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Developing a Framework for the Intelligent Wireless Web

In this chapter, we define what we mean by the Intelligent Wireless Web and discuss compatibility, integration, and synergy issues facing the five central technology areas that we believe will form its framework:

1. *User interface:* Transitioning from the click of a mouse to speech
2. *Personal Space:* Transitioning from local systems connected by a tangle of wires to interconnected multifunction wireless devices
3. *Networks:* Transitioning from a predominately wired infrastructure to integrated wired/wireless systems
4. *Protocols:* Transitioning from the current Internet Protocol (IP) to Mobile IP
5. *Web architecture:* Transitioning from dumb and static applications to those that are intelligent and dynamic

Wouldn't it be great just to tap your "combadge" and be able to speak to anyone, any time, anywhere—the way they do on *Star Trek*? Or to say "Computer," followed by a perplexing question, and receive an intelligent answer?

It is not difficult to imagine that, in the foreseeable future, advances in information science, the Internet, and communications will continue at a very rapid pace and that technology convergence will begin to yield major improvements in the usefulness and productivity of technology. Science fiction may become reality as technology provides devices that increasingly mimic the features of the *Star Trek* "combadge."

In reality, advances in technology have frequently followed the imagination of futurists and science fiction writers, but it is much more difficult to chart the course of technology development than it is to imagine the end point. Building the Intelligent Wireless Web requires developing the framework in which a science fiction-like end point can be achieved through advancement in five technology areas—areas in which considerable ongoing work is being successfully performed so that convergence[1] will enable the next major advance in productivity.

To begin, it is important to describe what we mean by the "Intelligent Wireless Web." Let's take each term in turn, explain how we are using it, and indicate how each relates to the contents of this book. First let's consider what intelligence in the Wireless Web implies.

- **Intelligence:** Although most people have an implicit understanding of what is meant by the word *intelligence*, there is little agreement, even among experts, on precise definitions. This is true for both biological systems (that is, human beings) and machines. Intelligence usually refers to the ability to reason, solve problems, remember information, and learn and understand new things. A chess player who can conceptualize and evaluate large numbers of alternative positions for the next few chess moves is thought to demonstrate intelligence. A mathematician who can calculate a complex math problem in his mind demonstrates a different type of intelligence. The child prodigy who can memorize a vast number of facts shows yet a different form of intelligence. Yet each of these forms of human intelligence has been well demonstrated by modern computing systems. Computers are at their best when used as tools in solving complex problems that require brute-force calculation and prodigious amounts of memory. And we have all observed the dominance of Deep Blue, the chess-playing supercomputer from IBM that finally, in May 1997, beat the best chess master in the world, the reigning World Champion, Garry Kasparov.

  Notwithstanding the difficulty of defining intelligence (in humans or machines), it is worth recognizing that terms such as *artificial intelligence, intelligent agents, smart machines,* and the like refer to the performance of functions that mimic those associated with human intelligence. These topics are reviewed in Chapter 6. Although one can formulate the concept of an intelligence quotient (IQ) for humans as a surrogate measure of the phenomena we associate with human intelligence, a similar concept of "Web IQ" or "Web per-

1. Technology convergence is expressed in several different ways. We see hardware convergence of products such as pagers, cell phones, and personal digital assistants where the features found in different devices are gradually being incorporated into multifunction devices. Functional convergence is seen in the use of the personal computer for such functions as telephone communications, audio and video broadcast reception, and a player for DVD movies. Software convergence is seen in the interoperability of office software packaged as a suite of programs.

formance index" will someday likely be developed to provide measures of the effectiveness of hardware and software systems in achieving the goal of delivering intelligence through their applications and of learning and growing in time.

- **Wireless:** "Wirelessness" is the current rage. In a sense, the term *wireless* is self explanatory and obvious. Even so, the current emphasis on development of new wireless technology is a symptom of the present evolutionary trend in information technology toward convenient, mobile access to information systems any time and anywhere.

  It's interesting to consider the development of telecommunications technologies over the past century and to note that hardwired connection has been the norm for communications for most of that time (for example, telegraph and telephone services), whereas, for broadcast information (for example, television, radio), wireless transmission has been the usual method. In the last few years, this arrangement has been dramatically altered. Both television and radio are frequently delivered to the home by hard wire (for example, coaxial cable) whereas telephone communications is rapidly shifting toward wireless delivery (that is, cell phone). In the rapid expansion of cell phone usage, we have become quickly accustomed to the idea of any time, anywhere connectivity. Expansion of this idea to include the full range of information services is the logical next step, and we are seeing the introduction of a variety of portable user devices (for example, pagers, personal digital assistants [PDAs], Web-enabled cell phones, small portable computers) that have wireless connectivity. Thus, although wireless connections among devices in our local area networks (LANs: see Chapters 4 and 5) are an important development, the extension of information services to the mobile user is perhaps even more exciting.

- **Web:** The word *Web* is another widely used but somewhat ambiguous term. Although it is usually used interchangeably with the term *Internet*, the distinction

The Internet and the World Wide Web

The Internet can be considered to be a huge network of networks. It links networks and users together through the use of a layered set of protocols known as Transmission Control Protocol/Internet Protocol (TCP/IP).

Computers connected to the Internet run software to access and view information. The Internet itself is the transport medium for the information stored in files or documents. Computers on the Internet may use any of the following Internet services:

- Electronic mail (e-mail) to send and receive mail or access e-mail based discussion groups
- TELNET or remote login to log onto another computer and use it remotely
- File Transfer Protocol (FTP) to rapidly retrieve complex files intact from a remote computer

The World Wide Web (WWW, the Web) is a set of protocols and standards for multimedia information exchange on the Internet. It includes the HyperText Markup Language (HTML), HyperText Transfer Protocol (HTTP), and Uniform Resource Locator (URL).

> between these two terms is itself interesting. The historical development of the Internet extends back nearly 40 years to concepts that were introduced for a highly reliable, fault- and damage-tolerant network of interconnected computers. At a critical stage in the resulting evolution of the Internet as a network of networks, the World Wide Web was introduced (in 1989) as a set of tools (that is, programs, protocols, and standards) to permit the creation, display, and transfer of multimedia information. Many attribute the rapid growth of use of the Internet to this critical development.
>
> Thus the term *Web* can be considered a shorthand term for the World Wide Web, but the common usage of the term is broader than this and is inclusive of the entire Internet, including the multimedia enhancements. The Web is what the Internet has become in its current form—a large, rapidly growing, multimedia-enabled network of networks.

But why do we suggest putting all three of these terms together into one concept—the Intelligent Wireless Web? It is certainly possible to develop intelligent applications for the Internet without media (that is, audio/video) Web features and/or wireless capability. It is our suggestion, however, that Web media, such as audio, can lead to improved user interfaces using speech and that small wireless devices, widely distributed, can lead to easier access to large portions of the world's population. The end result could be not just an intelligent Internet but a widely available, easily accessible, user-friendly, Intelligent Wireless Web.

As a result, the concept of an Intelligent Wireless Web weaves together important concepts related to the growing and evolving system of information technology software and hardware known as the Internet. Intelligence (in particular, the ability to learn) and "wireless" (with its attendant mobility and convenience) promise the delivery of increasingly capable information services to mobile users any time and anywhere.

Fundamentally, our vision for the future of an Intelligent Wireless Web is straight forward—an Intelligent Wireless Web is a network that provides any time, anywhere access to information resources with efficient user interfaces and applications that learn and thereby provide increasingly useful services whenever and wherever we need them.

What exactly do we want our future communications and information processes to become? How can we construct such a system? In the following sections, we will lay out the framework and building blocks for future communications and information resource processes that will enable the construction of the Intelligent Wireless Web.

The Wireless Communication Process

Where were you the last time the stock market dropped? Chances are you were in a car, in a meeting, or walking to your next appointment. In other words, you were away from your personal computer (PC) and unable to check your portfolio or make vital trades.

Or how about the last time you opened up your notebook computer and were unable to readily connect to your company network to transfer that all-important business report you were sure would guarantee your next promotion.

Today, our desire for immediate satisfaction in conveying our message is growing exponentially. How fast we communicate is becoming as important as what we have to say. The challenge is that we urgently want our technology to provide communication at a distance as conveniently as we communicate face to face. From e-mail to paging, fast is just not fast enough.

As we enter the twenty-first century, the use of wireless communication technologies—cellular telephones, personal communication systems (PCSs), satellite phones, paging systems, wireless modems, and local area networks (LANs), plus local multipoint distribution services (LMDS) for wireless delivery of television and Internet service—is expanding rapidly. The proliferation of components and devices offers multiple options for communication development.

Ideally, we would like the future wireless communication process to start with a user interface based on speech recognition by which we merely talk to a personal mobile device that recognizes our identity, words, and commands. The personal mobile device would connect seamlessly to embedded and fixed devices in the immediate environment. The message would be relayed to a server residing on a network with the necessary processing power and software to analyze the contents of the message. The server would link to additional Web resources that could then draw necessary supplemental knowledge from around the world through the Internet. Finally, the synthesized message would be delivered to the appropriate parties in their own language on their own personal mobile device.

Sounds good, doesn't it? But how is it going to be constructed? The ideal future wireless communication process will require us to explore the following inherent relationships of communications along with their essential components:

Part I: Connecting people to devices—the user interface. Currently, we rely on the mouse, keyboard, and video display. Speech recognition and understanding deployed for mobile devices is a key component for the future.

Part II: Connecting devices to devices. Currently, hardwired connections between devices limit mobility and constrain the design of networks. In the future, the merging of wired and wireless communication infrastructure requires the establishment of wireless protocols and standards for the connection between devices. Future smart applications require the development and improvement of artificial intelligence (AI) methods. Ultimately, a method is needed to measure the performance and/or intelligence of the Internet so that we can assess advancements.

Part III: Connecting devices to people. To deliver useful information to the globally mobile user, future systems require advances in speech synthesis and language translation.

We will present these topics in the subsequent chapters of this book, arranged according to these three parts.

By addressing these relationships between and among people and devices, and in particular by addressing the identified essential components for future systems, current systems of information services and communications can be dramatically transformed from their current limitations to a future of spectacular broadband global delivery.

Several challenges exist to the development and deployment of scalable, production-level, Intelligent Wireless Web applications. These include

- Device proliferation
- Bandwidth and interface limitations
- Applications with limited capabilities
- Emerging wireless standards

But perhaps the most daunting challenge is the integration, synthesis, and interfacing of these elements.

So, just how can the Web become smart enough to fulfill the vision of a robust global mobile system providing increasingly relevant and intelligent applications? The development of the physical components and software necessary to implement the Intelligent Wireless Web requires insight into the compatibility, integration, and synergy of the following five emerging technology areas:

1. *User interface:* To transition from the mouse click and keyboard to speech as the primary (but not exclusive) method of communication between people and devices
2. *Personal space:* To transition from connection of devices by tangled wires to multifunction wireless devices
3. *Networks:* To transition from a mostly wired infrastructure to an integrated wired/wireless system of interconnections
4. *Protocols:* To transition from the original IP to the new Mobile IP
5. *Web architecture:* To transition from dumb and static applications to new applications that are intelligent, dynamic, and constantly learning.

As the Web matures, the information technology community seems to be viewing the Web as a global database with a knowledge representation system. Although a database management system is simply a collection of procedures for retrieving, storing, and manipulating data, it is also possible to view the Web in terms of applied learning algorithms in which data is taken from a database as input and, after appropriate algorithmic operations (based upon statistics, experiment, or other approaches) are performed, an output statement is returned that contains enhanced data, thereby representing a form of learning. In building the Intelligent Wireless Web, we are seeking to create a Web that learns, yielding continuously improved applications and information.

In the next sections, we will highlight the innovative processes underway in each of these technological areas:

- *User interface:* From click to speech
- *Personal Space:* From wired to wireless
- *Networks:* From wired to integrated wired/wireless

- *Protocols:* From IP to Mobile IP
- *Web architecture:* From dumb and static to intelligent and dynamic

For each of these areas, we will introduce the technology requirements that are needed to achieve the objectives of the Intelligent Wireless Web. We also will identify the steps needed to advance the current state of technology. Finally, the results or attributes of the desired outcome will be indicated. Each of these topics then will be presented in greater detail in the subsequent chapters of the book.

User Interface: From Click to Speech

Communication between humans and their machines has been the subject of considerable technical research. Work on the "human-machine interface" has been conducted since the development of complex machinery, such as locomotive trains, automobiles, and washing machines. The need to efficiently provide information to machines, control their functions, and receive information from them to inform human operators of their status has increased dramatically over many decades.

Language—both written and spoken—is the primary means of human communication. Yet, communication through language has many obstacles, from the simple and obvious differences between the tongues spoken in different countries to the "untranslatable" slang differences between cultures. And, even for a healthy listener, background noise can make normal speech perception difficult.

So, how should we converse with a computer, its connected devices, and the machines they may control? If talking is the most natural way humans communicate, why not communicate with computers through ordinary language? After all, we learn to speak before we learn to read and write. Speech is also a highly efficient form of communication—people speak about five times faster than they type.

However, there are significant problems. The human voice is unique to each individual—no two people have exactly the same voice—and many words that sound alike have a different spelling or meaning. Minor differences in meaning can lead to major misunderstanding of language. Nuances of meaning can frequently be interpreted only by considering overall context. These problems present challenges for speech recognition software and speech-enabled applications.

Today there are two basic approaches to deciphering spoken commands. One approach uses matching algorithms that compare bit patterns of the spoken com-

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- *Networks:* From wired to integrated wired/wireless

human speech phrases or units to produce a more natural human sound. However, a large amount of memory is needed to store the recorded voice vocabulary.

Voice responses that are computer-generated use speech units termed phonemes. Phonemes are the fundamental elements of pronunciation. Phonemes provide the building blocks to voice and combine to form syllables and words. Many applications use a combination of speech recognition and speech synthesis to create a natural interactive environment.

The Speech Interface Framework working group of the World Wide Web Consortium (W3C) is developing standards to enable access to the Web using spoken language (see www.w3.org/Voice/). The Speech Synthesis Markup Language (SSML) specification is part of a set of new markup specifications for voice browsers. It is an Extensible Markup Language (XML)-based markup language for assisting the generation of synthetic speech on the Web. It provides authors content to synthesize in a standard way and allows them to control aspects of speech such as pronunciation, volume, pitch, and rate across different synthesis-capable platforms. The VoiceXML Forum (see xml.coverpages.org/vxml.html) is an industry organization established to promote VoiceXML as the standard for speech-enabled Web applications. Speech synthesis is addressed further in Chapter 8. Figure 1-1 illustrates the complete cycle of communications envisioned for the Intelligent Wireless Web.

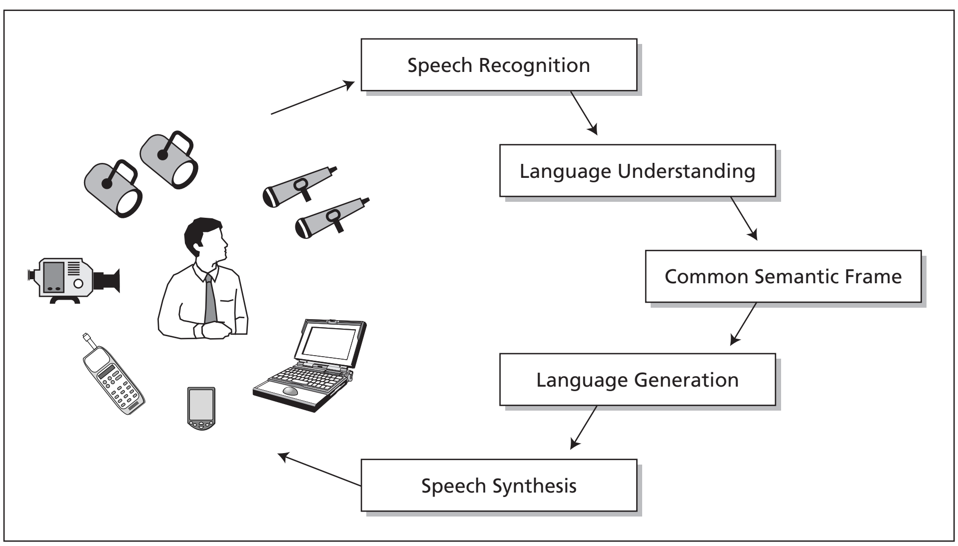


Figure 1-1 The communication process

Current computer systems use video displays and the keyboard or mouse (to point and click) as the primary methods for user interface. As small devices proliferate, what is needed to transition from the point-and-click method to the more natural use of human speech as a primary user interface? The main technology requirements are centered on speech recognition, speech understanding, conversion of text to speech, language translation, speech synthesis, and Speech Markup Language as well as greater available CPU processing power. These requirements, the current state of development, the steps needed to progress toward the Intelligent Wireless Web, and the expected results are outlined in Figure 1-2 and discussed in further detail in Chapter 2. Although we may expect speech interfaces to permeate society steadily, we anticipate that successful traditional interfaces, such as mouse and touch screen, will continue to be in operation for a very long time, particularly for such high-power applications as selecting data from detailed graphical representations.

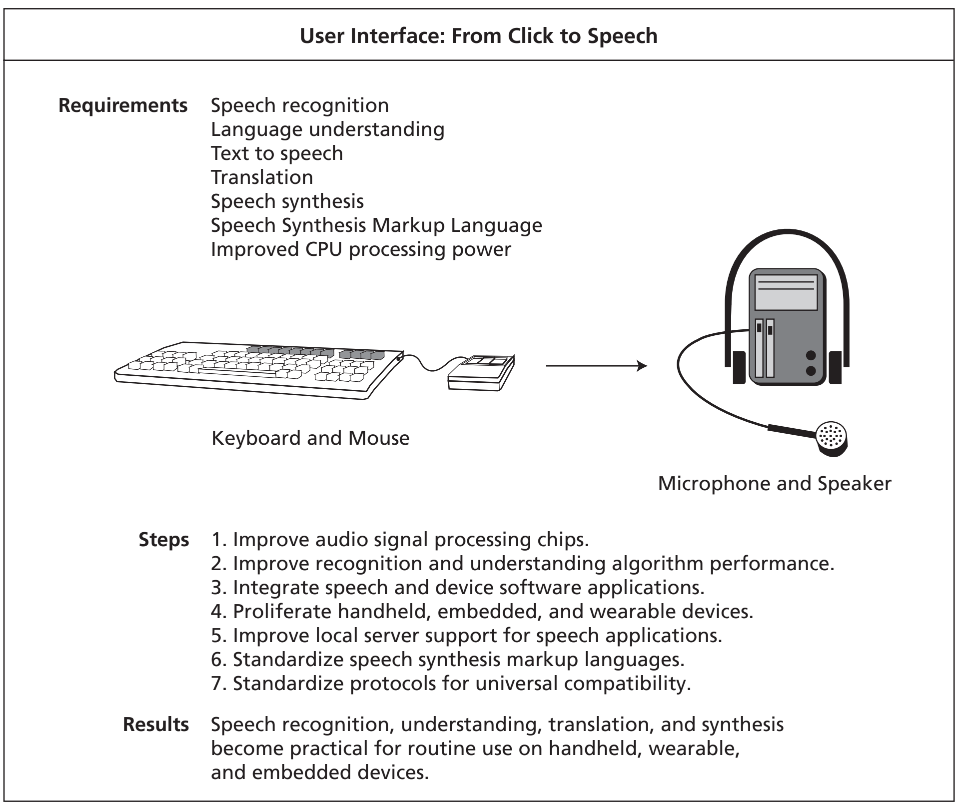


Figure 1-2 Transitioning the user interface

Personal Space: From Wired to Wireless

Imagine living your entire life within the confines of your own Personal Space (PS). Let's define Personal Space as the immediate vicinity that you can visually inspect around you. If you were to look around such a space, how many electronic devices would you see? How many wires would exist? With every new electronic device, you add to the "cable tangle" around you both at the office and at home. Wireless technology offers connectivity among these devices within your Personal Space without that encumbering tangle.

In the year 2000, there were over 15 billion devices of various types worldwide and 30 percent of all communication was actually conducted as device to device.[2] By 2010, 95 percent of all communication will be between devices. To understand how the new and emerging wireless networks will change communications it is important to consider how expanding communications will allow people to talk to each other and also to control the many devices that run our world. Clearly, device-to-device communication must become more efficient and intelligent if we are to realize our expectations of increased productivity.

With billions of devices already in use today, developing multipurpose communications systems that can be programmed to receive and transmit many different types of signals is a daunting challenge. At one extreme, we must consider Personal Space device-to-device network interfaces at home and at work—the personal area network (PAN). At the other extreme, we must recognize the need to adapt to a global interlacing complex of networks with potentially interconnected devices that must accommodate a large number of possible device-to-device combinations. This in turn makes obvious the need to establish and implement worldwide standards for interconnection of Web devices.

The next generation of networking will be Web-centric but with the introduction of the mobility factor, extending to devices such as wireless phones or PDAs. Only recently, through standards and advances in computing and communications technologies, has the convergence of wireless networks and the Internet begun to take place. The model extends the Enterprises' reach to a disparate range of devices, such as wireless phones, PDAs, pagers, LAN phones, automobile PCs, and cable television.

2. McInerney, F., and White, S. *FutureWealth.* Truman Talley Books, 2000.

In a wireless network with many mobile devices, channel conditions vary unpredictably over time. In addition, running a variety of applications over a network introduces significant variability in required bandwidth, error rate, and security. For example, electronic-commerce (e-commerce) applications require encryption, whereas an entertainment application may not.

Conventional network interfaces are inflexible. They are designed to operate under the worst conditions, rather than to adapt to changing conditions. This leads to inefficient use of spectrum and energy. Although great effort has been expended to simplify connectivity at the office, it continues to be difficult to plug your camera or cell phone into your company network to exchange data and images. The problems range from wires and connectors to operating systems (OSs) with annoying incompatibility and difficult component integration. Currently, wireless standards for connecting local devices are competing for dominance. The three near-term standard leaders are Bluetooth, Jini, and Universal Plug and Play (UPnP).

The Bluetooth standard is a short-range wireless capability to beam documents easily from a Bluetooth laptop to a compatible printer or to transfer data from a PC to a cell phone. Powerful device-to-device communications via SUN's Jini into smart devices is also coming along, though more slowly than Bluetooth. Microsoft's UPnP is further behind. MIT's Oxygen concept, described below, is further out in the future.

Project Oxygen

While Bluetooth, Jini, and UPnP are near-term technologies, Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory is embracing the next generation of computation with access from any location using interacting anonymous devices in a project named Oxygen.

Oxygen's vision is for there to be computation capability available all the time, everywhere, just as electricity is universally available from electric power sockets. Anonymous devices, either handheld or embedded in the environment, would personalize themselves in our presence by finding whatever information and software we need. We would communicate naturally, using speech, leaving it to the computer to locate appropriate resources and carry out our intent.

Project Oxygen's human-centric approach began in 1999 as a Defense Advanced Research Projects Agency (DARPA) project at MIT. A collaboration of MIT colleagues searched for radical new ways of deploying and using information. Their unifying goal was pervasive, human-centric computing. In May 2000, industrial partners joined MIT in the $50 million Project Oxygen. The Oxygen prototype devices and software will be completed in 2002, and the final testing by MIT will not be complete until 2004. The goal of the Oxygen system is to be pervasive, embedded, nomadic, and always on.

Oxygen rests on an infrastructure of mobile and stationary devices connected by a self-configuring network. This infrastructure supplies an abundance of computation and communication capabilities which are harnessed through several levels of software technology to meet user needs.

Devices in Oxygen, both mobile and stationary, will be universal communication and computation appliances. They would also be anonymous, not storing customized configurations to any particular user. In Project Oxygen, speech will replace keyboards and mice.

MIT's stationary devices are to be embedded in offices, buildings, homes, and vehicles to create intelligent spaces. They include interfaces to camera and microphone arrays and users will be able to communicate to the devices using speech.

MIT's handheld devices provide mobile points for users both within and without the intelligent spaces controlled. They will accept speech input, and they can reconfigure themselves for various protocols (see Chapters 3, 4, and 7 for more on Oxygen).

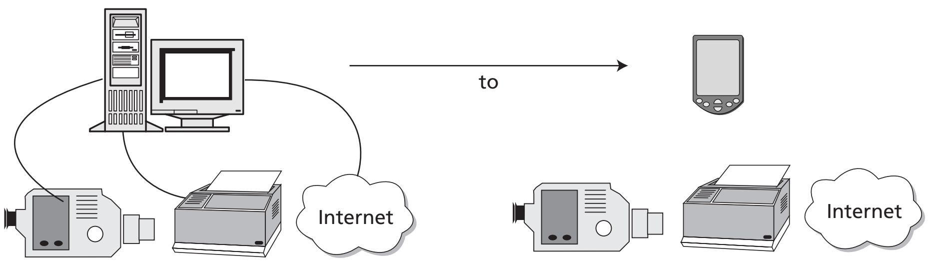
So, how do we transition from our present situation of fixed, wired Personal Spaces to the flexibility and efficiency of the Intelligent Wireless Web? Some of the key technology requirements are adaptable wireless devices and the establishment, acceptance, and development of wireless protocols, wireless small-screen applications, and "nomadic," or mobile, software for devices. These requirements, the current state of development, the steps needed to progress toward the Intelligent Wireless Web, and the expected results are outlined in Figure 1-3 and discussed in greater detail in Chapter 3.

Networks: From Wired to Integrated Wired/Wireless

The earliest computers were stand-alone, unconnected machines. To transfer information from one system to another, it was necessary to store the data in some form, physically carry it to the second compatible system, and read it into the computer. During the subsequent decades, mergers, takeovers, and downsizing have

Personal Space: From Wired to Wireless

Requirements Adaptable wireless devices
Wireless protocols
Wireless small-screen applications
"Nomadic" or mobile software for devices



Steps
1. Proliferate handheld, embedded, and wearable devices.
2. Provide efficient low-energy chips.
3. Improve server support for small-screen wireless.
4. Create daptable and compatible hardware.
5. Provide wireless access servers.
6. Standardize protocols.

Results Handheld, wearable, and embedded devices connect easily, without wires, and share software applications, as needed, producing office and home, wireless personal area networks.

Figure 1-3 Transitioning your Personal Space

led to a need to consolidate company data in fast, seamless, integrated databases for corporate information. With this consolidation acting as a driving force, intranets and local networks began to increase in size, and this required new ways for devices to interface with each other.

Over the past decade, enterprise models and architectures, as well as their corresponding implementation in actual business practices, have changed to take advantage of new technologies. Network computing has become the means to increased efficiencies in knowledge management—systematically finding, selecting, and organizing information. As knowledge management improves, employees, partners, and customers become better connected within an enterprise. As a result, mundane tasks can be easily relegated to computers while corporations focus on more important tasks.

One of the big lures of wireless networks is the potential for implementing architectures that can send packets from people with small personal devices, such as cell phones, to conduct e-commerce transactions. The number of wireless subscribers is expected to grow globally to more than 400 million by 2005. Although these prospects are attractive, the burst in growth demands that the wireless architecture proceed wisely.

For corporations that are heavily invested in legacy systems, however, deploying new wireless applications could mean that they must find a way to build on the existing infrastructure.

Networks are built upon three necessary elements that must be balanced:

1. Bandwidth
2. High-speed switching
3. Network intelligence

Many of us are already familiar with optical fiber developments expanding bandwidth and the contest between IP packet switching verses asynchronous transfer mode (ATM) circuit switching, but network intelligence is only recently showing its importance.

Intelligent Networking (IN) is a concept that is leading to new technological development, as user demands become more sophisticated. IN is more than just network architecture: it is a complete framework for the creation, provisioning, and management of advanced data transmission services.

The characteristics and quality of data transmission are determined by both the nature of the media and the signal. For wired media (copper wire, coaxial cable, and optical fiber), the medium itself is as important in establishing its limitations as the signal.

For wireless media, transmission and reception are achieved by antenna. To transmit, the antenna radiates electromagnetic waves into the air and the receiving antenna picks up the waves from the surrounding media.

Communication satellites compete with fiberoptics in delivering broadband signals for television, long-haul telephone, and private business networks. Direct broadcast satellite (DBS) uses satellites to directly distribute programming to the home. Satellite transmission is also used for point-to-point trunks between telephone exchanges. In addition, satellite transmissions are used for business data applications over private networks.

Wireless LANs have come to occupy a growing niche in the LAN market. Wireless LAN is viewed as a satisfying adjunct to traditional wired LAN, meeting the requirements of mobility, relocation, ad hoc networking, and coverage of locations difficult to wire. Until recently, wireless LANs suffered from high prices, low data rates, and licensing requirements.

Early wireless LAN products of the 1980s were marketed as substitutes for wired LANs. A typical wireless LAN configuration includes a backbone wired LAN, such as an Ethernet, that supports several servers, workstations, and one or more bridges or routers to link to other networks. A control module interfaces to a wireless LAN that regulates access by polling or token passing schemes.

Wireless wide area network (WAN) technologies include packet radio, analog cellular data, cellular digital packet data, satellite communications, meteor burst communications, and combining location devices with wireless WANs.

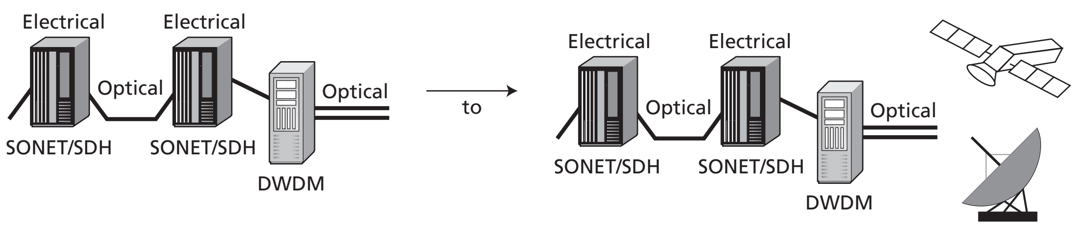
So, what are the key needs to enable transition from our present wired LANs and WANs to integrated the wired/wireless systems of the Intelligent Wireless Web? Some of the key technology requirements are the wireless LAN, the wireless WAN, satellite communications technology, commercial spectrum allocation, and wired/wireless Interfaces. These requirements, the current state of development, the steps needed to progress toward the Intelligent Wireless Web, and the expected results are outlined in Figure 1-4 and discussed in greater detail in Chapter 4.

Protocols: From IP to Mobile IP

Over the years, several protocols have been defined by various players in the market for various types of applications. In the beginning, Unwired Planet had its Handheld Device Markup Language (HDML), a protocol for Internet access to be used over cellular digital packet data (CDPD) networks. In 1997, Nokia launched a protocol named Tagged Text Markup Language (TTML), a protocol with a focus similar to that of the HDML protocol but designed to be used in the global system for mobile communications (GSM) world. Ericsson, in turn, was in the process of launching a protocol mainly focusing on telecommunications-related and messaging applications to be used inside the GSM networks, named Intelligent Terminal Transfer Protocol (ITTP).

Networks: From Wired to Integrated Wired/Wireless

Requirements Wireless LAN
Wireless WAN
Satellites
Wired interface
Commercial allocation of spectrum



Steps
1. Deploy more satellites.
2. Deploy more cell stations.
3. Deploy more fixed wireless capabilities.
4. Develop scalable compatible hardware.
5. Expand wireless LAN 802.11B usage.
6. Expand wireless WAN usage.
7. Develop flexible, adaptable protocols.
8. Efficiently integrate wired and wireless infrastructures.

Results Networks continue migration toward optical fiber with satellite support for the long haul while the last mile is met by fiber, wireless, and fixed wireless (LMDS and MDDS).

Figure 1-4 Transitioning networks

These three protocols represented only a fraction of the different wireless protocols defined by different organizations and available in the marketplace. This fragmentation limited the market growth for wireless applications. To clean up this fragmentation, forces were joined in defining a common platform and protocol and embracing Internet access and messaging.

The first joint meeting to consider wireless standards took place in June 1997. The intention was to broaden the group of companies working with the Wireless Application Protocol (WAP). In December 1997, WAP Forum Ltd. developed WAP. WAP is designed to provide data-oriented (nonvoice) services any time and anywhere (see www.wapforum.org).

The WAP microbrowser can be compared to a standard Internet browser. The applications must be written in the new markup language defined within WAP, named Wireless Markup Language (WML). WML is structured rather similarly to HTML.

In addition to specialized protocols, such as WAP, Internet Protocols themselves are undergoing transition. The Mobile IP Working Group of the Internet Engineering Task Force has developed routing support to permit IP nodes (hosts and routers) using either IP version 4 (IPv4) or IPv6 to seamlessly "roam" among IP subnetworks and media types. The Mobile IP method supports transparency above the IP layer.

Normally, IP routes packets from a source to a destination by allowing routers to forward packets from incoming to outbound network interfaces in accordance with routing tables. The routing tables maintain the next-hop (outbound interface) information for each destination IP address. The network number is derived from the IP address.

To maintain existing transport-layer connections as the mobile node moves from place to place, it must keep its IP address the same. However, in Transmission Control Protocol (TCP), the connection is indexed by a quadruplet IP address with port numbers for both endpoints. Changing any of the four numbers will cause the connection to be lost. The problem is that delivery of packets to the mobile node's current point depends on the network number contained within the mobile node's IP address, which changes at new points of attachment.

Mobile IP has been designed to solve this problem by allowing the mobile node to use two IP addresses. In Mobile IP, the home address is static to identify TCP connections. The "care-of" address changes at each new point of attachment and can be thought of as the mobile node's topologically significant address. This address shows the network number and identifies the mobile node's point of attachment.

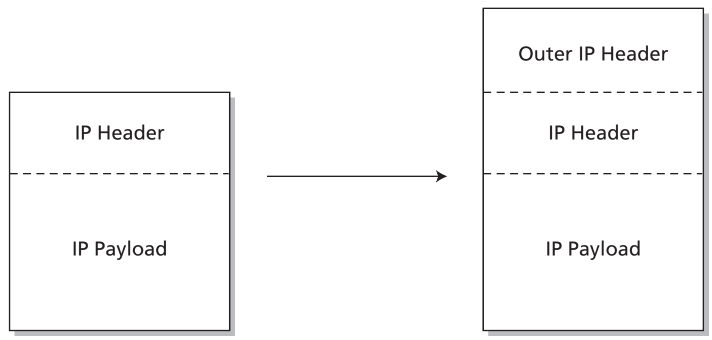
Whenever the mobile node is not attached to its home network, the home unit gets all the packets destined for the mobile node and delivers them to the mobile node's current point of attachment.

Whenever the mobile node moves, it registers its new "care of" address with its home unit. The home unit delivers the packet from the home network to the care-of address.

So, what are the key needs necessary to enable transition from the present system of Internet protocols to the additional protocols needed to bring about the promise of

Protocols: From IP to Mobile IP

Requirements IPv6
Mobile IP standard (or alternative)



Steps
1. Proliferate handheld devices.
2. Standardize Mobile IP.

Results Intelligent networking software for routing and tracking leads to general changes in IP networking protocols toward Mobile IP. Sitting on top of the entire layer infrastructure will be a new control plane for applications that smooths routing.

Figure 1-5 Transitioning protocols

the Intelligent Wireless Web? The primary technology requirement is the development and establishment of the Mobile IP to enable the same kind of information system access—any time, anywhere—that we enjoy with our current cellular phone technology. This requirement, the current state of development, the steps needed to progress toward the Intelligent Wireless Web, and the expected results are outlined in Figure 1-5 and discussed in greater detail in Chapter 5.

Web Architecture: Dumb and Static to Intelligent and Dynamic

We have said that fundamentally our vision for the future of an Intelligent Wireless Web is very simple—it is a network that provides any-time, anywhere access to information resources with efficient user interfaces and applications that learn and thereby provide increasingly useful services whenever and wherever we need them.

For the Web to learn, it requires learning algorithms and mechanisms for self-organization of a hypertext network. It needs to develop algorithms that would allow the Web to autonomously change its structure and organize the knowledge it contains, by "learning" the ideas and preferences of its users.

One way to move toward these goals has been suggested by W3C through the use of better semantic information as part of Web documents and of the use of next-generation Web languages such as XML and RDF. The Semantic Web Architecture will enable movement from IP to Mobile IP in addition to providing an XML layer, an RDF schema layer, and a logic layer.

Facilities to put machine-understandable data on the Web are becoming a high priority for many communities. Tomorrow's programs must be able to share and process data even when designed totally independently. The Semantic Web is one vision of having data on the Web defined and linked in a way that it can be used by machines not just for display purposes but for automation, integration, and reuse of data (Figure 1-6). An alternative to the Semantic Web is the successful development of Intelligent Web Services through Microsoft Net and Java2 Enterprise Edition (J2EE).

So, what are the key needs to enable transition from the current dumb and static systems to the intelligence and flexibility of the Intelligent Wireless Web? One key is the Semantic Web. Key technology requirements include XML schema, RDF schema (and its converging competitor, Topic Maps), logic layering, and distributed AI and AI service providers. In addition, information registration and validation will be an essential global service to support activities such as financial transactions. These requirements, the current state of Web Services development, the steps needed to progress toward the Intelligent Wireless Web, and the expected results are outlined in Figure 1-6 and discussed in greater detail in Chapters 6, 7, and 10.

XML and RDF

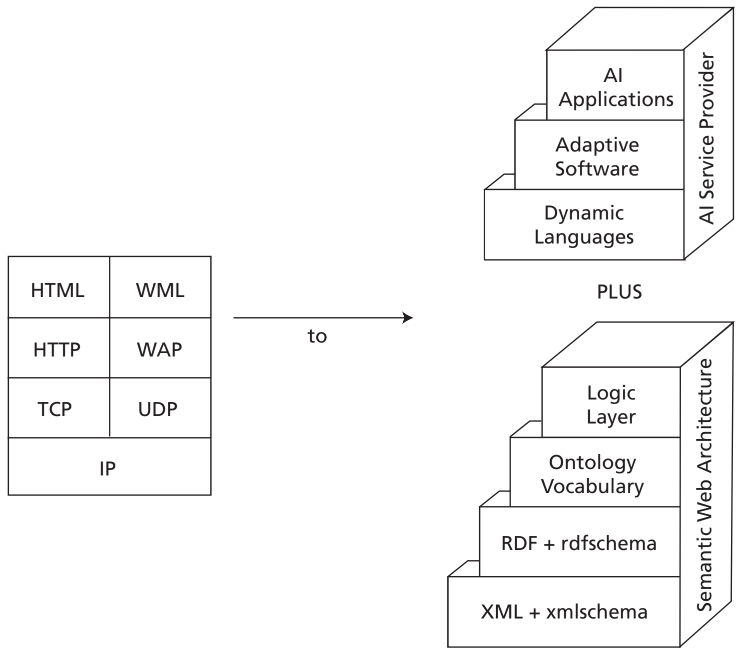
XML stands for Extensible Markup Language. The key feature of XML in comparison with HTML is that it provides the ability to define tags and attributes, not allowed under HTML. XML is part of the Standard Generalized Markup Language (SGML) designed for use on the Internet. It supports all the features of SGML, and valid XML documents are therefore valid SGML documents.

XML is designed to be very easy to implement so that application vendors can provide XML support internally or as plug-ins or downloadable applets. XML provides a ready entry point to structured markup for HTML users.

RDF stands for Resource Description Framework, which integrates a variety of Web-based metadata activities, including site maps, content ratings, stream channel definitions, search engine data collection (Web crawling), digital library collections, and distributed authoring, using XML as the interchange syntax.

Web Architecture: From Dumb and Static to Intelligent and Dynamic

Requirements
XML schema
RDF schema and Topic Maps
Logic layer
Dynamic languages and adaptive software applications
Distributed AI and AI Web services
Registration and validation of information
Intelligent Web Services



Steps
1. Implement Semantic Web Architecture.
2. Enable software objects and services to use a flexible naming system.
3. Deploy adaptive applications using dynamic programming. languages and Semantic Web layers.
4. Deploy AI applications on AI service providers.
5. Deploy "nomadic" software for on-the-fly applications.
6. Establish an authority to register and validate information.

Results Intelligent applications running directly over the Web, as well as AI applications served from AI service providers progressively increasing the percentage of tasks performed with adaptive, dynamic, intelligent products. In addition, a Web performance index will provide useful measures of Web progress.

Figure 1-6 Transitioning Web architecture

Self-Organizing Software and Adaptive Protocols

Traditional software development was based on principles such as exact specification, complex maintenance, and high levels of abstraction. Today software is expected to do more for us because of our increasingly complex environments. The complexity comes from users, systems, devices, and goals. Programmers are accustomed to a trade-off of time versus memory. Now they have to worry about bandwidth, security, quality of information, resolution of images, and other factors.

The problems with existing software are that it takes too much time and money to develop and it is brittle when used in situations for which it was not explicitly designed. Various software design methodologies can alleviate this problem.

The Web needs a significantly higher degree of dynamism and mobility, as well as a robust network infrastructure and protocols. Self-organizing software, adaptive protocols, and object-oriented dynamic languages can provide the Web with the tools it needs to learn.

Self-organizing software means the ability of networks to organize and configure themselves. Adaptation means the ability of protocols and applications to learn and adapt to the changing conditions in the network, such as levels of congestion and errors. The next generation of programming languages will support intelligent, adaptive, complex software systems. "Reflection," or reasoning, will be built into the language's own structure, performance, and environment, along with support for dynamic modification of behavior. Adaptive software will use information from the environment to improve its behavior over time.

Today, adaptive programming is aimed at the problem of producing applications that can readily adapt in the face of changing user needs and environments. Adaptive software explicitly represents the goals that the user is trying to achieve. This makes it possible for the user to change goals without a need to rewrite the program. A typical application is an information filter.

Adaptive software adds a feedback loop that provides information based on performance. The design criteria itself becomes a part of the program, and the program reconfigures itself as the environment changes.

Static languages, such as C, require the programmer to make a lot of decisions about structure and the data. Object-oriented dynamic languages form a higher level of abstraction and reflection. MIT's Dynamic Language (Dylan) and Common Lisp

Object System (CLOS) allow these decisions to be delayed and thus provide more responsive programming.

How will this produce significant change to improve the intelligence and efficiency of the Web? First, we must think of the Internet in terms of information instead of data packets. Instead of establishing TCP connections to some server, think of the device as a client of the information, rather than a client of the server. It becomes a distributed application that is running on some machine that requires some functionality or some service that exists somewhere in the network. As a result, large networks have a set of consumers and a set of providers of information. The network task is to match consumers and providers (one way to accomplish this is through the use of Intelligent Web Services or AI service providers).

Second, the network becomes efficient by learning about conditions on the network, such as changes in bandwidths, error conditions, and failure modes. And, finally, it begins to adapt.

Adaptive protocols can achieve this when they become a core component in the future Internet infrastructure. They will enable distributed applications that can be designed to organize themselves. So how do we architect a system to do this?

Deployable intelligence mechanisms can be associated with Learning Algorithms, including pattern recognition algorithms and data mining algorithms. And different applications can reuse the same algorithm-level software. It is important to be able to guide the automation process and to override decisions. Software areas under development include

- Agent technology acting for a user's preferences
- Data mining
- Decision theory providing terminology for expert systems for preferred outcomes
- Reinforcement learning finding actions to perform
- Probabilistic networks providing algorithms for computing optimal actions
- Expert systems: Computer applications making decisions in real-life situations that would otherwise be performed by a human expert
- Neural networks: Systems simulating intelligence by reproducing the types of physical connections found in animal or even human brains

Major research challenges are ahead in expanding intelligence offered as Web Services. The first is the problem of scaling to large networks and to large numbers of applications. The second issue is an end-to-end adaptation framework with underlying layers of the protocol stack to applications. This will allow learning about what's going on in the network and enabling new algorithms and new protocols to react. One method to achieve this is through a new protocol layer (see Chapter 7).

Artificial Intelligence

In 1947, shortly after the end of World War II, English mathematician Alan Turing started to seriously explore intelligent machines. By 1956, John McCarthy of MIT contributed the term *artificial intelligence* (AI). And by the late 1950s, many researchers were working in the area of AI, most basing their work on programming computers. Eventually, AI became more than a branch of science—it has expanded far beyond mathematics and computer science into such fields as philosophy, psychology, and biology.

Today AI is still a developing science with great potential, but it has not yet achieved the success expected. As a result, the introduction of AI applications to the Web is a prospect met with both skepticism and hope.

Web IQ

To achieve an Intelligent Wireless Web that learns we need an intelligence or performance measure for the Internet to measure progress. Basically, to be of value, such a measure need only provide a crude estimate of Internet progress toward an improving capability.

In seeking to evaluate Web IQ or Web performance, we are not specifically looking to pass Turing's test. But we are asking for an evaluation of the Internet's progress, as it grows more capable. Certainly the following elements play a role: data storage capacity, data transmission speed, device interface, protocols, database searching, data sorting and filtering, speech recognition and synthesis, video object recognition and tracking, object linking, expert systems, AI applications, and communication standards. How can we put it all together to find a useful measure to track the growth of expanding Web IQ? We believe this will be a continuing topic of interest as the capabilities and scope of the Web continue to expand.

Conclusion

In this chapter, we provided an introduction to what we mean by the Intelligent Wireless Web, a survey of how it may develop using wireless applications, and a discussion of how it will provide optimized performance while packaging knowledge in ways that are increasingly beneficial.

We have begun to consider what is necessary to produce a "learning" Web. It requires designing applications with Learning Algorithms and mechanisms for the self-organization of a hypertext network. We suggested that we need to develop algorithms that would allow the Web to autonomously change its structure and organize the knowledge it contains, by "learning" the ideas and preferences of its users. In addition, we suggested that intelligent applications would find their way onto the Web as Web Services through Enterprise Information Portals and through the evolution of Semantic Web Architecture.

We highlighted the compatibility, integration, and synergy issues facing the five merging technology areas that will build the Intelligent Wireless Web:

- User interface
- Personal Space
- Networks
- Mobile protocol
- Web architecture

Ten technological questions about the future of the Intelligent Wireless Web that we will specifically seek to address in subsequent chapters are as follows:

1. What is the status of developing speech recognition, understanding, synthesis, and translation?
2. What devices are being developed as handheld, wearable, and embedded devices that will contribute to Ubiquitous Computing?
3. What are wireless personal area networks and what role will they play in the office and at home?
4. How are wired and wireless infrastructures merging and performing together?
5. How will intelligent networking software for routing and tracking change from current IP networking protocols to address mobile requirements?
6. Will wireless devices play a central role in producing a dialog with the Web?
7. How will Enterprise Information Portals and Web Services contribute to the Intelligent Wireless Web?
8. What is Semantic Web Architecture and will it offer opportunities for intelligent applications?

9. How will intelligent applications using Learning Algorithms and AI be deployed on the Web in combination with either Web Services or Semantic Web Architecture?
10. Is the Intelligent Wireless Web the catalyst that will change the Information Age into the information revolution?