Spatio-Temporal Database Modeling And Applications For Assistance Of Huge Crowd In Hajj

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Abstract: The annual Islamic pilgrimage, Hajj has become very easy and planned in this era. Authorities in the Kingdom considering to make this Holy event more secure, convenient and controlled by planning strategically and comprehensively. For this, Government launched a program, called Vision 2030. This program intends to facilitate and serve Muslims who gathered annually in Makkah-tul-Mukarramah. Presented research proposes a model and architecture for the Hujjaj monitoring and tracking using a mobile based application. This application can function as a guide or facilitator for Hujjaj whilst performing Hajj (The Fifth pillar of Islam). The gathering of hujjaj for Hajj is taken into account as, the most important annual gathering of Muslims on earth. Hajj is a demonstration of the cohesion of the Muslim brotherhood, and their submission to ALLAH, entirely. The word Hajj is a manner of ritual or to intend a journey, which connotes each, the outward act of a journey and the inward act of intentions. Theme of this proposed application is to make sure that the Haji perform rituals (manasik) without a doubt, in accordance with the Sunnah. Presented application at the one hand is capable to improve Hajj services, and at the other hand, it additionally make sure that Haji is aware of that, 'wherein he/she is and in wherein he/she supposed to be'. We used the foundation

of spatio-temporal concepts and theory to model data, operators and functions. These spatio-temporal constructs are then integrated with geofence information to the proposed framework as a conceptual model for system. Presented application has the potential to increase the modern strategies in the way to offer assistance and provided quality of services.

Keywords: Spatio-Temporal Modelling, Hajj, Pilgrims, Huge Crowd Management System, Realtime Tracking and assistance, Mobile applications

نمذجة قاعدة البيانات المكانية والزمانية وتطبيقات مساعدة الحشود الضخمة في الحج

الملخص:الحج الإسلامي السنوي ، أصبح سهلا للغاية على غرار السنوات السابقة لعصر التكنولوجيا . تفكر السلطات في المملكة في جعل هذا الحدث المقدس أكثر أمانًا وملاءمة والقدرة على التحكم بهذا الحدث من خلال التخطيط الاستراتيجي والشامل. ومن اجل ذلك أطلقت الحكومة بما يسمى رؤية 2030. وتهدف الرؤية إلى تسهيل وخدمة المسلمين المجتمعين سنويًا في مكة المكرمة. وعلى صعيد نتائج البحوث المقدمة و المقترحة لرصد الحجاج والمساعدة في استخدام وانشاء تطبيقات الهواتف الذكية التي تخدم الحجاج . ومن الممكن أن تعمل التطبيقات كدليل للحجاج أثناء أداء الحج (الركن الخامس من الإسلام). مع الاخذ في الاعتبار العدد الكبير للحجاج المتزايد على مر السنين ، وهو يعد أهم تجمع سنوي للمسلمين على الأرض. الحج دليل على تماسك المسلمين ، وخضوعهم لله. كلمة الحج هي تعني طقوس أو رحلة ، والتي تدل على كل فعل خارجي وداخلي . فكرة انشاء التطبيق هي التأكد من أن الحجاج يؤدون طقوسهم بشكل كامل وسهولة وبلا شك او نقصان ، وفقًا للسنة. البرنامج المقدم قادر على زيادة الربحية وتحسين خدمات الحجيج. من ناحية أخرى ، والتأكد أيضًا من أن الحجاج لديهم العلم بذلك. وتم بناء التطبيق على عدد من الاسس و المفاهيم النظرية و المكانية و الزمانية لتجميع البيانات. ثم سيتم دمج هذه البنى المكانية والزمانية مع معلومات السور الجغرافي للإطار المقترح والنموذج المفاهيمي لنشر قاعدة البيانات. وسيزيد التطبيق من الاستراتيجيات الحديثة في طريقة تقديم المساعدة والرضا للسماح للعملاء بالتفاعل بأسهل طريقة ممكنة

1. Introduction

It is considered that the Hajj is most important pillar of Islam, covers all kinds of rituals. In the last month of Hijri calendar Hajj is done once in a year. In the Kingdom of Saudi Arabia Makkah, Hajj is performed by the Muslims. It is the duty of every healthy and wealthy Muslim to perform Hajj once in a life. All those Muslims who has a great health and good finance should perform Hajj. There are five pillars of Islam and Hajj is set on 5th. The word “Hajj” is to make intention to a Holy journey. Muslims start to perform Hajj from the 8 ZilHajjah to 12 ZilHajjah (13 ZilHajjah for other case). A man who pilgrims called Haji and Hajjah for female. Very large number of Muslims approximately three million of Hijjaj perform this sacred rituals of Hajj by gathering in Makkah. When the second last month of Islam ZilQadah starts the Hujjaj arrives to Saudi Arabia. With good preparation and great intention in their heart the Muslims enter in Meeqat. It takes a week to gather in Mecca. Every Muslim starts to walk seven times clock wise around the Ka’ba.

They run back between the hills Al-Safa and Al-Marwah where the drink zamzam well, then they move towards Mount Arafat where in the plain of Muzdalifa they spend a night, They through stones at evil three pillars which is also the part of Hajj. Then the time comes when they shave their heads and sacrifice animal and also celebrate three days of Eid-ul-Adha. There is also a details for the places they visited which is also has to follow. Now the Hajj is performed which starts 8th Zil Hajj to 12th Zil Hajj.

One of the main aims of this paper is to propose a novel definition of Hajj as spatio-temporal event. Hajj is defined as an event where Pilgrim has a mandatory religious obligation to move into a specific place at specific time and stay for a specific period; and leave a specific place at a specific time and perform rituals as per Quran and Sunnah". In this perspective, a Pilgrim (called Moving Object) is bound to move (enter into or depart) a specific place (a Spatial attribute) at specific time (Valid Time VT, or Transaction Time TT) for a specific period (time interval) during the course of Hajj (called Event). Therefore, the event of Hajj may be defined as spatio-temporal event where Pilgrim is the spatio-temporal object.

1.1 Problems Faced by Pilgrims during Hajj

In Islam Hajj is set of all rituals. Every year Not only the Hundreds or Thousands of Pakistani but also people of all over the world performs Hajj. These are not enough the facilities that are provided to Pakistani pilgrims, Major problems are also present especially for Pakistani not distant residence like stampede, lack of guidance etc. For performing Hajj millions of Muslims are gathered in Makkah_tul_Mukarramah every year. It becomes a challenge for the Kingdom authorities to give best security to pilgrims. Events are disturbed during this occasion with accidents and tragedies. Some of them are listed in (**Table 1)**.

Table 1: Accidental events and tragedies during Hajj [5]

Date	No. of Martyrs	Place	Reason
24-09-2015	310	Mina	Stampede
12-01-2006	360	Jamaraat	Stampede
22-01-2005	3	Mina	Stampede
01-02-2004	250	Mina	Stampede
11-02-2003	14	Jamaraat	Stampede
05-03-2001	35	Mina	Stampede
09-04-1998	118	Mina	Stampede
15-04-1997	343	Mina	Fire Spread
24-05-1994	270	Jamaraat	Stampede
02-07-1990	1426	Mina	Suffocation in Tunnel

The capacity of Haram for Hujjaj is being increased very fast. During performing of rituals see **(Table 2)** pilgrims may face various types of problems for instance lost and found scenarios.

Table 2: Spatio-Temporal-Event based application support [8]

Important Movements of Haji w.r.t Space, Time and Event	Application Support
Meeqaat Entrance and/or Exit	Location based notification to Haji using App. before and after entrance and / or exit
Perform Umrah	Notifies Haji step by step as per selection of Hajj Type and Classifies accordingly before entering into Meeqaat
Perform Tawaaf	Assist Haji by Automatic Tawaaf Counter
Perform Sa'ee	Assist Haji by Automatic Sa'ee Counter
Move to Mina	Location based notification to Haji using App. before and after entrance and / or exit with respect to date and time
Move to Arafaat	Location based notification to Haji using App. before and after entrance and / or exit with respect to date and time
Move to Muzdlifah	Location based notification to Haji using App. before and after entrance and / or exit with respect to date and time
Go to Jamaraat	Notifies Haji with respect to Location, date and time
Go to Building/Hotel	Notifies Haji with respect to Location, date and time

1.2 Primary Logical Flow Of Start Of Hajj Application (In Perspective Of UI Screens And Messages)

1) First residence select the type of Hajj.
2) Now it will check the Haji's current location that it is right or wrong based on above description.
3) Now next information is displayed.
4) Meqaat is validated.
5) Residence is validated.
6) With respect to event, location and time validate NEAR/IN/OUT of all other fences.
7) As per event, location and time information is displayed.

1.3 Application's Description:

It is worked as a remedial application by the proposed application to the problems which is defined above. To ensure the smooth performance of Ibadat the following three parameters of the application are focused by our application.

1.3.1 Monitoring

Aware that a right person is at the right place at right time.

1.3.2 Assistance

(a) The Nymi [4]

(b) Hajj QR wristband

Fig. 1: Wrist band approaches

Second measure feature of application is Assistance. On the basedof current location, date and time will be guided by Haji.

1.3.3 Tracking

Update the location of pilgrime by tracking them on server, for security reason it is reviewed the location of Hijaj.

Providing above facilities, several features will be able to provide by our application in future. Currently in our application it is focused on limited features. Key functions includes:

1. Location Based Routing and Assistance for Hujjaj
2. Immediate Monitoring and Controlling of Hujjaj as
3. Transportation Facilitation
4. Improved Disaster Management
5. uide/ Route Hujjaj for Load Balancing To Avoid Extreme Rush

6. Manage Every Single Person in Hujjaj for Timely Fulfillment of Every Activity (As Per 'Sunnah' صلى الله عليه وسلم)
7. Planning Hujjaj's Food
8. Making Prompt Decision Support
9. Improved Quality of Services during Hajj
10. Monitor and Track Hujjaj
11. Assist Hujjaj in His/her Native Language
12. Healthcare Management and Control

Hujjaj has been allotted QR wrist band (See Fig. 1b) first time in year 2016 that has following information printed:

1. Gender
2. QR code for location in Mina
3. QR code for location in Arafaat
4. Maktab Number
5. Muallim details
6. Jamaraat Timings
7. Tent Number

It has the only yet very strong power to passively assist hujjaj upon a manual trigger a smart phone application using Hajj Bracelets Reader to check the current location of Haji from its one of two destination locations during Hajj days i.e., Mina camp and Arafaat. Moreover, it has mentioned the date and time of Rami and Gender classification containing the tent number and Maktab number, region Haji belongs to, Mu'allim's name and finally the seven color code. In Mina, the location of bed for each Haji (i.e., around one square meter) is marked and valley of Mina is divided in these seven color codes. This can be visualized imply in a grid of 11x8 squares on a digital map (like google map).

1.4 NYMI Band

Nymi [4] is experimentaly used for identifying Hujjaj in this study but unsuccessful to fully integrate with obtaining unique heart ID of person as it has claimed, using the procured wrist bands. It claims a unique heart ID capturing function of every person with wearable wristband that exploit the features of Nymi that uses heart ID for identifying Haji. Person using his/her unique cardiac rhythm ECG by Nymi authentication. It is worked with sensors that is shown in **Fig. 1(a)**.

Table 3: Space vs Time[8]

Space	Time
Objects or containers for objects	Objects exist (move) in space with respect to time point or time interval
Spatial domains may be discrete, dense or continuous	Temporal domain may be discrete, dense or continuous
Random or predictable movement of objects in space	Time is not random, it is unidirectional
Spatial object in space is dynamic but static in case of container	Time is dynamic
Limited definition	Unlimited definition
Follows non-linear order	Follows linear order (T,<)
Limited dimensions	Unlimited dimensions

This module uses two electrodes one is on top and the other is on bottom. By opposite hand When the user touches the topside electrode ECG data can be captured, when the user touches the topside electrode with the opposite hand. For avoiding the Hassle and bussle in the days of Hajj NYMI band with improved, enhanced, more-adaptable, extensible version or alike gadget may be provided to pilgrim prior to departure for Hajj.

Table 4: Various mobile applications and features [8]

Application Name	Developer	Operating Mode	Monitoring	Tracking	Assistance	Spatio-Temporal features
Al Sirat	Zerone Innovations	Manual	No	No	Partial	No
سلام Salam	EtcAndroid	Manual	No	Partial	Partial	No
Hajj Organizer منظمالحج	project hajj	Automatic	No	Yes	Yes	No
Tawaf	GIS Technology Innovation Center	Manual	No	No	Yes	No
Tawaf and Sai in Hajj and Umra	Islamic Solutions	Manual	No	No	Yes	No
Hajj and Umrah	I.T. Department of DawateIslami	Manual	No	No	Yes	No
Labbaik: Hajj and Umrah Audio	AMPlified	Manual	No	No	Yes	No
Hajj player I ENGLISH	YUSUF YİĞİTALP	Manual	No	No	Partial	No
Manasik	Brainstorm Technologies Sdn Bhd	Manual	No	No	Partial	No
HajjSalam	Hajjnet FZE	Automatic	No	Yes	Yes	No
Tawaf and Sai Auto Counter	AboAdam	Automatic	No	Yes	Yes	No
My Tawaaf	TCMCORE	Automatic	No	Yes	Yes	No
SOFTnet Solat Times	Abu Bakar Hj Hasan	Manual	No	Yes	Yes	No
إحسانطواف IHSEN Tawaf	Generation IT	Automatic	No	Yes	Yes	No
Hajj Guider	Daira Tech FZCO, DTEC, Dubai Silicon Oasis	Automatic	Claims	Yes	Yes	No

2. Related work in Mobile Application Perspective and Analysis

We now analyze our literature review to identify the gap. In terms of components and functionalities Table 5 demonstrate the components and functionalities that would be given by various spatio-temporal data models.

Table 5: Comparitive analysis of various spatio-temporal models

Spatio-Temporal Data Models	Temporal Granularity	Temporal operations	Temporal Density Discrete: D Continious: C	Lifespan	Spatio-Temporal Ontology	Object-Relational Support for Moving Objects, Time and Moving Events	Event Handling Support	Transaction TT vs VT vs BT	Expendably	Type of Change All 8 types: A/N Discrete: D/N Continuous: C/N Movement: M/N	Application
Snapshot	Multiple	NO	D	NO	NO	NO	NO	VT	NO	N-N-N-N	LIS
STC	Multiple	NO	D	NO	NO	NO	NO	BT	NO	N-D-N-N	LIS
Simple Time-stamping	Multiple	YES	D	YES	NO	NO	Temporal	VT	NO	N-D-N-N	Historical Cadastral database
Event Oriented	Multiple	NO	D	YES	NO	NO	Spatial	VT	NO	N-D-N-N	LIS
3-Domain	Multiple	YES	D	YES	NO	NO	Temporal	BT	NO	A-D-C-N	LIS
History Graph	Multiple	NO	D/ C	YES	NO	NO	Temporal	BT	NO	N-D-C-M	LIS
STER	Multiple	NO	D	YES	NO	NO	Temporal	BT	NO	A-D-C-N	Cadastral Application
O-R	Multiple	NO	D/ C	YES	NO	NO	Partial	BT	NO	A-D-C-N	Rural –Urban Land Use application
O-O	Multiple	YES	D/ C	YES	NO	NO	Partial	BT	NO	A-D-C-M	LIS
STUML	Multiple	NO	D/ C	YES	NO	NO	Temporal	BT	NO	A-D-C-M	Regional Healthcare
Moving Objects	Multiple	YES	D/ C	YES	NO	NO	Partial	BT	NO	A-D-C-M	multimedia, forest fire controls

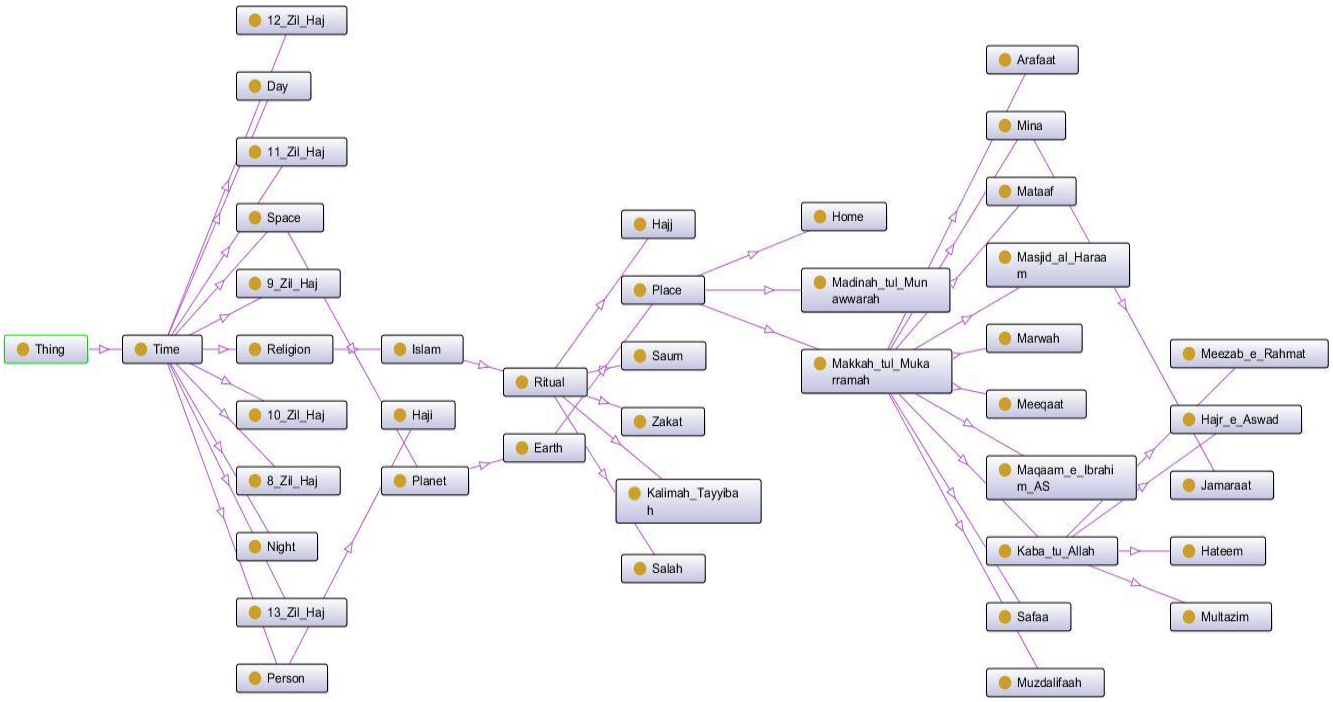

Fig. 2: A Brief ontology of Hajj [8]

We review the existing literature of Hajj through mobile applications and modeling like [7] [8] [9] in this section. There are various services and mobile phone applications are present, tracking and assistance applications are included. For assisting and tracking are listed in **(Table 4)** at some level.

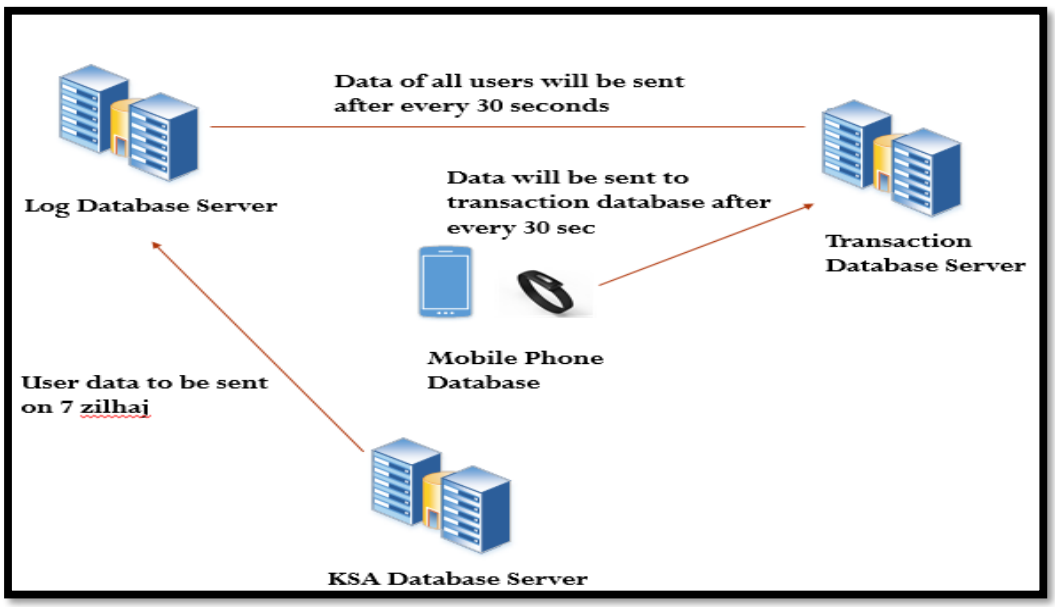

Fig. 3: Proposed Framework for application-database connectivity [7]

For instance, the easy interface to access the content publicity is *Al Sirat ,The Salam, Hajj Organizer, SoftnetSolat Times, Tawaf and Sai Auto Counter and Tawaf and Sai* in Hajj and Umra are the other additional features. It providesDu'a and keep you in Tawaf track by Tawaf counter, your progress also tracked by Sa'ee. The direction of Qiblah also determined by this program and counts the number of Tawaf rounds. It helps to remind the duties of his/her time to time and also helps to pilgrim the important steps of Hajj and keep them alert. The complete knowledge of Hajj and Umrah is provided by the *Hajj and Umra* which include Ihram, types of Hajj, The prayer assistance [31 application of tracking are IhsenTawaf, Hajj Guider' and *My Tawaaf* but except Hujjaj there is no any integrated monitoring and tracking avaibility. The applications *Tawaf and Sai in Hajj and Umra* used in collecting future data. So in monitoring, tracking and assistance for government control there is no any mobile applications, services and runtime facilitation are available. From the 1st Day our application guides the pilgrim based on his/her current location for addressing the problem. User is known at any instant by watching on screen all the supplications,

Table 6: Sptio-Temporal Existence of Hujjaj during Hajj Days with Application Assistance [8]

Date	Time	Current location	Notification
8 ZIL HAJJ	6:05 AM	Makkah	You have to move towards Mina after sunrise
8 ZIL HAJJ	6:36 AM	Makkah	Now move towards Mina.
9 ZIL HAJJ	4:20 AM	Mina	You have to move towards Arafat after Fajar prayer.
9 ZIL HAJJ	4:52 AM	Mina	Now move towards Arafat before zawal time.
9 ZIL HAJJ	11:57 AM	Arafat	Waqoof is started at the beginning of zawal time.
9 ZIL HAJJ	5:05 AM	Arafat	You have to move towards Muzdalifah after sunset.
9 ZIL HAJJ	5:36 AM	Arafat	Now move towards Muzdalifah.
10 ZIL HAJJ	6:00 AM	Muzdalifah	You have to move towards Mina when sun is about to rise.
10 ZIL HAJJ	6:25 AM	Muzdalifah	Now move towards Mina.
10 ZIL HAJJ	10:00 AM	Mina	Move towards HARAM to perform Tawaf-e-Ziarat after Qurbani and Halq or Qasr.
10 ZIL HAJJ	3:30 PM	Mashid-al-Haraam	Return to Mina for overnight stay. if tawaf-e-ziarat and sa'ee has done
11 ZIL HAJJ	11:57 AM	Mina	Perform Rami after zawal time.
11 ZIL HAJJ	3:30 PM	Mina	Perform tawaf-e-ziarat if you have not done yet and return to mina for overnight stay.
12 ZIL HAJJ	11:57 AM	Mina	Perform rami after zawal time if you have not done.
12 ZIL HAJJ	3:30 PM	Mina	Must Perform tawaf-e-ziarat before sunset and return to Mina for overnight stay.
12 ZIL HAJJ	7:00 AM	Mina	Return to Makkah for performing tawaf-e-Wida

salah timings, upcoming rituals etc by applications. . The complete knowledge of Hajj and Umrah is provided by the Hajj and Umra which include Ihram, types of Hajj, The assistance application of tracking are IhsenTawaf, Hajj Guider' and My Tawaaf but except Hujjaj there is no any integrated monitoring and tracking availability. The applications Tawaf and Sai in Hajj and Umra used in collecting future data. So in monitoring, tracking and assistance for government control there is no any mobile applications, services and runtime facilitation are available. GISTIC have developed applications [11] [12] [13] [14] for the service of pilgrims.

We discussed some applications above by studying various applications, for getting a pedestal support based on these applications it has no architecture, framework or model for presenting **(Fig. 3)**. It has not been presented, pointed and discussed the spatio-temporal ontology [1] [2] of Hajj see **(Fig. 2)** as per our best knowledge and belief. Founding this gap by us and spatio-temporal architecture presented it. Theory and the strength of spatio-temporal using this foundation. Their features are being offered and explored by various applications.

3. Spatio-Temporal Semantics

The concept of spatial and temporal aspect of Hajj is shown in (Table 3 and Table 6) by Spatio-temporal semantics (ontology) [6]. These concept incorporated by STDB model during its implementation. For creating STDB system it is so important to comprehending the data base. Realizing independently for the spatial and temporal's researches in first step. With the objects it focuses on design, modeling and querying dimensions (geometries) and it keeps in database. So these are static databases. Information is expanded by temporal databases, it helps to kept object of previous states along with the current state.

3.1 Spatio-Temporal database features

Managing the database applications is the capacity of STDBs that attributes both spatial (space coordinates) and temporal (timestamps) are possessed. Spatial database models are often the extensions of STDB's in which temporal features, in order to deal with complex dynamic environment, like moving objects, traffic flow etc. are also included. As a natural fact in a single application of both spatial and temporal data are needed to join.

3.1.1 Valid Time (VT)

$\overset{\Psi}{V}_x$ in the modelled reality the fact of time t is true. In Hijre calendar 8 Zil Hajj to 13 Zil Hajj is considered the valid time of Hajj. Time of entrance into Meeqat in KSA till the exit is considered as the valid time of Haji.

3.1.2 Transaction Time (TT)

$\overset{\Psi}{T}_{Z_e}$ in database the current element is Z_e. (e may be an object or event or time). 8 Zil Hajj to 13 Zil Hajj of Hijre present as a transaction time of Hajj. So during the valid time of Hajj an event moves form one place to another. When Haji enters it is set as a valid time for Haji. During this time they stay or leave.

3.1.3 Existence Time

$\overset{\Psi}{\exists}_O = \overset{\Psi}{V}_{\exists_o}$ is applied as a valid time of object's existence.

The time of Manasik is the existence time for Hajj (which starts the starting till exit time of Hajj) in this time we stay in Mina, Arafaat and Muzadlifah during Hajj. Transaction time is also the existence time of Hajji which is considered as IN valid.

3.2 Spatio-Temporal Modelling Requirements

a. In the literature many data is considering in modeling spatio-temporal [4][11][30]. Some requirements are given below.

b. The existence in time , the identification of object and spatial coordinates (attributes) representation.

c. Changing in object movement with respect to time need capturing.

d. Spatial attributes and organization definition sets into layers.

e. Changing of spatial attributes need capturing over the time.

f. Association of spatial attributes to objects.

g. It is the representation of spatial relationship with respect to time among different objects.

h. It is the representation of spatial attributes relationship in time.

i. For the data correctness spatio temporal integrity's specification is used.

3.3 Spatio-Temporal Query Languages

In the database environment for managing the spatio-temporal data, existing query languages have most of extended versions. There is an extension of DEAL called HQL (Hibernate Query Language) in which all the programming constructs is provided (nesting, loop, conditional sructure, functions etc). These operations similar to spatical relationship operators that handling the spatio-temporal query. In this context of Spatial query languages that includes Geo-Quel and GeoQ, STQL (extention of SQL)[10], and for query handling that is considered for Spatio-temporal. For the both spatial and temporal charactereistics which served a forementioned lanuages and also offers paradigms of spatial-temporal query lanugage. However, it is the big weakness of STQL represented for the objects that move continuously.

4. Proposed Framework and Application

- An ID is generated for each Haji with firebase with his complete details, for the identification purpose the details we get convey to the Hajj monitoring.With firebase this app is for

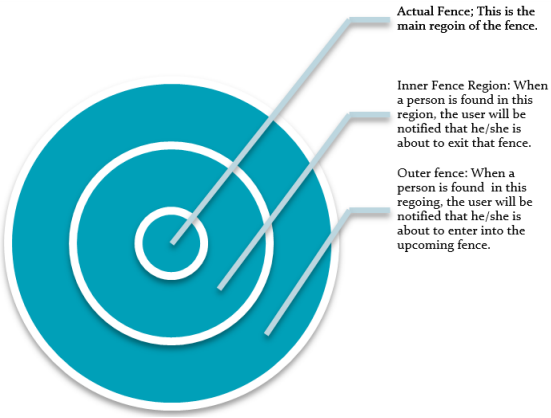

Fig. 4: Topology of fences used for mobile [8]

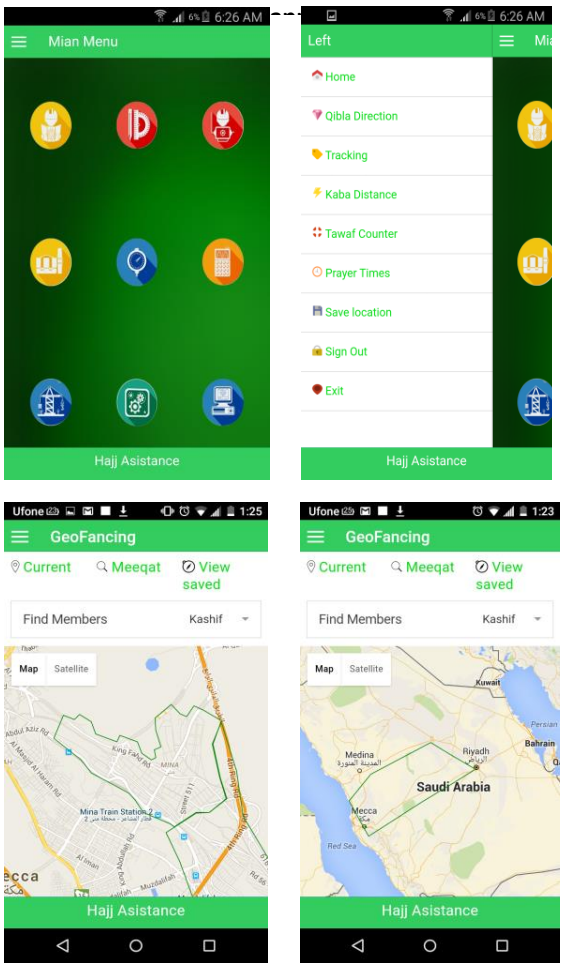

Fig. 5: Hajj App's screenshots (User + Admin) modules [7]

Hajj is integrated, On the basis of country, city the details we get is useful for the identification of Haji.

- The current and last locations of Haji's details uses in monitoring of hajj and it has been shared also to the team of Saudi Arabia.
- The hajj monitoring team will use this data if any tragedy or misfortune would be happen to haji to rescue.
- The risk of missing haji will be reduced during hajj with the cooperation of hajj monitoring team of Saudi Arabia.

Tawaaf is one of the most important ritual in Hajj. During Tawaaf hujjaj are being assisted,

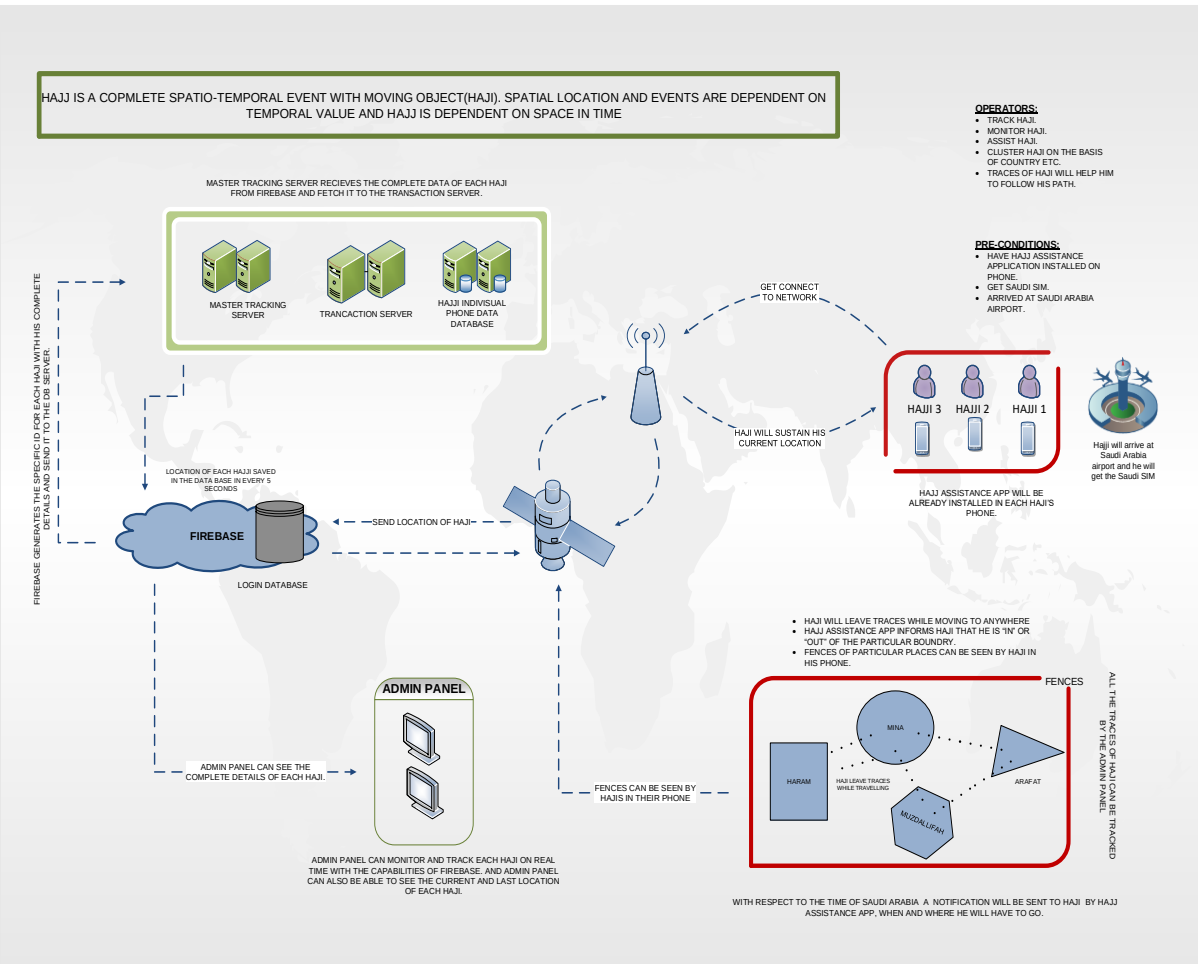

Fig. 6: Work flow model of proposed system [7]

monitored and tracked by automatic rounds counting. There is a Hajr-e-Aswad in the corner where Tawaf starts.

4.1 Smart Hajj Assistant

Two modules (user and admin) responsible to notify the user in our application about Haji's current location and keep monitoring to alert using spatio-temporal opertors **(Fig. 5)**. If Haji crosses any fence and get far from place during Hajj. There are three fences as a copy fences of each, shown in **(Fig. 4).** Key functions includes:

Fig. 8: View of Fence for Arafaat [3]

- *Location Based Routing and Assistance for Hujjaj*
- *Immediate Monitoring and Controlling of Hujjaj as*
- *Transportation Facilitation*
- *Improved Disaster Management*
- *Guide/ Route Hujjaj for Load Balancing To Avoid Extreme Rush*
- *Manage Every Single Person in Hujjaj for Timely Fulfillment of Every Activity (As Per 'Sunnah' صلى الله عليه وسلم)*
- *Planning Hujjaj's Food*
- *Making Prompt* Decision Support
- *Improved Quality of Services during Hajj*
- *Monitor and Track Hujjaj*
- *Assist Hujjaj in His/her Native Language*
- *Healthcare Management and Control*

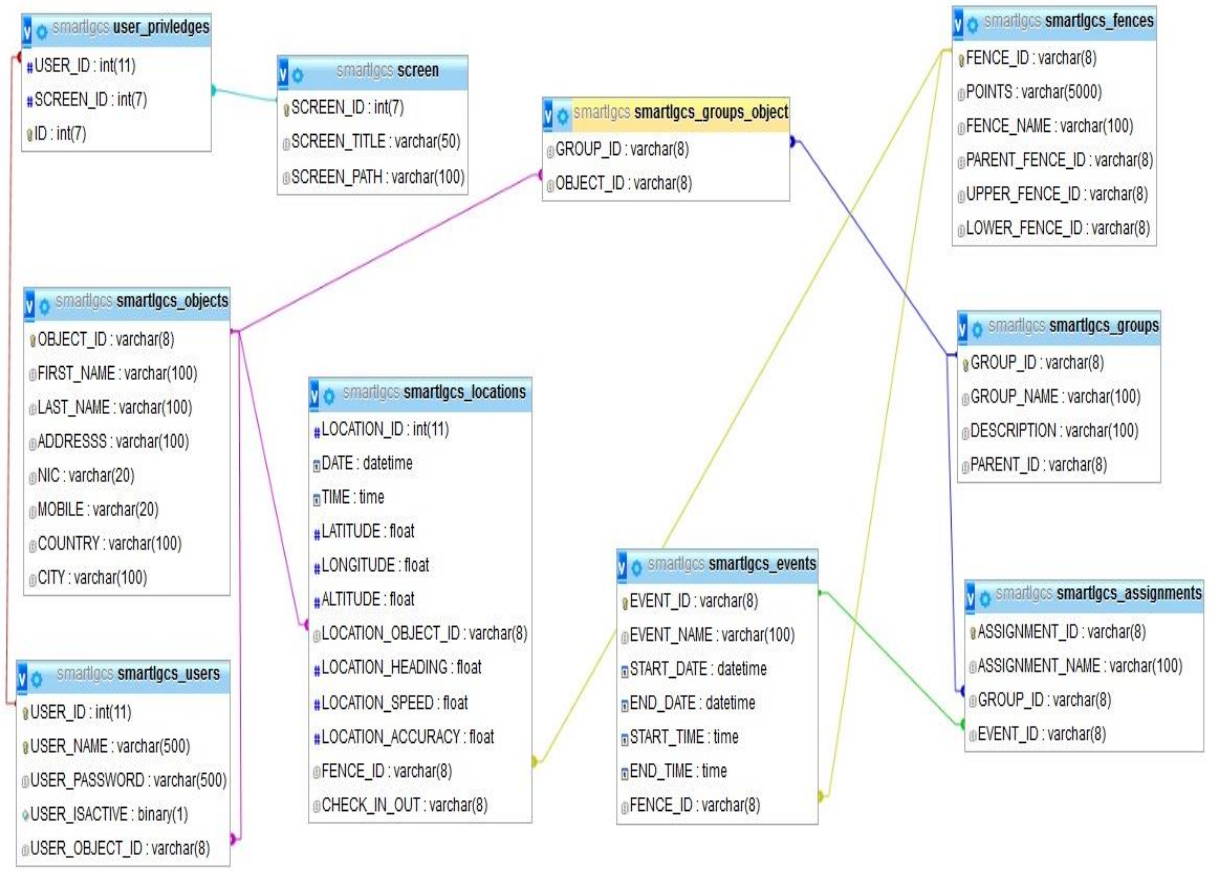

Fig 7: Conceptual data model for the system

5. Discussion and Analysis

Our all application is based on Geo Fences. By using the Google map "My Map"[3] we have described the fences in order to make the desired features locations of Saudi Arabia. Polygon based technique is used by us so the interest is defined by a geofence. In **(Fig. 6)** and **(Fig. 7)** the proposed workflow and conceptual database model for the modeled system is illustrated, respectively.

For example, there is particular sets of entities at outside of the polygon that is not expected to stray. Particular collections are applied to Geo fences. There are numbers of properties of each geofence which are ID, Name, Collection IDs, Polygon.

Geofences for Meeqat, Makkah-tul_Mukarramah, Haram, Masjid-al-Haraam, Mataaf, Safaa, Marwah, Mina, Arafaat and Muzdalifah for our application see **(Fig. 8)**. Based on their location and fence user/ Haji will get notifications.

6.Conclusion & Future Work

All those aspects which are necessary to tackle during Hajj are presented in this work. The handling of spatio-temporal data is presented in this research for real time applications and it is too useful for Hujjaj. his will also help for further assistance in future for monitoring and tracking of Hujjaj during Hajj. However, Nymi wristband did not function as expected during experiments. Reason is that NFC integrated in band not working. Hence it is dependant with the companion app. This requires application independent band, free to work without any other integrated hardware of software. In the future, the aim of this research is to be more practical, optimized and in a broader situations willing to deploy our prototype.

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