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# Challenging Issues and Limitations of Mobile Computing

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**Abstract:** Mobile computing is becoming increasingly important due to the rise in the number of portable computers and the desire to have continuous network connectivity to the Internet irrespective of the physical location of the node. Mobile computing has fast become an important new paradigm in today's world of networked computing systems. Ranging from wireless laptops to cellular phones and WiFi/Bluetooth-enabled PDA's to wireless sensor networks, mobile computing has become ubiquitous in its impact on the people daily lives. The goal of this paper is to point out some of the limitations, constraints, mobility, challenges and applications of mobile computing.

**Keywords:** constraints, mobility, challenges, applications, limitations

## 1. Introduction

**M**obile Computing [1]: A technology that allows transmission of data, via a computer, without having to be connected to a fixed physical link. The term "Mobile computing" is used to describe the use of computing devices, which usually interact in some fashion with a central information system--while away from the normal, fixed workplace. Mobile computing technology enables the mobile worker to create, access, process, store and communicate information without being constrained to a single location. By extending the reach of an organization's fixed information system, mobile computing enables interaction with organizational personnel that were previously disconnected.

The combination of wireless communication infrastructure and portable computing devices has laid the foundation for a new network computing paradigm, called mobile computing, which allows the users access information and collaborate with others while on the move [2]. Wireless mobile networks are typically characterized by severe constraints on resources, such as bandwidth and battery power, and by rapid fluctuations in availability of these resources; this makes it difficult for the system software to provide guaranteed quality-of-service at levels required by many distributed and collaborative applications. Also, due to mobility of the clients or the users, users may be disconnected from the network often and the users may also voluntarily switch off to save battery power; thus, management of this disconnection is a critical issue in designing mobile networks. Further, user mobility adds a new dimension to be distributed operating systems which has implications for specification, design, verification and implementation of both system and application software [3]. A challenging issue is to determine the interface and the guarantees that the system software must provide to the developers of both location-independent and location-dependent applications on mobile networks [4]. This has resulted in research on adaptive applications and system software which can gracefully respond to changes in operating conditions [5].

There are several articles which have identified the fundamental challenges in mobile computing. Mobile systems are (i) resource poor (ii) less secure (iii) have poor connectivity to the wired infrastructure and (iv) have less energy since they are powered by battery. In order to deal with these characteristics the mobile systems should employ dynamic adaptation schemes. One of the implications is that the solutions developed for mobile systems should be interoperable since as mobile clients move one domain to another they should be able to operate in the new domain. The mission of mobile computing is to allow users to access any information using any device over any network at anytime.

In general, a mobile-computing network may be characterized as follows. It consists of multiple mobile agents that require access to (i) information generated at multiple geographically dispersed sites and (ii) computing engines to execute their decisions. It may be include one or more stationary agents that perform information acquisition and propagation to the mobile agents. While a static interconnection network may link the stationary agents, a dynamic interconnection network will connect the mobile agents to the stationary nodes. The mobile nodes may connect to specific nodes asynchronously, i.e., at irregular intervals of time, to acquire information, and following completion they will disconnect. The use of the term connection in this context refers to the transport layer in the ISO-OSI terminology. The underlying physical layer, however, is at liberty to utilize either wired or wireless transmission. The mobile and stationary agents are located at geographically dispersed sites. While both stationary and mobile nodes may have computing and communication needs, the relative weights and frequency are problem-specific. In addition, the system must be designed to accommodate evolutionary growth. That is, the system must continue to function and deliver relatively undiminished performance as the cumulative number of stationary and mobile entities increases with time.

**2. Constraints of Mobility**

Mobile computing is characterized by four constraints:

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- Mobile elements are resource-poor relative to static elements.
  For a given cost and level of technology considerations of weight, power, size and ergonomics will exact a penalty in computational resources such as processor speed, memory size, and disk capacity. While mobile elements will improve in absolute ability, they will always be resource-poor relative to static elements.

- Mobility is inherently hazardous.
  A Wall Street stockbroker is more likely to be mugged on the streets of Manhattan and have his laptop stolen than to have his workstation in a locked office be physically subverted. In addition to security concerns, portable computers are more vulnerable to loss or damage.

- Mobile connectivity is highly variable in performance and reliability.
  Some buildings may offer reliable, high-bandwidth wireless

connectivity while others may only offer low-bandwidth connectivity. Outdoors, a mobile client may have to rely on a low-bandwidth wireless network with gaps in coverage.

- Mobile elements rely on a finite energy source.
  While battery technology will undoubtedly improve over time, the need to be sensitive to power consumption will not diminish. Concern for power consumption must span many levels of hardware and software to be fully effective.

## 3. Mobility

The volatility of some information is increased with the ability to change locations while connected to the network. Certain data that may have been considered static for stationary computing now becomes dynamic for mobile computing.
As mobile computers change location, they will use different network access points, or 'addresses'. To communicate with a mobile computer, its latest address must be known. Several techniques may be used to determine the current network address of a mobile unit.

- *Selective Broadcast:* If a mobile computer is known to be in a set of cells, then a message could be 'broadcasted' to these known cells asking the required mobile unit to reply with its current network address.
- *Central Services:* A logically centralised database contains the current addresses of all mobile units. Whenever a mobile computer changes its address, it sends a message to update the database.
- *Home Bases:* This is essentially the limiting case of distributing a central service, i.e. only a single server knows the current location of a mobile computer.
- *Forwarding Pointers:* This method places a copy of the new address at the old location. Each message is forwarded along the chain of pointers leading to the mobile computer. This requires an active entity at the old address to receive and forward messages.

Traditional computers do not move, hence location dependent information such as the local name server, available printers etc. can be configured statically. A mechanism is needed for mobile computers to obtain configuration data appropriate to the present location. There may be a need to obtain information on other mobile devices, and this may cause a breach of security. Privacy will need to be maintained in some cases where location information of a user maybe misused.

## 4. Challenges of Mobile Computing

The need for mobile computing leads to design challenges in several areas.

*4.1 Disconnection*

Today's computer systems often depend heavily on a network and may cease to function during network failures. For example, distributed file systems may lock up waiting for other servers, and applications process may fail altogether if the network stays down too long. Network failure is a greater concern in mobile computing than in traditional computing because wireless communication is so susceptible to disconnection. Designers must decide whether to spend available resources on the network, trying to prevent disconnections, or to spend them trying to enable systems to cope with disconnections more gracefully and work around them where possible. The more autonomous a mobile computer, the better it can tolerate network disconnection. For example, certain applications can reduce communication by running entirely locally on the mobile unit rather than by splitting the application and the user interface across the network. In environments with frequent disconnections, it is better for a mobile device to operate as a stand-alone computer than as a portable terminal.

In some cases, both round-trip latency and short disconnections can be hidden by asynchronous operation. The X11 Window system uses this technique to achieve good performance. With the synchronous remote procedure call paradigm, the client waits for a reply after each request; in asynchronous operation, a client sends multiple requests before asking for acknowledgement. Similarly, prefetching and delayed write-back also decouple the act of communication from the actual time a program consumes or produces data, allowing it to proceed during network disconnections. These techniques, therefore, have the potential to mask some network failures. The coda file system provides a good example of how to handle network disconnections, although it is designed for today's notebook computers in which disconnections may be less frequent, more predictable, and longer lasting than in mobile computing. Information from the user's profile helps in keeping the best selection of files in an on-board cache. It is important to cache whole files rather than blocks of files so that entire files can be read during a disconnection. When the network reconnects, Coda attempts to reconcile the cache with the replicated master repository. With Coda, files can be modified even during disconnections. More conservative file systems disallow this to prevent multiple users from making inconsistent changes. Of course, not all network disconnections can be masked. In these cases, good user interfaces can help by providing feedback about which operations are unavailable because of network disconnections.

*4.2 Low Bandwidth*

Network bandwidth is divided among the users sharing a cell. The deliverable bandwidth per user, therefore, is an important measure of network capacity in addition to the raw transmission bandwidth. Improving network capacity means installing more wireless cells to service a user population.

There are two ways to do this: overlap cells on different wavelengths, or reduce transmission ranges so that more cells fit in a given area [6].

The scalability of the first technique is limited because the electromagnetic spectrum available for public consumption is scarce. This technique is more flexible, however, because it allows software to allocate bandwidth among users. The second technique is generally preferred. It is arguably simpler, reduces power requirements, and may decrease signal corruption because there are fewer objects in the environment to interact with. Also, it involves a hardware trade off between bandwidth and coverage area: Transceivers covering less area can achieve higher bandwidths. Certain software techniques can also help cope with the low bandwidth of wireless links. Modems typically use compression to increase their effective bandwidth, sometimes almost doubling throughput. Because bulk operations are usually more efficient than many short transfers, buffering can improve bandwidth usage by making large requests out of many short ones. Buffering in conjunction with compression can further improve throughput because larger blocks compress better.

When available bandwidth does not satisfy the demand, processes the user is waiting for should be given priority. Backups should be performed only with "leftover" bandwidth. Mail can be trickle fed onto the mobile computer slowly before the user is notified. Although these techniques do not increase effective bandwidth, they improve user satisfaction just the same.

*4.3 High bandwidth variability*

Mobile computing designs also contend with much greater variation in network bandwidth than do traditional designs. Bandwidth can shift one to four orders of magnitude, depending on whether the system is plugged in or using wireless access. An application can approach this variability in one of three ways: it can assume high-bandwidth connections and operate only while plugged in, it can assume low bandwidth connections and not take advantage of higher bandwidth when it is available, or it can adapt to currently available resources, providing the user with a variable level of detail or quality. For example, a video-conferencing application could display only the current speaker or all the participants, depending on the available bandwidth. Different choices make senses for different applications.

*4.4 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. First, as they leave the range of one network transceiver and switch to another, they may also need to change transmission speeds and protocols. Second, in some situations a mobile computer may have access to several network connections at once, for example, where adjacent cells overlap or where it can be plugged in for concurrent wired access. Also, mobile computers may need to switch interfaces, for example, when going between indoors and outdoors. Infrared interfaces cannot be used outside because sunlight drowns out the signal. Even with radio frequency transmission, the interface may still need to change access protocols for different networks, for example, when switching from cellular coverage in the country. This heterogeneity makes mobile networking more complex than traditional networking [7].

*4.5. Security risks*

Precisely because connection to a wireless link is so easy, the security of wireless communication can be compromised much more easily than that of wired communication, especially if transmission extends over a large area. This increases pressure on mobile computing software designers to include security measures. Security is further complicated if users are allowed to cross security domains. For example, a hospital may allow patients with mobile computers to use nearby printers but prohibit access to distant printers and resources designated for hospital personnel only [8]. Secure communication over insecure channels is accomplished by encryption, which can be done in software. Security depends on a secret encryption key known only to the authorized parties. Managing these keys securely is difficult, but it can be automated by software.

**5. Limitations of Mobile Computing**

**1. Insufficient Bandwidth**: Mobile Internet access is generally slower than direct cable connections, using technologies such as GPRS and EDGE, and more recently 3G networks. These networks are usually available within range of commercial cell phone towers. Higher speed wireless LANs are inexpensive but have very limited range.

**2. Security Standards**: When working mobile, one is dependent on public networks, requiring careful use of Virtual Private Network (VPN). Security is a major concern while concerning the mobile computing standards on the fleet. One can easily attack the VPN through a huge number of networks interconnected through the line.

**3. Power consumption**: When a power outlet or portable generator is not available, mobile computers must rely entirely on battery power. Combined with the compact size of many mobile devices, this often means unusually expensive batteries must be used to obtain the necessary battery life.

Mobile computing should also look into Greener IT [9], in such a way that it saves the power or increases the battery life.

**4. Transmission interferences**: Weather, terrain, and the range from the nearest signal point can all interfere with signal reception. Reception in tunnels, some buildings, and rural areas is often poor.

**5. Potential health hazards**: People who use mobile devices while driving are often distracted from driving are thus assumed more likely to be involved in traffic accidents. Cell phones may interfere with sensitive medical devices. There are allegations that cell phone signals may cause health problems.

**6. Human interface with device**: Screens and keyboards tend to be small, which may make them hard to use. Alternate input methods such as speech or handwriting recognition require training.

## 6. Applications of Mobile Computing

Mobile working infrastructure can deliver real time business benefits, companies of all sizes are walking up to the fact that they can improve productivity and increase profits by giving employees remote access to mission critical corporate IT system. The importance of Mobile Computers [10] has been highlighted in many fields of which a few are described below:

1. ***For Estate Agents:***
Estate agents can work either at home or out in the field. With mobile computers they can be more productive. They can obtain current real estate information by accessing multiple listing services, which they can do from home, office or car when out with clients. They can provide clients with immediate feedback regarding specific homes or neighborhoods, and with faster loan approvals, since applications can be submitted on the spot. Therefore, mobile computers allow them to devote more time to clients.

2. ***Emergency Services***:
Ability to receive information on the move is vital where the emergency services are involved. Information regarding the address, type and other details of an incident can be dispatched quickly, via a Cellular Digital Packet Data (CDPD) system using mobile computers, to one or several appropriate mobile units, which are in the vicinity of the incident.

3. ***In courts***:
Defense counsels can take mobile computers in court. When the opposing counsel references a case which they are not familiar, they can use the computer to get direct, real-time access to on-line legal database services, where they can gather information on the case and related precedents. Therefore mobile computers allow immediate access to a wealth of information, making people better informed and prepared.

4. ***In companies***:
Managers can use mobile computers in, say, critical presentations to major customers. They can access the latest market share information. At a small recess, they can revise the presentation to take advantage of this information. They can communicate with the office about possible new offers and call meetings for discussing responds to the new proposals. Therefore, mobile computers can leverage competitive advantages.

5. ***Credit Card Verification***:
At Point of Sale (POS) terminals in shops and supermarkets, when customers use credit cards for transactions, the intercommunication is required between the bank central computer and the POS terminal, in order to effect verification of the card usage, can take place quickly and securely over cellular channels using a mobile computer unit. This can speed up the transaction process and relieve congestion at the POS terminals.

## 7. Conclusion

Mobile computing offers significant benefits for organizations that choose to integrate the technology into their fixed organizational information system. Mobile computing is made possible by portable computer hardware, software, and communications systems that interact with a non-mobile organizational information system while away from the normal, fixed workplace. Mobile computing is a versatile and potentially strategic technology that improves information

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