

A Context-Aware Search System for Smart Phones Based on Context-Aware Infrastructure

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Abstract— A context-aware architecture can be designed to collect the mobile user's context information, derive mobile user's current context, distribute user context among context-aware applications, and support the applications like context-aware search. The context acquisition is centralized at the context server to ensure the reusability of context information among mobile devices, while context reasoning remains at the application level. Implementation of such a proxy helps context aware applications to derive user context profiles. The integration of user context with search engines like Google and Yahoo proves how context-aware searches can meet user demands for tailored services and products in and around the user's environment.

Keywords— Context-Aware Architecture, Context Server, Mobile Devices, Context Reasoning, User Context Based Mobile Search

I. INTRODUCTION

The concept of context awareness originally stems from the research of human-computer interaction (HCI). One of the objectives in HCI research is to design computer interfaces that reduce user intervention while providing more relevant services to the user. "Context is the set of surrounding states and settings that either determines an application's behaviour or an application event occurrence in which the user is interested". In computing, "context" reflects the mobile user's current state including physical behaviour, artefacts, social interaction, surround events, and environment including the explicit and implicit input for mobile applications.

As mobile devices are becoming ubiquitous and are being widely adapted, set of context notions has very limited success in learning the mobile user's intention under various scenarios. The main objective of the proposed system is to develop a context-aware search application which can provide data and services relevant to the user's personalized profiles and history of search. It is not easy to single out the mobile user's context from objects and entities which are not relevant to users' intention [2]. Mobile users have different knowledge, expectations, experiences, skills, priorities, social roles, attitude to view the world surrounding them. Hence, individuals select the objects in the real world in a subjective way and describe context of the world complexity in an unstructured fashion.

Context-awareness is the ability of computing systems to acquire and reason about the situational context and adapt application accordingly. Context-aware system comes with gathering of low-level contextual data, interpret the low-level contextual data into high-level interpreted context,

reason the interpreted context to derive results and adapt the application behaviour on the basis of the implications.

A. Background

A decade ago, pioneer Mark Weiser envisioned that a human would live in an environment surrounded by hundreds of invisible computers connected with wireless networks. Metadata as a context is now widely incorporated and indexed for personal information retrieval. Memory context is also considered in personal information refinding [1].

To support such "context aware utility" anytime and everywhere, a context-aware architecture is required to actively acquire, analyse, and adapt to mobile user's given contexts, such as physical environment, social activities, and other dynamic characteristics at different levels without consuming much of the user's attention. Harry Chen proposed a context-aware architecture that separated the context acquisition completely from the mobile devices, which come in numerous combinations of hardware capabilities ranging from highly performant ones to the ones that provide bare minimum functionality.

Context-aware applications are often considered as location-aware applications, integrating GPS information into applications such as tracking delivery trucks, or equipment in a hospital etc. One might even have a context aware application that unlocks the car automatically when you walk up to it. But context-aware is a lot more than just location-aware.

The voice based assistants being rolled out in the smart phones add little more intelligence to HCI by being more interactive and serving user results based on his past preferences or habits like setting alarm, aggregating results from various search services. With the availability of user's context, mobile applications that serve real-time data in augmented/virtual reality mode are also being developed.

B. Issues of Context Awareness

The essential part of the context awareness is to design an artificial intelligent architecture, which acquires, analyses, learns, models, and distributes the mobile user's context [5]. The mobile devices can also contribute to undertake some of the context server's functions in terms of context acquisition and analysis, as more advances are made in this field of research and as new challenges are ultimately revealed.

Acquiring the user information is the first step towards understanding the changing context. The hardware infrastructure must be provided to collect user context. On

the one hand, technological advances enable hardware manufacturers to integrate more hardware logic into wireless devices, while on the other hand; wireless operators have little progress in deploying infrastructure due to the cost factor. Another issue is how mobile devices share user context if there is no such infrastructure available to support such context reusability [6]. Researchers proposed solutions ranging from context middle ware to context server in order to support reusability [7].

C. Context Modeling

The most important feature of a context-aware architecture is the reusability of context among applications such that the application developers can focus on the high level application development without the drag on context data acquisition. Because of the heterogeneous nature in context data acquired from various types of sensors & mobile devices, it is crucial to represent context data in a structured format.

D. Applications of Context Awareness

Following are some of the creative applications that consider mobile user's context.

1) *Sharing Context Information between Mobile Devices:* This application provides a user interface solution that displays the friends' positions in a customized map, which runs on mobile devices. The application interface provides easy access for the user to use context-aware applications. This application demonstrates a simple architecture design which enables mobile users in a community to share context information.

2) *Context-Aware Applications in a Hospital Setting:* Clinical computer systems, such as electronic patient records, do not use patient's given status and clinical situation into the system design. Physicians have to manually work with same user interfaces regardless of the individual patients in different clinical situations. The newly designed applications take advantage of given situation of physicians and patients. The context-aware hospital bed has for example a built-in computer and a mounted display for checking a patient or for displaying patient records.

E. Problem Statement

The search engine is no more a buzz word. It is the integral part of every convergent device. Various search optimization mechanisms available today are based on business needs and user's keyword based query search. At the same time, search engines do not have human intelligence yet to process large sizes of data, remove ambiguity and take decisions on the relevant data.

This problem adds considerable cost to the research and development activities to improve upon optimize searching algorithms, bandwidth utilization, larger data processing capabilities of mobile devices and user experience. Various search optimization mechanism available today are very specific to business needs and are keyword based. So there is a need to optimize the search engines by embedding more human intelligence and personalization based on user profiles, thus improving search results with more accuracy

and user specific data and hence the user experience. So, User Context Based Search (UCBS) services can definitely be one of the solutions to improve search capability.

II. CONTEXT AWARE ARCHITECTURE

In the world of ubiquitous computing, knowledge and communication are interwoven entities. Pervasive computing refers to the trend toward casual access to numerous invisible computing devices embedded in the environment. To support such "context aware utility" everywhere, the appropriate infrastructure for context awareness in the environment is essential. Context architecture takes care of acquiring mobile user's context at hardware level and distributing the user context to different context aware applications via the standardized API.

A. Context Service Model

The service registry interacts with third-party service providers to register services which will be available to mobile users. Server distributes service providers' information to mobile user according to the user's current context. In a sense, the server acts like a broker who matches services to user's need which is derived from the user context.

Service type basically describes the nature of the service. Service provider could register their services and products with the designed architecture.

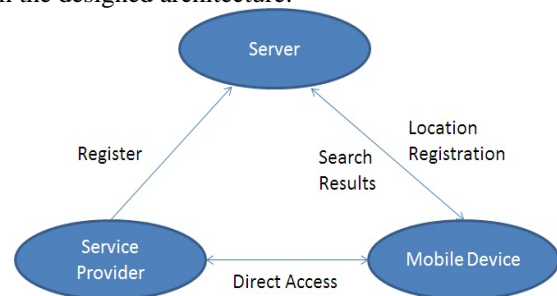


Fig.1 Context Service Model

Service scope specifies either the geographical area in which the service is available, time range, or other constraints. The location context can be specified either in geometric format or in symbolic format. The geometric format models the location in multiple dimensional coordinates.

Context inputs list all the required context information from the user. Each context aware application has its own required context. Context change reminder type specifies how the context-aware application is informed of the change in the related context.

B. Context Aware Search Manager

Major search engines such as Google, Yahoo, and MSN attempt to increase local content in the query results in the hope that users are provided more information around them. The proposed context-aware search manager improves the mobile search by personalizing the user query.

The context-aware search manager for mobile devices must, however, cope with some issues not encountered in the wired computers. First of all, hardware is bound to the

requirement of mobility. Even with the soft keyboards and touch screens, typing is not convenient on mobile devices. The display constraint implicitly requires a search engine to improve the accuracy of returned query results, because query results are limited to fewer references or links than the conventional wired computers.

Secondly, one of the challenges for the mobile search is to identify the query ambiguity. Short query such as "apple" is not clear for search engine to derive the right topic from user's point of view. Search engines usually returns documents that cover multiple topics to solve ambiguous queries.

Thirdly, the connection cost is much higher in mobile devices compared to the wired computers. Fourthly, mobile devices are not only the extension of personal space, but are widely utilized in places where PCs are readily available.

Mobile search stems from PC-based web search, but differs from PC-based web search due to these aforementioned factors. Mobile search has become the second most used application only after social networking in wireless internet.

1) *Context Aware Mobile Search*: Due to the concept of mobility, mobile devices are utilized in more diverse contexts than PC in office and home. Mobile search is becoming increasingly important for mobile users as mobile devices are more widely used. Mobile search differs from standard PC based web search in a number of ways: the user interfaces and I/O are limited by screen real estate and typing is not always convenient, limited bandwidth and costly connection time, increased local search due to mobility. Most mobile search queries are short due to the hardware limitations.

2) *Personalized Search Query*: The context profiles compiled by context proxy at client devices and processed at context server reflect the hardware configuration, user applications, usage history, network traffic, user activities, and derived user situation.

C. Context Reasoning

The crucial step after context acquisition is to recognize context from the collected context data. In the early years, researchers built context acquisition, extraction, monitoring, and analysis on the mobile devices. Another approach is to centralize the context acquisition and reasoning processes at the context server. Most existing server architectures try to build their context reasoning component which is based on context rules predefined.

The context rules are usually deposited into a persistent knowledge base. The context server determines the type of context after data acquisition and decides if context data can be interpreted or analysed by the rules in the knowledge base. The context rules are loaded to deduce high level context abstract from low level data. For example, compile raw context data into composite context and recognize the context to derive user intention. The extracted user context is searched along the context chain until it finds a match which triggers certain mode.

III. CONCLUSIONS

Context awareness within this design concept defines the user context in a changing environment under different situations, and provides solutions for useful applications. Context data acquisition in a cost-effective way using current technology is highly feasible.

The context aware architecture at the server side provides a platform to share the user context among context-aware applications. Context reusability shields application developers from low level context acquisition. The required architecture is envisioned to accommodate third-party service providers. Service provider could register their services and products with the designed architecture.

Furthermore, in order to address the issues of variability and instability in the notion of user context, the approach considered here addresses the source of the difficulty in context awareness at the client side through the extraction of useful feature/context from user situations that are dynamic in nature.

To meet real-world needs required of a testing environment without the imposition of a heavy cost such an infrastructure will demand, search APIs of popular search engines like Yahoo and Google are integrated (which come at no cost for certain volume of search queries) as a means to evaluate the effectiveness of the proposed design structure in a most realistic way.

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