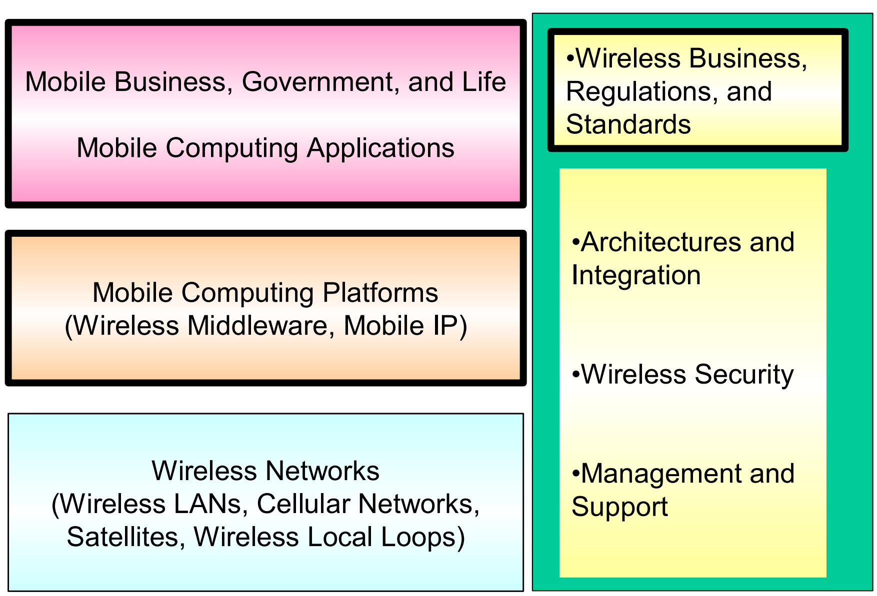
PART I

Mobile Computing Applications and Platforms

This part paints the big picture by introducing the main concepts and technologies based on a systematic framework shown below. The chapters of this part focus on mobile business, the applications that support mobile business, the underlying mobile computing platforms, and the regulatory/standards bodies (boxes with dark borders in the framework shown below).



1 Overview and the Big Picture

Wireless in Action – A Few Snippets

We are surrounded by numerous examples of mobile computing and wireless communications in our personal and professional lives. This exposure is increasing steadily. Here are a few, almost random, snippets (some of these will be explained later):

- Mobile phone penetration is growing rapidly, particularly in underdeveloped countries. Globally, the number of mobile phones surpassed the number of fixed/wired phones in 2003. This is also the case in many individual nations, including 49 middle-income and 36 low-income countries. Among these countries are Chad, Honduras, Indonesia, Jordan, Mexico, Mongolia, Nigeria, Philippines, Saudi Arabia, and South Africa.
- The US Federal Aviation Administration (FAA) has an email notification service that enables travelers with pagers, cell phones or Internet-enabled personal digital assistants to receive real-time airport status information via email. After the September 11 attack and the anthrax problems, each member of the House of Representatives was issued a BlackBerry device (a handheld device used for short message services) to facilitate communications between members.
- Doctors are increasingly using mobile devices in their practice. The physicians at the Children's Hospital of Wisconsin, for example, make their rounds accompanied by wireless carts that have wireless-enabled laptops for accessing drug suppliers and the Internet. This allows the physician to order new drugs quickly and also to use the Internet for instant research, if needed. These wireless carts have proved extremely helpful in recovery rooms where post-surgery patients need constant care and appropriate pain medications are needed immediately. The wireless carts have played a vital role in effective treatment of patients and helping the hospital to operate far more efficiently.
- The FCC has mandated that all cellular providers offer accurate location information for the users of E911 locations. The basic requirement is that the cellular providers should be able to locate the callers of the 911 emergency phone number with an accuracy of 100 to 300 meters. E911 support is one of the biggest drivers for location-based services (LBSs). LBS is an active area of work where you can, for example, locate a repair shop closest to where your car broke down, locate your children, and find the nearest bus stop. As another example, when driving by a grocery store, you could be reminded that you need to pick up eggs.
- Telecom carriers are increasingly using wireless technologies to address the "last mile" problem. This is especially popular in developing countries. For example, inhabitants of remote villages in India have been connected to the Internet through Wireless Local Loops (WLLs). The WLLs, based on fixed wireless technology, connect subscriber sites (homes, offices) to a local carrier office through microwaves. WLLs are an attractive alternative to wired networks in the last mile, where the subscribers are far-flung and cannot be connected through wires due to terrain or hazardous situations.
- Deep space communications, involving satellite communications beyond the earth orbit

(more than 11 million miles), is an active area of work for very long haul wireless networks. An example is the mission to Mars. A critical part of this mission is the communication system that allows the Mars rovers to receive commands from ground-based operators and to send its images and scientific data home by using wireless communications (it is somewhat difficult to connect Mars to the Earth through cables!).

- Coffee shops are providing wireless LAN capabilities. Starbucks, along with its partners Compaq and MobileStar, is offering wireless LAN capabilities to customers. Customers use their own laptops or PDAs, but are able to use the Starbucks wireless LAN access point to gain access to the Internet.
- Wireless "Hotspots" are being set up in hotel lounges and airport waiting areas. Airline carriers are providing wireless LAN capabilities in their lounges and at the gates. For example, using the MobileStar service in several airports in the United States, American Airlines was one of the first companies to roll out wireless LAN service to gates and Admirals Club lounges. At present, many such wireless hotspots exist in major airports and also major hotels.
- Wireless homes are a major area of potential growth. We are already used to numerous wireless devices in home settings, such as remote controls for TVs that allow you to change TV channels and control the videocassettes remotely, garage door openers that open garage doors by using a short-distance wireless network, and remote controlled and interactive toys that use wireless networks to control the movements of toy cars and airplanes. Now your cell phone can connect to your alarm clock to wake you up at certain times based on certain situations. Then you can have conversations with your alarm clock: "Hello, alarm clock? Wake me up at 5:30 am unless there is a traffic problem on the way to the airport, then wake me up at 5 a.m."
- Automotive manufacturers are building "mobile offices" in cars, where a laptop is fitted in the backseat with a mobile phone, wireless Internet and fax support. Additional telematics services provide drivers with emergency services (such as automatic collision notification, emergency response, and roadside assistance). They also provide navigation and information services, such as routing assistance, traffic, weather, news, financial information, and sports information.
- Wireless content delivery systems that broadcast TV, radio, educational, military, and other content over satellites have proliferated dramatically. For example, even cable TV gets its content from the content providers over satellites. PBS (Public Broadcasting System), for example, was one of the first TV networks to broadcast its contents over an extensive satellite system, and BBC was one of the first companies to broadcast radio services around the globe through wireless communications. The situation has changed considerably.
- The new breed of cellular phones and handheld devices includes features that could bring about totally new applications. We are all used to the mobile devices that can conveniently connect us to our corporate network or send/receive email while waiting in the doctor's office or having the car serviced, or even on a hiking trip. The new phones include digital cameras, capabilities to play audio/video clips, and the microbrowsers for surfing the net and accessing remote applications through a cellular network.
- Some companies, such as Inner Wireless, provide "passive cell tower" technologies to the commercial real estate industry. Commercial real estate property owners can gain revenue by placing wireless technologies that boost cellular carriers' signals inside a building. Cellular signals just one foot inside a building are often 100 times less powerful than those just one foot outside the building, with a corresponding effect on the service quality provided to the end user. The technology has proven successful in office spaces, in the parking garages and elevators of said properties.

1.1 Introduction

Guglielmo Marconi invented the wireless telegraph in 1896. By encoding alphanumeric characters in analog signals, he sent telegraphic signals across the Atlantic Ocean. This led to a great many developments in wireless communication networks that support radio, television, mobile telephone, and satellite systems that have changed our lives. The wireless networks themselves have improved tremendously with notable advances in cellular networks, satellite communications, and wireless local area networks. More recently, many mobile computing applications (computing applications that run partially or completely on mobile devices) have emerged that fully exploit the capabilities of wireless networks and mobile devices. The end result is numerous developments with far-reaching impact on business, education, entertainment, and daily lifestyles. Some of the examples were highlighted in the opening vignette, "Wireless in Action – A Few Snippets."

Mobile computing and wireless communications have created several opportunities because of the appeal of wireless communications – typified by the overused slogan of "communications anytime and anywhere." However, these developments have also raised several technical and business issues and have introduced a tremendous amount of jargon and new terms (see Figure 1-1). The purpose of this book is to explain the technical as well as business aspects of the field that span applications, networks, platforms, architectures, security, and management issues. In particular, the following questions drive the discussion in this book:

- What are the strengths and weaknesses of wireless and how they are driving and hindering the adoption of wireless?
- What are the basic building blocks of mobile computing and wireless systems and how do they interrelate to each other? Is there a framework that ties all these building blocks together?
- What are the initiatives such as mobile business, mobile government, and mobile life and why they are important?
- What are mobile computing applications and how do they support the initiatives such as mobile business, mobile government, and mobile life? Specifically, what roles are the mobile messaging systems (e.g., SMS), mobile commerce, location-based services, mobile portals, mobile customer relationship management, and mobile supply chain management systems playing to support m-business, m-government, and mobile life?
- What are mobile computing platforms, what do they consist of, and how do they support the mobile computing applications? Additionally, what do the technologies such as wireless middleware, wireless gateways and Mobile IP do?
- What are the different types of wireless networks available at present and how can they be classified and categorized? What are the core principles that underlie the wireless networks and how are these principles used in modern wireless networks that include Wi-Fi, Bluetooth, wireless sensor networks, UWB (Ultra Wideband), cellular networks ranging from 1G to 5G, wireless local loops, FSO (Free Space Optics), satellites communications, and deep space networks?
- What are the architectural, security, and management/support issues in building, deploying and managing wireless systems in modern settings? Specifically, how can integrated architectures be built that provide seamless services to the end-users on top of hybrid wireless-wired systems; how can effective wireless security solutions be

developed on top of relatively weakly secure wireless components; and how can a wireless project be planned, organized, developed, deployed, and monitored for succsess?

- What are the relevant regulatory and standards bodies and what role are they playing in this dynamic field? Specifically, what roles do FCC, ITU, ETSI, IEEE 802, IETF, and OMA play?
- What are the different types of businesses in the wireless landscape and what are they doing? Specifically, what roles do the network element providers, wireless telephone network operators, wireless software/hardware developers, wireless application service providers, and wireless engineering/consulting firms play?

This chapter gives a high-level answer to these questions and presents a broad overview of the subject matter. It presents a framework for discussion (Section 1.3) that exposes the main building blocks and their interrelationships. Later chapters of this book systematically follow this framework and present more details about the building blocks. Numerous examples and short case studies are presented to illustrate the key points.

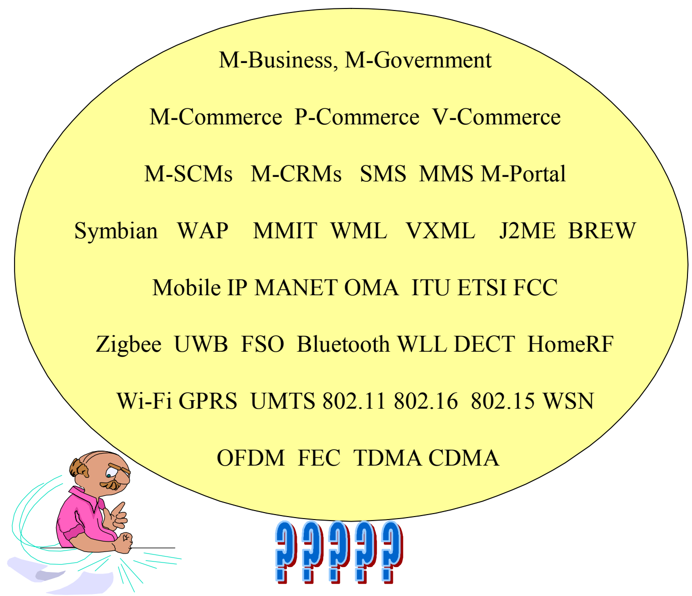


Figure 1-1: The Mobile Computing and Wireless Jungle

Before proceeding, let us clarify the difference between mobile computing and wireless communication networks. As shown in Table 1-1, mobile computing devices may or may not be connected to wireless networks. For example, you can have desktop computers – typically stationary devices – interconnected through a wireless network in an office building that is not wired for networking. This may happen in older buildings or houses being used for offices. In these situations, it is quicker to set up a wireless LAN than to wait for the facility to be wired. Similarly, you can have a mobile computer connected to a wired network. This is quite typical nowadays. For example, I am currently writing this chapter on a laptop (mobile device) that uses a wired telephone network for remote communications. I take my laptop with me when I am travelling on business (sometimes on vacation too!) and connect it to wired networks through a telephone line wherever I am (in a hotel, in a conference room, etc.). Naturally, however, many interesting situations represent mobile devices interconnected through wireless networks – the main focus of this book. We can add other dimensions to this discussion (see Chapter 2).

Table 1-1: Combinations of Mobile Computing Devices and Wireless Networks

Mobile Devices	Wireless Networks	Sample Applications
No	No	Stationary workstations in office
No	Yes	Wireless LANs to connect office workers in an unwired building ("Fixed Wireless Networks")
Yes	No	Using a portable computer in a hotel or conference room
Yes	Yes	Cellular phones, Palm Pilots, Laptops with wireless Ethernet cards, etc.

Chapter Highlights

- Mobile computing and wireless systems can be discussed in terms of:
  - Wireless networks that transport the messages
  - Middleware that hides the networking issues
  - Applications that are used to support mobile users
- Many mobile computing applications have been developed and are being developed at present. Examples include:
  - Mobile business (m-business) applications such as mobile commerce, mobile portals, and mobile supply chain management systems.
  - Mobile government applications that provide wireless access to health, education, transportation, and welfare services.
  - Mobile life applications such as multi-media message services between friends, and movie, restaurant, and route finders on mobile devices.
- Mobile computing applications need middleware that smooths over the mobile computing issues, as much as possible, so that the same applications can run on wired as well as wireless networks. WAP (Wireless Application Protocol) is an example of wireless middleware.
- Wireless networks transmit/receive the information over the air by using different signal encoding, modulation, and error detection/correction schemes. Cellular networks, wireless Ethernet, and satellite communication systems are examples of wireless networks.
- Wireless systems need to be designed carefully at several levels covering network, platform, and application architectures.
- Wireless security is a major concern and is considered to be a deterrent to mission-critical wireless applications.
- Many management issues and business opportunities exist in different aspects of wireless.
- Numerous regulatory (e.g., FCC) and standards bodies (e.g., IEEE 802) are playing an important role in mobile computing and wireless networks.
- Wireless systems have ushered in many business opportunities for wireless network operations, network element providers, wireless application service providers, mobile computing hardware/software developers, and consulting/engineering firms.

The Agenda
• Overview, Strengths/Weaknesses and Framework
• Mobile Applications, Platforms, and Networks
• Architectures, Standards, Business and Examples

1.2 Strengths and Weaknesses of Wireless

1.2.1 Strengths and Drivers

Mobile computing and wireless communication networks are playing an increasingly important role in our professional and personal lives. For example, large numbers of subscribers to mobile telephones (more than a billion in 2004) use mobile devices on a daily basis for personal and business communications. In addition, Wireless Ethernet (also known as Wi-Fi, abbreviation of Wireless Fidelity) LANs are being rapidly deployed in offices, homes, shopping malls, "hotspots," and apartment buildings. The result is a very large number of business, government, military, educational, and social applications. The strengths of wireless systems that are driving their growth are:

- **Social and cultural factors**. Wireless systems conform to our inherently mobile lifestyles. In our personal and business lives, our employees, partners, customers, relatives and friends are always moving around. Wireless systems fit well in this increasingly mobile environment with the need for information/transactions anytime and anywhere.
- **Advances in wireless networks**. A particular appeal of wireless systems, in addition to their flexibility, is the steady increase in wireless data rates. Higher data rates are achievable with broadband wireless technology for applications such as graphics, video, and audio. Broadband wireless networks give higher data rates that compete with wired networks, plus they enjoy convenience and reduced cost. For example, 802.11g wireless LANs yield data rates in the range of 50 Mbps (million bits per second) that compete with similar wired data rates. But broadband wireless services can be deployed faster than wired services with no cost of cable plants. In addition, service is mobile, and can be deployed almost anywhere.
- **Niche applications**. In some cases, wireless is the *only* option. For example, wired communications over very long distances (between the US and Australia, for example) are virtually impossible, and wireless is the only choice for space explorations. In addition, many law enforcement and battlefield applications can only work with wireless communications. For example, it is difficult to lay cables in a battlefield, or to carry a wired device when chasing a criminal.
- **Special situations**. Wireless communications make more sense in several situations. For example, satellite communication is a good choice to connect far-flung and hard-to-reach areas. In addition, it may be difficult to lay cables in hostile environments. In the war-torn country of Angola, for example, it was hazardous for the workers to lay cables along roads between major cities; so wireless links were used instead. As another example, consider the following quote:

Telkom (South Africa) also prefers (wireless) technology in high-theft areas such as the corridor between Soweto and the Central Business District of Pretoria. In this area, copper cables are stolen before Telkom has time to turn on the lines. (Source: N. Baker, “Telkom South Africa: Case Study in WLL Deployment,” *Pyramid Research Report*, www.itu.int/ITU-D/fg7/case_library/ documents/pyr001.doc)

- **Wireless for older buildings**. In many cases, wireless is chosen because the buildings are too old for installing cables. The University of Texas at El Paso, for example, deployed wireless networks at several campus locations because it was difficult to wire historical buildings and remote locations.
- **Developments in mobile devices.** The new breed of wireless handsets have many attractive features such as digital cameras, and pictures. The availability of new mobile devices such as powerful laptop computers, PDAs, and cellular telephones with Internet and wireless data access capabilities is also driving the growth.
- **Increased revenue and productivity possibilities**. The revenue opportunities created via location-based services and m-commerce have lured several companies and investors into this area. In addition, the productivity improvements to be gained via wireless extensions to enterprise applications and processes are tremendous. For example, mobile customer relationship management systems can capture customer information in real time and allow marketing reps to be more productive.
- **Industrial and regulatory factors.** The convergence of telecommunications and software industries coincides with the adoption of wireless standards such as WAP and Bluetooth, along with the cultural and regulatory drivers in various countries.

1.2.2 Weaknesses and Issues

Wireless is convenient and less expensive but some business, political and technical difficulties inhibit wireless technologies. A major limitation is security of wireless systems because wireless communications are technically easier to eavesdrop and intrude. There are also some additional limitations. These include lack of industry-wide standards, data rate limitations as compared to wired networks (despite progress), and device limitations. For example, small LCDs on mobile telephones can only display a few lines of text, and browsers of most mobile wireless devices use specialized languages such as wireless markup language (WML) instead of HTML, making application development harder. These weaknesses can be discussed in terms of social, business, and technology issues.

1.2.2.1 Social Issues

Wireless systems, despite their popularity, have raised some social issues. Privacy and security are among the top. Consider, for example, the privacy issue raised by location-based services (LBSs). Wireless networks have to keep track of the user location to direct the messages to the users as they move around. For example, cellular networks keep a Visitor Location Register (VLR) – a database – that records the location of a user as she moves from one cell to another. Suppose you take a train from Philadelphia to New York and turn on your cellular phone when you get on the train. Then the VLR will indicate that now you are in Philadelphia. As the train travels through “scenic” New Jersey, you will change several cells along the way (each cell is between 10 to 15 miles) and the VLR will be updated accordingly. Thus the VLR log will show when you were in Philadelphia and what path you took on your way to New York. This information traces your movement and could be considered private, but the cellular providers can sell or give this information to others – a potential privacy issue.

The general concern about wireless security is that wireless networks are easier to tap into. Within this broad area, users are concerned with several privacy and security issues. For example, the call setup information that includes the user ID and other information should be protected, and the speech and data transmitted during a wireless session should be kept private and confidential.

Some possible health issues have been raised due to the increased use of cellular phones and other wireless equipment. In particular, some media attention has focused on a possible link between cellular (cell) phone use and brain cancer, originally because of a lawsuit that alleged such a link. The American Cancer Society studied this issue and found no consistent association between cellular phone use and brain cancer.[1] A 2003 consumer information document issued jointly by the FDA and FCC states the following:[2]

> The available scientific evidence does not show that any health problems are associated with using wireless phones. There is no proof, however, that wireless phones are absolutely safe. Wireless phones emit low levels of radio frequency energy (RF) in the microwave range while being used. They also emit very low levels of RF when in the stand-by mode. Whereas high levels of RF can produce health effects (by heating tissue), exposure to low level RF that does not produce heating effects causes no known adverse health effects. Many studies of low level RF exposures have not found any biological effects. Some studies have suggested that some biological effects may occur, but such findings have not been confirmed by additional research. In some cases, other researchers have had difficulty in reproducing those studies, or in determining the reasons for inconsistent results.

The bottom line is that cellular telephones are a relatively new technology, and we do not yet have full information on possible health effects. There is no evidence at present that they cause brain cancer, but other studies are looking at other potential health hazards. Stay tuned.

Irritation and public nuisance are also a concern. With the increased use of cellular phones, for example, it is virtually impossible to find a quiet moment. Cellular phones ring everywhere at any moment – classrooms, meetings, quiet dinners, weddings, and funerals. Due to the increased number of accidents caused by drivers who were talking on their cellular phones, use of cellular phones while driving has been prohibited in many states.

1.2.2.2 Business Issues

From a business point of view, the major hurdle is a good business case for m-business. There have to be compelling business reasons for adopting mobile communications at the enterprise level. The two important questions [Kalakotta 2002] are:

- What can the customer do that could not be done before?
- What can a business do that it could not do before?

These two questions go to the heart of the matter. Of course, other questions need to be asked for developing a good business case: can a business make money by using this model; who are the customers and how will they benefit from this product or service; what exactly is the problem that is being solved; and can the end-users adopt and use this service? Variants of these questions need to be asked for new initiatives. For example, what is the learning curve for end-users, what training is required, and what capabilities and support services are required? These are typical questions that are asked in any new initiative [Evans 2001].

[1] "American Cancer Society report on Cellular Phones," available from: http://www.cancer.org/docroot/PED/content/PED_1_3X_Cellular_Phones.asp?sitearea=PED

[2] Food and Drug Administration, "Cellular phone facts. Consumer information on wireless phones," accessed Sept. 2003 from www.fcc.gov/Bureaus/Wireless/News_Releases/1999/nrwl9044.html

1.2.2.3 Technology Issues

Wireless systems, although improving steadily, encounter several technical barriers that deter the adoption of wireless technologies. For example, lack of security solutions at the enterprise level is a major concern. In addition, there are diverse standards for mobile computing applications, mobile computing platforms, and wireless networks that hinder adoption. The multitude of mobile devices with different form factors and capabilities, and slow and error-prone networks also do not help the cause of rapid adoption. In particular, it is difficult for wireless networks to compete with the data rates of fiber optic networks, especially if two sites can be connected easily with a fiber cable.

Different surveys at different times have stated the aforementioned reasons as the main concerns. A well-known survey was conducted by Information Week in December 2000. This survey, shown in Table 1-2, was responded to by 101 IT and business managers. Even though these concerns exist, it is possible to design wireless solutions that provide high security and provide an integrated and seamless experience to the user despite the heterogeneous networks and devices. Such an architectural approach is presented in Chapter 11.

Table 1-2: Wireless Internet IT Concerns (Source: Internet Week, December 2000).

Rank	Feature	Percentage
1	Security	77%
2	Lack of Reliable Standards	69%
3	Lack of Web or Enterprise Integration Products	61%
4	Inadequate Bandwidth	54%
5	High Costs of Technology	49%
6	Quality of Technology	44%

1.3 A Framework for Discussion and Analysis

Mobility involves several levels of issues that include wireless networks, computing platforms, middleware services, and applications. These issues are cast into a framework, shown in Figure 1-2, that will be used throughout this book as a guide (see the sidebar "Book Outline"):

- At the highest point in the chain are the initiatives such as mobile business, mobile government, and mobile life. Most of these "m" initiatives are the next stage of "e" initiatives such as e-business, e-government, and e-life. These provide the main impetus for widespread use of mobile computing and wireless systems in the business, government, and personal life settings (see Section. 1.4).
- The mobile computing applications that support m-business, m-government and mobile life. Several issues, such as personalization, are important at this level. Possible applications range from those currently available on the wired Internet (including banking, book purchasing, email, news, and travel) to new services designed specifically for mobile consumers (information about where to find the nearest store, for example, or the automatic notification to nearby employees). These applications use wireless technologies to support mobility of business activities, customers, suppliers, employees, managers, and other players in the corporate world. In addition, these applications

support other activities in our life such as heath, entertainment, and social contacts. Section 1.5 introduces mobile computing applications; Chapter 2 provides details.
- The mobile computing platforms provide the middleware and other software services needed to support mobile computing applications. Middleware services include general ecommerce middleware such as transaction support as well as wireless-specific services such as Wireless Application Protocol (WAP). Section 1.6 introduces this topic and Chapters 3 and 4 provide additional details.
- At the bottom is the wireless network – the infrastructure that transports information between mobile devices, mobile users, data sources, and application providers. The wireless networks consists of wireless LANs, cellular networks, wireless local loops, and satellites. These networks are briefly reviewed in Section 1.7 and discussed in more detail in Chapters 5 through 10.

In addition to these layers of issues, the security, architectures, and management issues span all these levels. For example, security needs to be considered at network, platform, and application levels. Similarly, systems need to be designed and managed at all levels. Section 1.8 introduces these topics and Chapters 11 through 13 provide additional details.

Several regulatory and standardizing bodies (e.g., FCC, ITU, ETSI, IETF, IEEE, OMA – the alphabet soup to be defined later) are playing a vital role in this field. These bodies also span several levels. For example, FCC and ITU (International Telecommunications Union) are mainly concerned with wireless network issues such as frequency allocations, while the Open Mobility Alliance is more concerned with mobile computing platforms and application issues. These bodies are briefly discussed in Section 1.9. Another important player in this area is the wireless business sector that is involved in different aspects of wireless. Examples are the wireless network element providers, cellular carriers, wireless Internet service providers, wireless application service providers, wireless hardware/software development companies, and the wireless consulting, engineering, and management companies. Section 1.10 gives a quick scan of this sector.

It should be also noted, as shown in the figure, that higher levels drive lower developments and the lower levels enable the higher levels. This is true in most cases, but not always. In many cases, the developments in wireless network technologies are driving the development of new applications and business initiatives.

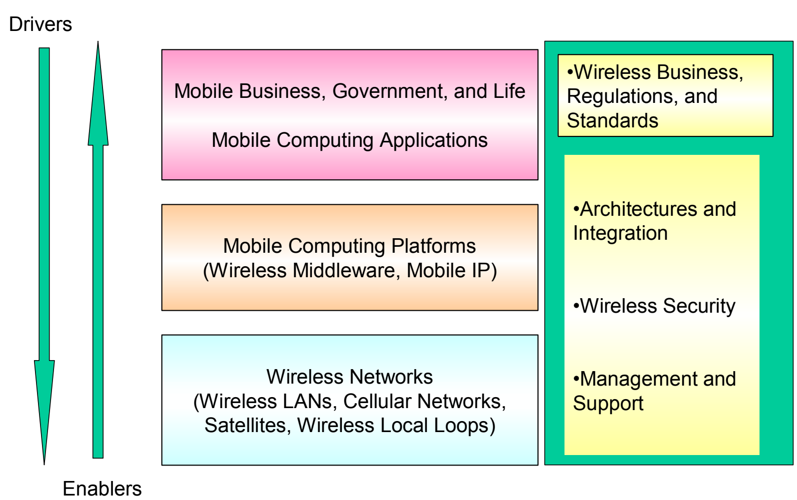


Figure 1-2: Framework for Discussion – Levels of Issues

Book Outline

1.4 Mobile Business, Mobile Government and Mobile Life

1.4.1 m-Business: An Evolution

A great deal of activity in mobile computing and wireless communications at present falls under the umbrella of m-business. Simply stated, m-business (mobile business) is conducting business by exploiting the mobile devices and wireless networking. m-Business goes beyond e-business to take advantage of the wide range of mobile, in many cases handheld, devices that are connected through wireless networks. Thus:

m-Business = e-Business + Wireless Networks + Mobile Devices e-Business itself has gone through several stages of evolution. Figure 1-3 shows one view that casts e-business evolution into four broad stages – the final stage is m-business [Kalakotta 2002]:

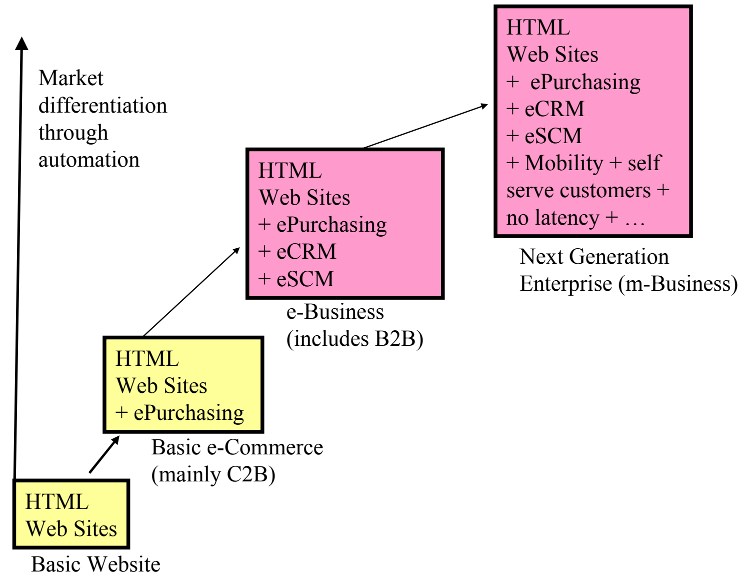


Figure 1-3: e-Business Stages of Evolution

Stage 1: Basic Websites. This stage became popular in the mid 1990s and is still the foundation of many corporate websites. The basic idea is to use the websites to display/advertise company products. All other company operations are largely unaffected. For example, the customers have to separately order the products that they select by browsing through company websites.

Stage 2: Basic e-Commerce. In this stage, the consumers could select the products through the Internet and then also buy them from a seller. This stage mainly concentrates on C2B (consumer-to-business) operations where the service is not only advertised but can also be purchased over the Internet by the consumers. In addition, the Web is used as an interface to corporate applications (i.e., new applications are developed by using the Web and existing applications are given "face lifts" by using the Web). This stage became popular in the late 1990s.

Stage 3: e-Business. This stage goes beyond the basic e-commerce sites by running the entire business through Internet technologies. In this stage, Internet and Web technologies take a central role in gluing services across multiple organizational units spanning different organizations. It adds B2B (business-to-business) interactions to C2B as encountered in the previous two stages. The B2B interactions, although hidden from the users, take place directly between business partners. This stage, popular at the turn of the 21st century, is at the core of contemporary e-business activities like online shopping, trading between business partners, and integration of business processes across organizational boundaries (e.g., workflows across organizations through IT). An example is Amazon.com – when you order a book from Amazon.com, many other suppliers may be involved in this transaction.

Stage 4: Next-Generation Enterprises (Mobile Businesses). This stage goes beyond stage 3 to add mobility, intermediaries (trading hubs, emarkets) and real-time business monitoring and control. In next-generation enterprises (NGEs), also known as ***"real-time enterprises,"*** the interactions between business activities within an enterprise are conducted, monitored, and controlled electronically and through mobile devices. The Internet-based IT infrastructure becomes the primary source of company business in this model. In fact, NGEs rely almost exclusively on the Internet-based IT infrastructure to conduct business, and often result in restructuring and transformation of the industry.

1.4.2 Mobile Business as an Integral Part of Next Generation Enterprises (NGEs)

m-Business is not a standalone activity – it is an integral part of NGEs. As stated previously, an NGE is stage 4 of the evolution, with emphasis on using up-to-date information, getting rid of delays, and using mobility and speed for competitive advantage. An NGE is an enterprise that fully exploits:

- Electronic services, as much as possible, for all internal as well as external business activities
- Real-time business activity monitoring (BAM) and control to make zero latency decisions (i.e., react to changes instantly instead of after monthly or quarterly reports)
- Mobility with mobile business operations and self-service for mobile customers to compete and succeed in the marketplace

We will concentrate on the mobility aspects of NGEs. Mobile devices and wireless networks are vital to the real-time operations of NGEs. Specifically, getting the best information to and from mobile users is crucial to take advantage of the effect this group has on sales and revenues. For example, access to e-business applications can be enabled through mobile devices, and monitoring of business activities can be achieved through handheld devices. Office workers, sales-reps, and executives, as well as customers, have laptops, cellular phones and PDAs (Personal Digital Assistants) instead of desktop computers to do their work. American Express, for example, has created a mobile portal to give cardholders a real-time and comprehensive view of their finances – accessible through wireless devices. The financial information is aggregated from cardholder relationships with banks, brokerages, mutual fund companies, and others.

Similarly, self-serve systems allow mobile customers to receive services without interacting with the human representatives, who are typically stationary. Examples range from automated teller machines to e-tickets that the customers can use to get boarding passes on airlines without interacting with the representatives at specific locations. Self-serve customer systems do not eliminate the need for customer care but expand customer services at different sites without having to add new staff. Many of these services are also exploiting "positional knowledge" of the mobile users. For example, a salesman on a visit to Chicago is only given information about contacts and leads in Chicago. Speech recognition on mobile devices is another area of development. SpeechWorks International, for example, teamed with Quixi to develop a mobile customer relationship management (CRM) system. This CRM is a speech application that combines call center and voice recognition capabilities on mobile devices for enterprise sales staff. At present, 50 to 80 percent of CRM systems fail because entering sales data is time-consuming and expensive. To attack this problem, speech recognition technology plays an important role in M-CRM.

The main enablers of m-business are the mobile computing applications, which fall into two broad categories. First, mobile e-business applications (MEBAs) include mobile access to existing e-business applications so that mobile users can use these applications from anywhere. Examples of these applications are mobile commerce, mobile portals, mobile customer relationship management systems, and mobile supply chain management systems. Second, other new business applications exploit the special features of wireless networks for business purposes. Examples are the location-based services and specialized applications that use mobile agents and wireless sensor networks. The major implication is that a sound, mobile-enabled IT infrastructure is necessary to achieve strategic business benefits. We discuss these topics extensively later in this book.

1.4.3 Mobile Government (m-Government)

m-Government, a subset of e-government, is the use of mobile computing and wireless communication technologies (ICTs) to improve the activities of public sector organizations. The goal of m-government is to make public information and government services available "anytime, anywhere" to citizens and officials. m-Government is not a fundamentally new idea because wireless technology has always been an important part of law enforcement. The difference is that today the law enforcement officers can use a laptop wirelessly connected to the Internet instead of the old two-way radios. For example, a Mobile Computing Project in Kentucky helps police officers use laptops to wirelessly connect to a database instead of talking to a dispatch operator. The database is linked with regional and national crime information, making the lookup much more comprehensive and accurate.

m-Government activities also allow health and safety inspectors to file their reports from the field in real time using a Pocket PC or handheld terminals. An area of considerable growth is to offer several government services to citizens through the Internet and government networks via mobile devices. Users can either "pull" the information through the mobile devices by issuing queries, or have some information sent ("pushed") to their mobile devices. For example, the California state government has established a Web page where citizens can register to receive notification services on handhelds for energy alerts, lottery results, traffic updates and articles from the Governor's press room.

Examples of m-government services are:

- C2G (Citizen-to-Government) and G2C m-communications. Governments recognize that the public has access to mobile devices. Thus these devices are being used to improve the communications between the government and the general public. For example, at the height of the SARS incident, the Hong Kong government sent a blanket text message to 6 million mobile phones to warn against rumours and explain government plans. The citizens can also send messages to government officials. In China, the 150 million mobile phone owners can send messages to the 3000 deputies of the National People's Congress.
- B2G (Business-to-Government) support through mobile devices. Many business-to-government (and government-to-business, of course) activities can benefit from mobility. The government sites in most developed countries currently provide a wealth of information to businesses, including legal restrictions, foreign trade rules, etc. This information is not only available through mobile devices but can also be "pushed" to the subscribers. Several national security initiatives are exploring emergency notification services to businesses through mobile and fixed devices.
- m-Transactions: Mobile devices can also be used to make payments (e.g., taxes, fines) and other transactional services. For example, Norway has introduced a mobile tax-collecting system. Taxpayers who have no changes to make to the tax form they receive, can now simply send a text message with a code word, their identity number and a pin code instead of returning the form by mail. In Finland, tickets for Helsinki's public transport system can be ordered by sending a text message and the user is billed through his or her regular mobile phone bill.

- m-Voting and m-Administration. Although somewhat controversial, several experiments in UK have explored voting via mobile phones to get the public more involved in political decision-making. m-Administration is concerned with improving the operations and communications between the government units (G2G). Many law enforcement agencies, for example, use wireless networks to communicate with other agencies on a regular basis. Another potential area is government-to-employee (G2E) information, where government employees can be notified or access information via a mobile device.

Many m-government initiatives are under way and a great deal of information is available on different aspects of m-government. See, for example, "M-Government: The Convergence of Wireless Technologies and e-Government," www.ec3.org/Downloads/2001/m-Government; and "mGovernment: Mobile/Wireless Applications in Government," http://www.e-devexchange.org/eGov/topic4.htm.

1.4.4 Mobile Life

In addition to being tangled up with businesses and government agencies, there is life (I hope, I hope!). This includes social contacts, entertainment, health, sports, etc. Mobile devices and wireless networks are playing an important role in these areas. For example, the current handsets can go beyond the now-familiar web access and email exchange applications. These devices can take and send/receive pictures, play audio/video clips, participate in chats, support voicedial (you speak, the device dials), forward calls, and offer conference calls between 4 to 5 people. These capabilities can be used in different aspects of our life – the mobile life.

The term mLife (a natural abbreviation of mobile life) is a multi-million dollar advertising campaign sponsored by AT&T to promote their wireless products and services. According to AT&T, the "m" in mLife goes beyond mobile and includes "messaging," "multitasking," "modern," and "managed." To differentiate the general concept of mobile life from the AT&T's rendition, we will refrain from using mLife and will refer to activities beyond m-business and m-government simply as mobile life.

Time to Take a Break

- ✓ Overview, Strengths/Weaknesses and Framework
- Mobile Applications, Platforms, and Networks
- Architectures, Standards, Business and Examples

1.5 Mobile Computing Applications: Supporting m-Business and m-Government

Mobile computing applications support m-business, m-government, and mobile life initiatives. These applications have profound impact on the way corporations conduct their business and the way government agencies deal with the public by exploiting mobility. Specifically, these applications enable the C2B, B2B, B2E, C2G, B2G, G2G, and G2E operations between customers, business units, government agencies, and employees (see Figure 1-4).

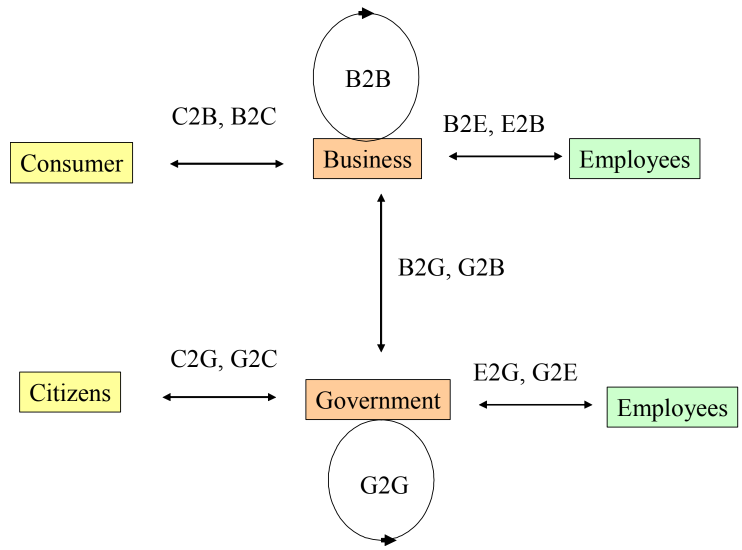


Figure 1-4: Interactions Between Consumers, Business Units, Government Agencies, Citizens, and Employees

A few observations are important before proceeding. First, most mobile computing applications are not fundamentally new applications. Instead, mobile device access over wireless networks is another aspect (dimension) of most existing arrays of applications. In fact, mobile access is being added to existing applications in a manner similar to the addition of Web access in the 1990s. Second, mobile access is not the only new feature of mobile computing applications – they also may include *positional* features that exploit location of the users, voice capabilities to support voice applications, and television features for interfacing with TV sets. These features, called MPTV (Mobile, Positional, Television, Voice) are shown in the sidebar "MPTV Applications" and explained in Chapter 2. Finally, there are some core mobile computing applications that are being used, with minor and necessary modifications, for m-business and m-government initiatives. Examples of these applications are:

- Wireless messaging services
- Wireless Websites and mobile portals
- Mobile commerce and its variants
- Mobile customer relationship management systems (m-CRM)
- Mobile supply chain management systems (m-SCM)
- Specialized applications involving mobile agents and sensor networks

Table 1-3 shows how these core applications support the m-business, m-government and mobile life initiatives. For this reason, we will not discuss separate mobile computing applications for m-business and m-government; instead we will briefly review these applications here and briefly discuss how variants of these applications are being used in different sectors of our professional and personal lives. Chapter 2 will provide a more detailed discussion of these applications.

Table 1-3: Mobile Computing Applications and their Support to M-Business, M-Government, and Mobile Life

Mobile Computing Applications	m-Business	m-Government	Mobile Life
Wireless messaging services (email, SMS, MMS)	SMS for B2E	G2C, G2G, G2B, G2E	Social messages

Wireless Web and m-Portals	m-Marketing, enterprise portals with wireless access	Government websites and portals with wireless access	Websites accessible through wireless and m-portals such as Mobile Yahoo!
Mobile Commerce	M-Commerce	C2G for tax payments, etc	Buying ticket for theater
M-CRM	M-CRM	Not Clear	Not Clear
M-SCM	Supplies of materials in B2B	Supplies of goods in G2G and G2B	Not Clear
Specialized M-Applications	LBS (location-based services), Mobile Agents for m-commerce, and wireless sensor networks (WSNs)	m-Voting Defense applications of Mobile Agents and WSNs	Location-based services to locate nearest restaurants, movie theaters, and repair shops

MPTV (Mobile, Positional, Television, Voice) Capabilities

Mobile capabilities enable mobile users, typically connected over wireless networks, to perform daily activities such as searching the Web, accessing remote applications, and invoking business transactions.

Voice capabilities support voice communications over mobile devices. Voice support over cellular phones and voice commerce are examples.

Positional capabilities support geographic position (location) for some applications. For example, positional commerce gives you information about deals in the Boston area when you are in Boston.

V capabilities exploit the TV to do purchasing, Web surfing, and other operations typically available on mobile devices.

1.5.1 Wireless Messaging

Wireless messaging is an interesting and important development in wireless applications. Access to important information and communications is critical for millions of people. Mobile users spend a significant amount of time away from their desk and can be frustrated by their inability to stay connected to the information that drives their day.

In order to allow remote access to email and corporate data, mobile professionals and IT departments have been forced to live with an imposing range of technical issues, workflow interruptions and significant costs. Common complaints include: security concerns, incompatible systems, constant dialing-in, bulky equipment, missed messages and overloaded inboxes.

Commonly known as "always-on email," these services are touted as the long awaited killer applications for cellular networks. Examples of these services are

- Short message services (SMS)
- Multimedia message services (MMS)
- Blackberry from Research in Motion (RIM)

These applications are used widely in m-business, m-government, and mobile life situations. For example, as we will see in Chapter 2, many B2E as well as C2G operations are supported by SMS.

1.5.2 Mobile Commerce and its Variants

m-Commerce describes the phenomenon of using wireless mobile devices such as digital phones and PDAs to search the Internet, access data and information, and conduct purchasing or business transactions. m-Commerce is fueled by the extreme popularity of mobile devices such as laptop computers, cellular phones, PDAs (personal digital assistants), and palm pilots. However, the vast majority of devices and usage continue to depend on laptops and PCs, which will remain the de facto standard of devices used to access enterprise data and applications. Although the mobile PDA and telephone device markets are growing rapidly, the growth in the North American market is slower than the European and Japanese markets. However, availability of wireless platforms will play a key role in this area.

One of the main value propositions of m-commerce is its ability to personalize applications for individual users. Providers that wish to offer the best m-commerce services need information such as the user's name, address, location, and billing details (the number of a credit card or a bank account, for example). In addition, because the size of the screen affects the kind of information that can be viewed, the type of device used to connect to the service is also specified.

Voice commerce (v-commerce) is gaining importance to support users who want to use telephones and other voice-driven devices for conducting ecommerce. For example, while driving and walking, it is easier to use a telephone than a computer. Technologies and standards such as Voice over IP (VOIP) and Voice markup Language (VML) will play a key role in v-commerce.

Positional commerce ***(p-commerce)*** is becoming popular to provide support to customers based on their geographic position (e.g., to give you information about deals in the Boston area when you are in Boston). The systems use a GPS (Geographical Positional System) to locate the position of the customers. In addition to GPS, wireless access is at the core of mobility support – thus developments such as the Wireless Application Protocol (WAP) and Wireless Markup Language (WML) are playing a key role in this area. In addition, mobile agents are being employed widely to support p-commerce.

1.5.3 Mobile Enterprise Business Applications (M-Portals, M-CRMs, M-SCMs)

Many mobile computing applications such as mobile portals, mobile customer relationship management systems (m-CRM), and mobile supply chain management systems (m-SCM) represent a mobile enablement of enterprise business applications. These *mobile* enterprise business applications (MEBAs) add the mobility capabilities to the core enterprise applications (ERPs, SCMs, CRMs, etc.) for availability to employees, partners, and customers who could be roaming around the globe. This idea has raised some issue – security and privacy are the main ones -- but MEBAs are becoming reality very quickly. Use of mobile devices such as laptop computers, personal digital assistants (PDAs), and digital telephones with Internet and wireless data access capabilities is widespread. The ability to support these highly mobile devices as part of an extended enterprise application strategy is critical. The mobile e-business applications enable mobile customers to conduct transactions with their financial services, telecommunications, or product suppliers of choice.

An interesting issue is content aggregators: businesses that design and operate portals (which provide information in a category) or search facilities to help users find their way around the Internet. This function is particularly important for mobile users because mobile telephones have small screens and limited input mechanisms – notably, no mouse and a non-QWERTY (i.e., not a computer terminal) keypad. Users need mobile portals that simplify the search, avoid displaying too much information, and require minimum input.

MEBAs create many opportunities such as business and revenue growth, support for new types of customers, and conformance to different social models of how and where business is conducted. But MEBAs also introduce several risks. Security and unauthorized access is a natural issue. In addition, highly mobile organizations need to manage the scores of laptops, as well as the data held on mobile devices. In particular, these organizations need to handle data synchronization, file distribution, software distribution, and systems management tools needed for mobile applications. This problem will only grow as more and new types of devices become part of the mobile enterprise. Some companies such as Synchrologic, Inc., provide tools to manage the synchronization, distribution, and control of data to mobile users on a variety of devices.

MEBAs naturally support the m-business initiative but they can be used for m-government and mobile life undertakings also. For example, mobile portals can be used by government agencies for C2G or B2G operations where agencies provide a portal for the citizens. For example, the IRS site for small-to-medium sized businesses is beginning to look like an m-portal. m-Portals, for example, can be used for health as well as entertainment purposes; Web MD is an example.

1.5.4 Specialized Applications with Mobile Agents and Sensor Networks

Several specialized mobile applications for specialized purposes are also being developed. Let us look at mobile agents and wireless sensor networks as examples.

An ***agent*** is a software entity (i.e., a program) that has some degree of autonomy. It carries out operations on behalf of a user or another program, and in this process, represents or has knowledge of the user's goals and wishes. In this sense, a software agent is similar to a real-life agent such as a life insurance agent, a car insurance agent, a travel agent, a real estate agent, and the like. All agents, software or human, carry out a set of operations on behalf of a user (customer) – they do so with some degree of autonomy to satisfy its user's goal. Software agents, like real-life agents, can be:

- Intelligent or dumb (I am thinking of my life insurance agent)
- Static or mobile

Mobile agents are programs capable of being transferred to remote hosts in order to carry out different tasks on behalf of their users. Mobile (transportable) agents have the ability to travel through the network. A mobile agent can halt its execution, move to another host on the network while maintaining its state, and resume execution on the destination host. Mobile software agents are also similar to mobile real-life agents who travel around on your behalf instead of sitting around and making phone calls or sending email. I can, for example, ask my nephew to buy a lawn mower for me by driving around in the neighborhood instead of making phone calls and getting on websites. We will look at mobile agents and their applications in Chapter 2.

Another possible area of mobile applications is ***wireless sensor networks (WSNs)*** and ***nano-technologies***. The extremely small sensors, or nano-computers, can be "sprayed" in a particular area to gather information. For example, many sensors are installed or sprayed in an area to detect vehicle movements, collect temperature fluctuations, or gather a variety of other useful information. But these sensors are not very useful by themselves unless they form networks, called wireless sensor networks (WSNs), which carry information to control/dissemination points. In general, these devices quickly form networks and send information to remote sites. Naturally, these computers are not wired – they form Mobile Adhoc Networks (MANETs) that are used in many military and civilian applications. We will discuss WSNs in later chapters (Chapter 7 and Chapter 10). Many interesting articles on WSNs can also be found in the June 2004 issue of *Communications of the ACM*.

1.6 Platforms to Support Mobile Computing Applications

1.6.1 Mobile Computing Application Development and Support Issues

Applications for mobile users face many unique challenges because wireless networks pose unique problems that more commonly available fixed networks do not have. Wireless networks, although improving dramatically with time, are typically slower, get congested frequently, and are more error-prone and susceptible to outages than their wired counterparts. Thus mobile computing application designers should have some knowledge of the underlying communication network. For example, database queries over wireless networks should not attempt to send thousands of rows because the network may not be available that long. Besides wireless network weaknesses, the limitations of mobile devices also need to be considered. There is a potpourri of new mobile devices, such as cell phones, pagers, and personal digital assistants (PDAs). Developing applications for these devices is challenging because they have different form factors (e.g., varying numbers of display lines), different browsers and markup languages (HTML, WML, and cHTML[3]), and different device capabilities (some can display images, some cannot).

Special platforms, called ***mobile computing platforms***, are needed to provide the unique services needed by mobile computing applications. These platforms, discussed extensively in Chapter 4, enable the operation and, in many cases, development and deployment, of mobile computing applications. Figure 1-5, a refinement of the framework shown in Figure 1-2, depicts three type of services provided by these platforms:

- **Local platform services** that support the applications on the individual mobile devices. These services consist of operating systems (e.g., Symbian OS) needed to run the mobile devices, and also include local system software services such as database managers, transaction managers, and utilities for mobile devices. These services are designed specifically to handle the unique features of the devices.
- **Network transport services** that are responsible for shuffling the messages over, in this case, wireless networks. These services, mostly handled by the Internet technologies (TCP/IP, in particular), operate on top of physical wireless and wired networks to route the messages so that the mobile users can access their emails, websites, and corporate applications. Specialized protocols such as Mobile IP are needed for mobile devices. See Section 1.6.2.
- **Middleware services** that interconnect mobile users, databases and applications with each other. For example, wireless middleware provides remote access to a corporate database from a mobile phone and may also encrypt and compress the messages for security and performance. An interesting trend at present is to package a variety of middleware services into "wireless gateways" and "mobile application servers" that can

[3] WML (wireless markup language) and cHTML (compact HTML)

support the current and future breed of mobile applications. Examples of such packages are WAP (Wireless Application Protocol), i-mode and J2ME (Java2 Micro Edition), and Microsoft Mobile Internet Toolkit. See Section 1.6.3.

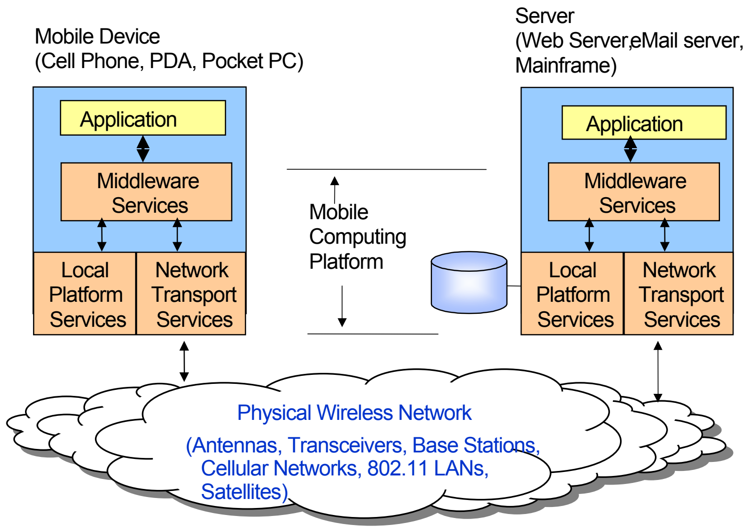


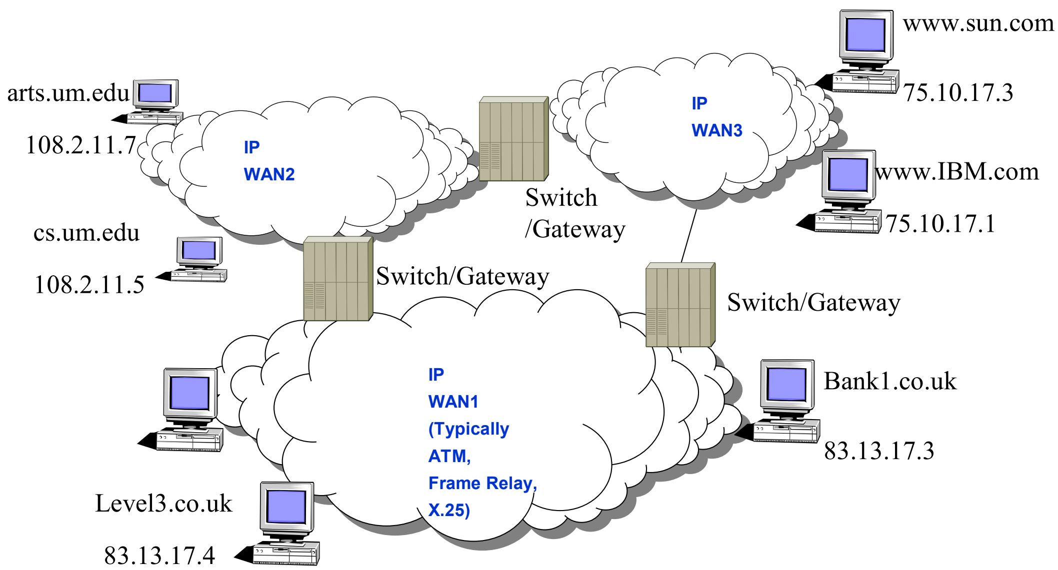
Figure 1-5: Platforms for Mobile Applications

1.6.2 Wireless Internet, Mobile IP, and Wireless Web

Technically speaking, an Internet is a network based on the TCP/IP protocol stack. At present, the term *Internet* is used to refer to a large collection of TCP/IP networks that are tied together through network interconnectivity devices such as routers and gateways. At present, the term *Internet* is used to symbolize the following two situations:

- **Public Internet**, or just "the Internet," that is not owned by any single entity – it consists of many independent TCP/IP networks that are tied together loosely.
- **Private Internets**, or intranets, are the TCP/IP networks that are used by corporations for their own business – they use the same technology as the public Internet but the underlying physical network is privately owned.
- **Extranets** are the TCP/IP networks that are jointly owned by corporations to conduct business.

Figure 1-6 shows a conceptual and partial view of the Internet. This Internet shows three networks (a university network with two computers, a commercial company network, and a network in UK). Each computer ("host") on this network has an IP address and has been assigned a domain name as well. The Internet is very heterogeneous (i.e., different computers, different physical networks). However, to the users of this network, it provides a set of uniform TCP/IP services (TCP/IP hides many details). Once a device (mobile device or a laptop) has an IP address, then it can send messages to any other device with another IP address. Thus a user at arts.um.edu can send email to someone at bank1.co.uk and browse the IBM website at www.ibm.com.



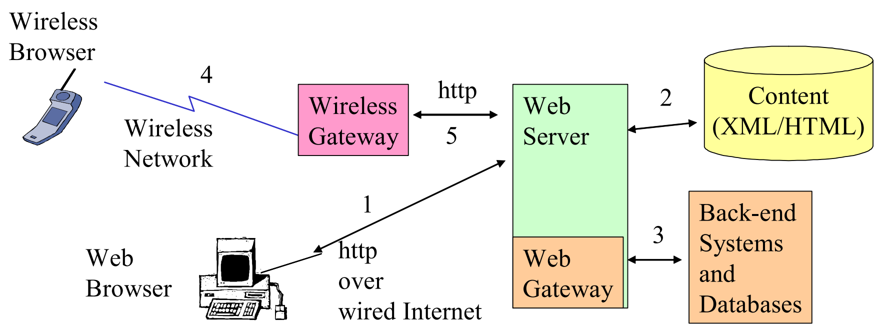
•DNS (Domain Name Services) translates cs.um.edu to 108.2.11.5
•Telnet cs.um.edu = Telnet 108.2.11.5
•FTP cs.um.edu = FTP 108.2.11.5

Figure 1-6: Partial View of Internet

To support highly mobile devices, a new protocol called Mobile IP has been introduced. Mobile IP allows mobile devices (PDAs, portable computers) to maintain Internet connectivity while moving from one Internet attachment point to another. This is done by using a concept similar to mail forwarding (the traffic is forwarded to the mobile device as it moves around).

How does wireless Web work? Web technologies reside on top of the Internet to support GUI operations. Figure 1-7 shows a conceptual view of how Web content is accessed from regular Web browsers (steps 1, 2, 3) as well as from cellular phones (steps 4, 5, 2, 3). The core building blocks of this view are:

- Web servers that are custodians of Web content and also provide access to non-Web content through Web gateways
- Web browsers that display the Web content (e.g., html pages) on PCs
- The Internet that carries the traffic between Web browsers and Web servers
- Wireless browsers that display the content on wireless handheld devices
- Wireless gateways that translate Internet protocols to wireless networks, if needed, and also convert ("render") the Web content to be displayed on handheld browsers
- Wireless networks that carry the data for handheld devices



1. Access from Web browser to Web Server over wired Internet
2. Access to Web contents from HTML/XML files
3. Access to non-Web content through a Web gateway
4. Access from cellular phone over a wireless network
5. Access from wireless gateway to Web Server over wired Internet

Figure 1-7: Conceptual View of Wireless Web

The "First Generation" of the Web is based on a few simple concepts and technologies. Due to the popularity of the Web, many limitations of the first generation started appearing. Based on this, a great deal of activity has focused on the "Next Generation" of the Web. Perhaps the best-known activity from this work is XML.

An important area of work is Web Services (WS), which are intended to provide global distributed applications whereby an inventory system in Singapore, for instance, can be combined with an order processing system in London to handle orders placed by someone in Chicago. Mobile Web Services is a specification that describes how WS can be used to handle mobile devices.

See Chapter 3 for details about the wireless Internet and Web.

1.6.3 Wireless Middleware and Wireless Gateways (WAP, i-mode, J2ME, MMIT, BREW)

Wireless middleware, also known as mobile computing middleware, smoothes over the mobile computing issues, as much as possible, so that the same applications can run on wired as well as wireless networks. It performs the following functions:

- Establishes connections between mobile clients and servers over wireless networks and delivers messages over the connection.
- Transforms data from one format to another (e.g., one type of markup to another).
- Detects the mobile device characteristics and optimizes the wireless data output according to device attributes.
- Compresses data to minimize the amount of data being sent over a slow cellular wireless link.
- Encrypts/decrypts data for security.
- Allows monitoring and troubleshooting of wireless devices and networks.

Naturally not all these features are needed for every mobile computing application. Some applications need less middleware support than others. Over the past few years, many wireless middleware services have appeared in the marketplace. Here are some examples (see Chapter 4 for detailed discussion and analysis):

- WAP (Wireless Application Protocol) is an open specification for mobile computing platforms. It supports a WAE (Wireless Application Environment) and uses WML (Wireless Markup Language).
- i-mode, developed by NTT DoCoMo, is a popular mobile computing platform in Japan and is currently gaining momentum in the US. It uses special phones capable of voice and packet transmission along with a browser installed. I-mode phones are specialized phones, with larger windows for multimedia, that display content in cHTML (compressed HTML) over packet-switching networks.
- Wireless Java is the general umbrella name under which Sun is supporting its Java platform for developing wireless applications. Java 2 Micro Edition (J2ME) is the core technology in wireless Java for writing applications that run on small handheld devices.
- The Microsoft Mobile Internet Toolkit (MMIT) is an extension of the Microsoft .NET framework for building Wireless applications. MMIT has two interesting features: it automatically generates code (WML, cHTML, and HTML) for different type of mobile devices, and it is built around .NET and Visual Studio – popular platforms for application development at present.
- BREW, from QualComm, provides application developers with a platform in which to develop their products, and to allow the same features as J2ME, including cross-device platform capabilities. BREW currently uses Microsoft .NET Visual Studio.
- VoiceXML is a markup language for voice browsers. It is designed for creating audio dialogs that feature synthesized speech, digitized audio, and recognition of spoken and digitized voice mail.

For the purpose of illustration, let us briefly review WAP. WAP is a set of protocols to enable the presentation and delivery of wireless information and telephony services on mobile phones and other wireless devices. The WAP model, shown in Figure 1-8, is based heavily on the existing Web; i.e., a WAP gateway translates between the Web server and the WAP clients. WAP provides a Wireless Application Environment (WAE) for creating WAP applications and services.

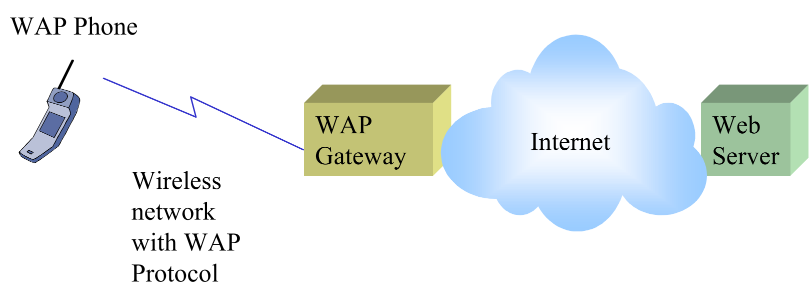


Figure 1-8: WAP Architecture

The main elements of WAE are:

- A markup language called Wireless Markup Language (WML) that is similar to XML but that has been optimized for wireless links and devices. A scripting language (WMLScript) is also provided.
- Specification of a microbrowser in the wireless terminal. This is analogous to the standard Web browser – it interprets WML and WMLScript in the handset and controls presentation to the user.
- A framework, the Wireless Telephony Applications (WTA) specification, to allow access to telephony services such as call control, messaging, etc. from within the WMLScript applets.

The initial versions of WAP supported a complete protocol stack designed specifically for the wireless environment. This protocol stack has been now replaced with the TCP/IP stack – WAE runs on top of TCP. How does WAP work? Wireless devices communicate through the wireless network to the WAP Gateway that converts data or Web pages between the front-end WAP and the back-end Internet. This conversion lets conventional Web servers send WML pages to wireless devices, which use micro-browsers that let users surf the Web. See Chapter 4 for additional details about WAP and other aspects of mobile computing platforms.

1.7 Overview of Wireless Networks

1.7.1 A Classification of Wireless Networks

Wireless networks, as the name implies, interconnect devices without using wires – instead they use the air as the main transmission medium. Wireless networks are enjoying widespread public approval with a rapidly increasing demand. The unique features of the wireless networks are:

- The bandwidths, and consequently data rates, of communication channels are restricted by government regulations. The government policies allow only a few frequency ranges for wireless communications.
- The communication channel between senders/receivers is often impaired by noise, interference and weather fluctuations.
- The senders and receivers of information are not physically connected to a network. Thus the location of a sender/receiver is unknown prior to start of communication and can change during the conversation.

A very large body of work on wireless networks exists, with emphasis on different aspects such as radio transmission technologies, standards, protocols, systems engineering, and carriers. See, for example, the Mobile Communications Series by Artech Publishing. For our purpose, wireless networks can be broadly classified in terms of distance covered: wireless local area networks, wide area networks and metropolitan area networks. Figure 1-9 displays an overall classification of wireless networks in terms of distance covered, from very short range (10 meters) to very long range (thousands of miles).

Wireless LANs (WLANs) allow workstations in a small area (typically less than 100 meters) to communicate with each other without using physical cables. The most popular example of Wireless LANs are the IEEE 802.11 LANs that deliver between 11Mbps to 54 Mbps data rate. Another example is the Bluetooth LANs (for the data rates in the 1 Mbps range over 10 meters). Very short range LANs such as Bluetooth are also known as Wireless Personal Area Networks (WPANs) We will discuss wireless LANs and PANs in Section 1.7.2.

Wireless metropolitan area networks (WMANs) have been used in traditional packet radio systems often used for law-enforcement or utility applications. An interesting area of growth for wireless MANs is the wireless local loop (WLL) that is quite popular with long distance telephone companies. WLLs are ***fixed wireless networks*** where the devices being connected are stationary. See Section 1.7.3.

Wireless WANs (WWANs) provide wireless support over long distances. Traditional examples of wireless WANs are paging networks and satellite systems. However, a great deal of wireless WAN activity at present revolves around the cellular networks that provide support for cellular phones and other handheld devices such as PDAs and laptops. We discuss cellular networks and the satellite communication systems in Section 1.7.4.

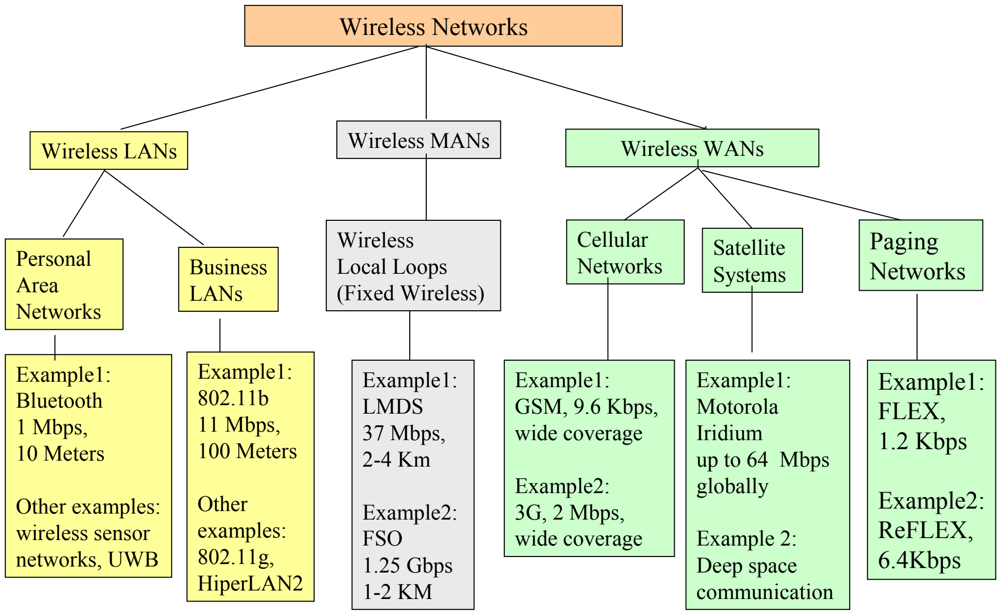


Figure 1-9: A View of Wireless Network Landscape

The wireless networks in the aforementioned categories are offering higher data rates than before. However, the wired networks are also offering higher data services. Table 1-4 summarizes the typical data rates in the wireless versus the wired world. As you can see, the wireless technology is much slower than its wired counterpart but it offers greater flexibility to the users.

Table 1-4: Wireless Versus Wired Networks

	Local Area Networks (LANs)	**Metropolitan Area Networks (MANs)**	**Wide Area Networks (WANs)**
Wired	Wired LANs Ethernet (10-100 Mbps, 150 to 500 meters) Token Ring (4 -16 Mbps, 200 to 500 meters)	Wired MANs FDDI (100 Mbps, 50 Kilometers)	Wired WANs Dial-up (56 Kbps) DSL/cable modems (200 Kbps-1 Mbps) ATM (44 Mbps to 140 Mbps) Frame Relay (44 Mbps) Higher data rates (over 100 Mbps) available
Wireless	Wireless LANs Bluetooth (1 Mbps, 10 meters) IEEE 802.11 LANs (11-54 Mbps, 100 meters)	Wireless MANs Wireless local loops (10-50 Mbps, 10 Kilometers)	Wireless WANs Current GSM systems at 9.6 Kbps, future 3G systems at 2 Mbps Satellites at 64 to 100 Kbps

1.7.2 Wireless LANs: IEEE802.11 and Bluetooth

Wireless LANs allow workstations in a building to communicate with each other without having to be connected to physical cables. This is a major benefit because LAN wiring can be the most expensive component of a LAN. At the time of this writing, wireless LANs have several limitations such as short distances, lack of wireless adapter cards for PCs and workstations, limited connectivity to other LANs, and relatively low speeds. However, this technology is still in its infancy. Technologies such as Bluetooth (discussed in next section) are examples. Currently available wireless LANs use one of three signal types to transmit data:

- infrared
- spread spectrum
- narrowband microwave

Infrared signals behave like ordinary light (they cannot penetrate sold objects). Thus infrared wireless LANs are limited to data transmission to line of sight. Infrared technology is simple and well proven (it is used commonly in remote controls for VCRs and TVs). In addition, infrared signals are not regulated by the Federal Communications Commission (FCC). Spread spectrum is most widely used in wireless LANs. These LANs transmit in the industrial, scientific, and medical bands designated by the FCC. These bands are not licensed but are regulated by the FCC to prevent interference. This technology was developed for military and intelligence operations (the message is "spread" over a range of frequencies to make it jam-resistant). Wireless LANs based on narrowband microwave technology use the 18.82-to-18.87 GHz and 19.6-to-19.21 GHz frequency ranges. These frequency ranges are licensed by the FCC, which means that a vendor must be approved by the agency to use these frequency ranges. Many wireless LAN vendors consider this to be a restriction.

1.7.2.1 IEEE 802.11 Standard for Wireless LANs

The IEEE 802 standards committee formed the 802.11 Wireless Local Area Networks Standards Working Group in 1990. The Working Group defined the IEEE 802.11 standard protocol for two types of networks: ad hoc and client/server networks. The 802.11 LANs are most widely used. These networks operate at 11 Mbps and 54 Mbps and can support distances between 100 feet and 500 feet. Detailed information about these LANs can be found at the Wireless LAN Association Website (www.WLANA.org).

Figure 1-10 shows a sample environment that supports wireless Ethernet LANs so that the students can access the school server as well as the public Internet. In this configuration, several wireless access points are connected to a wired LAN that is connected to the Internet and an internal server. Each access point supports mobile computers with wireless Ethernet cards in a wireless cell that spans around 100 meters. See Chapter 6 for additional details.

1.7.2.2 Wireless Personal Area Networks (WPANs), Bluetooth and UWB

Wireless Personal Area Networks (WPANs) are short-range (10 meter or less) radio networks for personal, home, and other special uses. Within the WPAN family, several specifications such as Bluetooth, wireless sensor networks, and UWB (Ultra Wideband) have emerged.

Bluetooth is a wireless cable replacement standard that provides a 1 Mbps data rate over 10 meters or less. It typically consists of a group of linked devices, such as a computer wirelessly connecting to a set of peripherals, known as as a "piconet." Multiple piconets can be formed to provide wider coverage. Due to its relatively low data rates and very short distances, Bluetooth is being used in home appliances, "Bluetooth-enabled" cars, and other such applications. Figure 1-11 shows a simple Bluetooth configuration. Bluetooth was designed to allow low-bandwidth wireless connections to become so simple to use that they seamlessly mesh into your daily life. A simple example of a Bluetooth application is updating your cellular phone directory. The main idea is that this could happen automatically as soon as the phone is within the range (10 meters) of your desktop computer where your directory resides.

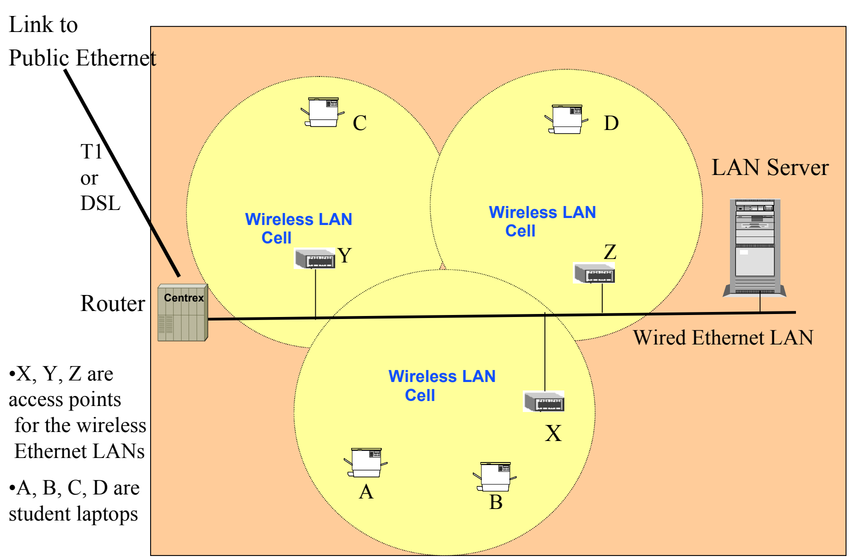


Figure 1-10: A Sample Configuration with Wireless Ethernet LANs

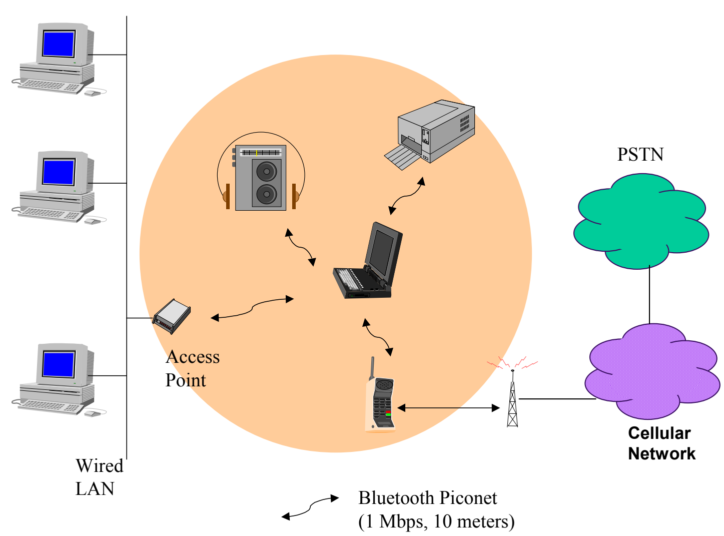


Figure 1-11: A Simple Bluetooth Configuration

UWB (Ultra Wideband) is a relatively new[4] technology and is stronger than the other short-range wireless systems (such as Bluetooth) because of its simpler device designs, lower power consumption and higher data rates. Another player in the short-range radios is the **wireless sensor networks (WSNs)** that are formed between small, low-powered sensor

[4] As we will discuss in later chapters, UWB is not a new technology; it has been around for several years for military use, but has been "declassified in 2002 for commercial use.

devices mainly for monitoring and data collection purposes. Yet another player in short-range wireless, HomeRF, was primarily aimed at the needs of the small office and home office (SOHO) networks. This effort has been currently sidelined due to the popularity of other alternatives such as Bluetooth and UWB. See Chapter 7 for detailed discussion of these networks.

1.7.3 Wireless Metropolitan Area Networks (WMANs) – The Wireless Local Loop

Wireless metropolitan area networks (WMANs) are the wireless local loops (WLLs) that are gaining popularity with long distance telephone companies. WLLs allow long distance carriers to bypass the existing wired local loops owned by local phone carriers. Consider, for example, AT&T long distance services that need to connect a caller in Chicago to a caller in New York. AT&T has to pay the local carriers in Chicago and New York because these carriers own the wirings at the two end points. These charges can add up to $20 billion in the US alone. Figure 1-12 shows a sample configuration in which a local wired loop has been replaced with a wireless local loop.

WLLs are quick and cost-effective for quick setup of local phone services. Imagine laying millions of miles of copper cables to set up a local wired loop. Several technologies exist for WLLs. Examples are wireless ATM and LMDS (Local Multipoint Distribution Systems). WLLs are examples of wireless metropolitan area networks and offer broadband wireless data rates between 10 to 50 Mbps.

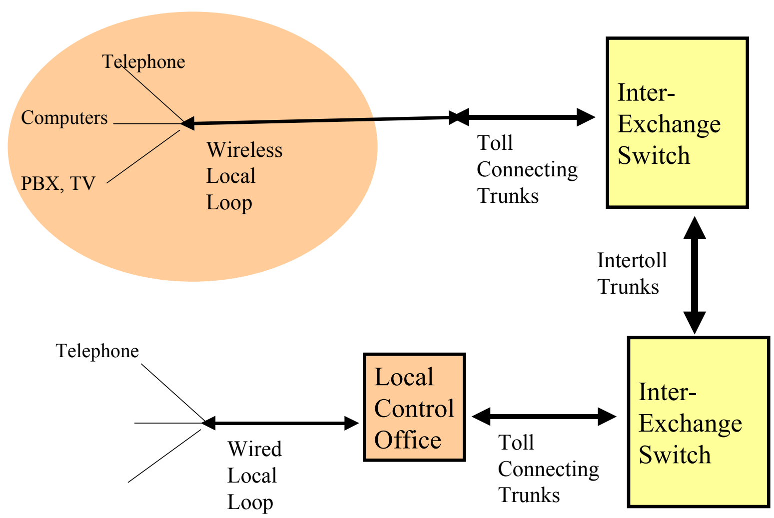


Figure 1-12: Wireless Local Loop

A relatively new entrant in the WLL market is **Free Space Optics (FSO)**, which uses laser beams to deliver extremely high data rates (around 1 Gbps) over a few kilometers. FSO is gaining popularity because of its high security – it is difficult to intercept laser beams! In the last mile, wireless local loop technologies (LMDS, MMDS, and FSO) are providing strong competition to the wired local loops based on copper or fiber optic networks. Wireless solutions have the advantage that they can be installed quickly and less expensively. See Chapter 9 for discussion of WLLs.

1.7.4 The Wireless Wide Area Networks – Cellular Networks

Wireless wide area networks (wireless WANs) are used widely to support mobile users over long distances. These networks can be discussed in terms of paging networks, cordless networks, and cellular networks.

1.7.4.1 Cellular Network Landscape

Cellular telephones were introduced in the mid 1980s. These technologies are enjoying widespread public approval with a rapidly increasing demand. To meet this demand, mobile communications technologies are emerging with digital speech transmission and the ability to integrate cordless systems into other networks. In the meantime, researchers are developing the next generation of technologies for the next century.

Figure 1-13 shows a high-level view of a cellular communication network used in wide areas. The cellular network is comprised of many "cells" that typically cover 1 to 25 miles in area. The users communicate within a cell through wireless communications. A base transceiver station (BTS) is used by the mobile units in each cell by using wireless communication. One BTS is assigned to each cell. Regular cable communication channels are used to connect the BTSs to the mobile telephone switching office (MTSO). The MTSO determines the destination of the call received from a BTS and routes it to a proper destination, either by sending it to another BTS or to a regular telephone network. Keep in mind that the communications is wireless within a cell only. The bulk of cell-to-cell communication is carried through regular telephone lines.

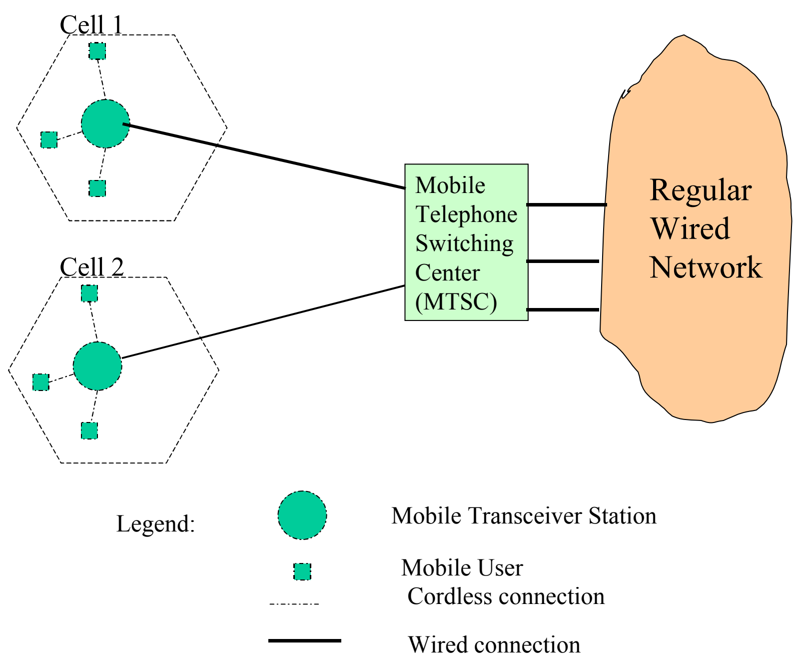


Figure 1-13: A Cellular Communication Network

Two issues are of fundamental importance in this conceptual model:

- **Cell sizes**. The sizes of the cells can be small or large. In some cases, such as cordless networks, the cell sizes are only a few feet. But in cellular networks, the cell sizes can be many miles (10 to 20 miles).
- **Location ("Roaming") support**. In some cases, the user is only covered for his "home cell"; in others, the user can roam between cells and still be covered adequately. For

example, in a cordless phone, the user is only covered at the home cell, while roaming is typically supported in a wide coverage area where the user can travel through several cells.

It is good at this point to differentiate between cordless and cellular phones. In a cordless network, such as the cordless phone in your home, each telephone handset is the base station. You cannot go far from the handset (perhaps not more than 100 feet) if you are using the cordless phone. Cordless networks have smaller cell sizes and have no roaming support. ***Cordless communication*** basically operates on the same principle as the cellular systems; however, cordless systems operate at lower power (suitable for light telephone devices), so the cell sizes are smaller (usually within a building as compared to several miles). Basically, a cordless system has many more cells that can be accessed by weaker cellular devices and does not support roaming services. Due to their general use, we will concentrate more on the cellular networks.

The common features of the cellular and cordless PCS networks are:

- The senders and receivers of information are not physically connected to a network. Thus the location of a sender/receiver is unknown prior to start of communication and can change during the conversation.
- The communication channel between senders/receivers is often impaired by noise, interference and weather fluctuations.
- The bandwidths, and consequently data rates, of communication channels are restricted by government regulations. The government policies allow only a few frequency ranges for wireless communications.

1.7.4.2 Evolution of Cellular Networks – The 3G Networks

The cellular networks are evolving through the following stages:

- **1G: First-generation wireless cellular:** These systems, introduced in the early 1980s, use analog transmission, and are primarily intended for speech. These networks are very slow (less than 1 kilobits per second).
- **2G: Second-generation wireless cellular**: Introduced in the late 1980s, these systems use digital transmission and are also intended primarily for speech. However, they do support low bit-rate data transmissions. The high-tier 2G systems use GSM and the low-tier systems are intended for low-cost, low-power, low-mobility PCS. These systems, most prevalent at present, operate at 9.6 Kbps.
- **2.5G Systems** are essentially 2G systems that have evolved to medium-rate (around 100 Kbps) data. As part of the 2.5G initiative, GSM is being extended by the General Packet Radio System (GPRS) to support data rates of 112 kilobits per second.
- **3G Systems,** discussed in more detail later on in this section, represent the future. These broadband multimedia applications can operate at 2 million bits per second. 3G systems will be based on evolution from 2G; they build on the success of GSM, and dual-mode terminals to ease migration from 2G to 3G are commercially available.

Let us go through the 3G system in some detail.

The third-generation (3G) vision is to create a unified global set of standards requirements that will lead to the commercial deployment of advanced multimedia wireless communications. The goal of 3G systems is to enable wireless service providers to offer services found on today's wireline networks.

3G systems are based on packet-switching systems instead of the older circuit-switching systems used in 2G. Thus, users can stay online throughout and yet not be charged for the time spent online. Rather, they only pay for the amount of data that they retrieve. This is in contrast to a circuit-switched network like the regular voice telephone network – where the communication path is dedicated to the callers, thus blocking that path to other users for that period of time. This means that although a 3G handset is, in effect, permanently connected to the network, it only uses bandwidth when needed. The most popular radio technology in 3G is Wideband CDMA (collision detect multiple access). This is similar to local area network technologies such as Ethernet.

Although most of the industrial cellular networks are concentrating on 3G, the research community is working on 4G and 5G cellular networks that are orders of magnitude faster than the 3G networks. See Chapter 8 for details about cellular networks.

1.7.5 Satellite Communication Systems

Satellites were first launched in 1962 and have ushered in the era of "celestial" and "global" communications. A satellite is essentially a microwave repeater in the sky which receives signals from transmitting stations on earth and relays these signals back to the receiving stations on the earth (see Figure 1-14). A satellite system consists of the following components:

- Earth Stations – antenna systems on or near the earth
- Uplink – transmission from an earth station to a satellite
- Downlink – transmission from a satellite to an earth station (different from uplink, typically faster, can be broad)
- Transponder – electronics in the satellite that convert/amplify uplink signals to downlink signals. There are typically 16 to 20 transponders per satellite, each with 36-50 MHz BW (bandwidth).

A satellite covers a certain area – the higher the satellite, the more area it can cover. The coverage area of a satellite is called the satellite's footprint. Only receiving stations within this footprint can receive the satellite's signals.

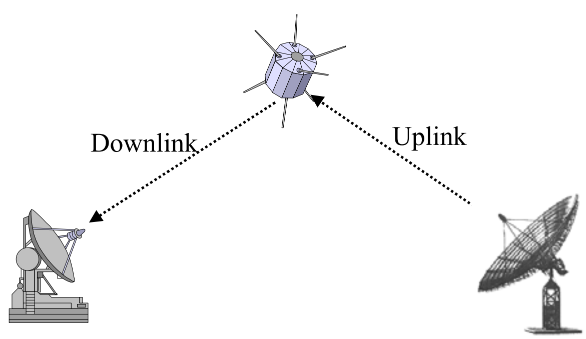


Figure 1-14: Satellite Transmission

The oldest example of satellites is the Geosynchronous (GEO) satellites that are in wide use providing international and long distance telephone services (to stationary users) and broadcasting services. GEO satellites are placed in the earth orbit at 22,300 miles – an area called the Clark Belt, after the famous science-fiction writer who first envisioned satellites in 1945. Once placed in the Clark Belt, the satellite rotates at the same speed as the earth's rotations so the satellite does not appear to move (this is called geosynchronization). Thus the sending and receiving dishes can stay pointed to the satellite without any readjustments. GEO satellites can provide high communications capacity and can support several thousand voice channels. However, each satellite message encounters a 0.25-second delay because of the distance a message has to travel between a sender and a receiver. In a satellite communication system, the transmission cost is independent of the distance between the sender and receiver (two stations 100 miles apart or 1000 miles apart still have to travel thousands of miles to and from the satellite). Because of this, satellite communication systems are used to broadcast (i.e., send) a message to several receivers simultaneously. See Chapter 9 for additional details.

An interesting area of satellite communications is "**Deep Space Satellites**" that communicate over hundreds of thousands of miles. In fact, NASA is working on an Interplanetary Internet that would form an Internet between the satellites in the sky. See Chapter 9 for additional information about deep space communications and the Interplanetary Internet.

A class of wireless wide area networks, not mentioned frequently in the popular press, is the paging networks that have been around for a long time. These networks are designed for short messages and are relatively slow. See Chapter 10 for additional information about paging networks.

1.7.6 Summary of Wireless Networks

Wireless networks, ranging from short-range networks such as Bluetooth and UWB to deep space satellites that communicate over millions of miles, are currently available. In addition, new technologies are always being introduced and the existing technologies are being refined and improved on an ongoing basis. From an end-user point of view, the two most important properties of wireless networks are data rates and the distance covered. Table 1-5 summarizes the characteristics of the available wireless network solutions in terms of these two factors. It can be see from this table that several technologies compete with each other directly or indirectly. Chapters 5 through 10 discuss the various wireless network issues in detail.

Table 1-5: Wireless Technologies Alternatives

	Data Rate (Mbps)	**Approximate Range (meters)**
Bluetooth	1 Mbps	10 meters
UWB	50 Mbps	<10 meters
IEEE 802.11a	Up to 54 Mbps	<50 meters
IEEE 802.11b	11 Mbps	100 meters
IEEE 802.11g	Up to 54 Mbps	100 meters
HiperLAN/2	Up to 54	30 meters
GSM	9.6 Kbps	Cell sizes 10 to 20 KM
3G Cellular	Up to 2 Mbps	Cell sizes 5 to 10 KM
WLL (LMDS)	up to 37 Mbps	2 to 4 KM
FSO	100 Mbps to 2.5 Gbps	1 to 2 kilometers
Satellites	64 Kbps	thousands of miles

Time to Take a Break
- Overview, Strengths/Weaknesses and Framework
- Mobile Applications, Platforms, and Networks
- Architectures, Standards, Business and Examples

1.8 Wireless Architectures, Security and Management

1.8.1 Integrated Architectures for Wireless Systems

Architectures play a vital role in wireless systems because they show how the individual systems tie together to satisfy the overall requirements. Simply stated, an architecture of a system is a structure that describes three things:

- Components of the system (what are the pieces of a system?)
- Functions performed by the components (what do they do?)
- Interfaces/interactions between the components (how do they work with each other?)

Our interest is in ***"integrated architectures"*** that consist of components that are, to some extent, *seamlessly* combined to support similar conventions or styles. An integrated architecture does not focus on one type of components, but instead combines wireless applications with the underlying IT infrastructure, including wireless network architecture. Specifically, an integrated wireless architecture would provide seamless access to a diverse array of resources across a hybrid network of wireless LANs, cellular networks (3G, 2.5G, GSM), Bluetooth WPANs, and a variety of public shared "hotspot" LANs in hotels, restaurants, airports, plazas, gas stations or other business centers.

Figure 1-15 suggests an integrated architectural vision that serves the needs of mobile workers and enterprises through a hybrid network architecture consisting of public shared or private wireless LANs and public-shared wireless wide area networks. The architecture presents a mixture of wireless LANs, cellular networks (3G, 2.5G, GSM), Bluetooth WPANs, and a variety of public shared "hotspot" wireless LANs in hotels, restaurants, airports, plazas, gas stations or other business centers. The growth of hotspots is an interesting development because they are filling the void as the 3G networks are being delayed. The main idea is that a wide range of individual wireless networks and fixed wireless LANs are interconnected through a mixture of wireless or wired networks to provide seamless services over the Internet.

This architecture provides high-speed (IEEE 802.11b LAN at 11 Mbps or 802.11g up to 54 Mbps) access within the hotspots and business LANs and lower-speed access (56 Kbps to 384 Kbps) when outside the LANs by utilizing GSM or 2.5G GPRS cellular networks. Bluetooth technology, although not as popular as 802.11, has found a niche in the wireless personal area networks (WPANs).

This vision also allows the user to perform different activities as they move from location to another. At a hotspot, for example, the user could do Web surfing and other Internet information-related work, and receive SMS messages while walking around or driving around in a car. The user can stay logged on and stay in touch, for example, even though 802.11 LAN signals fade, as the GPRS wireless WAN takes over. Thus different models of human interactions can be supported – relaxed and intense work while stationary at different sites but occasional short emails while in motion – without having to log on/log off [Dharwan 2000].

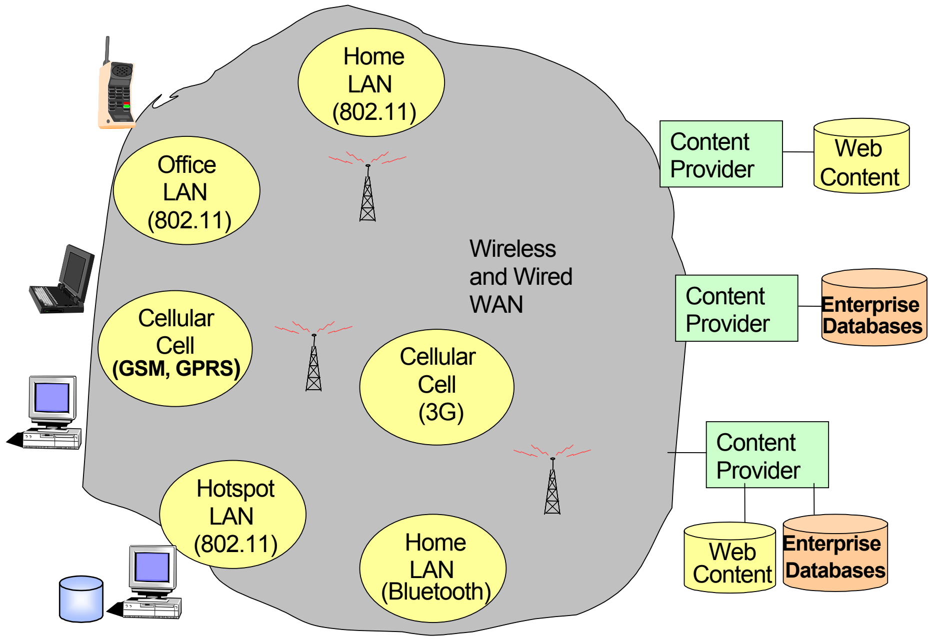


Figure 1-15: A Wireless Architectural Vision

Integrated architectures involve a continuum of services that go from low-level network interconnection technologies to business applications and processes. Specifically, integration in wireless systems requires facilities at the following levels (see Figure 1-16).

- **Physical communication level (Layer 1 and 2)**. At the very basic level, adapter cards are needed that can detect if a user is in a different coverage area. For example, a card that can recognize GSM, GPRS, and 802.11 signals is needed in mobile devices to operate in a hybrid wireless network. In addition, network protocol converters and gateways are needed between different types of networks.
- **Handoffs and roaming support between multiple networks**. Mobile IP is a major player in supporting handoffs as the mobile devices roam from one network to another and as the IP addresses change due to the roaming.
- **Mobile computing platforms for integration.** At higher levels, mobile computing platforms provide the middleware services such as WAP and i-mode to shield the applications developers from the underlying network heterogeneities. Mobile application servers, such as the Oracle9iAS-wireless server, combine several middleware services into a single platform.
- **Application and user interfaces.** At the application level, consistent user interfaces are needed for seamless operations. Microbrowsers and specialized markup languages such as WML (wireless markup language) support these facilities and also provide access to back-end systems.

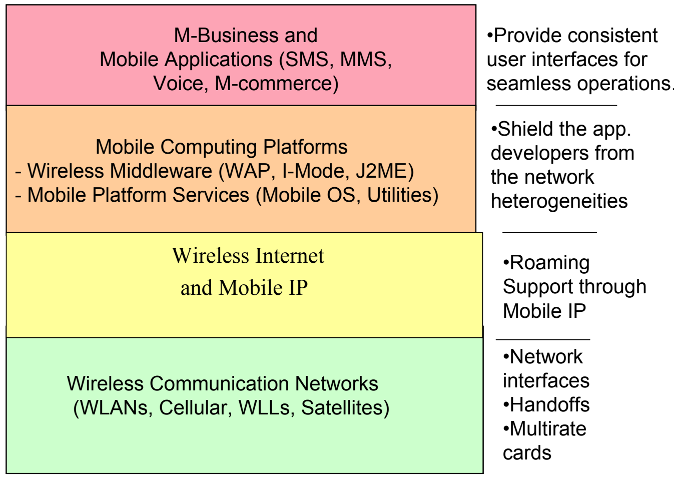


Figure 1-16: A Framework for Integration

By using many of these different technologies, mobile users can move from wired to wireless networks in a seamless manner. The mobile devices need a network adapter card that will tune to a wireless LAN or WAN as the users roam from the coverage area of LANs or WANs, respectively. For example, the mobile device will tune into a hotspot LAN when you enter the coverage area of the local LAN. The software in the mobile devices will dynamically load drivers to connect to the right type of network. The middleware and application interfaces maintain the logical connection while switching from one network to the other.

See Chapter 11 for a detailed discussion and examples of integrated architectures for wireless.

1.8.2 Wireless Security

The growth of wireless networks and mobile services over the last few years has been tremendous. Naturally, the security concerns are becoming more serious, concomitant with the growth of wireless. As more people access critical information, and as consumers begin to do their business and banking on devices that are connected over wireless LANs, MANs, and WANs, wireless security has moved to the forefront.

In essence, wireless networks face the same type of security issues (e.g., privacy, integrity, authentication) as the wired networks. Wireless security therefore is not much different from wired security. The same security concerns exist, wired or not: authenticate whom you are talking to, secure the data as it travels from the handheld device to the destination host, and ensure that the traffic has not been altered enroute. Companies such as Amazon.com and E-Trade do this in the wired world. However, wireless has some unique difficulties such as limited bandwidth, high latency and unstable connections. The main differentiating issue of wireless network security is that the information is transmitted over a common medium (the air). Thus it is easier to tap into wireless traffic.

There are a number of stories about eavesdropping of wireless traffic. For example, competitors have been able to capture the emails between HP personnel by simply sitting in the office parking lot with an antenna. Something similar also happened to Sun Microsystems. In addition, information sent by a federal agency wirelessly was intercepted and then used against the agency in a future negotiation. My own students, from a wireless network class that I taught, spent a day in Manhattan and captured a disk full of plain text (un-encrypted data) by simply driving around the Manhattan business district in a car with a simple antenna. They were just doing research to demonstrate how vulnerable wireless communications are (well, that is what they told me!). Chapter 12 discusses wireless security and attempts to answer the following questions:

- What are the core security principles?
- What are issues specific to wrireless LANs, cellular networks, satellites, WLLs, and cordless?
- How can TCP/IP security through VPNs and IPSec be used to secure wireless communications?
- How do higher-level security such as for WAP and SET interplay with wireless network security?
- Can a comprehensive wireless security procedure be developed that considers all security levels?

The issues of security are of vital importance for mobile services and need more attention. Basically, security involves the following aspects, called PIA4:

- **Privacy:** ensure confidentiality of information (i.e., no one other than the authorized people can see the information) when transmitting it over a network or storing it in a insecure place.
- **Integrity:** avoid corruption of information (i.e., no unauthorized modification allowed).
- **Authentication:** identify for certain who is communicating with you (i.e., make sure that you are who you say you are).
- **Authorization (Access control):** determine what access rights that person has (i.e., can you only read given information or can you also update, delete, add information?).
- **Accountability and Assurance:** ensure that you can tell who did what when, and convince yourself that the system keeps its security promises. This includes ***non-repudiation (NR)*** – the ability to provide proof of the origin or delivery of data. NR protects the sender against a false denial by the recipient that the data has been received. It also protects the recipient against false denial by the sender that the data has been sent. In other words, a receiver cannot say that he/she never received the data, and the sender cannot say that he/she never sent any data.

You also need to administer the security system, i.e., define and enforce the security policies that are consistent across all elements of applications, middleware services, and networks. These, and other aspects of security, are supported at various levels (network, middleware, application) by using a wide range of technologies (see Figure 1-17). Security is needed at these different levels since security at each level fulfills different requirements. Figure 1-17 can serve to build a comprehensive checklist for security design. Let us briefly review the security at various levels (details will be given in Chapter 11).

Wireless link security protects information transfer over radio links such as wireless LANs, cellular networks, satellites, and wireless local loops. Independent of the physical link, the network traffic can be encrypted at a higher level (TCP/IP) by using IPSec and VPNs. At the middleware level, SSL (Secure Socket Layer) is used for secure Web browser-Web server exchanges, and WTLS (Wireless Transport Layer Security) is used to secure WAP applications. A variety of security approaches exist at the application level, in which case authorization controls are used within applications to regulate access to specific data, and cryptographic infrastructures are built to strongly authenticate users and provide confidentiality. Examples of application level security is provided by database managers, Java Virtual Machines, email security packages (e.g., S-MIME), and SET (Secure Electronic Transactions). In particular, applications themselves provide access control and strong user authentication.

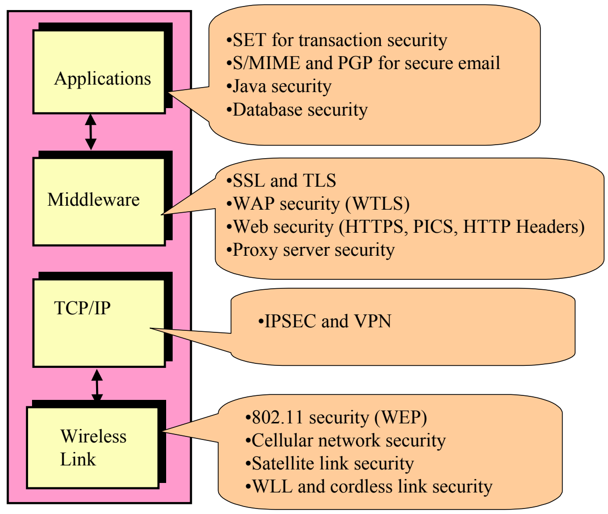


Figure 1-17: Levels of Security

Security must be considered at all levels. Securing a higher layer while keeping lower layers unsecured makes the system vulnerable to intrusions from the lower layers. In general, lack of security at a certain layer might compromise the overall system even if other layers are secured. Consider, for instance, a system where the application data is secure, but is transmitted over an insecure network. In this case, the overall security of the application could be suspect. Specifically, application security protects application data (e.g., database security mechanisms allow the data to be stored on the hosts in a protected manner) and system resources (e.g., Java Security) while SSL protects data while being transferred on the network. Detailed discussion about wireless security can be found in Chapter 12. See Umar [2004][5] for a comprehensive discussion of security.

1.8.3 Management and Support Issues in Wireless

Many examples exist where good technology was introduced but a solid business strategy did not exist. For example, the Motorola Iridium case study, described in Chapter 11, shows what happens when you have a marvelous technical vision without a good business model. It is important to tie the business and technical decisions into an overall approach, as shown in Figure 1-18. The approach starts with a strategic plan and then goes through capability evaluation, development/deployment, monitoring/control, and organizing/staffing decisions. This discussion suggests a set of iterative activities that can bring to the surface different business as well as technical views in wireless projects to avoid disasters like Iridium, Boo.com, and many others. From a management point of view, the wireless projects of any significance should iterate through the following activities:

Strategic planning takes a strategic look at business and identifies the role of mobile applications and wireless communications in satisfying the business goals. The focus is on m-business (rrecall that m-business = Internet + wireless + e-business). This activity includes asking questions such as the following:

- How will the customer benefit from m-business?
- How will the firms benefit from m-business?
- Is there a market for what we are building?
- What unique value do we provide?

[5] A. Umar, *Information Security and Auditing in the Digital Age,* 2nd ed., NGE Solutions, 2004.

- How will we make money from m-business?

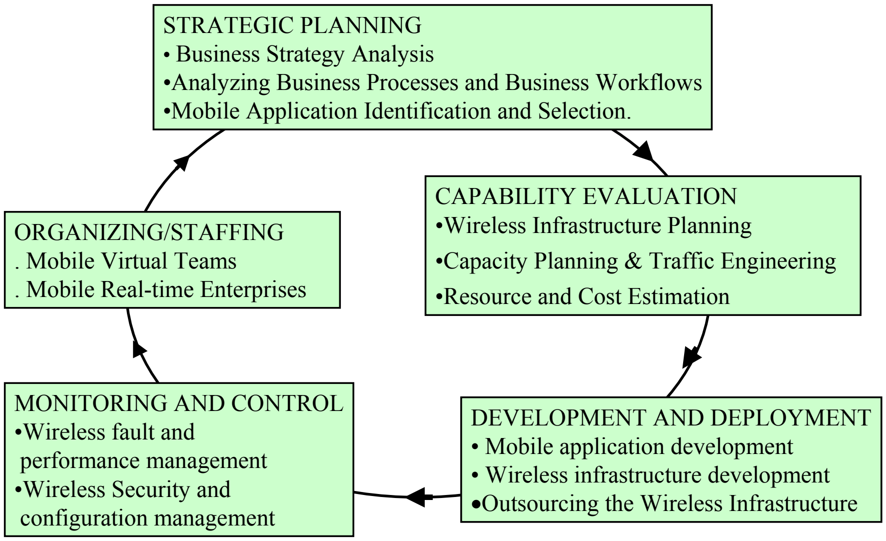


Figure 1-18: Management Activities

Capability evaluation and architecture analysis evaluates the wireless infrastructure (wireless networks, mobile computing platforms) needed to support the mobile applications and m-business initiatives identified in strategic planning. Capacity planning, traffic engineering, and cost estimation are also part this evaluation. This activity includes asking questions such as the following:

- What new capabilities are needed?
- Which ones do we already have?
- What are the basic building blocks of the solution?
- How will they fit with each other and with the existing systems?
- Will the new systems be able to handle the traffic expected?

Development and deployment reviews how the capabilities identified will be developed and delivered. The main issues are how to decide between options for purchasing, developing in-house, renting, and outsourcing, and then how to deploy the diverse array of wireless hardware/software systems needed. The specific questions that drive this process are:

- Do we need to purchase, develop in-house, rent, or outsource what we need?
- What are the best mechanisms for deploying the wireless hardware/software needed?

Monitoring and control is concerned with the day-to-day monitoring and control of the deployed systems. The purpose is to assure smooth customer services because the loss of wireless networks is a disaster at present due to the increased use of wireless LANs and cellular networks in various industries. Of particular importance are the wireless management platforms that are becoming available to monitor the network failures, performance bottlenecks, security breaches, and other problems in wireless systems. The wireless management platforms provide answers to the following questions:

- Are there any failures in the system?
- Are there any performance bottlenecks?
- Is security being properly enforced?
- Are changes in the system being propagated uniformly?

Organizing and staffing concentrates on the important issues of organizing and staffing the wireless projects. The objective is to produce an organizational structure that will adequately support the wireless projects. The specific issues are mobile virtual teams and the role of mobility to support the next generation of real-time enterprises. Questions include:

- What type of organizational structure will support the wireless projects?
- Can mobile virtual teams help?
- Can the next generation of real-time enterprises be managed through mobile computing?.

See Chapter 13 for detailed discussion and examples of these activities.

1.9 Regulatory and Standards Bodies

The regulatory environment helps as well as hinders, in some cases, the progress of wireless communications. Here is a quick review of the influential standards and regulatory bodies and the significant regulations and standards they have introduced.

1.9.1 Significant Regulatory Bodies

1.9.1.1 The Federal Communications Commission (www.fcc.gov)

The FCC was established in the United States by the Communications Act of 1934 as an independent United States government agency directly reporting to Congress. The FCC is responsible for establishing policies to govern interstate and international communications by television, radio, wire, satellite, and cable. For wireless communications, the most significant role of FCC is that it regulates all frequency allocations in the US. This, as we will see, has a profound impact on the cellular network industry.

1.9.1.2 NTIA – (www.ntia.gov),

The National Telecommunications and Information Administration is part of The United States Commerce Department. It maintains a spectrum chart that depicts the radio frequency spectrum allocations to radio services operated within the United States. The chart graphically partitions the radio frequency spectrum, extending from 9 kHz to 300 GHz, into over 450 frequency bands. Copies of this chart can be viewed online at http://www.ntia.doc.gov/osmhome/allochrt.html; and printed copies of this chart are available from the U.S. Government Printing Office (phone: 202 512 1800; stock #: 003-000-00652-2.

1.9.1.3 ITU (International Telecom Union) (www.itu.org)

Headquartered in Geneva (next to the UN), the ITU is responsible for worldwide coordination of both wired and wireless telecommunications activities. Previously known as CCITT, the ITU influences the development of telecommunications around the globe and operates several sectors, each with focus on different areas. Examples of some of the relevant sectors are:

- ITU-R (radio-communications) – several study groups and World Radio Conferences (WCRs)
- ITU-T (standards) – the activities of the former CCITT
- ITU-D (development) – for developing countries

1.9.1.4 Other Regulatory Bodies

Many regional as well as national regulatory agencies exist in different parts of the world. Here are a few examples:

- European Telecommunications Standards Institute (ETSI) for European countries (naturally)
- The British www.open.gov.uk/radiocom that is used in the UK
- Others such as the five agencies in Japan

An issue of particular importance in international wireless communications is the interference across national borders. These issues are handled through Radio Communications Bureaus.

A good discussion of different regulatory bodies and their role in frequency allocations can be found in [Bekkers 2000].

1.9.1.5 Allocation of Frequencies by Regulatory Authorities

One of the major roles the regulatory bodies play is in regulating the allocation of frequencies to various contenders. Wireless frequencies, also known as the radio spectrum, are part of the natural spectrum of electromagnetic radiation lying between the frequency limits of 9 kilohertz and 300 gigahertz. Because all wireless systems use these frequencies, allocation of these frequencies becomes a major point of contention between various parties.

The International Telecommunications Union (ITU) is actively involved in frequency allocations and for worldwide coordination of frequency use between different regions of the world. Frequency planning is conducted by the ITU Radio-communication sector (ITU-R), which has divided the world into several broad regions. In the United States, responsibility for radio spectrum is divided between the FCC and the National Telecommunications and Information Administration (NTIA). The FCC administers spectrum for non-Federal government use, and the NTIA – an operating unit of the Department of Commerce – administers spectrum for Federal government use.

One of the biggest regulatory activities is frequency allocation for cellular networks. Cellular operators in different parts of the world fight for desirable frequency bands (typically low frequencies because they need less expensive equipment).[6] It is highly desirable that the same frequency bands are used for the same technology in different parts of the world. But it does not work out that well. For example, GSM phones in the US operate in a different frequency range than the GSM phones in Europe because the FCC and the other agencies could not agree on the same frequency band for GSM. Thus, you either need a new GSM phone when you travel from US to Europe, or a "multi-band" card in the handset that operates on both frequencies. Historically, allocation of 3G frequencies has been a major issue with frequency bidding wars. Some 3G carriers paid millions of dollars for 3G frequencies. This has raised the cost of operating a 3G network extremely high. See Chapter 5 for more discussion of frequency allocations.

1.9.2 IEEE 802.11 Standards Body

The most influential body in wireless communications has been the IEEE 802 standards committee that was formed in February 1980 (hence the name 802 – second month of 1980). The focus of IEEE 802 has been on LANs and MANs (metropolitan area networks). Consequently, this committee has been responsible for the development of the following major wireless standards:

- IEEE 802.11 – Wireless LANs (also known as the Wireless Ethernet LANs)
- IEEE 802.15 – Wireless Personal Area Networks (includes Bluetooth, Wireless Sensor Networks, and UWB)

[6] Low frequency ranges are desirable because a) the low frequency waves travel longer distances and b) transmitters of lower power (cheaper) work in this range. The technical reasons behind this will be discussed in Chapter 5.

- IEEE 802.16 – Wireless Local Loops and Wireless Broadband

Although the IEEE 802 has developed many standards in wireless communications, the best-known is the IEEE 802.11 wireless LAN – almost a household name at present due to the tremendous popularity of 802.11 LANs. The IEEE 802 committee formed the 802.11 Wireless Local Area Networks Standards Working Group in 1990. The standard has been issued in several stages. The first part, issued in 1997, is simply called 802.11 and operates at 1 and 2 Mbps. The second part (802.11a), issued in 1999, operates at data rates up to 54 Mbps. The third part (802.11b), also issued in 1999, operates at data rates up to 11 Mbps and is the most widely used in the 802.11 family. The IEEE 802.11g was introduced in 2002 and operates at 54 Mbps.

The IEEE 802.15 Working Group was formed to develop standards for wireless personal area networks (WPANs) that operate in a very short range (10 meters or less). Within the WPAN family, several specifications such as Bluetooth, wireless sensor networks, and UWB (Ultra Wideband) have emerged. Bluetooth, a wireless cable replacement standard, is the oldest in this family and provided the base specifications for 802.15.

Due to the interest in WLLs (wireless local loops) that provide wireless coverage for metropolitan areas, the IEEE 802 committee started the 802.16 working group in 1999. The objective of this group is to provide standards-based solutions for implementing broadband wireless networks within metropolitan-sized areas.

The best source of information about IEEE 802 standards is the official website (http://www.ieee802.org), obviously! In addition, the palowireless site (www.palowireless.com) has good information on IEEE 802 activities.

1.9.3 IETF (Internet Engineering Task Force)

The Internet Engineering Task Force (IETF) is the main custodian of Internet developments and is responsible for the IP stack. From a wireless point of view, the main role of IETF is the development of Mobile IP – a core technology for the future wireless networks.

IETF is a loosely self-organized group of people who make technical contributions to the engineering and evolution of the Internet and its technologies. It is the principal body devoted to the development of new Internet standard specifications. The IETF is made up of volunteers who meet three times a year to fulfill the IETF mission. Unlike some other standards bodies (e.g., OMG, W3C), there is no membership in the IETF. Anyone may register for and attend any meeting. Serious folks join the IETF or working group mailing lists. The IETF is divided into eight functional areas: Applications, Internet, IP Next Generation, Network Management, Operational Requirements, Routing, Security, and Transport and User Services. Each area has several working groups. A working group is a group of people who work under a charter to achieve a certain goal such as creation of an Informational document, the creation of a protocol specification, or the resolution of problems in the Internet. Most working groups have a finite lifetime (i.e., once a working group has achieved its goal, it disbands). For information about the IETF activities, visit the IETF website (www.ietf.org).

1.9.4 Open Mobility Alliance (OMA)

While IEEE 802 is significant for the wireless networks, the Open Mobile Alliance (www.openmobilealliance.org) has gained similar significance for higher-level issues of mobile applications and platforms. OMA was established in June 2002 by a consolidation of the WAP Forum and the Open Mobile Architecture Initiative. The mission of the OMA is to help grow the market for the entire mobile industry by ensuring seamless application interoperability. Although relatively new, OMA has grown dramatically in its influence and scope. At the time of this writing, more than 300 of the world's leading mobile operators, device and network suppliers, information technology companies and content providers are part of the OMA. In general, the OMA is becoming quite influential in higher-layer (e.g., application and middleware) mobility issues.

1.9.5 Enhanced 911 (E911)

The Federal Communications Commission has published an E911 mandate that requires the wireless carriers to implement automatic location identification. The basic 911 rules require wireless carriers to provide the telephone number of the originator of a 911 call and the location of the cell site or base station receiving a 911 call. For example, if a cellular phone user calls 911, then the cellular operator is required to provide the phone number and the location of the caller to a PSAP (Public Safety Answering Point). The mandate is being implemented through phases. In the first phase, the operators are only required to report the cell ID. Later phases are requiring more accuracy for emergency services to find the caller, because a cell can be 20 miles wide. For example, Phase II of E911 requires an accuracy of 50 meters for 67 percent of calls, and 150 meters for 95 percent of calls.

The E911 mandate has provided the main driver for the very active industry of location-based services (LBS). The LBS industry is expected to reach between $7 billion and $9 billion by 2005. We will discuss LBS at length in Chapter 5. More information about the E911 mandate can be found at the FCC site (http://www.fcc.org/).

1.9.6 Telecommunications Act of 1996

The Telecommunications Act of 1996, although not directly related to wireless, has created an open and competitive environment for wireless providers. This law caused an overhaul of the telecommunications industry in the United States because it allowed anyone to enter any communications business. Before this law, AT&T was the primary provider of communication services in the US. This law caused a breakup of AT&T and forced the Bell Operating Companies to open up their local loops.[7] The Telecom Act has created a competitive environment in the telecommunications industry that has benefited the wireless industry, as many new players got into the wireless market due to the deregulation.

1.10 The Wireless Business – A Quick Scan

1.10.1 The Players in Wireless Business

Wireless is a multi-billion dollar business with a very wide range of players that provide different types of services, equipments, end-user devices, software packages, and consulting/integration support. There are many different views of the wireless business.

[7] On a personal note, this Act had a great impact on my own life. The Act caused the breakup of Bell Labs into Bellcore (Bell Communications Research) and AT&T Bell Labs. I worked at Bellcore for more than a dozen years and am still involved in many projects on a consulting basis.

Figure 1-19 shows a simplified conceptual view that uses the framework we introduced earlier (Section 1.3). The figure shows the main business sectors and illustrates one view of the complex and multidimensional aspects of wireless business in terms of the physical communication network, network transport and connectivity services, mobile computing platforms, and mobile computing applications. Some business sectors concentrate on higher-level services such as mobile applications, while others provide the low-level network elements. As expected, one large business may be involved in many business sectors, and vice versa. Similarly, many small businesses may provide different elements of one business sector. We will examine different scenarios later in this section.

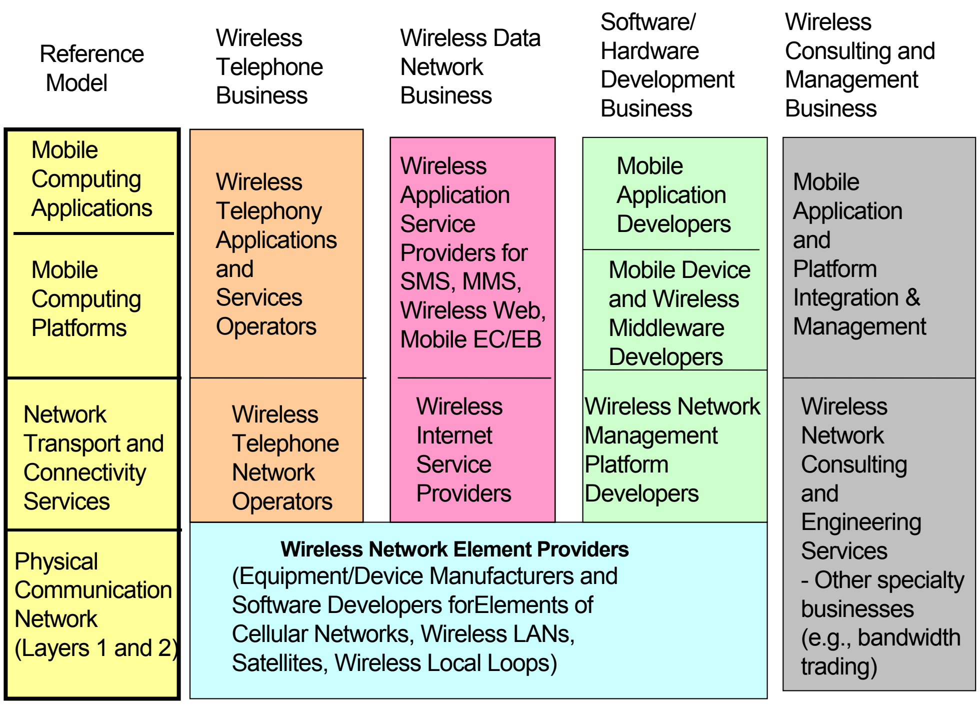


Figure 1-19: Conceptual View of Telecom Business

A major business sector, Wireless Network Element Providers, builds horizontal capabilities that are needed by many vertical businesses. Businesses involved in this sector build the basic network elements of wireless networks. For example, these businesses build base stations for cellular networks, communication satellites and satellite dishes for satellite communications systems, antennas and transceivers for the wireless local loops, and access points for the wireless LANs. Other business sectors concentrate on mobile devices (e.g., cellular handset manufacturers, PDA manufacturers, etc.) and wireless middleware providers such as WAP and i-mode gateway providers. An active business sector is the application service providers (ASPs) that support mobile applications on a rental basis (see Chapter 13 for details).

Several vertical business use the element providers' equipments and devices, and package them with other capabilities from other sectors to deliver services to different consumers. For example, the wireless telephone network businesses (e.g., T-Mobile) provide the telephone services over wireless, mostly cellular, networks. However, now some companies such as Vocerra systems are beginning to provide telephone services over 802.11 LANs. The wireless Internet service providers (WISPs) primarily enable wireless Web and mobile computing applications (e.g., m-commerce) over wireless networks. A WISP is essentially an ISP that connects its subscribers to the public Internet through *wireless* connections instead of the wired DSL, cable modem, or dial-up lines. These services are commonly provided by using IP (in some cases Mobile IP) over digital cellular networks or wireless LANs.

A large number of businesses develop software and hardware for the different business sectors – ranging from handsets to network monitors and mobile supply chain management systems. Due to the complexity of wireless systems, many wireless management and consulting businesses specialize in planning. organizing, staffing, engineering, re-engineering, and managing wireless initiatives. The consulting and management businesses can operate at lower layers (e.g., re-engineering of wireless networks, integration of wired with wireless networks) or at higher layers (e.g., management and integration of mobile applications and middleware services). See Chapter 13 for more details.

It is important to note that that the purpose of this section is to give a broad overview of the wireless business that could help in understanding the various mobile computing and wireless initiatives. The names of the companies mentioned here are not exhaustive and may change with time in this turbulent marketplace. For an up-to-date list of the key players, it is best to visit the websites such as www.palowireless.com, www.mbusinessdaily.com, and www.mobileinfo.com.

1.10.2 Example: Value Chain for Enterprise Wireless Services[8]

Let us consider an example to understand how different business sectors, and companies within the business sectors, position themselves to provide wireless services to an enterprise. Specifically, let us consider a company that wants to give wireless access to email, Internet, M-CRM and a corporate portal to its employees over a GSM network. A good way to illustrate this is to build a model that looks at every step from raw materials to the eventual end-user. This idea of showing how different activities provide value to help solve a business problem is called a "value chain" and is the foundation of competitive advantage model by Michael Porter [Porter 1998]. Figure 1-20 shows a typical value chain (based on Evans [2001]), from the network element provider to the enterprise customer. The value chain shows the main business sectors that would be involved in providing wireless access to email and Internet.

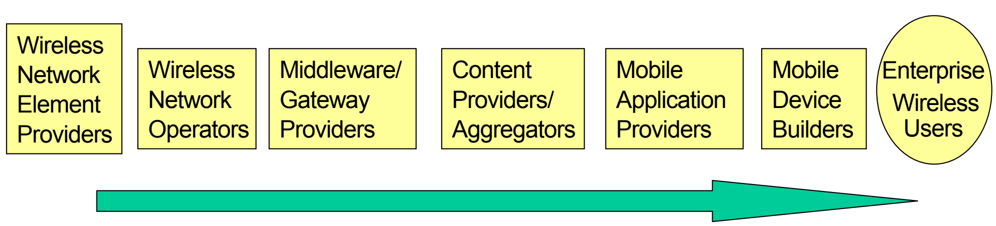


Figure 1-20: Wireless Value Chain for Enterprise User of Wireless Services

The major players in the value chain include the network components (the network elements), the operators of the wireless networks, the communications software components (including mobile computing platforms such as wireless middleware and gateways), content and application services, and the end-user devices.

The network element provider in this case provides the basic networking equipment such as the base stations and may be a company such as Cisco. The wireless network operator may be

[8] This discussion is based on [Evans 2001].

a GSM network operator such as T-Mobile or Sprint PCS. The middleware/gateway provider may be a company like Nokia that provides WAP gateways for email and Web access. The content providers in this case are of two types: the external content providers on the Internet and the corporate portal. The application provider in this case is an M-CRM application service provider. Finally, the device manufacturer may be a handset manufacturer such as Ericsson or Texas Instruments. The enterprise customer, in this example, accesses a WAP-enabled Internet site, his or her email on Microsoft Exchange, and M-CRM and the corporate portal over wireless Internet. This activity involves all players in the value chain.

This value chain may change if new services are needed. Consider, for example, that a location-based service (LBS) is needed so that the M-CRM system can send location-sensitive messages to the marketing reps whenever they are in a particular area. In this case, an LBS provider would be needed. The LBS provider may be an ASP that houses an LBS service developed by another company.

The value chain may also change if the wireless service is intended for the consumer market instead of the enterprise users. The main difference between the consumer-focused value chain and the enterprise-focused value chain is that the consumer value chain concentrates more on external retailers and content providers. Naturally this value chain becomes more complex as network operators work with any array of retailers, financial institutions, content providers, and advertisers to assemble their wireless data portals for the large consumer population. See [Evans 2001] for additional details of value chains.

1.10.3 Wireless Network Element Providers

The physical network elements (wireless access points, wireless routers, antennas, base transceiver stations, wireless adapter cards) are the basic building blocks of all wireless networks. Due to the interest in wireless communications, many companies such as Cisco, Ericsson, Lucent, Nokia, NEC, Nortel Networks, Siemens and others are building a diverse array of wireless network elements (WNEs). Examples of these WNEs include Bluetooth cards, wireless modems, wireless routers, antennas, base stations and other wireless equipment. In addition, satellite communications companies build and support satellite earth stations, transceivers, direct broadcast (DBS) stations, satellite phones, VSATs (Very Small Aperture Terminals) and other equipment needed for satellite communications. We will discuss the various network elements needed for wireless networks in more detail in Part II of this book (Chapters 5-10).

1.10.4 Wireless Telephone Network Operators

Many telecom companies at present operate wireless telephony networks. Examples of these operators, also known as wireless carriers, in the US are T-Mobile, Sprint-PCS, and AT&T Wireless, Cingular Wireless, Qwest Wireless, and Verizon. In Japan, KDDI and NTT DoCoMo are the major players and in Europe, BT Genie, NetCom, Orange, Telia, TIM, T-Mobile, and Virgin Mobile provide these services. In the Asia/Pacific region, KT FreeTel, LG Telecom, KTM.com and China Mobile are examples. These operators provide the basic cellular network infrastructure (base stations, master switching office, roaming support, etc.) to its subscribers. Although most of the wireless telephony networks at present are cellular networks, this situation could change as 802.11-based telephone services take hold in the marketplace. This will also change the infrastructure supported by these operators.

A major service provided by these operators is the connectivity of cellular networks to the PSTN (Public Switched Telephone Network). Without this support, you could not call your friend's cellular phone from your home telephone (part of a PSTN), and vice versa. Thus business agreement between a cellular operator and a PSTN operator is essential. Many telecommunications companies provide and support the PSTN. These are the local and long distance carriers such as AT&T, MCI, British Telecom, Verizon, and others. The large telephone companies are known as ***ILECs (Incumbent Local Exchange Carriers).*** In additional, several small telephone companies, called ***CLECs (Competitive Local Exchange Carriers)*** have also appeared to support rural areas. These companies own, or lease, the telephone circuits and switches.

Several general trends in wireless telephone network operators are worth noting. First, due to the close ties between PSTN and cellular phones, several ILECs are providing the cellular phone services (Vierizon and AT&T Wireless are examples) and/or merging with cellular companies (the merger of Cingular and AT&T is an example). Another major trend in the telecom industry is that the wireline and wireless carriers are seeking to leverage data services as a new value-added service offering, in addition to voice services. This provides possibly a new revenue stream and a differentiator in a highly competitive marketplace. As wireless voice services are becoming increasingly competitive and commoditized, these companies are moving into data services to minimize customer churn, increase customer loyalty and improve the bottom line. Typical data services include unified messaging and email, Internet and intranet access, and some targeted applications such as M-CRM. Yet another trend is vertical integration. Wireless companies are attempting to become full-service providers by providing the entire stack of services (network elements, the wireless network, mobile computing platforms and the applications). Vertical integration is common in many industry segments. In the computer industry, for example, many companies such as IBM and HP provide complete solutions from hardware to software.

1.10.5 Wireless Internet Service Providers (WISPs)

These providers mainly enable wireless Web and mobile computing applications (e.g., SMS, Web browsing, M-commerce, M-CRM, M-Portal) over wireless networks. As compared to the wireless telephony providers, these providers focus on data networks and data applications. Due to the popularity of the Internet, most data networks at present are based on the Internet Protocol (IP). In the wired Internet space, many companies such as Cisco and 3Com provide and support the IP network routing and flow control. Many ISPs (Internet Service Providers) in the wired world connect subscribers to the public Internet through DSL, cable modem, dial-up, ISDN, and other wired links. A WISP is essentially an ISP that connects its subscribers to the public Internet through *wireless* connections.

WISPs mainly use IP (Internet Protocol) over cellular networks or wireless LANs. IP is supported over WLANs such as 802.11, thus there is no need for extra service. However, supporting IP over older (1G and 2G) cellular networks requires additional infrastructure. For example, services such as CDPD and GPRS have been introduced to support IP over 1G and 2G, respectively (see Chapter 8 for a discussion of CDPD and GPRS). Thus CDPD and GPRS providers are WISPs. 3G cellular networks directly support IP, so no extra services are needed. A special version of IP, called Mobile IP, is used to allow users to move around without losing an IP connection. For example, you can initiate a large download and then move to another network without interrupting the download.

A major trend in WISPs at present is to support GPRS and Mobile IP. An interesting example is the Florian Flash OFDM cellular network that is based on IP and it also supports Mobile IP (see Chapter 10 for details). Another trend, mentioned previously, is that the cellular network operators are also becoming WISPs. On the other hand, WISPs are also supporting telephone applications by using voice over IP (VoIP).

1.10.6 Wireless Telephony Applications Providers

Cellular providers mainly provide telephony applications and operations. Examples are telephone support, call forwarding, call waiting, billing and customer care solutions. Many providers also offer telecom operation support systems (OSSs) that support the PSTN planning and provisioning. To illustrate OSSs in the wired networks, consider a company that needs 100 telephone lines. In this case, an OSS looks at the current telephone lines in the area and determines the unused circuits that could provide the needed telephone lines. OSSs for wired networks are built by companies such as Telcordia Technologies and Metasolve. The wireless OSSs make provision, in the same vein, for 100 new cellular phone users by looking at the base stations, MTSO, etc. Companies such as Cisco are beginning to provide wireless OSSs.

Several companies also support the call center (CC) operations through computer telephony Integration (CTI), call center outsourcing services, and call center software. Voice over IP (IP telephony), fax over IP (FoIP), interactive voice response (IVR), and universal messaging are also supported by many companies. Many firms also provide complete telecommunications business solutions such as 1-800, 1-500 and 1-900 numbers, answer & message services, calling cards, tele-conferencing, and unified messaging. These services are also provided by many cellular companies.

As mentioned previously, most cellular operators are paying more attention to wireless data services than to the wireless telephone service at present.

1.10.7 Wireless Application Service Providers (WASPs)

A major trend at present is for the wireless carriers to become wireless application service providers (WASPs) to enterprise customers. This gives an enterprise user wireless access to a variety of applications and content – an enterprise can access a set of mobile applications without investing in wireless infrastructure and application development. With this approach, the vendor provides a platform, hosted or licensed, that receives requests from mobile devices. Then, acting as a proxy for the mobile client, it uses standard Internet protocols (HTTP) to retrieve information from the ASP Website. The platform delivers the information in a format specific to the device.

Several ASPs are offering mobile/wireless application services at the time of this writing. This is result of two trends. First, many wireless carriers want to be WASPs. For example, in 2001 and 2002, almost every major wireless carrier in the United States announced plans to provide WASP services to the enterprise by teaming with systems integrators and software companies. For example, Sprint PCS announced a relationship with Compuware to deliver applications such as mobile enterprise resource planning and customer relationship management tools. Similarly AT&T Wireless announced a relationship with Accenture to wirelessly enable applications such as customer information management and inventory management, and Cingular Wireless announced a relationship with Siebel Systems to offer Siebel eBusiness Applications across Cingular wireless network [Evans 2001].

The second trend is that many traditional ASPs have added wireless access to their hosted applications, thus quickly becoming WASPs. In fact, most ASPs have announced plans to offer wireless access to their e-business applications. Examples include OracleMobile, Novarra, 724 Solutions, Broadbeam, and Snaz Commerce, among others. In addition, many wireless software vendors are providing their technology as a hosted service to the enterprise – in fact, this is how the wireless application service provider market got started. Examples of such companies include Aether Systems, Air2Web, and JP Mobile. These and other wireless ASPs offer different types of applications over different types of devices with different price structures.

In addition to WASPs, wireless data services, especially "wireless Web," is a growing area of business. An initial example of a wireless Web service was a cell phone equipped with a micro-browser via the Wireless Application Protocol (WAP). Naturally, carriers formed partnerships with multiple content providers to build "portals" with specialized content. At present, the market has opened up quite a bit – multiple content providers are offering Web access from a variety of devices by using different protocols over different types of wireless networks. A very popular example is the i-mode system from NTT DoCoMo.

1.10.8 Software/Hardware Development

1.10.8.1 Mobile Computing Applications Developers

Many software development companies build mobile computing applications that are delivered to the wireless users as shrink-wrapped packages or as hosted applications based on the Wireless ASP (WASP) model. An important strategy for these companies is to determine the "killer applications" and then build them. All these companies want to build killer applications that can sell many copies. Unfortunately, the answer is not that simple. In reality, different killer applications exist for different cultures, countries, and individual users. In the US, email via 2-way interactive pagers such as the RIM BlackBerry are quite popular. In addition, WAP-based wireless data portals providing news, stocks, and weather information have been also successful. In Japan interactive games and pictures via the NTT DoCoMo i-mode service are wildly popular, while in Europe, Short Message Service (SMS) text messaging has been a resounding success. Keeping up with trends, the killer applications will proliferate as mobile devices become more powerful and the wireless network become faster. In that case, the same applications in the wired as well as wireless space will be "killers."

The most common strategy being used by many wireless application development businesses is to take existing e-business applications and add mobility as an add-on feature to support m-business. This has led to the development of m-commerce, m-portal, m-CRM, and several other "M" applications. We will look at these applications more closely in Chapter 2. Naturally, the businesses adopting this strategy are the ones that developed many e-business applications. Thus companies such as Oracle, Siebel, PeopleSoft, SAP, and others are using this model. A different strategy is to develop fundamentally new applications that are unique for wireless. Many location-based applications to support E-911, child finders, and location-based routing fall into this area. Companies such as Cell-Loc, Openwave, and SignalSoft provide location-based services. In addition, applications for wireless sensor networks and mobile ad hoc networks fall into this category.

1.10.8.2 Mobile Computing Platform and Mobile Device Manufacturers

Many companies are building the wireless middleware, gateways, and mobile application servers. These businesses build WAP gateways, i-mode gateways, and wireless application development platforms. The key players are Nokia (WAP Gateway), NTT-Docomo (i-mode Gateway), IBM (Websphere with mobility support), and Microsoft (Mobile Internet Toolkit). We will look at these technologies and players extensively in Chapter 4.

In addition, many mobile device providers (e.g., cellular handset manufacturers, PDA manufacturers, pocket PC builders, etc.) are in the marketplace. These providers build the handsets plus the operating systems and software that resides in the handset. Examples of the companies that build operating systems for mobile devices are Microsoft, Openwave, Palm, and Symbian. The device manufacturers players include Compaq, Ericsson, Mitsubishi, Motorola, NEC, Nokia, Palm, RIM (Research in Motion), Sony, and Symbol.

1.10.9 Wireless Consulting, Engineering and Management (CEM) Business

As the complexity of wireless/wired data and telephony networks grows, the number of companies that provide consulting, engineering, and management services is also growing rapidly. For example, telecommunications consulting services provide network design, network security, network integration, call center consolidation, and phone rate audit services. Many companies are exclusively providing wireless network support ranging from satellites to cellular phones. As can be expected, many of the network element manufacturers and PSTN and data network providers are leveraging their expertise to succeed in the consulting business. A good example is Lucent Technologies.

1.10.9.1 Wireless Network Integration Business

Wireless network integration is a multi-billion dollar business activity at present, for numerous consulting companies that include large firms such as EDS and Cisco as well as smaller niche players such as Sterling and Vega. Although different things can fit under the general umbrella of wireless network integration, the main focus is on tying the wide range of wireless and wired network hardware/software components together to form a functioning network that satisfies the organizational requirements. Various aspects of network integration include:

- Secure, fast, and reliable end-user access (e.g., DSL, Cable Modem, Wireless) to a network service provider
- WAN network design that connects many local sites and provides high-bandwidth data transfer through packet-switching systems over fiber-optic and wireless links
- Corporate Intranet upgrade that may involve faster LANs (e.g., 802.11g instead of 802.11a, Gigabit and 100 Mbps Ethernet instead of 10 Mbps Ethernet) without disruption of services
- Introduction and deployment of wireless networks (cellular, satellites, wireless LANs) that interconnect with many existing wired networks
- Seamlessly introducing or upgrading network security services that span wired and wireless networks for corporations

The key technologies in network integration are the access points, base stations, routers, gateways, and bridges. From a business point of view, many business opportunities in developing countries exist at present for network integrators. For example, as some of the developing countries such as China, Pakistan, India, Thailand, Egypt, Brazil, and others attempt to move to the Internet and wireless networks, the basic network infrastructure needs major overhaul. In addition, many network integration projects at the time of this writing are focusing on wireless networks and network security issues. We will discuss these issues in Chapters 11 and 12.

1.10.9.2 Wireless Network Management Business

Management of wireless networks (cellular, WLAN, WLL) is another vital area of business activity. Several network management platforms for wired networks are commercially available from companies such as IBM (e.g., Netview and Tivoli), Hewlett Packard (e.g., Openview), and Computer Associates (e.g., Unicenter). These platforms allow monitoring and administration of networks and provide software for fault management, security management, and performance management of networks. The network management platforms for wireless are in their infancy at present. See Chapter 13 for an extensive discussion of wireless network management platforms.

1.10.10 Frequency Auctioning and Bandwidth Trading Business

Bandwidth trading is an active telecom business in wireless as well as wired networks and should be mentioned in this discussion. Let us first briefly examine the wired network situation. At present, many network providers have excess capacity that they would like to sell to anyone who needs it even for a short time. For example, you may need extra bandwidth to host a one-week conference in London. For this purpose, you can contact a bandwidth trader (a broker) who will try to find you cheap bandwidth from network providers that have unused telecom facilities. Trading bandwidth capacity is inherently a case of emarkets. The traders are all connected through a network, and the commodity being traded can be "delivered" entirely through software. Thus telecommunications capacity is starting to be bought and sold under radically new models, more closely related to the Wall Street commodity markets than to the traditional long-term contracts between carriers. In 1999, the field of bandwidth and voice-minutes trading exchanges was populated by about 15 companies, ranging from startups such as Arbinet in New York, RateXchange in San Francisco, and the London-based Band-X to large corporations such as the former energy giant Enron. The market has slowed down somewhat, with about 5 players at present.

While bandwidth is being traded in the wired network market, the frequency allocations are being traded in the wireless space with the same zeal. The main problem is that some frequency bands are highly desirable for the wireless operators, so they compete for them diligently. Many auctions are held around the globe, especially in Europe, to sell available wireless frequency bands. See, for example, the FCC site (http://wireless.fcc.gov/auctions/data/bandplans.html). Some "entrepreneurs" buy a bunch of desirable wireless frequencies in the low-frequency range and then sell them to the highest bidder. This practice is similar to the Internet domain name selling where some people buy a bunch of appealing domain names and then sell them for profit. As mentioned previously, auctions for 3G cellular frequency licenses have been very active around the globe because in order to provide 3G phone services, the providers must own the license to operate in those frequency ranges. Some companies have bid for 3G bands in billions of US dollars. Many countries have made a great deal of money by auctioning their 3G frequency bands. For example, Britain alone earned $32.2 billion in 2000 when the 3G frequencies were heavily sought after.

1.11 Short Examples and Case Studies

1.11.1 UPS Uses Wireless Communications

Fedex introduced a wireless network application to keep track of document and parcel shipments in the early 1990s. Pressured to respond with a similar or better service, UPS introduced a nationwide cellular-based wireless data service in 1993. Since then, UPS has exploited wireless, Internet and supporting technologies to achieve a competitive advantage as well as to improve worker productivity. The project has gone through several stages of evolution.

Pre-1996 Developments. Through cellular networks and a broad alliance of more than 70 cellular carriers, package-delivery information is transmitted from the company's 50,000 vehicles to the UPS mainframe repository in Mahway, NJ. This enables UPS to provide same-day package-tracking information for all air and ground packages. UPS uses DIAD (delivery information acquisition device), a custom-built electronic data collector that captures both delivery information and customers' signatures. This data is then entered into the cellular network through Motorola-supplied cellular telephone modems. The cellular network provides the connection between UPS vehicles and UPSnet, UPS' private telecommunications network. These systems are set up to be fault-tolerant, with cellular redundancies, dual access to UPSnet, and multiple connections to the data system.

The DIAD, custom built for UPS by Motorola, is a handheld electronic data collector that UPS drivers use to record, store, and transmit information. This helps UPS to keep track of packages and gather delivery information on site. The DIAD digitally captures customer signatures and package information – this capability enables UPS to keep accurate, paperless delivery records. The UPS field workers insert the DIAD into a vehicle adapter that in turn is connected to a cellular telephone modem (CTM) that transmits information from the UPS vehicle to the cell sites. The information is then routed through a cellular network to the UPSnet packet switching network. This network transmits the information to the UPS mainframe in Mahwah, NJ. Once the information is incorporated into the delivery-status database, it is available to the company's customer service representatives. The UPS circuit-switched cellular data network service is a very comprehensive radio system that covers a very wide area and is quite reliable. It provides immediate access to delivery information on more than five million UPS packages daily. Southwestern Bell, GTE and PacTel all played key roles in putting together the cellular network consortium of more than 70 carriers.

1999 Update to UPS Infrastructure. UPS has replaced its DIAD hardware with DIAD III – also manufactured by Motorola. It is also now using the Motient network. Due to these improvements the transit time for dispatch of information in real time has been reduced significantly.

2000 and Beyond Update to UPS's Use of Wireless & Mobile.

- UPScan – brand name of UPS's future parcel tracking application. UPS has started investigating both Bluetooth and wireless LAN technologies for local area access within its warehouses and customer drop-off centers in order to automate various business processes to a greater degree than what it was able to do before. UPS says that this initiative might cost UPS over $100 million during the next five years. While this capital expenditure sounds high, UPS expects quick payback in 16 months. This is quite significant, indeed.
- UPS will reduce 9 different wireless platforms to three over the next five years.
- Currently UPS uses 200,000 RF (wireless) terminals of different flavors – 18 models from 13 different vendors. This variety of devices is expected to be reduced to a small number (maybe two to three).
- The most important wireless device is the new Delivery Information Acquisition Device (DIAD) – code named Rub. This new device will be the fourth generation DIAD (DIAD I was installed in 1989, DIAD II in 1992 and DIAD III was installed in 1999).
- Another device that UPS is using internally in the warehouse (not in the driver's van or truck) is called Emerald – built by Symbol, equipped with a scanner attached to the employee's fingers and connected to a device worn on the worker's belt. As soon the information is scanned from a parcel, it is transmitted in real-time and updates UPS's

backend databases. Emerald is expected to be used for other in-warehouse tasks, such as tracking hazardous materials, fuel consumption, and issuing routing instructions to forklift operators.

- Within warehouses, UPS will use wireless LANs – it will install access points in these locations.
- UPS expects to install a fixed-mount wireless system called Saphire – either attached to a wall or inside a vehicle. Saphire is like a wireless access point. Within a building, Saphire is connected to either a fixed line network or a wireless LAN. In the vehicle, it will be connected through a wide-area wireless network.
- UPS expects to reduce the number of OS platforms for devices, and servers as well, during the implementation of its future mobile architecture.

Business Justification and Unique Features of UPS Application. UPS has estimated the total cost of the project at around $150 million. Senior executives point out that the resulting increase in market share – let alone retention of the company's competitive edge – completely justifies the investment. In addition to the business imperative, UPS cites the following benefits from the application:

- Higher productivity of operational staff resulting from the revamping of processes and reductions in parcel-handling times
- Improved accuracy; elimination of illegible handwritten records
- Speedier package delivery and tracking
- More information available for customer verification of package delivery and receipt

The UPS project is characterized by the following features:

- A unique implementation of analog circuit-switched cellular networks that meets UPS' wireless and OLTP file transfer application designs (the customer service inquiry application is based on wired networks)
- The business justification for implementation was based on a perceived need to maintain a competitive advantage, rather than on economic considerations.
- The complete re-engineering of package-handling business processes
- A unique ability to capture signatures on handheld, pen-based custom computers
- Huge back-end legacy systems (primarily IBM) – 15 mainframes with over 16,000 MIPS processing power and 149 terabytes of Database store – considered the world's largest IBM DB2 installation

Lessons from UPS & Fedex Projects for the Courier Industry (Source – Editors of MobileInfo Site)

As mobile computing consultants, we would like to suggest the following points to other organizations investigating similar solutions:

- Most courier companies (including small ones) can benefit significantly from mobile computing solutions, with positive ROI in 2 to 3 years. The question you should ask is not if but when, and how, to implement it.
- You need not (and should not, unless you are that big) utilize custom hardware. There is off-the-shelf hardware available now to serve most functional needs.
- The underlying wireless networks are improving and should be taken advantage of. Earlier CDPD networks (packet switching over 1G cellular) are now being replaced by GPRS (2.5G) networks. Satellite coverage is required for transportation companies, not for parcel delivery companies.

Sources:

- www.ups.com
- http://www.mobileinfo.com/Case_Study/ups.htm

- *InformationWeek* magazine (www.informationweek.com) – June 2001

1.11.2 Sample m-Business and m-Government Initiatives

Many case studies and examples of m-business and m-government can be found in the literature. Due to space limitations, here are a few examples, just as illustrations. For additional case studies and examples, visit the websites such as www.ebstrategy.com, www.mbusinessdaily.com, www.mobileinfo.com, www.ec3.org/Downloads/2001/m-Government, and http://www.e-devexchange.org/eGov/topic4.htm.

Progressive Insurance Corporation is taking a long-term strategic approach to improving customer service by investing in mobile technology to acquire, serve, and retain customers. The company is deploying mobile field service to streamline its claims processes and boost customer satisfaction. Progressive's claims representatives can perform up to 20 different transactions in the field on a single site visit. In addition, it highlights a potentially profitable application of mobile technology in one-to-one pricing of insurance services. As a result, progressive is growing much faster than the rest of the auto insurance industry, and enjoys profit margins of 8%. This is in stark contrast to its peers, who have been losing money due to underwriting losses over the past few years. See the full case study at http://www.ebstrategy.com/case_studies/Progressive.pdf.

The state of Oregon has embarked on many m-government initiatives. One of them, the Traffic Management Operations Center in Portland, is using GPS to keep track of their emergency management vehicles. The state is installing full-motion video cameras, using 802.11b technology, along the Highway 26 corridor. The 802.11b communications technology is being used between weigh-in-motion offices to help keep vendor trucks flowing through Oregon. The City of Portland has a wireless network that is used for notifying bus riders when their bus will be at their site. This system also helps with traffic flow and other traffic management issues.

London Ambulance Service (LAS), the largest ambulance service in the world, has deployed a wireless solution that is capable of differentiating between five different wireless connections including two GPRS networks, two GSM networks and their 802.11 wireless network. This application resulted in Best Practices in Mobile & Wireless Award for LAS in the Innovation and Promise category. Serving a vast area of approximately 620 square miles, LAS handles over 1 million calls per year through 70 stations. A solution was needed that would enable LAS to simultaneously switch between multiple wireless wide area (WWAN) and wireless local area (WLAN) network connections. The solution is based on the **Broadbeam ExpressQ** Wireless Platform that provides automatic switching between multiple wireless networks. Now, when a London Ambulance vehicle leaves the 802.11b WLAN environment, its connection can seamlessly switch to the GPRS (general packet radio service) and GSM (global system for mobile communication) networks as they become available for seamless communication. This allows the ambulance to stay in constant touch with different centers as it travels through different parts of London and surrounding areas. Source: http://mobile-data.microbus.com/news/news_las.html

1.11.3 Sample Wireless Internet Services

Many Web content and network service providers are offering wireless Internet services. Here is a very short sampling of a few for illustrative purposes.

Digital PocketNet Service is an early example of a wireless Internet service offered by AT&T Wireless. This service provides access to WAP-enabled websites, email, address book, calendar, alerts, and to-do functionality for the cellular phone. The users can customize the settings of their wireless data services either directly on the cellular phone or via the AT&T website at http://www.att.com/mypocketnet. For example, the website can be used to enter favorite links to websites or favorite phone numbers. The personal website provided by AT&T Digital PocketNet Service is powered by InfoSpace. Additionally, FoneSync software from Openwave is used to provide synchronization capabilities between the PocketNet Service and a user's Personal Information Management (PIM) software, i.e., Microsoft Outlook, Lotus Notes, Lotus Organizer, Symantec ACT!, and Goldmine. (Source: Evans [2001]).

AOL has announced AOL Anywhere, which makes AOL services available on numerous mobile devices such as cell phones, PDAs, and TVs. Offering different products aimed at different market segments is one of the main strategies of AOL. For email and instant messaging, for instance, the AOL product Mobile Communicator is available to subscribers. The Communicator uses Cingular's Mobitex network and is a customized version of Research in Motion's (RIM's) two-way pager. This product is not designed for surfing the Internet because it is basically a short messaging service (SMS) – it displays only a few characters at a time and can be used for real-time access to crucial information and to respond to email through short messages. For Web surfing and online shopping, another service called AOL Handheld is offered. AOL Anywhere runs on any Internet-enabled mobile phone such as AT&T Wireless, Sprint PCS, T-Mobile, Verizon, Voicestream and Nextel. The features include email, news, stock portfolios, local guides, etc. The content can be personalized by setting up preferences by using My AOL. (Source: http://www.aol.com/).

Yahoo! Mobile is an initiative by Yahoo to provide Yahoo! access on mobile devices. The capabilities include Yahoo! Messenger to send and receive instant messages, and connect with friends and colleagues; Yahoo! Mail to read, reply, and send emails; and variety of text-messaging services. It provides capabilities to create alerts so that real-time updates can be delivered ("pushed") to your phone and, of course, to access the Web by using mobile versions of Yahoo! services. Perhaps the most interesting service is "Find a Wi-Fi Hotspot" that allows the subscribers to locate a wireless hotspot and connect to the Internet through the hotspot. (Source: www.yahoo.com).

1.12 Concluding Comments

Mobile computing and wireless communications is an area of tremendous interest and potential growth due to the large number of subscribers to mobile telephones, growing popularity of wireless LANs, exciting developments in broadband wireless, increased reliance on mobile devices, and many new mobile computing applications. This chapter has given a broad overview of the subject matter in terms of the following building blocks of a systematic framework:

- Mobile computing applications that support the popular m-business, m-government, and mobile life business initiatives
- Wireless networks that transport information over wireless media to connect mobile as well as fixed users, databases, applications, and content providers
- Mobile computing platforms, especially the wireless middleware services that are needed to support mobile computing applications over wireless networks
- The architectural, security, and management/support issues in building, deploying and managing wireless systems in modern settings

- The relevant regulatory and standards bodies and their role in this dynamic field
- The different types of businesses in the wireless landscape and the type of services they provide

This chapter has exposed you to different aspects of a framework for discussion that was introduced in Section 1.3 (shown below). Later chapters of this book systematically follow this framework and present more details about the topics introduced in this chapter.

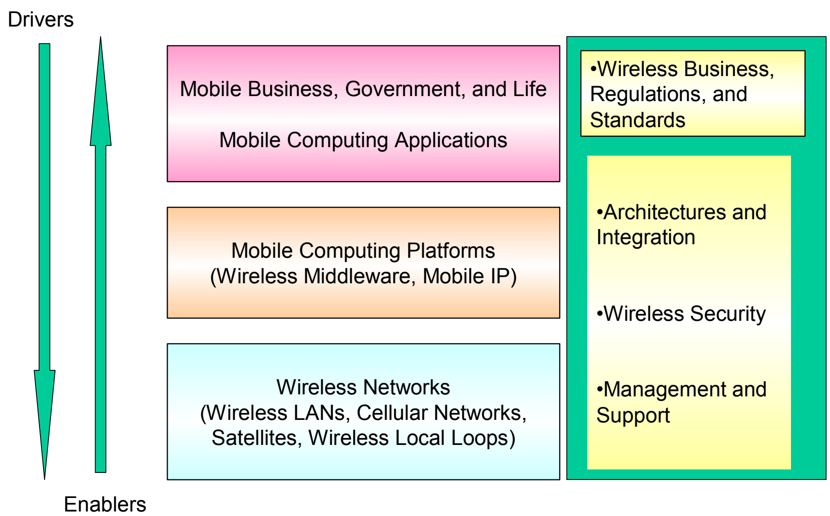


Figure 1-21: Framework for Discussion – Levels of Issues

1.13 Suggested Review Questions and Exercises

1) How is m-business related to e-business, m-government, and mobile life?

2) In your view, what are the top 3 strengths and weaknesses of wireless systems? Rank them in order of priority. What can be done to address the weaknesses?

3) What are the main building blocks of the framework introduced in this chapter? Show the framework as a table identifying the main elements of each building block. Can you suggest an improvement/extension of this framework?

4) What are the key mobile applications that support m-business, m-government, and mobile life? Which ones of these applications are common to all and which are specific to specific areas?

5) What is a mobile computing platform, what are its main components and how do these components support mobile computing applications?

6) What is wireless Internet and what role does Mobile IP play in wireless Internet?

7) What is wireless middleware and how does it differ from wireless gateways? Give an example.

8) What are the main elements of wireless networks? What is the fastest wireless network and what is the slowest? Which wireless networks go the farthest and which ones are designed for the shortest distances?

9) Consider a corporation with several regional offices, some of them overseas. The corporate office has many buildings in the same area. Choose wireless networks for each office (assume all offices are roughly of the same size) and for interconnectivity between the offices.

10) What is an integrated architecture and why is it needed for a wireless system?

11) Why is security such an important issue in wireless? List the main issues and approaches to deal with wireless security at various levels.

12) What are the main management and support issues in wireless? Why are they important?

13) List the main players in the wireless business. Suggest another framework for categorizing and analyzing the burgeoning area of the wireless business marketplace.

14) Develop a few value-chains for different wireless businesses. Suggested businesses: wireless network operator, wireless application service provider, and a wireless integration firm.

1.14 Additional Sources for Information

Some Useful Books

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Umar, A. *e-Business and Distributed Systems Handbook: Platforms Module*. NGE Solutions, 2nd edition, 2004.

Umar, A. *e-Business and Distributed Systems Handbook: Management Module*. 2nd ed. NGE Solutions, 2004.

Walker, J., editor, *Advances in Mobile Information Systems*. Artech House Mobile Communications Library, December 1998.

Some Useful Web Links

- www.palowireless.com: a very good website with nice tutorials, news, and sources for additional information on most topics of mobile computing and wireless communications
- www.mbusinessdaily.com: M-Business Magazine Website. A good site for industry developments and news
- www.mobileinfo.com: Mobile Info website with many case studies, examples, and analysis
- www.openmobilealliance.org: Open Mobile Alliance website. OMA has gained significance for higher-level issues of mobile applications and platforms and currently includes the WAP Forum.

- www.pcsdata.com: PCS website
- www.gsmdata.com: GSM website
- www.wlana.com: Wireless LAN Association Website
- www.pcca.org: Portable Computers and Communications Association
- www.bluetooth.com: the Bluetooth Website)
- http://www.satcoms.org.uk/: UK website for satellite communications
- www.wlana.org: Website for the Wireless LAN Association

Online and Other Magazines

- *Mobile Computing & Communications* (mobilecomputing.com)
- *Wireless Design Online* (wirelessdesignonline.com)
- *Wireless Design & Development* (wirelessdesignmag.com)
- *Wireless & Mobility* (wireless mag.com)
- *Wireless Review* (wirelessreview.com)
- *Wireless Systems Design* (wsdmag.com)
- *Wireless Week* (wirelessweek.com)
- *IEEE Wireless Communications Magazine*
- *IEEE Networks Magazine*