

*Pervasive Computing and the Patterns for e-business*

January 15, 2001

Leo Marland





# Pervasive Computing and the Patterns for e-business





# Pervasive Computing and the Patterns for e-business



---

## Table of Contents

<b>Chapter 1. Pervasive Computing . . . . .</b>	<b>1</b>	Systems management guidance. . . . .	16
<b>Chapter 2. Patterns for e-business . . . . .</b>	<b>3</b>	<b>Chapter 7. Voice mode . . . . .</b>	<b>17</b>
<b>Chapter 3. Pervasive Computing Modes . . . . .</b>	<b>5</b>	Application development guidance . . . . .	18
<b>Chapter 4. Synchronous Mode . . . . .</b>	<b>7</b>	Systems management guidance. . . . .	19
Application development guidance . . . . .	9	<b>Chapter 8. The Impact of Mixing Modes . . . . .</b>	<b>21</b>
Systems management guidance. . . . .	10	<b>Chapter 9. Intelligent Infrastructure for</b>	
Security . . . . .	10	<b>e-business . . . . .</b>	<b>23</b>
Subscriber management . . . . .	10	Intermediaries and pervasive e-business	
Quality of service . . . . .	10	infrastructure. . . . .	23
Product mapping . . . . .	11	Adaptive e-business infrastructure. . . . .	24
<b>Chapter 5. Notification Mode . . . . .</b>	<b>13</b>	Network architecture . . . . .	24
Application development guidance . . . . .	14	Pervasive programming models . . . . .	25
Systems management guidance. . . . .	14	<b>Chapter 10. Summary . . . . .</b>	<b>27</b>
<b>Chapter 6. Asynchronous Mode . . . . .</b>	<b>15</b>	Acknowledgments . . . . .	27
Application development guidance . . . . .	16	<b>Chapter 11. References. . . . .</b>	<b>29</b>



---

## Chapter 1. Pervasive Computing

Pervasive computing technology enables both extensions to existing e-business solutions and a whole new class of solutions for e-business development.

IBM defines Pervasive Computing as: Convenient access, through a new class of appliances, to relevant information, with the ability to easily take action on it when and where you need.

See the IBM Pervasive Computing Web site for more detail.

This paper focuses on mobile e-business solutions and investigates how they can be built as extensions of existing best practices in e-business architectures provided by IBM's Patterns for e-business. These patterns are part of a larger IBM initiative known as the Framework for e-business.

The IBM Application Framework for e-business provides significant guidance for e-business architects, designers and developers. The framework identifies the following set of services for the unique requirements of the mobile user:

- Mobile enhanced network services
- Transcoding services
- Disconnected services
- Pervasive device support
- Systems management

This list of services sufficiently shows that pervasive computing cannot be reduced to a discussion of only one or a few of these services, but must consider how these services together, and in combination with other e-business services, provide a complete end to end solution. Review the IBM white paper by Krishna Akella and Akio Yamashita entitled Application Framework for e-business: Pervasive computing (reference 1) on developerWorks for more details on the evolution and extension of the Application Framework for e-business to include pervasive computing.

Within the IBM Application Framework for e-business, IBM provides detailed architectural models, collectively known as the Patterns for e-business. This paper will assess how these architectural patterns can be extended to support pervasive computing solutions. Whether the taxonomy of the Patterns for e-business needs a review in light of pervasive computing styles will also be explored.



---

## Chapter 2. Patterns for e-business

The Patterns for e-business provide high level reference architectures, together with product mappings to accelerate decision making and e-business solution delivery. The patterns are cataloged according to the structure of e-business interaction they facilitate and currently include:

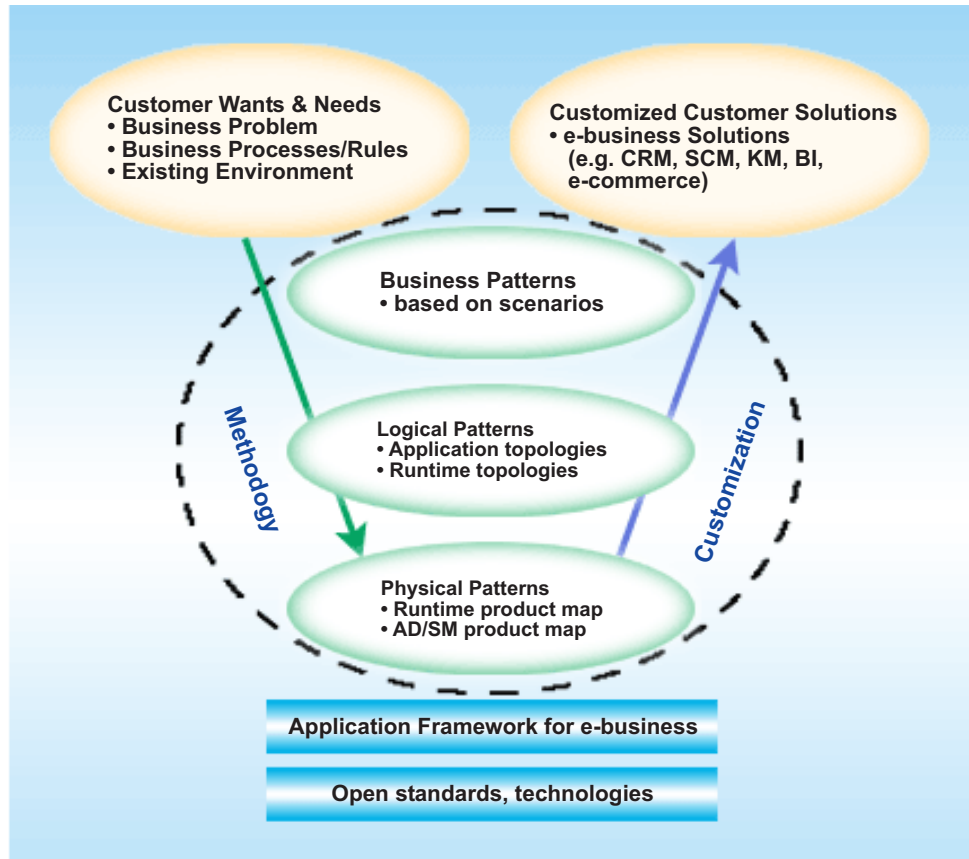
- User to Business (U2B): The general case of internal and external users interacting with enterprise transactions and data.
- User to Online Buying (U2OB): A subset of the User to Business pattern, where goods are sold online.
- Business to Business (B2B): Business interactions between parties who do not belong to the same company. Two styles of this pattern Business to Business Integration (B2BI) and Business to Business eMarketplace (B2BeMP).
- User to Data (U2D): The use of tools to extract useful information from large volumes of data, text, images, or video.
- User to User (U2U): Solutions that enable groups of users to work together and collaborate more effectively.
- Application Integration: The linking together of applications within a business. Also known as Enterprise Application (EAI), this pattern enhances server to server communication.

Those business patterns that involve user interaction (the U2X patterns) are currently influenced by the advent of pervasive computing devices and wireless connectivity. Future pervasive computing technologies may interact with unattended devices or appliances through the use of service gateways. This relationship may be viewed as an extension of the two server to server business patterns: Application Integration and Business to Business Integration.

For each Business Pattern, IBM has developed:

- Logical Patterns: Application Topologies and Runtime Topologies
- Physical Patterns: Runtime Product Mappings and AD/SM Product Mappings.

The following diagram represents all the elements of the Patterns for e-business and their interrelationships.



©Copyright IBM Corporation, 2000. All rights reserved.

## Chapter 3. Pervasive Computing Modes

These technical variables influence how a pervasive computing solution is categorized:

- Device
- Communications network
- Protocols

Each of these technical variables is evolving based on technology evolution, market pressures, and discovery of successful solutions.

The following tables consider some general modes of pervasive computing, exploring first the current correlation of these modes with emerging pervasive computing technologies, and second, the relevance of these modes to the Patterns for e-business.

A preliminary evaluation of devices with particular affinity to these modes is shown, but these devices are not the only possible options. Both convergence and specialization of devices will occur, and a more specific association between device and the identified modes is currently perilous at best.

*Table 1. The modes of pervasive computing and their relationship to emerging pervasive technologies.*

Mode	Device Affinity	Communication	Gateway	Protocol (device to gateway)	Data formats
Synchronous	PC	TCP/IP	N/A or Dial gateway	HTTP	HTML
	WAP enabled phone/PDA	WAP	WAP gateway	WTSP over GSM CDMA	WML
Notification	PC	TCP/IP (or other if using MOM)	MOM or Chat server	Various	Various
	PDA or Pagers	Paging network	Paging gateway	Paging network	Various paging formats
	Cellphone or PDA	SMS, WAP push	Cell gateway	GSM et al	SMS formats, email
Asynchronous	PDA	Serial port/ USB/ IP	Synch. server	SyncML (emerging)	SyncML
	PC	TCP/IP Netbios	Collaboration or mail server. MOM m/ware	Several	Several
Voice	Phone	Phone network	Voice server with VXML browser	N/A	VoiceXML

Table 1. The modes of pervasive computing and their relationship to emerging pervasive technologies. (continued)

	PC with voice client	Voice over IP	Voice server with VXML browser	N/A	Voice XML
--	----------------------	---------------	--------------------------------	-----	-----------

Considering the pervasive computing modes according to their relevance to the Patterns for e-business, two trends emerge:

1. The Synchronous mode is relevant across all the Patterns for e-business except Enterprise Application Integration.
2. Multiple modes are relevant to many of the Patterns.

For completeness personal productivity applications are also included in the analysis.

Table 2. The relevance of the pervasive computing modes to the Patterns for e-business

Mode	Pattern for e-business					
	U2B	U2OB	U2D	U2U	B2B	Personal Productivity
Synchronous	YES	YES	YES	YES	YES	YES
Notification	YES Application topology 7	YES, e.g. alerts for auctions	YES, e.g. alert for new portal content	YES Chat client	YES B2B process alerts	
Asynch.	Yes Topologies 9 and 10		YES Forms entry	YES email	YES	YES
Voice	YES IVR interface to application	YES IVR interface to application		YES, very much so		

The following sections consider each of the pervasive computing modes more thoroughly, and how their implementations can be related to the known structure of the Patterns for e-business. How these modes can be combined and whether there are any common architectural elements among them is also examined.

---

## Chapter 4. Synchronous Mode

The synchronous mode has attracted the most attention from developers and the public, as the "wireless Web" seeks to extend the reach of e-business applications to mobile devices.

The following assumptions have been made in the case of the synchronous mode:

1. The mobile e-business solution area is considered, as it represents a natural evolution for e-business solutions.
2. The mode of computing is synchronous.
3. The pervasive device user experience is focused on a thin client model where the application design is server-centric.

In examining other modes assumptions 2 and 3 will be relaxed, allowing other models for Pervasive Computing solutions for e-business.

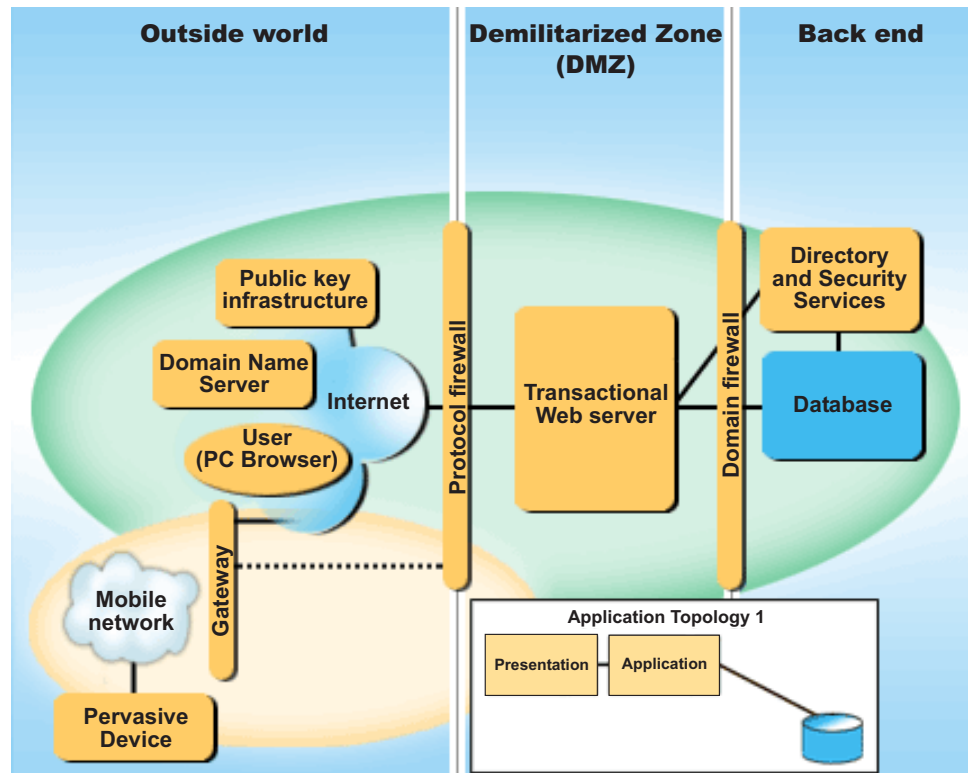
Based on early customer engagements IBM developers assert that, where the above assumptions are correct:

1. The Application Topologies of the Patterns for e-business, as currently expressed, remain valid.
2. The Runtime Topologies can be extended.
3. The Physical Patterns (Runtime and AD/SM Product Mappings) are a superset of existing product mappings.
4. The Runtime Topology extensions follow a sub-pattern that can be superimposed on other Patterns for e-business.

At present the first three of these assertions seem reasonable. For mobile e-business, the fourth assertion provides an intriguing simplification and extension to the Patterns for e-business, as supportive evidence for these sub-patterns emerges from IBM's service engagements in this area.

The following figure extends the User to Business application topology 1 runtime topology to enable pervasive functionality. Note the yellow ellipse area in the bottom left. This area illustrates the sub-pattern that can be commonly applied to those Patterns for e-business which have a User interaction through a Web browser to enable this pervasive functionality. The software components that populate this runtime design (shown in the product mapping) may change for each pattern, although they may all be contained within the umbrella WebSphere Everyplace

Suite.



©Copyright IBM Corporation, 2000. All rights reserved.

A common instance of this topology would be a WAP enabled device with a cellular network and a Gateway that includes the WAP gateway software. But there are other mobile networks ( e.g. campus Wireless LAN) that are relevant as well.

There is an important choice for the configuration of the gateway in this topology. It may be configured by the cellular network provider and connected to the public Internet. This is the most common configuration and is denoted as a solid connection. This gateway configuration is important for an ISP providing a set of public services to subscribers.

Alternatively, the gateway can be configured by the e-business solution provider and the mobile network provides a direct connection to that gateway and does not involve the public Internet. This option is shown here as a dotted line. In choosing between these alternatives, solution providers must consider the market reach required for their solution, performance, and security. This gateway configuration is relevant for a solution for a service intended only for an Enterprise group requiring mobile access to e-business services.

Finally note that a dial-up access server is required when using a cellular network, but as is the convention in showing a browser client access via the Internet, this is treated as a network detail in the runtime topology.

**Note:** There is always a choice of abstraction in denoting a runtime topology and how much detail of the network architecture is noted. It is a matter of opinion as to which services need to be included, but as a general rule, those services needed explicitly in the end to end behavior of the solution should be considered.

Unless the mobile network is an IP network (which it could be in the case of an RF campus LAN), the gateway acts as a proxy IP address for the pervasive device. This means that, in each interaction between a web application server and a PC browser, when that same application is extended to work with a pervasive device, each interaction is mediated by the gateway.

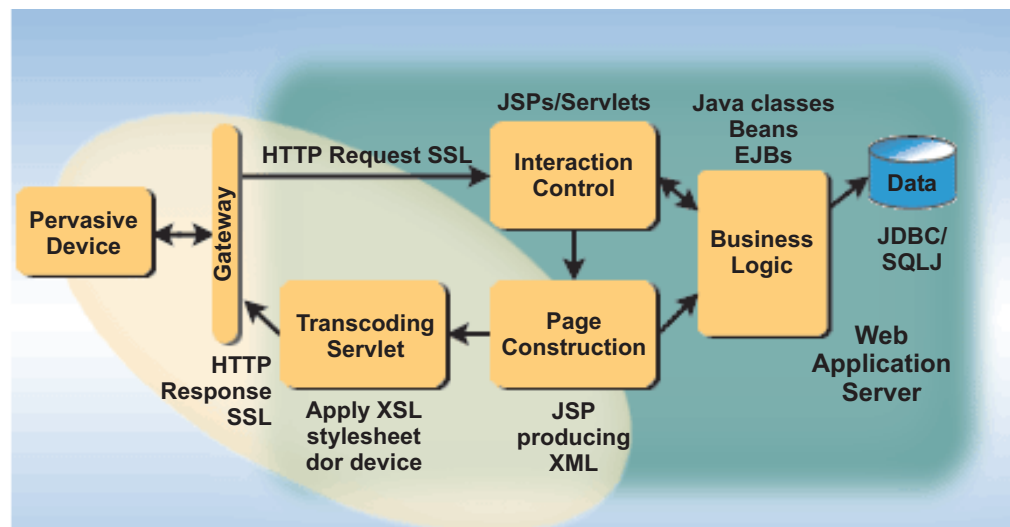
For example:

- Complete authentication requires both authentication to the gateway and authentication to the web application. Alternatively, the application can trust the gateway authentication.
- Service requests involve a device specific protocol from the device to the gateway, transformed into an http request to the web application.
- Service responses consist of an http response (containing device specific content format) to the gateway, transformed into a device specific format.

## Application development guidance

The application development guidance for the User to Business Topology 1 and 2 discusses in detail the application of the Model-View-Controller structure to web applications. The detailed design patterns use servlets for interaction control, use command beans and the command pattern for the interface to business logic, and Java Server Pages (or servlets) for page construction or View.

Experience from early pervasive computing engagements shows that this application architecture can be elegantly modified to support connected pervasive devices. This is shown in the following diagram with modified areas highlighted.



©Copyright IBM Corporation, 2000. All rights reserved.

The modification to the application architecture requires that:

- The device type is detected by the interaction control servlet when the HTTP request is received from the Gateway.
- The Java Server Page constructs a view or page in XML rather than HTML.
- The output from the Java Server Page is processed by the Transcoding servlet (using servlet chaining).

- The Transcoding servlet applies a style sheet (XSL) to the XML and produces a content stream appropriate for the particular pervasive device.

An alternative approach to consider, particularly when the number of possible supported devices is restricted, is to develop a Java Server Page specific to each supported device type, such as HTML for a PC Browser and WML for a WAP phone. An important design consideration for the application architecture is state management. As today's WAP phones do not support cookies, the user identification and session identity must be maintained by the Gateway.

---

## Systems management guidance

Mobile e-business introduces new considerations for the overall systems management of the solution.

### Security

The established basics for an e-business solution are the appropriate encryption of traffic, authentication of users, and policy based network access using firewalls. An overall policy-driven end to end approach to e-business security is developing and is reflected in leading architectures. Mobile e-business requires authentication and appropriate encryption between the pervasive device, gateway, and application server, but the standards and implementations of these requirements are not all in place. WAP 1.1 includes WTLS, which provides mutual authentication, integrity, and confidentiality services through the use of encryption mechanisms. Additionally, some gateways handle proxy interoperation with SSL. WAP 1.2 introduces a redirect technique, whereby the ISP gateway informs the device to connect directly to the enterprise WAP gateway, which will terminate the WTLS connection.

### Subscriber management

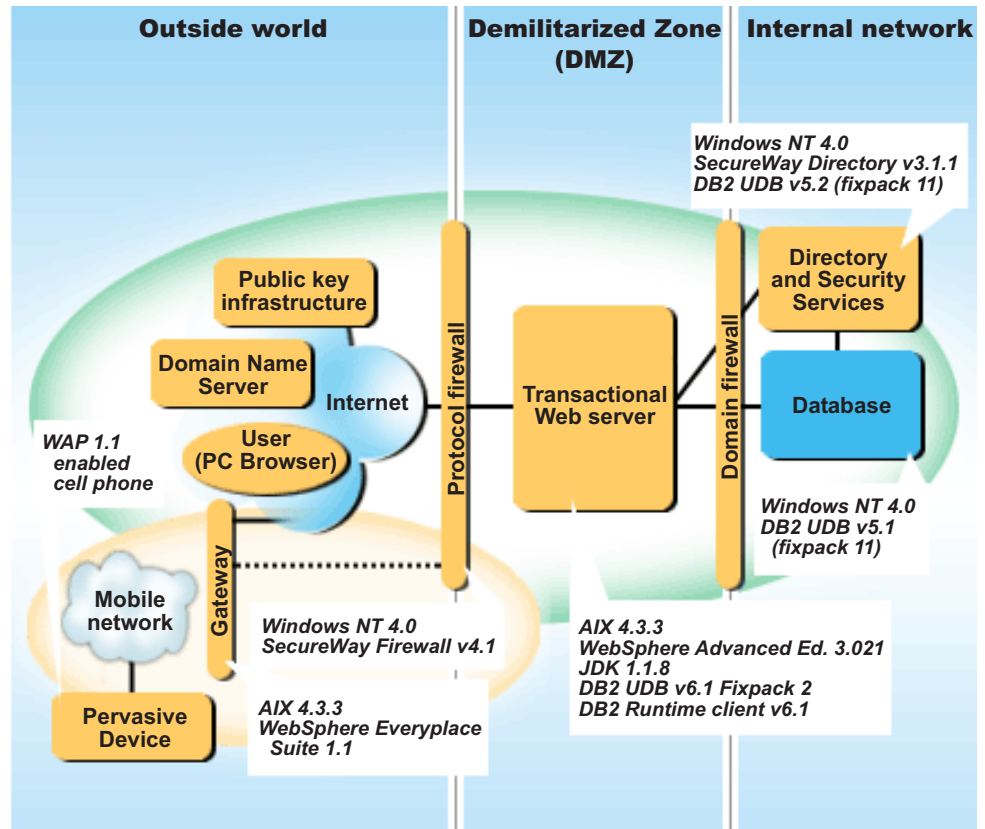
Related to e-business security issues, the management of device and subscriber issues is a challenge to solution development. Of particular concern is the volume of pervasive devices and the possibility that a user may use multiple devices to access e-business application services.

### Quality of service

The device, gateway and mobile network introduce new reliability and latency factors into the end to end solution development. Just as the ISP can affect an Internet solution accessed by a PC, a designer must consider the quality of service from the mobile network provider and the gateway.

## Product mapping

The following figure illustrates the products used in the Synchronous mode of Pervasive Computing.



©Copyright IBM Corporation, 2000. All rights reserved.



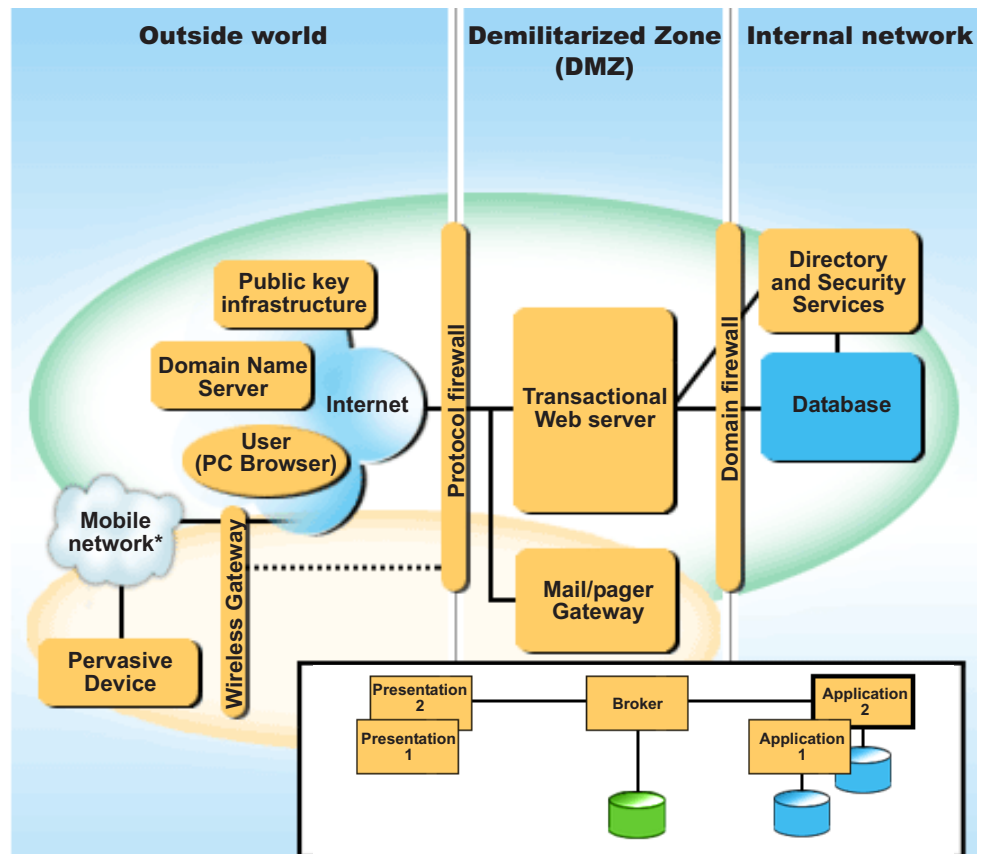
## Chapter 5. Notification Mode

The notification mode of pervasive computing enables e-business features such as real-time message alerts on a very small portable device. Additional examples include other appealing services such as:

- Instant messages on the NTT DoCoMo cellular network
- SMS messages on a GSM cellular network
- RIM Blackberry device interface to messages over a paging network

In order to be effective, the notification mode requires that the mobile network be "always-on." Channel switched mobile networks cannot support this mode because it requires packet switching.

The following figure shows how the notification mode can be employed as an overlay on a User to Business application solution.



©Copyright IBM Corporation, 2000. All rights reserved.

**Note:** The yellow area indicates a sub-pattern that can be overlaid on the runtime topology of the application to deliver this new mode of operation. In the case of the notification mode, this also overlays a second application topology.

The notification mode complements other application function. For example, the user can use a User to Business application and choose to receive a notification based on a particular state or application event.

The User to User business pattern also relates to the notification mode. Once again an event (such as "mail received" or "new item in discussion database") can trigger the alert. In addition, the user can directly initiate a message to another user.

---

## Application development guidance

Carefully consider your application's "event model." Is it based on an application call supported by the application server framework, a database trigger, or some other mechanism. Is the notification part of a broader workflow solution and does this require a full workflow engine or a lightweight messaging solution?

Develop your application in four logical tiers: Presentation, Application Control, Business Logic, and Data Access Logic. The Application Control layer is important when the application flow involves some degree of coordination between users.

---

## Systems management guidance

Carefully consider the quality of service of the mobile network upon which a solution depends. While you may add this to a solution as an attractive feature, you should expect that users will come to depend on the real time functionality and expect end to end reliability and a predictably short time from event occurrence to delivery of notification.

Otherwise, the areas of subscriber management and security are still relevant as per the Synchronous mode.

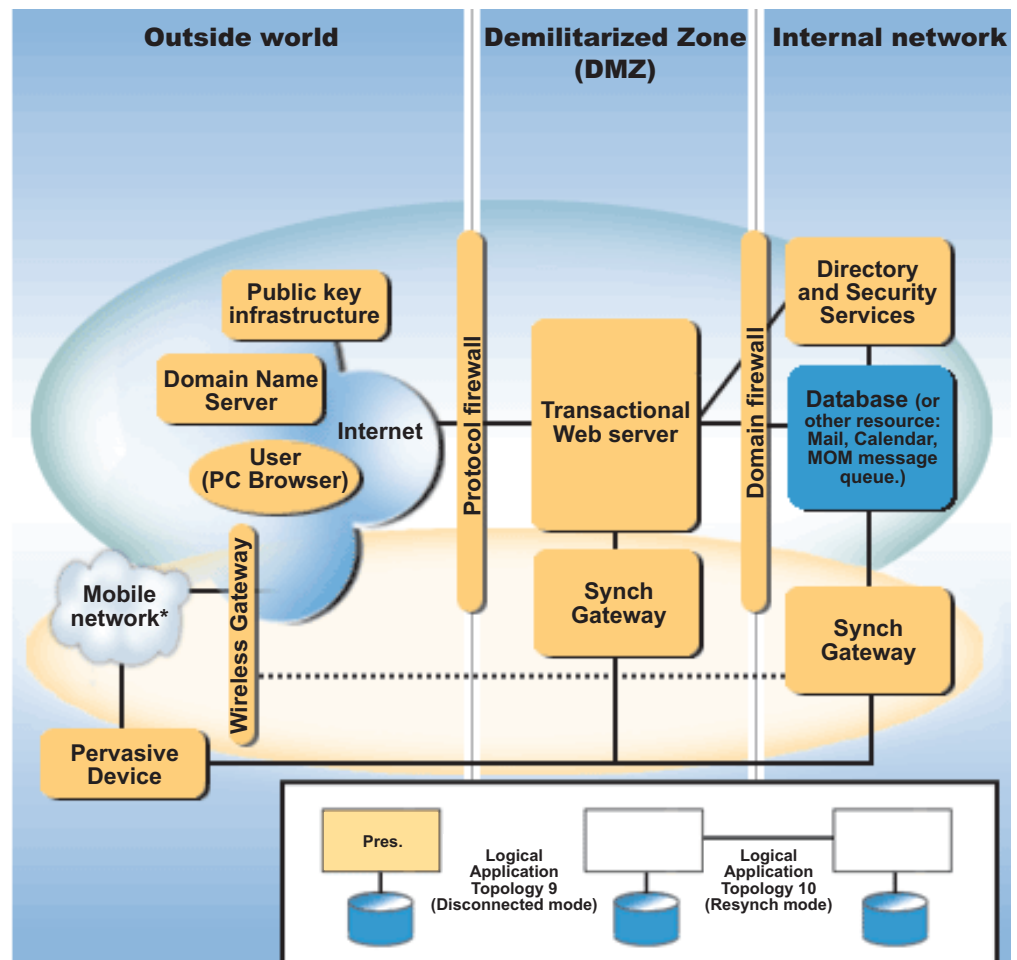
## Chapter 6. Asynchronous Mode

The asynchronous mode of operation is highly prevalent with the current generation of Personal Digital Assistants, whether they have occasional network connectivity or only connect to a PC for synchronization in the office or base location.

The range of content that can be considered under this mode includes:

- Personal productivity data: calendar, to-do lists, memos, e-mail, documents
- Web content
- Database forms input
- Application messaging (MOM)

The following diagram depicts the runtime topology when the Asynchronous Mode implements Application Topologies 9 and 10 of the User to Business pattern.



©Copyright IBM Corporation, 2000. All rights reserved.

As before, the yellow area indicates a sub-pattern that can be overlaid on the runtime topology of the application to deliver this new mode of operation. The

asynchronous mode of operation can run concurrently and complement the Synchronous mode, whether from the same pervasive device or from a PC based browser.

The Pervasive device may "synch" with the Synch Gateway (1) based on IP connectivity to a Synch server, or if that gateway is on a PC, using a serial cable, USB or infrared connection. The Synch Gateway (1) can connect the device to a range of content, not only a database in the case of forms input, but also personal productivity data.

For Web content, the Synch Gateway (2), allows the pervasive device to synch personalized Web content. The personalized selection is determined using the Synchronous mode, likely through a PC. The user selection can be associated with a profile in the Directory service.

---

## Application development guidance

The placement of application logic and data must be carefully designed when using this model, whether user access is through a pervasive device or a PC. This consideration can affect the user in the following areas:

- Personal productivity applications, which is the primary source for calendar data
- Database forms input; does the user recognize the latency in the form input and the 'work in progress' nature of the data until recorded on an enterprise data store?
- Applications written to use the local presentation services of the pervasive device and store processing requests as messages; is the application logic consistent with that provided in Synchronous mode through the Transactional Web Server?

The use of asynchronous mode to update a static cache on the pervasive device may improve performance in synchronous mode.

---

## Systems management guidance

As the amount of data stored on pervasive devices grows, the security guidelines for mobile PCs (or laptops) increasingly apply to these devices as well. These issues include: data security, virus protection.

User authentication can also be provided locally and is strongly advised if sensitive data is stored on the device.

---

## Chapter 7. Voice mode

With the limited keypad space and screen size of pervasive devices, voice technology promises enhanced input and output functionality for Pervasive Computing.

Technologies that enable voice interaction with applications has matured to the point where it can be used intelligently by application designers both for command input and for system response.

The voice mode of interaction with an application requires:

- Speech recognition
- Speech generation

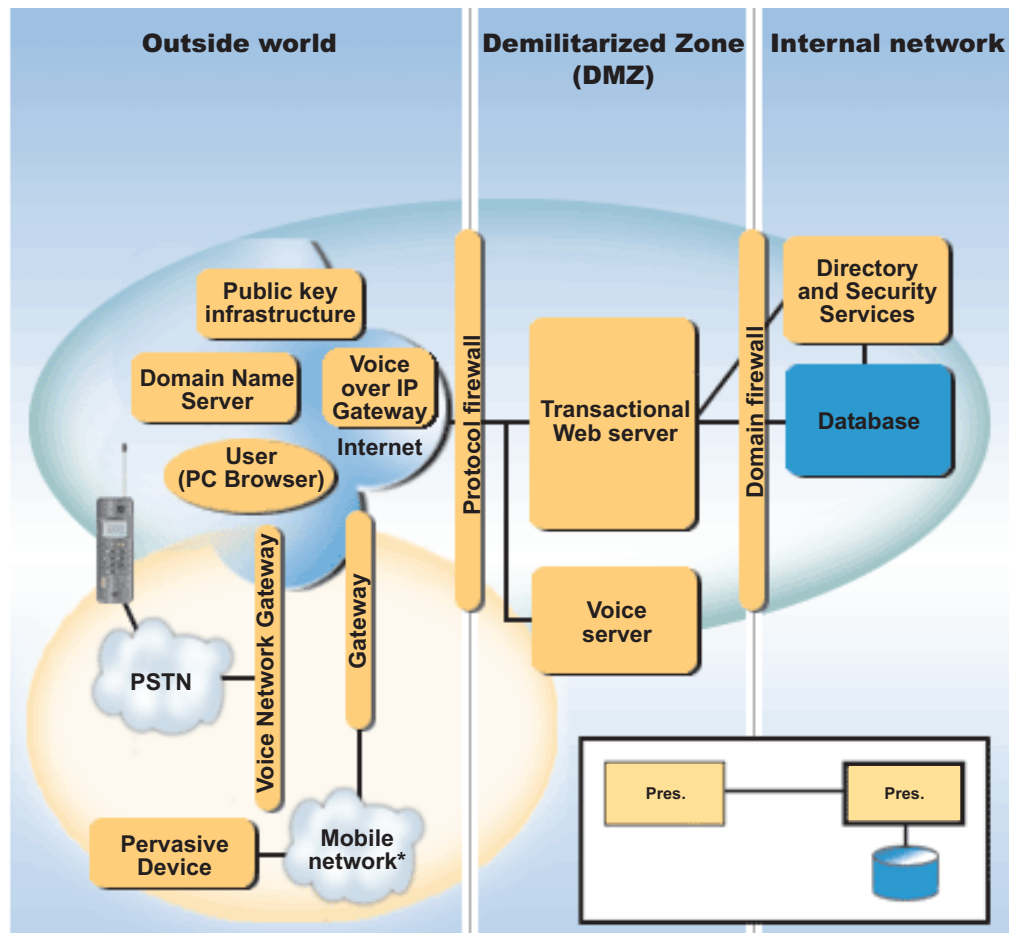
In principle, either of these transforms can occur on either a client or a server. However, unlike personal computers, the current generation of pervasive devices do not have the processing power to perform these transforms and so we assume in the following that they are performed on a Voice Server. We further assume that the range of input commands is constrained so that a personalized voice recognition function is not required.

For this mode, we will assume that the pervasive device is a cell phone. Let's consider some of the ways in which this device can be used:

- The user may use the device as a phone to connect to another voice user, whether on a mobile or a PSTN network.
- The cell phone could establish an IP connection if it had an IP stack and converse with someone or with a Voice Server using Voice over IP. This is not a likely scenario today, but possible from a PC and likely to become possible in the future.
- The cell phone can connect, via Mobile and PSTN voice networks to a Voice Network Gateway and then to a Voice Server.

Our primary interest here is the interaction with the Voice Server. The Voice Server acts as a proxy client to the Web Application Server. The Web Application Server provides dynamic content in an XML format known as VoiceXML. The Voice Server "renders" VoiceXML into speech. VoiceXML also contains dialogue tags that prescribe possible input. The user's vocal response can be matched to one of the allowed responses and the Voice Server transmits this as a new request to the Web Application Server.

The following figure illustrates an extension to the User to Business Application Topology 1 Runtime design that enables the pervasive computing Voice mode.



©Copyright IBM Corporation, 2000. All rights reserved.

## Application development guidance

The application design pattern discussed under Synchronous mode can be extended to cover the Voice mode of pervasive interaction.

In this case, the Java Server Page on the Web Application Server will produce VoiceXML as the content of the Service Response. The application architecture's ability to be extended in this way is not an accident. It is a result of the use of XML by e-business architects to distinguish content from presentation, and the development of device or mode specific XML schema.

There are limitations to the type of interfaces Voice Mode can support. At this stage, it is more suited to simple dialogues and inquiries.

The benefit of this application development approach is that it opens up Voice mode applications to a broader set of application developers, rather than only those proficient in call center and IVR (interactive voice response) specific architectures.

---

## **Systems management guidance**

Voice mode uses the pervasive device in an ultra-thin mode. Not even the content rendering is performed on the client, so there are no data or application placement considerations.



---

## Chapter 8. The Impact of Mixing Modes

It is already apparent from the previous discussion that these modes do not have to be used in isolation, but can be combined within an application design.

Furthermore, these modes of interaction have an affinity for certain device types and channels.

e-business application support of user access from different channels is known as multi-channel support. Some examples of this include:

- Using a PC to browse an online commerce site and setting alerts for later notification on a pervasive device
- Paying banking bills by voice mode and later reviewing account activity online through a PC based browser

The ability of a device (whether a PC or a pervasive device) to support several modes of interaction simultaneously is called Multi-modal interaction. This technology is now currently emerging and gaining greater sophistication. An example of Multi-modal interaction is when a Voice Mode request to an application that results in a micro browser rendering of the document output on the pervasive device. IBM's Voice Server has demonstrated just this kind of capability.

The sub-patterns outlined in this paper are powerful because they can be used as extensions to existing Patterns for e-business without abandoning the infrastructure already established by the pattern design. One or more of the sub-patterns identified in this paper can be applied to the base Runtime Topology diagram identified for a business pattern to enable pervasive functionality.

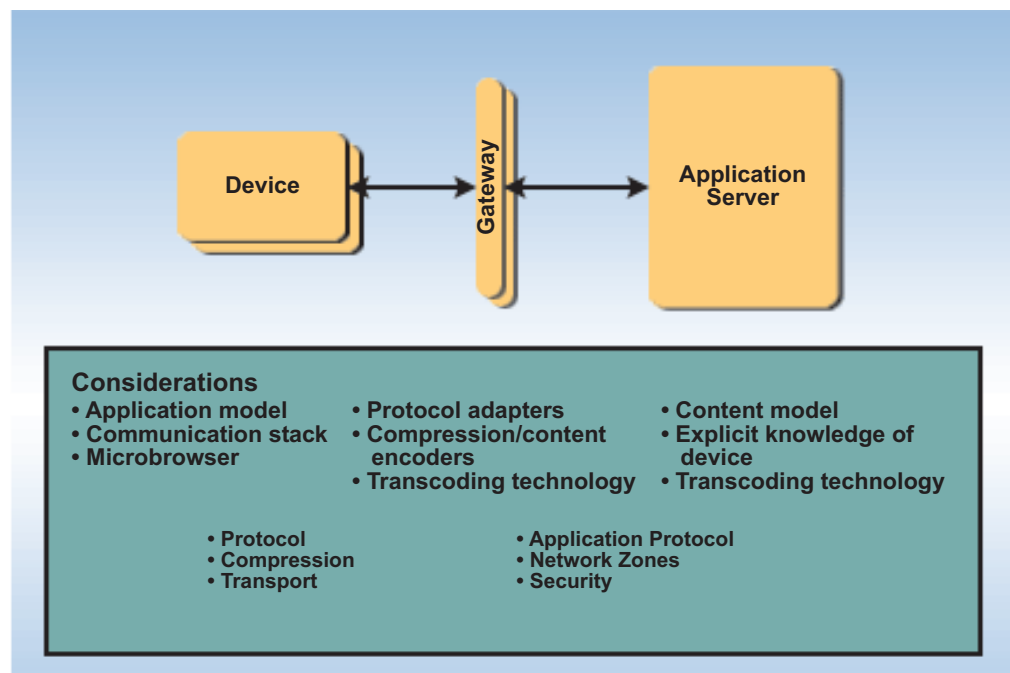


---

## Chapter 9. Intelligent Infrastructure for e-business

Pervasive computing is not limited to the delivery of content and dynamic pages to a thin client on a connected pervasive device. It requires intelligent infrastructure to perform transforms on content, protocols, and the underlying network. This intelligent infrastructure simplifies the application programming model so that the application architecture of the Web application server now primarily considers specific content formats, increasingly XML based, for presentation on the device or channel.

A simplified representation of these considerations is shown in the following figure.



©Copyright IBM Corporation, 2000. All rights reserved.

---

### Intermediaries and pervasive e-business infrastructure

In reality the infrastructure for pervasive computing, just as for e-business in general, requires a number of intermediary nodes. The intermediaries work at different levels and, depending upon the required abstraction, are explicit or implicit in a runtime topology diagram for an e-business pattern.

For clarity, the pervasive gateway at the edge of the network node, between the mobile network and the IP network is shown in the diagrams as a single node. The WebSphere Everyplace Suite provides a much more complete view of the set of services required in the gateway and application infrastructure. These include:

- Connectivity: Everyplace Wireless Gateway
- Security: Everyplace Authentication Server and Everyplace Wireless Gateway
- Content handling and adaptation: WebSphere Transcoding Publisher, Everyplace Synchronization Manager and MQSeries Everyplace

- Subscriber and Device Management services: Tivoli Personalized Services Manager
- Optimization: Edge Server (Load Balancer and Caching Proxy), Secureway Wireless Gateway

Where more specific gateway server function is needed (for example, in the Synch Server and Wireless Gateway) this is indicated in the Runtime Topology diagrams. It is recommended that the sub-patterns be considered a first level abstraction that require an additional level of definition with the complete set of nodes and services.

As is demonstrated in the Redbook on WebSphere Everyplace Suite (Reference 6), this next level requires consideration of architecture decisions in areas such as:

- Integration of Gateway security and directory services, both in the case where the Gateway is co-located with an enterprise's e-business infrastructure and in the case where the Gateway is at an ISP
- Optimization and high availability considerations such as use of Edge Server caching and load balancing as well as HACMP for data storage

---

## Adaptive e-business infrastructure

As the intelligent infrastructure for e-business evolves, a pervasive device will be able to analyze its particular environment and switch between communication networks and use service discovery protocols to work with the full set of services available. Mobile networks range from those based on cellular networks to Wireless LANs, and now to Bluetooth enabled short range wireless access. Ideally, the pervasive device will connect with the best bandwidth and quality of service available from these options.

Finally, some thoughts on two areas that could have profound implications on how pervasive computing solutions evolve:

- Network Architecture
- Pervasive programming models

---

## Network architecture

The sub-patterns introduce several networks: voice (PSTN and cellular), ISP dial access, Paging networks. In many e-business architecture diagrams, network details can be abstracted because of the ubiquity of the TCP/IP standards and the way that administration of the Internet backbone, DNS systems and ISP connection shields us from network architecture detail.

Because of this ubiquity, the routers, switches and network topologies are not shown in detail in the Runtime Topologies for the Patterns for e-business. These elements are also very much a part of the intelligent infrastructure for e-business. They will incorporate more infrastructure services into firmware, and are particularly important at network boundaries.

Until next generation Internet and mobile networks emerge as more complete and robust technologies, pervasive computing devices will in many cases be communicating to the IP network through a proxy. Therefore, it is important to consider the supplier(s) of network connectivity and services in pervasive computing designs.

---

## Pervasive programming models

The application design guidelines presented in this paper have focused on the server-side programming model and the use of device or channel based content to render the presentation interface on the device.

As more variation, power, and sophistication comes to pervasive devices, more discussion of programming models specific to these devices will occur. Server side programming models may become less popular when the relatively low bandwidth for mobile networks is no longer a confining programming issue. Furthermore, an effective client-side model may emerge that has sufficient market share and mind share among developers.

Among the contenders for the device platform and programming model are:

- Palm OS native programming model
- Microsoft PocketPC
- Java 2 Micro Edition (J2ME)

As discussed earlier, placing application logic and data on the pervasive device has implications for data currency and management, application consistency, and software distribution. The overlay of the Application Topology on the Runtime Topology becomes very important to communicate the placement decisions. These are familiar design decisions from Client/Server application designs. They have been greatly simplified by the server centric placement of application logic and data in most e-business systems.

Where the pervasive device offers an application model that is attractive to the user, such designs will emerge. Designers will need to consider how to blend these designs with the more ubiquitous e-business infrastructure.



---

## Chapter 10. Summary

The Patterns for e-business have been an effective means for e-business architects to capture and communicate the essential structure of e-business solutions.

Pervasive computing can also be understood within the patterns design schemes, although pervasive architectures require careful use of application topologies beyond those assuming a connected, synchronous mode of communication using a PC-based browser.

Pervasive Computing will change e-business solutions across the full range of the Patterns for e-business. Current Patterns work can be extended by the use of sub-patterns that capture the new modes of e-business solutions relevant for pervasive computing.

Many other issues relevant to a full consideration of pervasive computing have not been discussed in this paper due to space constraints. Review the following resources for more information on these specific pervasive computing issues.

- User experience: see Donald Norman's work, *The Invisible Computer*, MIT Press paperback, 1999.
- Communications technology: from the physics of packet radio networks to questions of integration and/or convergence of voice and data networks
- Standards: Content, protocol, communications transport

---

## Acknowledgments

This paper represents the thinking of many colleagues within IBM with whom I have collaborated over the past year, some of whom are represented here.

- Jonathan Adams - Software Group
- Chris Couper - Communications ISU
- George Galambos - IGS Canada
- Rudolf Jetzelsperger - IGS Pervasive Computing
- Eric Lawton - IGS Canada
- Larry Porter - IBM Hursley
- Jeff Whitehill
- Les Wilson, technical lead, IBM Voice Server



---

## Chapter 11. References

- Visit IBM's Pervasive Computing Web site at: <http://www.ibm.com/pvc>
- Visit IBM's Patterns for e-business Web site at <http://www.ibm.com/developerworks/patterns/>
- Learn more about Pervasive Computing and the Application Framework for e-business in Krishna Akella and Akio Yamashita's November 1999 white paper available at: <http://www-4.ibm.com/software/developer/library/pvc/index.html>
- A cursory overview of IBM's Pervasive Computing initiative and its relationship to the Patterns for e-business is available at: <http://www.ibm.com/developerworks/patterns/library/pervasive-summary.html>
- Read the IBM Redbook, Patterns for e-business: User-to-Business Patterns for Topology 1 and 2 using WebSphere Advanced Edition, SG24-5864 for detailed information about implementing the User to Business pattern. This redbook is available at: <http://www.redbooks.ibm.com/abstracts/sg245864.html>
- For more information on user experience as it relates to Pervasive Computing, review Donald Norman's book, *The Invisible Computer*, MIT Press paperback, 1999.
- Learn more about the WebSphere Everyplace Suite from Juan Rodriguez's redbook, An Introduction to IBM WebSphere Everyplace Suite Version 1.1 Accessing Web and Enterprise Applications, SG24-5995 available at: <http://www.redbooks.ibm.com/abstracts/sg245995.html>
-







Printed in the United States of America  
on recycled paper containing 10%  
recovered post-consumer fiber.

Spine information:



Pervasive Computing and the Patterns for e-business