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STATUS AND TRENDS OF WIRELESS WEB TECHNOLOGIES

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ABSTRACT

In the last decade the separate technologies of the Internet and mobile computing have started converging with the advent of two major technologies, WAP and i-mode, that emerged and attempted to realize the vision of wireless Internet. This paper reviews the main technological, architectural and business issues related to WAP and i-mode. It also discusses their main assets and weaknesses as well as their current status and the trends expected to affect their market share and customer basis in the future.

KEYWORDS

Wireless web, mobile devices, WAP, i-mode.

1. Introduction

During the last years, we have witnessed an increasing demand for mobile data communications which led to the deployment of 3G mobile networks, offering higher throughput and basic multimedia services together with voice capabilities. In addition, wireless LANs and MANs have also evolved rapidly, complementing the wireless networking landscape [1].

The phenomenal growth of the Internet and the evolution of mobile wireless computing have naturally led to a convergence of these two worlds, giving rise to the wireless access to Internet resources by users of handheld devices. Within this relatively new paradigm, the wired Internet resources are still utilized, however through mobile terminals and a wireless network (either a wireless LAN or a mobile network) [2]; hence, Internet resources and services are available regardless of the end user's physical location [3].

Wireless computing presents many key characteristics: (a) ubiquity and convenience: mobile devices satisfy the need for real-time communication with not time and place constraints, (b) positioning: users may receive and access information and services specific to their location [3], (c) personalization: handheld devices are typically operated by a single user, thereby enabling the provision of personalized services by wireless web portals [4]. Some characteristics of mobile computing though need to be carefully evaluated by manufacturers and service providers: (a) the physical restrictions of handheld devices (limited energy capacity and color number support, small display size, hard to use keyboard) convey poor user experiences compared to PCs usage [5], (b) limited bandwidth and high cost of wireless connections, low processing capabilities, available memory, (c) Internet services tailored to mobile users are relatively new; the development of new, innovative applications is expected to become a significant market driver in this field.

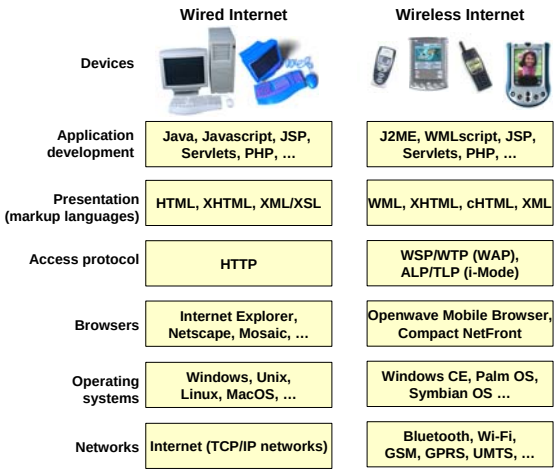

Figure 1. Wired vs. wireless Internet technologies.

Recently, technologies that use wireless infrastructures for Internet access have emerged realizing the vision of wireless Internet. The primary purpose of this paper is to review the status and current trends related to the two

existing technologies of the wireless Internet (WAP and i-mode) and compare their main assets and shortcomings.

A comparison of the technological status of wired and wireless Internet is illustrated in Figure 1, where features are categorized according to their corresponding functional layer (networks, operating systems, browsers, access protocols, markup languages for content presentation, programming technologies for application development). It is noted that a review of the technology status in relation with browsers software and operating systems of mobile devices is beyond the scope of this paper.

The remainder of the paper is organized as follows: Sections 2 and 3 present WAP and i-mode technologies, respectively, and discuss their main advantages and weaknesses. Section 4 discusses the factor that will influence the future of wireless Internet technologies and concludes the paper.

2. The Wireless Application Protocol (WAP)

WAP represents the first serious effort to emulating the success of the Internet in the wireless world. Backed by the entire telecommunication industry (through the WAP Forum [6]), coupled with then fact that it combines two of the hottest innovations in recent times (mobile phone and the Internet), WAP has raised high expectations [7].

2.1. WAP: Architecture, Operation and Evolution

The user of a WAP device 'calls' a WAP gateway through a mobile network and sends requests for web pages located on a WAP site. The role of the gateway is to translate requests from the WAP protocol stack to the WWW stack, so they can be submitted to web servers. The received data are then rendered for display by the mobile device's microbrowser. The architecture and operation of WAP is illustrated in Figure 2.

Similarly to the contents of a conventional web site, WAP sites contents are typically stored on a web server. The main difference is that they are developed in the Wireless Markup Language (WML), so that their format is tailored for small-sized screens and fast transfer over the mobile network. WML [8] is an XML application; it follows a stricter syntax than HTML and allows for the use of variables, which greatly improves the functionality of the code. WAP also supports WMLScript, a lightweight scripting language that enhances user interactivity with WML content. WML has been chosen instead of HTML because the latter includes information of such complexity and size that modern handheld devices either cannot render or is too expensive to download. Namely, the transfer of documents with sophisticated design (with considerable charge due to the engagement of the wireless channel for a long time) only to be presented on small-sized, low-resolution screens would be unacceptable. A number of WML editors are available to simplify and automate the authoring of WML code (see Figure 3).

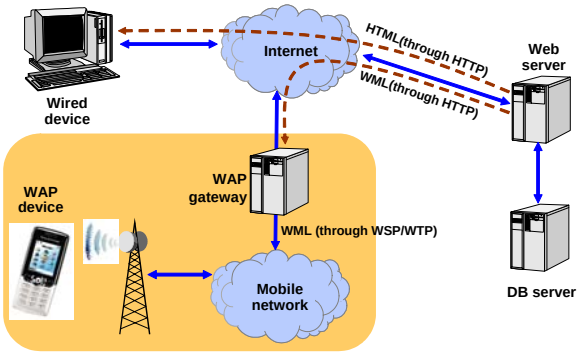

Figure 2. WAP architecture and operation

Essentially, WAP is a protocol stack optimized for low bandwidth wireless connections established by devices with slow processor, low memory and small screen size. The protocols comprising WAP stack are inspired by the 'wired' TCP/IP protocol stack. Hence, low-level protocols control data transfer over the mobile network[1], while high-level protocols specify the way that applications access wireless communication services. Mid-level protocols are directly mapped to Internet protocols, e.g. the Wireless Transfer Protocol (WTP) corresponds to TCP and the Wireless Session Protocol (WSP) to HTTP.

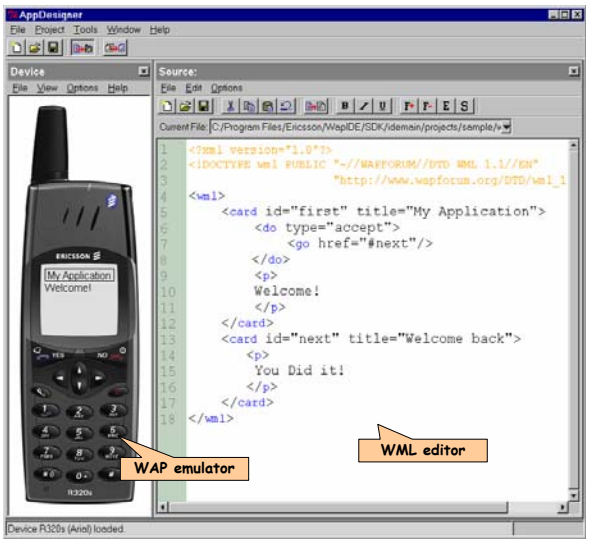

Figure 3. A WAP Integrated Development Environment with a WAP emulator

The practical problems revealed with the usage of the WAP's first version (analyzed in the following subsection) led to the standardization of two new versions of the protocol. Version 1.2 incorporated the 'push model', wherein the content may be pushed to mobile terminals with minimal intervention and enables WAP users to be notified as soon as an important event occurs.

[1] In particular, the first generation of WAP (WAP 1.x) operates over circuit-switched networks (GSM) with data rates of 9.6 Kbps. In contrast, WAP 2.0 may operate over packet-switched (e.g. GRPS, 3G) networks taking advantage of their higher transmission rates.

A more recent WAP version (WAP 2.0) leads to a reformation of WAP standard, adding support for content developed in a subset of XHTML, the XHTML MP[2] (eXtensible HTML Mobile Profile) [9]. WAP 2.0 is backward compatible with the previous versions, i.e. WAP 2.0 terminals may process WML pages. Thus, WAP 2.0 has realized a major step on the direction of compatibility with web content (typically authored in HTML). Moreover, in WAP 2.0, the content is transferred through HTTP, removing the requirement for WAP gateways that translate content among WSP and HTTP. Indeed, it is expected that future versions of WAP will converge towards terminal devices able of accessing real web content (and not content especially developed for them).

2.2. Advantages, Shortcomings and the Future of WAP

It is now acknowledged that WAP technology has been overhyped, unrealistically raising consumers' expectations although it has gained remarkable acceptance, mainly in Europe but also in Japan. WAP technology offers advantages like:

- It supports WML that has been specially designed for optimizing content presentation on terminals with small-sized screens and low processing capabilities.
- Data are 'compressed' (encoded) prior to their transfer to the requesting WAP device so as to reduce the delay experienced by users connected through slow wireless links.
- The lightweight protocol stack comprising WAP is specially designed for minimizing the consumption of wireless bandwidth and making WAP standard independent of the underlying mobile network system (e.g. GSM, GPRS, 3G).

However, WAP is considered a commercial failure, mainly owned to its inherent weaknesses:

- Pricing: WAP 1.0 (which still maintains the largest user basis among WAP compatible devices) has been mainly operated over circuit-switched systems, wherein charges apply on connection time basis. That has proved a major counterincentive since users were not keen on surfing the net with a tiny screen over unacceptably slow and overrated wireless connections [10].
- Slow speed, poor usability and perceived experience: WAP typically operates on GSM networks with transmission speed of 9.6 Kbps. WAP users are not constantly online: they need to dial the gateway's number to get online. Thus, it might take several minutes to access a WAP site, especially in peak hours. Together with the small screen size and the hard-to-use keypad, WAP conveys an overall usage experience which is unacceptable for traditional Internet users [7].
- Incompatibility with existing web content: WAP devices may only access pages 'translated' to WML, thus excluding the vast majority of web content. Besides, WML poses restrictions on the maximum file size, while WML pages are not straight-forward to author as WML follows a strict syntax (possible syntax errors are not overlooked by WAP browsers, as in the case of HTML).
- Security: WAP gateways represent a security hole since encrypted data are decrypted on their passage over the gateway and re- encrypted prior to their re-transmission (this problem has been addressed in WAP 2.0) [11].

The industrial giants that back the WAP Forum and the technological enhancements of WAP 2.0 are expected to increase the adoption of WAP technology in the near future. WAP is an application protocol suite designed to function over any bearer service. Currently, most WAP service providers still use WAP 1.x, version, however, version 2.0's backward compatibility should lead to relatively rapid upgrades. These upgrades also make sense since the industry is moving toward adopting XML-based formats for almost every kind of data interchange. Through supporting XHTML MP, WAP 2.0 has made a step forward towards web compatibility and simplified the rapid development of WAP content. Finally, the operation of WAP over packet-based technologies will decrease the cost of WAP services and will probably broaden WAP's customer base.

3. i-Mode

i-mode [12] is a more recent, alternative to WAP, approach for the wireless Internet, which addresses the main weaknesses revealed with the practical implementation of WAP.

3.1. Architecture and operation of i-mode

In principle, i-mode is a service of wireless Internet (in contrast with WAP which is a protocol stack), with large subscriber basis on Japan and increasing acceptance in the rest of the world. It has been developed by the Japanese NTT DoCoMo and is available since 1999. The phenomenal success of i-mode is mainly owned to its carefully designed services and business model. The data transfer is carried out by DoCoMo proprietary protocols: ALP (corresponding to HTTP) and LTP (corresponding to TCP). Initially, the device connects to protocol conversion gateway (translates packets among LTP and TCP). The

[2] XHTML encompasses most of the expressive capabilities of HTML, yet, with stricter syntax. XHTML is based on XML and is expected to replace in the near future the HTML as the de-facto web standard. XHTML MP is a subset of all available XHTML features, including images, forms, basic tables, and object support and removing features inappropriate for small devices.

gateway maintains a broadband connection with i-mode server and returns the "official" (approved by the NTT DoCoMo) services menu. Requests for unofficial services (the user needs to type an i-mode site's URL address) bypass the i-mode server and are directly routed –through the Internet – to the corresponding service providers (see Figure 4).

Unlike WAP, i-mode borrows from successful web document markup standards and supports the cHTML (Compact HTML) [13] language which is based on HTML. cHTML is designed with the restrictions of the wireless infrastructure in mind, such as the limited bandwidth and high latencies of the networks, and small screens and limited functionality of the devices. By removing certain features of conventional HTML, such as tables and frames, the speed of content delivery is substantially increased (albeit reducing display sophistication). However, cHTML added new features, like accesskeys (for selecting hyperlinks), keys as phone number shortcuts, etc. Recently, i-mode has made a further step towards compatibility with web standards, adding support for XHTML Basic[3] [15].

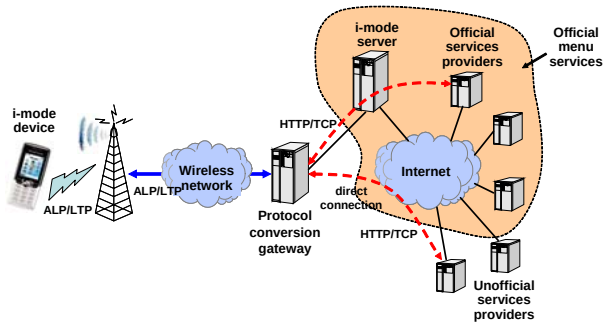

Figure 4. The i-mode system's architecture.

In Japan, i-mode uses a proprietary packet-switched network (PDC-P) and employs a pricing policy based on the volume of transferred data [16]. Thus, the i-mode service is continuously activated, i.e. the users are always connected online. i-mode devices essentially are wireless web terminals with the additional mobile phones capabilities. It is noted that i-mode is independent of the underlying network infrastructure, for instance in Europe, i-mode implementations run over GPRS networks.

3.2. Advantages / Disadvantages and Comparison of i-mode Against WAP

WAP and i-mode are alternative technology solutions for the wireless web. However, i-mode is considered a major success as opposed to WAP which is regarded as a failure. The main reasons for that i-mode's success are:

- i-mode uses cHTML which, as a subset of HTML, simplifies content development and is certainly more compatible with existing web content [17].
- i-mode operates over packet-switched networks, hence, its users are 'always online' and may surf in i-mode sites without worrying about the connection duration, due to the 'pay-per-packet' pricing policy [16][17].
- Tens of thousands of i-mode (official and unofficial) sites currently exist (most of them are unofficial), offering a broad range of services [14].
- The upper limit for cHTML pages size is 5 Kbytes (although sizes up to 2 Kbytes are recommended), considerably higher to the 1.4 Kbytes limit of WML.

However, there are some disadvantages of i-mode compared with WAP:

- cHTML does not support a script language (as it is the case with WML which is accompanied by WMLscript).
- i-mode is a monopoly of NTT DoCoMo. Thus, i-mode devices need to comply with the specifications determined by this company which completely controls the evolution of i-mode. In contrast, WAP technology is telecom operator and device-independent since the WAP Forum includes more than 500 members, practically all the important players in the wireless arena.

Last, a common disadvantage of the two competing technologies is that they both require constant connection (airtime) of the mobile device with mobile network to offer access to Internet resources. Thus, when a user is out of coverage of the mobile network (i.e. 'has no signal') he/she cannot have access to any service.

The question "which of the two (WAP or i-mode) will prevail" is not easy to answer, not only because of their rapid evolution and the fluidity in the field of wireless communications. Certainly, i-mode will significantly influence the future of wireless Internet technologies, mainly due to its current popularity. Hence, one of the two competitors may prevail; maybe none, since the possibility of a co-operation among the WAP Forum and NTT DoCoMo towards the specification of a common standard cannot be overestimated. Current trends though demonstrate that the two technologies converge to supporting subsets of the XML-based XTML language (XHTML MP for WAP 2.0, XHTML Basic for i-mode). The convergence of wireless Internet markup languages is shown in Figure 5.

[3] XHTML Basic is a markup language (XML application) mainly used in mobile devices. It is a subset of XHTML, supporting document structuring, images, forms and basic tables. Unlike WML and cHTML, XHTML Basic is presented in different ways by web browsers and mobile devices, relaxing the need for developing two versions of the same page. XHTML Basic does not contain XHTML features inadequate for mobile devices, e.g. cascading style sheets, frames, and scripting. XHTML Mobile Profile (the markup language of WAP 2.0) is based on XHTML Basic, with the addition of some elements and attributes from the full version of XHTML.

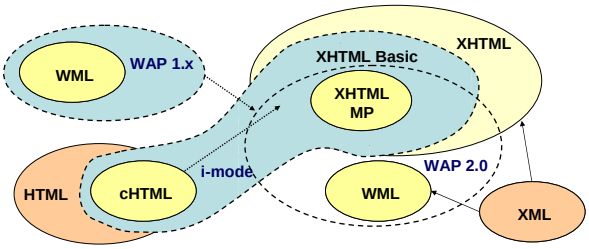

Figure 5. The convergence of wireless Internet markup languages

4. Discussion & Conclusions

It has been almost a decade since WAP Forum was founded and the traditionally separate technologies of the Internet and mobile computing started converging. Within this time, two major technologies emerged and attempted to materialize the vision of wireless Internet. Despite the progress already made, sufficient ground still needs to be covered towards the ultimate goal of unifying the wireless and the wired worlds and enabling the seamless access of mobile terminals to real web content. In this section, we identify the major factors expected to judge the future of wireless Internet:

- The evolution of broadband wireless networks: the pricing policy of mobile operators, the transmission rates and the process of 3G networks deployment will affect the trail of wireless Internet. The users of 3G networks will enjoy faster wireless connections, be always online, and use mobile services independently of their location [3].
- The design of a new generation of devices with: (a) capabilities of managing any kind and format of multimedia content, (b) simplified user input and content browsing.
- The development of a new or the domination of an existing wireless web technology standard. In addition, the convergence towards a single markup language, entirely compatible with wired web standards (current trends on web technologies would mandate the use of a simplified version of XHTML for that role); a global web standard would boost the development of content and services accessible by mobile devices and simplify the conversion of existing content.
- The evolution of mobile services and applications:
  - Alongside the increased transfer rates offered by new generation mobile networks, the first applications that take advantage of these higher rates will emerge (multimedia presentations, telemedicine services, mobile teleconference, interactive entertainment, high-quality music download, etc).
  - Growth of content and sites accessible by mobile devices (mobile portals).
  - Design of innovative services that take advantage of the unique characteristics of mobile devices, e.g. location-based services. These services should also satisfy requirements like: (a) usability, (b) user interface intended for users who are not necessarily familiarized with technology and -possibly- with PCs and Internet usage [5].

A summary of the main features and comparison among the two main currently available wireless Internet technologies may be found in the Appendix.

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APPENDIX: WAP vs. i-MODE

	WAP	**i-mode**
Type of technology	Protocol stack	Service
Standardization	Open standard of WAP Forum	Proprietary (monopoly of NTT DoCoMo)
Target devices	Mobile phones, PDAs, palmtops	Mobile phones
Accessible content format	WML, XHTML MP (WAP 2.0)	cHTML, XHTML Basic (will soon be supported)
Client technology	WML-compatible microbrowser	cHTML-compatible microbrowser
Pricing policy	per minute (per packet when implemented over GPRS/3G networks)	per packet
Support for location-based services	No	Yes (identification of the region where the user is located)
Transport mechanism between client and server	WSP over WTP (end-to-end HTTP in WAP 2.0)	ALP over LTP
Support for disconnected operation	No	No
Support for scripting	Yes (WMLscript)	No
Security	Security hole at the WAP gateway where protocol conversion is done (resolved in WAP 2.0)	Support for SSL
Compatibility with existing web content	Incompatibility of WML (content translation required), enhanced compatibility with XHTML MP (WAP 2.0)	Satisfactory compatibility of cHTML, enhanced compatibility with XHTML Basic
Simplicity of application development	WML enforces strict syntax; content is not straight-forward to develop even for web developers	Easy, especially for web developers
Client-server communication	Standardized (content readable by WML browsers)	Content readable by cHTML browsers, but cHTML is not a W3C standard
Support of push model	Yes (in WAP 1.2)	Possible (e.g. SMS notifying for incoming email)
Regions where it is mainly used	Europe, Japan	Japan