INDUSTRY AND PRACTICE

Issues in Mobile Electronic Commerce

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In this article we address delivering highly personalized context sensitive (i.e. time and location dependent) information to mobile clients. We believe providing highly personalized information to mobile clients from a variety of resources like e-mail servers, Web servers, and content providers will be an important service. Mobile network operators can play a major role in delivering this information to users by being strategically positioned between customers and content/service providers. Currently many Mobile Network Operators (MNO) and software companies are offering some personalized services. However the level of personalization is limited to choosing from available content links, icons and services. We believe that the mobile clients will benefit from a much higher level of personalization where it is possible to express complex queries involving variety of data resources. For such a system to gain acceptance by the users, the process of defining personalized information (that is, user profiles) must be very easy for the user. The most important objective of such systems should be to provide scalability, that is, acceptable performance when the number of users increases dramatically. The article also elaborates on the nature of location dependent services.

INTRODUCTION

The inherent limitations of mobile devices necessitate highly personalized information to be delivered to mobile clients. This information may be coming from a variety of resources like Web servers, company intranets, email servers and can be context sensitive (location and time dependent) and need to be delivered to the user according to his profile. Mobile network operators can play a major role in delivering this information to customers by being strategically positioned between customers and content/service providers. Currently many Mobile Network Operators (MNO) and software companies are offering some personalized services based on SMS (Short Message Service) that is available almost all mobile phones. For example Nokia has developed Artus Messaging platform for MNOs, which acts as a gateway between information and applications residing in the Internet or company intranets, and a mobile phone. Messaging platform allows the MNOs to create value-added Wireless Application Protocol (WAP) and messaging applications for all GSM users. For example users are able to select from the available content links and services the operator has provided. This allows each user to personalize and control the information they see on their mobile devices. Other systems available in the market today provide similar services; however the level of personalization is limited to choosing from available content links, icons and services.

We believe that the mobile clients will benefit from a much higher level of personalization. For example, the user may wish to receive an immediate alert if within a period of two hours from the start of the trading day, either IBM stock or Microsoft stock is up in at least 3% more than the change in the Dow Jones index. Such complex requests can only be expressed through query languages and none of the systems on the market today provide this level of personalization. In other words a querying power just like SQL provides on relational databases is necessary for expressing highly personalized profiles. Since the queries will be executed on the documents fetched over the Internet, it is natural to expect the documents to be XML documents, XML being the emerging standard for data exchange over the Internet. Then the user profiles need to be defined through an XML (XML, 1998) query language. XML-QL (Deutsch, Fernandez, Florescu, Levy, & Suciu,1998). is a good candidate in this respect since it has very elaborate mechanisms for specifying query results through the CONSTRUCT statement. This will allow generating the results directly in Wireless Markup Language (WML), ready to be pushed to the mobile clients. A point to be noted here is that the users should not be expected to express their profiles through XML-QL but rather a user-friendly interface should be provided to them to automatically create the XML-QL statements.

When such a system providing highly personalized services is deployed on the Internet, the performance becomes a critical issue since the number of users can easily grow dramatically. A key challenge is then to efficiently and quickly process the potentially huge set user profiles on XML resources. This boils down to developing efficient ways of processing XML-QL queries on XML documents.

The highly personalized profile of the user can also be exploited in delivering location dependent services to mobile clients. For example, when a user is looking for a cinema, the

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type of pictures that he likes can be obtained from his profile.

In this article we propose an architecture, called MobeCom, to address these issues. The specific aims of the system are as follows:

1. Providing highly personalized information to mobile clients from a variety of resources like e-mail servers, Web servers, and content providers.
2. Providing location dependent services to mobile clients by enriching the directives with online information from the Web like traffic density on the roads. To handle location dependent services a digital map processing system is necessary to locate the user on the map. The data to locate the user on the map can be obtained from a Global Positioning System (GPS), which is available in some of the mobile devices. However if the GPS or a similar mechanism is not available on the user's mobile device, a mechanism should be provided to locate the user on the map by obtaining the street and building number from him. Another important aspect of location dependent services is that it may be necessary to obtain some of this information on line from the Web. For example, stored information about restaurants and cinemas may easily become out of date. Therefore the system should have mechanisms like Internet search agents to obtain information from the Web when needed.
3. For such a system to gain acceptance by the users, the process of defining personalized information (that is, user profiles) must be very easy for the user. For this a set user-friendly graphical interface must be developed both for the user's desktop and also for his mobile device.
4. The most important objective of such systems should be to provide scalability, that is, acceptable performance when the number of users increases dramatically.

RELATED WORK

Recently, push-based, event-driven, content-sensitive information delivery (also termed as **continuous queries** or **push-based data delivery**) has become an active research and development field. Push-based means the active delivery of information without user intervention. Event-driven means that the events of interest that will result in the delivery of data are specified explicitly. Content-sensitive means that information is delivered according to its content (Liu, Pu & Tang,1999).

The execution model of these systems is based on continuously collecting new data items from underlying data sources, filtering them against personalized user profiles (in another terminology evaluating the continuous queries) and finally delivering the result of the queries to the users.

The most notable of examples of push-based data delivery are as follows: OpenCQ project (Liu, Pu & Tang,1999), developed at the Oregon Graduate Institute, employs an SQL-like language and runs on top of a distributed information mediation system which integrates heterogeneous data sources. The system is not scalable since optimization issues have not been considered.

NiagaraCQ system (Chen, DeWitt, Tian & Wang, 2000) developed at the University of Wisconsin, Madison, uses XML-QL and works on distributed XML files. It provides some measure of scalability through query groups, cost based execution plans and cashing techniques. However many issues like what type of index structures specific to XML documents are used or how delta files are obtained and processed are not described. More importantly the performance results are not promising, that is, the execution times of queries are considerably long and this indicates that further research and development is necessary in this area.

A more recent system, Xfilter (Altinel & Franklin, 2000), from UC Berkeley and University of Maryland, uses the Xpath language and works on XML files. This system includes measures for scalability such as index organizations and search algorithms and has impressive performance results. However XFilter, rather than delivering the personalized information, delivers the whole document to the user, which is not feasible in mobile environments.

In (Ozen, Kilic, Altinel & Dogac, 2001), an architecture is provided for mobile network operators to deliver highly personalized information from XML resources to mobile clients. To achieve high scalability in this architecture, the user profiles are indexed rather than the documents because of the excessively large number of profiles expected in the system. In this way all queries that apply to a document at a given time are executed in parallel through a finite state machine (FSM) approach while parsing the document. Furthermore the queries that have the same FSM representation are grouped and only one finite state machine is created for each group. To provide for user friendliness and expressive power, a graphical user interface is developed that translates the user profiles into XML-QL. XML-QL's querying power and its elaborate CONSTRUCT statement allow the format of the results to be specified. The results to be pushed to the mobile clients are converted to Wireless Markup Language (WML) by the delivery component of the system.

Related with location dependent services, there are a number of companies providing real time map support on mobile phones like Webraska (Webraska) and Innovations (Innovations). The challenge in this respect is providing context sensitive services like finding places of interest to the user through the Web by exploiting his or her profile information, locating addresses of these places on the map, providing the user the direction to a destination while processing on line information such as the traffic density on the way and also the opening and closing hours of the places. In (Sharma, 2001) a wide range of wireless Internet applications are described and in (Banerjee, Chrysantis & Pitoura, 2001) data engineering issues for wireless and mobile access are addressed.

A survey of the current state of the mobile commerce is addressed in (Siau, Lim & Shen, 2001). The paper presents an

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overview of mobile commerce business activities and technologies, and suggests possible research directions.

SYSTEM ARCHITECTURE

The aim of MobeCom architecture is to deliver highly personalized and context sensitive (time and location dependent) information to mobile clients. Providing highly personalized information to the mobile clients will create better customer satisfaction and can create a multiplier effect and increase the demand for mobile services. Needless to say serving highly personalized information will also to ease the strain on the network bandwidth.

The main components of the system are as follows:

I. Mobile user interface: Mobile users will be presented with a user interface to define their profiles and to receive their location dependent requests, such as the name and the location of the the nearest pizza restaurant or cinema. The interface may get a series of requests from the user with priorities and by proper search on the Web may provide suggestions. The interface will also be capable of giving the user the directions to the destination chosen. The mobile user interface will be developed with Wireless Markup Language (WML).

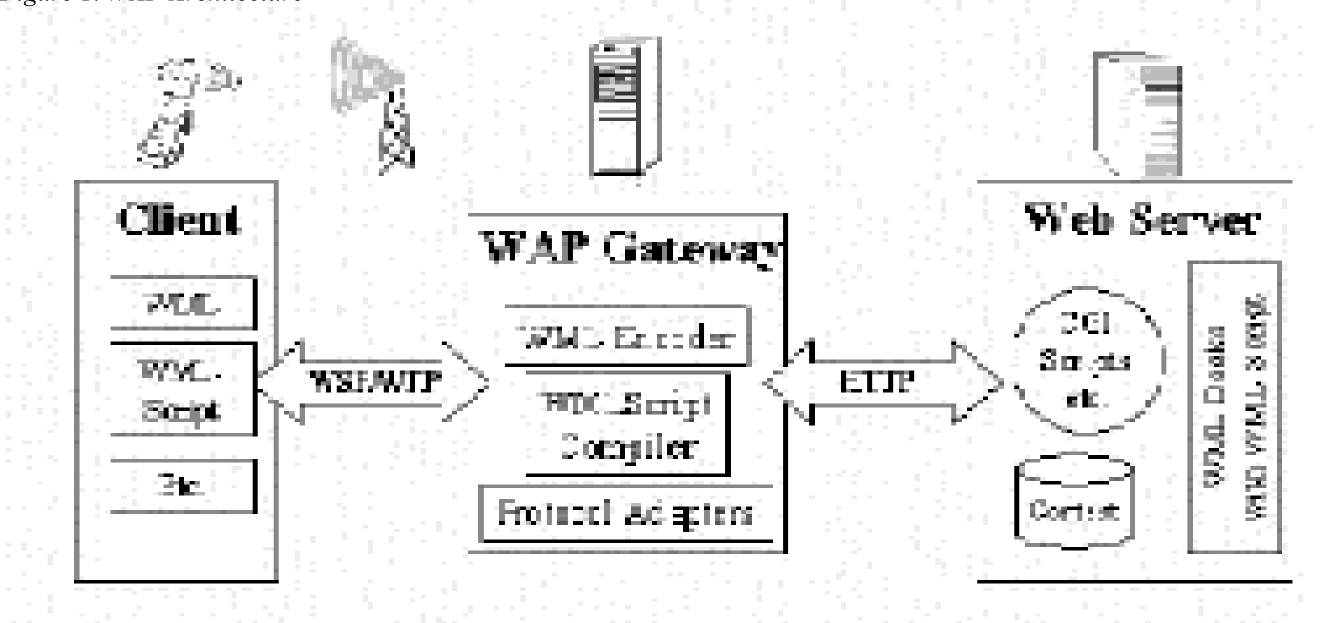
WML is designed for Wireless Application Protocol (WAP) which enables wireless devices to access the Internet directly through a "micro browser". The WAP architecture is shown in Figure 1. Internet standards are inefficient over mobile networks, requiring large amounts of mainly text based data to be sent. Standard HTML web content generally cannot be displayed in an effective way on the small size screens of pocket-sized mobile phone. WAP bridges the gap between the mobile world and the Internet by optimizing Internet standards for the constraints of the wireless environment: low bandwidth, high latency, and less connection stability. WAP enables the delivery of value added services independently of the underlying wireless network technology, bearer and terminal; in this way the mobile terminals together with WAP can access the Internet world. The WML language used for WAP content makes optimum use of small screens and allows easy navigation with one hand without a full keyboard, and has built-in scalability from two-line text displays through to the full graphic screens on smart phones and communicators.

II. Data Collection: Data coming from diverse data resources like channels (news, entertainment, stock prices, etc.), email, Web, file servers will be collected and converted to XML. That is we will provide wrappers for transforming non-XML data to XML. A way of providing XML wrappers for non-XML data is given in (Florescu, Kossmann, Manolescu & Xhuman, 2000). Then XML-QL will be used to extract profile information from the resources.

The data sources could be pull based or push based. Push based data sources will inform MobeCom whenever interesting data is changed. MobeCom will further personalize the data if requested by the user. On the other hand, changes on pull-based data sources need to be checked periodically by MobeCom.

Another interesting issue to be considered is the following: a user may wish to be notified when a composition of events and other situations occur. This issue has been studied in "Amit" middleware framework (Adi, Boltzer, Etzion & Yatzkar-Haham, 2000) which personalizes push technology

Figure 1. WAP Architecture



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through event correlation and enables each client to detect customized situations.

III. Personalization: A graphical user interface for personalization will be provided to users both for their mobile devices and their desktops. The profile information provided by the client on the desktops will be mapped to an XML-QL query. XML-QL is one of the candidates being considered by the World Wide Web Consortium (W3) for the standard way of querying XML documents. XML-QL has a SELECT-WHERE construct, like SQL, that can express queries, to extract pieces of data from XML documents. It can also specify transformations that, for example, can map XML data between Document Type Definitions (DTDs) and can integrate XML data from different sources. Although XML-QL shares some functionality with XML's style sheet mechanism, it supports more data-intensive operations, such as joins and aggregates, and has better support for constructing new XML data, which is required by transformations.

Profiles can be classified into two categories depending on the criteria used to trigger their execution. Change based queries are fired as soon as new relevant data becomes available. Timer-based queries are executed only at time intervals specified by the submitting user. The profile specification will be through a user-friendly graphical interface to include the following information (Chen et al, 2000):

CREATE PROFILE name
XML-QL Query
DO action
{START start_time} {EVERY time_interval} {EXPIRE expiration_time}

The query will become effective at the start time. The time_interval indicates how often the query is to be executed. A query is timer-based if its time_interval is not zero; otherwise, it is change-based. Queries will be deleted from the system automatically after their expiration_time. "Action" is performed upon obtaining the query result. For example it could be "Push to +903122105598".

Profile definition on mobile clients will be through Wireless Markup Language. The mobile user interface will be able to get a series of requests from the user with priorities and by proper search on the Web will provide for suggestions for requested items/services. The interface will also be capable of giving the user the directives to the destination chosen.

IV. Providing Scalability: One of the key aspects of this project is providing scalability, that is, the system shows acceptable performance when the number of user's increases dramatically. For this purpose, the following issues need to be addressed:

1. For efficient processing of XML documents, proper index structures should be in place. When indexing XML documents an issue to be decided is whether to index the text file or the DOM the parser creates. Another issue is the type of indices where (McHugh & Widom, 1999) provides some good insights on the type of indices that might be useful. There are also some efforts in indexing XML documents, which may provide further hints (XMLindex).
2. Generating query plans, pruning the search space, grouping similar queries, caching techniques are necessary for effective execution of user profiles on XML documents.
3. Another issue to be tackled is the evaluation of queries on only the changed portions of the updated XML files, which may provide very important performance gains. Some work has been done in this respect at the Stanford University in cooperation with University of Maryland for detecting, representing and querying changes in semi-structured data (Chawathe, Rajaraman, Garcia-Molina, Widom 1996; Chawathe, Abiteboul, Widom, 1999). XML TreeDiff package provided by IBM gives the ability to efficiently differentiate and update DOM trees (XMLtreediff).
4. The work presented in (Ozen, Kilic, Altinel & Dogac, 2001), on the other hand, seems very promising for providing scalability. In this paper, the queries are grouped and indexed such that each element in a query group corresponds to a state in the Finite State Machine (FSM). The system also contains an XML repository. When either there is a change in related XML documents or a timer based query (or a set of queries) needs to be invoked, an event based XML parser is activated that starts sending the events to the Query Execution Engine component of the system that causes the related FSMs to change their states. The Query Execution Engine is capable of capturing the intermediate results during state changes. It should be noted that all the queries that apply to a document are executed in parallel when a document is being parsed and for queries that have the same FSM representation, only one FSM is generated. The results produced are pushed to the related mobile clients. The system is demonstrated to be highly scalable with excellent performance. However there seems to be a need for further investigating executing queries only on the changed data (delta files) rather than the original data file.

V. Providing Context Sensitive (Time and Location) Services: A digital map processing system needs to be developed which will provide capabilities like positioning the user and the destination on the map and providing the shortest path to the destination by also considering the information that may effect the travel like the traffic on the roads. There are many commercial GIS products in the market such as ArcView and GeoMedia. These are very professional and powerful products with many capabilities, which are not actually needed for providing location dependent services. Therefore a map processing system need to be developed whose main functionality will be to find a path (route) in a map to the closest place of a sort, relative to the user position (i.e. finding the nearest drug store). We believe that it will be more

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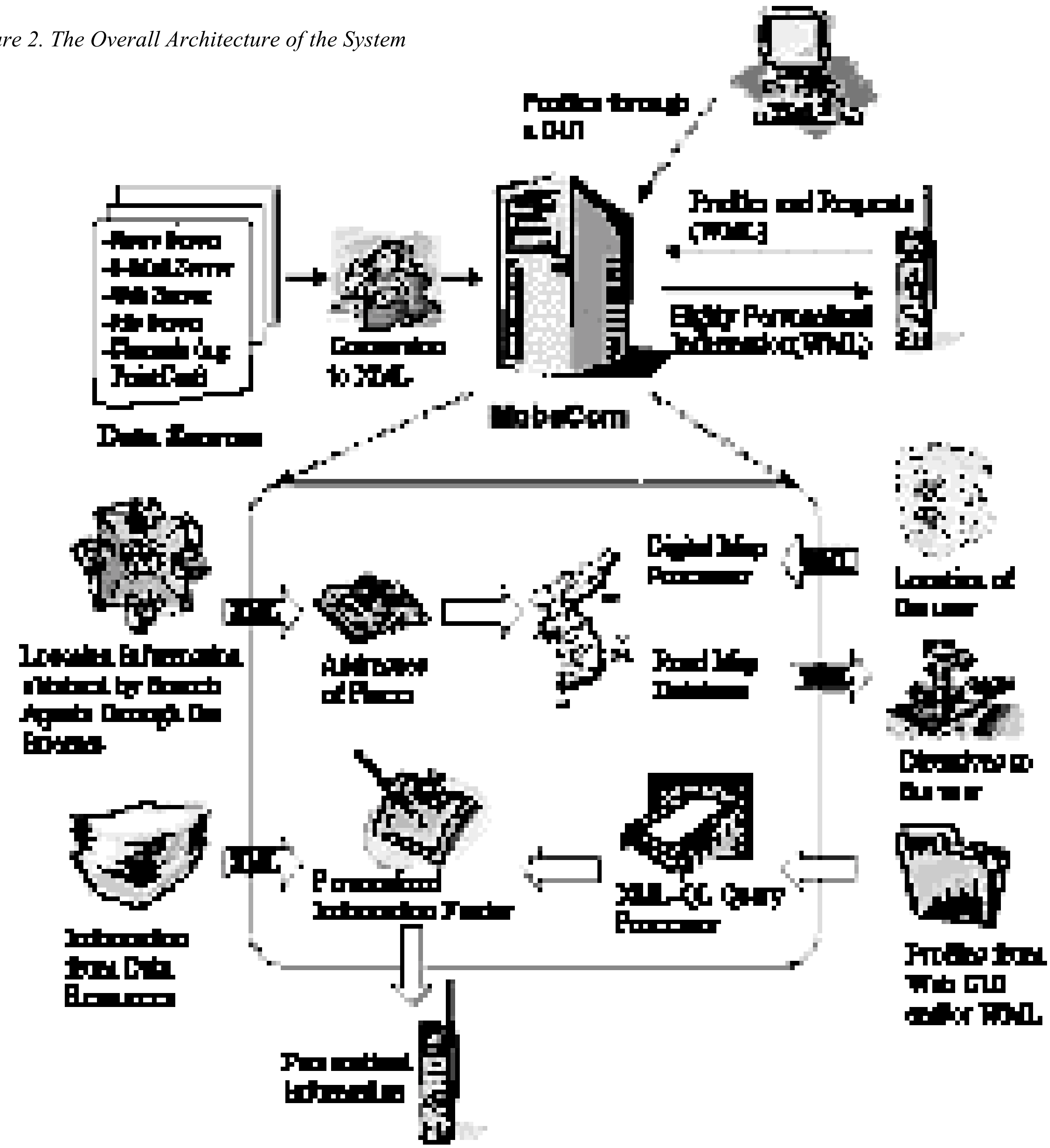
convenient to integrate this custom made Digital Map Processing System with the other modules of the system.

We plan the following digital map processing functionalities:

Describing the map of a part of a city or a whole city in relational database structures: The map of a city (or a region) will be described through relational database structures. A digital road map is basically composed of *arc*s and *node*s. The *node*s are binding and bounding points on the map, such as conjunctions or ends of roads. The *arc*s are road segments between the *node*s. This structure needs to be enhanced with relevant tables in order to store the information like traffic density, road availability, etc.

Finding the shortest path between two points on the

Figure 2. The Overall Architecture of the System



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map depending on traffic density and the availability of the roads: One of the shortest path algorithms will be used. The *node* and *arc* tables will include the necessary attributes in order to reflect the traffic information on the map. For bookkeeping the traffic information, heuristics will be used, like assigning a *foreseen* traffic density on a road for each time interval in a day.

Mapping a set of addresses obtained from the Web to a map and finding a path among these nodes that can be travelled with the least effort (i.e. shortest time). The addresses of the places will be mapped by creating virtual nodes on the digital road map. For this purpose each arc segment will have attributes representing the intervals of the numbers of the buildings they contain, i.e. the street numbers of the buildings at the beginning of an *arc* and at the end of that *arc*. The places will be located with another algorithm based on radial-out search. In this algorithm, starting with the position of the user, the map will be traced for places within an area of a growing circle. The system will try to find the closest place of a certain sort, depending on the time that will be spent to reach the destination (the average travel speed on a certain part of a street matters for finding the closest place).

An Internet search engine to gather location dependent information: An Internet search engine will be developed to gather location dependent information on services/products such as finding the service (e.g., a pizza restaurant) the user requested on the Web and locating its address on the map and thus providing the user with a destination.

The overall architecture of the system is depicted in Figure 2. The data obtained (either pulled or pushed by the resources) from the resources are converted to XML and fed into the MobeCom engine. A search engine will also be provided for data requested from unknown resources. On the other hand users specify their profiles either from their desktops or from their mobiles through the user-friendly interface to be provided. Mobile user interface will allow users to specify their location and time dependent requests and can also provide the user with the directives to the desired destination.

For location dependent requests the digital map processing component of the system will be consulted. For positioning the user on the map, a Global Positioning System (GPS) can be used if this is available in user's mobile. If not, a mechanism to locate the user on the map by obtaining the street and building number from him will be in place. The destination(s) satisfying user requests will be obtained from the Web if they are not available in the map database. A map processing system will provide the user the shortest path by also considering the information obtained online from the Web that may effect the travel like the traffic density on the roads, bus schedules, etc.

The user profiles either obtained from the user's mobile device through WML or from the user's desktop through a graphical user interface will be transformed into XML-QL queries. These queries will be executed on the XML documents representing the data coming from a variety of resources. The queries can be change based or timer based. It should be noted that the number of such queries can grow dramatically once the system is deployed over the Internet. Therefore one of the main objectives of the project will be to develop mechanisms like index structures, search algorithms, grouping of queries and caching for efficient execution of these queries.

CONCLUSIONS

Mobile access to Internet is increasing dramatically and therefore serving highly personalized information to mobile clients seems to have a huge market: According to IDC, by 2003, 62 million people will use wireless devices to connect to the Net and the Strategis Group predicts that 25 million users will want cell-phone access to the services like news and sport headlines, stock quotes, email and online shopping. Yahoo and Amazon.com currently offer content to the users of SprintPCS phones through Wireless Application Protocol (WAP). In March 2000, AOL, EarthLink, Microsoft's MSN and Oracle have announced efforts to bring stripped-down versions of their Web portals to the cell phones. In fact Oracle's Portal-to-Go service already lets users access e-mail and check quotes or flight times on the phone's screen. OracleMobile announced that the service they will provide will let the users sign up on their phone as opposed to visiting the Web on a PC first to select what content they want to see on their handset.

What we propose in this article complements these efforts by providing a highly personalized mobile electronic commerce architecture based on XML. We describe the challenges and indicate the future research directions. One big lesson about Web-based electronic commerce is already clear: success comes to those who find ways to deliver to customers orders of magnitude better services. The architecture we propose aims for providing a variety of services for mobile ecommerce and in achieving this, places utmost importance on ease of use and efficiency of the system.

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