Contextual Requirements for Mobile Native Applications

Contextual Requirements

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***Abstract*—Mobile apps have found wide acceptance in today's world which heavily depend on smart technology to access data over wide location. The apps are mostly of native type which can be used for accessing data even without the internet availability. In this paper the development of mobile native applications requires the assimilation of various analytical contexts depending on the requirement of users. We have done an empirical study of various papers based on ubiquitous systems and mobile apps for finding out the contexts in building mobile native apps and the mobile contexts are such as device context, user context, mobility context and social context. We have found that the overall weight of each mobile context is an empirical study. We have taken various activities which are performed among a user and mobile native apps and formed them into questionnaires which are sent to different mobile native app developers of different software industries. The mapping is done among these activities with the attributes and their associated mobile contexts. We have identified and obtained four contexts as main requirements for developing mobile native apps under any domain. The analysis of requirements is done modeling the contexts and their attributes through OWLDL language. We have determined from the empirical study that the overall weight of device context is more than the other contexts. Hence it is clear that the device context with its numerous features have a great impact on developing mobile native apps under any domain.**

Keywords—Mobile contexts; pervasiveness; device usability; mobility interaction

I. Introduction

Mobile devices are the ubiquitous devices embedded with various sensors and powerful processors which provide information about any domain like agriculture, health care system and learning system. There are various platforms of mobile phones like ios phone, windows phone, android phone which are open for third party services. It means user can install third party applications from the central mobile application stores. These apps are stand alone in nature and don't always require the web services to access the data and hence are termed as mobile native apps. The mobile native apps are developed for smart phone applications that run specifically for native applications and don't require the internet connection for web services. These apps are written in 'objective C' or java programming languages depending upon the OS used by the mobile device. Mobile native apps are high performing and have a great deal of reliability for the user. Since the mobile native apps are platform dependent, different versions are required to be developed for different platforms thereby increasing its cost of development. Context awareness in mobile apps discovers information based on contexts like device specific, user's activity specific and mobility specific. By enabling context awareness in mobile apps, these apps can provide information subject to any domain. Mobile context aware applications are more effective and adaptive due to the providing of required contextual information to users without taking so much attention of users. In generic domain, users need information about different domain specific entities. This information can be given to users through mobile apps with or without web services.

There also exist various frameworks or process models such as Mobile-D, Scrum, MASAM (Mobile Application Software Development using Agile Methodology) and SLeSS (Scrum Lean Six Sigma) which are used for building mobile native apps [1], [2]. But the requirement analysis phase in these frameworks or process models do not identify the requirements contextually under any domain. The word "context" is used to define and describe any entity based on different aspects. To build mobile native apps which can be used in any domain, it is necessary to identify the contexts of the mobile native apps. In this paper a study is done on the basis of the important context specific components of the mobile or ubiquitous device and from this study mobile context elements have identified as requirements for developing mobile native apps such as device context, user context, mobility context and social context. Its associated components and the commonalities are identified from the relationships among the contexts which give a clear idea to the developer of the native applications about the extent of its optimum usage by the user of a particular domain.

Here the research process is to identify the optimum context under mobile domain and identifying the overall weight of four contexts through empirical study. The four contexts are such as device context, user context, mobility context and social context which are referred to as mobile contexts in our research work. The overall weights of each mobile context have been determined. From the empirical study we have found that the overall weight of device context is more than other contexts. We have specified various activities and arranged them into questionnaires and send them to various mobile native app developers of different software industries. These activities are the actions performed among a mobile native app user and mobile system. Further these activities are mapped with the mobile contexts under any domain. We have identified that most of the activities are mapped into device context and its associated attributes. Hence device context have a great deal in developing mobile native applications under any domain. The requirement specification described the contexts under mobile domain and its associated attributes. The requirement analysis describes the commonalities among mobile contexts under any domain.

The rest of the paper is organized as follows. Section 2 discusses related works on contexts in ubiquitous systems and context-awareness in mobile apps. Section 3 provides the research approach for the requirement specification. Section 4 discusses about empirical study and identification of requirements in mobile native apps. Section 5 provides requirement specification and requirement analysis for the development of mobile native apps. Section 6 provides discussion. Section 7 provides conclusion and future work, respectively.

II. Background Study

A. Contexts and Context Awareness

Context is information which is used for identification of the situation of entities, that is whether a person, place or object is considered relevant to the interaction between a user and an application, including the user and the application themselves. Context [3] can be segregated into different dimensions such as external context and internal context or physical context and logical context. Context can [4] also be divided into four categories such as computing context, physical context, user context and time context. It is a fact that context has no uniform or standard definition. So everyone can give his understanding about context and it can be classified into any dimension. However in mobile computing area, the target of using context is to enable the device to better serve for people, either human computer interaction or context-aware mobile application or service.

Classification of context should establish the human-centric essence. It includes classification of context [5] into three dimensions such as physical context, internal context and social context. Physical context refer to the real world nearby user, making up physical things. Internal context is composed by abstract things inside people, such as feeling, thought, task, action, interest, goal, etc. which is very related to people. Social context means user's social surrounding, that is social relationship of user. This social context consists of persons related to user. The Generic Context Management Model consists of three basic components such as context semantics, context instance data and context related rules. Context semantics represents the semantics, concepts and relationships in the context data. It is formed by ontology that describes domain independent generic contexts and domain specific contexts. Context data represent instances of contexts. These are classified into various classes such as user context, device context, application contexts, network contexts, and resource context [6]. The rules represent derivation of axioms that are used by context aware systems to derive decisions and conclusions about the actions that follow. These rules have two sources such as rules that are explicitly given by the users through the user interface and rules that are implicitly learnt by the system itself.

Mobile learning is the learning of different contexts. Mobile learning is unique in the sense that it is the combination of mobile technology and it's affordances that create a unique learning environment and opportunities which can span across time and place [7]. Content delivery, to the user should be based on their current context. Context plays an important role while designing the m-learning environment. The mobile learning context is where the situational and learning context meets in a learning environment. Contexts are created through mobile learning and classified as [8], learning context, situational context and learning environment context. The COMET [9], provides a semantic model for designing mobile learning applications and this model designs the mobile learning system into three aspects such as learner centric context, activity context and environment context. The learner centric context is segregated into profile, preference, physiological and cognitive abilities. The environment context is composed of many other contexts such as physical environment, social environment, virtual environment and computational environments. The activity context for mobile learning is composed of many activities such as physical exercise games, participatory simulations, field trip and visit, etc.

Context aware systems are able to adapt their operations to the current context without explicit user intervention and thus aim at increasing usability and effectiveness by taking environmental context into account. Due to the nature of context-aware applications, which often react to changes of the context during their execution, context server is provided a subscription-based push mechanism [10], which provides synchronous access to the context. Context data distribution [11], is the capability to gather and to deliver relevant context data about the environment to all interested entities connected to the mobile ubiquitous system. In fact, context data distribution is extremely significant from both the service and the middleware perspectives. The Muffin is a multi-sensory mobile device for providing context awareness to users. It is used as a prototype for extraction of different contexts. Here the contexts are categorized into three contexts [12], such as muffin terminal's context, user context and environmental context. Muffin's terminal context could be extracted accurately by using sensors and validating the output data. Furthermore muffin's state can be classified into exclusive classes and applies simple algorithms such as threshold analysis for finding the Muffin's state. In order to extract user context, a user has to carry Muffin in some ways. However available sensors and algorithms may change according to the position or situation in which Muffin mobile device is used. Environmental context such as air temperature and air pressure are directly extracted from sensors.

The Knotti project has designed and implemented a context aware platform for providing context aware services to mobile users. The platform enables the sharing of contexts and contextual contents. It provides the context aware services to users by segregating the contexts into various types [13], such as location, mood, mode of spending time, time and social context, etc. The middleware platform [14] is developed to support context aware mobile apps development. It is capable of locating and extracting relevant context data from a large number heterogeneous data sources distributed over many different operating environments. This platform is designed as a service oriented architecture including various system functionalities as context data acquisition, reasoning, service registration and discovery. These are all designed and deployed as system services for developers and end-users to access. The middleware architecture consists of four logical layers such as physical space layer, context data management layer, service management layer and application layer. A mobile guide [15], is a mobile app that provides context dependent services, indoor and outdoor navigation to users operating on personal digital assistants (PDA) and smart phone applications. Mobile guide also provides [15], location awareness, map based navigation, bookmarking, collaboration, contextual information with multimedia mechanisms to users. The contexts in mobile guide are such as user, service, environment, system and social. Mobile guide architecture consists of three tier architecture such as application tier, middle tier and data tier. Mobile native apps can also be providing information about health care apps. For example mobile e-healthcare app [16] can be developed using HTML5 and provides context aware diabetes information to users or patients. For developing the e-health mobile apps, it uses various sensors such as accelerometer, low pass filter, magnitude filter for monitoring diabetes in the body when the user is in moving, walking or running stage.

III. Research Approach

In order to explore the issues around mobile native application requirement analysis processes and what characteristics are typically included in these requirement specifications, we have established three research questions (RQ1to RQ3). These are as discussed below.

A. *RQ1*

How the requirement gathering is done in building mobile native apps under any domain?

This question RQ1 is established to identify, understand the attributes or elements under mobile domain which are included in the requirement specifications for mobile native applications.

B. *RQ2*

How the different attributes or elements under mobile native app development are identified in order to give effective requirement specification for building mobile native applications?

This question RQ2 is established to identify different attributes or elements under mobile domain with a particular focus on mapping of attributes with mobile contexts for building mobile native applications.

C. *RQ3*

How the requirement analysis is done in building mobile native applications under any domain?

This question RQ3 is established to specify the requirement analysis under any domain with a particular focus on establishing of commonalities among four mobile contexts for building mobile native applications.

IV. Requirement Specification under Mobile Domain

A. *An Empirical Analysis on Context Elements under Mobile Domain*

We have taken the contexts from the papers as mentioned in this study which is shown in Table 1 and assigned some values to these contexts. Here the assignment is done through taking a total of 100 values and dividing the total number of contexts from total value to get the desired value. This desired value is assigned to each context of papers in the study which is shown in Table 1. For example the contexts specified such as learner's personal status context, situational context and learning environment context in [8]. Hence the individual value for each context will be 33.33% that is 0.33 values. The context elements under the learner's personal context are learner's preferences, demographic information, and learner's history. So the value of each context element under this learner's personal status context will be assigned to the desired value as 33.33/3=11.11% that is 0.11value. For example the learner's preferences, demographic information and learner's history context element will obtain the desired value as 11.11% that is 0.11value. Here the learner' history, demographic information and learner's history are identified and classified as user contexts in our proposed work.

TABLE I. An Empirical Study on Contexts

Sl no	Authors of specified papers	Ref no[ ]	Context specified in these papers	Context elements under these contexts of specified papers	Contexts classified in proposed work	% of Overall value of contexts in the proposed work
1	Genevieve Stanton and Jacques Ophoff	[8]	Learner's personal status context (33.33%) Situational context (33.33%) Learning environment context (33.33%)	Learner's preferences (11.11%) Demographic information (11.11%) Learner's history (11.11%) Social interaction (11.11%) Cultural surrounding (11.11%) Rules around communication (11.11%)	User context User context User context Social Context Social Context Social Context Device context Device Context Mobility Context	User context (19.71) Device context (48.67) Mobility context (22.72) Social context (8.87)

				Functional ability of the device (11.11%) Physical attributes (11.11%) Technical attributes (11.11%)		
2	Sohaib Ahmed and David Parsons	[9]	Learner centric context(33.33%) Activity context (33.33%) Environmental context (33.33%)	Learner's profile (8.33%) Learner's preferences (8.33%) Learner's physiological state (8.33%) Learner's cognitive state (8.33%) Physical exercise games (8.33%) Participatory simulations (8.33%) Field trips and visits(8.33%) Content creation(8.33%) Physical Environment (8.33%) Social environment (8.33%) Virtual environment (8.33%) Computational environment (8.33%)	User Context User context User context User context User context User context User context User context Device Context Social Context Mobility Context Device Context	
3	Dejene Ejigu and Marian Scuturici	[6]	User context (12.5%) Device context (12.5%) Application context (12.5%) Physical environment context (12.5%) Resource context (12.5%) Location context (12.5%) Network context (12.5%) Activity context (12.5%)	User's Identity (3.12%) User's preference (3.12%) User's activity (3.12%) User's location (3.12%) Processor speed (4.16%) Screen size (4.16%) Device location(4.16% Vesion (6.25%) Availability (6.25%) Illumination (6.25%) Humidity (6.25%) Availability (4.16%) Size (4.16%) Type (4.16%) Inclusion of contents (12.5%) Minimum speed (6.25%) Maximum speed (6.25%) Start time (4.16%) End time (4.16%) Actor (4.16%)	User Context User Context Device Context Device context Device Context Device Context Device context Device context Mobility context Device context Device context Device Context Device Context Device context Device context Mobility Context Mobility Context Device Context Device Context User context	
4	Tetsuo Yamabe and Tatsuo Nakajima	[12]	Muffin terminal's context (33.33%) User context (33.33%) Environmental context (33.33%)	Device motion (11.11%) Device posture (11.11%) Placement (11.11%) User's activity (8.33%) User's physical condition (8.33%) Emotion (8.33%) Geographical information (8.33%) Air temperature (8.33%)	Device Context Device Context Device Context Device Context User Context User Context Device context Device Context Device context Device Context Device context	

				Air humidity (8.33%) Air pressure (8.33%) Ambient noise(8.33)		
5	Espoo	[13]	Location context (16.66%) Time (16.66%) Mood (16.66%) Mode of spending time (16.66%) Social context (16.66%) Virtual context (16.66%)	Fixed location (5.553%) Moving location (5.553%) Relative location (5.553%) Weekdays (5.553%) Weekends (5.553%) Seasonal Changes (5.553%) Relaxing (16.66%) Management board(5.553) Project meeting (5.553%) Economy committee (5.553%) Reminders (8.33%) Sending of personal messages (8.33%) Connection of mobile materials to virtual places (16.66%)	Device Context Device Context Device context Device Context Device context Device Context User Context User Context User Context User Context Device Context Device context Mobility Context	
6	MARGUERITE L. KOOLE	[7]	Device aspect (33.33%) Learner aspect (33.33%) Social aspect (33.33%)	Physical characteristics (5.55%) Input capabilities (5.55%) Output capabilities (5.55%) File Storage (5.55%) Error rates (5.55%) Processor speed (5.55%) Learner's prior knowledge (6.66%) Discovery learning (6.66%) Emotions and motivations (6.66%) Memory(6.66) Context and transfer (6.66%) Conversation and Cooperation (16.66%) Social Interaction (16.66%)	Device Context Device Context Device Context Device Context Device Context Device Context User Context User Context User Context Device context Social Context Social Context	
7	Thomas Hofer and Wieland Schwinger	[10]	Time context (20%) Location (20%) Device (20%) User (20%) Network (20%)	Current time (20%) Current position of the device (20%) Device type (20%) Information content by user (20%) Available network (10%) Connection types (10%)	Device Context Device Context Device Context User Context Mobility Context Mobility Context	
8	Li Han and Salomaa Jyri	[5]	Physical Context (33.33%) Internal Context (33.33%) Social Context (33.33%)	Real world nearby user (16.66%) Making of physical things (16.66%) Feeling (8.33%) Thought (8.33%) Task (8.33%) Interest (8.33%) Social surrounding (16.66%)	Device Context Device context User Context User Context User Context User Context Social Context Social Context	

				Social interaction (16.66%)		
9	Karel-Henk Nijhuis	[32]	Context related to human factor (50%) Context related to physical environment (50%)	Information about the user (16.66%) User's social environment (16.66%) User's task (16.66%) Location (16.66%) Infrastructure (16.66%) Physical conditions (16.66%)	User Context Social Context User Context Device Context Device Context Device Context	
10	Jacqueline Floch and Svein Hallsteinsen	[27]	User context (50%) Network context (50%)	User mood and role (25%) User physical location (25%) Network capacity (25%) Accessed I/O devices (25%)	User context Device Context Mobility Context Device context	
11	Panu Korpipä and ä, Jani Mäntyjärvi	[28]	Location (20%) Time (20%) Environment (20%) User (20%) Device (20%)	Device/user location Time of the day Sound (5%) Temperature (5%) Humidity (5%) Light (5%) User's activity (20%) Device activity (10%) Application (10%)	Device context Device Context Device context Device context Device context Device context Device context Device context Device context	
12	Qusay H. Mahmoud	[29]	Location (25%) Time (25%) User's preferences (25%) Device capability (25%)	Device context (25%) Device context (25%) User context (25%) Device context (25%)	Device context Device context User context Device context	
13	PAOLO BELLAVISTA and ANTONIO CORRADI	[11]	Computing Context (25%) Physical Context (25%) Time Context (25%) User Context (25%)	Device capabilities (12.5%) Connectivity (12.5%) Device/user location (6.25%) Noise level (6.25%) Lighting data (6.25%) Temperature (6.25%) Time of a day (6.25%) Month (6.25%) Week (6.25%) Season of the year (6.25%) User's profile (8.33%) People nearby (8.33%) Current social situation (8.33%)	Device context Mobility context Device Context Device Context Device Context Device Context Device Context Device Context Device Context Device Context User Context Social Context Social Context	
14	Anind K. Dey and Gregory D. Abowd	[30]	Location (25%) Activity (25%) Identity (25%) Time (25%)	Device/user's location Device/user's activity User's profile Time of the day	Device Context Device context User Context Device Context	

15	George W. Musumba and Henry O. Nyongesa	[31]	Location (12.5%) Activity (12.5%) Identity (12.5%) Mood (12.5%) Social Context (12.5%) Physical Context (12.5%) Network Context (12.5%) Device Context (12.5%)	Device/user location (12.5%) Device/user activity (12.5%) User Profile (12.5%) User mood (12.5%) Relationship with people (12.5%) Lighting level (12.5%) Round trip time (12.5%) Device capabilities (12.5%)	Device Context Device Context User Context User Context Social Context Device Context Mobility Context Device Context	
16	Emmanouilidis, C., Koutsiamanis, R. A	[15]	User (20%) System (20%) Service (20%) Social (20%) Environment context (20%)	Emotional state (2.85%) User category (2.85%) Preferences (2.85%) History (2.85%) Activity (2.85%) Location (2.85%) Orientation (2.85%) Device characteristics (3.33%) Network conditions (3.33%) QoS constraints (3.33%) Privacy (3.33%) Security (3.33%) Energy consumption (3.33%) Available service (6.66%) Task sequence (6.66%) Constraint (6.66%) Relationships (6.66%) Group (6.66%) Interaction (6.66%) Crowding (6.66%) Time (6.66%) Noise readings (6.66%)	User context User context User context User context Device context Device context Device context Device Context Device context Mobility context Device context Device context Device context Device context Device context Device context Social context Social context Social context Device context Device context Device context	
17	Preuveneers, D., Berbers, Y.	[16]	Time (33.33%) Location (33.33%) Accelerometer sensor readings (33.33%)		Device context Device context Device context	

Here in Table 1, we have analyzed the contexts in papers and classified them under device context, user context, mobility context and social context in our proposed work. We have obtained the total number of device context element from various papers (17) that can be obtained as calculating sum of all the device contexts of various papers (17). This can be done using the formula, which is given below:

The total number of device context element = $\sum_{i=1}^{i=17} Devicecontext(i)$.

Therefore the total number of device context elements is such as 9.38.

Similarly the total number of mobility context, social context and user context can be calculated using the formula as given above and are such as 4.38, 1.71 and 3.8, respectively.

After that all the four context elements are added to obtain a total value 19.27. Further the overall value of device context in our proposed work is calculated by using the formula (total number of device context elements / total value *100). The overall value of device context can be found as (9.38/19.27*100) and is obtained such as 48.67. Similarly the overall value of user context, mobility context and social context in our proposed work are 19.71, 22.72 and 8.87 respectively. In this empirical study we have obtained the four contexts such as device context, user context, social context and mobility context in mobile domain and these contexts are specified as requirements to develop mobile native apps in generic domain.

Here we have taken the total overall value as 100 and out of 100, the % (percentage) of overall value of device context is 48.67. Similarly the % (percentage) of overall value of mobility context, user context and social context are 22.72, 19.71 and 8.87 from 100. From these four contexts, the % of overall value of device context is more than other contexts. Hence it is observed that, the device context with numerous and efficient features have a great impact in developing mobile native apps. After that mobility context has to be taken into account while developing mobile native apps under any domain. The user context and social context have a little impact on developing mobile native apps under any domain.

B. Identification of Requirements

We have taken numerous activities of various components in mobile native apps and organized them into a set of questions through Google forms and have sent to various mobile app developers of different software organizations for specifying the requirements under mobile domain. We have received their response and the requirements are determined based on their responses. Some of the questions are discussed below.

Q1. The native mobile app development requires what type of storage to save data?

a. Shared preference

b. Device memory or internal memory

c. External storage

d. Private database

e. All

No of respondents for a=2

No of respondents for b=5

No of respondents for c=0

No of respondents for d=0

No of respondents for e=5

Q2. The app widgets require which layout classes?

a. Linear layout.

b. Relative layout

c. Frame layout

d. Grid layout

e. All

No of respondents for a=0

No of respondents for b=0

No of respondents for c=2

No of respondents for d=0

No of respondents for e=8

Q3.Which gestures are used in mobile native app development, while interactions are done among user and mobile device.

a. Drag

b. Drag and Drop

c. Pinch

d. Zoom in and Zoom out

e. All

No of respondents for a=0

No of respondents for b=0

No of respondents for c=0

No of respondents for d=0

No of respondents for e=10

Q4.Is it possible for a mobile device to be built, with all types of sensors to measure user's location, orientation and all types of environmental conditions?

a.Yes

b.No

No of respondents for a=10

No of respondents for b=0

The questionnaire and responses are shown in bar graphs in Fig. 1 and 2, respectively.

Getting the responses from various mobile native app developers in various software industries, we have identified their attributes. Further these activities and their attributes are classified into contexts which are identified as requirements based on contexts for building mobile native application under any domain.

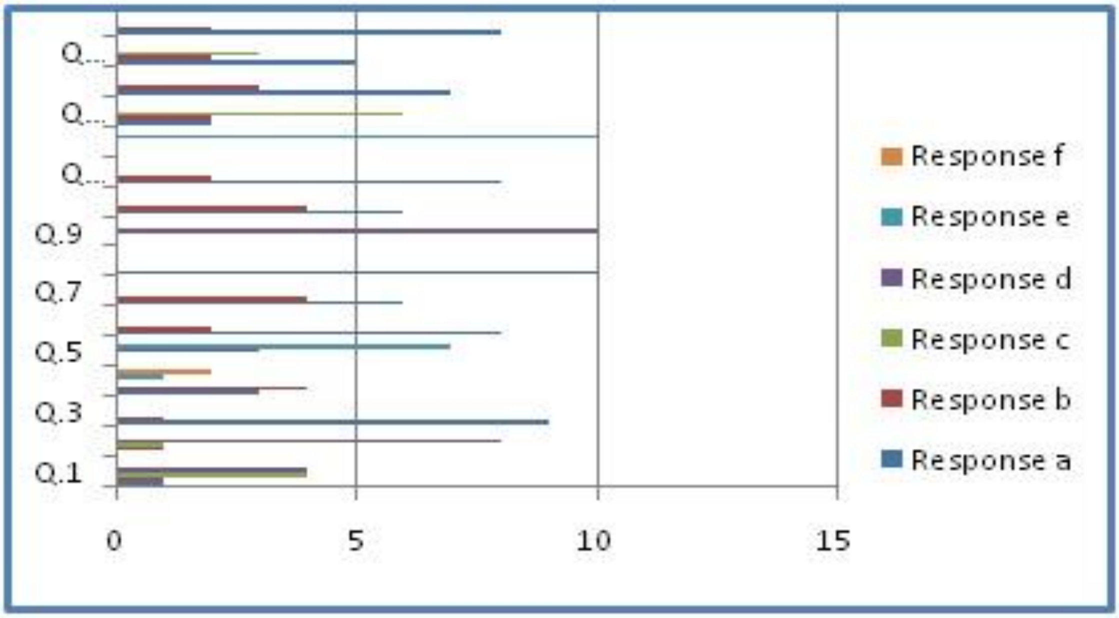

Fig. 1. A sample of questions Vs mobile native app respondents.

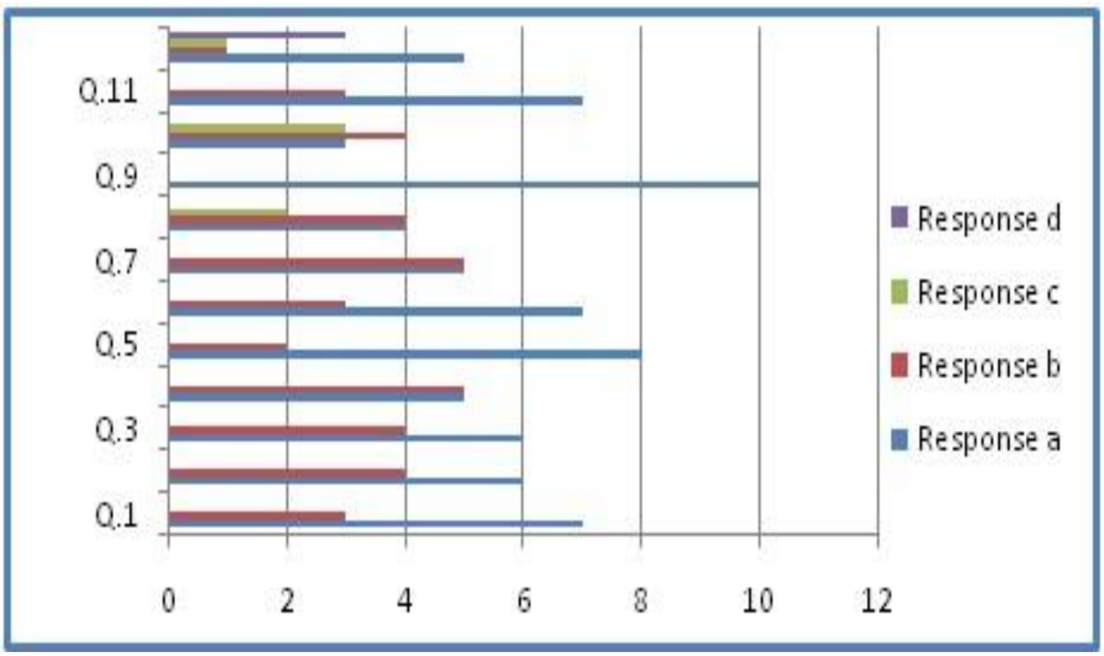

Fig. 2. A sample of questions Vs mobile native app respondents.

1) Mapping of Various Activities into Mobile Contexts

At first we have taken various activities which are done among mobile native user and mobile device and put them into a set of questions and collect the responses from various mobile native app software developers. Depending upon the responses, the activities are specified and classified into attributes and contexts under generic domain for mobile native apps. Further these activities are classified into different attributes and contexts which are shown in Table 2.

Here in Table 2, we have specified an activity, i.e. drag and drop and this activity is placed in form of question in Google forms. This activity or question is shown as Question No. 3 as above in Section 4.2. We have identified its attribute such as gestures and this gestures attribute is mapped to device context as shown in Table 2. Similarly from the other we have identified the other attributes and mapped them to contexts such as user context, mobility context and social context.

Further these attributes under various contexts are identified as requirements for building mobile native apps and given in requirement specification as below.

TABLE II. MAPPING OF VARIOUS ACTIVITIES INTO CONTEXTS

Activity	Attributes	Context
Doing operations on screen of mobile device	Screen size and density	Device context
Doing operations on app widgets of a mobile app	Layouts or app widgets	Device context
Doing operations on menus of an mobile app	menus	Device context
Accessing the content of an mobile app	Content providers and content size	Device context
Saving the data in an mobile app	Storage	Device context
Providing controls to a user for selecting the input field	Input control elements	Device context
Extending the app widgets with the screen size	Margin	Device context
Drag and drop	Gestures	Device context
Finding location and weather data	Sensors	Device context
Connecting the mobile app with web server	WLAN	Mobility context
Connecting the mobile app with web server	GPRS	Mobility context
Connecting the mobile app with web server	EDGE	Mobility context
Retrieving information from the mobile app specified on user's role and task	Based on role	User context
Finding effectiveness on information from app	Based on preferences	User context
Finding efficiency on information from app	Based on preferences	User context
Finding ease of use on the mobile app	Based on usefulness	User context
Obtain trust on the retrieved information	Based on usefulness	User context
Accessing the audio and video files	Blogs	Social context
Sharing of information among users	Social networking	Social context
Searching relevant information	Wikis	Social context

V. REQUIREMENT SPECIFICATION

The requirement specification specifies different mobile contexts which can be applied to any domain area which are as follows in Sections (A-D).

A. *Device Context*

Device context includes features of mobile device through which user get information about any web domain area. Feature of a mobile device includes physical characteristics, functional characteristics and technical characteristics [7]. The physical characteristics [17], of a mobile device include screen size, screen resolution, overall physical dimensions, weight etc. The functional characteristics of a mobile device include input mechanisms, gestures and output mechanisms. The technical characteristic of a mobile device includes processor speed, sensors and storage capabilities. The motion, posture and placement of a mobile device can be extracted from various sensors [12], which includes 3D accelerometer, digital compass and skin resistance sensor. The device context parameters are taken from device context of mobile devices to use web apps are as follows.

1) Sensors: The sensors [18], form an important device context parameter of the mobile device. The sensors can be categorized as location, touch, proximity, environmental, data, motion and visual sensors. The location sensors sense the geographical position of the device in a particular area. The touch sensors are vital in accessing the touch screen technology in the modern smart phones. They sense the specific touch gestures on the screen which is sensitive to finger sensation in particular gestures. This touch gestures [19], is passed to the input component and is interpreted by the mobile operating system as a particular input. The proximity sensor senses and provides information on the distance, direction and area of the mobile device from that location point.

2) Input output mechanisms: The input mechanism device context parameter plays a key role of accepting input data in form of text , code or any other type of data to provide the input for possible and analyzing the data for the user of the mobile devices. The input mechanism can be facilitated by the most basic input device context parameters like the keyboard. The keyboard can be either touch based called the smart keyboard or physical key based called the standard keyboard.

The touch based keyboards are mostly present in the smart phones to efficiently enter the test based data to be used in numerous applications. The most common smart key boards are QWERTY keyboards and Swift Key keyboard. The output mechanisms of a mobile device includes speakers and screen display.

3) Gestures: Gestures form important device context parameters for smart and efficient input style for navigating web apps in smart phones. Gestures are the different typing or finger movements on the smart keyboard of the touch screen based smart phones for different input styles required for different applications. The various types of gestures used commonly in smart phones are touch, long press, swipe, drag, long press drag, double touch, double touch drag and pinch.

4) High Screen Resolution: High screen resolution is one of the essential requirements for data visualization of the smart phones. It is the ideal mix of sharpness, contrast and brightness of the screen for a comfortable and clear visualization of data.

5) RAM size: This is the data storage aspect which acts as an important device context parameter from the primary memory storage of the mobile devices. The larger the RAM size, the faster is the data loading rate for the web apps. This increases the efficiency of the usage of various native apps on the mobile device.

B. User Context

User context includes the user context parameters such as user's profile, role of user, preferences, process and task [8], associated with user from a general common social aspect. User and role holds context information related to user and its activity [6]. The user context also determines the belief of a user that interacting with the mobile system will enhance its task that is termed as usefulness [20]. The user context parameters are based on the involvement of the user with the native mobile apps considering certain important parameters which are classified into functional requirements and non-functional requirements such as Based on role, Based on preferences and Based on usefulness. These parameters are as follows:

1) Based on Role: The user context parameters are considered according to the basic roles they perform during their interaction with the native apps running on the mobile device.

2) Based on Preferences: The user context parameters according to the preferences of the user based on certain aspects of the mobile apps are effectiveness, efficiency, satisfaction and memorability [21]. The effectiveness shows the ability of a user to access the information in a particular context. The efficiency shows the extent of speed and accuracy of specific features of the mobile native apps used by the user. Satisfaction is the extent of fulfilment of the user's requirement by the usage of the mobile apps for a particular purpose by the user with the different aspects of mobile apps. Memorability is the ability to retain the step wise actions for accessing a specific feature of the mobile native apps.

3) Based on Usefulness: The user context parameters are analyzed on the basis of the extent of the usefulness of a native app user with the different contexts of mobile device like device contexts and social contexts. The parameters determining the aspect of usefulness are perceived ease of use, perceived usefulness, intention to use and trust [20], [22].

C. Social Context

Social context includes the concept of relevance of social media to the user context and the mobility context of the mobile apps. Web 2.0 includes the social media tools such as wikis, blogs, podcasting, micro-blogging, content hosting, social networking, e-Portfolios and social-bookmarking [23], [24]. Among them most of the social media tools include (www.unimelb.edu.au), wikis, content hosting, social networking, blogs and podcasting. The social context determines the relationship of the social media parameters with respect to its usefulness to fulfill the requirements the user intends to satisfy through the mobile apps. The social context parameter includes.

1) Blogs: Blogs are type of commentary or information dealing with a specific topic. It is an important social context parameter which acts as a medium to express user's information about a specific topic which is utilized by the user to benefit for a particular purpose.

2) Content Hosting: Content hosting is a social context parameter which enables the sharing of user's specific information by the public user of the content hosting sites to be viewed and used by the users using the web apps.

3) Social Networking: Social networking is the social context parameters through which a user can create and maintain a user profile for sharing the information on specific topics to be used by other users for their relevant requirements and purposes.

4) Podcasting: Podcasting is a social context parameter through which audio and video files can be accessed by the user through specific file formats compatible with specific devices to be listened or viewed or downloaded for offline usage purpose.

5) Wikis: Wikis are social context parameters which allow the users to contribute and edit the information available publicly to the community of users searching for their relevant information. Wikis provide information about specific topic which the users easily searches and views them. This social context parameter provide the user an easy access to almost every information and edit and add more information if they choose to.

D. Mobility Context

Mobility context is the flexibility and portability of a wireless mobile device in moving from one pale to another and continuing to access the data connection network facility throughout its location inside the network zone. It plays an important role in the modern emerging wireless network technologies. Mobility brings freedom to personalize the computing experience and work satisfaction of a user and also empowering agility of a mobile device using any one wireless standard, such as WLAN, GPRS and EDGE [25]. The mobility context determines the various parameters which are used by the social and device context parameters to access the information for a user using the mobile native apps. The complex mobility pattern can be implemented using a hierarchy of filters through GPS on a mobile device [26]. The mobile native applications for mobile devices are seen as inherently insecure due to their open interactions with other applications on the device. Hence these native apps should use standard built in OS browsers, (powering state and local mobility) for achieving mobility and interacting with outside world since they do not encrypt cookie, history or cache information.

1) WLAN: WLAN stands for wireless LAN which is a wireless network which links two or more devices using an interface like a network interface card for the wireless devices for a limited area of network access like the college campus, home ,office campus or business establishment.

2) GPRS: It stands for the general packet radio service which is a mobile data accessing service using the GSM technology on mobile phones. The GPRS provides the packet data rate of up to 172 kbps.

3) EDGE: EDGE stands for enhanced GPRS or enhanced data rates for GPRS evolution. IT provides 3 times faster speed than the original GPRS system. The data rate varies from 135 kbps to 473 kbps in 8 time slots which conserves these spectrum resources.

4) Bluetooth: Bluetooth is a common wireless network communication technology between the wireless mobile devices to transfer or share data in form of data files of various types like text, picture graphics, audio or and video files.

5) GPS: Global positioning system or GPS is a navigation technology which is used for providing the time and location information of an object which can be a mobile device in all type of environmental conditions on the earth or within its atmosphere in a range close to its surface. GPS information is provided by GPS satellites which can be one or more a number providing images of the mobile device with in the unobstructed line of sight.

6) Browser: Browser is a mobility context parameter, which is used for mobile devices for accessing the information over the web by using the mobile web apps. Mobile browsers are optimized for the effective display of user friendly screen interface compatible to portable mobile devices.

E. Requirement Analysis

The requirement analysis is done through defining the commonalties among various contexts in a mobile domain for design and development of mobile native apps. The commonalities include device usability, pervasiveness, social interaction and mobility interaction. The device context, mobility context, social context and user context are taken into consideration to form mobile ontology. Here in this mobile system ontology, the device context and the other contexts are treated as classes. This mobile system ontology is built using OWLDL language in protégé 5.0 beta framework. The commonalities are built in mobile ontology through using property axioms among these classes. Here the device context and its components are treated as class and sub classes to build the mobile ontology. The mobile ontology is shown in Fig. 3.

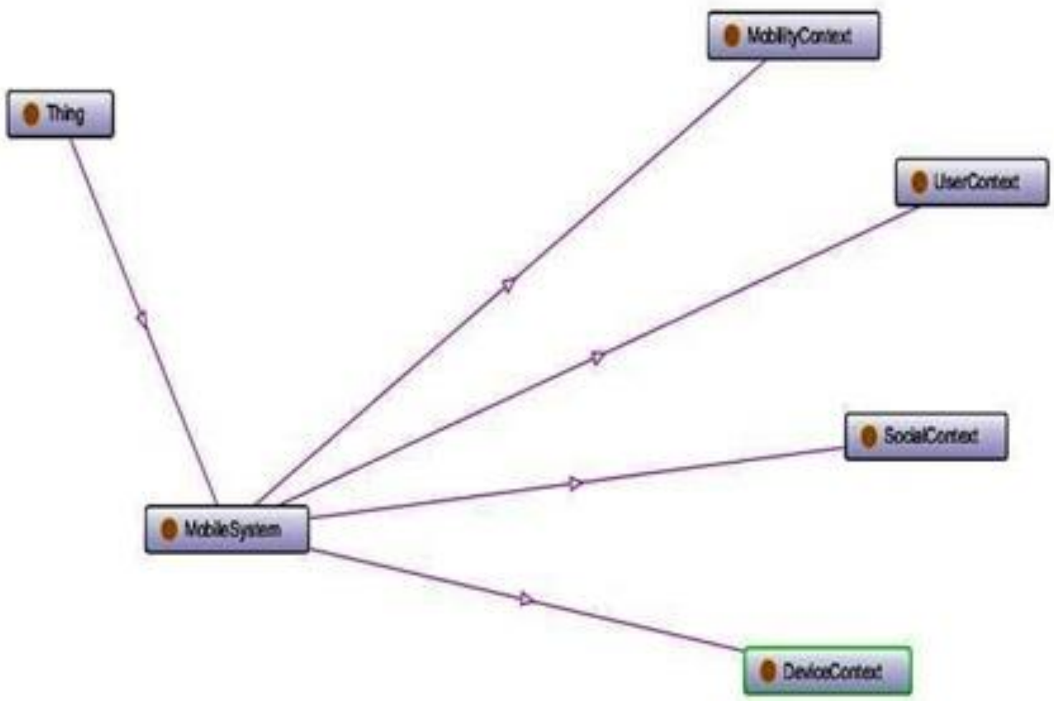

Fig. 3. Mobile system ontology.

1) Device Usability: The mobile device usability is the co relationship between the parameters of device context and the user context taking into view the commonalities which satisfy each other's criteria for a mobile device in accessing native apps over the mobile device.

2) Pervasiveness: Pervasiveness is the movement of the device inside the network area determined by the mobility context parameters. It shows the utilities of the device context parameters like sensors, gestures, input mechanism, high screen resolution and ram size inside the network area as shown by mobility context parameters.

3) Mobility Interaction: The mobility interaction is the usability of social context parameters in the mobile network area supported by the mobility context parameters showing the interaction between social context parameters.

4) The social interaction: It is the user interaction over the internet using social media web apps for sharing and transferring information from one user to another.

The classes under device context identified are as follows:

Device Context:

- SENSOR
  - Data sensor
  - Proximity sensor
  - Location sensor
  - Environmental sensor
  - Touch sensor
  - Visual sensor
- Gestures
- Keyboard
  - Swift key keyboard
  - Qwerty keyboard
  - High screen resolution
- RAM size > 1

These subclasses under device context are modeled to form device context model through OWLDL in protégé 5.0 beta framework. The device context model is shown in Fig. 4 below.

Mobility Context: The classes under this context are as follows:

Mobility Context

- WLAN
- GPRS
- EDGE Bluetooth
- Browser
- GPS

These subclasses under mobility context are modeled to form mobility context model through OWLDL in protégé 5.0 beta framework. The mobility context model is shown in Fig. 5 below.

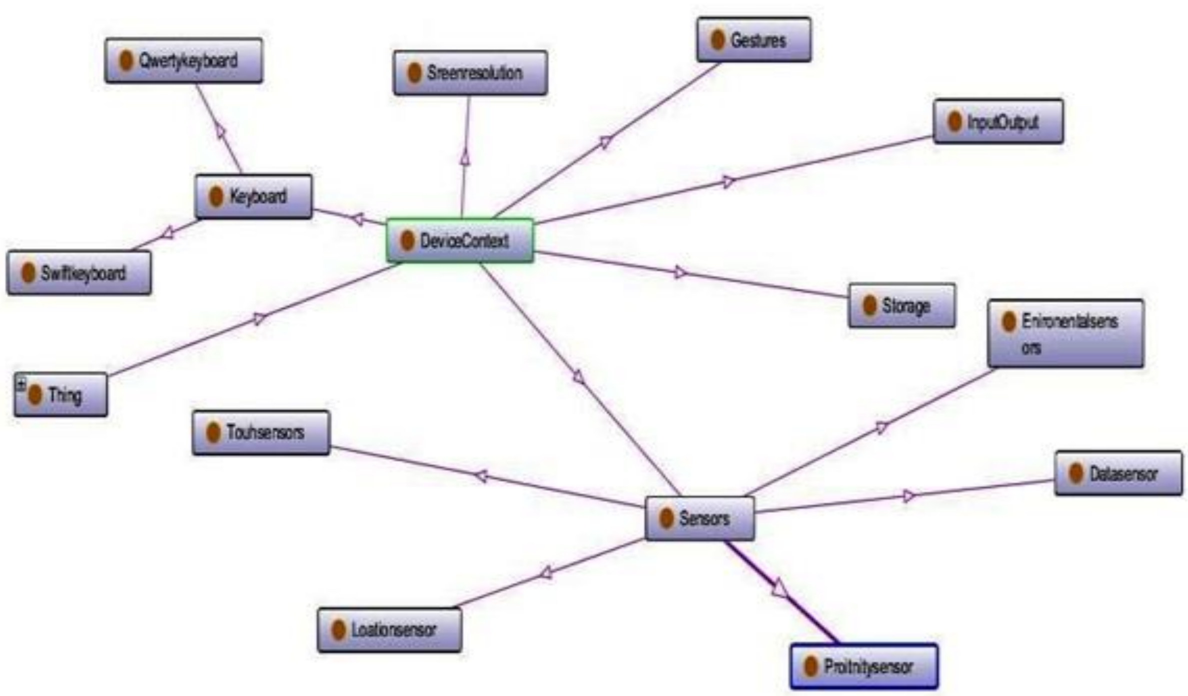

Fig. 4. Device context model.

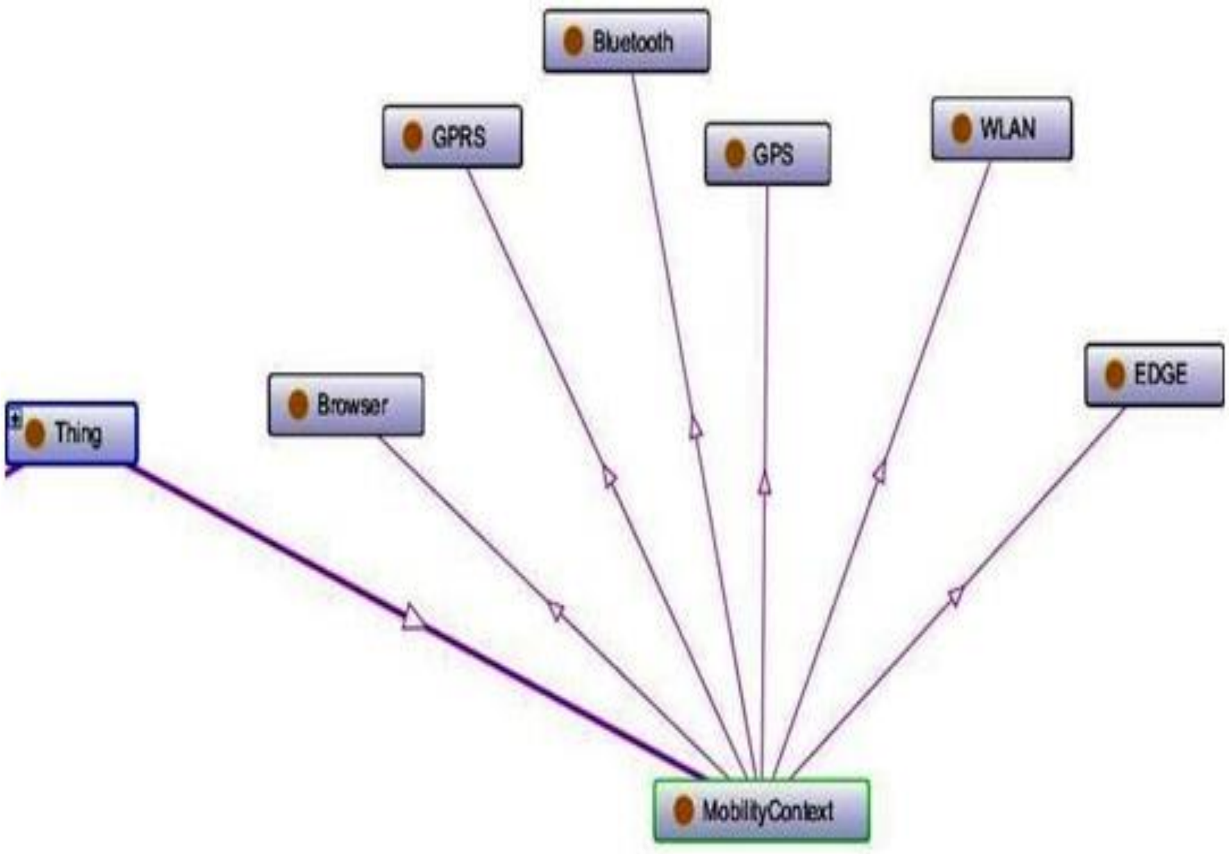

Fig. 5. Mobility context model.

User Context: The classes under this context are as follows:

User Context

- Based on role

  Category A

  Category B

  Category C

  Category D

  Category X

  Category Y

  Category Z

- Based on preferences

  Effectiveness

  Efficiency

  Satisfaction

  Memorability

- Based on usefulness

  Perceived ease of use

  Perceived usefulness

  Intention to use

  Trust

These subclasses under user context are modeled to form user context model through OWLDL in protégé 5.0 beta framework. The user context model is shown in Fig. 6 below.

Social Context: The classes under this context are as follows:

Social Context

- Blogs
- Content hosting
- Social networking
- Podcasting
- Wikis

These subclasses under user context are modeled to form social context model through OWLDL in protégé 5.0 beta frame work. The social context model is shown in Fig. 7 below.

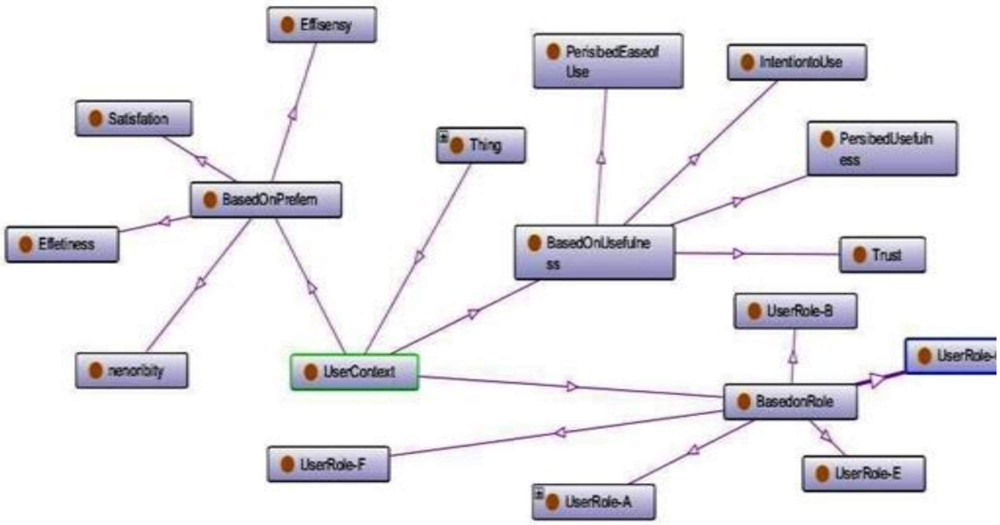

Fig. 6. User context model.

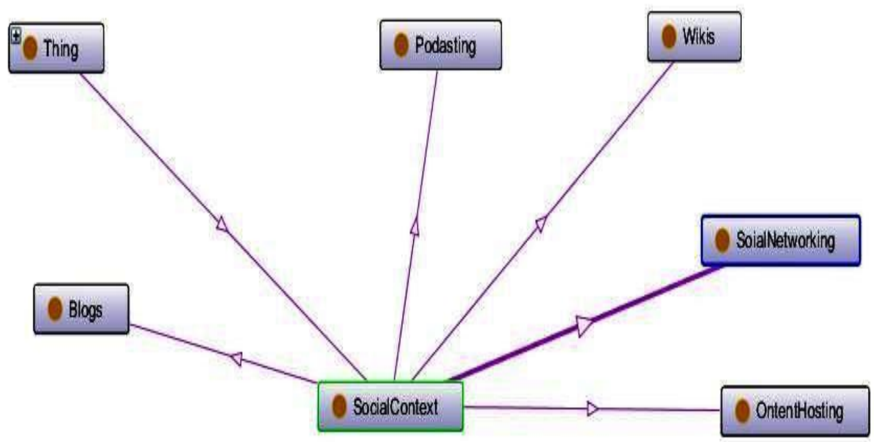

Fig. 7. Social context mode.

VI. State of the Art

From the empirical study, we have obtained the four contexts such as device context, mobility context, user context and social context under mobile domain. Among these four contexts, device context has a greater impact on building mobile native applications. The requirement specification also specifies these four contexts and their attributes. The requirement analysis provides modeling of these four contexts and their corresponding attributes which are shown in Fig. 5-8. Further these contexts and their attributes have more importance on designing and developing mobile native apps. Here we have taken some activities which are performed in mobile native apps. Further these activities will be drawn from the four contexts elements which will undergo several design phases for developing mobile native apps. These are shown below in Table 3.

The first one deal with doing operations on the keyboard and gestures are the attributes of device context which we have explained in Section 5.1. These attributes will be taken into consideration for user interface design in designing and developing mobile native apps. The third one imposes the attributes such as WLAN, GPRS and EDGE, etc. which undergo mobility context. These elements are hardcoded into the hardware of the mobile device through establishing connections via adapters and sockets irrespective of any platform. These mobility context elements are configured in the mobile device through protocols and their features are accessed by applications developed for building mobile native applications irrespective of platform. Hence these mobility context attributes will be put in architecture design in building mobile native applications. The fourth activity concerns about installation of any mobile native application which is dependent on Ram size and platform of the device. These attributes are under device context and taken into account for architecture design in mobile native apps.

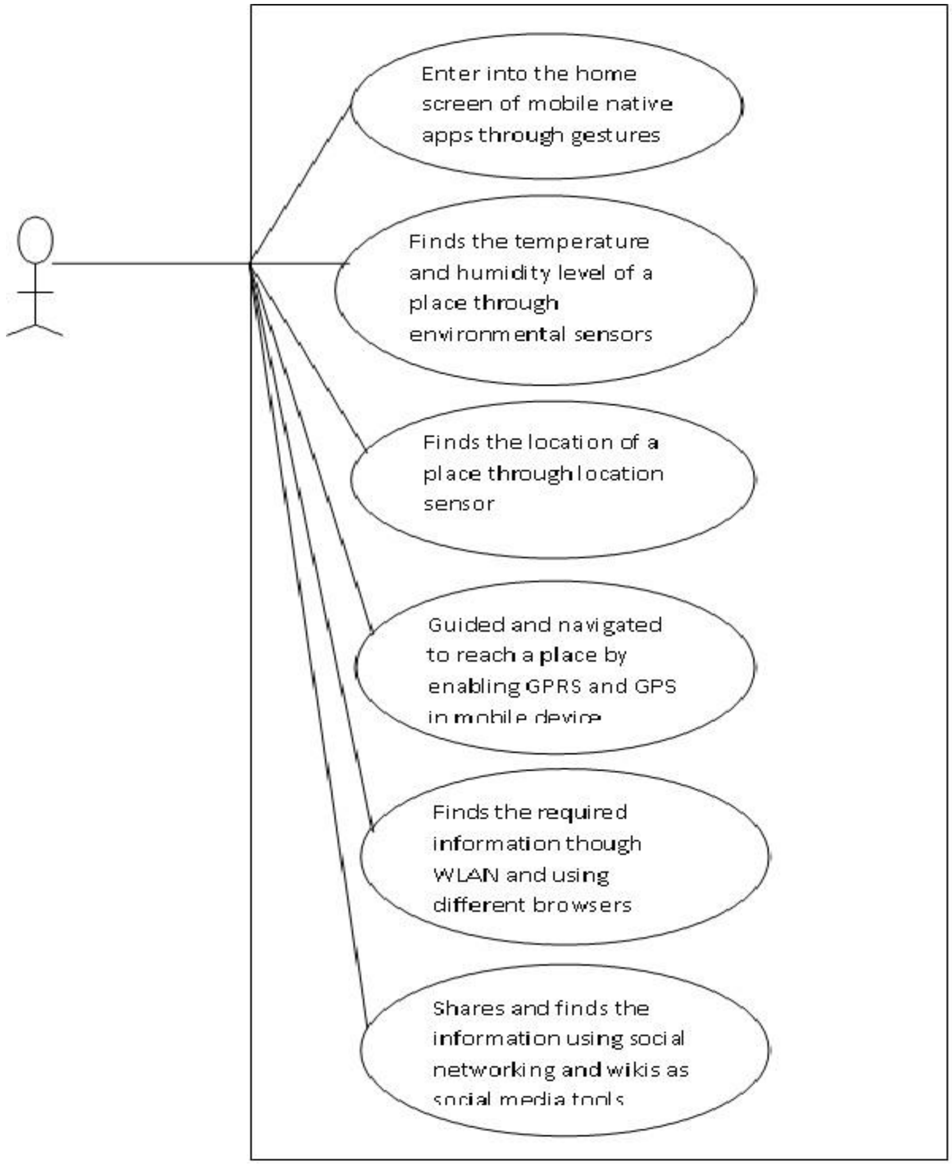

Fig. 8. Use case scenario between the user and mobile native applications.

The fifth one concerns about users based on different role. The based on role attribute undergo user context which is specified in Section 5.1. The content design for mobile native apps will be done based on user's different kind or role.

Similarly the user interface design and navigation design for building mobile native apps will be done based on different users. The conceptual design provides meaningful and consistent information in a semantic manner and it will also be done based on users of different domain. The presentation design deals with presenting views to users of various domain using transition animations. Hence the user context will be considered in content design, user interface design, navigation design, conceptual design and presentation design for designing mobile native apps.

The sixth activity deals with effective information retrieval of users under various domains. This attribute is considered under user context which is specified in Section 5.1. Similarly, the user context will be considered in content design, user interface design, navigation design, conceptual design and presentation design for designing mobile native apps. The seventh activity deals with sharing of information which is done through social media tool like social networking in mobile native apps. The social networking is the attribute of social context which is discussed in Section 5.1. The personification design is used for achieving customization and personification in native mobile apps, where the mobile native app user should be connected with other users through the social media tools so that mobile native app user can share and find its desired information about any domain. Hence social context is considered in personification design for designing and developing mobile native apps.

The state-of-the-art concludes how the four context elements are used in different design phases for building any mobile native app under generic domain.

TABLE III. MAPPING OF MOBILE CONTEXTS TO DIFFERENT DESIGN PHASES IN MOBILE NATIVE APPS

Activities performed on any mobile native app	**Mobile contexts**	**Design phases of any mobile app to be built**
1. Clicking on the app widgets of a mobile native app	Device context	User interface design
2.Opening the menus of a mobile native app	Device context	User interface design
3.Loading of any mobile native app from the play store	Mobility context	Architecture design
4.Installation of any mobile native app on the mobile device	Device context	Architecture design
5.Users of different kind retrieve information from the mobile native app	User context	User interface design, content design, navigation design, conceptual design and presentation design
6.Users of different kind obtain effective information from any mobile native app	User context	User interface design, content design, navigation design, conceptual design and presentation design
7.Information sharing among the mobile native app users	Social context	Personification design

VII. DISCUSSION

We have done an empirical study on contexts specified in various papers (17) of ubiquitous systems, mobile learning apps and pervasive based systems. We have identified contexts and classified the context elements under the contexts of different papers. Further these context elements are classified to the contexts such as device context, mobility context, user context and social context in our proposed model and weight assignment is done to the contexts of our proposed model accordingly which is shown in Table 1. We have obtained the overall value of all the four contexts which is shown in Table 1. We have taken the total overall value as 100 and from this value the % of overall value of device context is 48.67 and % of overall value of mobility context, user context and social context are such as 22.72, 19.71 and 8.87, respectively. Hence device context and its associated efficient features have a greater impact for building mobile native apps. After that mobility context has to be considered for building mobile native apps under any domain.

Here we have validated our result by taking the use case as running example of any generic mobile native application which is shown in Fig. 8.

Based on user's role the specific native mobile app is to be built in a mobile device. In first use case, when a mobile native app user wants to enter into the mobile apps, he/she has to use the keyboard and gestures of a mobile device which are the context parameters of device context. Hence the first use case uses two device context parameters (2). In second use case, the user can find temperature and humidity level of a place using environmental sensors in mobile native apps subjected to any domain. The environmental sensors are also the context parameters of device context. Therefore this use case provides two device context parameters (2) which is to be considered. In third use case, the mobile native app user also can find the location of a place through location sensors which are built in the mobile device. The location sensor is also a context parameter (1) of device context. Hence the third use case gives again one device context parameter of device context.

In the fourth use case, the users of any domain can be guided and oriented to reach a place through GPRS and GPS which are the context parameters of mobility context. The fourth use case drags two mobility context parameters of mobility context. In the fifth use case, the user specific to any kind, can retrieve information from web and browse through web in mobile native apps using browsers and WLAN. The browser and WLAN are the context parameters of mobility context. Hence this use case gives again two (2) mobility context parameters of mobility context. In the sixth use case, the user subjected to any domain, also can share information in a mobile native app using social media tools. The social media tools are the context parameters of social context. Therefore the sixth use case gives two (2) social context parameters of social context.

Here we have built this use case based on user's role, preferences and usefulness which are considered as three (3) user context parameter of user context. It can be shown from the above example, that the six use cases provide approximately five (5) device context parameters of device context. We have found that device context has % of overall value 48.67 which is validated and proved from above example, the device context have an approx. of five context parameters than other contexts. Again these six use cases drag four (4) mobility context parameters of mobility context which have % of overall value 22.72 determined from empirical study. The six use cases provide three (3) user context parameter and two (2) social context parameters which have the % of overall values 19.71 and 8.87, respectively obtained from the empirical study.

Hence from the four contexts, device context have a great importance when building mobile native apps and secondly mobility context is to taken into account for the same. Further user context and social context is taken into account for developing mobile native apps. Therefore we conclude that the device context has maximum overall value than other contexts under mobile domain. That means device context and its context parameters have more impact while developing mobile native apps.

VIII. CONCLUSION AND FUTURE WORK

In this paper we have taken various activities which are placed in form of questions in Google Forms. Out of 20 numbers of overall selected activities which are specified in Table 2, 9 numbers of activities are mapped to device context and its attributes. Again from 20 numbers of activities, 5 numbers of activities are mapped to user context, 3 numbers of activities are mapped to mobility context and 3 numbers of activities are mapped to social context. Hence it is concluded that out of overall selected activities under mobile domain, the maximum percentage of activities are mapped to device context. From the empirical study it is obtained that the overall weight of device context is more than the other contexts. This is validated from the running example which is shown in Fig. 8 that the use cases are drawn maximum context parameters of the device context. Hence device context and its efficient context parameters or features play a vital role for building mobile native apps. For building mobile native apps under any domain, more emphasis is to be given to mobile device with its efficient numerous features.

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