# Wireless Java-enabled MIDP devices as peers in a Grid infrastructure

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**Abstract.** Combining Mobile Internet and Grid technologies could mean the ability to command the power of supercomputers with a mobile device. The computing and data transfer capacities of mobile devices are expanding and Grid-related technologies are already being employed in them. In this paper, we survey the current technologies and standards, mainly concentrating on MIDP (Mobile Information Device Profile) devices and Java (J2ME) interfaces. The technology has a potential for many new interesting applications. This paper outlines a feasibility study, a technological review and examples of applications.

## 1 Introduction

While wireless devices such as high-end Personal Digital Assistants (PDA) and Mobile Communicators have become as powerful as some Personal Computers (PC), the fact that they can be constantly connected to the Internet opens doors for new types of networked applications. Although Microsoft Windows has dominated the desktop computer, eventually the mobile phone will be dominated by Java [19]: All major mobile phone manufacturers have introduced handsets based on the Java 2 Micro Edition [20] language in order to provide a homogeneous application platform for 3rd party developers. The market tendency is that soon every new phone is Java-enabled which will steadily propagate to cover the current one billion subscriber base by year 2006, as the ARC Group researchers estimate [12].

Besides the Mobile Internet traditional Internet computing is experiencing a conceptual shift from a Client-Server model to Grid and Peer-to-Peer (P2P) Computing models. In these models, computing and information resources as well as the meta-data about them are scattered throughout the Internet. The precursors of Grid technology are used e.g. to find extra-terrestrial intelligence from outer space (Seti@Home) [24] or to find cure for AIDS (fightAIDS@Home) [15] by donating unused computing cycles or to share digital music files with peer groups (Napster) [13] by extending searches to every computer in the P2P network.

As these two key trends: Mobile Internet and the Grid, are likely to find each other, the resource constraints that wireless devices pose today affect the level of interoperability between them. The goal of this research is to investigate how well the most limited wireless Java devices (MIDP) [20] can make use of Grid technologies.

## 2 Motivation and Background

Grid is the umbrella that covers many of today's distributed computing technologies. Grid technology attempts to support flexible, secure, coordinated information sharing among dynamic collections of individuals, institutions, and resources. This includes data sharing but also access to computers, software and devices required by computation and data-rich collaborative problem solving [11]. As a scientific example the Grid will help European Organization for Nuclear Research (CERN) to effectively share and manage the collision data from the new Large Hadron Collider (LHC) with rate of 100-1000 Mb/s. The difference between Computational Grids and P2P networks is roughly that they are currently targeted for different audiences. The vision of Computational Grids is to provide tools for power users and usually scientists to harness the power of the grid in the same way as plugging into a socket on the wall for electricity. Today P2P networks are used to create virtual communities to access commodity resources such as MP3 files.

A Computational Grid is a collection of computers, on-line instruments, data archives and networks all tied together by a shared set of services that, when taken together, provides users with transparent access through interface devices to the entire set of resources [9].

A P2P network is a collection of users, interface devices, computers, on-line instruments, data archives and networks all tied together by a shared set of services that, when taken together, provides all the elements transparent access to each other [9].

So far the use of Grid services has required a modern workstation, specialized software installed locally and expert intervention. In the future these requirements should diminish considerably. One reason is the emergence of Grid Portals as gateways to the Grid. Another reason is the Web Service boom in the industry. The use of XML as a network protocol and an integration tool will ensure that a future Grid peer could be a simple wireless device.

The special resource constraints that today's wireless devices pose are numerous [20]:

- Persistent storage is limited and shared by all applications. Modern low-end PDAs are pre-equipped with maximum of 8 Mb memory. Simple mobile phones have only 256 kb of memory.
- Runtime heap is small, 128-256 kbs.
- Network bandwidth is very limited and latency is high: GSM 9.6 kb/s, HSCD 43.2 kb/s, GPRS 144 kb/s, WLAN 11Mb/s.
- Processor performance is modest RISC/CISC 16-50 Mhz.
- Electrical power is confined to that available from small batteries.
- Screen size for building a user interface is minimal. Mobile phones may only have space for 3-6 lines of text on screen.

We will concentrate on the most limited category of wireless Java 2, Micro Edition (J2ME[tm]) devices that use the Mobile Information Device Profile (MIDP). The MIDP specification contains Java packages (see Figure 1.) that have to suffice for applications limited with 128 kilobytes of Java runtime and 8 kilobytes of persistent memory. The MIDP implementation itself has to fit into 256 kilobytes of non-volatile memory [20]. The Applications that these devices understand are Midlets (analogues to Applets, Servlets etc). Typically the maximum size of a midlet varies from 30-50 kbs and a user can download four to six applications to their mobile phone. J2ME is a set of technologies and specifications developed for small devices like smart cards, pagers, mobile phones, and set-top boxes. J2ME uses subset of Java 2, Standard Edition (J2SE[tm]) components, like smaller virtual machines and leaner APIs. J2ME has categorized wireless devices and their capabilities into profiles: MIDP, PDA and Personal. The MIDP and PDA profiles are targeted for handhelds and Personal profile for networked consumer electronic and embedded devices.

As the technology progresses in quantum leaps any strict categorization is under threat to become obsolete. It can already be seen that J2ME Personal profile (a.k.a. PersonalJava) are being used in high-end PDAs such as PocketPCs and Mobile Communicators. These device profiles are likely to grow after new releases. Despite the physical limitations of wireless devices that may remain constant, memory and processing power is increasing all the time. For example Samsung has recently introduced an integrated chip that contains most functionality of a mobile phone, with support for multiple operating systems (Windows CE, Palm OS, Symbian and Linux), 356 Mb of Flash ROM and 256 Mb of RAM memory together with a 203 Mhz Arm processor [2].

## 3 Mobile Devices and Grid

### 3.1 Feasibility

A Wireless PDA/Mobile phone can be envisioned in the following roles in a Grid Infrastructure:

- Data consumer: Provide an intelligent user interface for remote analysis and control.
- Data producer: Ability to register physical phenomena by functioning as a sensor or captor.
- Storage element: Provide a persistent storage for data produced or configuration information used in the Grid.
- Computing element: The capability of running small computational tasks or jobs on demand.

Planned further research will provide a detailed analysis of how feasible each role is for Java-enabled wireless MIDP device by means of literature study and prototype construction.

Special attention will be given to application of industry standard protocols and their derivatives for facilitating the devices' possibilities to act in these roles. Nevertheless the biggest factor remains the extent that the Grid Security Infrastructure (GSI) model can be applied.

## 3.2 Emerging technologies and related work

### Comparison with Wireless Application Protocol

One of the advantages that MIDP has over browser-based technologies such as WAP is that it is universal and it provides the same application programming interface (API) to various devices whether they are mobile phones, two-way pagers, or low end PDAs. Furthermore MIDP includes facilities for persistent storage of data which are kept intact throughout the normal use of the platform, including reboots and battery changes. As in the J2SE Java development environment, MIDP provides an enhanced user experience by providing tools for building richer and responsive graphical user interfaces (GUI) for applications that load the server and the network more optimally. MIDP applications are able to process small tasks in the background while transferring data. This fact will alleviate the higher response times resulting from wireless networks. According to Nokia's internal studies and informal tests [1] the average latency for a HTTP based round trip accross GSM based network is 5-10 seconds for first round and 2-4 seconds for following round trips. These figures are much larger than from those of accessing Web pages with modern personal computers connected to wireline network.

### Wireless Clients with Enterprise Java.

Java 2 Micro Edition (J2ME), as part of the overall Java framework, is designed to interoperate with Java 2 Enterprise Edition (J2EE), which includes tools for developing Internet-aware distributed multi-tier applications. This specification not only enables Object Oriented Web application development but also standalone Java applications. Sun has published blueprints for 'Designing Wireless Clients for Enterprise Applications with Java Technology' [14], which takes advantage of various J2EE specification methologies. Technologies that are particularly of interest for wireless application development are XML-based protocols, Java Messaging Service (JMS) and Java Servlets.

### Open Mobile Alliance.

MIDP-enabled mobile phones have the potential to become de facto the mobile payment and personal access medium by incorporating X.509 certicates as digital fingerprints inside the WIM/SWIM [7] card. Open Mobile Alliance (OMA) has published specifications for such a WAP Public Key Infrastructure (WPKI). In addition to hardware based smart card storage, X.509 certificates can be stored from MIDP applications into the Record Medium Storage (RMS) on the phone.

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|---|---|
| java.io | MIDP subset of system input and output through data streams |
| java.lang | MIDP subset of the core Java programming language |
| java.util | A small subset of utility classes |
| javax.microedition.io | Networking support using the Generic Connection Framework; MIDP 2.0 includes new socket, UDP, serial, and secure connection types, and push functionality |
| javax.microedition.lcdui | MIDP user interface classes |
| javax.microedition.lcdui.game | Gaming classes such as sprites, game canvas, and layer manager |
| javax.microedition.media | The interfaces for controlling (Control) and rendering (Player) audio - sound classes compatible with the Mobile Media API (JSR 135) specification |
| javax.microedition.media.control | Sound -control classes (ToneControl and VolumeControl) - compatible with the Mobile Media API (JSR 135) specification |
| javax.microedition.midlet | The application (MIDlet) interface, its life-cycle classes and its interactions with the runtime environment, and the application manager |
| javax.microedition.pki | Public key class for certificates used to authenticate information for secure connections |
| javax.microedition.rms | Persistence classes for storage and retrieval of data |

**Fig. 1.** The J2ME MIDP 2.0 API package structure [20].

A prominent software for building PKI-aware wireless applications is the Bouncy Castle Crypto package [21], which is an Open Source implementation of popular cryptographic algorithms including a lightweight cryptographic API for J2ME.

**Project JXTA.**

Another technology that has potential for J2ME devices is JXTA, a P2P protocol framework, that contains an implementation for J2ME. JXTA for J2ME is a lightweight edge peer that operates through JXTA relays. JXTA relays act as proxies for completing more complex tasks for wireless devices and collecting and trimming incoming data for forwarding through a low-bandwith connection. Meanwhile wireless peers have to poll the relay periodically to acquire the collected responses. JXTA for J2ME implements basic JXTA features such as User, Group and Peer discovery, creating pipes and groups and communicating with other peers. JXTA is based on simple a XML message-passing technique and JXTA for J2ME is primarily targeted for online gaming, financial services and instant messaging. JXTA has also been studied as a large framework for a distributed computing platform [17] and as a development platform for a large economics-based Grid computing marketplace [23].

#### Open Grid Services Architecture and XML protocols

The XML protocol-based Web Services interfaces were initially promising as a communication method between wireless devices and back-end servers. A prime candidate for wireless Grid applications is the new Open Grid Services Architecture (OGSA) model used in the Globus Toolkit 3 [10]. Wrapping the existing Grid middleware with XML interfaces holds the promise of providing a universal solution also to wireless devices. However given account to the limited memory constraints, Web Services technology is likely too heavy for MIDP devices. The fact remains, that Web Service protocol implementations such as kSOAP [3] weigh 41 kilobytes i.e. over 30 percent of standard application memory of low-end MIDP device whereas more lightweight protocols such as kXML-RPC [3] requires only 24 kilobytes. The overhead of Simple Object Access Protocol message parsing in light J2ME-based wireless devices has also been studied and the results show 2-3 times slower response times compared to a proprietary protocol that communicates with a proxy client that utilizes Web Services on behalf of the wireless client [26].

#### Software Agents for Wireless Devices

The Foundation for Intelligent Physical Agents (FIPA) [4] was formed in 1996 to produce software standards for heterogeneous and interacting agents and agent-based systems. The FIPA lists publicly available Agent platforms [5], some of which are built with wireless devices in mind such as Agent Development Kit, Fipa OS and LEAP. According to the Wireless World Research Forum (WWRF), Agents are one of the key enabling technologies for future wireless devices especially combined with web services and instant messaging capabilities [8]. The Helsinki Institute of Physics has also studied GSI enabled Agent platforms in development of the Mobile Analyzer concept [16]. The Java Community Process (JCP-87) is also currently specifying a new Application Programming Interface (API) for Java Agent Services (JAS) [22].

### 3.3 Example applications

The most natural way for small wireless devices to function on the grid is to provide ubiquitous access to timely information as data consumers. As such they provide a handy alternative and extension to traditional access media such as stand-alone networked applications or Web browsers. While the capabilities of acting as a Computing Element or a Storage Element is very limited, wireless devices such as mobile phones can be used as sensors or captors in novel ways:

- By default, base stations report locations of mobile phones into the central database of Mobile Switching Center. Individual phones can be tracked anonymously and timed as they move from point A to point B. This mobile phone location and related data can be used in e.g. traffic planning and monitoring [25]. When mapping velocities of mobile phone users on public highways, it is possible to measure traffic flow and indicate possible traffic jams and thus provide valuable, accurate and cost efficient information via radio, Internet and Short Message Service.

- The movement of lungs and heartbeats cause interference with mobile phone connections and can be detected by an active phone close to the human body. This data can be used to produce valuable information of pulse and breathing rate for realtime healthcare applications [18]. It can be used as an inexpensive way of monitoring vital signs of victims of earth quakes or avalanches or as a remote diagnostic tool for doctors and their patients.

These two examples were presented because they require few or no modifications to standard mobile phones. This is an important factor for maximum deployment potential. Currently sensors like cameras, global positioning systems (GPS) and thermometers are being introduced into wireless devices. Especially cameras and the digital images they produce will catalyze novel applications e.g. in computer vision and pattern recognition area that would require increasing amounts of computing power in the future:

- Although the resolution of today's camera phones are limited (Nokia 7650, 300k pixels), Optical Character Recognition (OCR) techniques developed by IBM are able to interprete 4000 chinese characters in 6 fonts. Combining this with a translation service (An IBM Zurich research laboratory showcase) would be useful for western tourists with camera phones in China.

While today's mobile phones are able to download new ringtones, logos, and new games from the wireless network, the Software Defined Radio (SDR) Forum [6] defines an open architecture for reconfigurable wireless technology. This technology plays key role in seamless network convergence for multi-mode wireless devices that are capable of roaming into heterogenous access environments and to utilize applications specific to these environments.

- The Software inside mobile phones is becoming complex and such software can already be referred as an operating system in the same way as in personal computers and workstations. Many of the problems or bugs that users face in daily operation are not hardware based and can be fixed with software updates called patches. A scenario where constantly connected wireless devices could update themselves automatically would need a security infrastructure similar to one used in the Grid, where users and service entitities trust each other.

## 4 Summary and discussion

In this paper, the role of mobile devices in a Computing Grid environment was outlined. We presented the current state of mobile devices, their feasibility for different roles in a Grid, and presented some example applications.

The P2P and Grid concepts represent two ends of the same problem. P2P has already viable tools to connect most limited wireless devices in a Grid-like fashion. Academic Grid tools like Globus, Condor or Legion on the other hand are suitable for creating global grids connecting computing centers. The missing link between these high and low end Grid computing concepts could be filled with emerging technologies to create end-to-end distributed computing applications with mobile control.

The research work will rely on the capabilities of the GridBlocks framework (http://gridblocks.sourceforge.net) being developed by the Helsinki Institute of Physics. The framework will be extended to provide the required functionality to connect a Wireless Java device to the Grid. The outcome is also dependent of the maturity of J2ME specification implementations. MIDP profile has been chosen for this reason. The current release of MIDP specification is version 2.0, but it is not yet supported by existing hardware. MIDP specification version 2.0 includes many important new features such as Secure Socket Layer and Wireless Transport Layer Security support, signed midlets, over-the-air provisioning and push architecture.

The future activities will be as follows:

- Creating a wireless test environment. Studying the development environment and the limits of chosen wireless devices (a recent low-end PDA and a mobile phone). Designing and implementing a P2P network for these devices.
- Designing and implementing wireless Grid applications (in Data Consumer and Data Producer roles). Study the possibilities to make the applications secure (Grid Security model). Designing and implementing security features where possible.

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