the pilgrim's campaign, and escorts. Even the applications that provide such service do not work appropriately such as in the case of تفويج Tafweej [7] application. Therefore, the researchers aim to provide such personalized services in the proposed application. The same case applies for the applications that provide health and well-being services and notifications to the pilgrim. They often provide general information about the health state of the pilgrim before, during and after the pilgrimage, and the diseases that she/he may experience, such as المطوف Mutawef [5] application. بطاقة شعائر الذكية The Shaaer Smart Card [3] application considers health services, as it provides a health history of the pilgrims and a meal selection service. In the proposed application, Maad, the researchers aim to provide a set of health and well-being services and notifications such as enabling the recording of the medication schedule and refill dates beside health history, setting alerts for the extent of the crowding of the holy places, and setting weather alerts for rain, sun and high temperatures with clothing recommendation outside ritual time.

Regarding the applications that provide guidance services on how to perform Hajj and Umrah, the researchers found most of these applications provide guidance in a visual text format, such as the applications مناسكنا Manasikana [4], الرفيق الذكي Smart Companion [8], 3D Hajj [9], بطاقة شعائر الذكية Shaaer Smart Card [3] , Hajj Smart ID [10], Hajj and Umrah Dua [11] , Hajj quick Guide[12] , Hajj Navigator [13], نظام حملتي Hmlaty [14] , and رفيق الحاج Hajj Companion [15]. The المطوف Mutawef [5], Labbaik [16] and رفيق الحاج Hajj Companion [15] applications provide audible service beside the text. In this application, the researchers aim to provide gender-based guidance service in three forms: visual text, audio, and sign language to serve a wider range of the society such as the deaf, speechless, blind and the elderly. the researchers have also planned to support Arabic and English languages in the current prototype and extend the range to other languages such as (Urdu, Turkish, French, Indonesian, Malaysian, and Bengali) in the future. This selection is based

on supported languages in some existing applications such as مناســكنا Manasikana [4], AlMaqsad [17] , نظام حملتي Hmlaty [15] and Hajj navigator[13] .

Table3 . a comparative study between Maad, the application we proposed, and applications in thr literature

System name	Target		Application type		Output type		Location -based services	Health and well-being	Hajj permit and proofs	Hajj and Umrah Guides	Language			Awareness services		Feedback type	
	pilgrim	campaign owner	informative	interactive	Personalized	General					Arabic	English	other	crowd	weather	visual	audible
مناسكنا	✓			✓	✓		✓			✓	✓	✓	✓			✓	
المطوف	✓		✓	✓		✓	✓	✓		✓	✓			✓		✓	✓
الرفيق الذكي	✓			✓		✓				✓	✓					✓	
3D Hajj	✓			✓		✓				✓		✓				✓	
اعتمرنا	✓			✓	✓				✓		✓	✓				✓	
EatmarnaBusiness		✓		✓		✓			✓		✓	✓				✓	
بطاقة شعائر الذكية	✓			✓		✓	✓	✓		✓	✓	✓				✓	
تفويج	✓			✓		✓	✓				✓					✓	
Al Maqsad	✓			✓		✓	✓				✓	✓	✓			✓	
Hajj smart ID	✓			✓	✓		✓			✓	✓	✓		✓		✓	
Ershad		✓		✓		✓			✓		✓	✓				✓	
Hajj and Umrah Guide : Dua for Hajj	✓					✓				✓		✓				✓	
Labbaik	✓			✓	✓					✓		✓	✓			✓	✓
Hajj quick Guide	✓			✓		✓				✓		✓				✓	
Hajj navigator	✓			✓		✓	✓			✓	✓	✓	✓			✓	
نظام حملتي	✓			✓	✓		✓	✓		✓	✓	✓	✓			✓	
رفيق الحاج	✓			✓		✓		✓		✓	✓					✓	✓
حج وعمرة	✓			✓		✓	✓	✓		✓	✓				✓	✓	
our proposed system: مَعاد	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

2.2. Challenges in the Existing Systems

Based on the comparative study results, the researchers found some challenges that need to be addressed based on the most related applications which are اعتمرنا Eatmarna [2],بطاقة شعائر الذكية Shaaer Smart Card [3], مناسكنا Manasikana [4] and المطوف Mutawef [5]. The researchers aim to solve most of these challenges in MAAD application with respect to their work. Some of the challenges are:

1. There is no application available that serves two different targets (pilgrim, campaign owner) simultaneously.
2. Most applications don't provide pilgrim's and campaign's permits information.
3. There is no application that provides personalized location-based services which are:
   a. Determining the location of the pilgrim's campaign.
   b. Determining the location of the pilgrim's escorts.
4. Most applications don't provide health services for the pilgrims which include :
   a. Enabling the recording of the medication schedule.
5. Most applications don't provide awareness/notification services which include :
   a. Weather condition notification (sun heat, rain).
   b. Crowding in holy places.
6. Some applications don't provide the guidance information in a clear classification.
7. There is no application that provides gender-based guidance information.

8. Most applications provide the guidance information in a visual text format and only three of them provide audible format beside text.
9. There is no application that provides the guidance information in sign language.
10. Most applications just provide Arabic and English language.
11. Most applications don't provide a meal selection service.
12. Most applications don't provide automatic alerting emergency center in abnormal vital signs cases.

3. MAAD: Proposed System

3.1. Application Description

The researchers proposed MAAD to facilitate Hajj and Umrah obligatory for pilgrims through digitalizing the whole experience and provide personalized services while addressing the challenges from 1 to 8 in the list mentioned above. The target users are pilgrims and various authorities, hence MAAd aims to help various stakeholders in managing the affairs of pilgrims. Specifically, this application will serve pilgrim and campaign owner simultaneously, because separating the services provided to pilgrims and to campaign owners into different applications (apps) may affect apps efficiency due to the close relationship between pilgrims and the campaign owner so they need to interact often. The researchers also aim to provide a set of personalized location-based services to the pilgrims and campaign owners. They will also provide a set of health and well-being services.

3.2. Development Method

The researchers adopted Waterfall methodology , which is "a sequential development process that flows like a waterfall through all phases of a project"[18].Regarding the prototype implementation, they considered pilgrims and the campaign owners as an example of authority. Thus, the researchers designed and conducted a questionnaire targeting those stakeholders to confirm the value of MAAD services that they suggested. The researchers will publish the details of the questionnaire design and results analysis in a future paper. The researchers also designed MAAD to support two languages: Arabic and English. Regarding the provided services, Maad application will provide general and specialized services. General services classified into three categories (notification, location-based, and user information) as shown in the following taxonomy (Figure 1).

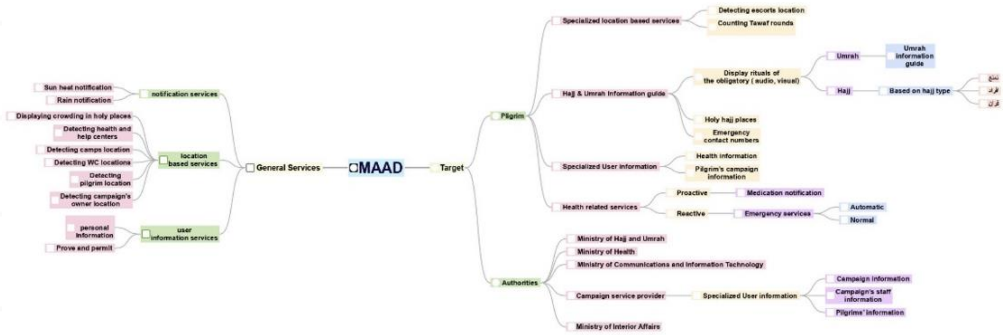


Figure 6. MAAD Components: Services and Targets

3.3. Requirements Collection: Questionnaire

3.3.1. Questionnaire Design

The researchers designed two different questionnaires: one for the campaign owners (15 questions) and one for the pilgrims (14 questions). The researchers will present the campaign owner questions in the following. They will present the pilgrims questions and the analysis of questionnaire results in a separate paper due to the limited space. As for now, the researchers collected answers from 35 campaign owners and 148 pilgrims.

In the following, each question is represented using an arrow (Figure 2) to highlight its purpose (the why part), the question itself, and how the result will be interpreted (the how part).

In Question 1 (Q1.), the researchers asked the campaign owners if they agree to participate in this questionnaire. This question has two options: Agree and Don't agree. They asked for a reason for the later and provided options, which are:

- Why don't you agree?

- ☐ I don't care about using technology in the Hajj and Umrah experience.
- ☐ I don't prefer using technology in the Hajj and Umrah experience.
- ☐ I won't carry a mobile that enables me to use smart applications during the Hajj and Umrah experience.
- ☐ Personal reasons.
- ☐ Other...

In Question 4 (Q4.), the researchers asked the campaign owners if they tried an application in the context of Hajj and Umrah before. The researchers also asked them to write the application name in case of Yes and evaluate their experience with the previously used app(s). In Question 7 (Q7.) and Question 8 (Q8.), the campaign owners were asked about the problems facing pilgrims (Q7.) and campaign owners (Q8.), based on their previous experience. Then these owners were provided with a list of common problems and provided with checkboxes to select the answers as follows:

Q7- Based on your previous Hajj and Umrah experience, what are the problems facing pilgrims? (As checkboxes)

- ☐ Getting lost.
- ☐ Health problems.
- ☐ Weather fluctuations.
- ☐ Difficulty obtaining information on how to perform Hajj and Umrah.
- ☐ Other...

Q8- Based on your previous Hajj and Umrah experience, what are the problems facing campaigns owners?

- ☐ Difficulty organizing pilgrims' information.
- ☐ Difficulty organizing campaign's staff information.
- ☐ Difficulty guiding the pilgrims to sites.
- ☐ Difficulty finding the lost pilgrims.
- ☐ Other...

In Question 9, the campaign owners were asked about the important places if there is a map based service in the app:

- ☐ Health and help centers
- ☐ Camps location
- ☐ WC location
- ☐ Other...

In Question 10 (Q10.), The campaign owners were asked about the prefered form to provide guidance information:

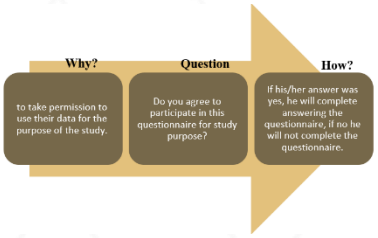
- ☐ text
- ☐ audio
- ☐ text and audio

In Question 11 (Q11.), we asked the campaign owners:

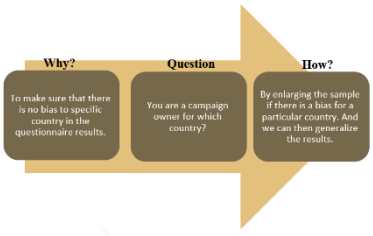
What are the notifications you hope to be included in the application?

- ☐ Sun heat notification
- ☐ Rain notification
- ☐ Medication notification
- ☐ Other...

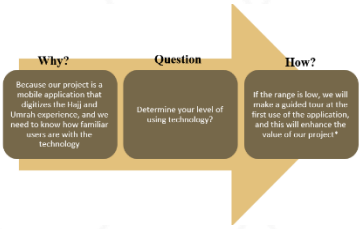
Q1.



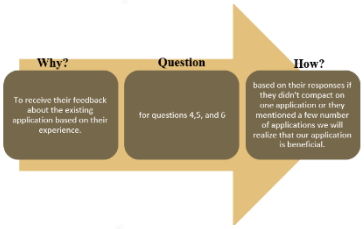
Q2.



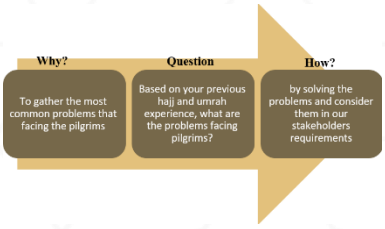
Q3.



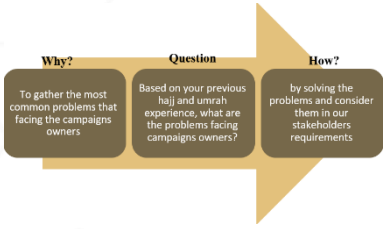
Q4. -Q5. -Q6.



Q7.



Q8.



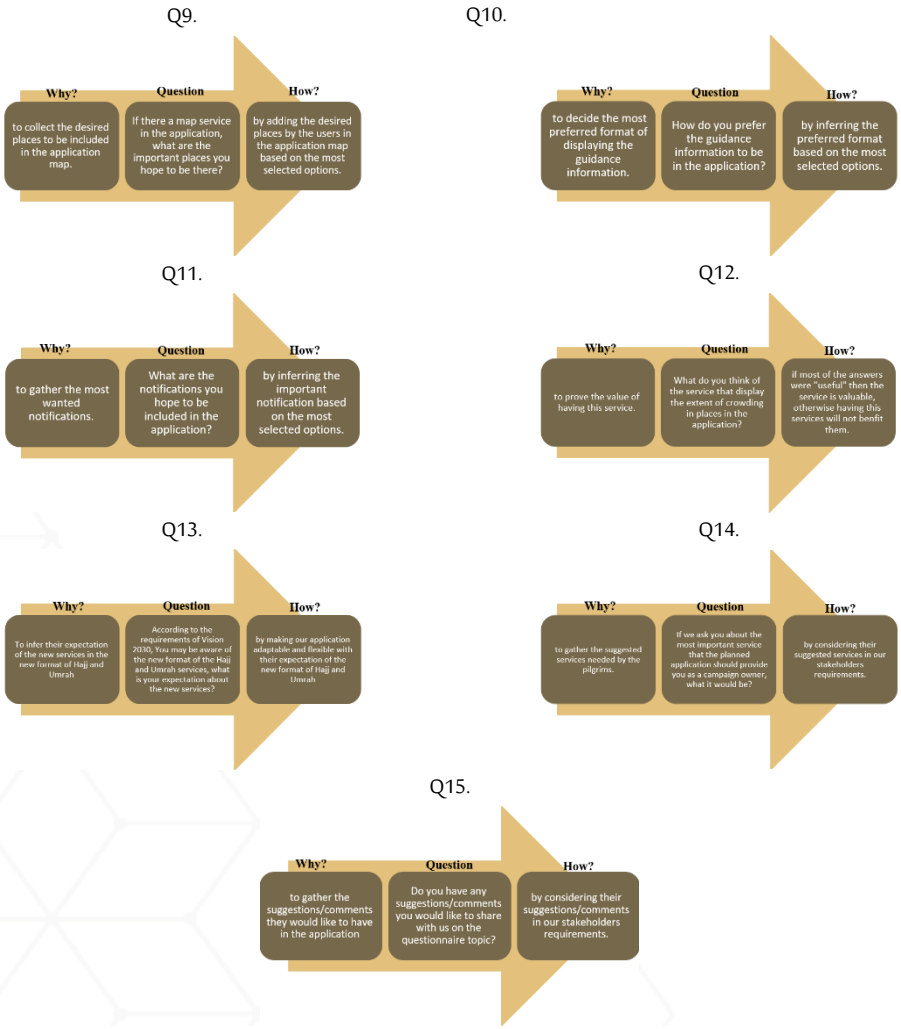


Figure 7. Questionnaire questions, their purposes and how yo interprete them

4. Conclusion and Future Work

In this paper, the researchers proposed MAAD, which is a Mobile Advisory Application for Digitalizing Hajj and Umrah Experience. It aims to address some of the existing applications challenges while providing services to different stakeholders simultaneously in one app. The research started by defining the importance of the app and presented a comparative study between MAAD and other app. existing in literature and listed the challenges. Then, a description of the app is presented and requirements collation stages are specified.

Two different questionnaires were designed and presented. The questions of the first one were dedicated to campaign owners. The second questionnaire was dedicated to pilgrims. The results will be discussed in the future. The work on the app is under progress and further details will be provided in the future.

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الملتقى العلمي
الـ 21 لأبحاث الحج
والعمرة والزيارة

التحول الرقمي في منظومة الحج والعمرة والزيارة 5-7 شعبان 1443هـ

Third Theme

Decision-Making Development Processes and Services Provision

A smart Application Prototype for Emergency Relief Shelter Response for Hazards in Holy Places

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نموذج أولي للتطبيق الذكي للاستجابة الطارئة لتقديم الإيواء أثناء حدوث المخاطر في الأماكن المقدسة

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الملخص

زاد حدوث المخاطر في السنوات الماضية بشكل كبير في مدينة مكة المكرمة والمشاعر المقدسة (منى وعرفة ومزدلفة)، ومن أمثلة هذه المخاطر الفيضانات المفاجئة وارتفاع درجات الحرارة وحدوث العواصف وتساقط الصخور والحرائق والأوبئة مثل وباء كوفيد ١٩وتهدد هذه المخاطر حياة ضيوف الرحمن خلال موسمي الحج والعمرة، وتضر بالاقتصاد والبيئة في المملكة ، وتسبب خسائر في الممتلكات مثل الخيام والمباني والبنى التحتية. ولازدياد هذه المخاطر ظهرت الحاجة لتحسين خطط الاستجابة للطوارئ من خلال توفير المأوى المناسب لضيوف الرحمن والتنسيق التام بين كل الجهات المعنية لإدارة الحدث بكفاءة، وهذه الإجراءات يمكن أن تنقذ الأرواح وتقلل من المعاناة وتضمن عودة الحجاج والمعتمرين بسرعة لإكمال مناسكهم.

ولأهمية توظيف التكنولوجيا الحديثة في هذا المجال واهتمام المؤتمر بالتحول الرقمي لنظام الحج والعمرة وفقا لرؤية المملكة 2030، طور المباحث نموذجًا أوليًا لتطبيق ذكي لتحديد المأوى المناسب في حالات الطوارئ عند حدوث أحد المخاطر في مكة المكرمة والمشاعر المقدسة. يعمل التطبيق على الأجهزة المحمولة كالهاتف الذكي أو الجهاز اللوحي، ويمكن استخدامه في أي زمان ومكان، ويتيح لمتخذي القرار مثل موظفي الدفاع المدني ووزارة الحج والعمرة ووزارة المالية وغيرهم، تحديد طبيعة الخطر واختيار المأوى المناسب لحجاج بيت الله الحرام بيسر وسرعة. اعتمد البحث على المنهج النوعي لإجراء تحليل كيفي لعدد من دراسات الحالة والأطر النظرية ذات العلاقة واعتمد كذلك على جمع البيانات من خلال المقابلات الشخصية المنظمة لدراسة سبل تحسين خطط الاستجابة للطوارئ وتعزيزها وتجريبها.

الكلمات الدالة: الايواء للحالات الطارئة، الأخطار، ضيوف الرحمن، العوامل التصميمية، اطار الاستجابة الطارئة ، التطبيق الذكي للاستجابة الطارئة لتقديم الإيواء.

Abstract

During the past years, the occurrence of hazards has increased significantly in Holy Places in Makah, including Masjid Al-Haram, Arafah, Muzdalifah, and Mina (Almashaeir Almuqadasa). Such hazards include flash floods, high temperatures, storms, falling rocks, fires, epidemics, and pandemics like Covid-19. During the Hajj and Umrah seasons, hazards threaten the lives of Rahman guests, (pilgrims) the economy and the environment, and damage property, such as tents, buildings, and infrastructures. Hence, there is a need to improve emergency response plans to provide adequate shelter for Rahman guests (pilgrims) when these hazards occur. Working with relief & aid workers to efficiently manage the event can save lives, minimize sufferings, and ensure that people can quickly return to the holy rituals. Considering the development of modern technology and the forum's interest in digital transformation of the Hajj and Umrah system as part of the 2030 vision, the author has developed a prototype for a smart application to identify emergency relief shelter (ERS) when hazards occur in the holy places. The application operates on a mobile device, such as a smartphone or tablet, and it can be used at any time and any place. The application allows key decision makers, such as employees in Civil Defence, Ministry of Hajj and Umrah, Ministry of Finance and others, to determine the nature of the hazard and identify the appropriate shelters for the pilgrims easily and quickly. The implement methodology for this research used qualitative method to conduct an in-depth analysis of case studies and guidelines. The structured interview method used to analyse the ERS response application enhancements, refinement, and testing.

Keywords: Emergency relief shelters (ERS), hazards, Rahman guests, design factors, ERS response framework, and ERS response application.

1. Introduction

The city of Makkah is particularly vulnerable to various hazards, such as security threats, health emergencies, natural hazards, and accidents. Heavy rainfall is likely to cause flash floods in Makkah because of the arid and semi-arid regions that lack vegetation and have surface soils with a poor infiltration capacity. These factors lead to large volumes of surface runoff. Large urban centres throughout the world, specifically Makkah, are concerned about the effects of flash floods mainly because these centres have enhanced their infrastructure development to accommodate an increasing population. Therefore, buildings have been constructed in regions that have low-lying topography, and this hinders the natural drainage of rainwater (Hussein and Zaidi, 2012). Since construction has increased, the natural land available for infiltration is limited, leading to additional surface runoff. At times, the runoff is more than the urban sewage system can bear, and this causes flooding. In addition, there are other hazards that raise concerns. For example, COVID-19 is a pandemic that affected the entire world. Other hazards frequently occur and cause destruction, like fires, accidents, and security threats (Ministry of Hajj and Umrah, 2021).

In the KSA, the response documents related to the ERS and the guidance for Hajj and Umrah have been analysed. These documents contain general information. The documents do not explain the actions that should be taken in response to emergencies and do not identify the shelter that is provided for individuals impacted by hazards while performing Hajj or Umrah. These types of resources are not available, so decisions made during these emergencies are improvised and rushed, creating chaos for organizations, survivors, and workers. This lack of information can increase the injury and death

rate, affect infrastructure breakdown, and damage the environment and property, such as cars, buildings, and tents. Property damage is especially concerning during flash floods because the water rises to such a high level (Youssef et al., 2016; Abdalla, 2018). Therefore, developing the ERS response application is crucial to providing a quick response to manage hazards in Makkah and other holy places while performing Umrah or Hajj (General Directorate of Civil Defence, 2021a). When a hazard occurs, the decisionmakers must be able to identify and understand the requirements. This information can be obtained by analysing the ERS response solution database to determine the requirements that were applicable in prior situations. Thereafter, the appropriate decision must be quickly executed and an action plan must be developed to implement the ERS response solution. The ERS response application that has been created can be further enhanced and updated to identify other ERS responses that have been successful best practices. Another option with the application is to provide responses that have been successful in specific onsite situations. This tool can be interactive and beneficial to users by identifying the needs before presenting the solutions. Using this approach, the relief aid worker presents onsite information, and the application provides the ERS response that has already been proven effective. This .method ensures a speedy decision-making process

2. Hazards

A hazard is a temporary-to-permanent disruption of a community's ability to function on an economic, sociological, ecological, and human basis that damages materials and the surrounding and immediate economy and inflicts severe environmental losses (such as coastlines, mountain ranges, and other geographic changes) in such a way that immediate communities cannot address these issues due to the lack of immediately available resources (Lloyd-Jones, 2006; Brebbia, 2013). In the future, hazards may impact zones which have not yet experienced such events. (Centre for Research on the Epidemiology of Disasters and UN Office for Disaster Risk Reduction, 2015). Alamri (2010) and EM-DAT (2019) divide hazards into two categories: technological hazards and natural hazards.

Technological hazards include accidents and non-accidental technological hazards, such as acts of aggression (war or terrorism), vehicle accidents, and other miscellaneous accidents. Natural hazards include geophysical occurrences (e.g., earthquakes), volcanic movements, meteorological events (e.g., extreme temperatures), fog, massive storms, floods, landslides, wave actions, drought, glacial lake outbursts, wildfire, epidemics, massive insect infestations, animal accidents, and space events. The Ministry of Hajj and Umrah (2021) have divided hazards into four groups: (1) natural hazards (e.g., flash floods, storms, extreme temperature changes, shifting sand dunes, and dust storms); (2) security hazards (e.g., demonstrations, sit-ins, mass strikes, accidents that threaten crowd safety, overcrowding); (3) health hazards (e.g., diseases and epidemics like Covid-19); and (4) accidents and industrial hazards (e.g., vehicle accidents, fires, building collapse). For the present study, the author focuses on those hazards that most commonly occur and that frequently cause widespread destruction to life and property in Makkah.

Makkah is an arid region, and consequently, flash floods frequently occur and destroy life and property. This phenomenon is complex and is caused primarily by regional geology, drainage basin morphometric features, and the plain area of the floods (Subyani and Al-Dakheel, 2009). Rainfall intensity and duration, evaporation, surface runoff, and the rate of infiltration also influence the severity and occurrence of the flash floods. Scholars have recently opined that flash floods

are a threat to life and property because of the improper planning of land use and population pressures. (Al Saud, 2015; Abdalla, 2018).

Global warming has changed the development of the global precipitation pattern, which has subsequently altered the hydrological cycle of the planet (Benthall, 1993; Centre for Research on the Epidemiology of Disasters and UN Office for Disaster Risk Reduction, 2021). Because of this global change, the frequency of flash floods has increased in various areas, specifically arid regions. The flash flood magnitude in these regions is further exacerbated when there is soil saturation from earlier rainfall (Abdulaziz M Al-Bassam et al., 2012). Severe flash flooding has occurred in Makkak. For example, the Rowboa flooding occurred in 1941 when heavy rain fell from morning to evening and entered the Masgid al-Haram, eventually reaching the Kaaba. It was not possible to pray in the Kaaba or walk around it because the Masgid al-Haram was flooded with so much water that it was like a sea. Similar to the streets, the Masgid al-Haram was also filled with dust. This flood destroyed many shops, forests, old homes, and the graves of Al-Mualla. In 2002, heavy showers continued in Makkah for seven days, causing flooding in many zones and claiming lives. The General Directorate of Civil Defence evacuated almost a hundred Makkah citizens during this week of flooding. In 2003, Makkah experienced another heavy rainfall at a time when the area had not fully recovered from the previous year's rain. This rainfall was considered one of the worst in Makkah in the past 25 years. The water level reached six metres. Some were killed, but it was not possible to obtain an accurate account of the extent of the physical injury.

In 2005, torrential rains fell on the plain of Mina near Makkah, but the rain did not prevent the peaceful end of the Hajj rituals. On the last day of the Hajj rituals in Mina, the heavy rain led to unexpected crowds on the Jamarat Bridge before the pilgrims headed to Makkah for the farewell circumambulation. The pilgrims were rescued by helicopter. A spokesman for the Saudi Ministry of Interior explained that people were moving strangely and that the area had to be controlled because the police found chairs, wheelchairs, and bags that would have caused a hazard if they were left behind. Traffic to Makkah was disrupted as many people waded through flooding waters to push their cars as they became immobilized in the wet sand. As the pilgrims performed the farewell circumambulation around the Kaaba, they had to avoid one side of the Grand Mosque courtyard because it was flooded with water. More than 2.5 million Muslims participated in the rituals during this year and started leaving the Holy Land the next day. Hajj of 2019 was severely impacted by a heavy shower that lasted for several hours and swept through the pilgrims' camps in the fields of Mina.

Hazards involving crowds have also occurred at or near holy sites. For example, in 2006, hundreds were wounded and killed in a stampede near the Jamarat Bridge on the second day of Tashreeq. In 2015, a stampede occurred at Mina. This was the worst accident to occur during Hajj in 25 years. According to Saudi official statistics, hundreds of people were injured, and the death toll exceeded more than two thousand.The worst fire incident occurred in 1975 when a gas cylinder exploded in the pilgrims' camps, causing a huge fire to erupt and killing hundreds of pilgrims near Makkah. In 1997, a gas heater exploded in the pilgrims' camps in Mina and caused a massive fire that killed hundreds of pilgrims and wounded more than a thousand others. Located in the centre of Makkah, the Pearl Al-Khair Hotel collapsed at the beginning of the Hajj season in 2006 where pilgrims were staying in preparation for the Hajj rituals. Approximately tens people were killed and injured. Congestion from the large number of international visitors during the Hajj season increases the possibility of

transmission of infectious respiratory diseases, such as influenza, meningitis, and Covid-19, an extremely dangerous disease. In an effort to reduce the spread of disease and infection, the number of pilgrims decreased in 2020 and 2021.

A thorough analysis of these incidents demonstrates that in Makkah, these hazards have a detrimental impact on lives, livelihoods, homes, and resources. Because of limited planning guidelines, the ERS response is typically delayed, and decision-makers are unable to save lives and mitigate damage in a timely manner. Hence, it is necessary to develop an ERS response application that allows relief agencies to act quickly and provide an appropriate ERS response to Rahman guests. When there is an emergency, the ERS response application must be effective and efficient. If the ERS response is effectively planned, then it is possible to mitigate the damage from a hazard at a maximum level (Zhao et al., 2017; General Directorate of Civil Defence, 2021b).

3. ERS response framework

The ERS response framework is a tool that supports onsite relief aid workers by analysing the variables relevant to minimizing the impact of the incident on the environment and the public. An appropriate ERS response incorporates this information as well as the sociocultural, technical, economic, and environmental factors that influence the community (IFRC/RCS, 2013; UNHCR, 2018). This framework can also be used to analyse the database of potential ERS solutions in an efficient manner. When there is an emergency, the response needs to be effective and swift. If the response is delayed and appropriate action is not taken, then lives, livelihoods, homes, and resources are needlessly lost or damaged (Abosuliman et al., 2014; Youssef et al., 2016; Ali and Ameur, 2018). It is hard to find a specific ERS response method from the previous shelter response methods that can be used as the ERS response for holy places. There are, however, some stages involved in the different methods that could be used in-part, such as considering the factors that help to provide an appropriate ERS response and evaluating the stages to reach the final decision for an ERS response. Thus, the author develops the first stage of the ERS response framework by considering the factors with questions to be addressed by responsible people in order to identify the appropriate response of ERS for hazards (IFRC, 2010; IFRC and Oxfam GB, 2007; United Nations, 2004; Shelter Centre, 2012; Humanitarian Aid and Civil Protection, 2016).

The ERS response in the Hajj and Umrah system involves many organizations. Therefore, there needs to be a stage for gathering information from all responsible organizations in one template as this will be the second stage of the ERS response framework in order to increase the coordination level between all organizations (United Nations, 2004; IFRC and Oxfam GB, 2007; IFRC, 2010; Shelter Centre, 2012; Humanitarian Aid and Civil Protection, 2016). For the following stage, the author is considering developing a database in order to gather the ERS successful responses that have been used previously in hazard situations in SA. During an emergency, quick and effective action is required. If the appropriate actions are not taken quickly, or if the response is delayed, lives, resources, houses and livelihoods will be needlessly lost (Abosuliman et al., 2014; Youssef et al., 2016; Ali and Ameur, 2018). In addition, the use of a successful database allows for many future successful ERS responses to be included, which proves the quality of the database and so improves the response framework. Furthermore, good practice can, in this way, be recorded and used again instead of being forgotten. The next stage will appear to show the initial results that match the needs of the current situation for ERS. However, the initial results might indicate that there is more than one solution for the ERS response. Therefore, there needs to be a stage

that has research to choose from them. The most appropriate ERS responses will quickly and easily match the flood-affected victim's needs (Trans-European and Education Networking, 2006; Battelle, 2005).The final stage will review the selected ERS response(s) with the final recommendations (Lawson, 2006). The stages that have been developed and categorised into seven stages are: Define the ERS response need (IFRC, 2010; IFRC and Oxfam GB, 2007; United Nations, 2004; Shelter Centre, 2012; Humanitarian Aid and Civil Protection, 2016); Identify the basic response requirements for the hazard. (General Directorate of Civil Defence, 2021a); identify successful ERS responses and categorise them for inclusion in a searchable database (Abosuliman et al., 2014; Youssef et al., 2016; Ali and Ameur, 2018); create a searchable database of ERS responses (Trans-European and Education Networking, 2006; Battelle, 2005); create a shortlist of possible ERS responses (Lawson, 2006); review the shortlisted ERS responses in order to select the final ERS response(s) (Félix et al., 2013a; United Nations et al., 2009) Milton and Rodgers, 2013) and make a final recommendation (Cross and Roy, 1989). The seven stages have been illustrated in Figuer 0-1. Those stages will be developed as options in a smart applicatio for emergency relief shelter response as explained in sub-section 5.

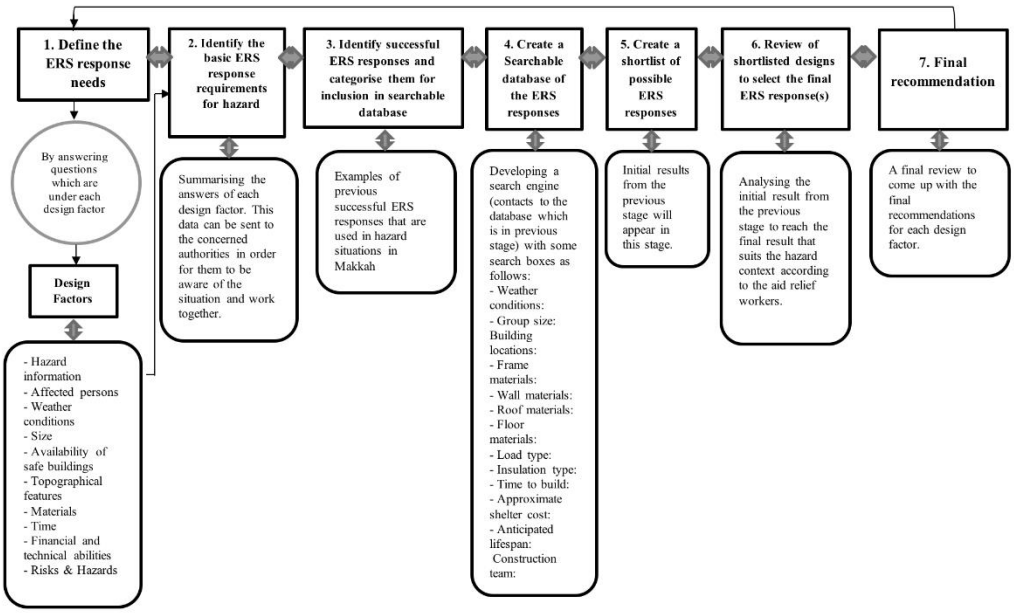

Figure 0-1: An ERS response framework in SA (Bashawri., 2019).

4. Research methodology

The qualitative process employs several specialized research methods. The current study utilized this qualitative method to conduct an in-depth analysis of customers and their unintentional interests (Saunders et al., 2009; Robson, 2016). The research has a subjective nature, and the descriptive survey allowed for the extraction of the ERS responses related to the hazards that occur in Makkah. The descriptive surveys included responses to questions of who, what, when, where, and how. The number of responses that reflected a certain perception or attitude toward an issue were counted, and these responses were assessed or compared to future trends.

The framework was developed through in-deapth analyse, case studies, interviews (verified), and questioners (validated) techniques, and published in 2019 as a PhD thwsis by same author and is referred to as 'An Emergency Relief Shelter Response Framework For Flash Floods In Saudi Arabia'. The reasons for developing were there was a lack of understanding when it comes to using an ERS response framework in a hazard context and its importance. Some organizations have their own plans for responding to hazards (some of the plans are not made available to the public) but with only a tiny amount of information available on the ERS response, which is hard to apply in a hazard situation. In many past hazard situations, the affected victims did not know where to go or where to stay safely immediately after the hazard occurred. It will also the aid relief workers and decision makers who do not know how to respond in easy and quick way to protect affected people's lives and to achieve their wants and needs. Thus, the results say that there is a strong need to develop a framework to use to support aid relief workers at a hazard site to allow them to provide an appropriate and quick ERS response. In addition, it was also said by some of the responders that the framework should be improved as a smart application which can be easily and quickly used. Therefore, the framework developed as a smart application and a structured interview technique was used to validate the ERS response application by some experts as shown in Table 1.

Table 1: Details of the experts interviewed to validate the ERS response smart application.

No	Organisation	Task	Experience	Years Experience
1	Emirate of Makkah region - Crisis and Disaster Management Centre	The Head of the Centre	Floods – Jeddah and other cities	30
2	Emirate of Makkah region - Crisis and Disaster Management Centre	Head of Operation in Crisis and Disaster Management Centre	Floods - Jeddah	15
3	Research and Consulting Studies Institute – Umm Al-Qura University	Institute's deputy	Emergency's plans, courses and consultations	4
4	Saudi Red Crescent Authority	Training Management	Jeddah floods and incidents	15
5	Emergency and Disaster Centre – King Abdulaziz University	Deputy director of the centre	Consultations	16
6	Ministry of Finance	Delegate	Jeddah floods and incidents	21
7	General Authority for Meteorology and Environment Protection – Disaster Management	Director of Disaster Management	Natural disasters (hazards)	5

According to Naoum (2012), the structured interview method is usually applied with this type of research to ensure that all respondents are asked the same questions (Bryman and Bell (2015). The questions were all linked to one another in a standard format. The interview began with open-ended questions but eventually led to close-ended questions. Throughout the interview process, the respondents controlled the questionnaire. The Likert scale was applied to the quantitative close -ended questions because it provides simple components that are equally measured (Oppenheim, 2000). Open-ended questions were used to obtain qualitative comments. There were various sections within the questionnaire. Personal questions, such as name, qualification, email, and experience, were asked in the first section. The

next section assessed the ERS response application options, and the third section evaluated the design factors. The last section analyzed six variables: practicality, efficacy, decision-making, helping hands, saving lives, and saving time and money. The objective of the interview process was to analyze the ERS response application enhancements, refinement, and testing using feedback from experts (including an individual who was involved in a hazard event that impacted Rahman guests who were sheltered during Umrah and Hajj) regarding the ERS response application, options, design factors, and procedures. All specialists assigned ratings of high or very high significance to smart application prototype for emergency relief shelter response for hazards in holy places.

5. A smart application prototype for an ERS response for hazards

The ERS response application has been developed (from the ERS response framework) to run on a mobile device, such as a smartphone or tablet computer. It also operates on a laptop computer for use at sites. It is explained below that how the farmework's stages are adopted and improved into the smart application options. The portability of the application allows relief aid workers in Makkah who work in the Hajj and Umrah system to define the nature of the problem at the site and then use the application to quickly identify the appropriate ERS response. This process will hopefully expedite the decision-making process to maximize fitness for purpose, provide monetary value, improve the quality of life, and save lives, property, and time. The application has five main options that can be selected from the bottom of the home screen including Home, Need an ERS Response, Hazard Data, Database, and Languages, as illustrated in Figure 0-2.

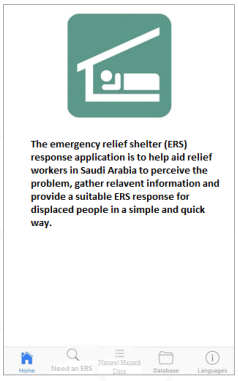

Figure 0-2: A screenshot of the home page of the smart application for emergency relief shelter response.

5.1 Home

The home screen explains the purpose of the application, which is to guide relief aid workers in selecting the most suitable ERS response to manage hazardous events. Other options are provided at the bottom of the screen, including Need an ERS response, Hazard Data, Database and Languages.

5.2 Need an ERS response

The Need an ERS response correlates with the first stage of the analytical framework to 'define the ERS response need'. This tool asks questions of the users related to the design factors (hazard information, affected persons, weather conditions, size, etc.). This information can then be saved in the Hazard Data option. Some of the questions are closed questions that allow the users to select one or more short answers from a list of options. These closed questions are

linked to the next question and are easy to answer. However, some of the questions are open questions that require more information as shown in Figure 0-3.

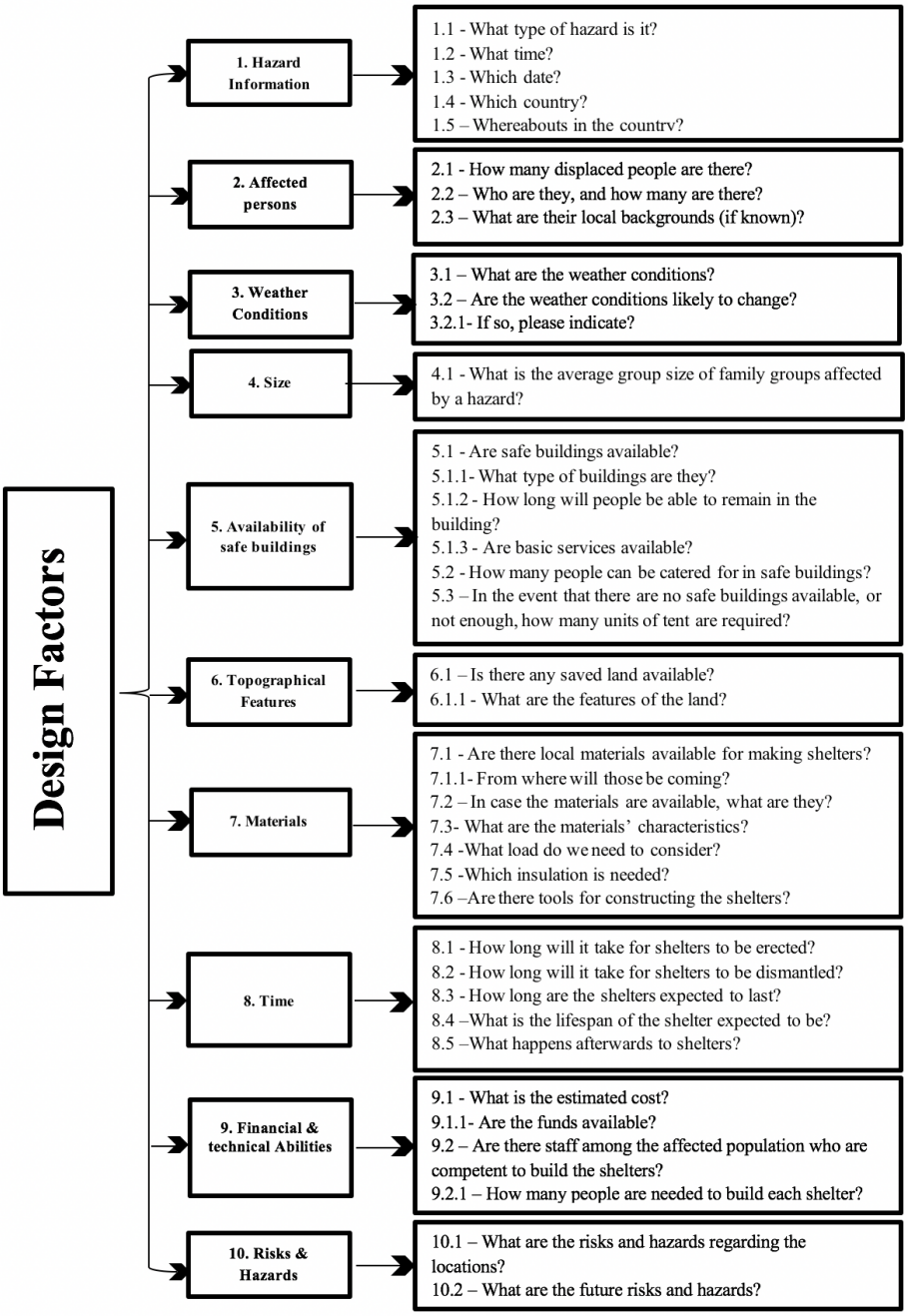

Figure 0-3: Factors that impact the possible ERS responses

5.3 Hazard data

The Hazard Data tool displays the answers that were submitted in response to the questions related to the design factors. Since other responders may need the information, the responses can be shared with other individuals or stored for additional editing. At this point in the application, the answers are the basic design requirements needed for the second stage of the framework to 'identify the basic response requirements for hazards stage'. This option will help relief workers select a suitable ERS response based on the needs and wants of Rahman guests.

5.4 Database

The previous successful ERS responses are stored in one part of the application as the third stage of the framework to 'identify successful ERS responses and categories them for inclusion in a searchable database'. Several sheltering centers are located around the holy sites in Makkah which need to be considered while providing an ERS response, such as Al-Mu'aisem Shelter Centre, Arafat's Shelter Centre 1, Arafat's Shelter Centre 2, Muzdalifah Shelter Centre, and Shumaisi Shelter Centre as shown in Table 2.

Table 2: Sheltering centres in Makkah and Almashaeir Almuqadasa.

Name	No. of Camps	Total Area	Location
Al-Mu'aisem Shelter Centre (Figure 0-4)	39 camps	22550 m^2	Fourth Ring Heading to Al-Mu'aisem in Mina https://goo.gl/maps/xz4JRYekvCsR4vNr5
Arafat's shelter Centre 1 (Figure 0-5)	44 camps	20,300 m^2	On the Royal Palace Road (Area 4) https://maps.google.com?q=%D9%85%D8%B1%D9%83%D8%B2%2
Arafat's shelter Centre 2 (Figure 0-6)	35 camps	22,218 m^2	On the Main Ring Line, Road 91, District No. 5, Square 521/91 https://goo.gl/maps/Q4BhKf7xi11F1mAL9
Muzdalifah Shelter Centre (Figure 0-7)	202 camps	330,000 m^2	On the Fourth Ring Road, on the Muzdalifah side https://goo.gl/maps/rF4MiYJjzWNCJF6o6
Shumaisi Shelter Centre (Figure 0-8)	480 rooms	More than 2.5 million m^2	Shumaisi https://goo.gl/maps/Hff8NjiP5nayA5pe7

Figure 0-4: Al-Mu'aisem Shelter Centre

Figure. 0-5: Arafat's Shelter Centre 1

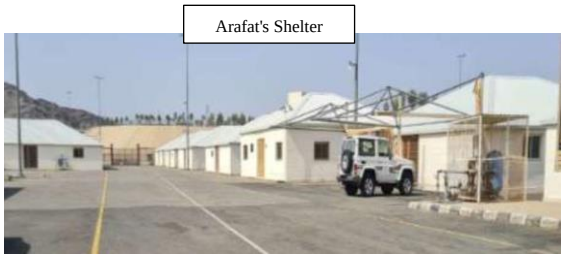

Figure 0-6: Arafat's Shelter Centre 2

Figure 0-7: Muzdalifah Shelter Centre

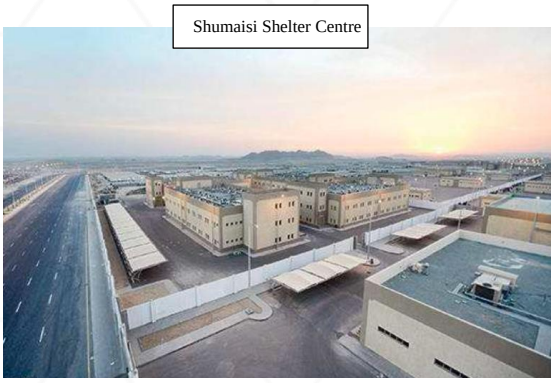

Figure 0-8: Shumaisi Shelter Centre

To easily access past examples of successful situations, research boxes have been included to facilitate the fourth stage to 'create a searchable database of ERS responses', including hazard type, weather conditions, group size, materials, load type, insulation type, time to build, approximate shelter cost, anticipated lifespan, and construction team. The user must fill these research boxes with information to obtain results. In addition, the application allows the user to select design requirements that have been previously saved to fill the research boxes automatically. After the research boxes have been completed, similar examples that match the design requirements are shown as part of the fifth stage to 'create a shortlist of possible ERS responses'. The application also shows the percentage level of similarity between the current situation and past situations. This tool allows the user to select the highlighted example or edit the information to mirror the specific requirements more closely. The goal is to quickly advance to the sixth stage to 'review the short-listed ERS responses in order to select the final ERS response(s)' and the seventh stage to 'make a final recommendation'.

5.5 Languages

To facilitate use of the application by international organizations, the information in the application can be translated into various languages, including English, Arabic, Dutch, and Urdu as shown in Figure 0-9.

Figure 0-9: Shumaisi Shelter Centre

6. Validation of an ERS response smart application

The ERS response smart application is procedure-based and needs to be validated without any time restraints or resource obligations from the organization. Reviewing the ERS responses for use in developing and improving the application may take close to a year, and the validation technique may not always be possible to use. However, there are several experts who can validate the application based on face-to-face interviews. Using this method increases the chances of validation and provides significant insight regarding the subject. The enhanced ERS response application components were objectively tested using descriptive statistical analysis and Excel. The experts rated each option and design variable in terms of their significance. They also identified and evaluated the design variables and options that were important but missing. Furthermore, feedback was obtained regarding the addition of any variable for the ERS response application. All

specialists assigned ratings of high or very high significance to application options, including stage 1 (O1); home 2 (O2) needs an ERS response; stage 3 (O3) hazard data; stage 4 (O4) database; and stage 5 (O5) languages (Figure 0-10).

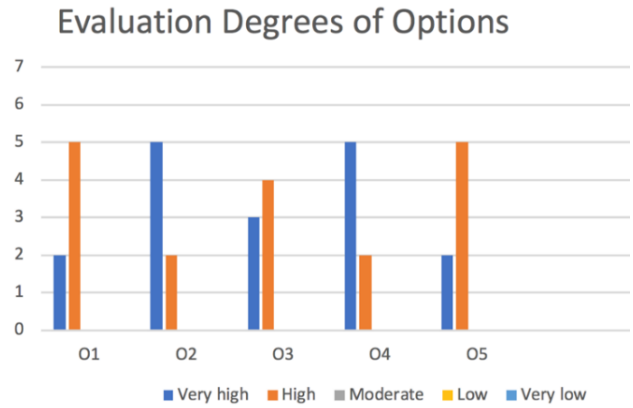

Figure 0-10: Evaluation degrees of options.

Furthermore, as indicated in Figure 0-11, the experts assigned ratings of high and very high to the following design factors: hazard information (HI), affected persons (AP), weather conditions (WC), size (S), availability of safe buildings (ASB), topographical features (TF), materials (M), time (T), financial and technical abilities (FTA), and risks and hazards (RH).

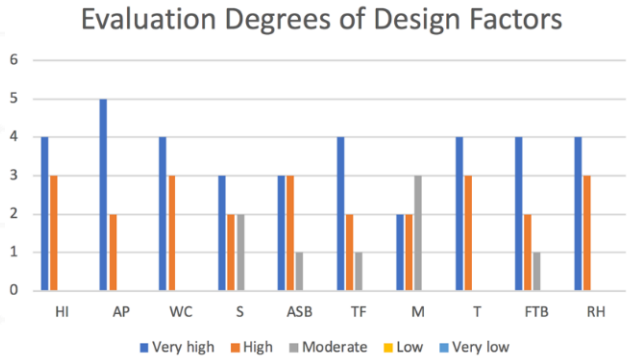

Figure 0-11: Evaluation degrees of design factors.

Efficacy is the ability of the ERS response application to achieve the desired outcome. In this case, the desired outcome is to assist the relief aid workers by identifying the issue and relevant information. Subsequently, the database is searched to determine possible options for the ERS response, to assist with decision-making, and to implement the action plan using the ERS response application in a quick and simple manner.

This helps to mitigate the hazards, protect lives, and establish a course of action to return to normalcy. The ability of the ERS response application to manage the hazard is based on practicality—not theory or speculation. The ERS response application assists decision makers in assessing the situation in order to achieve their objectives and to save lives, time, and money as shown in Figure 0-12.

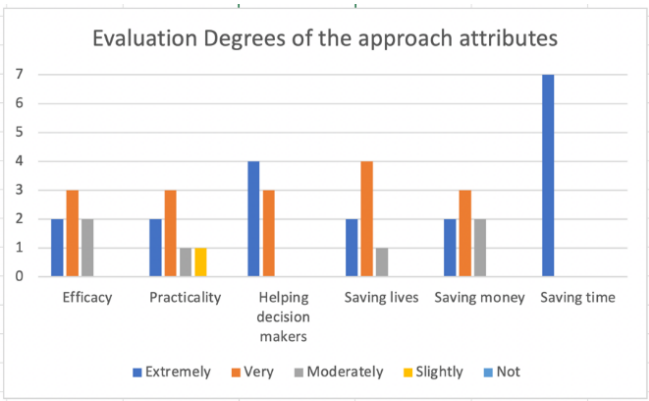

Figure 0-12: Evaluation degrees of the approach attributes.

7. Conclusion

The ERS response provides people with a place to live and ensures their well-being, security, privacy, and protection when they are in areas affected by hazards. The Rahman guests are provided not only short-term countermeasures, but also the ability to recover from the trauma and injury inflicted by the calamity. They are provided all resources needed for rehabilitation and completing worship.

The ERS response smart application was developed to support relief agencies during a hazard by helping them define the problem and the issues. Because the database can be searched for potential solutions, the staff can develop a plan of action that is effective and efficient. The application includes five options which are Home, Need an ERS Response, Hazard Data, Database, and Languages. Hence, the application achieves its fitness for purpose, provides monetary value, saves time, and enhances the quality of life.

The ERS application considers the most significant short-term design factors to help the decision makers choose an appropriate ERS response and develop a long-term plan. If a hazard occurs, an appropriate ERS response is chosen for the Rahman guests impacted by the event. Therefore, the variables should be considered before generating an ERS response. This response cannot be standardized, and a one-size-fits-all approach will not be effective since each hazard affects communities differently. Using the current application, assessments are made to provide focused support and hope to individuals to rehabilitate themselves. Future research and analysis can be conducted on these issues and the use of the ERS response application for other types of hazards and national disasters, particularly where a quick response is required.

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Digital Monitoring of Radiological Risks in Mass Gatherings Safety Management

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المراقبة الرقمية للمخاطر الإشعاعية في إدارة سلامة الحشود

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الملخص

في المناطق المزدحمة، مثل مكة المكرمة، وخاصة خلال موسم الحج، يجب تقييم العديد من سيناريوهات المخاطر المحتملة والحوادث وإعداد خطط الطوارئ لمواجهة تلك المخاطر . وهذا يشمل حالات الطوارئ الإشعاعية التي تركز على تحديد وفحص وقياس ومراقبة الجمهور المتعرض للإشعاع أو التلوث من المواد المشعة في حادث محتمل. وهذا الاجراء يتضمن عملية إزالة التلوث للأشخاص الذين تم إجلاؤهم بسبب حادث إشعاعي واسع النطاق. فهناك العديد من أوجه التشابه بين انتشار مرض مثل COVID-19 وحادث تلوث إشعاعي. فكلاهما يمثل خطرا غير مرئي، ولهما أعراض كامنة يمكن أن تظهر لاحقا بعد بعد الإصابة بالعدوى أو التلوث الإشعاعي. إن التلوث بالمواد المشعة وكذلك عدوى COVID-19 ، لا يشكلان تهديدًا مباشرًا للحياة في معظم الحالات. ولكن حركة وتنقل الأفراد في كلتا الحالتين يمكن أن تؤدي إلى عواقب خطيرة . فكلا الأمرين يتطلب استخدام تقنيات خاصة لاكتشاف العدوى أو التلوث المحتمل، وتلك التقنيات قد تشمل اختبارات تفاعل البوليميراز المتسلسل (PCR) لـ COVID-19 وأجهزة الكشف عن الإشعاع في حالة التلوث الإشعاعي. تقترح هذه الورقة إطارًا يمكّن من المراقبة الرقمية لحادث تلوث إشعاعي محتمل في منطقة مزدحمة ويساعد على تتبع حركة الأشخاص المعنيين. إن الهدف من هذا النظام المقترح هو التخفيف من المخاطر الناشئة عن انتشار التلوث الإشعاعي خلال السيناريوهات المحتملة. ويُقترح أن يتم تزويد الهواتف المحمولة بتطبيقات تمكّن من تتبع المخاطر المحتملة بسبب حوادث التلوث الإشعاعي وتقليل الوقت المطلوب لتحجيمها وزيادة كفاءة الاستجابة لحالات الطوارئ المشابهة.

Abstract

The latest COVID-19 pandemic has put the spotlight on the importance of a robust information network that can be reliable during such exceptional circumstances in which restrictions on movement are being in place. In crowd areas such as Makkah Al-Mukarramah, especially during Hajj seasons, several potential risks and accident scenarios should be evaluated and emergency plans should be prepared. This includes radiation emergencies in which population monitoring emphasizes ~~on~~ the identification, screening, measurement, and monitoring populations for exposure to radiation or contamination from potential radioactive sources. This involves decontamination process to people evacuated due to a large-scale radiation accident. This paper suggests a framework that enables to digitally monitor a potential radiological accident in a crowded area and track the movement of the involved individuals. The objective of this proposed framework is to mitigate the hazards arising from the spread of the radiation contamination during potential scenarios. The suggested framework of Digital Monitoring of Radiological Risks (DMRR) consists of four subsystems: mobile radiation detectors, radiological impact assessment, navigation and tracking systems, and emergency procedures application. It's proposed that a mobile application could be supplied with a feature that enables to track potential risks due to radiation contamination incidents. This system will help to identify the affected group of people in a potential radiological accident and eases the activation of the emergency plans in the contaminated area.

Keywords: digital monitoring, radiological risks, crowd safety management**.**

1. Introduction

Various environmental disasters have resulted in widespread of air pollution, such as the Bhopal chemical accident, Chernobyl and Fukushima Daiichi nuclear accidents. Local communities should be aware of the actual risks of such situations to avoid incorrect information and inappropriate reactions. Providing trustworthy sources of information would lead to lesser negative results of a certain accident. Experts such as scientists, engineers and medical practitioners, play major roles in providing the required qualitative and quantitative knowledge to the community about radiation measurements and radiation protection procedures in a potential radiological accident (Ishigaki et al., 2015).

The latest COVID-19 pandemic has put the spotlight on the importance of a robust information network that can be reliable during such critical circumstances in which restrictions on movement are being in place. There are several similarities between the spread of a disease such as COVID-19 and an accidental radiation contamination. Both are unseen hazards and have latent symptoms that could appear after a certain period of time after getting the infection or the radiation contamination. Contamination with radioactive materials, as well as COVID-19 infection, are not immediately life-threatening in most cases. The movement of people in both cases leads to more severe consequences. Both scenarios require special techniques for detecting probable infection or contamination, such as PCR tests for COVID-19 and radiation detectors in case of radiation contamination.

This paper suggests a framework that enables to digitally monitor a potential radiation contamination accident in a crowd area and track the movement of the involved people. The objective of this proposed system is to mitigate the hazards arising from the spread of the radiation contamination during potential scenarios. It's proposed that a mobile application could be supplied with a feature that enables to track potential risks due to radiation contamination incidents.

Radioactive contamination is the deposition of radioactive material into an object. Industrial radioactive materials in the environment cause pollution of water, soil, buildings and animals. The incidence of radioactive contamination can result from one of several ways, such as: a sabotage act in which radioactive materials are released, a severe accident in a nuclear power plant (NPP), a transportation accident involving radioactive sources, excessive radioactive releases from medical or industrial applications. Low levels of radiation do not cause harm to the human body, while high levels cause symptoms such as nausea, vomiting, diarrhea, swelling and redness of the face.

Usually, radioactive materials are transported with dust or rain in the air. Contaminated people carry traces of the radioactive materials through their clothes or shoes when they come into contact with seats or other people. The radioactive material can be internally transmitted from infected people through urine, blood and sweat. When another person comes into contact with these liquids, there will contamination with these radioactive substances (IAEA, 2021). A radiological incident response planning is based on the following principles (Radiation Studies Branch, 2014):

1. Rescue people first: Treating wounds and critical medical conditions take priority over treating contamination, and protection must be provided for emergency workers and responders.
2. Get rid of radioactive contamination by removing clothes, showering with water and soap.
3. Actions should be focused first on protecting the population and preventing the harmful effects of radiation. Decontamination comes next, especially when the population is seriously affected.
4. Expansion and flexibility are vital factors in the planning process: Contamination examination and radiological surveys would expand according to the screening criteria and available resources.
5. People's fear of radiation is usually high because it is related to unseen hazards. So, controlling the flow of the accident information and the required emergency actions are important factors in order to prevent the propagation of the accident consequences or other undesired situations such as stampede that happens sometimes in crowd gatherings.
6. One of the key entities for implementing and supervising the response plans of radiological emergency is the Nuclear and Radiological Regulatory Commission, where specialists and experts in the field of radiation protection can heavily contribute. Emergency response plans should be studied and periodically reviewed by health physicists and radiation safety officers.
7. Local officials and initial responders might not be primarily aware that a radiation accident has happened. The initial response of emergency and public health personals to an accident might be an all-hazards way. Nevertheless, once these workers have recognized that a radiological incident is in place, they have to start addressing the matters related to this certain type of incident.
8. Recommendations on radioactive decontamination differ from those for biological or chemical agents. Decontamination for biological or chemical agents must be accomplished instantly. In a radiation incident, however, individuals might be instructed to self-decontaminate at their accommodations or at a local reception center. Radiation decontamination should be performed ASAP, but it typically does not necessitate the same immediacy as biological or chemical contamination does.

Monitoring people in a crowded environment is a critical task. During different phases of Hajj, crowd monitoring in real-time is important in order to take immediate decisions to prevent potential risks (Abuarafah & Khozium, 2012). The spread of transmissible diseases like recent COVID-19 and other security matters have let the crowd management of large events more serious than ever before. Several challenges faced in managing crowd events can be minimalized by utilizing smart phone applications. These technologies are already being utilized in managing and administering several activities in our daily life (Yamin & Ades, 2009).

Population monitoring is a key factor in emergency response plans but it is often neglected during contingency planning. It's recommended to take this into consideration and emphasize on the training required and the equipment needed for the first responders in the accident site. Monitoring the population in radiological accidents requires examining people and measuring radiation doses and contamination from the radioactive materials. This requires the establishment of examination centers in the concerned areas. These centers should involve physicians, health physicists, emergency services personnel, mental health and psychiatric physicians, environmentalists, and risk analyzers (Radiation Studies Branch, 2014).

2. Methodology

This paper proposes a framework that enables monitoring digitally a potential radiation contamination accident in a crowd area and track the movement of the involved people. The objective of this proposed system is to mitigate the hazards arising from the spread of the radiation contamination during potential scenarios. Below are some points which the emergency planners should consider:

1. Gather the basic data from participants (pilgrims') prior to the event (Hajj).
2. Familiarize the identity card system and the entry permit to the site.
3. Identify detecting points (radiation detectors) and their locations.
4. Assign health check-up and emergency treatment centers.
5. Use the obtainable technologies such as: the RFID wristband to be worn and the integrated smartphone app carried by all participants.
6. Plan for appropriate arrangements for the isolation and decontamination of the potential affected participants by a radiological accident. The affected zones are determined by a simulation software such as HOTSPOT or HYSPLIT.
7. Introduce health tips and emergency arrangements by the library of the integrated smartphone app.

It's suggested that a mobile application could be supplied with a feature that enables to track potential risks due to radiation contamination incidents. The framework of this system is composed of four subsystems, as shown in Figure 1. The following subsections illustrate the components of this framework. This framework involves two parts. The first part includes early detection of high levels of radiation with modeling of the radiological impact assessment for this detection, and the second part involves the tracking system to the concerned population and the health and the emergency instructions care for the affected individuals.

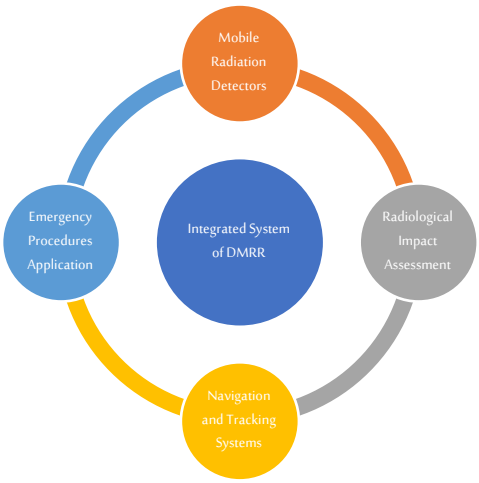

Figure 1. The proposed integrated system for Digital Monitoring of Radiological Risks (DMRR).

2.1. Mobile radiation detectors

In order to radio logically monitor a population-dense area, there is a need for a system of networked radiation detection that will be reconfigurable, agile, with capability of rapid threat assessment and a high degree of certainty and fidelity (Mukhopadhyay et al., n.d.). There will be a need for a series of low-cost and reliable mobile radiation detectors that can be used in emergency situations by individuals to monitor and share radiation measurements with the concerned groups. This proposed system is assumed to afford a style of practical model of radiation detection, which utilizes the features of participatory design and sensing, and employs recent communication platforms and open-source applications (Ishigaki et al., 2015). Radiological monitoring, scouting and inspection could be performed using drone radiation detectors (Pinto et al., 2021). It is proposed that these drone detectors will be digitally connected to a central monitoring unit to promptly detect any indication for high level of radioactivity.

2.2. Radiological impact assessment

Radiological impact assessment (RIA) includes the study of the effects of radioactive releases on the surrounding environment and population (IAEA, 2018). Evaluation of atmospheric dispersion and estimation of radionuclide release doses are vital for emergency planning. Nevertheless, evaluation of radiation doses received by the individuals at various receptor locations is crucial in order to secure safety for public and environment (Birikorang et al., 2015; IAEA, 2014). RIA results are also a necessary input for probabilistic safety assessment (PSA) that is performed to evaluate emergency arrangements in case of severe accidents which involve radioactive releases to the surrounding environment.

The atmosphere is one of the fastest mediums to transport radionuclides released from a potential accident to the environment and to the human body. So it is important to evaluate the impacts of these radionuclide emissions on the neighboring environment and the public prior to considering further protective actions (Zhang et al., 2014).

Radioactive releases diffuse through the atmosphere and could cause severe effects on the environment and public. So, selecting the proper atmospheric dispersion model for environmental impact assessment is of high importance for decision-makers (Cao et al., 2020). RIA could be performed utilizing specialized software codes such as HYSPLIT and HotSpot.

2.3. Navigation and tracking systems

In order to identify the location of a potential radiological accident, a navigation system would be linked to the proposed drone radiation detectors. Signals will be sent to identify the individuals in the affected area. It's assumed that all of the participants in the event are equipped with an RFID (radio-frequency identification) wristbands or having smartphones with a programmed application. Global Positioning System (GPS) will be required to identify the location of personals and tracking.

2.4. Emergency procedures application

It is necessary to afford a smart phone application that provides instructions for radiological emergencies to the ways to respond to them. One of the good examples of this application is REMM (Radiation Emergency Medical Management) that was released by the US Department of Health and Human Services. The purpose of this application is to:

- Afford instructions for health care staff about clinical diagnosis and radiation treatment injury during nuclear and radiological emergencies.
- Afford instructions for the wider community about subjects related to radiological emergency arrangements and responses.
- Afford just-in-time practical knowledge to make complex subjects comprehensible to those without specialized radiation scientific background.
- Afford a web-based version that is can be downloaded beforehand, so that it would be accessible during an emergency situation if the internet network is not available.

3. Results and Discussion

The objective of this section is to demonstrate the radiological impact from a hypothetical accident in which a fire happens and an Am-241 source is released in a large populated site within Makkah Al-Mukarramah, i.e., Mina, during Hajj season. The RIA includes estimation of radiation doses accompanying a radioactive material dispersal and deposition released from an accidental fire. This will present a guidance on a plan of action to support and guide decision-makers responding to such an accident.

The hypothetical scenario was simulated utilizing the HotSpot code for the selected radionuclide: Am-241. HotSpot is a software code that uses Gauss equations to predict and simulate radioactive releases at short ranges ~ 10 km and short term to establish emergency preparedness and response plans. The input parameters for this scenario are shown in Table 1 which includes information about the radioactive material and the relevant meteorological data such as wind speed and direction in the selected site. The outputs for this simulation as in Table 2 and Figures 2-5 provide a guidance for

decision-makers on the areas of relocation, evacuation and sheltering. It also identifies the affected area in which direct treatment for residents must take place. This will help to focus on the affected group of people who received the higher dose and avoid spread the fear of radiation among others which might lead to disturb the event and cause stampede that could result in another disaster.

The proposed integrated framework of the DMRR system will start from a signal of high dose rate from the drone radiation detectors. This will be followed by a rapid preliminary RIA. The navigation and tracking system will be activated to track the population in the affected area, and notifications will be sent through a smart phone application to make use of the instructions related to the emergency procedures and the required actions. This will help to identify: the group that needs urgent medical treatment; the group that needs screening and the group that needs to be isolated to prevent further spread of radiation contamination.

Table 1. Parameters of the radioactive material and the relevant meteorological data for a hypothetical scenario.

Material-at-Risk (MAR)	1.8500E+12 Bq
Damage Ratio (DR)	1
Airborne Fraction (ARF)	1.00E-02
Respirable Fraction (RF)	5.00E-02
Leakpath Factor (LPF)	1
Respirable Source Term	9.25E+08 Bq
Non-respirable Source Term	1.76E+10 Bq
Release Radius	1 m
Wind Speed (h=10 m)	1.00 m/s
Wind Direction	200.0 degrees Wind from the SSW
Avg Wind Speed (h=H-eff)	0.72 m/s
Stability Class (City)	C
Respirable Dep. Vel.	0.30 cm/s
Non-respirable Dep. Vel.	8.00 cm/s
Receptor Height	1.5 m
Sample Time	10.000 min
Breathing Rate	3.33E-04 m^3/sec

Table 2. Results from HotSpot indicate information about the maximum dose distance and maximum TEDE.

Maximum Dose Distance	0.010 km
Maximum TEDE	13 Sv
Inner Contour Dose	1.0 Sv
Middle Contour Dose	0.050 Sv
Outer Contour Dose	0.010 Sv
Exceeds Inner Dose Out To	0.034 km
Exceeds Middle Dose Out To	0.13 km
Exceeds Outer Dose Out To	0.27 km

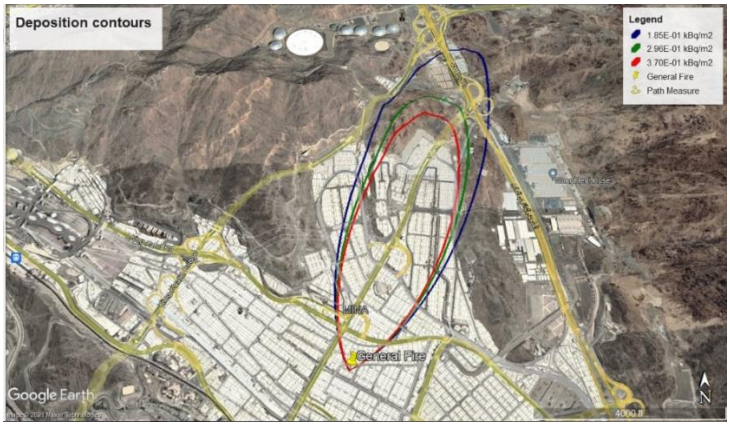

Figure 2. An output from HotSpot showing the deposition contours in kBq/m2. The contour in red color shows the highest deposition concentration, followed by the contours in green and blue, respectively.

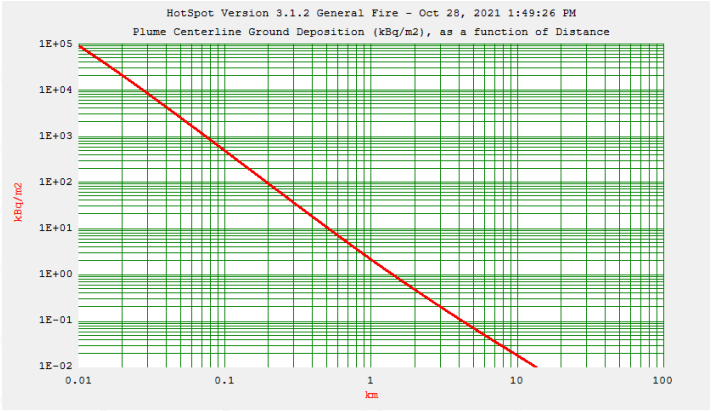

Figure 3. An output from HotSpot showing the ground deposition (kBq/m2) plume centerline as a function of distance.

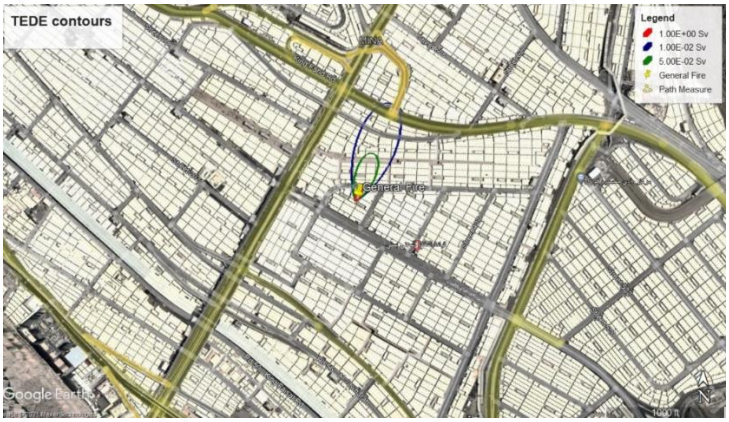

Figure 4. An output from HotSpot showing the contours of the Total Effective Dose Equivalent (TEDE).

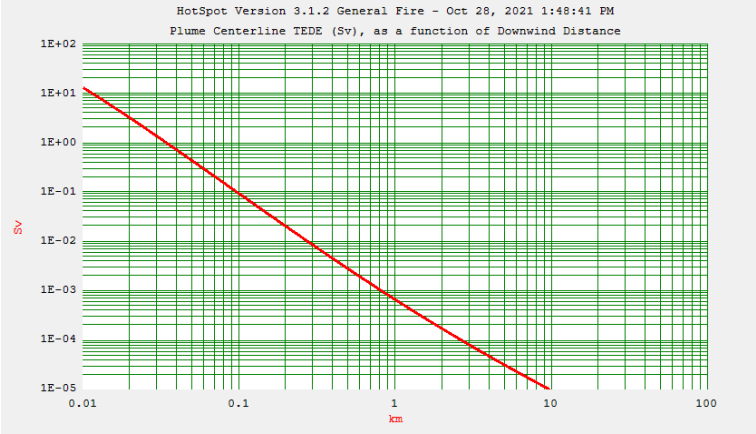

Figure 5. An output from HotSpot showing the TEDE (Sv) plume centerline as a function of downwind distance.

4. Conclusions

This paper addressed the importance of proper planning for crowd management and population monitoring. Several risks and threats should be assessed and appropriate and practical solutions should be worked out for such events. One of the potential risks are radiological accidents in a densely populated area in which radioactive contamination could spread. A hypothetical scenario of a radiological accident in which a fire happens and an Am-241 source is released in a large populated site within Makkah Al-Mukarramah, i.e., Mina, during the Hajj season. The radiological impact assessment includes estimation of radiation doses accompanying a radioactive material dispersal and deposition released from an accidental fire. This will present a guidance for a plan of action to support guide decision-makers responding to such accidents.

5. Recommendations

It is recommended to build an integrated framework of Digital Monitoring of Radiological Risks (DMRR) that consists of these subsystems: mobile radiation detectors, radiological impact assessment, navigation and tracking systems, and emergency procedures application. It is suggested that a mobile application could be supplied with a feature that enables tracking potential risks due to radiation contamination incidents.

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Pilgrims Housing Rental System based on blockchain Technology in line with reshaping the future of Smart Hajj

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استخدام تقنية البلوك تشين لنظام إيجار إسكان الحجاج القائم بما يتماشى مع الحج الذكي

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الملخص

حديثاً، في عصر التحول الرقمي في قطاع الإسكان زاد الاهتمام بالتقنيات التي تدير المعاملات وتحفظها ومنها على سبيل المثال تقنية البلوك تشين. حيث تعمل هذه التقنية على استحداث قاعدة بيانات تشكل سجلاً كاملاً لكامل المعاملات التي تحدث خلال عمليات الايجار وذلك ضمن شبكة موزعة رقمية. تهدف هذه الدراسة إلى تقديم مقترح لتطبيق تقنية البلوك تشين لقطاع الايجار في سكن الحجاج في مدينة مكة المكرمة. إيجاد هذا المقترح سيعزز من الخدمات المقدمة للحجاج من خلال زيادة الكفاءة التشغيلية للعمليات التي يشارك بها الحجاج خلال رحلة الحج. المنهجية المطبقة لهذا البحث هي منهج دراسة الحالة لأنها الطريقة المناسبة للتعرف على الآلية الحالية للإدارة في نظام إيجار مساكن الحجاج. تقدم الدراسة أيضًا نظاما ذكيا لإدارة منظومة إسكان الحجاج بطريقة تقنية وتقليل عدد الوسطاء المتداخلين في نظام الإيجار. يضمن هذا المقترح تبادل للمعلومات رقميا وتبادل القيم واتمام المعاملات بطريقة صحيحة ودقيقة كما يتميز بالشفافية والموثوقية، لذلك فهو يعمل على إدارة وتأمين المعاملات عبر الإنترنت حيث ستتغلب تكنولوجيا البلوك تشين على مركزية الآلية الحالية. بالإضافة إلى أنه يوفر العديد من الميزات التي تخدم هذا القطاع وتسهل عملية إدارة المعلومات بكفاءة لهذا الغرض، لذا فإنه يوفر بيئة آمنة لتخزين المعلومات وتنظيمها وتبادلها واسترجاعها في أي وقت حسب الحاجة.

Abstract

The Kingdom of Saudi Arabia seeks to achieve digital transformation for all its sectors by 2030. The Blockchain has increased attention in all sectors in the age of digital transformation where it manages transactions and saves them in a database that forms a complete record for these transactions within a distributed network. Blockchain technology is one of the most important modern practices that allows the exchange of value and the completion of transactions digitally and ensure the validity and accuracy of transactions. It is also characterized by transparency and reliability, so it works to manage and secure transactions through the Internet. Blockchain technology overcomes the centrality of the existing

mechanism. In addition, it provides many features that serve this sector and facilitate the process of information management efficiently. To that effect, it provides a secure environment for information storage, organization, exchange, and retrieval. This study aimed to present a proposal for Blockchain technology application in the current Pilgrims Housing Rental System (PHRS) in the Unified Portal for Hajj system. The reasoning behind choosing this service lies in its importance and the production of a huge number of transactions and information that will be used in the study. OCEANX (2021) noted that Makkah City has over 1500 hotels. In addition, to enhance the services provided for the pilgrims by increasing the operational efficiency of the processes that pilgrims are involved in during their journey of Hajj. The implemented methodology for this research is a case study supplemented by interviews methods to identify the current mechanism of management in the pilgrim's housing rental system. In addition, the study offers a proposal to implement Blockchain technology for the management of the rental process.

Keywords: blockchain, Rental, System, Housing, technology, Hajj.

1. Introducing:

The twenty-first century is an information age, and data are becoming increasingly valuable. In a standard Internet application, there are typically more users and data to obtain higher economic value, and this data can only be managed by one organization. Internet applications with large enough listings and users who may freely adjust the listing price (Yu, Dong, & Guo, 2018), control the market, and even create a monopolistic house rental market, have this problem (Zhuang, 2017). The publishing and presentation of listings information are insufficient to meet the demands of the landlord and the tenant. The tenant and the landlord would normally use a classical lease agreement to protect their assets during the lease; however, the two parties' funds utilize third-party payment instruments in the transaction process of turnover, which cannot guarantee the realization of irreversible transactions or fully store the transaction records generated during the lease period, making it easy for both parties to create inevitable coordination disputes. The drawbacks of the present rent areas, such as centralized access management and the inability to manage the leasing process systematically, can be solved using blockchain technology. The blockchain employs peer-to-peer technology (Yu, Xu, & Liu, 2017), allowing for the development of decentralized applications (Wilkinson et al., 2016). Proof of work (POW) (Gupta, Saia, & Young, 2017) is a technique for ensuring that the stored block information cannot be tampered with (Cheng et al., 2018). The introduction of blockchain also paved the way for smart contracts. A blockchain network is a novel decentralized infrastructure and cloud computing model that programs and manipulates data using an automated scripting language.

The Kingdom of Saudi Arabia seeks to achieve digital transformation for all its sectors by 2030, and digital transformation means investing in technology to transform traditional work into electronic. Blockchain technology is one of the most important modern approaches that allow the exchange of value and the completion of transactions digitally and ensure the validity and accuracy of transactions. to preserve information in a decentralized manner, and to organize it in a cascading chain linking different information and transactions of the same thing; In the sense that the information of a plot of land can be retrieved since the creation of its instrument to the last person who owned it in a coherent and sequential manner, through which this information is also exchanged between the parties to the network, and allows access and retrieval, and therefore it is concerned with information since its inception, through its organization and

preservation to its availability, So it can be considered as one of the techniques that help in information management. The use of this technology in the real estate rental sector contributes to achieving digital transformation, as well as providing many advantages that facilitate digitally managing a process in the Kingdom of Saudi Arabia (Al-Rahili & Al-Dahwi, 2020). Therefore, the current research was carried out with the aim of emphasizing the importance and necessity of using blockchain technology to develop systems for renting pilgrims' housing and thus enhancing the services provided to pilgrims by increasing the operational efficiency of the operations in which pilgrims participate during the Hajj journey. Also, it facilitates the processes of issuing permits of the premise for the landlords to host pilgrims.

2. Blockchain Applications in housing market

Xue et al. (2021) built a housing lease Alliance chain utilizing blockchain technology and encryption algorithms. Smart contracts allow the landlord and tenant to establish lease agreements, decide the lease relationship, pay and collect rent on a regular basis, and refund the due money, when it is due. The accredited department node and the record management node are introduced in the Alliance chain network design to authenticate the authenticity of the house source and personal identity data, backup the lease project details, record the housing rental situation, and attain the impact of safe leasing. This strategy avoids the need for mediation, saves money, provides clear home rental information, and allows for government market oversight. Qi-Long, Rong-Hua, and Fei-Long (2019) suggested a blockchain-based solution for house rental systems that would allow the peer-to-peer exchange of listings information without the use of a middleman. Their system turns traditional lease agreements into smart lease agreements programmatically, improving the leasing process' effectiveness and storing transaction records for the leasing process to provide constitutional protection to tenants and landlords. This system makes use of developing technologies such as smart contracts and IPFS (Inter-Planetary File System). The IPFS protocol is used to store listings data. A smart lease agreement is created to make the house rental process traceable and visible, and it uses Ethereum's Smart Contract to handle the hash of IPFS listings data. Rajendar et al. (2020) proposed a distributed-record-keeping mechanism for home rental systems between tenants and property owners based on blockchain technology.

It ensures the integrity of digital transactions and enables peer-to-peer information sharing without the use of intermediaries. Hyperledger Sawtooth is used to implement the suggested system. Throughout the leasing process, the smart contract captures all transactions as well as the data of both the renter and the property owner, assuring security for all parties. Alotaibi, Alsaigh, & Yamin (2019) recommend that current technology should be used to efficiently control and handle permits and visas. They recommended, in particular, a system that would leverage Blockchain technology and a smart contract platform to better manage Hajj and Umrah permits and visas, as well as effectively address the issue of fraudulent documents. Because Saudi Arabia's Vision 2030 aims for a thirty-million-strong pilgrimage, this study came at an ideal time to tackle the threat of fraudulent documents.

3. Blockchain structure

A blockchain structural form is a chain structure in which each block is linked to the next. The hash procedure is used to join the blocks. Hashing is a one-way, irreversible process. The transactions packed by blocks will be determined once a particular number of blocks have been created. The tenant must generate forks to change the block production direction

if you want to nullify the original block record. The blockchain network's participants use a consensus process to package the transaction records acknowledged by the participating nodes into the chain (Fu, Wang, & Shi, 2021).

Furthermore, it is decentralized, allowing for the elimination of middleman services and a one-to-one handover between the landlord and the tenant. Private landlord nodes, tenant nodes, rental business nodes, public rental housing nodes, certification department nodes, and record management nodes all join the network and participate in the leasing process based on the Alliance chain architecture (Cai & Deng, 2019). Simultaneously, the online agreement is reached and implemented automatically based on the programmable smart contract, saving time and effort and facilitating market management (Yu et al., 2019). In The following explain the internals of blockchain in details:

Block

The block header and body are the two parts of a block. Specifically, the block header contains:

1. Block version: specifies which set of block validation criteria should be used.
2. Ions in the block.
3. Timestamp: the current time has been expressed in seconds in universal time Since January 1, 1970.
4. N-Bits: target threshold of a valid block hash.
5. Nonce: a four-byte field that normally starts with 0 and grows with each hash calculation.
6. Parent block hash: A 256-bit hash value pointing to the previous block.

A transaction counter and transactions are included in the block body. The maximum number of transactions that can be contained in a block is determined by the block size as well as the size of each transaction. To ensure that transactions are authenticated, Blockchain employs an asymmetric cryptography approach (Nomura Research Institute, 2015). In an untrustworthy environment, a digital signature using asymmetric cryptography is utilized. Following that, the researchers will go into digital signatures in a little more detail.

Digital Signature

A private key and a public key are owned by each user. To sign the transactions, the private key, which must be kept private, is utilized. The transactions that have been digitally signed are disseminated across the whole network. The signing and verification processes of a typical digital signature are split into two parts. A user named Alice, for example, wishes to send a message to another named Bob.

1. During the signature step, Alice encrypts her data using her private key and delivers the encrypted result as well as the original data to Bob.
2. Bob verifies the value using Alice's public key during the verification step. Bob could simply check if the data had been manipulated in this way. The elliptic curve digital signature technique (ECDSA) is the most common digital signature algorithm used in blockchain (Johnson, Menezes, & Vanstone, 2001).

4. Key Characteristics of Blockchain

In conclusion, the following are the fundamental properties of the blockchain (Zheng et al., 2017):

- **Decentralization:** Each transaction in traditional centralized transaction systems must be validated by a central trusted agency (for example, the central bank), leading to cost and performance bottlenecks at the central servers. In contrast to the centralized option, blockchain does not require the use of a third party. Consensus algorithms are employed in blockchain to keep data consistent across a distributed network.
- **Persistency:** Invalid transactions would not be accepted by honest miners because they can be validated immediately. Once a transaction is incorporated into the blockchain, it is nearly impossible to erase or reverse it. Invalid transaction blocks could be identified right away.
- **Anonymity:** Each user interacts with the blockchain using a randomly generated address that conceals the user's true identity. Due to the inherent constraint of blockchain, it is impossible to provide absolute privacy protection.
- **Auditability.** The Unspent Transaction Output (UTXO) model is used to store data on user balances on the Bitcoin blockchain: Any transaction must reference some previously unspent funds. The state of those referred unspent transactions changes from unspent to spent once the present transaction is recorded into the blockchain. As a result, transactions could be easily tracked and validated (Nakamoto, 2008).

5. Taxonomy of blockchain systems

There are three types of blockchain systems now in use: public blockchain, private blockchain, and consortium blockchain (Buterin, 2019):

- In a **public blockchain**, all records are exposed to the public, and anyone can participate in the consensus process. A consortium blockchain, on the other hand, would only allow a small number of pre-selected nodes to participate in the consensus process. In the case of a private blockchain, only nodes from a single company would be permitted to participate in the consensus process.
- A **private blockchain** is considered a centralized network because it is completely controlled by one company.
- The **consortium blockchain** created by numerous organizations is partially decentralized because just a small percentage of nodes are chosen to determine consensus.
- **Consensus determination:** Each node in a public blockchain might participate in the consensus process. In a consortium blockchain, only a limited number of nodes are responsible for validating the block. In the case of a private chain, it is entirely controlled by one entity, which can decide on the ultimate consensus.
- **Read permission:** A public blockchain transactions are open to the public, whereas a private blockchain or a consortium blockchain transactions are private.
- **Immutability:** It is practically hard to tamper with transactions in a public blockchain because records are stored by a large number of people. In contrast, because there are a restricted number of participants in a private blockchain or a consortium blockchain, transactions can be readily tampered with.

- **Efficiency:** Because there are so many nodes on the public blockchain network, propagating transactions and blocks take a long time. As a result, transaction throughput is constrained, and latency is excessive. Consortium and private blockchain could be more efficient with fewer validators.
- **Centralized:** The primary distinction between the three types of blockchain is that public blockchain are decentralized, consortium blockchain are partially centralized, and private blockchain are entirely centralized because they are managed by a single entity.
- **Consensus process:** The consensus process of the public blockchain might be joined by anyone on the globe. Both consortium and private blockchain are permissioned, unlike public blockchain.

Because public blockchain is accessible to the entire world, it can attract a large number of users and active communities. Every day, new public blockchain arises. The consortium blockchain could be used in a variety of business applications. Hyperledger is now working on blockchain frameworks for business consortiums. Ethereum has also made tools available for creating consortium blockchain (Zheng et al., 2017).

6. The disadvantages of blockchain

Despite the importance of blockchain technology, it has many problems, most notably the following (Sarmah, 2018):

- Because each node in the blockchain repeats a process to establish consensus, blockchain are expensive and resource-demanding.
- Users authenticate transactions on the blockchain using certificate authentication, land titles, cryptocurrency, and other methods. However, even if both parties are willing to reverse the transaction or if the transaction does not work for whatever reason, there is no method to do it.
- Only when all of the nodes on the blockchain have successfully verified the transaction is the transaction finalized. This could be a lengthy procedure because the block inserted must be confirmed by all nodes for the transaction to be marked as valid. A novel concept known as a lightning network, which allows transactions to be validated instantly, could be a viable answer to this problem.
- When a block is added to the blockchain, it expands in size. To participate in validating transactions, a node must keep the complete history of the blockchain, which causes the blockchain to grow over time. Because the viability of a blockchain is based on the number of nodes in the network, it will expand faster if it has huge blocks. This will split the miners and have an effect on the blockchain viability.
- One of the downsides of blockchain is its difficulty in understanding the average person. Blockchain is full of complex concepts and processes that have yet to be perfected so that knowledge on how to use it, can be simply digested and consumed by the average person, and so it is not yet ready for widespread adoption.
- When distributed ledgers are utilized in sensitive situations, including dealing with government data or patients' medical data, all transaction-related information is publicly visible on the blockchain, which can be a significant disadvantage. The ledgers should be changed, and only those with valid clearance should have access.

7. Makkah housing and existing rental system (challenges and opportunities)

The Kingdom of Saudi Arabia (KSA) has excellent infrastructure and provides all of the amenities, technologies, and other elements that modern visitors require. Visitors should educate themselves with fundamental information, just as they should in other countries, in order to make their stay as pleasant as possible. In order to achieve its Vision 2030, the Saudi government is implementing technology to deliver high-quality care services, specifically for Hajj and Umrah pilgrims. It aims to double the number of Umrah pilgrims to 15 million by 2022 and 30 million by 2030. By 2030, the number of Hajj pilgrims is expected to reach five million (Alotaibi, Alsaigh, & Yamin, 2019).

In light of the digital and technological developments that the world is witnessing today, the Ministry of Hajj and Umrah in the Kingdom of Saudi Arabia has developed a unified electronic portal for pilgrims at home and abroad. It is a network designed to collect all information from different sources in a unified manner, and each piece of information is presented in the form of pages, so that the user can choose what he wants to display from the information available in the portal. This portal provides many services such as guarantees and contracts, including housing contracts, renting, issuing visas, and others.

The current mechanism in managing the real estate rental sector in the Kingdom of Saudi Arabia is centralized in the presence of a real estate broker managing this process, and now we need to abolish centralization in this type of contract. The use of blockchain technology allows eliminating the role of the real estate broker and guarantees the authenticity of data and maintains its security (Al-Rahili & Al-Dahwi, 2020).

8. Problems of managing a rental system based on centralized smart transactions

Despite the fact that service providers participating in the leasing process have improved their services to better serve their consumers, the existing method still has certain flaws for a variety of reasons, the most notable of which are listed below (Zyskind & Nathan, 2015; Varfolomeev, Alfarhani, & Oleiwi, 2021):

- Using a real estate broker to manage the process. The system cannot function without a real estate broker because it is entirely reliant on the broker, which means that it is at the center of the process rent, which is the input to the data, and it is documented and approved for the validity of the data, in fact, there is no control over the real estate broker to ensure the accuracy of the data entered, and due to the existing mechanism's lack of transparency, the process is completed by a single broker.
- The system prevents the renter from searching for available real estate units, therefore the tenant must rely on data and information about the property provided by the real estate broker or the lessor himself, which may be inaccurate or incomplete.
- The difficulties with financial transfers, as well as the lack of transparency and the failure of all parties to view uniform facts, make this type of system full of bumps that stymie transactions.
- Confidence and safety. Because of the possibility for falsification of legal documents and the distribution of printed copies of personal documents with unknown parties like real estate brokers.

- The method is slow. This is due to the necessity to visit many entities to finish the procedure, as well as the fact that each step must be completed manually.

Conversely, blockchain technology can fix these issues by having a single decentralized ledger. A single, decentralized peer-to-peer ledger will allow the owner to have more control over the data and the tenants can access more reliable data at a lower cost.

9. Research Methodology:

This section presents the methodology used to collect the data and address the research aim. The methods used in this research are presented in (Figure 1). After reviewing the related literature, a case study method is used (which falls under the descriptive approach), where the Pilgrim Housing Rental System (PHRS) that provided by The Ministry of Hajj through their Unified Portal System for Hajj in Makkah Saudi Arabia is studied and analysed.

After that, four interviews were supplemented the study to have wider perspective. In order to choose the right interviewees, to participate in this study, a set of criteria are established; Expert landlords in the Hajj market were identified, dealt with various pilgrimage nationalities, Witnessed the evolution of the pilgrims' housing system and become familiar with the current rental system which is the Pilgrims Housing Rental System (PHRS) in the Unified Portal for Hajj system and having more than five premises. Then, a distinctive proposal of Blockchain technology is used in this field to develop the current system in a way that fills the gaps in it, and ensures the achievement of greater advantages and benefits in line with the digital transformation that Saudi Arabia is living in right now.

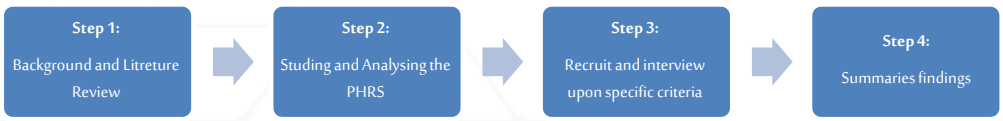

Figure 8: adopted research process.

10. Data Results

The Ministry of Hajj has clarified guidelines for pilgrims' housing service providers called Pilgrims Housing Rental System (PHRS), with lines to be followed for contracts to be approved and documented in the Ministry. The model consists of three stages, and it is very important to note that the workflow of the housing provider representative is formed as the figure 2 below in a sequential manner. For example, Workflow 2 can only be executed when Workflow 1 is completed, and Workflow 3 also cannot be executed unless Workflow 2 is completed in the model. As discussed with interviewees, the model has been applied since Hajj season 2012 and still working until now. The modification for the Blackchin will be located between stage 2&3 in the existing model.

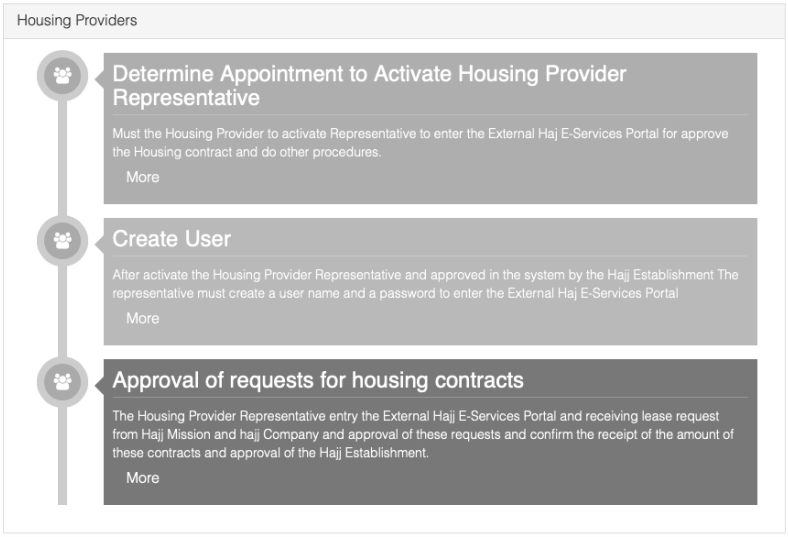

Figure 9: Existing Model

Stage one:

The landlord seeks to login to the Pilgrims Housing Rental System (PHRS) in the Unified Portal for Hajj system by determines an appointment to activate housing provider account. By that, filling the basic information of the landlord or representative of the housing provider which includes the Hajj housing permit number and IBAN bank account details. Next, detail information regarding the property such as the Property deed, location, various pictures of the property including the rooms are filled and uploaded. After that, the landlord chooses an appropriate appointment for him to attend it in the Ministry of Hajj with the required documents to activate his account.

Stage Two:

After checking the documents and approve it in the system by the Ministry of Hajj. The landlord or representative have to create a username and a password to enter the Pilgrims Housing Rental System (PHRS) in the Unified Portal for Hajj system. **The gap of this study is clearly lining here as the property information were not showed to the expected tenants (Hajj Company)**

Stage Three:

The landlord waits to receive requests from Hajj Company (tenant) for housing contracts. **This creating instability in the hajj properties market as the landlord and the tenant are searching for each other as well as seeking initial agreement through Real Estate Broker.** Then, he either refuse or approve these requests and confirm the receipt of the amount of these contracts after the approval from the Ministry of Hajj. Which means, by the landlord acceptance of the contract, the money will be transferred from the Hajj Company (tenant) to the Ministry of Hajj which hold form the contract amount (15%) as deposit then the rest of the amount will be transfer to the landlord and a receipt is issued. The deposit is for the landlord to fulfil the requirements until the end of the contract then transferred to him. The time taken from the landlord approval to receiving (85%) of the contract takes around 4-6 minutes.

The proposed mechanism for applying blockchain technology to manage the rental and linking process.

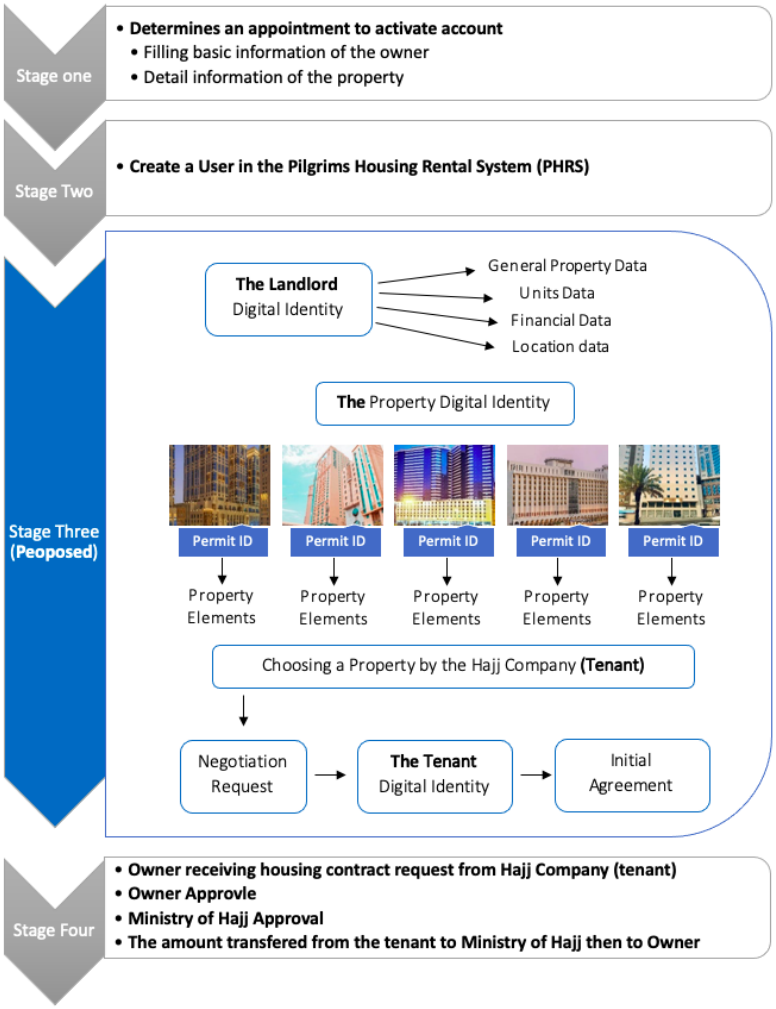

Figure 10: Prposed Model

a. Eliminating brokers

Existing model: the current system stage 2 is depending on the landlord to searches for tenant and market for the prices and the location. In this method, landlord rely on real estate brokers to find them tenants, and this makes the broker the controller and dominator of the market. Thus, the broker is the one who evaluates the property and often shares large proportions from the landlord's profit percentage.

Solution provided by the Blochian: Abolishing the role of the real estate broker as shown in stage 3 Figure 3 above where Blockchain is a (peer-to-peer) network, so the completion of a process within it is between the two parties without the presence of third-party operation, dependent on the devices in the network and the information provided about the property available in the model. This by default will eliminating all the expanses assign for the

brokers in the old model. Also, this stage will ensure the validity of operations without the presence of a third party to approve and document this process. This also will be allied with facilitating the entire process of controlling the financial operations that take place within the blockchain, and thus monitoring all the financial amounts that take place during the housing rental process.

b. Providing a channel for the available properties

Existing model: the current system stage 2 is depending on the tenant to search for available property, and the tenant depends on the provided data and information obtained through the broker or the lessor himself. This process also secondary with that mush of the information may be incorrect, or incomplete.

Solution provided by the Blochian: As shown in stage 3 the Blochian provides a channel for the available properties ensuring confidence in the displayed data. The technology allows the information to be added by the landlord in a way that allows managing that data and controlling access to it while ensuring trust and credibility. The process started with the landlord to enter the digital identity and provide all the information about the available unites, data specifications, prices, and location. The tenet after that will be allowed to search for the appropriate choice. At this stage, some features are available in the search process, such as: search by, sorting according to the age, the area, the size of the unit, etc.

c. Collecting payment

Existing model: the current system stage 3 is depending on traditional way of collecting money where the Hajj Ministry deduct the amount form the tenant to hold 15% of the amount as an insurance and transfer the rest to the landlord account. The system doesn't provide any mechanism for refunding amounts Insurance as well as, not deducting the VAT TAX for the contract.

Solution provided by the Blochian: Creating a lease contract through the blockchain allows the automatic collection of the rental amount according to the agreement contained in the smart contract (rent value, payments and payment dates), so the amounts are automatically transferred from the tenant to the lessor.

11. Discussion:

The tokenization function of blockchain technology is ideal for this use case since it is a necessary feature for the processing of transactions and the updating of property ownership registries and transfers. Blockchain technology's distributed architecture enables the integration of process transactions while keeping a single view and uniform updates to the required data. This capability also addresses transaction transparency, since the blockchain allows for greater visibility of transaction history and chain of custody. By facilitating speedier transactions, the distributed design minimizes the cost and complexity of the operations. Furthermore, blockchain technology's provenance and the cryptographic integrity of transactions encourage increased trust in the details for the entire chain of custody and property transaction. Moreover, the blockchain smart contracts can help with process automation and streamlining multiparty operations, reducing complexity and the time it takes to provide a service to a customer. Furthermore, the user digital identity, which is a component of blockchain technology, aids in the elimination of physical documents and allows for digital signing, which improves the rental process' speed and efficiency.

Based on the blockchain technology of encryption algorithm, this paper constructs a housing leasing Alliance chain. The landlord and tenant sign lease agreements through smart contracts, determine the lease relationship, pay and collect rent automatically on a regular basis, and return the rental right when due. In the design of the Alliance chain network, the certification department node and the record management node are introduced to authenticate the authenticity of the house source and personal identity information, and backup the lease contract information, register the housing rental situation and achieve the effect of safe leasing. This method eliminates the mediation, less cost, clear housing rental information, and is conducive to government market supervision.

12. Recommendations

Based on the foregoing, the current research recommends the following:

- Providing high quality services to the pilgrims.
- Facilitating the hosting for the pilgrims and providing sufficient information to enable them to take appropriate decision before they set out in their journey.
- The necessity of developing the current leasing system in Saudi Arabia using blockchain technology.
- Conducting more studies and research related to the application of blockchain technology in the development of smart systems.
- Adopting educational curricula for creating, programming, and using blockchain technology in Saudi Arabia.
- Establishing blockchain platforms to manage real estate operations in Saudi Arabia, such as the rental process, digitization of assets, transfer of ownership, and land registration.

13. Summery

The rental market is one of the most important worldwide industries for any country's economic development. The expansion of this industry is highly supported by the expansion of the corporate environment, which includes increased demand for office space, industrial plots, housing units' accommodations, agricultural areas, and so on. Nevertheless, the real estate industry world is hampered by a lack of transparency in transactions like leasing, purchasing, and selling, as well as a failure to achieve integrated data confidentiality and authenticity. Many areas of its operations, including property selling prices, sale history, lease rental rates, market valuation, and so on, are expected to see an increased need for transparency, data integrity, and security—in other words, a trusted environment. As a consequence, property-related data can be digitized and stored in a decentralized database of records on dispersed platforms, reducing the risk of fraud and mistakes. Mutual deception and concealment throughout the sale, rental, and lease processes can be removed, resulting in real estate ownership digitization. By implementing blockchain numerous benefits into everything from real estate investment decisions to property selection, it may become standard practice. The goal of this article is to transform the time-consuming, paper-based system of ownership and rental into a next-generation computerized system based on blockchain technology.

A blockchain is a series of blocks that, like a traditional public ledger, store a comprehensive list of transaction records. With the rise in popularity of digital crypto currencies, blockchain has arisen as a new decentralized infrastructure and

distributed computing paradigm. It can reduce friction and risk while also reduces the ability to refund or cancel transactions. The open history of transactions is recorded in a decentralized peer-to-peer network.

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