A Weight based Context Analysis System to Provide a Required UMM Service

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Abstract— *Ubiquitous Computing is an emerging paradigm which facilitates user to access preferred services, wherever they are, whenever they want, and the way they need, with zero administration. While moving from one place to another the user does not need to specify and configure their surrounding environment, the system initiates necessary adaptation by itself to cope up with the changing environment. In this paper we propose a system to provide context-aware ubiquitous multimedia services, without user's intervention. We analyze the context of the user based on weights, identify the UMMS (Ubiquitous Multimedia Service) based on the collected context information and user profile, search for the optimal server to provide the required service, then adapts the service according to user's local environment and preferences, etc. The experiment conducted several times with different context parameters, their weights and various preferences for a user. The results are quite encouraging.*

Keywords: Ubiquitous Multimedia Service; Composite Context; Essential Context-derived Reasons; User Profile Information;

1. Introduction

With the convergence of various networks (wired, wireless, etc.), and devices (PDA, Smart Phone, TV, etc.), the Ubiquitous Computing [7] is becoming a reality. Tremendous growth in the mobile access technologies has enabled services to enter in almost every part of the life. Dramatically, it has stimulated even the demand of multimedia applications to be ubiquitous.

UMMS means provision of different kind of multimedia (audio, video, graphics, etc.) to the user any time, irrespective of location, device he/she carries and without explicit user request. To achieve this system needs to ensure that services must support mobility, interoperability, location awareness, situation awareness, seamlessness, pervasiveness and timely adaptation [5]. UMMS have broad application areas such as remote health care, e-business, ubiquitous learning, on-line entertainments (sports, movies, etc.) and so on.

There exists a strong relationship between the various contexts and types of service required based on it. User would like to have services that self configure themselves in the user's physical environments and integrate seamlessly with their everyday tasks in an intuitive, and non-intrusive way. With contextual information, the system foresee the user's requirements and acts proactively, without any user's explicit interaction. It enables system to determine relevance of service in the user's operating environment, which improves user satisfaction and service quality.

Many researchers have given various definitions of conext [1], [4]. Any environment attributes that is related to the particular application domain can be considered as a context data, like temperature, location, any object, its status, etc. However among all the available contextual parameters some are more critical or have more weightage as compared to other depending on different types of situation. We consider a system with different weights of context values. These weightage can be varied and decided dynamically, while finding the appropriate service for the user. In our work we are concentrating on on-line ubiquitous multimedia services, such as live sports as a case study to discuss the usability of our system. Servers that contains required service are connected to the Internet, and as user activates his/her device, it can connect to a nearby available network (WiFi, GSM/GPRS, etc.) thus can connect to nearby available server via Internet.

1.1 Proposed Idea

We propose a new approach, to make use of context information with different weightage and user profile information for ubiquitous multimedia service identification, which is proactive and adaptive based on various changes in user's surrounding environment. Collected Preliminary Contexts *(PCs)* information, we analyze as a Composite Contexts *(CCs)* which further analyzed as Essential Context-derived Reasons *(ECRs)*. This inferred *ECRs* along with User Profile Information *(UPIs)* is used to identify the required ubiquitous multimedia service. This identified service is optimally trace to cater the user services at the required time.

1.2 Organization of Paper

The remainder of this paper is structured as follows. Section 2 describes some of the existing works, Section 3 presents our approach of context information analysis, Section 4 provides an overview of the system architecture and discusses the functionality of each components, Section

5 presents a case study to show the usability of the system, Section 6 explains simulation and results, followed by conclusion in Section 7.

2. Related Works

Many works states the context awareness and user profile in their applications and also, context deduction and use of composite context for various applications in different ways. In [2] have proposed a personalized context-aware services architecture depending on user contexts that are collected from ubiquitous sensor networks. In [3] an exploration the relationship between context awareness and user modelling, through the design of a context-aware personal assistant is shown. The DUPS (Dimension User Profile System) architecture is explained in [6], to recommend services to user based context. It stores location, time, and frequency information of often used services which enables system to provide more accurate service in less time. None of these system has considered the weights of context parameters to identify the appropriate service requirement.

3. Context Information Analysis

The system uses the various context information based on weight to infer a multimedia service corresponding to a definite circumstances of a user. Following section describes the weight allocation.

The context analysis process is done in three steps, starting with *PCs* acquisition to *ECRs* identification, major building blocks are as shown in Figure 1. Using *PCs* parameters step by step derivation and analysis is described in the following sections.

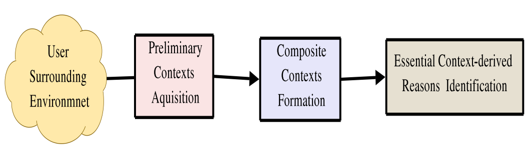

Fig. 1: Context Analysis Procedure used in the System

3.1 Preliminary Contexts*(PCs)* of the System

This represents the context parameters obtained directly from various types of sensors, embedded devices, etc., in the environment. These are common for all users.

We also consider the task and physical environment context which are related to a multimedia application and we categorize them into three sets of *PCs* values: user's physical environment*(PE)*, user's context*(U)* and task context*(T)*. For example preliminary context values of a multimedia application *X*, is given as PC_X = {*PE, U, T*}. They further define as follows;

User's Physical Environment(PE): It indicates user's surrounding environment which is characterize as e.g., location(p1), time(p2), temperature(p3), noise, light, available resources, etc. We consider a *PE* context of a user as,

$PE = \{p_1, p_2, \cdots, p_j\}$

User's Context(U): It includes information related to the user, its social and physiological parameters etc., e.g, social relation(u1), people surrounded by(u2), blood pressure(u3), heart rate, etc., Thus we can view user's context as,

$U = \{u_1, u_2, \cdots, u_k\}$

Task Context(T): These are the parameters required to adapt various multimedia contents related to a specific service. Based on the types of service, in what format is it required. e.g. device memory(t1), available networking interface(t2), supporting media format(t3), etc. so we take task context as,

$T = \{t_1, t_2, \cdots, t_l\}$

3.2 Composite Contexts*(CCs)*

It is a context information that can be inferred from *PCs* information. It combines and relates various *PCs* information(same or different types) along with different weightage(based on the services required). Combining various *PCs* information may generate a more accurate understanding of the current situation, rather than taking into account an individual context. In generic terms, for example,

$CC_1 = \langle p1, p2\rangle$; *where* $p1, p2 \in PE$.

$CC_2 = \langle p1, p2, u1, u2\rangle$; *where* $p1, p2 \in PE$ *and* $u1, u2 \in U$.

Steps to formulate *CCs* is given in Algorithm 1, and some of the examples of formulated *CCs* is given in Table 1.

Algorithm 1 Composite Contexts*(CCs)* Formation

Begin
Input: *PCs* and corresponding weights; **Output:** *CCs*.
while not end of user session **do**
  collect *PCs* from various sources.
  if context changes **then**
    get $PE = \{p_1 \cdots p_j\}$;
    get $U = \{u_1 \cdots u_k\}$ and $\{T = \{t_1 \cdots t_l\}$;
    assign weights to each *PCs* based on relevance.
    derive *CCs* based on context rules.
  else
    wait for context change;
  end if
end while
End

3.3 Essential Context-derived Reasons*(ECRs)*

It is derived abstract information. For applications to make context aware decisions, *CCs* information must be further inferred, by considering appropriate weights of *CCs*. This significantly helps in making right decision to identify an appropriate service under certain situation. Various *CCs*

Table 1: *CCs* Formulation

Various PCs involved in CCs Formulation	***Formulated CCs***
CC1-⟨`location, time`⟩	*Object position at a given time*-It gives the notion, how far a particular service is suitable at some location at a particular time instance.
CC2-⟨`noise level, temperature, light, pressure, humidity, available resources`⟩	*Ambiance of surrounding environment*- The aggregate of surrounding things and conditions, creates an atmosphere, that influences the user mood.
CC3-⟨`location, time, people surrounded by, social relation`⟩	*User behavior*- User behavior changes according to place, surrounding people and interrelationship among them.
CC4-⟨ `blood pressure, skin respiration, heart rate`⟩	*User physical status*- Physiological parameters helps to determines the physical status of the user.
CC5-⟨`memory, screen size, resolution, battery power, processing power`⟩	*User's device capability*- Every user carries different devices with dissimilar capacities in terms of processing power, memory etc. thus multimedia service has to be tailored according to user device capability.

Table 2: *ECRs* Formulation

Various CCs involved in ECRs Formulation	***Formulated ECRs***
ECR1-⟨`Object position at a given time, ambiance of surrounding environment, devices capabilities` ⟩	*Service consumer position*- By knowing the ambiance of surrounding environment, devices capabilities*(HDTV, Laptop, etc.)*, and approximate location, one can determine exact position of a user where the service needs to be consume, like- In a home (living room, kitchen etc.), office(cafeteria, conference room etc.)
ECR2-⟨`user behavior, user physical status`⟩	*User's mood/Emotion*- By understanding user behavior, his physical status, according to people surrounded by, etc., one can recognize user's mood whether he is relaxed, stressed, physically tired, etc.
ECR3-⟨`device capability, network conditions`⟩	*Service consumption capability*- User may carry several devices with different networks available in his surrounding environment like - Laptop with WiFi, PDA with GPRS, etc. For efficient execution of service system must understand the device and network capability where service needs to be consumed.

information integrates together with some sets of predefined inference functions that results into *ECRs*. One can deduce exact service or location from it. For example exact location like if user is at home, whether he is in kitchen, or living room, etc., an activity of the user like eating while watching TV, or walking in garden or frontyard, etc. In generic terms, for example,

ECR_1 = ⟨ CC_1, CC_2, CC_5⟩,
ECR_2 = ⟨ CC_3, CC_4⟩

Steps to formulate *ECRs* from *CCs* is given in Algorithm 2, and Some examples of identified *ECRs* is given in Table 2.

Algorithm 2 Essential Context-derived Reasons*(ECRs)* Identification

```
Begin
Input: CCs and corresponding weights; Output: ECRs
while not end of user session do
   collect CCs information.
   if context changes then
      get CC_1, CC_2 ··· CC_n;
      assign weights to each CCs based on relevance.
      derive ECRs based on context rules.
      store inferred ECRs in context history database;
   else
      wait for context change;
   end if
end while
End
```

3.4 Weight Allocation

All the available information within a specific domain may be considered as a context data but not every context data is equally relevent to infer a higher level composite context information. We assume that the *ECRs* and *UPIs* are involved in determining the UMMS. Thus with an assumption that *UPIs* is accurate, and if we consider that *ECRs* is also accurate, system identifies accurate service. If we keep the weight of *ECR* as unity, {w_{ecr_m}=*1*}, we compute the weights of the *CCs* involved in the formation of *ECRs* as per their importance. By assigning weight to each *CCs* according to eq. 1, we get significance of it to formulate *ECRs*.

$$w_{cc_i} = \frac{k_{im} w_{ecr_m}}{n_{CC}} \tag{1}$$

where $w_{cc_i} \in [0,1]$, k_{im} is a degree of relevance of CC_i with ECR_m based on various applications, which is decided based on empirical observations after conducting various experiments while finding the appropriate service for the user, and n_{CC} represents number of *CCs* involved in formulating a ECR_m.

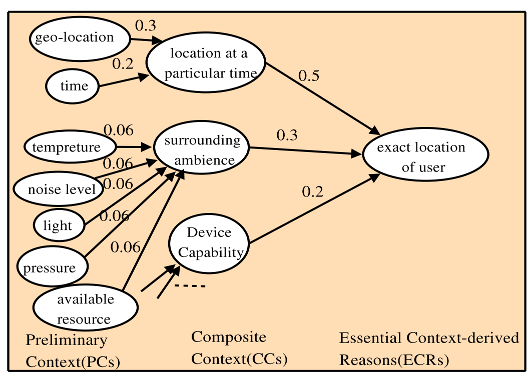

Fig. 2: An Overview of Weight Based Context Analysis

Figure 2 gives an overview of the weight based context analysis scheme. For example, to understand at home, exactly in which room user is in? with geographic location and time we know user is at home, he may be in living room or kitchen, etc., then with the ambiance of surrounding and available devices capabilities, we can determine that user is in living room. In this example, Geo-location and time is important to identify that user is at home, as compared to other context information. As shown in Figure 2, we computed more weightage (0.5), for location at a particular time as compared to surrounding ambiance with weightage (0.3), which in turn has more weightage as compared to device capability with weightage (0.2). Similarly, we assign appropriate weights to *PCs* based on their relevance while formulating *CCs*.

4. UMMS System Architecture

Ubiquitous multimedia Service(UMMS) system architecture is as shown in Figure. 3. We assume that user in a ubiquitous environment carries multiple devices, with multiple networking interfaces, and surrounding environment of the user consists of various sensor based biometric technologies to uniquely identify the user. We are considering this context based multimedia service provision at the application layer to directly provide UMM service functionality to the users. We also assume that the network is connected and equipped with appropriate routing and transport layer protocols for reliable communication.

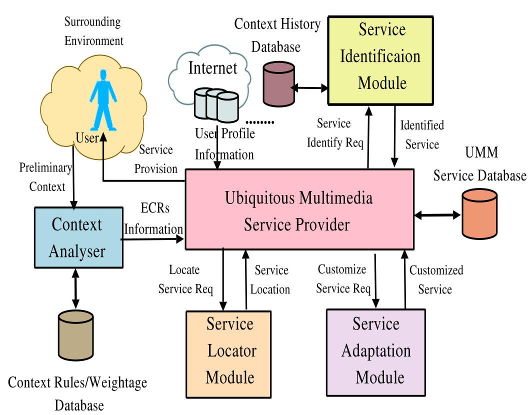

Fig. 3: Ubiquitous Multimedia Service System Architecture

UMMS system consists of three main modules; *1) Service identification module 2) Service discovery module 3) Adaptation module*. We discuss the functionality of these modules after introducing the databases used in the system.

Context Rules/Weightage Database

It contains the logical predefined rules to formulate *CCs* and *ECRs*, that are expressed as conditional and action statements. Conditions are expressed distinctly in the form of boolean expressions, and logical operators like or, equal, more than, and less than, etc. Also it stores the corresponding weights assigned to *PCs* and *CCs* while providing an appropriate service to the user based on the situation. For example- It stores weights of *PCs* like Geo-location as (0.3) and time as (0.2), while determining exact location of a user, to provide a service of on-line cooking recipes. As explained above context analyzer utilizes the information stored in database while formulating *CCs* and *ECRs*.

Context History Database

A persistent storage is needed that includes history-based organization of identified service for a user, corresponding to the specific combination of *ECRs* and *UPIs*. Before any service identification, respective trends in the context history database is evaluated by service identification module. Thus for a known user, it supports service identification module, for retrieving information in much faster way.

UMM Services Database

UMM service provider maintains the database of some of the often used services, to provide access in lesser time and better service in terms of quality. Some of the offered *MM* services and its locations is as shown in Table 3.

Table 3: Some of the multimedia services and its locations

Multimedia Services	***URL/Location***
On-line Games	umm@og.pet.ece.ernet.in
On-line Restaurant Lists	umm@rl.pet.ece.ernet.in
On-line Music	umm@omus.pet.ece.ernet.in
On-line Movies	umm@omov.pet.ece.ernet.in
On-line Cooking Recipes	umm@ocr.pet.ece.ernet.in

User Profile Information(UPI)

User profile information are obtained from unique identification of user or its device. Without a notion of the unique identity, information of a user profile like preference, etc. could not be used for adapting the system. UMM service provider collects *UPIs* from some social networking site. Although the user's profile information is quite steady, and hence his service requirements too, but different types of multimedia services are recommended as a function of his mood, presence of other people, surrounding environment etc.

Service Identification Module

At any time instant, it uses *ECRs* information genrated by context analyzer, along with *UPIs*, to invoke any one of the multimedia service, as represented in eq. 2, which can be interpreted in the form of various definitions like *context based preferred service(CBPS), context based probable(CPS)*, etc., as explain below. In addition *service identification module* checks respective trends in context history database, for a known user. Different understandings of all this information, when inclined to one direction, will results into focused and accurate multimedia service identification. It stores that identified service corresponding to a user and *ECRs* in context history database. At any time instant $t = t_1$, we have

$$(ECRs(t1) \times UPIs(t1)) \Rightarrow TriggerUMMS(t1) \quad (2)$$

- *Context Based Preferred Service(CBPS): Service position + User's activity + Preference ⇒ CBPS;* If one knows user's present location, current situation and preference, one can judge a strong liking or whether a person is in favor of something. As preference of a user is dynamic, it varies according to different conditions. For example- while travelling in a bus to the college, Paul usually would like to listen music but since he has exam today, he would like to revise his lecture notes through on-line education video lectures on his PDA/Mobile.
- *Context Based Probable Service(CPS): Service position + History ⇒ CPS;* History of a person gives static context information that can be retrieved from a stored database. With this one can have a reasonable basis for establishing presumption under specific circumstances. For example- while travelling, on the way to college, Paul has habit of watching on-line education video lecture, on his PDA/Mobile.
- *Context Based Service Prediction(CBSP): Service position + Preference + History ⇒ CBSP;* Including past patterns and through a logical reasoning one can anticipate the service requirement for the user at any given point of time. If the past history is known one can guess user's multimedia service requirement and based on the preference that can be filtered further according to present conditions. For example- Paul and his friends usually watch mathematical video lectures but, but today since exam is over, so system understands the situation and provides some comedy movie of their liking.

Working of module is as shown in Algorithm 3.

Algorithm 3 Service Identification Logic

Begin
Input: *ECRs* and *UPI*; **Output:** Identified Service
while not end of user session **do**
    collect *ECRs* and *UPIs* from UMM service provider.
    formulate different combinations using *ECRs* and *UPIs*, e.g. *CBPS, CPS, CBSP* etc.
    if user is known **then**
        check respective trends in context history database.
    end if
    determine inclinations of all this information towards one direction.
    if inclined to one service **then**
        identify the service;
        send it to UMM service provider.
    else
        wait for further change in context information;
    end if
end while
End

Service Locator Module

This module is responsible for the discovery of the server. Once service is uniquely identified for a user, it needs to be discovered and fetched from the service provider. If multiple or replicate service providers are available for the same service, optimal service provider is chosen based on user's context like location, device and available network etc. Working of module is as explained in Algorithm 4.

Algorithm 4 Working of Service Locator Module

Begin
Input: Identified Service; **Output:** Service Provider Location
while not end of user session **do**
    collect the information of required service from UMM service provider.
    discovered and fetch the optimal service provider.
    send the service location to UMM service provider.
end while
End

Service Adaptation Module

Dynamic service adaptation is required for the user, so as to the user it appears that data is coming from a unified source. For adaptation of services it is important for a system to understand where the service needs to be consumed. The adaptation module takes adaptation decisions based on user's needs, preferences, device capability and network conditions, and fetched customized service from adaptation proxy, on which various functions like transcoding, content filtering, etc., has implemented. Working of module is given in Algorithm 5.

Algorithm 5 Working of Adaptation Module

Begin
Input: Original Service(S_o), *UPIs* and *ECRs*; **Output:** Customized Service(S_c)
while not end of user session **do**
    get S_o
    collect adaptation parameters = $\{AP_1, AP_2, \cdots, AP_n\}$ that represents various network, device characteristics and user preferences∈*{UPIs, ECRs}* information, from UMM service provider.
    fetch (S_c) according to adaptation parameters. $S_c = F(S_o, UPIs, ECRs)$
    Send S_c to the UMM service provider.
end while
End

UMM Service Provider

UMM service provider can handle multiple user requests at a time. It collects *ECRs* from context analyzer, and *UPIs* from social networking site one by one, and sends this information to service identification module. UMM service provider gets the identified service from service identification module, It checks for the identified service in its UMM service database, if service is available in the desired format, it directly send it to the user, else send it to the adaptation module for the required customization along with *ECRs* and *UPIs*. If service is not available in the UMM service database, it forwards service locating request to service locator module to discover and fetch optimal service provider based on the context.

If some of the information is misssing then based on other collected context based information, we can only prejudice the service requirement which may or may not be correct. If we have all information available, we can identify a unique multimedia service requirement in a systematic way and one can have focused and accurate service.

We define a service response time of the system is the time required for processing of context data, to identify a multimedia service, for discovery and customization. Service response time is defined as below.

$$\textit{Service Response Time} = t_{ccf} + t_{ecrf} + t_{sid} + t_{sl} + t_{sc};$$

where, t_{ccf} is the time required to formulate *CCs* from simulated preliminary context data, t_{ecrf} is time required to formulate *ECRs*, and t_{sid} to infer *ECRs* and *UPIs* to identify required service, t_{sl} is the time required to locate the service provider, t_{sc} is the time taken to customize the service.

5. Case Study

The working of proposed system is explained using a case study for a live sports ubiquitous multimedia service.

Consider Paul(a college student) is in hostel room. and formulated *ECRs* indicates that Paul is alone in hostel, sitting on a sofa in a relaxed mood, having a Laptop with WiFi connectivity and his profile information reveals that he usually prefers watching sports, shows inclination towards watching a world cup. Thus system understands the situation of Paul, identify his service requirement, according to his current situation and trigger a live match on his Laptop. Following four cases shows, how system understands different situation of Paul and customize service accordingly.

*Case1:*Paul is in a hostel room, having a Laptop with WIFI connectivity. System recognizes his device and network characteristics, and since high bandwidth, high memory, high battery power is available. It sends a high profile Mpeg video stream on his laptop, and Paul starts watching live sports video on his laptop.

Case2: Suddenly his friend called and ask him to come to the department, Paul don't want to loose a match for a single moment. He started driving bicycle. He is carrying a mobile with GPRS connectivity. System understands his context and bandwidth limitations, thus send audio stream so that he can listen match commentry while cycling.

Case3: Paul reach to the department and start moving towards lab to meet his friend, system understands his situation and adapt accordingly, and Paul started watching close-up shots of his favorite player movements on his mobile screen.

Case4: As soon as Paul reach to the lab, he switched on his Laptop and connect to a WiFi. System identifies his environment and again starts sending a high profile Mpeg video stream on his laptop, and Paul can watch live sports video on his laptop.

Timing diagram of various sequence of events is as shown in Fig. 4. As shown in the event sequence diagram service provision is dynamically adapted based on the acquired context information like capability of a device, available resources and accessed network, user preference etc.

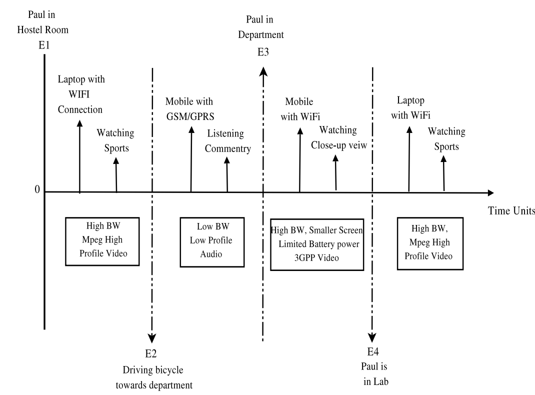

Fig. 4: Event Sequence Timing Diagram of a Case Study

6. Simulation and Results

6.1 Simulation Environment

We have conducted series of experiments in order to evaluate our approach. We have simulated the scheme in a hybrid environment which has WIFI, bluetooth and a GSM network units as shown in Fig. 5. *PCs* are simulated in the given simulation environment and *CCs* and *ECRs* are inferred from them. Further addition of *UPIs* to *ECRs* gives service identification.

Result corresponding to percentage of information available verses cumulative accuracy of service identification is shown in Fig. 6. Cumulative accuracy is the accuracy of a service prediction over a set of 50 users session. As shown in Fig. 6 we consider three different sets of context parameters, based on the weightage. If important sets of context parameters(Context Set3 like time, location, preference, etc.) are missing, it greatly influences inference and accuracy reduces suddenly, similarly some context parameter have less and moderate influences on inference and thus affects service identification accuracy accordingly, plotted with Context Set1 and Set2 respectively.

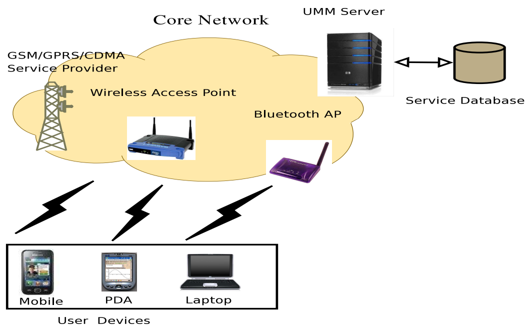

Fig. 5: Simulation Environment of the System

More the user interact with the system, more the system learns from past history and keeps on refining user's profile. System also maintains the database of often used services. As information stored in the data base corresponding to a particular user grows we can identify service more accurately, as usually user's daily routine is fixed. Total service response time will reduce as shown in Fig. 7, and accuracy of the system to provide a service will increase as shown in Fig. 8, with the increase in database of the user.

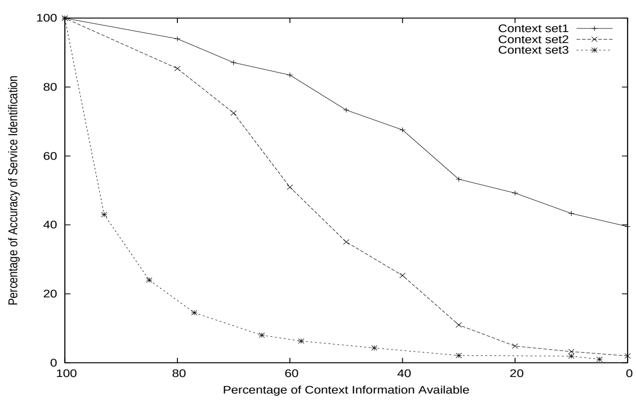

Fig. 6: Context Information Vs. Accuracy of Service Identification

7. Conclusion

This system is designed to support multiple ubiquitous multimedia service access in a ubiquitous environment. The paper suggests a new approach to analyze context information based on weight, in association with user profile information as a base to provide an appropriate multimedia service to the user. This approach is beneficial with respect to ubiquitous environment in providing adapted services to the user proactively, which can be applied to various ubiquitous applications such as ubiquitous museum, ubiquitous smart home, office etc., to improve the quality of user experience. The key feature of the approach is not only in accurate service identification, but also dynamic adaptation according to various situation so as to maximize user satisfaction.

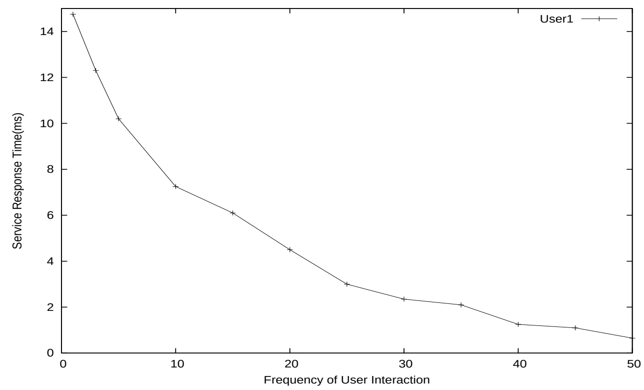

Fig. 7: Service Response Time Vs. User Interaction Frequency

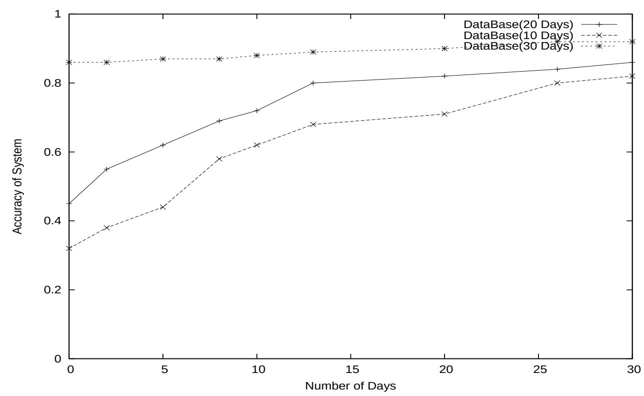

Fig. 8: Number of days Vs. Accuracy of System

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