Pervasive Context-Aware Tour Guide for Addis Ababa City

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Abstract

Pervasive computing is a new computing trend that emerged out of distributed, mobile, and ambient computing. Pervasive computing has many characteristics such as context awareness, invisibility, ad-hoc networking, and sensor based. Context refers to information that is used to express a situation of an entity, where the entity can be a person, or any other thing. Hence, the ability of a given system to understand the context of an entity is termed as context-awareness. Context awareness is important for pervasive computing environments to adapt computational entities to changing situations such as the users' needs and technical capabilities.

Context-aware smart car, smart office, smart home, pervasive medical systems, and context aware tour guide systems are some of the application domains of pervasive computing. Mainly in context-aware tour guide systems, context aware tourist information system, wikitude and cyber guide are among the applications of pervasive in tourism domain.

There are some gaps that are identified in this paper from the tour guide systems mentioned in the related works. The services provided are not based on the dynamic user context which changes over time and space. The context considered in most systems is location but other contexts like user preference are not considered.

This paper, therefore, aims at developing a generic architecture for pervasive context aware tour guide in cities that is based on the user and environment context like user interest, time, location, weather, and other history profiles. So this service is based on dynamic user context and uses most profound technology which is invisible to recommend the user using different devices that can capture user context, analyze context, and also be able to notify a user.

A prototype for the proposed architecture is developed for the Addis Ababa city using android mobile as the client side device. Tourists visiting Addis Ababa can get the information about the city easily, customized to their context. Information they need is like getting the nearest hotel, nearest restaurant, places to visit, nearest travel agency, and different places based on their interest not based on product list of companies which frees the tourists and from being overloaded by unnecessary information.

Keywords: Pervasive Computing; Context-Awareness; Tourist Guide

1. Introduction

Pervasive computing is a new computing trend that emerged out of distributed, mobile, and ambient computing. Pervasive computing has many characteristics such as context awareness, invisibility, ad-hoc networking, and sensor based. Context refers to information that is used to express a situation of an entity, where the entity can be a person, or any other thing [15]. Context can be location, preference, emotion, or activity of the entity from which the context is captured. Hence, the ability of a given system to understand the context of an entity is termed as context-awareness [1]. In mobile and ubiquitous computing, the term context is primarily used in reference to the physical world that surrounds the use of a mobile device [5].

A typical pervasive environment comprises of tiny and embedded devices that tend to work well with no or minimal user interference through its invisibility nature. An ad-hoc network is characterized by the connection of devices without previously configured physical infrastructures, and an application or device detects context by sensors [2, 7, 8].

Context awareness is important for pervasive computing environments to adapt computational entities to changing situations such as the users' needs and technical capabilities. The fundamental for context-awareness is a formal context model which is needed to represent the context in a way computers can interpret it. In distributed environments, it is especially important that this context information can also be shared between different computational entities which enable interoperability. Furthermore, it is necessary to reason on the context knowledge, e.g., to solve inconsistencies of sensor data or to deduce high-level situational context information from low-level sensor data [3].

2. Background

Office and home based systems [9], health care [6, 10, 11] and tourism [12] are some of the promising and vast application domains of pervasive computing being explored [1]. Mainly in context-aware tour guide, the context information used is the location [13], personal interests of the visitor, current time, weather and so forth. A context-aware Addis Ababa city tour guide serves tourists and other people who want to visit Addis Ababa without a human guide needed.

In Ethiopia, specifically Addis Ababa, the tourism industry is growing from time to time. Figure 1 shows the number of foreign tourists who visited Addis Ababa each year. The average annual growth rate is around 7% [14].

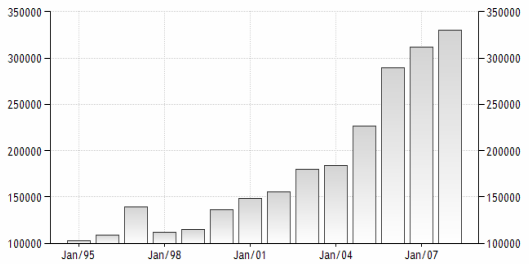


Figure 1: Number of foreigners from 1995 - 2008

This shows that investment facilities that improve qualities of services to tourists in Ethiopia is not only a good choice but a must. Such services are being made available in those technologically advanced countries. Among such systems, "Where", "Trip Journal", "TripIt", "Wikitude", "Cyber Guide", "Context Aware Information System", and "Trip Advisor" are the main ones. These are explained in detail in the literature.

In this work, we investigate how pervasive context aware systems can be built to provide tour guide services. The work also aims at designing architecture for the system based on the findings and implements the architecture.

There are a lot of tourists that come to Addis Ababa and different parts of the country to visit historical sites, museums, and national parks with indigenous plants and animals and diverse cultures. For example, Lucy (one of the most remarkable discoveries about the human origin), Ertale live volcano, and the nine UNESCO world heritages are found in Ethiopia [16]. All tourists who come to Ethiopia pass through Addis Ababa and visit the city. Addis Ababa is not only the capital of Ethiopia, but also serves as a seat for the African Union. Because of these reasons, many foreigners come to Addis Ababa to stay for some days and go to other parts of Ethiopia or sometimes they come to stay and visit Addis Ababa. One of the needs of tourists is to get the information about the city easily; information they need is like getting the nearest hotel, nearest restaurant, and so on.

3. Related Work

Once the idea of pervasive computing comes into play, a number of research works have been conducted to make it adaptable for different application domains. Having comparable architectural layout, many of these works have different research components focused on context data storage, management, reasoning, and usage. The difference in these components is an outcome of addressing generic problems across domains or adapting a generic architecture to a specific domain of the researcher's interest. On the other hand, being in the same domain, research works on pervasive computing may vary in principal issues they address. For instance, two distinct research works, being in the pervasive health domain, one may address issues of quality of context-information in terms of context data refinement and the other may address the issue of decision support in terms of knowledge extraction. They may also differ in their software architecture

[1]. In this section, some of the pervasive context aware researches around tourism and related to the work are presented.

3.1 Context-Aware Tourist Information System (CATIS)

A Context-Aware Tourist Information System is a web service based tourism information system [12]. It is based on the scenario of a tourist located in the main road of the Chicago metropolitan area. Since it is noon, the system requests restaurant information around the current location of the tourist. The retrieved information considers of food preference and economical class of the tourist. Finally, the resulting restaurant list is transformed into Web pages in a format appropriate for display of the client's wireless device.

The elements of context in this work are location of a tourist, time of the day, speed and direction of travel, personal preferences, and device type. It describes how these elements are leveraged to adapt Web-based information that is delivered to mobile tourists. It has Web services-based system architecture having wireless client device for browsing, application server for coordination, UDDI (Universal Description, Discovery and Integration) server to act as services registry, context manager that manages both dynamic and static contexts, and collection of web-services to provide different services.

The web application services comes from different web servers not on server which makes the algorithm complex enough to implement and uses thick server and thin client architecture which leads the system to look more previous history than the current context of the user.

3.2 Trip Advisor

This is a travel guide application in android which provides extensive information about the help lines, nightlife, hotels and restaurants, bars and clubs, events, transports, shopping, about city and best of city. About city is a feature which is easy to find out weather, country code, continent, capital, and languages spoken in a city. Best of city feature guide is one-stop digital book to the city, showing the sights, the most fashionable bars, and the tastiest food. Hotels and restaurants features over 2,000,000 recommended and inspected hotels, from spa retreats to coastal locations, and from country house hotels to iconic city center venues. Travel guide mobile application is a guide in true sense which makes travel enjoyable and gives valuable information without exerting too much effort or money [4].

It is mainly based on traveler reviews and ratings have specific application for major cities in the world. It use GPS to show direction and there is no automatic recommendation here except the rating recommendation randomly or when the user remembers and has no detail of the services of the hotels, café or restaurants.

It uses web application service as an input to the mobile application which the web application service is on one server and also has specific application for the city and information about the specific city even if it is not based on the user context. Among the parameters used to compare services provided by such systems are web based, mobile service, integration of weather information, location, time, user preference context, context of the environment, rating and review, proactive recommendation, active request, dynamic current context data, and central database server. Table 1 shows summary of services provided by related works based on selected parameters.

Table 1: Comparison between different related works

Parameters	*CATIS*	*Trip Advisor*
Web based	+++	+++
Mobile based	+++	+++
Location, time, profile (user interest) context	+++	
Detail information about the context of the environment		+
Rating and review		++
Active request	+++	+++
Dynamic current context data	+++	+
Central database server		+++

+++ - integrate all feature, ++ - integrate partial feature, + - integrate one feature

4. The Proposed Solution

In this section, we present the architecture of pervasive context aware tour guide (PCAT-G). We start with discussion about how the pervasive context aware tour guide web application is made in general. We have used questionnaires to identify what is more important for tourists and questionnaires to identify the need for pervasive context aware tour guide web application. From the questionnaires we have collected and from on site observation at hotels, cafés and restaurants, we have found the most important interest of tourists when they come to a city, in our case Addis Ababa.

The server side architecture and the client side are based on responses as tourists are also asked about their interest. These responses are identified to be:

- Places to stay
- Places to eat
- Knowledge about the city
- Places to visit in the city
- Tour guides to help them travel to other part of the country

Literatures are also used to enhance on the components required for the architecture.

The overall architecture of the system looks like Figure 2. There are always requests and responses and therefore the architecture is of client server type. The request comes from the user, from the client side, or the request comes proactively based on the context of the client and the response comes accordingly from the server side.

The server side is where the static context and other information is stored and prepared to give response to the client request. The server side includes the Google server, weather online server, web application server of the PCAT-G. The client side is where the context is captured, analyzed and the request is sent to the server side. The client side can be any device which can capture, analyze, and request the information from the server side like mobile phone, car system, watch, smart device, laptop, etc.

4.1 Server Side

The server side of PCAT-G has three components: Web application of PCAT-G, Google Server, and Weather Online Server. The system uses the Google server for the map display, showing direction, to get location name and to get near search location for the client. The weather online server is used to get weather information about the city where the user is located.

The main purpose of the web application is to provide detailed information besides the information provided by Google server. It is developed for the company owners who are related to tourists such as travel agencies, hotels, cafés, restaurants and any other related user which is called web client in the architecture. The web application architecture is MVC architecture so that there will be no direct contact with the model to the viewer or client side. The model will have direct contact with the database and the controller will allow any client side to access what it has to access. The web application is prepared or designed in such a way that any client side will have an access to interpret the information the server provides. The web application provides information such as travel agency, hotel, statue, rating of different places, etc. So it uses web API (Application Programming Interface) for the response of the request of any client side. A web API is typically a defined set of HTTP request messages along with a definition of the structure of response messages, typically expressed in JSON (JavaScript Object Notation) or XML (Extensible Markup Language).

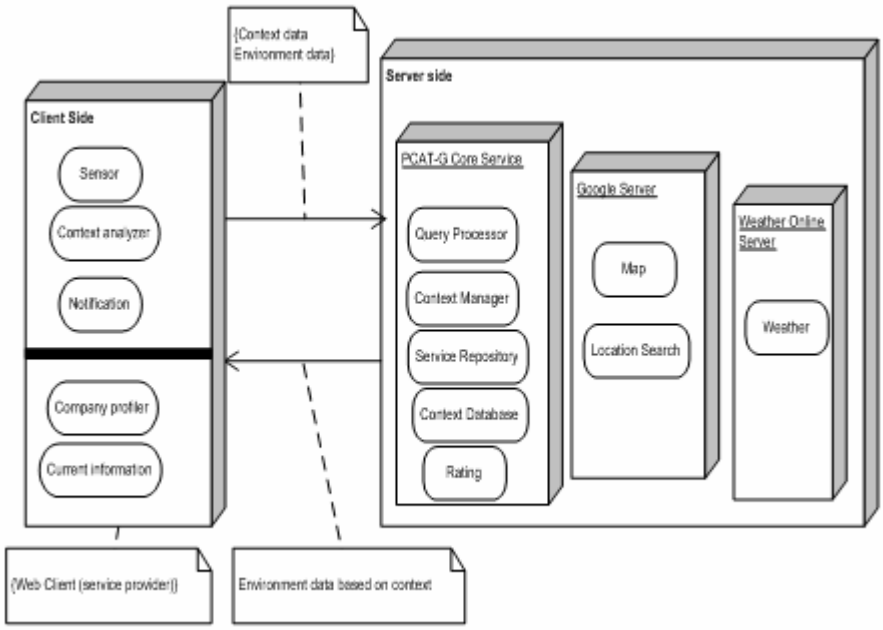


Figure 2: Overall architecture of PCAT-G

4.2 Client Side

For the client side, we can prepare many modality interfaces so that any device can use its own interface for its own fit. Figure 3 shows how different devices can be entertained in the client side but for the demonstration and prototype purpose, this paper uses a mobile application as a client side. The mobile application is developed to have many modules. It has search, background service, location service, rating, display, notification, previous history, help phone, tools, and others.

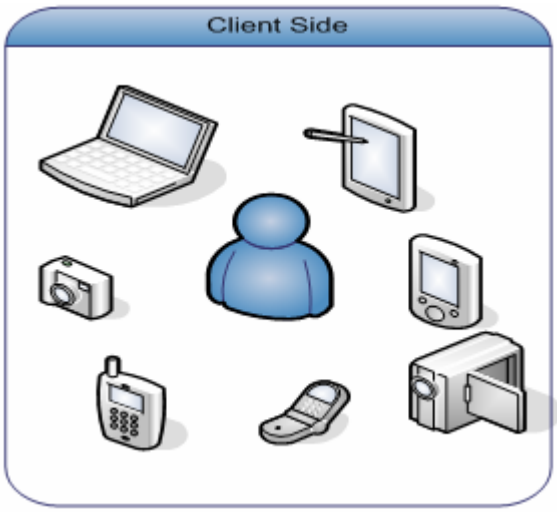


Figure 3: Client side devices

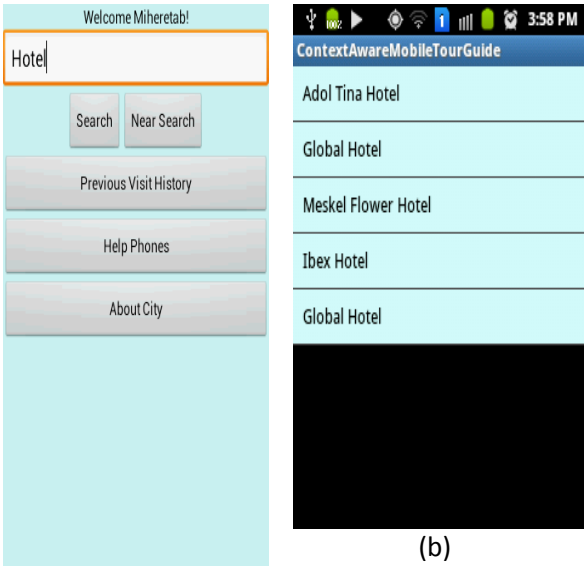
5. Prototype

For the server side, the web application is developed using open source web technology. The programming language used is PHP, the database is MySQL, and the framework is CAKEPHP because CAKEPHP uses model view controller architecture. This web application is for supporting the context-aware tour guide with current information.

For the client side, the mobile phone application for the tour guide is developed using Java, specifically on android operating system for android phone.

The technology used for showing the map, to find near search, to get direction, and to get location name on the phone is Goggle map and the technology used for showing weather is world weather online API.

Let us look at one scenario. If a user wants to search the nearest hotel, s/he can type hotel in the home interface input box and click near search and the output is shown in Figure 4. Here the screen shot is taken while the mobile is between Gotera and Wello Sefer. So the nearest search is using the frequent distance 1km that is set in the profile.



(a) (b)

Figure 4: Screen shot of the home interface with typing hotel and after clicking near search

If the user selects a place to see the details, for instance in Figure 5 the user selects Global hotel, it shows the details of Global hotel and also has a map button to see the map view.

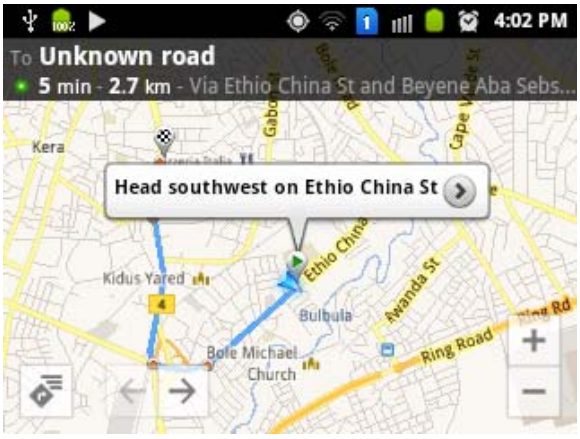
Figure 5: Screen shot of the detail interface of Global hotel

Then by clicking the map button, we can see the exact place of Global hotel in the map plotted as shown in Figure 6.

Figure 6: Screen shot of the map

After viewing the map, we can go back or click menu and *guide me there* menu will pop up as shown in Figure 7a and if we click on it, the direction from the current location to Global hotel will be plotted on the map as shown in Figure 7b with direction and hint included in the direction, we can see hints of where to turn and in which direction to go, by clicking the path shaded in blue.

(a)



(b)

Figure 7: Screen shot of guide me menu (a), with direction (b)

6. Conclusion

The number of tourists coming to visit Addis Ababa and also the whole Ethiopia are growing from time to time. Historical sites, museums, national parks with indigenous plants and animals and diverse cultures are among the tourist attractions in the country that are getting popularity nowadays. Such growth invites the development of some automated system that supports tourists to independently discover the services available and get more information by their own. There are some tourist guide systems that already exist but all have limitations in providing customized tour guide information that depend on background and different preferences and context of the tourist. Tour guide services based on reviews and ratings only, services that are not based on the dynamic context and profiles of the particular tourist are not sufficient and are not dependable.

In this work, we proposed an architecture that can be used to develop a mobile tourist guide service that is based on particular preference, profile and context of the user. Using a system developed based on this proposed architecture, tourists can get information about the city easily based on their interest. This work contributes towards automation and improvement of tourism service one step ahead because it creates convenient environment and thus attracts more tourists as it allows tourists to stay and visit a city without a need for human guide which sometimes is even misleading due to subjective bias.

From the questionnaires and on site observations, we identified the most important interest of tourists, the type of service that tourist agents and service providers like hotels and restaurants provide, and pertinent parameters for developing such systems. Extensive literature reviews and modeling techniques are also used to come up with client-server architecture for the purpose of providing pervasive context aware tour guide.

The architecture is designed to support any client to access and/or provide information from/to the server. The architecture can be implemented using any client side device such as mobile phone, systems in a car, systems in wearable devices like a wrist watch, laptops and so on and the architecture can be developed for any city depending on the data that goes into the backend database. It is a web based architecture in which tourist related companies feed their data into a central database, have a client side device which can capture context and request for information, integrate weather information, location, time, user preference as a context of the tourist. It is also based on rating of other tourists. It provides a proactive recommendation and reactive request based service based on the current context data collected.

The proposed architecture, therefore, is mainly based on the context of the tourist and the context of his/her surroundings. Collection of context in the surrounding environment is supported with the information gathered from tourist related companies like hotels, cafés, restaurants, travel agencies, museums, etc.

Many of the reviewed related works do not contain or consider all the necessary services for pervasive context aware tour guides. The closest related work to our proposed system architecture is Trip Advisor which also lacks the context awareness and pervasiveness part which is the main contribution of this work. Table 1 shows comparison of reviewed related works and all the parameters mentioned there fulfilled with our proposed architecture.

The prototype of the proposed architecture is implemented and tested in android mobile phone for Addis Ababa city. The system is deployed on a freely acquired server, http://miheretab.alwaysdata.net/, and

on android mobile phones. From the demonstrations we made, the system is found to work as planned and provides all the necessary functionalities of pervasive context aware service.

As a future work, it can be implemented on other smart phones and regular phones for other cities as well based on the architecture developed in this work. The prototype is based on GPS for tourists outside buildings but as we know, GPS has limitation of accuracy inside buildings, so in future work; this can be implemented using other location support systems inside buildings.

If this work is implemented in car systems to guide a tourist to a destination, incorporating traffic information is also another future work. In Ethiopia, currently we don't have such kind of organized traffic information. This kind of work is highly recommended to increase the pervasiveness of the tour guide.

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