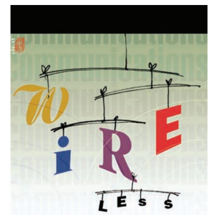
Bringing the Wireless Internet to Mobile Devices



Transcoding and Relational Markup Language are promising middleware solutions to the problem of bringing Internet content to the extremely diverse and dynamic mobile wireless devices universe.

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Effectively mapping Internet content to mobile wireless devices requires not only new technologies and standards, but also innovative solutions that minimize cost and maximize efficiency to the benefit of both content providers and consumers. The wireless Internet must deliver information to handheld device users regardless of where they are and how they are connected, and in a suitable format—a challenge complicated by the dizzying array of devices, wireless standards, and applications.

UNDERLYING TECHNOLOGIES

A complex, interlocking set of technologies underlie wireless Internet services and devices. Equipment providers such as Motorola, Nokia, and Siemens produce the devices and the infrastructure to support wireless data networking. Microsoft, Palm, Symbian, and other companies provide operating systems and microbrowsers for handheld devices. Application platform solutions from vendors including Openwave, Nokia, and Ericsson contribute the middleware infrastructure such as WAP (wireless application protocol) gateways. Middleware also includes a new generation of wireless application platform infrastructure software to provide wireless applications and device independence for the increasing variety of handheld devices.

Network technologies

Most digital cellular networks are second-generation (2G) networks. A complicated set of overlapping, mutually incompatible 2G and 1G (analog) standards exist in the United States, while the Global System for Mobile communications (GSM) technology is the most prevalent standard in Europe. The maximum data rate in most 2G networks is 14.4 Kbps or lower.

The next several years will see the rollout of 3G systems in the United States, Europe, and Asia.[1] 3G will initially support data rates in the tens to hundreds of Kbps range, with possible future support for data rates as high as 2 Mbps—most likely for low-velocity motion and short mobile-to-base transmission distances. Intermediate 2.5G solutions will leverage much of the existing network infrastructure and offer data capabilities in excess of what is available in 2G but short of the eventual 3G speeds.

Although the exact form in which these various high-speed wireless data services will develop is uncertain, we will clearly see substantial improvement over today's data rates in the very near future, thereby removing one of the wireless Internet's most significant hurdles.

Service technologies

Another obstacle lies in the mobile devices themselves, which typically suffer from small displays, limited memory, limited processing power, low battery power, and greater vulnerability to inherent wireless network transmission problems. These usability challenges make supporting common Internet standards such as HTML, HTTP, and TCP/IP difficult because they are inefficient over mobile networks.

WAP. To address these issues, a group of leading wireless and mobile communications companies developed the wireless application protocol for transmitting and presenting wireless information and telephony services on mobile handheld devices. Whereas HTTP sends its payload in a text format, WAP uses a compressed binary format for greater efficiency. It offers a scalable, extensible protocol stack that handles security, session establishment, and other aspects of mobile communications to make systems run more efficiently over today's low-bandwidth wireless networks.

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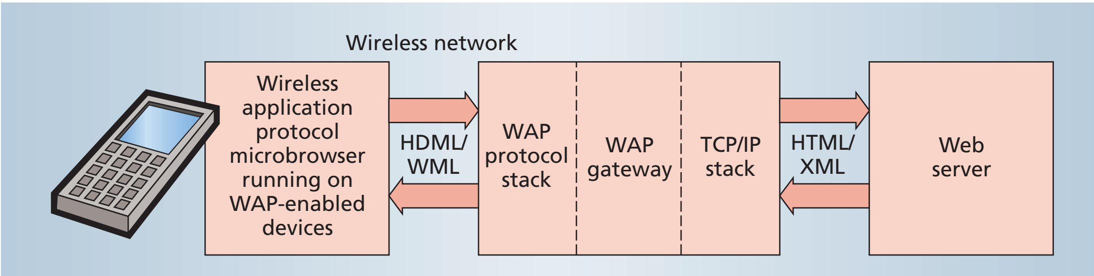

Figure 1. Accessing the wireless Web using a wireless-application-protocol-enabled device. A WAP gateway produces a more efficient representation of the Web content that can be more easily transmitted over wireless networks.

Instead of using HTML, WAP uses Wireless Markup Language (WML), a small subset of Extensible Markup Language (XML), to create and deliver content. As Figure 1 shows, the WAP gateway translates requests from the WAP protocol stack to the TCP/IP stack so they can be submitted to Web servers. The gateway translates WAP content into compact encoded formats that reduce the amount of data it sends over the low-bandwidth wireless network.

WAP is currently the most widely adopted wireless protocol in the world among carriers and handset manufacturers.

Launched in 1997 by Phone.com (now OpenWave), Motorola, Nokia, and Ericsson, the WAP Forum (http://www.wapforum.org) has grown to include more than 95 percent of the global handset market.

The forum is planning to update the WAP protocol to ensure compatibility with 2.5G and 3G wireless standards. On 30 January 2001, OpenWave unveiled its product architecture for wireless general packet radio service and 3G systems. This new platform, which simplifies migration from current WAP-based mobile services deployed on 2G systems, supports not only WML, but also XHTML, HDML (Handheld Device Markup Language), Compact HTML (a subset of HTML that emphasizes text and simple graphics), and WAP 2.0, scheduled for release later this year. The updated protocol will support full-color graphics, multimedia, and, for wireless operators, subscriber management capabilities.

iMode. WAP is not the only protocol aimed specifically at the wireless Internet. In fact, in recent months, some have questioned WAP's long-term viability,[2-4] particularly in view of the explosive growth in competing technologies. The best-known non-WAP solution is iMode, a wireless Internet service that NTT DoCoMo introduced in Japan in February 1999. iMode relies on modifications and extensions of existing protocols. With iMode, smart-phone users can browse the Net with a touch of a button. iMode has a transmission speed of 9.6 Kbps, utilizes a packet-switched connection, and has adopted CHTML as its markup language.

Other technologies

Location-based services that use device location information to modify communications content are likely to become important for applications such as commerce and emergency services. Clearly, location-aware systems also raise complex privacy issues. Voice-based access is also likely to be important because of limited device display capabilities and because voice interaction has advantages in situations where keypad entry is impractical—for example, while driving a car. Indoor wireless networks are also likely to be extremely important for Internet access. Because wireless LANs and PANs have less severe bandwidth constraints than wide-area cellular networks, they allow access that is closer to "wired" Internet access.

MIDDLEWARE CHALLENGES

Common to WAP, iMode, and other similar solutions is the need to specifically recode Internet content for wireless devices. A content provider offering a Web site to both desktop and wireless users currently must maintain two parallel versions of the site customized to wired and wireless devices. Middleware, one of the most dynamic and yet least understood technologies, offers an alternative to manually replicating content. Its basic purpose is to seamlessly and transparently translate a Web site's existing content to mobile devices that support numerous operating systems, markup languages, microbrowsers, and protocols. Creating a wireless presence using middleware, however, presents several key challenges.

Application integration

One challenge is integrating disparate content sources. Although some Web developers are beginning to store information in XML, most existing content was developed for desktop-based, nonmobile HTML browsers. Typically, most Web sites have a layered structure that closely ties a presentation layer to an underlying logic layer. However, wireless devices require a drastically different presentation layer, and rearchitecting the entire site to decouple these layers would be extremely expensive.

Device independence

Another challenge is the proliferation of devices, browsers, and markup languages.[5] For example, markup languages include such variants as HDML

Internet Markup Languages

SGML
Standard Generalized Markup Language is a generalized common standard for describing an electronic document's structure and organization. It does not specify a structure but instead allows for customized tag sets. SGML provides the primary framework for other languages including HTML and XML.

HTML
Developed as the World Wide Web was coming to prominence, Hypertext Markup Language facilitates the visual presentation of information over the Internet. Its subsets include HTML 4 and HTML Strict, which address presentational and structural issues differently.

XML
As Web developers recognized that SGML document distribution and presentation required unique tools, Extensible Markup Language emerged as a powerful alternative to HTML, which has predefined tags for specialized tasks. XML lets developers define their own markup elements and gives content authors greater flexibility for structurally and stylistically customizing Web documents. XML also offers HTML developers a framework for customizing and adding proprietary elements to HTML.

XHTML
Extensible Hypertext Markup Language supports modular and extensible Web access based on XML. With a few notable exceptions, it strongly resembles HTML 4. Released in January 2001 upon recommendation by the World Wide Web Consortium (W3C), XHTML represents the most significant evolution of HTML since HTML 4's introduction in 1997. XHTML essentially reformulates HTML as an XML application, enabling viewing by both HTML browsers and XML-based systems. Consequently, most users can access Web pages regardless of their browser device.

XSL
Extensible Stylesheet Language enables transformation of XML documents into a format recognizable to a browser. For example, developers can use XSL to transform each XML element into an HTML element. XSL also provides a means for reformatting organization of the display elements: It can add completely new elements; remove, rearrange, and sort elements; and test and make decisions regarding which elements to display.

RML
Relational Markup Language is an XML application just as HTML and XML are SGML applications. RML is tailored to meet the specific needs of wireless Internet technologies. Developers use RML's customized elements to add structural context to a Web site's content for multiple presentation formats. RML retrieves and caches client data from requested URLs, then uses predefined rule sets to convert the data from HTML and XML to RML. RML follows XML's structural rules, but its specific elements are unique.

WML
Wireless Markup Language evolved from XML, HTML, and Phone.com's Handheld Device Markup Language. Designed to develop Web pages that developers can easily render on small wireless devices, WML permits more flexible information displays than HTML and lets users input commands without a keyboard. Currently, developers must write a Web site in WML or a server must convert HTML to WML to translate the site and render it properly on WAP-enabled devices. WML is scalable and extensible because, like XML but unlike earlier versions of HTML, it lets users add new markup tags to meet changing needs. The WAP Forum is cooperating with the W3C to ensure that WML and XHTML will work together.

3.0, WML 1.x for OpenWave, WML 1.x for Nokia, TinyHTML for PalmPilots, and CHTML for iMode. Different browser features—support for non-nested tables and images, nested tables but no images, images and nested tables but only one font size, and so on—compound the problem. Display capabilities range from two-line black-and-white displays to full-color displays with tens of thousands of pixels.

Optimal user interface
Creating a compelling user interface that is appropriate for different device classes is another challenge. For example, a stock-trading site might want to expose a market research function containing charts and graphs to a PalmPilot but not to a limited-display cell phone. To avoid forcing the cell phone user to scroll down numerous lines or navigate through multiple menus to access desired content, the two devices' information architecture would have to be drastically different.

MIDDLEWARE SOLUTIONS
At first glance, it seems that the easiest way to address these problems is to rewrite existing Web content in a language appropriate for a particular protocol (see the "Internet Markup Languages" sidebar). This would involve, for example, creating WML-

formatted content to fit various WAP devices, CHTML-formatted content for iMode devices, and so on. However, the wide range of devices, browser functions, gateway interfaces, and markup language nuances make this approach intractable.

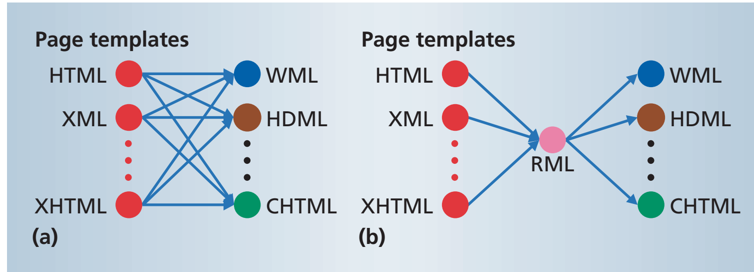

Figure 2. Creating a modular architecture using Relational Markup Language. (a) A traditional wireless implementation can require different transcoding steps for each possible combination of markup languages. (b) In contrast, an RML-based implementation provides an intermediate format for the automatic markup of all markup languages. The output can then be generated without regard to the original input markup language.

User-transparent transformation

In user-transparent transformation, a middleware application transparently reformats content "on the fly" into a user-specific presentation, interface, and protocol. In this context, a middleware application sits between the existing content server and the user agent. Because the middleware application can automatically detect the kind of device being used and format the contents accordingly, it is not necessary to maintain Web content in multiple formats.

User-transparent middleware approaches can process transcoding with or without a priori information. They can either strip down the content from an under-described source such as HTML or build up content from discrete pieces. However, end users still must scroll through hundreds of lines to get to the content in which they are interested.

Relational Markup Language

Relational Markup Language incorporates two concepts—relational hierarchies of content and adding context to content—to resolve these problems. Because it describes content through relationships, RML provides a write-once-deliver-anywhere solution. An interpreter can use the relational information to create an optimal information architecture. As Figure 2 illustrates, converting application content to a normalized RML format facilitates creating a modular architecture. When a new device, browser, gateway, or markup language emerges, adding one new module supports both current and future users.

Atomics and groups. The RML framework uses *atomics*—discrete pieces such as a word, sentence, paragraph, image, link, or any other piece of content—to create a framework that supports the addition of both relational data and context. RML encapsulates atomics into *groups* to create a complex relational hierarchy. As Figure 3 shows, groups contain one or more

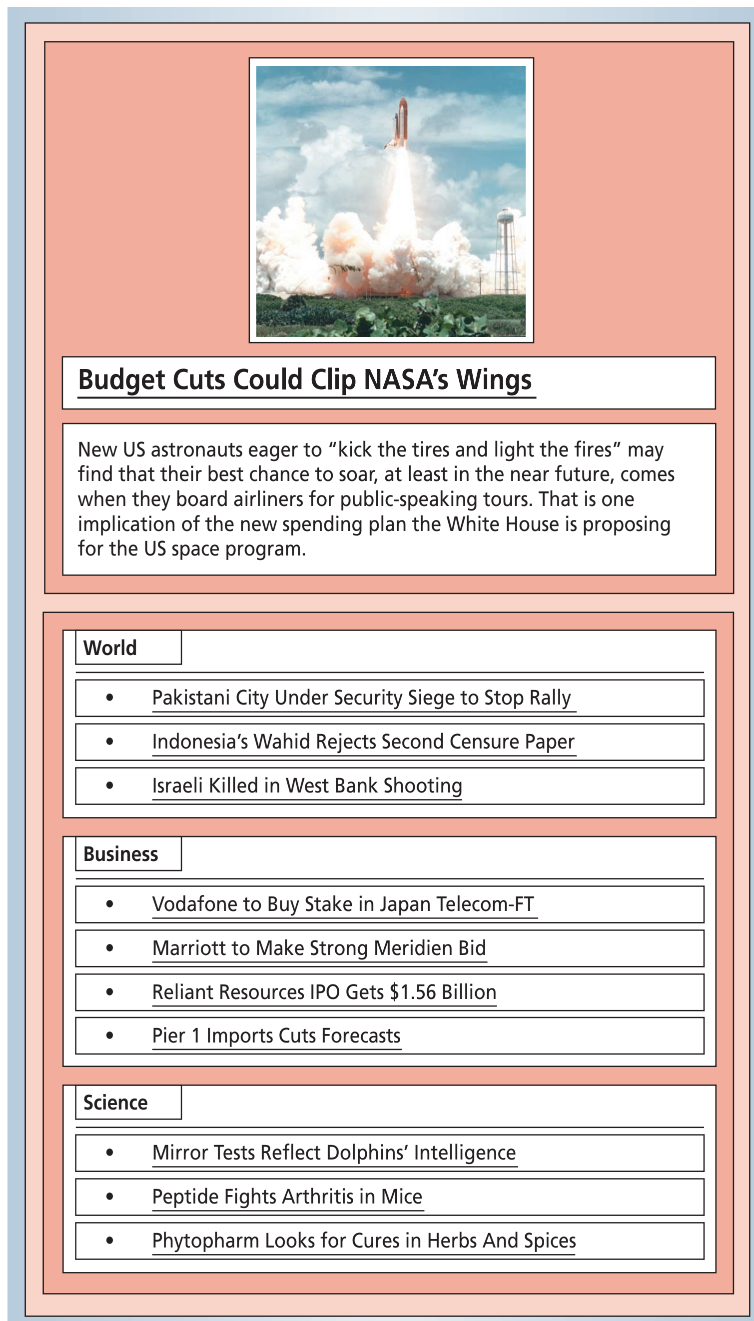

Figure 3. Breaking Web content into atomics and groups. This typical news site's content decomposes into discrete pieces—links, sentences, paragraphs, and images—to create a framework supporting the addition of both relational information and context. The main group consists of all the atomics and groups that make up the site. Each top story's image, headline, and introductory text form another group. The headline group includes three subsections: world, business, and science. Finally, each subsection and its associated story links form a group.

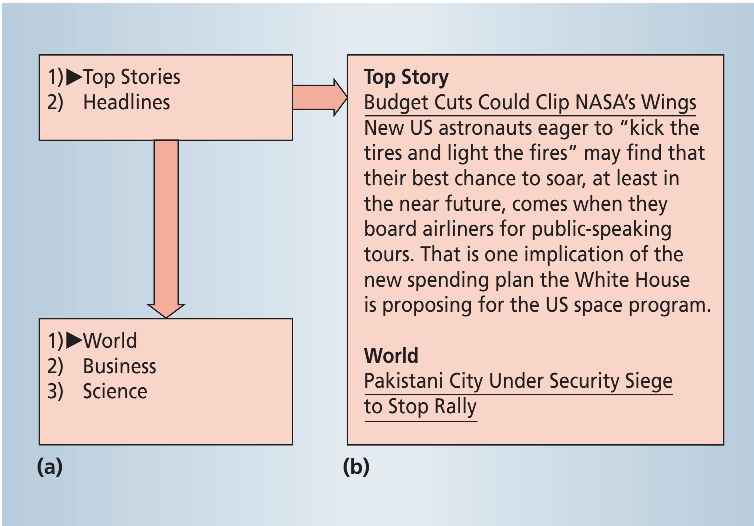

Figure 4. Transformed Web content on two mobile devices. (a) The first page of a four-line cell phone display consists of a link to the top story and a link to headlines, which in turn link to the world, business, and science stories, respectively. (b) A larger-display device includes the top story followed by expanded headline subsections.

atomics, and they can themselves be part of larger groups.

Context. An interpreter can add contextual attributes to the atomics and groups to optimize the information architecture for a specific mobile device. Adding context allows the RML document to handle current and future application calls that different devices make from the browser. The context attribute defines the type of application call, and context data defines the parameters the document needs to make the function call. Figure 4 shows how an interpreter can use relational information to create an optimal user experience.

RML also can differentiate between sequential and nonsequential content. For example, a page of text is sequential content, and a list of links to news stories is nonsequential content. If nonsequential content does not fit on one page—for example, the headlines subsection—RML collapses the associated groups into links.

Device-specific tasks may include click-to-dial, creating an address book entry, or sending e-mail. Developers can use the RML framework to develop algorithms that optimize the user's experience on a variety of mobile devices.

Bringing Internet connectivity to wireless devices offers a number of well-known challenges. Simply delivering bits at a high enough rate to untethered devices and creating devices with sufficient display, memory, and user interface features to allow efficient interaction with the Internet requires innovative technologies and new standards. The rollout of 3G systems in the next several years will address many of these challenges. Equally important but less familiar hurdles lie in the mechanisms for bringing Internet content to an extremely diverse and dynamic universe of devices. Middleware such as RML will be critical to meeting the challenge of creating a wireless presence. We anticipate that open standards based on this or similar techniques will gain acceptance. ✷

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