

Design and Applications of Context Aware Data Framework

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ABSTRACT

Context aware data analysis refers to analyzing data with respect to context. Here, context mean location, time or surrounding environment of a person or an object or any other entity. Usually such information can be obtained from some dedicated device or smartphones. However, some of the latest developments in this domain are done using smartphones. Because, context awareness is more relevant to dynamic environment, which is possible when user is mobile and that's the reason why context aware applications are implemented on smartphones which are much powerful now. Other factors can be their availability and their capabilities of acquiring and processing contextual information. And since they can be connected to internet, they can be used as a unit for any larger system

However, the data which is acquired by the devices is later processed on some server or framework. Usually data is managed at the backend of such servers or frameworks. And later used for decision making or to give some service. But in the end, outcome is generated on the base of context which enhances user experience with the system. The concept of context awareness and context aware data framework will help in developing application which will require least user interaction. But still will in control of user

Keywords

Context, Context awareness, Context aware data framework, applicaton of context aware data framework, Context aware applications

1. INTRODUCTION

Context aware data analysis is much applicable in mobile domain because of two factors. Firstly because of dynamic nature of context and secondly, currently available smartphones are good enough for this purpose. Currently available smartphones can automatically sense the data and obtained data can be implicitly use as behavior of application.

However, such applications usually depend on context awareness. And context awareness refers to the property of mobile device by which they sense location. And determine how to act as per the location or interact with user as per the context. Context awareness can be active or passive. In active awareness, application adapts itself automatically to the changed context (Example: a GPS system showing way of car).

While in passive context, information is updated or stored and user can use it later (Example: seat availability of a particular train can change on browser refresh)

Another important aspect here is context aware data mining (if required). Data mining aim at extracting the interesting information from large collection of data and this method is widely used in decision making. Mining of dataset in the presence of context factor my improve performance and efficiency of data mining by identifying the unknown factors which are not easily detectable in the process of generating an expected outcome.

2. UNDERSTANDING CONTEXT

A number of studies have investigated the concept of context and stated the definition of context. However, Schilit B, Adams N and Want R[6] stated some crucial aspects of these. They stated that, the only important aspects of context are user location, neighbours of user and the resources near to the user. Further they define, context is subject to the constantly changing execution environment.

And those environments can be:

- Computing environment: this refers to processor, input-output, network, cost of computing, etc.
- User environment: this refers to location, neighboring devices or may refer to social context like neighboring users, public place, etc.
- Physical environment: this refers to temperature light, noise, etc.

3. CONTEXT INFORMATION ACQUISITION

The goal of context information acquisition should be, to determine what user is trying to accomplish. Ideally, application senses the data automatically without the permission of user. This can be a privacy concern but this can enhance user interaction with the system. Context aware application is based on context acquisition method. Hence they vary depending on hardware, software and sensors. Some methods of information acquisition are as follows:

A. Direct Sensing

This method is much common in dedicated devices where sensors are hardwired. In this method of information acquisition, built in sensors of the device are used to gather information. And an inbuilt software or client software can gather the desired information from sensor and process the data. This method does not require additional processing of the obtained information.

B. Context Server

This method is distributed approach, where many clients are permitted to have access to remote data source. This approach extends middleware based architecture by introducing access management components. A feature of this approach is that, gathered data goes to context server. So any other application can use this data if required. Or any operation can be done using that data. Hence, it can be said that this approach support multiple access.

4. ATTRIBUTES OF CONTEXT

Collectively, context can be any information that can be used to characterize the situation of entities that are relevant. Like context of the user can be combination of various entities like their identity, activity, location, physical context like light exposure, temperature, etc. Attributes of context information can be based on the entities for which context is assessed including place, people and object with below mentioned characteristic of context information:

- 1) *Identity*: This refers to the ability to assign a unique identifier to an identity
- 2) *Location*: Location is expanded to include orientation, elevation, source and destination or and other spatial data. All the obtained information is used to deduce spatial relationship between entities such as co-location, proximity, etc
- 3) *Status (or activity)*: This refers to intrinsic characteristic of the user that can be sensed. Like high blood pressure, anger or other emotions. Which can be obtained by some dedicated devices
- 4) *Time*: Time helps in characterize a situation, which enable us to increase richness and value of historical information.

5. APPLICATION OF CONTEXT

As mentioned earlier, currently available smartphones are capable of collecting and processing context data [5]. But it is possible that user may have more than one such devices and even cars, trains and other public transportation means can have such abilities. In the scenario, it is difficult to manage interaction between these devices. Also it is troublesome to manage the data which they gather.

Consider a scenario where user don't pick phone call while driving. But his car have feature of attending call. In such condition, there comes the role of context aware analysis. By contextual analysis, application can detect this behavior and can automatically transfer the call to voicemail or to the car.

A good context aware application must serve features like Presentation of information and service, Automatic execution of service, Storage and retrieval of context application.

1. *Presentation of information*: This basically refers to the presentation of data on the screen. Either presenting context information to user or give context based option to user. Example: location on map.

2. *Automatic execution*: This refers to automatic execution of some service or some event to trigger at some condition.

Example: direction and route prediction while driving.

3. *Storage and retrieval*: This refers to storage and retrieval of data when required.

Example: suppose few animals are tagged by zoologist and they use obtained data for some analysis or research work

6. DESIGN PRINCIPLES

The basic aim that design should serve [7], is to show how the system will represent, store and communicate with contextual information. Context aware system can be implemented in many ways but the typical factors which are as considered are follows:

- Number of special requirements and conditions
- Location of sensor (local or remote)
- Number of possible users
- Available resources (high end PC or mobile device)
- Extensibility of the system

Context awareness models:

A context awareness model is required to define and store contextual information in a machine readable form. Thomas Strang and Claudio Linnhoff-Popeinhas[1] summarized some of the most relevant context modelling approaches which are based on data structures used for representing contextual information. Some of them are detailed below

- 1) *Key value models*: This is the simplest data structure for context modelling. And this approach is frequently used in distributed frameworks. In such frameworks, Key and value pairs are used to describe the capabilities of a service. Service discovery is then applied with matching algorithms, which use the key-value pairs.

Even though this approach is easy to manage and implement. But lack capabilities for efficient context retrieval.

- 2) *Graphic models*: In this approach, contextual aspects are modelled using UML (Unified Modelling Language). Which have a strong graphical component and also it is generic in nature. Which makes UML appropriate to model the context.

An example of nicely designed graphic oriented context model was given by Henricksen[11]. Which is a context extension to Object-Role Modelling (ORM) approach. In ORM, the basic modeling concept is the fact and the modelling of ORM involves identifying appropriate fact type. And the role that entity type play in there. He extended ORM to allow fact types to be categorized, according to their persistence and source which can be static or dynamic.

C. Object-Role Modelling (ORM)

Figure 1. depicts the basic concept of ORM [2]

- a. Entities are represented as ellipses containing a name and an optional reference that describe the representation of instance of entity type
- b. Entity type are the simple value types and they do not need a reference scheme and are shown as dashed ellipse

- Fact types are shown as sequences of role boxes, with each box attached to an entity type
 - Each fact type has a label that describe its semantics in natural language
- c. Bars are placed over roles in a fact type to indicate which roles or combination of roles must not contain duplicate values

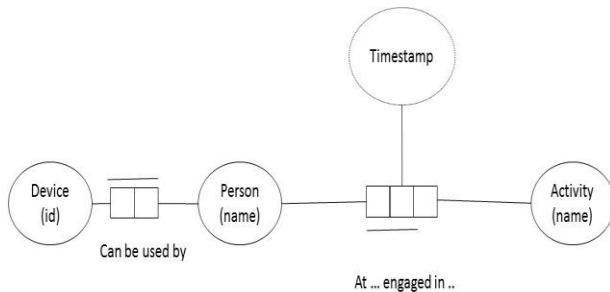


Figure 1. Modelling a binary and ternary fact type using ORM

- 3) *Object oriented models*: In this approach, object oriented principles (like encapsulation, inheritance and reusability) are applied to the context modelling. Here various object are used to represent different context (such as location, temperature, etc.). And details of contextual processing and representation are encapsulated and kept hidden from user
- 4) *Logic based models*: These models have a high degree of formality and typically facts. Expressions and rules are used to define a context model. A logic based system is used to manage the previously defined terms and allow addition, removal or updating of new facts. Usually Artificial Intelligence is used to process and derive new facts, based on existing rules in the system
- 5) *Ontology bases models*: Ontology represents a description of context and their relationship with each other. These models are very promising for modelling contextual information due to their high and formal expressiveness and possibilities of applying ontology reasoning techniques

D. Context aware development framework

1. CyberDesk

Context awareness describe as information is not much relevant to the desktop system. For achieving this, language like Java is used. Mostly applets. CyberDesk[4][12] is a framework that was developed to automatically integrate web-based services.

What these frameworks do?

- Let application specify what user want
- Notify that user when right information is available
- The architecture of modular support automatic interpretation of individual and multiple pieces of context to produce new set of context
- However, it do not support multiple simulations application, querying and storage of context

2. Context and Location Aware Information Service (CALAIS)

CALAIS[8] is another architecture which was design to support context aware applications and was proposed to solve two problems:

- Behavior of sensors works as per context
- Lack of fine location information management system

Here, an abstraction was developed to hide details of sensors from context aware application. However that is very little support to developers in adding new sensors.

Also architecture doesn't support storage or interpretation of context, so application developers have to provide their own mechanism.

CALAIS supports use of distributed context sensing and provides query and notification mechanism.

Example: an application can request to be notified when event 'B' occurs. Which is supposed to happen after event 'A'. If there are no events in between. This makes acquisition of data much easier.

3. A sample layered framework

As per functional point of view, context-aware systems can be represented in layers. Which consist of sensors, raw data retrievals, preprocessing, storage management and an application layer.

A context management system is responsible for retrieving raw data from sensors, abstracting and combining the sensed fata into high level context and then making it available for the context aware application.

1. *The First Layer (sensor)*: This layer is the collection of sensors responsible for raw data from the user environment (example: user access network)
2. *The Second Layer (raw data retrieval)*: This layer make use of specific applications programming interfaces or protocols to request data from the sensor layer.
3. *The Third Layer (preprocessing)*: This layer is responsible for reasoning and interpreting contextual information. It transform the information returned by the lower layer to higher layer. Example: to check if given GPS location is of work or home.

It not only sense data but also describes data.

4. *The Fourth Layer (Storage and management)*: This layer organize the gathered data and make them available to their party application in a synchronous or asynchronous way.
 - In first method: Third party applications use remote method calls to check the status of server for change.
 - In second method: Third party application subscribes to specific events of interest and notified when the event occurs.
5. *The Fifth Layer (application)*: This is where the reaction to changes in context is implemented (Example: changing location on the screen as object moves).

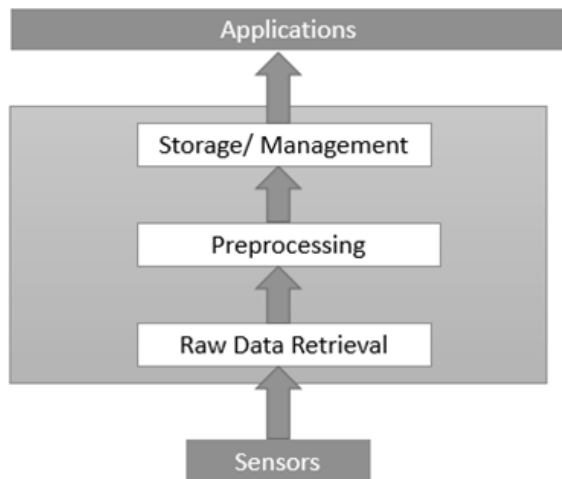


Figure 2. Layered framework of context aware system

7. CONTEXT AWARE APPLICATIONS

1. Adaptive and context aware user interface

This is the most simple use of context aware information [6] like automatically increasing backlight in dark environment. In advance, changing the profile as per the context. Example: Activating silent mode in meeting.

2. Context aware browser

Context Aware Browser [10] overcomes the limitation of search engines which usually process the user's query but ignore their context. Context Aware Browser does consider the context of the use, process it and gives out the relevant information as per the context.

Example: User went to airport to catch his flight. As user reaches the airport, CAB shows him the way to nearest enquiry counter, the gate number from which flight will leave, his flight details and some other relevant details.

Context Aware Browser (CAB) uses the inbuilt sensors and software present in cell phones or smartphone. Hence it is much practical.

Above mentioned feature can also be achieved by other methods but what makes CAB different is, its processing depends upon the user's context.

The top layer manages user interaction, the middle layer acts as a bridge and the bottom layer handles the sensors and inferential network and manages the filter engine.

3. Context based workplace awareness

Basically an application to co-ordinate in workplace from contact list, give the status of each worker at the workplace.

Example: Doctor 'A' is busy in surgery, Doctor 'B' is on the way, Doctor 'C' is somewhere near to blood bank.

However, others user can also interact with the system. Example: Patient may enter some query if he wishes to.

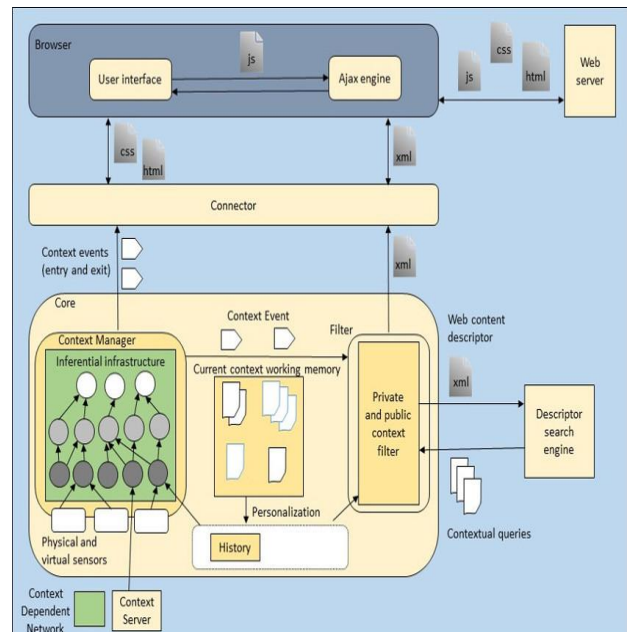


Figure 3. Context Aware Browser (CAB) overall architecture

4. Context aware communication service provision

This application is also used for the workplace.

Workers have smartphones, they communicate on call, emails, messages and other. Sometimes these disturb or may interrupt their way of processing but by the use of this application, it will help people to coordinate in workplace.

Example: Doctor 'A' wants to talk to either of doctor 'B' or 'C'. But doctor 'B' is busy with surgery. And doctor 'C' is checking a patient. Hence, this application will show that worker 'B' is busy. But user 'C' is available on message.

5. Context Aware Learning Space (CALS) [9]

Context Aware Learning Space (CALS) is a framework which is built on the foundations of mobile learning.

A typical CALS comprises of number of mobile devices (clients), wireless connectivity, a server and a set of context-aware technologies.

CALS integrates with the surrounding contextual resources into the virtual learning framework.

However, due to sensitivity of learning context, the learner is encouraged to make observations and interact with surrounding objects and phenomena.

The flexible nature of CALS allows for creation of new types of applications with minimal development efforts.

8. SECURITY AND PRIVACY ISSUES

Some major security concerns with context aware applications are [3]:

- Ensuring privacy of the locations and identity information
- Ensuring secure connections

Authenticating the location is also a major problem with this system. Because, user can disable sensors which can detect his location.

Another issue is protecting origin and destination of the user. Some of the expensive context aware application care

about security. Else this is usually ignored. However, access control to the system can assure some privacy to the system.

9. FUTURE DEVELOPMENT

Suppose if technologies like camera and some motion sensing input devices are included in appliances and placed in someone's home and office. Recognizing where people are and what they do, will enable developers to create attentive application that look at what people do and react appropriately.

Example: Lights and AC may go off if they detect no one in the room or shower may change its water temperature by guessing which member of family is going to use it.

This may help developer in developing applications which requires minimal interaction with the end user. However the concern here is, user must have choice to correct wrong choice made by the system. In other words, system must be in control of user. So that the user can feel system is in control.

10. CONCLUSION

For better understanding of context aware analysis and its applications, authors had surveyed the literature in this area. And also listed the context aware applications that have been built. And discussed current approaches to sense information and models and also looked into supporting infrastructure and security and privacy issues.

And it was observed that, the research of accurately discovering context, maintaining contextual information and making use of available context are still at the early stage.

However, it was observed that the context awareness is the key factor for new applications in this domain.

Some of explained future development may seems much closer to IoT(Internet of Things) but context awareness is the basic concept which is applied in IoT. Context awareness can help in making application which require minimal user interaction but which is still in control. And which may have larger aspect to cover than IoT

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