User need and experience of Hajj mobile and ubiquitous systems: Designing for the largest religious annual gathering

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Abstract: The Hajj pilgrimage is one of the largest annual events in the world. Each year, millions of Muslims visit the holy sites in Makkah. While Hajj mobile applications that help pilgrims perform Hajj activities efficiently are gaining popularity, little has been done to investigate pilgrims’ needs and their experiences of these applications. During the 2017 Hajj season, we conducted a study to investigate the needs and experiences of Hajj mobile service users. We used a questionnaire to investigate the need for 20 Hajj mobile features and found that maps (particularly offline maps) were the most needed feature. We also interviewed 16 pilgrims to investigate user experience (UX) of Hajj mobile applications. Three major themes emerged from our qualitative analysis of the perceptions reported by our participants: UX problems with the current mobile applications, the importance level of application features, and opportunities for improving the UX of applications. We relate these themes to specific implications for designing a better UX of mobile applications used for Hajj and its related domain (religion) and to applications for use in similar contexts (e.g., crowd and movement situations).

Subjects: Computing and Information Technology; Human–Computer Interaction; Mobile Information Systems

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PUBLIC INTEREST STATEMENT

Mobile software products are used widely to support religious practices across different religions. Islam is one of the main religions that dominate mobile applications dedicated to spiritual purposes. Several applications have been developed to support pilgrims in performing the rituals of Hajj (the annual Islamic pilgrimage). While user experience design is the key determinant of the success and the acceptance of products, there is not yet adequate research by the human–computer interaction community on religious-oriented mobile applications, including those used during Hajj. This article describes the user needs and experiences of Hajj mobile applications, based on data gathered via a questionnaire and an interview. The work also highlights user experience design considerations for mobile applications used for Hajj and their related domains and contexts of use.
1. Introduction

A pilgrimage is a ritual journey that a person undertakes in search of moral and spiritual relief. There has been a growing number of people participating in pilgrimages within different religions (Alliance of Religions and Conservation, 2014). Hajj is an annual Islamic pilgrimage to the city of Makkah, Saudi Arabia. This pilgrimage is one of the five pillars of Islam. Muslim adults who are physically and financially capable must perform Hajj at least once in their lifetime. Hajj is the largest annual religious gathering in the world. Millions of pilgrims from all over the world participate each year (Brunn, 2015; Jamil, Basalamah, Lbath, & Youssef, 2015). Around 2.3 million pilgrims performed Hajj in 2017 (1438H as per the Islamic calendar) (General Authority for Statistics, 2017).

Mobile technology is used widely to support different spiritual purposes across different religions (Campbell, 2006, 2010). In Islam, several applications have been developed to help pilgrims perform Hajj rituals efficiently (Khan & Shambour, 2017). However, limited research has been performed to investigate pilgrims' need for features implemented in these applications and the user experiences (UXs) of these applications.

While conducting this research during the 2017 Hajj, we heard many reports of problems with Hajj mobile services experienced by pilgrims. One of these reports was by Ahmed, who went to Hajj with his 70-year-old mother and 45-year-old sister. On one of the Hajj days, Ahmed and his family went out to perform a specific Hajj activity. To return to their tents, they used the map feature in the Hajj mobile application that Ahmed had downloaded. However, the map service kept updating the path frequently because of fluctuations in network connectivity. Because of this, they spent approximately four hours walking and searching for their tent. Their tents were not far from where they were lost—less than 500 m away. The health of Ahmed’s mother and sister, both of whom had diabetes, was affected and remained unstable for three days because of the time they spent walking and searching for their tent.

Less research has been conducted by the human–computer interaction (HCI) community on religious-oriented mobile applications, in particular, in the domain of Hajj mobile applications. Our study sought to investigate user needs for features that are used in Hajj applications and to inspect UX of these applications. We attempted to answer the following questions:

RQ1. What is the level of need for features used in Hajj mobile applications?

RQ2. What are the current UX problems with Hajj mobile applications?

RQ3. What is the level of importance for features used in Hajj mobile applications?

RQ4. What are the opportunities for improving the UX of Hajj mobile applications?

We investigated these questions through an analysis of 65 responses to a questionnaire and 16 interviews with pilgrims. Our aim was to contribute to the body of knowledge of HCI in the domain of digital religion in general, and digital Hajj in particular, as well as HCI in specific contexts of use (e.g., in a large group environment).

Our study focused on a group of domestic pilgrims living in Saudi Arabia, leaving the exploration of foreign pilgrims' need for and experiences of Hajj mobile applications for future studies. Domestic pilgrims represented around 25% (600,000) of the total pilgrims in 2017 (General Authority for Statistics, 2017).
2. Background

2.1. What is Hajj?

In this section, we discuss some aspects of Hajj to explain the context of this paper. The Hajj occurs in the last month of the Islamic calendar (Dhu al-Hijjah), for a period of six days, from the 8th to the 13th (or, in some cases, for five days, ending on the 12th). There are a number of rituals performed during Hajj. The Tawaf ritual (an Arabic term for circumambulation or circling) requires pilgrims to circle the Kaaba—a building at the center of the Masjid al-Haram (the sacred mosque)—counterclockwise seven times (Al-Uthaimeen, 1992). The Tawaf ranges approximately from 1.4 km to 4.1 km, depending on the crowd and which floor it is performed, and how close is a person to the Kaaba (Sridhar et al., 2015). Figure 1(a) shows the Tawaf activity on the last day of the 2017 Hajj. Sa’ay, another ritual, requires pilgrims to walk back and forth between two hills (Safa and Marwah) seven times (Al-Uthaimeen, 1992). The ritual walking begins at Safa and ends at Marwah. A walk from Safa to Marwah is counted as one walk and from Marwah back to Safa is counted as another walk. This continues until seven walks are completed with an approximate distance of 2.8 km (see Figure 1(b)). A pilgrim performs Tawaf and (in some cases Sa’ay) upon arriving at Makkah, on the third day, and before leaving Makkah. Pilgrims also perform other activities during Hajj, such as standing in the area of Arafat (Figure 1(c)) and devil stoning—in which pilgrims throw pebbles at a three-walled pillar called Jamarat at Mina (Figure 1(d)). Hajj activities vary depending on which form of Hajj a pilgrim is performing: Hajj At-Tamattu’, Hajj Al-Ifrad, or Hajj Al-Qiran. Each form is governed by specific rules and regulations.

Hajj activities are performed with spatiotemporal constraints. Figure 2 shows the approximate areas and approximate periods within which a pilgrim performs activities and the examples of activities within each area. A typical Hajj journey is also shown in Figure 2, with the approximate distances between areas. For further information and explanation of Hajj activities and types, refer to Islamweb (2010, 2016)).
2.2. Religion and mobile phones

Digital religion research has gained popularity as an important subfield within Internet studies over the past two decades (Khan & Shambour, 2017). The term digital religion was used by Campbell (2012) to refer to the technological and cultural space that is shaped when the online and offline spheres are integrated. Digital religion can be understood as “a bridge that connects and extends online religious practices and spaces into offline religious contexts, and vice versa” (Campbell, 2012). Religion has been playing roles in the Internet and digital culture since decades, and it continues to expand online (Campbell, 2012). In 2004, a Pew study found that 64% of 128 million American Internet users have used the Internet for spiritual or religious matters (Hoover, Clark, & Rainie, 2004).

The study of religion and mobile phones is closely related to the broader field of digital religion (Cho & Campbell, 2015). A review by Bell (2006) of a set of surveys indicated that there is a growth in using technology (including mobile phones) to support religious practices. The use of mobile phones for the practice of—or to support the practice of—religion is common across different faiths, including Islam, Christianity, and Judaism (H. A. Campbell, Altenhofen, Bellar, & Cho, 2014; Wyche, Caine, Davison, Arteaga, & Grinter, 2008). Researchers have studied the use of mobile phones for various religious purposes. For example, Roman (2014) examined the use of mobile phones in the spread of the Christian faith through texting in the Philippines, and Wyche et al. (2008) studied the design of an application that supports Muslim prayer practices.

Currently, several religious-oriented mobile applications are available from mobile application stores. Campbell et al. (2014) conducted an extensive review of 451 religious applications from the iTunes application store. Their study extended the work by Wagner (2013) with the aim of
producing a classification system for religious applications. They identified 11 categories of religious applications and grouped them under two main categories: applications oriented around religious practice and applications embedded with religious content. Two examples of categories of applications oriented around religious practice are sacred textual engagement, which includes applications connected to sacred texts such as the Bible and the Quran, and ritual applications, which are focused on recognized religious practices. While their study provides a starting point for researchers interested in analyzing religious mobile applications in order to understand the integration of religious goals into the design of applications, it also suggests the need to investigate how users actually use these applications. Responding to this need, our study aimed to investigate the UX of religious applications that are used to support the performance of Islamic religious practices in Hajj.

2.3. Mobile and ubiquitous UX

UX is one of the major areas in the field of HCI. It is defined as “a person’s perceptions and responses that result from the use and/or anticipated use of a product, system or service” (ISO, 2010). UX practices include analyzing and designing the user’s experiences of a technology. They help in developing deep insights into users and their needs, expectations, values, preferences, and limitations. UX practices seek to improve the user’s interaction with, and perceptions of, a system. Similarly, mobile UX concerns user perceptions of a mobile system. Mobile UX emerged because of the rapid increase in mobile usage. UX researchers have been developing and adapting research methods, design guidelines, and tools to address the challenges and opportunities of mobile devices (e.g., Binti Ayob, Hussin, & Dahlian, 2009; De Sá & Carriço, 2006; De Sá, Carriço, Duarte, & Reis, 2008; Inostroza, Rusu, Roncaglilo, & Rusu, 2013; Kjeldskov & Stage, 2004; Lee & Grice, 2004). Mobile UX research has been seen across different domains, fields, and contexts (e.g., Arhippainen & Tähti, 2003; Arning, Ziefle, Li, & Kobbelt, 2012; Djamasi et al., 2014; Gong & Tarasewich, 2004; Kukulska-Hulme, 2007; Medhi, Ratan, & Toyama, 2009; Stoyanov et al., 2015). In the religious domain, there have been some studies that sought to investigate the UX of religious mobile applications (e.g., Al-Aidaroos, Mutalib, Zulkifli, & AbuHassira, 2013; Wyche et al., 2008).

Much UX research has been conducted in the field of ubiquitous computing systems. Väänänen-Vainio-Mattila, Olsson, & Häkkilä (2015) undertook a systematic literature review of UX studies of ubiquitous computing systems, including mobile applications with some ubiquitous aspects. Their work found that user studies have emerged in the field of ubiquitous computing systems, and most of these studies appeared recently. Their findings also showed that UXs of ubiquitous computing systems have often been investigated in simplistic ways (e.g., collecting ratings by simple or predetermined scales). They argued that a deeper investigation is required to help develop more successful ubiquitous computing systems. Our study sought in-depth insights into UXs of Hajj mobile applications, which often involve ubiquitous aspects, to discover UX design implications to improve Hajj mobile applications.

2.4. Hajj mobile services

Islam is one of the main religions that appear to dominate applications dedicated to religious purposes (Campbell et al., 2014). Several mobile applications have been developed to support Hajj pilgrims. Khan and Shambour (2017) conducted an analytical study of Hajj-related mobile applications offered by the Google Play store. Their survey covered 246 applications with 51 different services. Their results showed that the “Hajj ritual” service constituted the largest percentage compared with other services provided by the applications. The applications contained between 1 and 23 services. Their results indicated that providers mostly focused on developing Hajj and Umrah (a smaller-scale pilgrimage) ritual services in a basic and noninteractive manner. They also found that the attitudes of users were directed toward visualized application services. In general, the study by Khan and Shambour (2017) focused on the behavioral trends of mobile application providers and users, based on an analysis of applications. Khan and Shambour (2017) also assessed the quality of Hajj applications against a set of categories, including engagement, functionality, aesthetics, and information quality, based on a “mobile application rating scale”
used in the health domain (Stoyanov et al., 2015). The sample used for assessing the applications comprised expert users of Islamic applications. In contrast, our study aimed to investigate the actual need for features and experience of services with actual users in the usage environment.

Ahmad et al. (2014) proposed a framework to define user context and deliver appropriate and customized services. They implemented their framework as a mobile application for Hajj and Umrah. Their framework included a set of features, such as a rituals guide and offline maps, to support performing Hajj efficiently. They tested the usefulness of the system with a specific group of users who were aware of the Hajj context. Both Khan and Shambour (2017) and Ahmad et al. (2014) did not provide qualitative insights into features and applications, resulting in a need for a deeper investigation of the UX aspects of Hajj mobile applications. Instead of relying on a specific scale to evaluate UX, our study was designed to qualitatively investigate the UX of mobile applications with users who had different backgrounds and levels of expertise, in order to identify UX problems and potential opportunities for improving Hajj mobile applications.

A number of Hajj applications have been developed by researchers for Hajj. Al-Aidaroos and Mutalib (2014) and Al-Aidaroos, Zulkifli, & Mat (2013) developed a mobile application to help pilgrims recite and understand supplications (Dua and Zik) during Hajj and Umrah. Alssayh (2009) and Anad (2009) conducted studies for the purpose of developing mobile applications to guide pilgrims. Mitchell, Rashid, Dowood, and AlKhalidi (2013) examined the integration of different mobile technologies for supporting Hajj crowd management and navigation systems. Amro and Nijem (2012) proposed the use of mobile phones as trackers to assist monitoring of the movements and locations of pilgrims by pilgrim group guides (Mutawwif). In our study, rather than designing or developing custom mobile software for Hajj, we were interested in assessing user need for and experiences of features and applications of current Hajj mobile applications.

3. Approach and methodology

This study had two goals: (1) to gain information about actual user need for the features implemented in current Hajj mobile applications, and (2) to gain a deeper understanding of the UXs of users of Hajj mobile applications. In this section, we describe the data collection methods, the evaluated Hajj mobile application features, recruitment, participants, and data analysis used in this study. Figure 3 shows an overview of our approach and methodology.

3.1. Data collection

We employed questionnaire and interview methods for our study. These methods enable gaining understandings of the goals, needs, practices, concerns, and attitudes of people who interact with systems (Lazar, Feng, & Hochheiser, 2010). These methods are used widely in similar HCI and UX research (Kjeldskov & Paay, 2012; Väänänen-Vainio-Mattila et al., 2015). The questionnaire was designed to investigate the usage and the need for Hajj mobile features. The initial questionnaire was developed based on the literature reviews and the experience of the author in the field. The questionnaire was revised by an expert panel consisting of three HCI researchers. We pilot tested the revised questionnaire on Day 4 with two pilgrims. Reported problems, such as ambiguity, were fixed. The questionnaire was administered mostly during Days 5 and 6, after pilgrims performed a
set of Hajj activities from different categories (e.g., Tawaf or devil stoning). In the questionnaire, pilgrims reported whether they used a set of features during Hajj and their perception of their need for these features. We also asked an open-ended question to allow participants to add additional comments about their experiences of the evaluated features of Hajj applications.

During Days 5 and 6, we also conducted in-person semi-structured interviews. Our interviews involved questions on a set of major topics of interest: participants’ impressions of the Hajj applications they had used, reflections on the importance of Hajj mobile application features, and thoughts on things that need to be changed in the applications. The questions and probes were developed by the researcher based on his experience in the field and the review of the literature. We used general questions to allow participants to describe their experiences with the Hajj mobile application(s) in their own words. The questions and the probes were revised by three HCI researchers experienced in qualitative research methods. The interview questions and the follow-up probes are listed in Table 1. The second interview question in Table 1 was used to confirm and to better understand the results generated through the questionnaire.

All interviews took place in an empty room, apart from a table and two chairs. Each interview session was audio taped. An experienced researcher, specialized in social science, but without an extensive background in HCI, moderated the interview sessions. The four questions were asked during each session. The follow-up probes were used to ensure that all participants are able to share their full experience with the Hajj mobile applications. Since pilgrims did not have time for a long interview, we ensured that interview sessions did not exceed 35 min. Interviews were conducted in Arabic, the native language of the author, the moderator, and the participants. Participants did not receive compensation for participation in the study.

### 3.2. Hajj mobile application features

The author and an HCI researcher analyzed a set of Hajj applications that target both domestic and foreign pilgrims and selected the main features implemented in these applications for evaluation. During the analysis, we took into consideration a set of features proposed in a related work by Ahmad et al. (2014) and the results of an analytical study of mobile applications for Hajj and Umrah services conducted by Khan and Shambour (2017). The final list of features was determined based on the agreement of the author and the HCI researcher using criteria such as the importance of the feature and the number of Hajj mobile applications offering the feature. The evaluated features are listed below with their descriptions:

| Table 1. Semi-structured interview questions and probes |
|---------------------------------------------------------|
| (1) In general, what are your overall impressions about the Hajj mobile application(s) that you have used? |
|   • Tell me about things that worked particularly well and those that worked not so well. |
|   • What challenges, constraints, difficulties, or problems you have encountered when using the Hajj mobile application(s)? |
| (2) In responding to the questionnaire, you specified the actual usage and the need for a number of Hajj mobile application features. Now, we want you to explain in more details the importance of each feature. Features (with descriptions) are listed on the sheet in front of you. |
|   • Why do you think that specific features are important? |
|   • Why do you think that specific features are not important? |
| (3) Was there anything that you think needs to be changed in the Hajj mobile application(s)? If so, what and why? |
|   • Do you think that specific Hajj mobile application features need improvements? If yes, please elaborate. |
|   • Do you think that there are missing features in the current Hajj mobile applications? If yes, please elaborate. |
| (4) Is there anything else you would like to say about the Hajj mobile application(s) or their features? |
Out of boundary: checks whether a pilgrim is inside or outside the bounds of Mina, Arafat, Muzdalifa, or Haram with border-monitoring notifications.

Guide for rituals: provides detailed step-by-step guides for performing Hajj activities based on day, time, and location.

Maps: provide route planning for traveling by foot, car, or public transportation.

Point of interest (POI): locates places of interest, such as tents in Mina and Arafat, and finds the shortest route to a POI from the user’s current location.

Prayer timings: pilgrims can check prayer timings and receive a notification for each prayer.

Qibla direction: shows the direction of Qibla (Kaaba) to which pilgrims turn at prayer.

Information of Hajj agency: provides information about the Hajj agency responsible for the pilgrim. For example, their contact information and the time allocated for the pilgrims within the agency to perform Hajj activities.

Tawaf counter: counts the number of completed circles around the Kaaba.

Sa'ay counter: counts the number of completed movements between Safa and Marwah.

Offline content: accesses content without an Internet connection.

Traffic update: shows traffic conditions around the location of pilgrims.

State of crowd: shows the state of the crowd in the buildings where pilgrims perform Tawaf, Sa'ay, and devil stoning.

Quran reader: pilgrims can read the Quran within the Hajj application.

Lost and found: pilgrims can locate friends, family members, and Hajj fellows and also see the path to their friends.

Hajj messenger: pilgrims can chat with each other.

Emergency contacts: provides the contact information of emergency services, including police, fire stations, medical services, and Hajj agencies.

Activity notification: provides notifications related to Hajj activities based on day, time, and location of pilgrims.

Content customization: presents the user with content that is relevant to the form of Hajj (At-Tamattu', Al-Ifrad, or Al-Qiran) that they are performing based on their user settings.

Translation: helps pilgrims who speak different languages communicate with each other.

Hajj progress: informs a pilgrim about what Hajj activities they have completed, their current activity, and which and how many activities still remain.

3.3. Recruitment
The author, who was performing Hajj, recruited participants for the questionnaire by distributing the questionnaire in social media groups used by pilgrims during Hajj. The author was granted
permission by Hajj agencies to distribute the questionnaire to groups under the agencies’ supervision. We targeted social media groups from different cities in Saudi Arabia with the aim of recruiting participants from different backgrounds. Since female pilgrims were using segregated social media groups for cultural reasons, we asked a female pilgrim to distribute the questionnaire in female groups.

Pilgrims who responded to the questionnaire and agreed to be interviewed were contacted for the interview. Sixteen participants agreed to provide further details about their experience of Hajj applications. We recruited participants until we believed that data saturation had been reached (i.e., most themes were repeating in the data). We judged that saturation had been reached after 10 interviews, but we conducted six additional interviews to confirm that no new themes or problems were emerging and to involve participants from different demographics. However, since self-selection bias and cultural norms affected the recruitment process, our results might not be representative of the whole user group of local pilgrims. For instance, all pilgrims who participated in the interview sessions were male, as we were not able to interview females because of cultural norms in Saudi Arabia.

3.4. Participants

Sixty-five pilgrims responded to the questionnaire. Table 2 shows the age, gender, and education-level profiles of the respondents. All participants had been using smartphones for more than a year. Participants had different major areas of study, such as computer science, medical science, and engineering. Of the participants, 72.3% were performing Hajj for the first time, 10.8% for the second time, and 16.9% for at least the third time.

Our participants reported the use of different Hajj mobile applications including Mutawef, Smart Hajj, Salam, Manasikana, and Navi Hajj. These applications offer a set of features to the pilgrims (Khan & Shambour, 2017). That is, 23 features are provided by Mutawef, 17 by Smart Hajj, and 12 each by Salam and Manasikana. The most used application by our participants was Mutawef. These applications offer services with some ubiquitous computing aspects, such as location sensing.

As mentioned above, we conducted interviews with 16 participants. Of the participants, seven were performing Hajj for the first time, four for the second time, and five for at least the third time. The ages of the participants were 26–35 years (56.25%), 36-45 years (12.5%), 46–55 years (25%), and >55 years (6.25%).

| Table 2. Demographic profile of respondents |
|--------------------------------------------|
| Category                    | No (#) | Percent |
|-----------------------------|--------|---------|
| Gender                      |        |         |
| Male                        | 56     | 86.15   |
| Female                      | 9      | 13.85   |
| Age (years)                 |        |         |
| 18–25                       | 7      | 10.77   |
| 26–35                       | 27     | 41.54   |
| 36–45                       | 21     | 32.30   |
| 46–55                       | 9      | 13.85   |
| >55                         | 1      | 1.54    |
| Education level             |        |         |
| Less than a high school     | 3      | 4.61    |
| High school                 | 9      | 13.85   |
| Diploma                     | 6      | 9.23    |
| Bachelor                    | 45     | 69.23   |
| Master                      | 1      | 1.54    |
| PhD                         | 1      | 1.54    |
3.5. Data analysis

The survey data were analyzed statistically using IBM SPSS software. The interview data were interpreted using thematic analysis. All interview audio files were transcribed verbatim and translated into English by the first author. The author speaks both Arabic and English and has experience in idioms and terms used in the Saudi dialect, which participants used extensively during interviews. During the transcribing process, 181 statements were extracted. The transcripts were checked for accuracy by the moderator.

The author then open-coded the transcripts using the words and key phrases of participants. During this phase, the moderator met four times with the author to discuss the emerging codes and to resolve coding problems. In the next phase, an HCI researcher, who also has experience in the Saudi dialect, collaborated in the analysis of the data. The generated codes were used by the author and the collaborator during the axial coding stage and the clustering process. We also used affinity diagraming (as explained in Holtzblatt and Beyer (2016)) to identify additional thematic clusters. We focused only on themes related to our study goals. Two interview participants were asked to verify our extracted themes, interpretations, and conclusions. Participants were encouraged to correct errors and provide additional information if necessary. Two new participants, who performed Hajj in 2017, were also invited to verify our results and add new information (needs or experiences). These four participants generally agreed with our results, interpretations, and conclusions.

4. Findings and analysis

In this section, we present the results of our study. First, we present results relating to the need for Hajj application features based on the participants’ responses to the questionnaire. Second, we present themes generated from the analysis of interview data.

4.1. User need for Hajj application features

We analyzed user responses to the questionnaire to identify user need for Hajj application features. Since the different Hajj applications offer different features (Khan & Shambour, 2017), we expected that participants would not have used all the features listed in our questionnaire (refer to section 3.2 for a list of these features). Therefore, we designed the questionnaire to allow participants to choose one of four responses representing their use of as well as their need for each feature: (1) “I used the feature and I felt it was needed”, (2) “I used the feature and I felt it was not needed”, (3) “I did not use the feature and I felt I needed it”, and (4) “I did not use the feature and I felt I did not need it”. The number of responses to the questions related to the actual use and the need for the features ranged between 50 and 53 per question.

Figure 4 shows the features and percentages associated with each response. The four most needed features that participants used during Hajj were maps, prayer timings, Quran reader, and Qibla direction. This could be because these four features are used more frequently during Hajj than the other features. For example, pilgrims need to travel multiple times between different areas during the days of Hajj, resulting in the need for the maps feature, in particular, for offline maps “due to the poor mobile network coverage in the different areas” according to the comments of 15 participants in the questionnaire. The prayer timings feature is also used frequently to check the timing of five prayers each day. In addition, as pilgrims travel from one place to another to perform Hajj activities, they become unable to locate the direction of Qibla. This could lead to the need for frequent access to the Qibla direction feature before prayers and when pilgrims offer supplication, a recommended act in Islam.

The offline content feature was the least used feature, although participants reported that it was highly needed (see Figure 4). This could be because the mobile Hajj applications used by pilgrims did not allow access to some content in the offline mode, because the mobile network was very poor.
The Hajj messenger feature was the least-needed feature. Approximately 57% of the participants did not use it and felt that they did not need it. Approximately 8% of the participants who used it reported that it was not needed.

The state of crowd feature was reported to be “used and needed” by 33% of the participants, and “unused and needed” by 35%. This could mean that it is an important feature that needs to be given priority in Hajj applications. However, approximately 15% of those who used the state of crowd feature reported that they did not need it. Some of those participants reported that they had problems with this feature, which might have affected their perception of it and their responses.

In Figure 5, we classify features according to the need for them based on participants' responses. We combined the responses of participants who used the features and felt that they were needed and participants who did not use them and felt they needed them. The reason for this combination was to find the overall need for features, regardless of actual use. Features reported as needed by at least 70% of the participants were classified as high needed features. Features needed by 50%–69% of the participants were classified as medium needed features.
Features needed by 30%–49% of the participants were classified as low needed. Offline map was the most needed feature, while Hajj messenger was the least used.

We compared the need for features of two groups of pilgrims (first-time performers and at least second-time performers). We found that there were no statistical differences between the needs of the two groups.

4.2. Qualitative results
In this section, we present our themes from the interviews in three major clusters: UX problems with Hajj mobile applications, the importance level of features, and opportunities for UX improvement.

4.2.1. Current UX problems
In analyzing UX problems with Hajj mobile applications, we identified three types of problems: implementation problems, design and content problems, and trustworthiness problems.

4.2.1.1. Implementation problems. Participants discussed some problems with the implementation of features. The main implementation problem identified was inaccuracy of out of boundary, state of crowd, and activity notifications. Regarding the out of boundary feature, four participants indicated that the application gave them inaccurate information about area boundaries (e.g., at Arafat, Muzdalifa, and Mina). The pilgrims were very concerned about this problem because some Hajj activities should be performed within specific areas. For example, standing in the area of Arafat on Day 2 is a compulsory act. If this activity was not performed within the exact area, the Hajj of a pilgrim might be invalid. In addition, spending certain nights of Hajj days at Mina is also an obligatory act. If this activity was not performed within the correct area, a pilgrim might need to offer a sacrifice. One participant commented:

“I am very concerned about the accuracy of the information provided by the application about the boundaries of the areas. The application is always sending us inaccurate notifications about the area boundaries. Today, I am staying at Mina and the application keeps notifying me that I am out of the Mina boundary. After a period of time, although I do not move from my place, the application sends other notifications saying that I am within the boundary of Mina. Information is inaccurate and leads to confusion and disappointment. What if it was showing me that I am in the area of Arafat during the day of Arafah [Day 2], and it was wrong. It will be a problem” (P8).

Participants also commented on the inaccuracy of the state of crowd feature. They reported that the feature provided incorrect information about the state of the crowd in the buildings where pilgrims perform Tawaf, Sa’ay, and devil stoning. One participant used this feature and found that according to the application a certain level of the devil-stoning building was less crowded than the other building levels. He decided to go to this level of the building to perform the activity. However, he found that the level was very crowded. According to the pilgrim, he was approximately 100 m away from the building when he checked the state of the crowd using the application. The participant was unsatisfied and mentioned that his experience of the inaccuracy of this feature influenced his overall perception of the application:

“I had a negative experience when using the feature today. I checked the level of crowd at a certain level of the devil-stoning building and the application showed that the level was less crowded than the other. When I went to perform the devil-stoning activity, I was surprised that the state of crowd was opposite to what the application was telling me. The building was very crowded. I was not far from the building. The distance from the building was approximately 100 meters. If I had found it a medium crowd, I would not care because it cannot be a hundred percent accurate but there is a difference between the two states: low crowd as displayed in the app, and high crowd as in the reality. Generally, today’s experience influenced my overall perception of the app” (P10).
Incorrect detection of the location of pilgrims by the activity notification feature was another problem. Three participants complained that some notifications for specific activities were not related to the location where these activities should be performed. P9 commented:

“The notification of activities was not always correct. Some of them were not related to my current location, but to different locations” (P9).

The second implementation problem was the lack of supporting offline content and functioning. Developers may assume that mobile users have continuous stable network connectivity. During Hajj, the quality of network connections is affected by different factors, including poor coverage from providers, the simultaneous use of networks by many users, and use in buildings that block network connections. Almost all participants complained that they were not able to benefit from many features (e.g., maps, information about their Hajj agency, the latest state of the crowd and traffic, and translation) because of the poor Internet connection. One participant commented:

“Without connection, I was not able to check information about the Hajj agency (e.g., their contacts, the location of their tents in the different areas). I was also not able to use the maps when the network was bad. Furthermore, I was not even able to check the latest update of crowd in the different places” (P9).

The third implementation problem was with the use of manual counters for Tawaf and Sa'ay, two main activities that require effort and might need to be performed more than once during Hajj. Participants who used the counters commented on the difficulty of using mobile phones to count completed circles around Kaaba manually because of the huge number of people surrounding them. This difficulty is explained in the following statement by P4:

“Using your mobile application to add completed rounds manually after finishing them is not an easy process. There are a huge number of people surrounding you and you need to protect yourself and your family from the crowd. You may not even be able to put your hand in your pocket and take out your phone to interact with the app. Furthermore, the point where you are supposed to add a round is even more crowded because people stop the circling at this point to do certain activities” (P4).

Some participants mentioned that they sometimes forget to add a round or movement after each completion with the manual Tawaf and Sa'ay counters. Four participants (P1, P3, P4, and P15) from three different age groups said that it was difficult to always remember to record each completed round. This seemed to be because their attention was divided, as they were doing multiple tasks at the same time (e.g., walking and offering supplications). One participant commented:

“I think the Tawaf counter is very important, but it should count the completed rounds automatically instead of forcing us to make inputs because sometimes I forget to add a round after each circling because I am concentrating on other tasks, for instance, offering supplications” (P3).

4.2.1.2. Design and content problems. Our participants reported some problems with the design and content of Hajj applications. Three participants, who used three different applications during Hajj, criticized the interfaces (especially homepages) of the applications. The participants mentioned that the interfaces were “rich in features and elements”, making them complex and difficult to interact with in several situations during Hajj, especially “while moving in the crowd” (P9).

Another problem, described by four participants, was that the interfaces of applications employed small buttons, icons, and tabs, which were difficult to see and select in some situations. P9 commented:
“Smaller touch targets are harder for users to hit in normal situations. So, while Hajj involves using the phone in a walking and crowded context, it becomes harder and harder to hit small targets in such situations” (P9).

Five participants were not satisfied with content usability (e.g., the legibility of the guide for rituals). P10 criticized the use of a “tiny font size” in applications that were designed for pilgrims from different age groups, including older users who often need bigger text. This problem was confirmed by P3 and P15, who were over 55 years old. P8 mentioned that Hajj applications were used outdoors and in crowd situations, as well as while walking and performing activities, and “fonts with tiny size are hard to read in such situations”. He added that the application did not allow him to “change the font size”. P3 reported that “having low contrast between characters and background” made it difficult to read the text on the interfaces. P9 indicated a legibility problem because of the “small spacing between lines”. He mentioned that when he was performing some activities (e.g., Tawaf and Sa‘ay), he needed to read some content in the application (e.g., supplications), but it was hard for him to read text with a small line height while walking.

Our participants mentioned that there were complex words and sentences used in the guide for rituals. P10 said that the content in the application he used was not written with consideration for “pilgrims with different education levels, as well as people who have not performed Hajj before”. P9 also mentioned that guides used “complex terms and long sentences” that were “difficult to understand”. This participant said that the application should not waste users’ time by providing “ambiguous content” that takes time to comprehend, as they did not have time to comprehend difficult texts (e.g., “when performing an activity in a crowded situation”). This participant indicated that he needed to check some instructions while he was performing an activity and he was not able to comprehend the instructions quickly.

Some participants were unsatisfied with the interface of the Tawaf counter because it did not explain how it should be used. Other participants mentioned that the interface design of the Tawaf and Sa‘ay counters did not match their activities in the real world. For example, participant 10, who used the Tawaf counter, explained that the interface used a circle that was divided into seven parts. To count a complete round of Tawaf, a pilgrim needed to press a part of the circle (see Figure 6 (a)). The participant said that the interface “does not match the real activity” and suggested the usage of “seven circles” to match the real activity. P9, who used the Sa‘ay counter, explained that the interface of the Sa‘ay counter also employed a circle divided into seven parts. When a pilgrim completed a walk between the hills of Safa and Marwah, they needed to press one part of the circle (see Figure 6 (b)). This participant indicated that using a circle in the design of the Sa‘ay counter does not match the straight back and forth movement of Sa‘ay, and he found this counter was difficult to manage and use. The participant stated:

“The Sa‘ay counter interface confused me because it does not conform to the real Sa‘ay activity. Selecting part of a circle does not simulate the real movement between the two hills” (P9).

4.2.1.3. Trustworthiness problems. Three users expressed their concerns about the trustworthiness of the application content and features because of the lack of information about the authority that approved them. They said that guides and features should have been verified and approved by a Hajj authority. P9 said “I feel that I do not trust the application because of the absence of information about the authority that approved it”. P7 was also very concerned about the credibility of the content and the features. He said that since standing within the Arafat area is compulsory, the out of boundary feature should have been verified and tested by a specific authority to ensure it was accurate for pilgrims. This participant indicated that if the application did not show information about the authority that verified it, then he “would not use and rely on features (e.g., out of boundary, guide for rituals) and content that may have a degree of inaccuracy, so as not to invalidate” his Hajj “by following incorrect information”.
Problems with some functions also affected the trust that participants had in the applications. There were two types of problems: real, when functions provided inaccurate results, and perceived, when users believed that some functions were not going to be accurate, so they did not rely on them. In the case of a real problem, P10, who faced accuracy problems with the state of crowd function, stated that his “negative experience” with this function influenced his “overall trust of the app” and he preferred not to continue using the state of crowd feature, as well as other features that required “precise accuracy, such as out of boundary and prayer timings”. In the case of perceived problems, three participants believed that the automated Tawaf and Sa’ay counter functions would have many problems and they did not trust them to support performing these “very important Hajj activities”. P8 stated:

“I would not trust automated counters if they are implemented in the applications. They might not work correctly, and lead to incorrect counting and finally result in incomplete Hajj activities.”

4.2.2. The importance of features
We identified three subthemes when we analyzed participant responses to our questions regarding the importance of features: very important features, somewhat important features, and not very important features. The findings in the following subsections are generally consistent with the results regarding the need for features generated from participant responses to the questionnaire (refer to Figures 4 and 5).

4.2.2.1. Very important features. Participants identified the key features in Hajj applications. P4 said that, while some Hajj applications provide many features, the applications should focus on some “key features and improve the design for these features because they are the most important”. P8, who had performed the Hajj six times during the last 10 years, believed that “offline content and offline maps are the most needed features due to the poor network coverage”. Eleven more participants also emphasized the importance of these two features.

The Quran reader, prayer timings, and the guide for rituals features were mentioned as important features that should be given priority in the design of Hajj mobile interfaces. For example, P9 said that prayer timings should be given primacy in the design and “the application should show the timings in the homepage, so users can see the timings without the need for interaction (touches) with the applications because this feature is accessed frequently”. With the Quran reader, most
participants were satisfied with the provision of Quran texts in the application. Four participants (P5, P9, P11, and P12), who had different Hajj experiences (first-time or return Hajj experiences), appreciated the guide for rituals feature since “it provides a quick reference when needing some information about Hajj activities” (P9). Participants also commented on the importance of providing emergency contacts because “it is highly needed, particularly at some critical situations” (P1).

4.2.2.2. Somewhat important features. Our participants also expressed their need for other features. However, their expressions when describing the importance of these features were not as strong as when describing the very important features mentioned in the above subsection. We classified these as somewhat important features. These features are those listed in Figure 5 as medium needed features.

Some of the medium importance features tend to have different degrees of importance for some participants. For example, although most participants generally saw both the Tawaf and Sa’ay counter features as important, some participants, such as P9, argued that the “Tawaf counter feature is more needed because Tawaf requires more mental efforts and pilgrims can get confused when performing it compared to Sa’ay. Hence, the Sa’ay counter is important but it is less needed than the Tawaf counter”.

We analyzed responses regarding the need of the translation feature because it was assumed that it would be used more by foreign pilgrims. Six participants said that translation was not important for local pilgrims but would be for “foreign pilgrims”. Yet, P4, P5, and P9 said that translation, especially “offline translation”, was also important for local pilgrims because it could be used to communicate with foreign pilgrims (e.g., when they asked for help).

4.2.2.3. Not very important features. Most participants saw Hajj messenger as “not as important as the other features” (P6) and “not needed during Hajj” (P8). P14 said Hajj messenger was not important because pilgrims used other popular chatting applications such as WhatsApp, and “they will not switch to use other services that they need to learn while the current chatting applications can provide a better experience”.

4.2.3. Opportunities for improvement
Participants not only reported problems with Hajj mobile applications, but also provided insight into ways of enhancing the applications. Participants provided their ideas about the ways technology can play a role in helping pilgrims perform Hajj efficiently and recommendations for features that they felt were missing in the applications.

4.2.3.1. Enhancement of current features. Many participants recommended automating the Tawaf and Sa’ay counters because of the difficulty of using manual counters while performing these activities. P4, who had many problems with the Tawaf counter, said “the Tawaf counter feature should be automated”. P9, who had difficulty using the manual Sa’ay counter, recommended the automation of the counter. However, there were still some participants who preferred using manual counters because of their distrust of the technology mentioned above. P8 suggested that Hajj mobile applications should provide both manual and automated features to allow pilgrims to choose the option they prefer:

“The application should provide manual and automatic counters. The manual option can be used by participants who have certain fears and concerns about automated counters and have no problems using manual counters. For those who often face difficulties when using manual counters and often trust technology, they can benefit from the automated counters” (P8).

Participants also expressed the need for an improved state of crowd feature. They recommended a real-time state of crowd feature to allow pilgrims to monitor the crowd as it fluctuates at different
places. For instance, P9 said the “state of crowd should be updated continuously to allow monitoring of the crowd and to get real-time information, so when deciding to go to perform activities, we can choose places with less of a crowd”. P14 suggested that the application should download the latest update of the state of the crowd every time a user connected to the network for “a better experience during offline interaction”. Similarly, P6 said:

“We are using the application in a large gathering event, where changes of state of crowd can happen in few minutes or maybe in seconds due the enormous number of people who want to do the same activities. Hence, the state of crowd feature needs to be updated frequently whenever the mobile connects to the network to show information similar to real-time” (P6).

P9 and P10 recommended that the application should not only download the latest update of the state of the crowd for offline functioning, but also display the time of the latest update. The time of the latest update would help the pilgrim judge “if the status of the crowd has changed based on analyzing the period of time between the latest update and the current time” (P9). P10 said that providing the time of the latest update of traffic is also necessary for offline use of this feature.

In addition to what we have mentioned about participant need for offline interaction, most participants recommended that all content should be accessible offline and all features should function offline because of the poor network coverage. Some of the requests for offline content included “Quran, information of Hajj agency, guide for rituals” (P9), and for offline functioning it included “maps and translation” (P4).

### 4.2.3.2. Implementation of more features.

Some participants requested improvements to the technology that guides them during Hajj. For them, Hajj is not an easy journey. P9 said “It is not easy to perform all the activities without a mentor”. Participants said that the guide for rituals was good, but that it was sometimes difficult to understand. P10, who was performing Hajj for the first time, had difficulty understanding how to perform Sa'ay. He recommended that the technology should “guide him to perform activities correctly and efficiently”. He suggests, for instance, that after his location has been detected, the application should not only show the activities that he needs to do in that place, but “should include images showing how to do these activities, rather than textual description”. Another participant suggested the implementation of features that can detect activities and provide feedback to enhance the performance of the activity. He gave an example of a feature that could confirm whether his current location was correct for starting and ending Tawaf. P10 suggested the same feature for Sa'ay to correct pilgrims when performing Sa'ay activities incorrectly.

While accuracy of the state of the crowd can be difficult to achieve, three pilgrims recommended implementing a “live streaming of Haram and Jamarat” feature to provide pilgrims with “another mechanism” to check the state of the crowd at the Haram and Jamarat buildings.

Five participants discussed the importance of providing a “Hajj Frequently Asked Questions” feature to provide answers to questions commonly asked during Hajj. P10 said “it is important to show a list of questions and answers that are frequently asked during Hajj. Lots of effort could be saved if a feature like FAQ was provided in the app”. This participant was performing the Hajj for the first time and he mentioned that he had many questions that required contacting people to find answers.

Pilgrims must be accommodated at Hajj ritual places (Mina, Arafat, and Muzdalifah) and move between these areas during Hajj days. The movement of this huge number of people causes many problems. Hajj authorities use crowd management techniques to manage pilgrims. For example, each Hajj agency or group of pilgrims is allocated a specific time for movement to prevent crowd crushes. Our participants suggested implementing a feature that can help pilgrims search for times allocated to their groups for movement and performing activities. P5 said “we should be able to search for times allocated to us to move from one place to another and perform activities.”
Four participants discussed the importance of providing indoor maps for the Haram and Jamarat buildings, as they have multiple gates and levels. This would require “offline indoor maps” (P9). P9 also suggested implementing a live chat feature with scholars who could provide information about how to perform activities, or alternatively providing the contact numbers of available scholars in the application.

5. Discussion and implications

In this section, we discuss our findings and highlight UX considerations for Hajj mobile applications. In addition, we discuss some UX considerations that are applicable to scenarios beyond the Hajj context, which are relevant for designing systems in the religious domain, in particular, for supporting religious activities and mobility, and for use in large gatherings. Our discussion and UX considerations are organized according to three main topics: implementation, design, and content.

5.1. Implementation

5.1.1. Offline content and functioning

In some environments, such as large events, the quality of the network connection is not always reliable. Applications designed for such environments should ensure continuous functionality in a local mode. In the Hajj context, application functions (e.g., state of crowd and maps) and content (e.g., guide for rituals) should function in both modes (online and offline) to lessen the effect of changes in connectivity. For example, if a break in network connectivity occurs before launching the application, or while a user is using the application, functions should still work based on the latest update in local storage. Applications should also resynchronize and update local storage when reconnecting to the network without user intervention and display the time of the latest update for each specific function or data set.

5.1.2. User attention and automation

User attention is divided when users are engaged in multiple tasks while operating a mobile device, which leads to difficulties in user interaction, as found in previous research (Majrashi, 2016; Öquist, Goldstein, & Chincholle, 2004; Pascoe, Ryan, & Morse, 2000; Yamabe & Takahashi, 2007). Majrashi (2016) stated that user attention can be affected by walking, which affects their interaction with mobile applications. In our study, user attention was affected by walking, performing other activities, and moving in a crowd. The limited attention of users should be considered when developing applications for Hajj and similar contexts (e.g., walking, supporting human activities, and large events). For instance, features should be developed that require a minimal number of user interactions. Designers might consider providing users with hands-free or even eye-free interactions. Poupyrev, Maruyama, & Rekimoto (2002) discussed work proposing to replace visual input with sound input to overcome the difficulties of interacting with mobile applications with divided attention. For Hajj applications, we propose that features that require visual interaction and user input while performing an activity (e.g., the Tawaf counter) should be automated in order to minimize the need for interaction when the user’s attention is divided.

However, although many participants requested automated features in our study, some participants had some concerns about the automation of features for specific Hajj activities. These concerns might not stem from the resistance to technology that may exist in some religious communities (Bell, 2006), but from perceptions about the efficiency and accuracy of technology supporting religious activities. Therefore, providing both manual and automated features for specific Hajj activities is recommended to satisfy different user groups.

5.1.3. Supporting activity

Developments in technology have enabled the use of smartphones to support physical activity (Fanning, Mullen, & McAuley, 2012). In the Hajj context, many pilgrims—especially those who have
not performed Hajj before—need supporting technology. Pilgrims need to perform many activities with different requirements, which gives rise to a need for assistance technology to help them understand these requirements and perform activities precisely. If the Hajj mobile application plays a role in supporting physical Hajj activities, as well as providing feedback to correct mistakes when performing activities, pilgrims’ experience of the application could be improved. For example, the system may use an algorithm to detect the pilgrim’s location, determine the type of activity they are currently performing (e.g., Sa’ay or Tawaf), and provide support for performing this activity. For example, to support pilgrims while performing Sa’ay, an application could detect incomplete movements between the hills and notify the pilgrim about the remaining movements. This feature might be generalized to other applications that are designed to support human activities. That is, such applications should not only provide instructions about how to perform the activity, but also provide advanced guidance and deliver feedback for a user while they are engaged in the activity.

5.1.4. Accuracy
We recommend that location-based features (LBF) (e.g., out of boundary) should provide highly accurate results to improve UXs with the applications. In Hajj, there is a set of activities that a pilgrim needs to perform in exact locations, which requires ensuring that LBF is very precise. Similarly, applications used for supporting outdoor activities or in mobile or crowd contexts need to ensure LBFs are highly accurate to improve UX.

In our study, real and perceived accuracy problems influenced user trust in applications. This confirms a previous finding that problems in functionality influence trust (Fogg et al., 2003). In applications designed for religious practices, such as Hajj, problems with functionality could have a significant effect on trust because they could result in invalidating religious practices.

Additionally, it seemed that the level of confidence in the Hajj applications was highly influenced by inaccuracy of information, which was observable to users in real time. For example, the inaccuracy of the activity notification and about the state of the crowd experienced by P9 and P10, respectively, were observable to the participants in real time. This seemed to highly influence their levels of confidence in the applications. This accords with the finding of Harrison, Consolvo, & Choudhury (2010) about the effect of visible inaccuracy on trust.

5.1.5. Crowd checking and management
To improve the UX of mobile applications at large events such as Hajj, applications should provide an accurate state of crowd feature to enable users to check the size of the crowd in different places of interest. However, a highly accurate state of crowd feature can be difficult to implement because of many factors, such as the fast changes of crowd flow mentioned previously. Implementing a feature such as live streaming of places (e.g., Haram and Jamarat), as recommended by participants, to serve as another mechanism for checking the crowd might enhance UX of Hajj mobile applications. A related study found that Hajj and Umrah applications that supported live video services were downloaded more frequently than applications that did not provide this service (Khan & Shambour, 2017). As requested by our participants, applications should also provide relevant information to users about crowd management (e.g., the time allocated for their movements). This need might arise from inefficient pilgrim crowd management features in current Hajj applications, as reported by Khan and Shambour (2017).

5.2. Design

5.2.1. Prioritization
In this study, we investigated the level of need for a set of features used in Hajj mobile applications through a questionnaire. Our results led to classifying the features according to three levels of user need: high, medium, and low. This finding was also confirmed by the results of our interviews. The designers of Hajj applications should consider these levels of need. This is because participants reported that Hajj applications offer several features, leading to difficulty using the applications in
some situations (e.g., while performing an activity, moving, and surrounded by many people). A previous study showed that many Hajj applications offer several features (Khan & Shambour, 2017), leading to the need to prioritize features in the design of Hajj mobile applications. That is, the design should focus more on the most needed and frequently accessed features to make interaction with the application easier. For example, highly important features should be shown with minimal interaction on the first screen, while less important features should be shown on secondary screens. For instance, prayer timing is one of the most important features of Hajj applications (refer to Figure 4) and is used repeatedly and possibly in different circumstances during Hajj. It should therefore be given priority in the design, for example, by being prominent on the first screen.

5.2.2. Enlargement
Small touch-sensitive areas can increase the risk of touching the wrong target in normal interaction contexts (Budiu & Nielsen, 2011). In a walking context, small elements can be harder to recognize and touch (Majrashi, 2016). Our analysis of participant comments consistently showed that small touch-sensitive areas are a critical problem in different Hajj interaction contexts, such as while walking, performing activities, or moving in the crowd. The enlargement of user interface elements to ease interaction and prevent errors in different usage situations (e.g., during Tawaf) needs to be considered.

5.2.3. Reduction
Our study participants reported that the content in application interfaces, particularly on the first screen of the application, should be minimized to enable more efficient interaction. This finding is consistent with a recommendation for mobile usability by Nielsen and Budiu (2013). In accordance with the conclusions of Majrashi (2016), our study revealed that the reduction of content may be more essential for mobile applications that are designed for difficult interaction situations, such as while walking, performing activities, or at large events.

5.3. Matching the real world
Match between the design and the real world is a traditional design principle that enhances usability (Nielsen, 1994, 1995). Participants reported a problem with the design of some feature interfaces (e.g., the Tawaf counter). That is, the design did not match the real activity. The design of feature interfaces that are used to support human activity should match the real activity (e.g., Tawaf and Sa'ay). This might help users learn the design and enable more efficient interaction by taking advantage of people's knowledge of the real activity.

5.4. Content

5.4.1. Legibility and readability
Problems with the content (such as the ambiguity and complexity of the guides used for rituals) influenced the UX of Hajj applications. Applications designed for Hajj and similar contexts should consider legibility and readability of content guidelines. For instance, font size should be appropriate for reading in different situations, including while performing activities, moving, or in a crowded context. The user should also be able to change the font size. High contrast between characters and background and large spacing between lines should also be considered. Another recommendation is to use simple terms and short sentences.

5.4.2. Content visualization
Visualizing contents of mobile applications targeted for use in moving and crowded contexts such as Hajj might improve UX. The user needs to comprehend the text quickly, especially while performing activities. Pictures and diagrams can sometimes enable a faster understanding of content than words. This finding might explain the results of Khan and Shambour (2017) that Hajj applications that supported visualized services were more frequently downloaded.
5.4.3. Content for building trust

Much research has investigated the factors that affect user trust of systems (e.g., Fogg et al., 2003; Li & Yeh, 2010; Siala, O’Keefe, & Hone, 2004; Vance, Elie-Dit-Cosaque, & Straub, 2008; Zhou, 2012). One of these factors is affiliation. The work by Fogg et al. (2003) on website credibility found that a site had more credibility if it showed an affiliation with an organization users knew and trusted. Another work on the effect of religious affiliation on trust in the context of electronic commerce found that Muslims placed significantly more trust in the Muslim site than in other religious sites or neutral sites (Siala et al., 2004). Our study revealed that trust was affected by the absence of information about the authority that had approved the applications. Participants were concerned about the accuracy of application content and functionality and needed to see information about the authority that had provided accreditation to the application. Our finding seems related to the affiliation factor. Show affiliation, as well as affirmation from a trusted authority regarding the accuracy of content and functions, may contribute to building trust with users. Furthermore, since there are different beliefs about how to perform specific Hajj activities, the accuracy of application content should be confirmed by the relevant religious sect or any trusted agency to increase the credibility of the application.

5.4.4. Questions and answers, live chatting, and indoor maps

Hajj applications should also provide answers to common questions about Hajj activities, as recommended by our participants. Some Hajj applications do provide this content (Khan & Shambour, 2017). However, the applications used by our participants did not provide this content, which appears to be necessary for all Hajj mobile applications. In addition, there are limited virtual communication systems in current Hajj applications (Khan & Shambour, 2017). This could be the reason why some participants in our study requested a feature that allows live chatting with scholars specializing in Hajj to answer questions regarding specific Hajj topics. The provision of live chatting, as well as “offline indoor maps”, which was also requested by our participants, could be appreciated by Hajj mobile application users.

5.5. UX elements for Hajj mobile applications and beyond

In Figure 7, we summarize the UX elements generated by our discussion of the findings under three categories: implementation, design, and content. To improve UX of Hajj applications, these elements need to be considered in accordance with our discussion and recommendations in the previous three subsections.

Some elements shown in Figure 7 are applicable in related domains and contexts of use: the religious domain, performing physical activity, crowded environments, and walking situations.

6. Limitations and future work

The type of pilgrims that we were able to interview limited the study. All participants in our study were local pilgrims. In addition, while we recruited for diverse participants who represented different Saudi cities or subcultures, we did not find a representative sample. Therefore, future studies are required to identify any other needs that may be associated with foreign pilgrims and with different categories of local pilgrims.

The methods we used also limited the study. During interviews, some participants were unable to remember some details of the problems with the applications they had used. In addition, some pilgrims had difficulty describing their use of technology, so their reports may have differed from their actual experiences. In future research, we plan to use different methods to investigate this topic and triangulate findings between the two studies.

In the upcoming Hajj, we aim to complement this work by studying specific design aspects of mobile Hajj interfaces with a focus on usage conditions (e.g., the best size for touch-sensitive areas when walking in the crowd). The challenges we faced during data collection also provided us with
insights for improving future research. For example, since we were not able to interview female participants, a female researcher will be invited to join us to conduct future research with females.

Future studies are required on other large events to identify similarities and differences between our findings in Hajj and other events.

7. Conclusion
We investigated the use of and the need for 20 common mobile application features used to support pilgrims in Hajj, as well as UX of Hajj mobile applications. Through questionnaires and interviews, we found that offline map was the most needed feature. Three major themes emerged from our analysis of the reports of our participants: UX problems with mobile applications, the importance of application features, and opportunities for improving UX of applications. We discussed our findings and related our themes to specific considerations for designing UX of Hajj mobile applications. We believe that some of the UX considerations are applicable to some scenarios beyond Hajj because of the similarity of the related domain (e.g., religion) and contexts (e.g., while performing physical activity, in a crowd, or walking).

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Appendix: The questionnaire

Thanks for agreeing to take part in this survey. Our aim of the survey is to investigate the usage of and the level of need for features used in Hajj mobile applications. The ultimate goal of our study is to identify and highlight the user experience design elements for Hajj mobile applications. The survey will only take 10–20 min and your responses are anonymous and will only be used for research purposes.

| What is your gender? | ○ Male | ○ Female |
|----------------------|--------|---------|
| What is your age category? | ○ Less than 18 years | ○ 18–25 years | ○ 26–35 years | ○ 36–45 years | ○ 46–55 years | ○ More than 55 years |
| What is the highest level of school you have completed or the highest degree you have received? | ○ Less than high school degree | ○ High school degree | ○ Diploma degree | ○ Bachelor’s degree | ○ Master’s degree | ○ Doctorate degree | ○ Other, please specify……... |
| What is your field of study? | | |
| How many times did you perform Hajj in the last five years (including this year Hajj)? | ○ Once | ○ Twice | ○ Three or more times |
| How long have you been using smartphones? | ○ Less than a year | ○ 1–3 years | ○ More than 3 years |
| Which of the following Hajj mobile applications have you ever used? | ○ Mutawef | ○ Smart Hajj | ○ Salam | ○ Manasikana | ○ Other, please specify | ○ I have never used Hajj mobile applications |

Based on your experience, choose an answer for each of the following features offered in Hajj mobile applications. (Note: participants were able to see the descriptions of features upon clicking on a link).

| Feature | I used the feature and I felt it was needed | I used the feature and I felt it was not needed | I did not use the feature and I felt I needed it | I did not use the feature and I felt I did not need it |
|---------|------------------------------------------|---------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Out of boundary | ○ | ○ | ○ | ○ |
| Guide for rituals | ○ | ○ | ○ | ○ |
| Maps | ○ | ○ | ○ | ○ |
| Point of interest (POI) | ○ | ○ | ○ | ○ |
| Prayer timings | ○ | ○ | ○ | ○ |
| Qibla direction | ○ | ○ | ○ | ○ |
| Information of Hajj agency | ○ | ○ | ○ | ○ |
| Tawaf counter | ○ | ○ | ○ | ○ |
| Sa‘ay counter | ○ | ○ | ○ | ○ |
| Offline content | ○ | ○ | ○ | ○ |

(Continued)
(Continued)

| Feature              | Yes | No |
|----------------------|-----|----|
| Traffic update       | ○   | ○  |
| State of crowd       | ○   | ○  |
| Quran reader         | ○   | ○  |
| Lost and found       | ○   | ○  |
| Hajj messenger       | ○   | ○  |
| Emergency contacts   | ○   | ○  |
| Activity notification| ○   | ○  |
| Content customization| ○   | ○  |
| Translation          | ○   | ○  |
| Hajj progress        | ○   | ○  |

Please add any additional information about the features above:

- Do you agree to be contacted for an interview to provide further details about your experiences with the Hajj mobile applications and their features?
  - Yes, please provide your mobile phone number and/or email address below.
  - No

Mobile Phone:  
Email:  
Please note that the mobile phone and email provided will be strictly confidential and is intended only for contacting you regarding the interview.

Thank you