A Survey on Hajj Mobile Applications

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Abstract

Hajj is one of the five pillars of Islam. It is an annual pilgrimage, mandatory on every Muslim and must be performed at least once in a lifetime. To perform Hajj in a perfect manner, one has to follow location and time correctly as per guidelines. The task is quite challenging as more than 4 million pilgrims gather from around 140 countries to perform rituals from 8th Zhul Hijjah to 13th Zhul Hijjah of the Hijri lunar calendar. Every pilgrim wants to perform their rituals in the best way. Many smartphone applications have been created to help pilgrims perform their rituals during Hajj. In this survey paper, we present taxonomy of Hajj applications. One aspect of this taxonomy is that it covers Hajj applications in different essence. There is no application that provides all services for Hajj due to complexity in the application. Other important aspects are taken into account in taxonomy are offline services over online services due to limited availability of mobile data especially during five days of Hajj. The survey takes an in-depth knowledge of each application and presents services for each group in the taxonomy. The apps are discussed and analysed based on various factors such as languages, individual service and group of services based on downloads. Moreover, this paper help pilgrims to see available Hajj applications with their list of services on one platform. It will also help developers to enhance their Hajj applications or develop new applications based on the available list of services. The document can also help authorities to enhance Hajj by providing valuable services to pilgrims.

Key words:

Hajj; Mobile Applications; Survey

1. Introduction

The pilgrimage of Muslims, Hajj, which is one of the five pillars of Islam, is an annual recurring event which is performed in the month of Dhul-Hijjah (12th month of the lunar Islamic calendar), where more than four million of pilgrims around the world gather in Makkah Mukarramah from 8th to 13th. The hajj rituals consists of following five steps a) entering in the state of ihram from Miqat before arriving Makkah, b) moving to Mina on 8th Dhul-Hijjjah, c) proceeding to Arafat on 9th Dhul-Hijjah and staying there till sunset, d) moving to Muzdalifah after sunset and collecting pebbles for stoning at Jamarat form 10th-13th Dhul-Hijjah, e) performing Tawaf-e-Wadaa (farewell circumambulation around Ka'bah) as shown in Figure 1 [1, 2]. Hajj is a special opportunity to worship Allah in a large gathering and it is evident from the steps that pilgrim must perform their rituals at different places and at specific time constraint. Although Hajj lasts for almost a week time, many pilgrims stay beyond this time zone to perform additional Umrah and visit Masjid Al-Nabawi in Madinah Munnawarah (the holy city of Prophet Mohammad, peace be upon him).

A lot of pilgrims, due to lack of knowledge and guidance faces immense challenges while performing Hajj and Umrah. With the popularization of smartphones and advanced hajj applications and services, their problems are expected to be solved and they can perform their rituals in a successful manner. There are numerous mobile applications (apps) that are developed by public and private agencies for both IOS and Android users that provide detailed information of both Hajj and Umrah rituals along with supplications. This document provides exhaustive information of the applications developed by different agencies that are published by Google play. The novelty of this paper is that it provides a taxonomical classification of the Hajj and Umrah apps with an aim of helping the developers and users to understand how each application works and, when needed, help them to decide which app or service is useful for a given scenario. Figure 2 illustrates the proposed taxonomy where each branch describes a specific category of services required in Hajj. The remaining of this manuscript is structured as follows: section 2 discusses the taxonomy, section 3 presents the related work, section 4 talks about the ritual services, section 5, 6, 7 and 8 provide insight to location-based services, context-based services, navigation-based services and other services respectively. Finally, section 6 concludes the manuscript.

Fig. 1 Zones of Hajj along with different routes to enter the holy city Makkah.

2. Related Work

The use of smartphones and their applications has become a part of daily life for the majority of people in the world. Smartphones penetration is continuing to increase every year. Many applications have been developed to help people manage different aspects of their daily life. For example, in the area of tourism, almost every major company in this industry has a smartphone application [3], whether it is the airline carriers, hotel chains, or online agents such as Booking, Kayak, AirBnB and many others. Clinician used smartphones to communicate and to provide better treatment and care [4]. Another example is in the banking industry, where banks have competed to give better services to their customers using mobile applications. In nearly all industries, mobile applications have been used, both to reduce operational costs and to provide more services to end clients. Due to this fast adoption of mobile apps by nearly all industries, there have been many survey papers to study these applications. For example, in the area of healthcare, there have been many reviews for the applications that help and enhance the physical well-being of people. One study [5] reviews physical activity applications and their effectiveness in promoting health. Another [6] reviews the applications that promotes sun protection practices. Another study [7] reviews smoking cessation apps and their effect on patients. Another paper [8] investigates smartphone apps in geoscience (e.g., geology/soil, minerals and rocks, petroleum and gas). A relevant study [9] by the University of California at Berkeley, sponsored by California Department of Transportation (Caltrans) discusses how mobile apps are impacting the field of transportation and the travel behaviour. It also reviews apps and categorizes them by innovation, disruption and rating.

The mobile applications have been reviewed for various fields, including tourism [10, 11], spiritual and religious services [12, 13]. Another recently published paper [14] studies mobile applications in Hajj and Umrah analytically. It mainly focused on installation rates with respect to services. However, there is no such review related to mobile application for Hajj that can taxonomically define services and enlist the applications in each one of them.

The research and developers launched various mobile applications for Hajj to track the movement of pilgrims [15, 16, 17], to find path [17, 18] and guide to perform Hajj [2] with supplications [19,20]. The author [15, 16] detects the movement of the pilgrim and track them using Bluetooth Low Energy (BLE) tags and smartphone in Hajj. They proposed a hybrid approach of using smartphones connected with multiple BLE tags to understand the dynamics of a large group [15]. The authors [16] used mobile GPS to collect the pilgrim location and track them whereas authors [17] used RFID along with the smartphone. The application also provides an option for emergency help. The author [18] provides context-aware optimized path in Hajj using crowd-sourcing platform. They developed a framework that collects traffic information from heterogeneous sources and recommends an optimized path. The author [2] developed an application that provides Spatio-temporal services including crowd-sourcing platform. The application also provides context-aware services using mobile sensors. Most of the pilgrims perform Hajj once in a lifetime and therefore they often prefer to carry books or mobile applications for Hajj rituals. The author [2] provides a ritual service to explain Hajj in detail and [19, 20] developed a mobile application for various prayers during Hajj. The author [21] developed a mobile application to count the number of tawaf rounds, Tawaf counter and updates the status of crowd in Holy Ka'bah. The author [22] developed a mobile application that track the location of the pilgrim, counts the Tawaf round and provide a guide for hajj and umrah services.. Authors [21] developed an application that provides translation services in several languages, supports text and voice recognition and thus facilitates easy communication between pilgrimage.
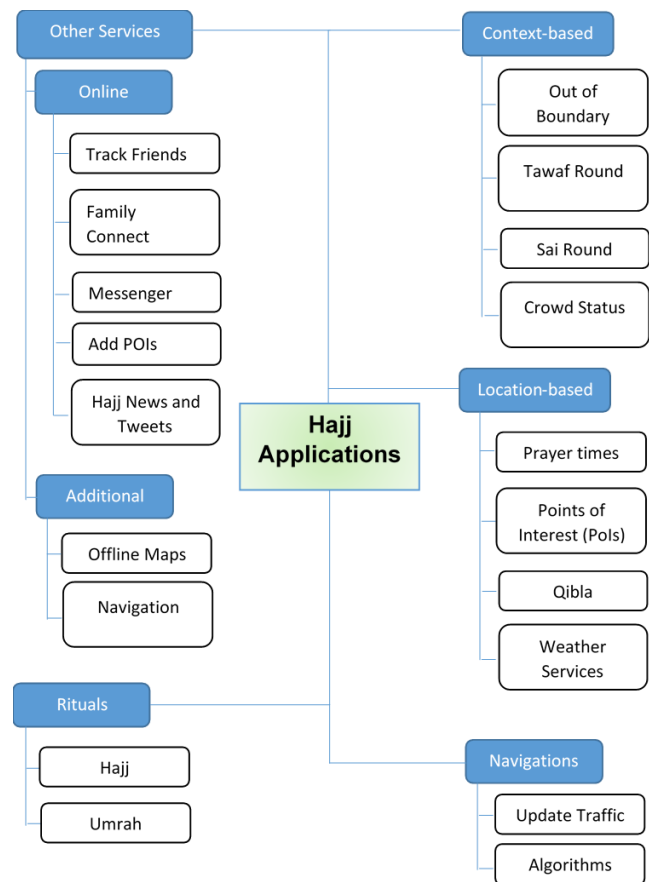

Fig. 2 Taxonomy of Hajj Applications

3. Taxonomy

As shown in Figure 1, the taxonomy of Hajj applications has been classified into five main groups. Some services can also be a part of other groups, but we classified based on their importance. For example, services such as rituals can be a part of location-based and as well as context-based services. Navigation can be a part of online and as well as offline services. The idea of our designed taxonomy is to explain different required services for the pilgrimage of Hajj. User can select the best application as per their needs whereas stakeholders or application developers select features that are important and useful for pilgrims.

The Ritual group describes step by step guide to perform Hajj and Umrah. Hajj is further divided into three sub-categories (Hajj Ifrad, Hajj Tamatu, Hajj Qiran). The ritual service is very important as some of the rituals are mandatory to perform in Hajj. If someone misses any obligatory part of Hajj or was not able to perform within specific time and location, then their Hajj is said to be incomplete.

Pilgrims travel to different cities of Saudi Arabia as part of their pilgrimage and they need services related to their current location and context. The Location-based services are, therefore, very important for pilgrims to get an idea of the nearby area, to search for point of interests (PoIs), to get updates about weather, to find Qibla direction and to check whether one is inside or outside boundary including Makkah, Madina, Mina, Muzdalifah and Arafat. The Context-based services are not only limited to location, but they also consider other parameters including time, temperature or any other information that can be collected through sensors. With respect to Hajj, the context-based services are used to detect whether pilgrim is inside or outside certain boundary based on time, date and location, to automatically calculate round of Tawaf and Sai' and to raise the alarm by sending a message to nearby location in case of emergency situation such as certain hike in temperature.

To provide routes for a huge crowd from starting location to destination location, an intelligent algorithm that can compute the path based on the shortest time are required. The Navigation service is used for 1) Track Friend: to find the routes towards the friends, and family members, 2) Prayer Times: to find the routes of the nearest mosque, 3) Places of Interest: to find the routes towards the selected point of interest, 4) Currency Convertor: to find the routes of the nearest currency exchange. As in Hajj ritual, a person needs to go from one place to another and they use routing service most of the time and the existing routing service shows results based on shortest time period, but the scenario is different when millions of people are using the same path. Therefore, it is need of the hour that application will take feedback from users and recommend the best path.

Other than above-mentioned services, there are still more online and offline services that are kept in the group of other services in taxonomy. The online services required internet connectivity to operate as it needs to communicate with the server. Track Friends service is used to track friends and family members. The service also shows routes between them. The family connect service is like track friend service, but it is basically for the friends and family members of pilgrims that are not a part of pilgrimage. This service notifies friends and family members when pilgrims enter Makkah, Madina, Mina, Arafat and Muzdalifah. The friend and family members also track the location of their pilgrims from their home countries. The messenger service allows communicating with friends and family members. To handle huge crowd, new PoIs open on temporary basis in Makkah and Madina to serve pilgrims. The information of newly open PoIs is not available on existing maps. Add PoIs service allows pilgrims to add new PoIs on maps which can be later shared with other pilgrims. Hajj news and tweets service shows the latest tweets and news related to Hajj and Umrah. It is important to get some updates and notification from stakeholders.

Due to huge crowd in a specific location and on a specific time, the mobile operator's towers are not enough to provide internet connectivity that results in failure of some Hajj applications. In this regard, some application provides offline services such as Maps and Navigation. They allowed pilgrims to download maps of Makkah, Madina and Jeddah and support navigation within this area. For location-based services, offline maps are helpful and provide guidance to pilgrims that are not familiar with locations.

4. Ritual Services

It is obligatory for every Muslim (who have enough money) to perform Hajj at least once in his life. Most of the Muslims perform Hajj only once in their life and it's very difficult for them to remember every ritual properly with its time and location. Also, if they miss any mandatory ritual then they must sacrifice an animal. Therefore, it is necessary to provide ritual service in the form of mobile application so that pilgrims can perform Hajj and Umrah correctly. Figure-2 shows the screenshot of the Haj guide from [A10] application.

Hajj Help [A1] provide details about Hajj including the procedure of Hajj and Umrah, merits of Hajj, types of Hajj, purpose of Ihram, things that are prohibited in the state of Ihram. Hajj help application also provides Quran and supplications services for pilgrims.

Hajj App [A2] provide hajj guide with a list of supplication during the pilgrimage of Hajj. The application supports Arabic, English and French but supplication list and supplications are in Arabic.

Hajj Help [A1], Hajj App [A2] shows the rules to be followed and necessary guidelines for Hajj pilgrimage

Hajj Umrah Guide [A3] is the pure ritual app that displays pictures, map and supplications with audio support. It displays different places that need to be visited in Hajj along with Hijri date. The application provides Quran and Hadith related to Hajj along with the instructions of necessary things to carry or not to carry. The application supports English language only but supplications are in English, Arabic and their translation is in English.

Hajj Or Umrah Ka Masail [A4] application focusses on steps to perform Hajj and Umrah and queries related to it. Basically, it's an electronic version of a book with a full guide on Hajj and Umrah. The application is in Urdu language only and it displays scanned pages of books.

Hajj And Umrah [A5] application are similar to the application [A4] but instead of showing scanned pages of books, the contents are properly written and documented with Hadith. It shows the benefits of different rituals and supports Urdu language only.
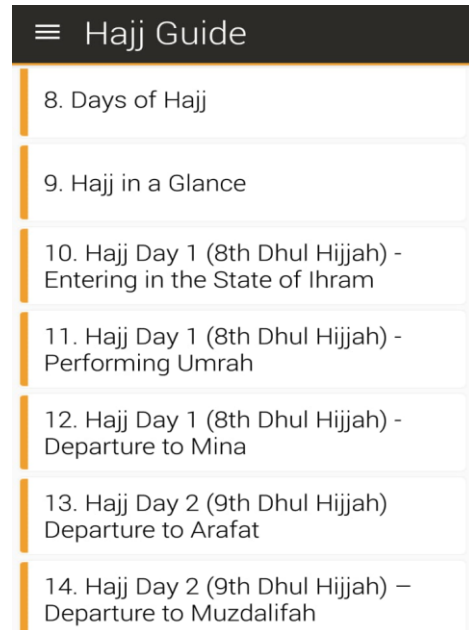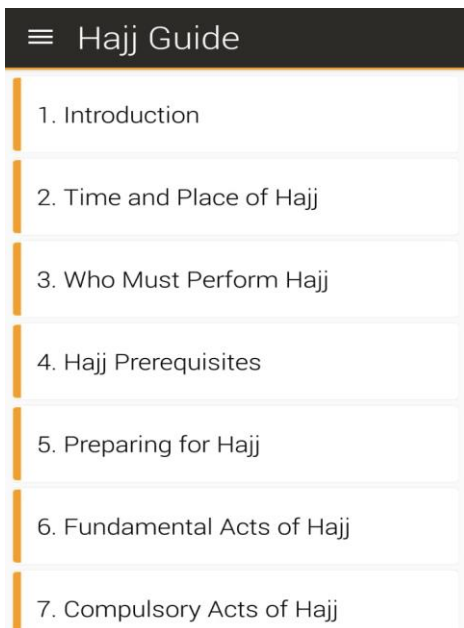

Fig. 3 Haj Guide Screenshot ([A10] Application)

Hajj & Umrah Guide English Step By Step [A6] application contains a guide to perform Hajj and Umrah in English only. It also shows supplications and information related to Ihram. Duas for Hajj and Umrah [A7] focusses mostly on supplication for Hajj pilgrimage. It shows supplication for every ritual of Hajj with audio support. The text and audio of each supplication are in English and Arabic languages.

Hajj And Umrah [A8] application are quite popular with more than 100,000 downloads that contain a comprehensive guide to perform Hajj and Umrah with video support. The app comprises 3D sign and supplications that are necessary during the pilgrimage. Moreover, it provides information about the places where supplications are not rejected and things to do before going for pilgrimage.

Hajj And Umrah Guide Urdu [A9] application contains step by step information along with supplication in Urdu language only. The application also consists of Quran, Hadith and do's and don'ts of Hajj.

Umrah & Hajj Guide [A10] application contains Ihram instruction, Haj Guide, Umrah Guide and supplications. The guide includes time and places, prerequisites, preparation, mandatory acts and farewell tawaf details. The application support English language.

Hajj Malayalam Guide [A11] contains step by step instruction to perform Haj with a list of do's and don'ts actions. The application also provides instruction for visiting Makkah and Madinah. The application support only Malayalam language.

Haj Umrah & Ziyarate Madinah [A12] provides a method of performing Umrah and Haj in video and text format. The user can download video or view online. The application shows steps to visit Masjid Al Nabawi in Madinah along

with all actions that should be performed inside the mosque. There is also a diary that helps a pilgrim to remember the actions (sunnah, wajib and fardh) that he does while performing Umrah or Haj (Ifrad, Qiran and Tammatu). It allows user to tick the action once it is done. The application stores that action with date of completion. The application provides a zoom-in feature for better readability and is available in English, Hindi and Urdu languages

Hajj ka Tarika [A13] provide videos to perform Hajj and its supplications. It also provides information about farewell tawaf. The videos are in Urdu language and application is developed in Hinglish where Urdu text is written with English script.

Hajj and Umrah Guide [A14] contains step by step guide to perform Hajj and Umrah along with supplications for each step. The supplications are in Arabic with English pronunciation and translation. The application is in the English language.

Hajj Guide Hindi [A15] application contains a scanned book that gives information about how to perform Hajj and supplications recited during Hajj journey. The application allows users to select the chapter of the book from the index page. The application and the scanned book are in the Hindi language.

Hajj Umrah Guide [A16] application provide details for Hajj and Umrah. It talks about all three types (Qiran, Ifrad and Tammatu) of Hajj. The supplications are in Arabic with English pronunciation and translation. It also contains information regarding the rituals to be performed in Masjid Al Nabawi and important Islamic places in Madinah. The application allows user to change the size of the text and is available in the English Language.

Al-Hajj Guide and Hajj & Umrah Guide Urdu [A17, A25] contains step by step instruction to perform Hajj with a list of do's and don'ts actions. It also contains a part of the Quran and Hadith that mentioned about Hajj with translation in English.

HajjAp – Your Hajj App Companion [A18] provides Hajj guide and supplications during the Hajj journey. It was developed explicitly by tour operators for their pilgrims. The application is in the English language for Australian pilgrims.

Hajj Guide and Hajj ka Tareeqa [A19, A22] application contain a scanned book that gives information about how to perform Haj and supplication recited during Haj journey. The application allows users to select the page of the book from the index page. The application is in English language, and the scanned book is in the Urdu language.

Adkarul Manasik – Hajj Adkar [A23] provides hajj guide and supplications in the Malayalam language. The application divides Hajj into different sections includes arrival, Tawaf and Sai, Ihram, Mina, Stoning and Farewell tawaf.

Hajj Guide [A24] contains information for Umrah and Hajj. The application provides each and every guideline for Hajj and Umrah starting from preparation from Haram to the end of Hajj. The application also mentions details of different days of Hajj and the list of mandatory (fardh), obligatory (wajib) and desirable (sunnah or mustahab) rituals and actions. The application is developed by Taif University and supports English and Arabic languages.

Hajj & Umrah (Step by Step) [A26] contains step by step guide about hajj and umrah. This application has clearly indicated the fardh, wajib and sunnah in red, orange ad green colour, respectively. The app has explained the steps for each day of Hajj and is developed in the English language. The supplications are in Arabic with English translation.

How to Hajj and Umrah step by step [A27] contains hajj (day by day) and umrah guide. This app is developed in 13 different languages, i.e. English, French, Arabic, Russian, Japanese, Turkish, Tagalog, Italian, German, Farsi, Spanish, Dutch and Portuguese. The supplications are in Arabic with translation in respective languages as per the app.

Hajj Umrah Guide [A29] is a comprehensive step by step guidance app for all the three types hajj, i.e. Ifraad. Qiran and Tamattu and Umrah. It also contains supplications, Ihram instructions and checklists. The application supports English Language only.

Hajj Umrah Adhkar (Kannada) [A30] is in English and Kannada languages that contains step by step guide for Hajj. The application also shows a graphical representation of Mashaer area and supplications are in Arabic along with travel tips.

AL Qudus Hajj and Umra [A31] application launched by Umrah company as a guide to perform Hajj and Umrah. The app is in Kannada language

WeSalam- Hajj and Umrah Guide [A32] contains the necessary information to perform hajj and umrah rituals along with supplications lists. It also includes tawaf and sa'i tool to count the number of rounds, complete Quran for recitation and a tracker to check the reading progress, prayer times, and a section of some inspiring news and posts. The application supports Arabic, English, French, Urdu, Indonesian, Malay, Turkish, Russian, Hindi, and Bengali languages.

Hajj and Umrah [A33] contain guidelines of hajj and umrah, tawaf-sa'i, first-fifth days of Hajj and visit of Madina. The scanned pages in the applications are available in multiple languages including English, Urdu, Hindi, Arabic, Bengali, Chinese, Creole, Danish, Indonesian, Italian, Sindhi, Tamil and Turkish.

Smart Hajj [A35] is an interactive app to perform Hajj and Umrah. It provides step by step guide for Hajj, Umrah and Tawaf in English, Arabic, Bengali, Urdu, Hindi and Malay. The app shows the latest update about the rituals on the home screen.

Hajj & Umrah guide [A36] shows steps to perform Umrah and Hajj. The Hajj guide is further divided based on day 8th to day 13th Dhul-Hijjah and supports the English language.

Zia e Hajj and umrah [A37] is a detailed guide to perform Hajj and Umrah. It provides information starting from

travelling, explanation about Ihram, the importance of Hajj and Umrah with respect to Hadith, issues of Hajj and Umrah and books related to them. The supplications are in Arabic and application are in English and Urdu.

Hajj and Umrah guide 2018 [A38] and Hajj and Umrah [A39] provide information about Ihram, Umrah and Hajj. The application also contains details of visiting Madinah city. The application and Arabic supplications are written in English.

Hajj and Umrah urdu guide [A41] and Hajj wa Umrah ka masnoon tariqa [A43] contain book in Urdu providing information of Hajj and Umrah. The application [A41] shows the pictorial representation of various steps and places. The supplications are in Arabic with Urdu translation. It also has the list of Islamic places in Makkah and Madinah cities of Saudi Arabia [A41]. Application also has a video explaining about Hajj [A43]

Umrah guide hajj guide and Makkah map [A42] enlists step for Hajj and Umrah along with necessary supplications. The app also provides information about Madinah city and supports the English Language.

Hajj guide hindi [A44] talks details of Hajj and Umrah in Hindi along with the blogs of pilgrims who already performed Hajj. The supplications are the Hindi translated version of Arabic.

Navi Hajj [A45] talks about Hajj and Umrah rituals and the ways to perform different kinds of Hajj. The app provides an option to mark the ritual once it is done. The application also gives an information about Ihram, Miqat and impermissible acts in Ihram. The application is in Arabic and English

HCOI [A47] is developed by Hajj committee of India that explained Hajj and Umrah rituals by video tutorials. The supplications are written in Arabic with their audio. The application is developed in English, but videos are explained in Hindi.

Alharamain [A49] provides details of umrah ritual with text and images. The contents are in Arabic along with supplications.

Almutawf [A51] is an interactive app to perform Hajj and Umrah. It provides step by step guide for Hajj, Umrah and Tawaf in Arabic. The app shows demonstration and steps using a graphical representation of Mashaer area. The supplications are in Arabic along with Audio option.

5. Location-based Services

Hajj Help [A1] provides weather service, prayer times and Qibla service. The weather and prayer services need to select your city from a given list of cities.

Hajj App [A2] shows nearby list of PoIs and mosques. It displays Google maps on nearby PoIs and show PoIs that are available in google.

Hajj And Umrah [A8] shows list of PoIs near to your current location. It contains prayer times of Makkah, Madina and Jeddah along with weather services. User can also view Qibla direction through the app.
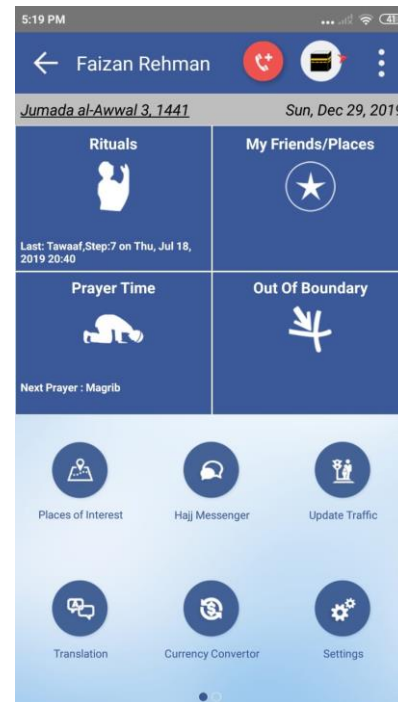

Fig. 4 Online Services ([A35] Application)

Al Hajj Guide [A17] provides prayer times for Makkah and Madina cities along with PoIs addresses and contact number of hospitals, hotels, bus stands, shops and markets.

Hajj Navigator: Mina Locater & Hajj Umrah Guide [A21] shows the list of PoIs including slaughterhouse, train stations, mosques, Arafat, Mina, Muzdalifah, Hospitals, hotels, Al-Haram and historical places in Makkah and Madina.

Hajj and Umrah navigator [A28] contain information for addresses, hajj camps, streets, districts, public services in Mashaer area. It also contains a search option, for camps, Hajj companies. The app is developed by Saudi Post and it shows the national address of the buildings and Hajj camps. The application supports English, Urdu, Arabic, Malayu, Bengali, French, Italian, Turkey, Spanish, Dutch, Portuguese, Indonesian and Bosnian languages.

WeSalam- Hajj and Umrah Guide [A32] contains Qibla direction and Places of Interest. The application shows direction using Google maps.

Manasikana and Smart Hajj [A34, A35] are an interactive app to perform Hajj and Umrah. They use highly accurate maps of the sacred areas in the Out of Boundary service to make sure that the pilgrims are in the right place at the right time. The app provides currency converter, money exchange, weather updates, prayer times, Qibla locator, and regularly updates itself to show all POIs based on pilgrim's location.

Umrah guide hajj guide and Makkah map [A42] provides a clear map of Makah city with the list of categories including airports, restaurants, hospitals, banks, ATMs, and parking. The application has the option to mark the points in the maps and see the distance between them.

Navi Hajj [A45] contains prayer times, Qibla direction and places of Interest-based on your location.

Alharamain and Almutawf [A49, A51] contains prayer times of Makkah and Madina.

6. Context-based Services

Smart Hajj [A35] notifies pilgrims and their friends and family members whenever they enter Makkah, Mina, Muzdalifah and Arafat. The friends and family members also need to install the application and connect with the pilgrims with the "Add Friend" feature. Once they add each other, friends and family members could get the notification of the pilgrims and track their location.

Tawaf & Sa'ay Counter Makkah [A40] counts the round of tawaf using GPS. The application automatically increments the tawaf counter by one once the pilgrim completes the round. Alharamain [A49] provides the status of the crowd in the Holy Mosque of Makkah. The application provides the status of the crowd in Mataf area, entry doors and general area of the different floor of the mosque including basement, ground, first and roof using green, yellow and red (as shown in Figure 5).

Fig. 5 Crowd Status in the holy mosque of Makkah ([A49] Application)

Almaqsad [50] provides indoor navigation inside the holy mosque of Makkah using Bluetooth beacons that are placed inside the mosque. The application uses the data of users to identify the gates that are open for entry and exit and update the same in navigation.

Almutawf [A51] provides status and prediction of the crowd during different hours of the day in the Holy mosque of Makkah. The application provides the status of the crowd and prediction in Mataf area, Sai area and Jamarat area for all the floors. The user can select different hours of the day to see the prediction of the crowd in Jamarat, Mataf and Sai area for all the available floors.

7. Navigation Services

Hajj Help [A1] provides navigation service to the hotel, Mina and Arafat.

Umrah and Hajj Guide and Al Hajj Guide [A10, A17] application also provide distance and time between different predefined landmarks of Hajj such as Makkah and Madina, Mina and Arafat, Mina and Jamarat.

Hajj Navigator: Mina Locater & Hajj Umrah Guide [A21] display a route on google map using google routing service from your current location to landmarks including a slaughterhouse, train stations, mosques, Arafat, Mina, Muzdalifah, Hospitals, hotels, Al-Haram and historical places in Makkah and Madina.

Hajj Guide [A24] provide an icon of Google maps with "explore nearby" that allows selecting points of Interest and navigation to that place.
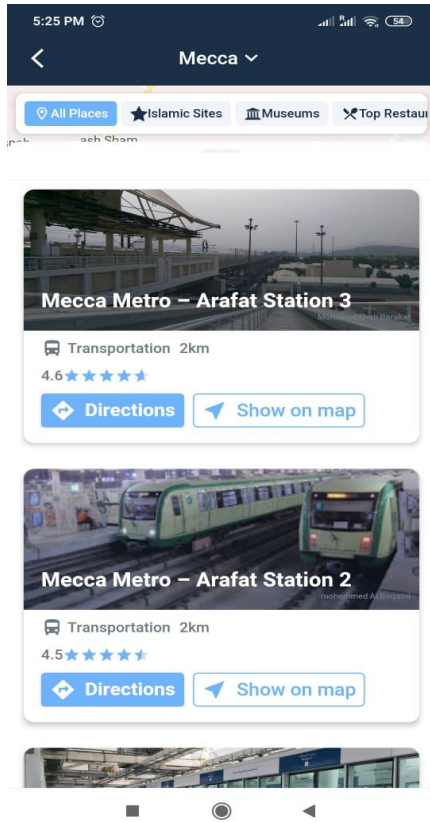
Fig. 6 Navigation to Places of Interest ([A32] Application)

WeSalam, Manasikana and Smart Hajj [A32, A34, A35] provides navigation to places of interest as shown in figure 6. The application shows many types of places of interest including restaurant, miqat, hospitals, pharmacy, mosque, barber, slaughter house, toilets.

Umrah guide hajj guide and Makkah map [A42] and Navi Hajj [A45] provides proper direction of Holy places and list of PoIs using Google maps.

Haj Navigator [A46] shows points of interest and its direction using Google Maps. The points of interest include Hospitals, Mosques, Hotels, Islamic Centre, Slaughter house and PoIs in Madina. The application also displays panorama image of Mashaer area.

Mina Locator [A48] help pilgrims and volunteers to find the route of different camps, train stations, mosques, slaughter house, hospitals and other important locations in Mina. The app also contains posts of previous hajj volunteers.

Alharamain [A49] provides navigation to different area inside the Holy mosques using google maps.

Almaqsad [50] provides indoor navigation inside the holy mosque of Makkah. The application provides turn-by-turn navigation to find PoIs or friends. The application gets the direction using Bluetooth beacons that are placed inside the holy mosque of Makkah. Moreover, they make their own 3D maps for indoor navigation.

Almutawf [A51] provides navigation to the holy mosques in Makkah and Madina cities of Saudi Arabia using google maps navigation services.

8. Other Services

There are many services that are under other services such as live video, audio, safety tips, emergency service, translation service, news service, social media, offline maps, things to carry for Hajj etc.

A. Online Services

Hajj App [A2] supports a facility to add a friend from a contact list and chat with them. To add a friend, he/she must use the application.

WeSalam- Hajj and Umrah Guide [A32] shows Makkah live stream and news related to Hajj.

Manasikana [A34] app provides emergency services, news services, hajj and umrah tweets, translation services etc.

Nav Hajj [A45] allows to share your photos in social networks.

HCOI [A47] app contains the form to apply for a Hajj and ways for digital payments. The application also shows pilgrim accommodation in Makkah and Madinah along with with flight details, their training schedule, vaccination schedule and updates related to Hajj.

Alharamain [A49] provides live broadcast of prayer and sermon of the Holy mosque. The application also allows requesting for wheelchair, itikaf, mutawef, to visit Kiswa factory and questionnaire system.

Fig. 7 List of Emergency Number screenshot from [A17] application

B. Additional Services

Hajj Help [A1] provides tasbi service, lost and found service, qurbani, Hadith and Quran. In lost and found service, the person can report about lost items and see the list of found items.

Umrah and Hajj Guide [A10] provides a list of glossaries that is related to Hajj and umrah, along with their meanings. The application also contains a sketch of Mashaer area including Mina, Muzdalifah and Arafat to demonstrate the places that need to be visited in Hajj.

Applications [A1, A3, A6, A8, A10, A12] provides fitness & safety tips and essential things including medicine to carry during the journey of Hajj.

Al Hajj Guide[A17] allows you to set any reminder with date and time. The application also provides a list of all emergency number that is very useful for pilgrims in case of any emergency as shown in figure 7.

HajjAp – Your Hajj App Companion [A18] is specially designed by an Australian tour for the pilgrim operator of Australian nationality with the information of trip and flight details and important announcement.

Manasikana [A34] app provides offline maps of Jeddah, Makkah and Madina. The users can use the offline maps of Smart Hajj [A35] to find whether they are inside or outside of Mina, Muzdalifah, Arafat or Makkah boundaries as shown in figure 8.
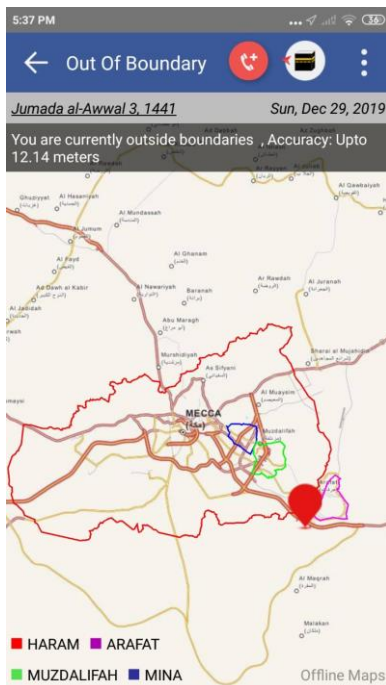

Fig. 8 Offline Maps ([A35] Application)

9. Discussion

As per our taxonomy, there are plenty of applications related to Hajj in different languages. Rituals are one of the most important categories in our taxonomy based on the number of applications, downloads and languages. Hajj is a series of Spatio-temporal rituals and every pilgrim wants to perform it in a correct and best way. Mobile applications are a convenient solution to put all the information related to Hajj. Figure 9 shows the percentage of available applications with respect to categories of taxonomy. The list of services is mentioned in Appendix-B.
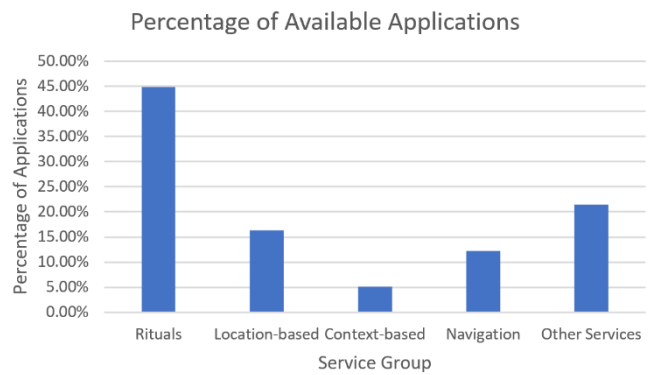
Fig. 9 Comparison of applications with respect to taxonomy categories
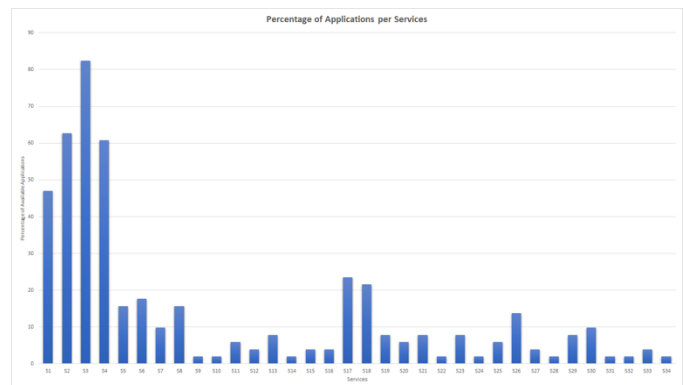
Fig. 10 Comparison of applications with respect to individual services

Other than ritual services (S1, S2, S3 and S4), the navigation (S17) and location-based (S6, S7, S11, S13 and S18) are also important services that serve an important parameter to download the applications. The applications [A20, A21] that provide navigation and places of interest services only in Mina or Mashaer area also have a good number of downloads. Figure 10 shows the percentage of applications based on individual service.
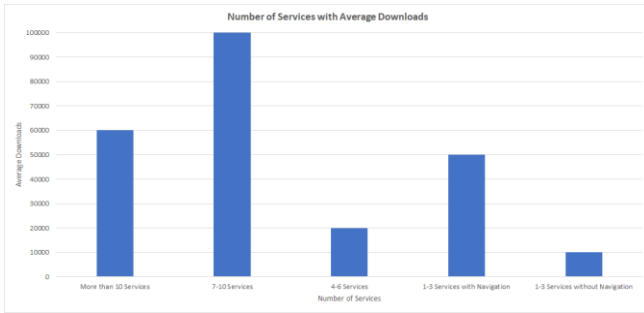
Fig. 11 Impact of number of services related to downloads of Hajj applications

Some applications provide more than 10 services, but this application has a low average number of downloads as compared to 7-10 services in an application as shown in Figure 11. Increasing the number of services in one application makes it more complicated or hide the important services which are the reason that pilgrims avoid installing such applications. Table-1 shows the top 5 languages in which Hajj applications are developed and are mostly downloaded.

Table 1: Top 5 Languages Used in Hajj Applications

Languages	Percentage
English	72
Urdu	38
Arabic	30
French	10
Turkey	10

Apart from ritual, places of interest and online navigation services, the offline maps and navigations are the important features that are important for a pilgrim due to limited availability of connectivity during Hajj days. In our view, such a feature will make the application more appealing to the pilgrims and increase the chances of installation.

10. Conclusion

In this paper, we present a taxonomy to review available Hajj applications. It considers the main branches of the services required in Hajj. We review existing Hajj applications based on the taxonomy with respect to services, downloads and languages. The survey takes an in-depth knowledge of each application and presents services for each group in the taxonomy. Later, we discussed and analyzed the applications and found that Rituals services are the most important service for pilgrims other than location-based and Navigation services. As most of the pilgrims perform Hajj only once in their lifetime and they want to perform the Hajj in a correct manner, so they use the apps with ritual services in their native languages. Location-based and navigation services are very popular whenever person visit any new city or country. Google Maps and other big giants are not as popular in Makkah as in other places of the world due to lots of changes and outdated data. Pilgrims prefer to download the app for navigation and location-based services that helps them to find nearby clinics, toilets, friend or family members, restaurants, prayer times and Qibla directions that are not available on Google maps or any other big giants in Mapping services.

Acknowledgments

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Appendix – A : Language Code for Languages Used in Hajj Applications

Language Code	Language	Language Code	Language
Ar	Arabic	Bg	Bengali
Bs	Bosnian	Ch	Chinese
Cr	Creole	Da	Danish
Dt	Dutch	En	English
Es	Spanish	Fa	Farsi
Fi	Filipino	Fr	French
Ge	German	Hi	Hindi
Hg	Hinglish	Id	Indonesian
It	Italian	Ja	Japanese
Kn	Kannada	Ml	Malayalam
My	Melayu	Pr	Portuguese
Rs	Russian	Si	Sindhi
Tg	Tagalog	Tk	Turkey
Tm	Tamil	Ur	Urdu

Appendix – B : Service Code for Services Used in Hajj Applications

Service Code	Service Name	Service Code	Service Name
S1	Tawaf Ritual	S18	Places of interest
S2	Umrah Ritual	S19	Q&A/ Fatwa
S3	Hajj Ritual	S20	Contact Us
S4	Supplications	S21	Video tutorial/TV episode
S5	Hajj program and scheduling	S22	Dua accepted places
S6	Prayer schedule and timing	S23	Currency conversion
S7	Compass	S24	Glossary/Dictionary
S8	Travel tips and checklist	S25	Graphical Representation of Mashaer Area
S9	Lost and found pilgrims	S26	Visit Al-Madina
S10	Lost and found items	S27	Fardh/wajib steps tracker for Haj and Umrah
S11	Friend service	S28	Reminder
S12	Complete Quran	S29	Dos and don’ts
S13	Temperature and Weather	S30	Talbiya
S14	Hadith	S31	Offline Maps
S15	Sacrifice	S32	National Address
S16	Tasbeeh counter	S33	Live video/Audio
S17	Navigation	S34	Ministry Messages

Appendix – C : List of Applications and their details on Google Play Store used for Hajj

S.No	Apps Name	Application Link	Downloads	Date	Version	Service code	Langua ges
A1	Hajj Help	https://play.google.com/store/apps/details?id=com.labbayak	5,000+	Jan, 2019	4.1.5	S3, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17	En
A2	Hajj App	https://play.google.com/store/apps/details?id=com.torch.android.hajj	500+	Dec, 2018	1.0	S3, S11, S16, S18,	Ar, En, Fr
A3	Hajj Umrah Guide	https://play.google.com/store/apps/details?id=com.paradox.trailumarhhajjguide	10,000+	Dec, 2018	1.0	S1, S2, S3, S4, S8,	En
A4	Hajj Or Umrah Ka Masail	https://play.google.com/store/apps/details?id=com.AppsBit.Hajj.Umrah.Masail.Guide.Islamic.Urdu	1,000+	Jan, 2019	1.2	S19	Ur
A5	Hajj And Umrah	https://play.google.com/store/apps/details?id=hajjandumrah.ittihadeahlesunnat.com.pk	500+	Mar, 2019	1.1.7	S2, S3, S5, S19, S20	Ur
A6	Hajj & Umrah Guide English Step By Step	https://play.google.com/store/apps/details?id=com.islam.hajj.umrah	1,000+	Dec, 2018	1.1	S2, S3, S4, S8	En
A7	Duas for Hajj and Umrah	https://play.google.com/store/apps/details?id=com.ilib.hajjumrahdua	10,000+	Dec, 2018	1.2	S4	En, Ar
A8	Hajj And Umrah	https://play.google.com/store/apps/details?id=com.hasshub.hajjoumrah	100,000+	Dec, 2018	3.4	S2, S3, S4, S6, S8, S13, S18, S21, S22, S23,	Ur, En
A9	Hajj And Umrah Guide Urdu	https://play.google.com/store/apps/details?id=com.suave.urduhajjguide	50,000+	Feb, 2019	1.2.5	S2, S3, S29	Ur
A10	Umrah & Hajj Guide	https://play.google.com/store/apps/details?id=com.ilib.hajjumrahdua	10,000+	Jun,2019	1.7	S2, S3, S4, S5, S8, S24, S25	En
A11	Hajj Malayalam Guide	https://play.google.com/store/apps/details?id=hajj.malayalam.guide&hl=en_US	10,000+	Aug, 2016	1.0	S3, S29	Ml
A12	Haj Umrah & Ziyarate Madinah	https://play.google.com/store/apps/details?id=com.deeniyat.HajUmrah&hl=en_US	10,000+	Aug, 2018	7.0	S2, S3, S8, S26, S27	En, Hi, Ur
A13	Hajj Ka Tarika	https://play.google.com/store/apps/details?id=com.hajjkatarika.video&hl=en_US	1,000+	Sep, 2018	2.0	S3	Ur, Hg
A14	Hajj and Umrah Guide	https://play.google.com/store/apps/details?id=com.hajj.umrah.guide&hl=en_US	1,000+	Oct, 2018	1.1	S2, S3	En
A15	Hajj Guide Hindi	https://play.google.com/store/apps/details?id=com.thunkable.android.malik782799.hajjumrahindi	5,000+	Sep, 2018	3.0	S3, S4	Hi
A16	Hajj Umrah Guide English Free	https://play.google.com/store/apps/details?id=com.hajjumrah.guideenglish	10,000+	Apr,2019	2.5	S3, S4, S26	En
A17	Al Hajj Guide	https://play.google.com/store/apps/details?id=com.suave.hajjguide	5,000+	Feb, 2019	1.9.4	S3, S4, S5, S6, S18, S28, S29, S30	En
A18	HajjAp – Your Hajj App Companion	https://play.google.com/store/apps/details?id=com.ms.ha&hl=en_US	1,000	Jul, 2018	3.1	S3, S4	En
A19	Hajj + Umrah Guide in URDU	https://play.google.com/store/apps/details?id=com.PakApps.HajjGuide	5,000+	Jul, 2017	1.0	S3, S4	Ur

A20	Hajj Navigator	https://play.google.com/store/apps/details?id=sa.iff.minatentlocator	50,000+	Aug, 2018	6.4.2	S17, S31	En
A21	Hajj Navigator: Mina Locater & Hajj Umrah Guide	https://play.google.com/store/apps/details?id=com.masha.hajj.navigator.finder	10,000+	Aug, 2017	1.0	S17, S18	En
A22	Haaj ka Tareeqa	https://play.google.com/store/apps/details?id=com.islamichub.hajjkatariqa	1,000+	Aug, 2017	1.4	S3,S4	Ur
A23	Adkarul Manasik – Hajj Adkar	https://play.google.com/store/apps/details?id=skssf.cyberwing.hajj.umra	1,000+	Sep, 2016	1.0	S3, S4	Ml
A24	Hajj Guide	https://play.google.com/store/apps/details?id=hajj.com.hajjguide	5,000+	Apr, 2016	1.1	S1, S2, S3, S4, S5, S18	En, Ar
A25	Hajj & Umrah Guide Urdu	https://play.google.com/store/apps/details?id=com.islamicappsworld.urduhajjguide	1,000+	Aug, 2015	1.5	S3, S4, S5,	Ur
A26	Hajj & Umrah (Step by Step)	https://play.google.com/store/apps/details?id=com.andromo.dev531271.app503595	5,000+	Sep, 2018	3	S2, S3, S4, S26	En
A27	How to Hajj and Umrah Step by Step	https://play.google.com/store/apps/details?id=hajj.and.umrah.englishguide https://play.google.com/store/apps/details?id=hajj.and.umrah.frenchguide https://play.google.com/store/apps/details?id=hajj.and.umrah.japaneseguide https://play.google.com/store/apps/details?id=hajj.and.umrah.turkeyguide https://play.google.com/store/apps/details?id=hajj.and.umrah.tagalogguide https://play.google.com/store/apps/details?id=hajj.and.umrah.russianguide https://play.google.com/store/apps/details?id=hajj.and.umrah.italianguide https://play.google.com/store/apps/details?id=hajj.and.umrah.germanguide https://play.google.com/store/apps/details?id=hajj.and.umrah.farsiguide https://play.google.com/store/apps/details?id=hajj.and.umrah.espanolguide https://play.google.com/store/apps/details?id=hajj.and.umrah.nederlandsguide https://play.google.com/store/apps/details?id=hajj.and.umrah.portugueseguide https://play.google.com/store/apps/details?id=hajj.and.umrah.arabicguide	5,00+	Aug, 2017	1.1	S3, S4	En, Fr, Ar, Rs, Ja, Tk, Tg, It, Ge, Fa, Es, Dt, Pr
A28	Hajj and Umrah navigator	https://play.google.com/store/apps/details?id=sa.com.sp.mashairlocator	10000+	Oct, 2018	5.0.5	S32	En, Fr, Ar, Tk, Tg, It, Es, Dt, Pr, Id, Bs, My
A29	Hajj and Umrah guide	https://play.google.com/store/apps/details?id=com.ilib.hajjumrahguide	5000+	Feb, 2018	1.2	S2, S3, S4, S8, S30	En
A30	Hajj and Umrah adhkar (Kannada)	https://play.google.com/store/apps/details?id=com.andromo.dev474440.app432425	5000+	Aug, 2017	1.0	S3, S4, S8, S25, S30	En, Kn
A31	AlQudus Hajj and Umrah	https://play.google.com/store/apps/details?id=com.andromo.dev403604.app609243	1000+	Sep, 2017	1.1	S2	Kn

A32	WeSalam- Hajj & umrah guide	https://play.google.com/store/apps/details?id=com.hajjnet.salam	100,000+	Jun, 2019	4.0.6	S1, S2, S3, S4, S6, S7, S12, S17, S18, S21, S33	Ar, En, Fr, Ur, Id, My, Tk, Rs, Hi, Bg
A33	Hajj and Umrah	https://play.google.com/store/apps/details?id=com.greenprologix.hajj.ummrah	1000+	Sep,2016	1.1	S2, S3, S6	En, Ur, Hi, Ar, Bg, Ch, Cr, Da, Id, It, Si, Tm, Tk
A34	Manasikana	https://play.google.com/store/apps/details?id=com.hajj.manasikana	10000+	Sep,2018	1.0.12	S3, S4, S6, S7, S13, S17, S18, S20, S23, S30, S31, S34	En, Ur, Hi, Ar, Bg,
A35	Smart Hajj	https://play.google.com/store/apps/details?id=com.smarthajj	10000+	Nov 2017	2.1	S1, S2, S3, S4, S6, S7, S11 S13, S17, S18, S20, S23, S27 S30, S31	En, Ar Ur, My, Tk, Bg,
A36	Hajj & Umrah guide	https://play.google.com/store/apps/details?id=org.uthmaanlk.hajj	100+	Aug, 2018	1.0.2	S2, S3	En
A37	Zia e Hajj and umrah	https://play.google.com/store/apps/details?id=com.ziaetaiba.hajj_and_umrah	500+	Sep, 2018	3.4	S2, S3, S4, S5, S15	En, Ur
A38	Hajj and Umrah guide 2018	https://play.google.com/store/apps/details?id=com.andromo.dev738202.app834746	500+	Sep, 2018	1.0	S2, S3, S4, S26	En
A39	Hajj and Umrah	https://play.google.com/store/apps/details?id=com.rnsolution.hajjandumraperforming	50+	Jan, 2019	1.2	S2, S3, S4, S26	En
A40	Tawaf & Sa'ay Counter Makkah	https://play.google.com/store/apps/details?id=com.enricher.tawafsaeecounter	1000+	Sep, 2019	1.0.9	S1	En
A41	Hajj and Umrah urdu guide	https://play.google.com/store/apps/details?id=com.ibe.hajjumrah.urduguide	1000+	Jun, 2018	1.0	S1, S2, S3, S4, S26	Ur
A42	Umrah guide hajj guide and Makkah map	https://play.google.com/store/apps/details?id=com.makkah.map.offline	10000+	Aug, 2017	1.1	S1, S2, S3, S4, S17, S18, S26	En
A43	Hajj wa Umrah ka masnoon tariqa	https://play.google.com/store/apps/details?id=com.hmabid.hajjwaumrahkatariqa	500+	Jul, 2018	2.0	S1, S2, S3, S4, S21	Ur
A44	Hajj guide hindi	https://play.google.com/store/apps/details?id=com.hindi_treadinapps.hajj_guide	500+	Oct, 2018	1.0	S2, S3, S4	Hi
A45	Navi Hajj	https://play.google.com/store/apps/details?id=com.urbsoft.navihajj	5000+	Sep, 2015	1.0	S1, S2, S3, S5, S6, S7, S18	Ar, En
A46	Hajj Navigator - Makkah O Madinah Live Navigation	https://play.google.com/store/apps/details?id=com.glowsmartsolutions.hajlocations.navigator	1000+	Sep, 2018	1.1	S17, S18	En
A47	HCOI	https://play.google.com/store/apps/details?id=com.hajapp.hcoi	10000+	May, 2019	3.0.6	S2, S3, S4, S21, S29	En
A48	Mina locator	https://play.google.com/store/apps/details?id=com.MinaLocator.AndroidApp	50,000+	Aug, 2019	1.0.29	S17	Ar, En, Ur

A49	Alharamain	https://play.google.com/store/apps/details?id=com.rize.alharamain	50000+	Sep, 2019	1.1.1.48	S2, S4, S6, S17, S19, S33	Ar, En, Ur
A50	Almaqsad	https://play.google.com/store/apps/details?id=app.navibees.alharam	50000+	Jan, 2019	1.0	S17	Ar, En, Fr, Dt, Ur
A51	Almutawf	https://play.google.com/store/apps/details?id=com.madar	500000+	Sep, 2019	13.5	S2, S3, S4, S17, S19, S23, S25	Ar