

Uwe Hansmann
Lothar Merk
Martin S. Nicklous
Thomas Stober



Pervasive Computing Handbook



Forewords by
Philippe Kahn and
Nick Shelness



Springer

Uwe Hansmann Lothar Merk
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With 183 Figures



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Uwe Hansmann
Lothar Merk
Martin S. Nicklous
Thomas Stober

IBM Deutschland Entwicklung GmbH
Pervasive Computing
Schönaicher Straße 220
71032 Böblingen, Germany

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Preface

"...a billion people interacting with a million e-businesses with a trillion intelligent devices interconnected ..."

(Lou Gerstner, IBM Chairman and CEO)

Information is the nucleus of today's interconnected economy. We need to be able to exchange and retrieve our personal information quickly, efficiently, and securely, at any time and regardless of our current physical location. Electronic storage, transmission, and access of information are common tasks we rely and trust on.

Information
everywhere

Convenient applications for helping users manage information in daily life and business environments will be an essential growth factor in tomorrow's IT industry. Such applications will integrate software, hardware, infrastructure, and especially services and will focus on the needs and convenience of their potential users. Those who provide these applications will be able to offer added value, allowing them to differentiate themselves from their competitors. Traditional off-the-shelf software and even hardware will serve only as enabling components for these integrated solutions. These components will be standardized and exchangeable.

"Everywhere at anytime" ...

Pervasive
Computing

This common slogan expresses in a nutshell the goal of *Pervasive* or *Ubiquitous Computing*. Both terms describe the visible and mobile front-end for the next generation of integrated IT applications. Pervasive Computing includes flexible and mobile devices like personal digital assistants, mobile phones, pagers, hand-held organizers, and home entertainment systems, which will access or provide a rich diversity of applications. As part of our daily life, these intelligent devices will offer an emerging number of private and professional transactions. They connect to worldwide networks without boundaries and provide quick and secure access to a wealth of information and services.

A new era of applications

The early pilot applications of Pervasive Computing seem to originate from the pages of a science-fiction novel:

A supermarket chain equips its customers with free mobile devices accompanied by an application for placing online orders. A salesman for agriculture seeds accesses, from a remote farm, his company's order systems via a wireless network. Theatergoers pay for their ticket using a mobile WAP phone. In a networked home equipped with intelligent appliances, the microwave and the air-condition are controlled through the Internet using a common browser.

Integration behind the scenes

Nevertheless, Pervasive Computing is far more than just plugging in new incredible devices for multiple purposes. Behind the scenes, an increasing number of these new devices must be integrated into the IT organization. Device management as well as application management are two issues back-end systems have to deal with. Gateways, application servers, and communication networks are just some of the components used for building Pervasive Computing solutions. Small footprint clients for common systems, like databases or web servers, have to be supplied for numerous platforms.

Services

Besides making the systems ready for Pervasive Computing, the service infrastructure has to be extended. Internet Service Providers must be prepared to react to a rapidly growing demand for network access by everyone. GSM has turned out to be the dominant wireless network for communicating anywhere, making it the first choice for accessing Pervasive Computing applications from any point. Upcoming Internet portals will act as an "anytime available" intermediary between users and providers offering payment facilities, shopping opportunities, or information access. Nevertheless, even more complex services, like a public key infrastructure adding enhanced security and privacy to transactions, are beginning to be established.

Common standards

To make all these things work together seamlessly, the industry is currently agreeing upon the required standards. SyncML is one promising approach for ensuring the possibility to synchronize all kind of data on different devices. XML is definitely the basis for standardized data exchange.

About This Book

Technology

This book explains the fascinating variety of front-end devices for ubiquitous information access and their operating systems. It also covers the powerful back-end systems, which integrate the Pervasive Computing components into a seamless IT world. Fundamental topics include such commonly used terms as XML, WAP,

transcoding, cryptography, and Java, just to mention a few. Another focus is set on the evolving industry standards, like SyncML, WAP, on which these new technologies are based.

The book presents an overview of the different development strategies and tools for different Pervasive Computing platforms. In order to ease the planning and development of new solutions, concepts and considerations are explained specific to a variety of different target environments, such as handheld computers, home networks, smart phones, and others.

Finally, this book has a strong emphasis on the business aspects, such as the new generation of services, delivering added value to a growing number of customers. E-Business, private home, finance, or travel will not be the only industries which will change their face entirely due to a new class of mobile computing devices, making the customer omnipresent.

We try to give an impression of what Pervasive Computing is about and how it differs from conventional computing. We avoid losing ourselves in details, but provide a way through the jungle of terms, concepts, standards, and solutions instead. The major goal of this book is to put the various facets of Pervasive Computing together to a consistent and comprehensive view.

Development

Business

A red line
through the
jungle

The Audience of This Book

Giving a comprehensive and profound overview of Pervasive Computing makes this book very valuable for a wide audience of readers. Following the main thread of this book, they will find an easy and quick entry to the related topics.

Business managers will learn what impact Pervasive Computing has on economy and society. The knowledge about Pervasive Computing paradigms, new business models, and a new generation of applications will affect their work as well as their decisions. They will see where Pervasive Computing can help businesses to offer new services and new products or how to improve existing businesses to reach a new range of customers. This book gives an overview about the broad range of possible as well as already existing solutions in the field of Pervasive Computing.

Those software architects and project managers who extend their e-business activities to a new front-end will read about which components pervasive solutions are made of and how these building blocks are related with each other. This book gives an overview of state-of-the-art pervasive technology and shows which components are available as well as how they fit together to build a complete solution.

Business
Managers

Software
Architects and
Project
Managers

About This Book

■ 3
■
■

Application developers getting involved with a particular segment of Pervasive Computing will find a high-level but profound introduction leveraging the start before digging into mazes of programmer guides. They will learn how to rapidly enable applications for the use of pervasive devices. They will also learn some typical patterns of Pervasive Computing and how to trade off various desirable properties in making design decisions. Typical development processes and tools are described.

No Need to Read the Whole Book

Most of us no longer have the time to read a book cover to cover. Therefore, we have broken this book into chunks that may be read in almost any sequence:

- "Introduction",
- "Part I, Devices",
- "Part II, Software",
- "Part III, Connecting the World",
- "Part IV, Back-end Server Infrastructure",
- "Part V, New Services", and
- "Part VI, Appendices"

At the end of each chapter, you will find a list of interesting links and suggestions for further reading.

Introduction

We set the stage by providing an overview of Pervasive Computing in general.

Chapter 1 What Pervasive Computing is all about

We describe the evolution from conventional computing via e-business to Pervasive Computing. We explain the paradigms and principles of Pervasive Computing, like decentralization, diversification, connectivity, and simplicity.

Part I *Devices*

In this part, we cover the most commonly used pervasive devices, like handheld computers, smart phones, telematics, smart cards, and many more. We describe their characteristics from a user's perspective, explain the areas of usage, their basic applications, their look-and-feel and everything else you need to know to get a good under-

standing of these devices. This part groups the vast mass of devices into four categories, which are described in more detail within the different chapters.

Information Access Devices

The first category covers handheld computers and smart phones, which are primarily used to access and communicate information. They are currently the most important group of Internet connected devices beside the traditional PC.

Chapter 2

Smart Identification

The second category comprises tiny labels and smart cards, which offer a huge possibility for identifying objects electronically in pervasive applications.

Chapter 3

Embedded Controls

This category shows how everyday devices, such as controls, refrigerators, or vending machines can provide additional services and applications while connected to a network. Another section describes the automobile as a versatile pervasive device.

Chapter 4

Entertainment Systems

Finally, the fourth category covers devices, which provide manifold sort of entertainment, such as game consoles and interactive television. For these devices analysts predict a promising future.

Chapter 5

Software

In this part, we cover the most commonly used software components needed to build pervasive applications, like, Java, operating systems, middleware, and security building blocks. We also show which components are necessary to develop applications for these operating systems and how to start doing this.

Part II

Java

Java is used in almost every area of Pervasive Computing, in some of the devices as well as in the server back-end infrastructure. The different flavors of Java, especially the ones for Pervasive Computing, are covered and explained here.

Chapter 6

Operating Systems

There is a wide variety of different operating systems used in the field of Pervasive Computing. In this chapter, we cover the most-widely used ones in handheld devices: Palm OS and Windows CE.

Chapter 7

About This Book ■ 5



as well as EPOC, which is used within phones and smart card operating systems like Java Card and Windows for Smart Cards. We describe the architecture and list the necessary tools to start developing for the respective platforms. This chapter also contains small sample programs for most of these operating systems.

Chapter 8 Middleware Components

Basic plumbing or middleware is necessary to leverage application programming for the devices themselves. Developing on top of common components helps to achieve independence from a particular Pervasive Computing device used by the customer. Middleware components are used to integrate the clients to their backend servers. We describe an exemplary selection of widely used components, like DB2 Everywhere, MQ Everywhere, the JavaTV and JavaPhone APIs, as well as OpenCard Framework and PC/SC.

Chapter 9 Security

Security is an extremely important part of every mobile e-commerce solution. We explain the background of security and the cryptographic techniques used to secure Pervasive Computing and give an overview of the different standards, algorithms, and protocols used.

Part III *Connecting the World*

Pervasive Computing and the different devices get really powerful if they are integrated with each other and the back-end infrastructure to form powerful solutions. This Part covers the important industry standards and technologies that provide connectivity and enable communication.

Chapter 10 Internet Protocols and Formats

As Pervasive Computing is somehow an extension of the Internet, most of the protocols and formats you might already know from the Internet are also used here. This chapter introduces HTTP, HTML, XML, and XSL for those of you who are not yet familiar with these standards.

Chapter 11 WAP

The Wireless Application Protocol (WAP) is today's standard for enabling wireless information devices and especially mobile phones to send and receive information and HTML-like pages in an efficient and performant way. We introduce you to the secrets of WAP and describe to you the most important facts that you need to know.

Connectivity

We cover the different protocols used to connect traditional and Pervasive Computing devices. We explain the background of wired networks, infrared communications, Bluetooth, as well as cellular and short-range radio wireless connections.

Chapter 12

Service Discovery

With a set of distributed Pervasive Computing devices offering different services to each other, a mechanism for service lookup and discovery is needed for an easy and automatic configuration of this complex environment. We explain the three mechanisms Jini, uPnP, and Salutation.

Chapter 13

Back-end Server Infrastructure

Behind the scenes, the server systems need to be prepared for Pervasive Computing and its requirements, which differ significantly from the needs of today's PC-focussed networks. We discuss the applied technologies and concepts.

Part IV

Gateways

Gateways are intelligent interceptors between servers and specific classes of devices. We show how they can be used to prepare data and to establish own subnets, for example the wireless network of a particular service provider.

Chapter 14

Application Servers

In most cases, Pervasive Computing devices are used to interact with data residing on back-end servers. This chapter describes the different additional jobs a back-end server has to do for Pervasive Computing front-ends. Load balancing, servlets, and Enterprise Java Beans are among the captions of this chapter.

Chapter 15

Device Management

This chapter deals with managing the incredible amount of devices and applications that are deployed in the field. Examined aspects include customer profiles, accounting, and billing. Another topic is the management of device capabilities and life cycles. And of course, the distribution and maintenance of applications are an important issue covered within this chapter.

Chapter 16

Chapter 17 Synchronization

Keeping data consistent on the server and on various mobile devices requires intelligent synchronization mechanisms. Aspects of synchronization are detailed within this chapter.

Part V New Services

Pervasive Computing offers a vast amount of new possibilities to create services, streamline processes and to start new businesses. The following chapters provide an overview on these areas, which are the most likely ones to boom first. They describe some of the most known Pervasive Computing solutions, which are in use by the customers today already.

Chapter 18 Portals

Portals are the central points of access to services in a connected world. A portal must be very attractive, interactive, complete, and easy to use to make the customer come back. In this chapter we describe functionality that is common to most portals and explain some exciting examples.

Chapter 19 Home Services

Today a Personal Computer is the only computer that a user directly interacts with at home. We explain how Pervasive Computing offers a huge potential for new and additional services at home, like intelligent appliances, home automation, remote home health care, energy services, new communication services, and many more.

Chapter 20 Travel & Business Services

A person who is traveling is mobile per se. Offering to a traveler the services he normally uses from his office and additional ones that ease his travel, like checking-in from a mobile phone at an airport, are some examples. Pervasive Computing can also make the daily life in the office easier. This chapter describes the new service opportunities that service provides in these areas face.

Chapter 21 Consumer Services

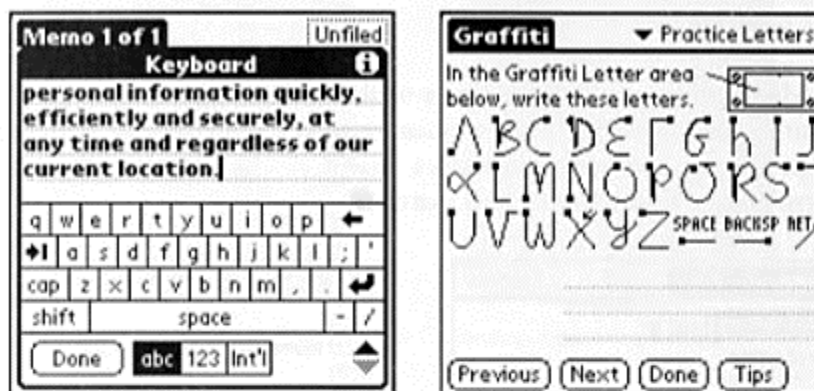
This chapter describes the new services that businesses will offer to consumers, like offering the possibility to shop using mobile devices, or ordering stocks and checking the balance of a checking account from the road. In this chapter, we will explain what is available today and what will come in the near future.

different writing styles. Almost every letter can be formed by a single stroke.

HotSync

The synchronization mechanism between a Palm OS based device and a desktop PC is HotSync. The changes made since the last HotSync are automatically updated on the Palm device and the desktop PC. If corresponding records are changed on the PC and the Palm OS device, HotSync will detect a version conflict.

Figure 2.4:
Graffiti and
Keyboard



Infrared port

The infrared port offers a convenient possibility to exchange data between different devices. Business cards, calendar entries, and entire applications can be "beamed" from one Palm to another without the detour over HotSync and a PC. The infrared port can also be used to communicate with a cellular phone instead of an attached modem to connect wirelessly to a network.

Internet access

The Palm allows to access Internet sites either through an Internet connected PC or directly by going online via modem. There are several Web browsers available. Similar to the capabilities of a PC based Web browser, the Palm Web browsers are able to cache Web sides. This feature is extremely important, since a Palm device usually doesn't have a permanent Internet connection. There are several providers for delivering Internet content, especially for handheld devices. One access point for synchronizing content is AvantGo:

- Internet content can be downloaded by the AvantGo software installed on a PC. AvantGo offers selected Web sites related to manifold topics, which are referred to as *channels*. Users can subscribe individually to particular channels of interest and receive updated content with every HotSync. The information is stored in HTML, thus also graphics, tables, and different fonts can be displayed. The Web pages are compressed before they are transmitted to the Palm OS device.

- Since version 2.0 of AvantGo was introduced, it is also possible to use AvantGo as an online Web browser. A proxy server at AvantGo.com modifies the Web pages in a way that they can be displayed on Palm devices.

Similar to the Web access, there are two ways of working with emails – via a desktop PIM application or directly via mail server.

- Choosing the PC way means that sending and receiving emails takes places on the PC. The email is synchronized between the Palm device and the PC whenever a HotSync with the email program takes place. An email written on a Palm has to be delivered to the PC mail application before it is sent to the mail server in a second step.
- For direct Internet access the Palm uses a modem connection and an email server running the standard POP3/SMTP protocols.

2.1.2 Windows CE-Based Handheld Computers

Windows CE is the second major operating system for handheld computers, taking almost the remaining rest of the market share. Windows CE has been developed by Microsoft and is applied by manufacturers like Casio, HP, and Compaq.

Comparing Palm OS and Windows CE devices is somehow pretty philosophic: Microsoft wants to extend today's Personal Computer platform to mobile computers. Users should be able to do the same things in the same way on any computer alike device – as far as such is possible under the given constraints of form factors and reduced processing power. Windows CE provides the same consistent look and feel, both on the common PC and on the smaller handheld. For instance Word and Excel will welcome you on Windows CE and the mailing tool is an Outlook derivative, of course. From the Microsoft perspective, a handheld is nothing else than a miniaturized PC! This philosophy is reflected by terms as PocketPC, Palmheld PC, and Handheld PC.

Palm propagates PC companions instead. They are different and complementary to PCs. Since the usage scenarios are different, the applications and their usage must be different too. Palm OS user interfaces are pretty straight-forward to use and are optimized for quick mobile information access – even in a crowded subway.

Windows CE
versus Palm OS

High-end
Windows CE
hardware

Figure 2.5:
E-115
PocketPC
from Casio

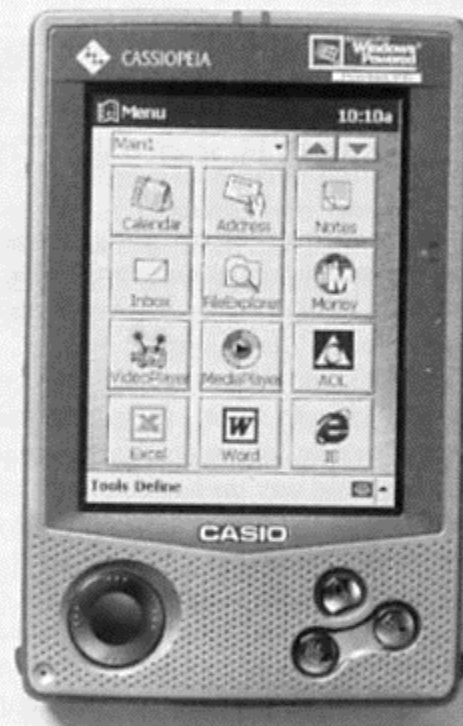


Photo courtesy of Casio

Personal
Information
Management

In fact, the opinions about these different approaches are split: Some get started more easily with Windows CE because of the familiar user interface and because they have similar applications on their handheld, as they have on their PC. Others dislike the more circumstantial usage of Windows CE. There are more windows, more controls, and more taps required than a Palm III needs for the same operation.

Compared to the competing Palm OS, Windows CE requires plenty of memory and processing power making devices much more expensive. The Casio E-115 (Figure 2.5) for example takes a minimum of 16 MB of RAM and has a 133 MHz processor embedded. Palm devices instead are shipped with up to 8 MB RAM and include a cheap 20 MHz processor, which keeps them easily affordable for a broad audience.

While Palm concentrates on state-of-the-art mobile information management, Windows CE devices are technological wonderboxes, generously equipped with fancy hardware features: They usually have a color display with a good resolution, enabling multimedia applications such as computer games. There is a built-in microphone for a voice recording facility and a MP3 player. A stereo output is pro-

14 Gateways

Pervasive Computing is dominated by a variety of non-IP network protocols, which are either proprietary or specific to a particular industry. As soon as devices want to access the Internet or other computer networks a protocol conversion is required. This task is done by a *connectivity gateway*. Gateways are the point of entry into a server network. They isolate the individual communication channels and their specific requirements from the rest of the back-end systems. Gateways, like a WAP Gateway or a Palm Webclipping Proxy Server convert TCP/IP to protocols optimized for wireless data transmission.

Besides protocol conversion, content can also be adjusted for specific classes of devices. Using appropriate *transcoding gateways*, a web application server can deliver content in various formats to different types of clients. The ProxiWare Server is one example for this type of gateway, which will be covered later in this chapter.

Gateways can either be part of the back-end system or they can belong to an user's personal setup. The first possibility could be a gateway which is installed by a service provider offering wireless access to his customers.

The second possibility covers workstations or other systems taking the role of a gateway between devices and the Internet. Local gateways can act as a focal point for personal application management and integration of manifold subordinated devices. One example is the classical PC to which a handheld companion connects. Another example is a *residential gateway* acting as a local interface between appliances connected to an in-home network and the external network, like the Internet. The residential gateway can dispatch external services entering a home network to the connected devices. Or it can route wireless appliances within an office to a high bandwidth Internet line.

14.1 Connectivity Gateway

This section covers three examples of connectivity gateways: the Palm Webclipping Proxy Server, a WAP gateway, and the Secure-Way Wireless Gateway.

14.1.1 Palm Webclipping Proxy Server

The developers of the Palm VII handheld computer decided not to use regular web browsing for wireless Internet access: Initially the Internet was not designed for small devices. To achieve a better performance they introduced web clipping. Instead of using a generic Internet browser, web clipping needs a corresponding standalone client application for *each* particular web site. This application implements the required browsing capability and has to be downloaded and stored locally on the device first. It holds the hard coded request forms for each query to the corresponding web page. Web site developers need to develop and deploy such a query component complementary to the regular HTML files. Web clipping uses HTML version 3.2 with some extensions and limitations. For example, there are special tags to identify a device. Applets, Java Script, frames, and cookies are not supported. Only simple queries and no complex hyperlinks to other web clipping sites are possible. The HTML files are converted into a binary format, which can be rendered on the Palm VII device. That technology minimizes storage requirements and the amount of data transferred. The benefits are lower transaction costs and longer battery life.

Palm.Net
Data Center

All Palm VII communication goes through a proprietary connectivity gateway, the Palm Webclipping Proxy Server. That proxy server is part of the Palm.Net data center, which provides wireless Internet access to Palm VII users (Figure 14.1).

The communication between a Palm device and the gateway is based on the UDP protocol, which allows one packet to be sent as a request to the server and multiple packets to be replied. The data is compressed and encrypted to be optimized for wireless transmission with low bandwidth and latency. When a Palm VII sends an UDP query to Palm.Net, the gateway translates that query to a standard Internet request and forwards it to the corresponding web server. The server returns a response, which can be displayed on the Palm VII browser.

Frequency agility, network authentication, and the Certicom elliptic curve cryptographic algorithm are used to establish a secure connection between the Palm VII and the Palm.Net Data Center. The connection from the Palm.Net data center to an Internet server can be protected with SSL using a 40 or 128 bit key. The Palm.Net Data Center itself is protected by firewalls.

Bearer for the Palm VII wireless communication is Bell South's Mobitex Network. It only operates within the US and uses the 900 MHz frequency. Every Palm VII device has a built-in radio frequency transceiver with a unique Mobitex access number. A direct line to Palm.Net Data center is configured.

One obstacle of the applied communication technology is that the radio frequency bearer allows only about 8 kilobytes per second for data transmission. This limits the amount of information, which can be exchanged in a reasonable response time. About 50 bytes for the query and 500 bytes for the response are the recommended sizing.

Although the Palm VII device only accesses the Mobitex network from Bell South, the architecture is basically open for devices based on other network technologies and providers.

Mobitex
Wireless
Network

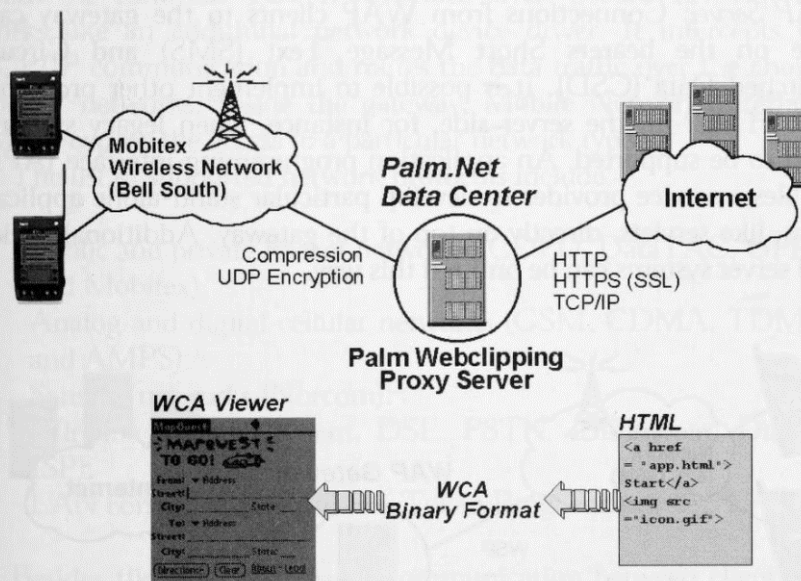


Figure 14.1:
The Palm.Net
Data Center

14.1.2 WAP Gateway

In order to connect WAP phones to the Internet the standard HTTP Internet protocol used by web servers must be converted into WAP's Wireless Session Protocol (WSP). As described in Chapter

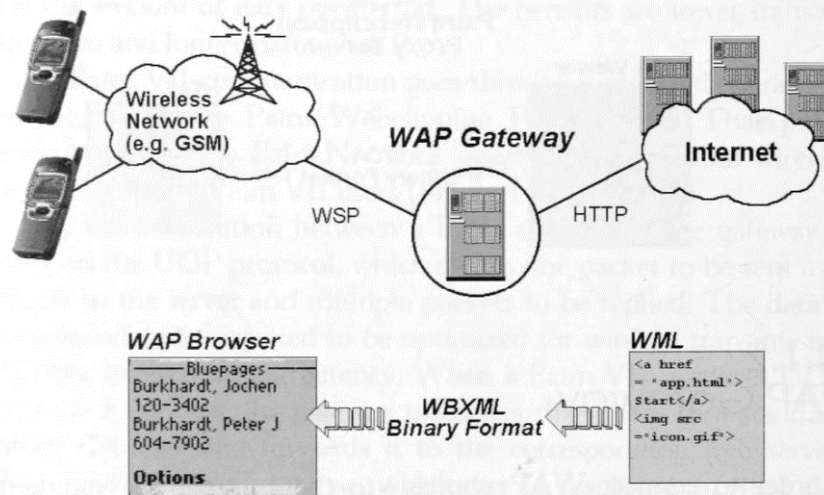
11, this task is done by a WAP gateway. Additionally the content, which must be provide in the Wireless Markup Language (WML) format is translated into a binary content representation (WBXML) to optimize transmission.

Besides content and protocol transformation, the server initiated client notification needs to be supported, which was introduced with WAP 1.2. This "push"-mechanism is a bit circumstantial, since normal HTTP servers can only respond to requests received from clients. The initiator of a push acts as a HTTP client of the WAP Gateway, which takes the role of a Web server, referred to as Push Proxy Gateway (PPG). The PPG forwards the push notification to the WAP client over WSP. Each push message consists of two components: the content to be pushed to the WAP client and a control entity, which holds information, like the message expiration date.

Since WAP is an open standard and independent from a specific telecommunication network any gateway should work with any WAP compliant phone.

Among the available commercial gateway products is *Nokia's WAP Server*. Connections from WAP clients to the gateway can base on the bearers Short Message Text (SMS) and Circuit Switched Data (CSD). It is possible to implement other protocols than HTTP on the server side, for instance, when legacy systems need to be supported. An application programming interface (API) enables a service provider to develop particular stand-alone applications, like servlets, directly on top of the gateway. Additional back-end server systems can be omitted this way.

Figure 14.2:
WAP Gateway



14.2 Wireless Gateway

The *IBM SecureWay Wireless Gateway* tunnels the IP protocol through a diverse set of wireless and wireline networks. Applications on client systems can communicate with enterprise networks based on TCP/IP, although this protocol is actually not supported by the communication bearer. Any application developed for the standard TCP/IP interface, will run on top of SecureWay Wireless without modifications.

Gateway

The *SecureWay Wireless Client* is the counterpart of the gateway and must be installed on the user's client system. A user interface allows to initiate the communication to the gateway. The mobile user can select the network type, which meets best his current needs, without making any changes to the installed applications.

Client

In order to setup the network transparent to the application, different network characteristics are encapsulated by SecureWay Wireless. On the client side, all network specific details are hidden beneath the common TCP/IP interface layer. SecureWay Wireless works like an additional network device driver. It intercepts the TCP/IP communication and routes the data traffic over the chosen non-IP networks. Inside the gateway, Mobile Network Interfaces (MNI) expose the access to a particular network type.

The list of supported network protocols include:

- Public and private Packet networks (CDPD, DataTAC, GPRS, and Mobitex).
- Analog and digital cellular networks (GSM, CDMA, TDMA, and AMPS).
- Satellite networks (Norcom).
- Wireline (Cable modem, DSL, PSTN, ISDN, and Dial-up ISP).
- LAN connections (Ethernet, Token Ring, and wireless LAN).

Besides the simple IP-based communication between client and gateway, SecureWay Wireless optimizes the network traffic using data compression mechanisms. Increasing efficiency is extremely important for low speed wireless networks. The benefits of less data traffic are better response times and often lower network fees. Additionally, an idle connection can be disconnected automatically and will resume as soon as communication continues. The user will not notice that interrupt (short-hold mode).

Efficient

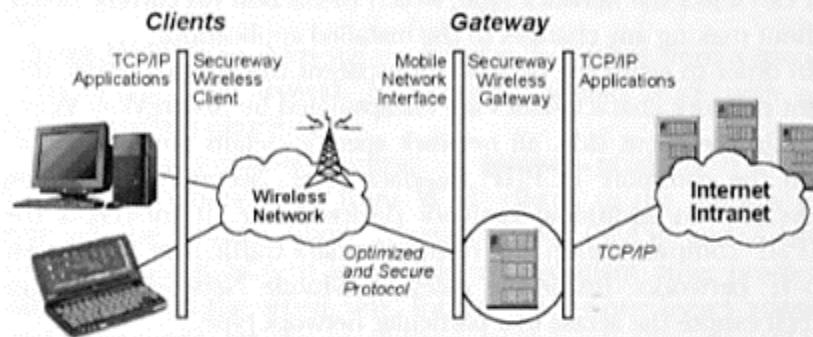
Secure

For reliable data privacy, all data transmitted through public networks from the client device to the gateway can be encrypted with RSA. Two way client/gateway authentication mechanisms prevent unwanted access.

Besides gateway and client, IBM provides the *SecureWay Wireless Gatekeeper*. This tool enables system administrators to configure multiple wireless and dial-up network, and define users, resources, and access rights. LDAP is used to store user profiles and network management data.

WebExpress is an enhancement for HTTP communication through SecureWay Wireless. WebExpress features HTTP header reduction, as well as HTML data stream compression and content caching.

Figure 14.3:
SecureWay
Wireless
Gateway



14.3 Transcoding

Transcoding is a content adaptation technology, which tailors information for a specific device by transforming its format and representation. Multimedia data as it can be found on Web pages, is filtered, converted, and reformatted, until it matches the capabilities of the displaying device.

Why
transcoding?

The purpose is obvious: When providers deliver content to various pervasive clients, they need to accommodate device specific constraints such as limited memory, slow data transmission, and small screens. Transcoding automatically translates content into different representations for each class of receiving client systems. This simplifies authoring, deployment, and maintenance dramatically! An arbitrary multimedia web page can be provided to Internet TVs, handhelds, and WAP phones without change. It is even possible to adapt content from legacy systems into a standardized Internet rep-

resentation, or transcode Web pages to the proprietary format of a specific client device.

Besides adapting content according to particular device capabilities, another aspect of transcoding gains importance: information is personalized for a particular user, depending on his preferences and organizational policies. For instance, content of interest can be transcoded into individual user interface styles or a preferred language.

Transcoding is typically done by a gateway or proxy, which intercepts the data exchange between the content server providing multimedia data and the client rendering the received information (Figure 14.4). The transcoding proxy analyses the content and identifies the included media objects. In order to determine graphical navigation buttons, images, and related textual content, the semantics of each object is examined. According to defined preferences, appropriate methods for content manipulation are invoked. Preferences can be device capabilities, user profiles, communication bandwidth, and others. They indicate what kind of information has to be transcoded in which way.

Transcoding
Proxy

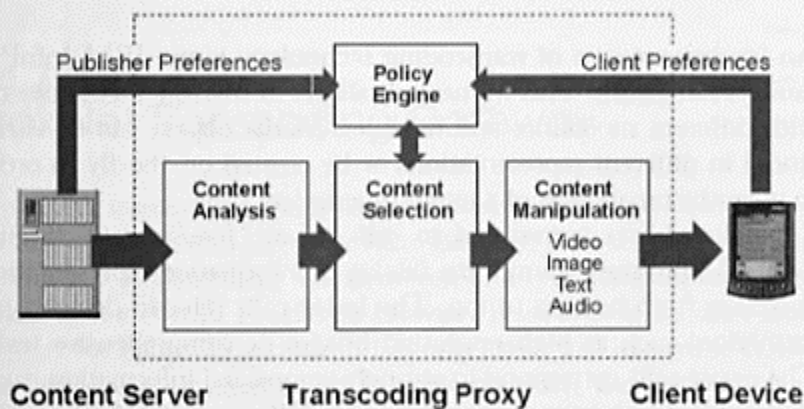


Figure 14.4:
Internet
Content
Transcoder

This content adaptation comprises two dimensions:

Modality and
fidelity

- *Modality:*
Multimedia includes video clips, images, text and audio data in manifold formats. Since not all of these modalities are suitable for all devices, transcoding translates data according to the targeted devices needs.
- *Fidelity:*
Reducing the fidelity of information is another approach to reach even small devices with multimedia information. Compressing and filtering are techniques applied in this context.

The following list shows several common methods for content manipulation:

- Conversion of images to hyperlinks, allowing the user to retrieve them separately only when explicitly needed.
- Compression and reduction of scale and color level of images.
- Substitution and removal of images.
- Conversion from one image format to another.
- Translation of XML documents according to a given style sheet.
- Video skimming.
- Video-to-image conversion.
- Text-to-speech conversion and speech recognition.
- Text summarization from detailed text to headlines.
- Text reformatting from tables to simple lists.
- Language translation.

14.3.1 InfoPyramid Framework

An implementation of transcoding technology is the IBM InfoPyramid Framework. This framework allows to manage media objects with different modalities and fidelities. Media objects can be either stored in different representations or be created on-the-fly in order to meet the capabilities of a requesting device.

Media objects correspond to cells in an "InfoPyramid" (Figure 14.5). Within the pyramid, the fidelity of information representation decreases from bottom to top. The lower cells refer to detailed information, such as high-resolution images or comprehensive texts. The upper cells correspond to strongly compacted information, such as simplified images or summarized text. When moving horizontally within the pyramid, the modality changes. For instance text-to-speech conversion changes a text based representation to audio.

The framework includes methods to manipulate media objects. These are referred to as *transcoders* and are distinguished between *translators* and *summarizers*. Translators convert modality, while summarizers change fidelity. The framework is extensible and allows to add new transcoders using a provided developer toolkit. It is also possible to define additional modalities, such as different languages of text.

The framework has been implemented as a stand-alone proxy server as well as a servlet. The proxy server intercepts HTTP requests

Uwe Hansmann

Lothar Merk

Martin S. Nicklous

Thomas Stober

Pervasive Computing Handbook

This book is a guide for the world of Pervasive Computing. It describes a new class of computing devices which are becoming omnipresent in everyday life. They make information access and processing easily available for everyone from anywhere at any time. Mobility, wireless connectivity, diversity, and ease-of-use are the magic keywords of Pervasive Computing. Devices include handheld computers, mobile phones, interactive television, smart cards, household appliances as well as intelligent automotive equipment. The book covers these front-end devices as well as their operating systems and the back-end infrastructure which integrates these pervasive components into a seamless IT world. A strong emphasis is placed on the underlying technologies and relevant standards for building pervasive solutions. These fundamental topics include commonly used terms such as XML, WAP, UMTS, GPRS, Bluetooth, Jini, transcoding, and cryptography, to mention just a few. Besides a comprehensive state-of-the-art description of the Pervasive Computing technology itself, this book gives an overview of today's real-life applications and accompanying service offerings. M-Commerce, e-Business, networked home, travel, and finance are exciting examples of applied Pervasive Computing.

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"Very good coverage of Pervasive Computing – ranging from the device level up to the server. They cover the range with authority and state-of-the-art knowledge." Peter Thompson, Senior Software Engineer, Starfish Software

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"Pervasive computing is the extension of applications and services to a variety of devices, including mobile phones, PDAs (personal digital assistants), vehicles, home appliances, kiosks, and medical and security devices. It provides immediate access to information and transactions, offering great convenience to mobile users of these services. The companies that embrace these technologies today will gain a competitive advantage over those who wait to see how the market develops." Jonathan L. Prial, Director of Marketing and Strategy, IBM Pervasive Computing Division