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Decentralized Registry Based Architecture for Location-Based Services

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***Abstract*—The explosive growth of mobile devices and wireless networks has raised the interest for information and online service access anywhere and anytime. Due to user mobility, users will have a much closer relationship with their surrounding physical environment and will thus have a much stronger need for search and consume services that are relevant to that environment. This need has driven the development of architectures for supporting the provision of location-based services in which services are associated with particular locations or geographical positions. Location sensitive applications can use such services to provide users with the information that is relevant to their current location. This paper explains the decentralized registry based architecture which provides local services to mobile users depending on their current geographic location using the Web services technology.**

***Index Terms*—Location-Based Services, Mobile Services, Wireless Devices, Web Services.**

I. Introduction

Services provided to mobile users according to their geographic locations are known as Location-Based Services (LBS) [1]. Requesting the nearest ATM, petrol pump, restaurant, hospital and ambulance services are some examples of the location based services in a mobile environment. Location is an essential parameter for all location-based wireless services.

At present, the LBS, provided by most service providers are tightly coupled with their own system. This architecture ensures security, privacy and the convenience of billing but limits the scalability, extensibility and interoperability of services. Service provider dependency is the major concern for end users. A key research challenge in the development of LBS systems is how to allow location sensitive applications to dynamically discover and consume services they need for the user's current location. Dynamic discovery is a major issue as user changes his/her location frequently and known service providers may not provide services in every location that the user visits. Also, mobile users are unaware of service providers of each and every location they visit. Openness and heterogeneity are the key issues as mobile devices, wireless networks and information providers use different technology and standards. An adequate solution should address the issues of dynamic service discovery, openness and heterogeneity.

Service-Oriented Architecture (SOA) is the latest step in the evolution of software aimed at facilitating the design and development of applications on distributed systems [2]. SOA uses the publish-find-bind and execute paradigm to facilitate dynamic discovery of services. In SOA, service providers publish their services by registering them in a registry. This registry is used by service consumers to find the required services. The registry provides the consumer with a contract and an endpoint address for those services which match the search criteria. Web Services [3] technology is the preferred standards-based solution to realize SOA. Web services are loosely coupled components and use open standards to provide interoperability between various applications. Web Services support openness and heterogeneity in addition to the dynamic discovery of services by using XML, SOAP, WSDL and UDDI open standards. The data is tagged with XML and transferred using SOAP. Services are described using WSDL and published in UDDI. Applying Web services technology to the mobile environment is known as Mobile Web Services (MWS) [4]. User mobility with their terminals is a distinguishing characteristic of Mobile Web services compared to conventional Web services.

This paper explains decentralized registry based architecture using Web services technology which provides local services to mobile users depending on their current geographic location and facilitates dynamic service discovery, openness and heterogeneity.

II. Related Work

Different approaches have been proposed by the researchers in the area of discovering Web services in a mobile environment dependent on the location of mobile users.

A middleware based solution supporting the integration of local services and applications available in Value ADded Environment (VADE) environments into an external portal is explained in [5]. Each mobile user has his own Context Manager and the Personal Portal collects user context information from his Context Manager. The context information may contain a notification of the user entrance in some VADE domain. This notification includes a reference to the VADEs internet domain name. This reference is a basis to access the VADE Entry Point at a well-known URL.

A context-aware tourist information system is explained in [6]. This system architecture is Web services-based and includes a context and profile manager (CPM) that manages both dynamic and static context like location, time of day, speed, direction of travel, personal preferences, and device type. In this system, a tourist seeking local information about nearby restaurants, for example, connects to the application server to request the information. The application server forwards the query to the CPM, which gets a list of addresses of available

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restaurant Web services by querying the UDDI server. The CPM then sends a request to the identified Web services specifying a service area for the user. The Web services search their databases for the appropriate resources, which fall inside the specified area, and return an XML list to the CPM. The CPM filters the XML list according to the users context and preferences such as the users cuisine preference level and distance and direction to the restaurant. This system follows centralized architecture where tourists always connect to the common web server to get the local information.

An infrastructure for organizing and efficiently accessing m-services in broadcast environments is explained in [7]. "An m-service is a Web service that is accessible by mobile hosts through wireless networks". An example for m-service is a stock quote service providing stock quote prices to users on the move. Authors define a multi-channel model to carry information about m-services available within a given geographic area. Registry information about m-services is included in the UDDI channel. The description and executable code of each m-service is included in the m-service channel. The actual data needed while executing the m-service is included in the data channel. Mobile clients download the UDDI channels content to their mobile device and store it for later use upon entering a new geographic area. Frequent access to the UDDI channel is avoided by caching the directory of m-services in user devices and hence minimizes power consumption. This system is designed to download and execute m-services on mobile devices to minimize power consumption. The information contained in the UDDI channel is customized to fit the characteristics of wireless environments. For example, the accessPoint attribute within UDDIs bindingTemplate structure contains the frequency of the wireless channel through which the m-service can be accessed instead of the HTTP or FTP addresses to access the service.

A middleware system called GLWSA (Geo-Located Web Services Architecture) is explained in [8]. "A geo-located Web service is a Web service that is offered in a specific geographical region or area". This architecture is designed to help mobile clients to discover the geo-located Web services and also to maintain the service execution closest to their geographic location. Authors have defined protocols to discover and inform a Supplier Application Server (SAS) to migrate the service execution to the nearest SAS based on the mobile clients geographic location. This system follows a distributed architecture but user always connects to his home network before proceeding to access local services. Service covered area information is stored in the UDDIM database. The emphasis is given to service migration so that distance between the SAS and mobile client is minimum.

The proposed system follows decentralized registry approach as in [8] but at the location level instead of mobile access network level. Unlike other Web services technology based solutions where clients always contact a well known broker or registry, the proposed solution connects to the relevant local registry depending on their current geographic location. Cellular network cells or group of cells are considered as locations and broadcasting mechanism concept is considered as mentioned in [7] but the proposed solution broadcasts local registry address instead of services registered in it.

III. The Proposed System

The proposed system explains the organization of registry and its discovery in a mobile environment. It explains why to decentralize and how much to decentralize the registry for location-based services. It includes a novel way to discover local registries in a mobile environment. Components of the proposed system and functional details are included in this paper.

A. Registry Organization

A centralized registry model is probably the most efficient in terms of design, configuration, control and maintenance. In this case, mobile clients only have to maintain the location of one registry. The main drawbacks as is in any centralized system lie in the bottleneck of the central registry and the inactivation of entire system when the central registry shuts down or crashes. Centralized registry models results in lower performance if there are too many services to be registered or queried. Furthermore, storage may be a constraint when the number of service registrations grows very large, since one node must host all service registrations.

Registry replication attempts to overcome the disadvantages of the centralized approach by replicating the entire information and put them on different sites. However, replication may temporarily improve the performance if the number of publishers and subscribers is limited. Also, data becomes less consistent when the system has more number of replication sites.

Decentralization is a natural development when a system grows large and becomes complex. There are several reasons why a decentralized approach is attractive in case of location-based services. It improves query processing as services are distributed in multiple servers and hence the response time. Decentralized systems have no weak point that can bring the entire system down if individual registries crash or go down and hence are robust against failure and attacks.

In a mobile environment, users of the mobile terminals are interested in searching and consuming services located within some distance from their own current position. In other words, distance between the consumer and service provider should be as short as possible. When the user moves out of the current location to a new location, he would like to request services available in the new location. Thus, in a mobile environment, dynamic service discovery is required based on the users current location and the discovery is limited to the services available within that locality. This requirement motivates to have decentralized registries at the location level to facilitate dynamic discovery of local services.

In the proposed system, cellular network system is considered in order to divide the entire geographical area into locations. In a cellular network system [9], a cellular service area is divided into smaller areas called cells. Each cell is served by a base transceiver station (BTS), also known as a base station(BS). The BTS is the Mobile terminal's access point to the cellular network and is responsible for carrying

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out radio communications between the network and the mobile terminal. The size of each cell is determined usually based on the local traffic distribution and demand. If the concentration of traffic demand in the area is high then the cell has to be sized smaller in order to avail the frequency set to a smaller number of roaming subscribers and thus limit the call blocking probability within the cell.

Thus, based on the cellular system, cells or group of cells are considered as locations in the proposed system. Whenever a mobile user is roaming in cell X, user is considered to be in location X. Service registry is decentralized and registries are placed in these locations. Registry located in each location or cell is called as local registry (LR). Search response time increases due to less number of service registrations in LR and location based service search accuracy increases as LR contains only local service registrations.

B. Registry Discovery

An important question is how to discover local registries while user is in mobility. In [7], the authors have identified three modes for accessing m-services. Similarly, registry discovery can be made in three modes: in-hand, on-demand and by-broadcast. In the in-hand mode, user knows the local registry address and manually enters the registry address in mobile applications. This mode is clearly not suitable in mobile environments where location changes are very frequent due to user mobility. In the on-demand mode, mobile users always contact a well known broker to get the local registry address. This method involves centralized broker access and additional cost to mobile users as they should pay the broker for their services. The other problem with this approach is that the centralized broker server becomes a performance bottleneck and forms a single point of failure. In the by-broadcast mode, a broker in every location periodically broadcasts the local registry address over the wireless channel. Mobile clients listen to the wireless channel and download the local registry address to discover local services.

In the proposed system, by-broadcast mode has been used. As already discussed earlier, a cellular system's service area is divided into multiple cells. Each cell is served by a BTS. Each BTS broadcasts both the Location Area Identity (LAI) and the Cell-ID on the Broadcast Control Channel to its cell. A mobile terminal always knows its Cell-ID and LAI as it always receives these broadcast messages. In the proposed method, the cellular network base station is configured to broadcast the local registry address along with other existing parameters. Broadcasting the local registry address using base stations avoid third party brokers and hence the reduced cost. Broadcast is suitable for a large number of mobile clients since performance does not depend on the number of mobile clients.

Following is the J2ME source code which is used to get the Cell-ID and LAI of users current location.

String cellid = System.getProperty("CellID");
String lac = System.getProperty("LocAreaCode");

Similarly, in the proposed system, the below given code is suggested to use to get the local registry address.

String lraddress = System.getProperty("LRAddress);

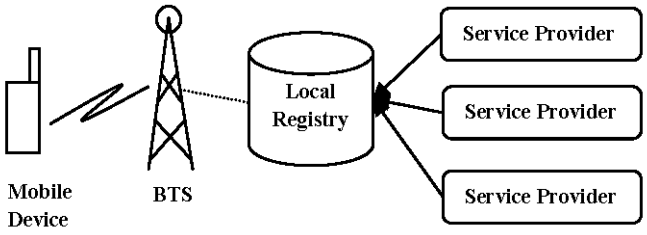

Fig. 1. Components of the proposed system

Once the local registry address is obtained, users can proceed with local service discovery process.

C. System Components

The main components of the proposed system are shown in Fig.1. The main components are mobile devices with location sensitive applications, service providers, local registry, the wireless mobile network and BTS. Mobile devices like cell phones, smart phones, etc are used by the end users to access local services. Location sensitive applications deployed on these wireless devices are used by the end users to consume services available in their current geographic location. These applications are responsible for providing user interface to the end user to accept inputs and to display the results by dynamically searching and consuming services available in the current location. Service providers are the providers of actual services within the given location. The service provider creates a web service and publishes its interface and binding information to the local registry. The local registry is the one which allows service providers to register their services and service consumers to search for required services. The wireless mobile network allows service consumers to communicate with the service providers and local registry. Cellular network BTSs are associated with local registries and are configured to broadcast the associated local registry address.

D. Functional Details

Whenever a mobile client is interested in searching for local services, it listens to the base stations broadcast channel and downloads the local registry address. Once the local registry address is discovered, it proceeds with the service discovery process. The functional block diagram of the proposed system is shown in Fig.2 and an algorithm is given below with the main steps which are required to be executed to search and consume local services by the location sensitive applications.

Algorithm: Search&ExecuteLocalServices
/* executed by location sensitive applications whenever mobile users wants to consume local services */.
Begin

1) Get service search parameters from the user.
2) Get the Local Registry address by listening to the BTS's Broadcast Channel.
3) Find services in the local registry by using the address obtained in step 2 and passing the search criteria data obtained in step 1.

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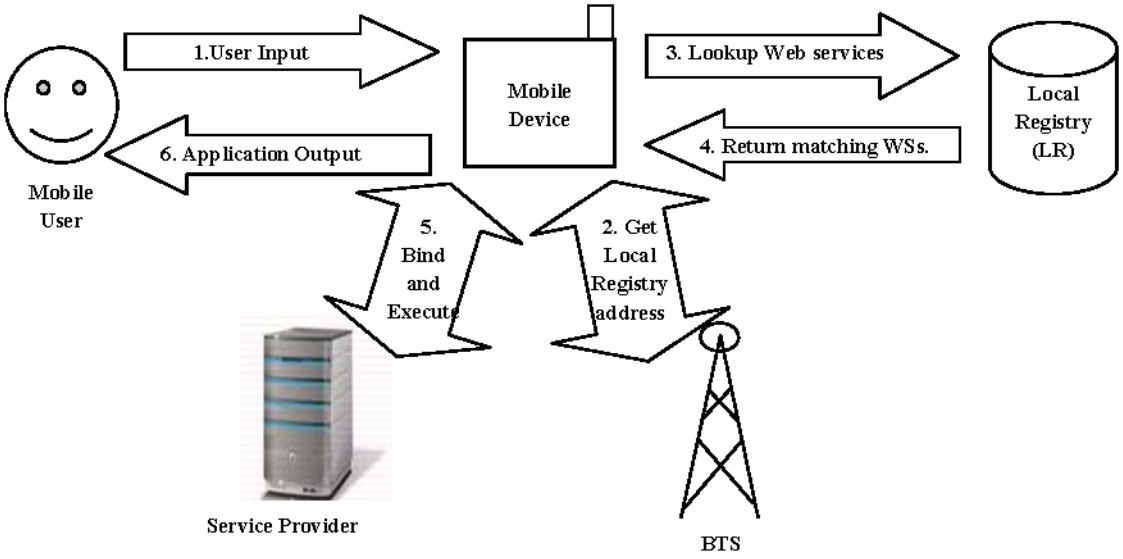

Fig. 2. Functional diagram of the proposed system

4) Select a service and download its binding information.
5) Bind and Execute the service.
6) Display the result to the user.

End

IV. Conclusion And Future Work

This paper explains decentralized registry based architecture for discovering and consuming local services using the Web services technology. Web services technology supports dynamic discovery, openness and heterogeneity. A novel way of discovering local registries is introduced to avoid single point of access. Local registries results in reduced search time and increased accuracy in search results as they contain services relevant only to their geographic locations. Future work involves search query propagation to neighboring registries in case of requested services are not available in the current local registry or the mobile user changes his location.

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