Infrastructure support for mobile computing

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Abstract

Mobile computing is emerging as the prime focus of next generation computing .One of the prime issues of mobile computing is to provide infrastructure support in terms of computing devices, seamless mobility, application middleware, data and user security, and user applications/services. Mobile commerce is one of the driving forces that has evinced enormous interest in mobile computing .The thought of conducting commerce on the go is what is driving the huge investments corporations are making in researching this area. This paper discusses the various challenges in providing infrastructure for wireless computing.

1. Introduction

Computing today has evolved from an environment were devices were plugged into wired networks to a wireless environment with no limitations on their mobility, were users can access anything anywhere anytime. The emergence of mobile computing has brought into focus new challenges in providing computing infrastructure for mobile devices, which had been taken for granted in a wired environment. The user needs to be unaware of the activity that is being carried out in the background and promises to provide him with seamless mobility and uninterrupted service. Applications have to be provided with infrastructure and services to mask the limited availability of resources in which they are executing .The devices need to be aware of the context/location they are in to provide better information for the user and make optimal use of the resources that are available to them.

The infrastructure support is now a reality at the physical layer. Mobile devices that are capable of processing information like PDA's and Cell Phones with their own

memory and processors are available in the market. Network connectivity is being provided by Wireless LAN's, Bluetooth and cellular networks .At the same time the infrastructure in the higher layers have been slow to develop and support only a small subset of applications that can be carried out in a wired network today. Various factors can be attributed to this like device heterogeneity, device mobility, computing power, battery capacity, low bandwidth, frequent disconnection, limited storage, and small user interface. These limitations have made the implementation of various applications difficult.

This paper will try to summarize the infrastructure support required for design and implementation of various distributed applications for mobile computing and describe it in the context of infrastructure framework for Mobile E commerce.

2. Challenges

2.1 Heterogeneous network.

"In contrast to most stationary computers, which stay connected to a single network, mobile computers encounter more heterogeneous network connections in several ways."[3] When they are moving from one network to another, they may need to change protocols and select the best interface if there are several interfaces available. They need to maintain all ongoing connections without loss of information and without the knowledge of the user. This requires providing mechanisms for interface selection, switching mechanisms, smooth handoffs, and mobility support on the wired network.

2.2 Heterogeneous devices.

Devices in a wireless network are heterogeneous with different mechanisms for connectivity and wide differences in hardware and software. "Heterogeneous devices will be required to interact seamlessly, despite wide differences in hardware and software capabilities."[5] This requires an infrastructure that maintains device profiles and manages their integration into a coherent system

2.3 Mobility

Mobile computing provides the support for user mobility while connected to the network, which makes some of the user information dynamic. “For example a stationary computer can be configured statically to prefer the nearest server, but mobile computing needs a mechanism for determining the best server to use.”[3] This requires automatic mechanisms for handling the changes in location. In addition frequent changes in the network addresses and location of the device affects the way certain applications are handled .For example consider the following application that is location based. *Justin Timberlake needs to take his family to the Texas Fair. He is driving down on Interstate 35 and requires directions on his handheld device, which is GPS enabled. When he is on his way to the fair there is an accident on the route he is taking and he could be running late. This scenario requires that the device be aware of the route he is taking his current location and context to provide him with alternate directions and if he will be able to make it on time or propose a different attraction were his family can picnic for the day*.

2.4 Portability

2.4.1 Battery Power.

The race to make devices smaller, lighter, and faster has resulted in devices that are light and portable. They have become so small users can carry them in their pockets or strap them on their wrists. However this has put considerable pressure on application designers, “Batteries are the largest Single source of weight in a portable computer” [3]. The battery life of these portable devices is very low resulting in frequent recharging. This has generated the need to develop applications that conserve battery life, low uplink traffic, and power saving mechanisms.

2.4.2 Data Security

Mobile devices being portable are prone to the risk of physical damage, unauthorized access, loss of data, and theft. Having only essential data on the devices and mechanisms for maintaining the data integrity in such scenarios reduces these risks. This could be handled by having encryption mechanisms, backup data stores, and user

authentication. The backup mechanisms use file systems like coda or echo to replicate files in secure media whenever the devices are connected to the wired network although data modifications between back ups are not safeguarded.

2.5 Small user interface

The constraint on the size of the computing devices places a limitation on the size of the user interfaces. This requires that the user interfaces be small and functional. Traditional windows user interfaces used on bigger devices are not well suited for a small screen .So new interfaces that are highly functional and are adaptable over heterogeneous devices are required. In addition, mobile devices have no available means for inputting data like traditional computing devices this requires sophisticated voice recognition and hand writing recognition techniques for user input.

2.6 Limited Storage

The storage capacity on mobile devices is limited by the size and battery capacity of the device .So the devices have to operate with a limited storage available. The challenge is to reduce program size. This can be done using interpreted script languages instead of compiled object code, which are typically larger than source code [3].

2.7 Low Bandwidth

Mobile computing devices have higher constraints on the available bandwidth when compared to traditional computers. The highest observed available bandwidth for portable wireless devices is about 2Mbps in comparison to about 10Mbps that Ethernet provides .The network bandwidth can be delivered by either increasing the no of cells or by reducing the transmission power to accommodate more cells. Software compression techniques may be used to reduce traffic. Applications have to be capable of adapting to varying bandwidth availability.

2.8 Security

Connection to a wireless link does not require physical access to the network, as in traditional networks .So it is easy to compromise security, and is further complicated if users are mobile across domains since the user should be known in the domain it is moving into and requires authentication mechanisms for gaining access. It is also easy to lock on to signals to gain access to information, which can be overcome by encryption at the application layer and frequency hopping or code multiplexing at the physical layer.

2.9 Disconnections

Frequent disconnections are the greatest concern in mobile computing .The wireless connection is highly susceptible to disconnections. “Designers must decide whether to spend available resources on the network, trying to prevent disconnections, or spend them trying to enable systems to cope with the disconnections more gracefully and work around them where possible”[3]. This frequent disconnection requires that the applications reduce the communication by running applications in the mobile device itself and hiding disconnections and latency by providing smart caching mechanisms and file systems. The Coda file system is a good example of how to handle network disconnections .The profile of the user determines the best files to be stored on the users device and whole files are stored instead of the blocks so that they can be read during disconnections, and allows modifications to files even during disconnections.

3 Challenges in Mobile Commerce

The parameters that have been discussed in section 2 are the fundamental parameters that influence the development of infrastructure and middleware for Mobile commerce applications. Mobility and location dependence play an important role than other factors since the current location of the user determines the context of operation .For example a registered user in the state of Texas were there is a state sales tax on purchases currently buying a product in the state of New Hampshire were there is no sales tax. It would be beneficial to him to charge no state sales tax saving him on costs and the seller could save on shipping costs by shipping from the nearest warehouse. This kind of information plays an important role in B2B and B2C Mobile commerce. Location

management requires sophisticated mechanisms like Geographical Positioning Systems (GPS). The next two sections describe a framework for supporting Mobile commerce and a case study for mobile retailing.

4 Framework

The following frame work as proposed [1] allows developers and service providers to effectively implement mobile commerce applications." The framework defines multiple functional layers, simplifying the design and development, so different parties (vendors, service providers, and designers) can focus on individual layers"[1]. This enables an entity to focus on functionality without having to worry about the other aspects of the applications. This will speed up the development process since developers can assume certain functionality to be provided by the under lying infrastructure.

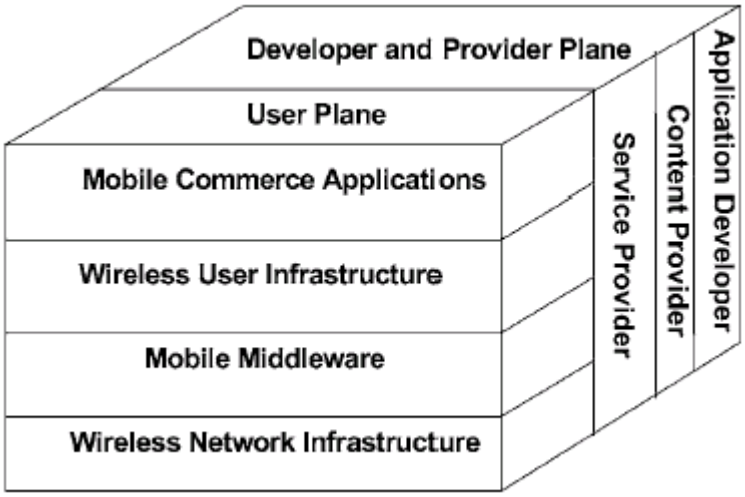

Figure 1:A framework for m-commerce.

The framework has four levels Mobile Commerce applications, user infrastructure, middleware, and network infrastructure. The framework takes into consideration the general capabilities of mobile devices without considering any device in particular, thus applications developers can obtain a level of abstraction and do not have to worry about how the underlying infrastructure has been provided and assume a certain functionality to be provided by the underlying layers. The development of an open framework enables the

development of proprietary products and services that may be built in an ad hoc fashion. The development of an open framework will enable interoperability of applications and products from different vendors. The framework also provides for a developer and provider plane that address the needs of application developers, content providers, and service providers. There can be multiple layers in this plane were an application provider may aggregate content from other developers to provide services for content providers. Similarly content providers may build their services using applications from various application developers or content providers." Service providers act as a clearing house for content and service providers in advertising and distributing their products to its customers"[1]. The Mobile commerce lifecycle and interactions between various providers is as shown below.

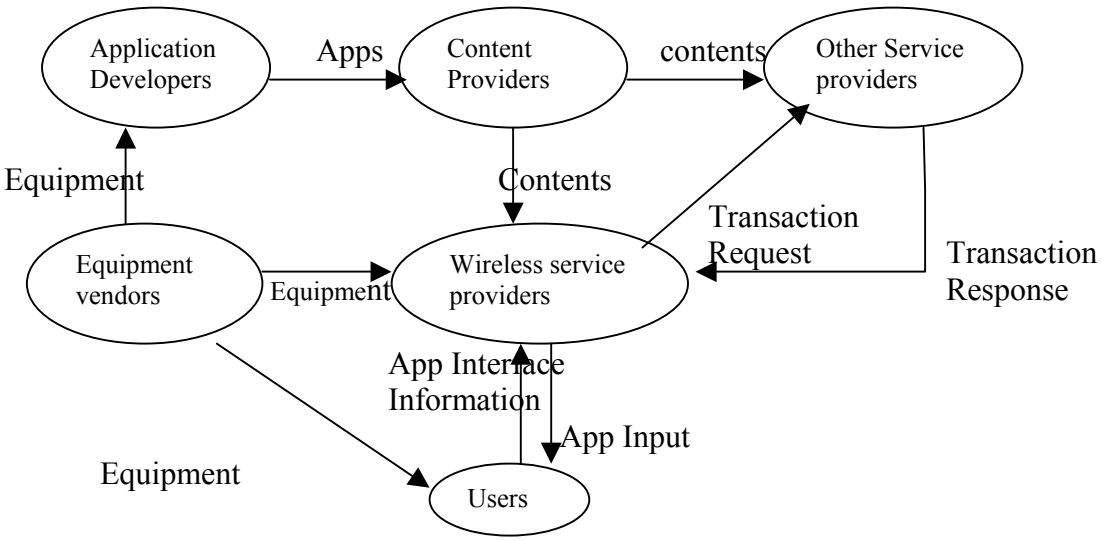

Figure 2:Mobile commerce life cycle.

5 Emerging M Commerce applications

Many M commerce applications can be conceived. This section provides a few example categories of applications and discusses their requirements. The application categories that will be discussed are mobile financial applications, and proactive service management**.**

5.1 Mobile Financial applications

There are varieties of services such as mobile banking, mobile payment solutions, money transfer, and brokerage services that can be offered to mobile clients. To provide these services requires infrastructure support like secure transaction processing, WEP, and network infrastructure .The following example [1] gives a view on how a micro payment system is implemented.

E.g.: The Micro –Payments used by SONERA, a Finnish wireless provider is a soda vending machine where the client dials a number were the charges per minute is equivalent to the machines cost of vending a soda this communication can actually use the local network instead of the cellular network saving bandwidth.

There are several factors that influence the feasibility of developing and deploying an application one of the key factors the real –cost involved in making the Micro –payment itself .It would make no sense to make a micro payment that will incur communication costs that is greater than a certain percentage of the product.

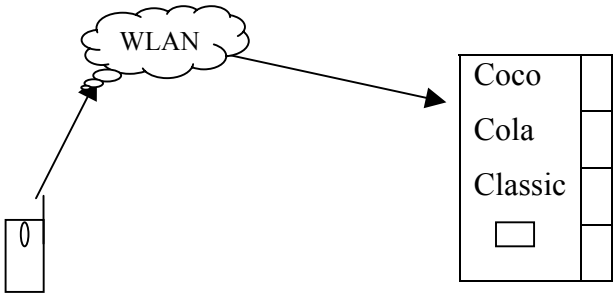

Figure: 3 E.g. Micro –Payments by SONERA

5.2 Mobile inventory management (MIM)

This category of application requires location tracking of goods services and people**.** This tracking mechanisms can help manufacturers to plan their production, determine the time goods will be delivered to customers so the next time a customer calls

he can say sir he is on his way at such a street and not just tell him he left so many minutes ago, thus improving customer satisfaction. The "rolling inventory " proposed [1] involves the location of a truck in the near vicinity of the store to deliver goods just in – time. Another application of MIM is just in time movement of components for an assembly line reducing assembly cost and inventory cost. MIM requires wireless technologies like GPS or E-911 [1]. It may also require intelligent mechanisms to take care of JIT movement and network infrastructure middleware.

The following table [1] gives a set of requirements and middleware required by a class of applications.

Class of applications	Wireless networking requirements	Comments
Mobile financial applications (B2B, B2C)	Location management Network dependability Roaming across multiple networks	Secured unicast communication required
Mobile Inventory Management (MIM)	Location Management Multicast Roaming across multiple networks	Multicast Preferred but a series of unicast may be tolerated

Table 1: Networking requirements of m-commerce applications.

6 Wireless user infrastructure and middleware

6.1 User infrastructure

To support applications that have been described in the previous section we need mobile devices that provide sufficient memory, display and communication facilities .The limitations of these user devices may influence the type of applications that may be run on them. Some of the capabilities that need to be provided for enabling m commerce transactions are

- dynamic, adaptable user interfaces
- ability to accept many forms of input like handwriting and speech recognition
- location awareness
- multiple interface capability

- security
- service discovery mechanisms

6.2 Middleware for M commerce

Mobile middleware is defined as "The enabling layer of software that is used by applications developers to connect their M-commerce applications with different networks and operating systems without introducing mobility awareness in the applications"[1]. The middleware allows support better response times and greater reliability. Some of the middleware that are available are ExpressQ from nettech (www.nettechRF.com), which provides message storage and forwarding when users are disconnected. Middleware for M commerce environments are required to provide push based information transfer to devices since many applications require periodical information to be sent to the user.

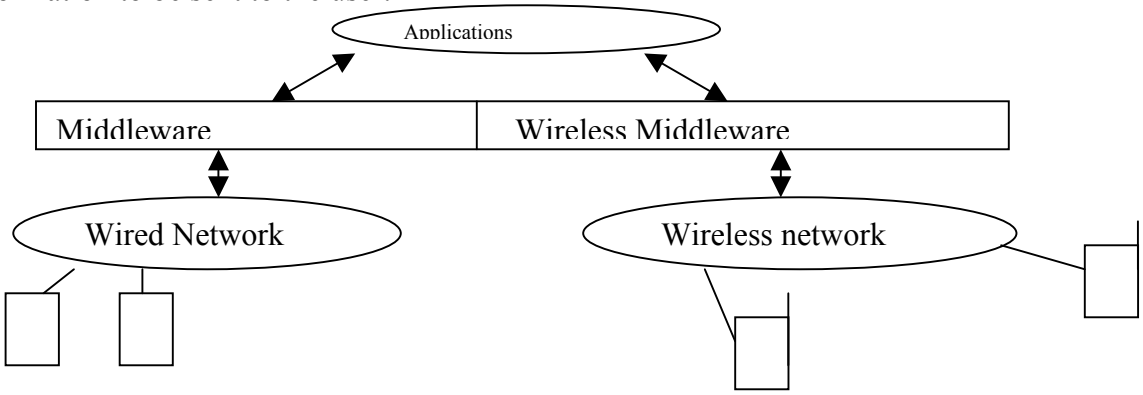

Figure 4:Mobile middleware for applications and content adaptation.

An example middleware for M commerce is the Gold Rush: Mobile Transaction Middleware with Java-Object Replication. The mobile middleware provides support for a wire-efficient access protocol, object caching and replication, logging of deferred transactions, and server-side object server to reduce the frequency and duration of slow-link connections [6].

6.3 Wireless networking infrastructure

In addition to mobile devices middleware, networking support from wireless networks is crucial there are five general networking requirements. The following table summarizes the wireless infrastructure requirements for M commerce applications [1].

Networking requirements	Specific attributes
Location management	1. Location tracking for determining the location of an object 2. Location accuracy and response time 3. Frequency of location tracking 4 Horizontal and vertical location tracking
Multicast support	1. Support for multicast in infrastructure wireless networks 2. Support for multicast in ad hoc wireless networks (much more difficult due to dynamic topology and other factors) 3. Group connectivity under mobility/failure 4. Synchronization/atomicity of transactions from multiple users
Network dependability	1.Impact and frequency of component failure 2. Fault-tolerant design 3. User access to multiple networks 4. Levels of network availability
Quality-of-Service	1. Bandwidth requirements 2. Delay and delay variation 3. Tolerable loss characteristics
Roaming across multiple networks	1.Handoff among multiple wireless networks 2. Keeping track of users across networks

Table 2:Wireless infrastructure requirements for m-commerce

7 Conclusions

Mobile computing presents various challenges to researchers in computer science and other fields of engineering. Many issues that have been discussed in this paper present some good research topics. Mobile commerce is an emerging area of mobile computing and has some inherent differences from traditional E-commerce. This requires adaptations and modifications to existing E-commerce framework to work in a wireless environment. This paper summarizes the various issues in providing infrastructure for wireless networks in general and Infrastructure for M commerce applications in particular that is currently being researched or is yet to be addressed.

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