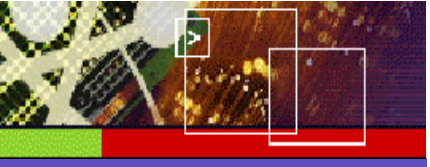

April 8, 2002

Unwire Me: The User Perspective on Mobile Broadband

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Mobile Broadband Today: Not Yet a Reality?

Businesses and consumers alike have taken to the biggest technology trends of the last decade—mobile communications and broadband—in an unprecedented way. In the mobile world, penetration rates of more than 40% to 50% of the population are common while broadband technologies have recently experienced growth rates of 100% per year or more, with a market penetration of nearly 10% of households in the US.

As users get more familiar with the benefits of mobility for their voice communications and as broadband-enabled data applications—ranging from email to Enterprise Resource Planning (ERP)—become increasingly intrinsic to doing business, a wide range of business users will desire a service that combines the best attributes of both.

Unfortunately, the first generations of mobile data services, many of which are built on top of existing circuit-switched mobile voice networks, do not have the speed, reduced latency, and widespread coverage required to meet the needs of business customers. Indeed, mobile data services are still in their infancy in most parts of the world, particularly in the US. They are typically only available in limited "pockets" of coverage, offering average network connection speeds between 14.4Kbps and 56Kbps, no better than dialup.

These low-bandwidth mobile data systems, limited as they are by inherent data performance tradeoffs of the circuit-switched voice infrastructure on which they are built, offer users the ability to perform very basic, application-specific activities such as downloading and sending email, text messaging, and limited web access. These applications are a good start, but business users require more data throughput to take advantage of data services truly useful to them—services like file transfers, access to the corporate LAN, and rich messaging services.

Mobile broadband data services are even more rare. While some markets outside of the US, notably Japan, have begun to offer mobile data services with higher speeds, these services are not yet ubiquitously available and typically offer speeds only slightly higher than dialup—not the broadband speeds offered by T1, DSL, and other non-mobile broadband services. True mobile broadband service should provide the user with always-on bandwidth that "feels" like it is on the corporate LAN (at least 384Kbps) while providing the low latency needed for time-sensitive applications and accessibility in a ubiquitous fashion.

An instructive example of a technology that meets most (but not all) of these criteria is the use of wireless LAN technologies (typically the 802.11b or WiFi standard) to provide public data access in hotspots like hotels, airport lobbies, and cafes. This model provides a starting point for true broadband speeds via wireless. Unfortunately, the "hotspot" nature of their deployment means that public LANs can never provide the truly mobile solution needed by business users, but the success of this technology provides an excellent example of the kind of performance and application support required for mobile broadband. There is also some question as to the financial viability of a business model based solely on transient "hotspot" users. WLAN is probably a better fit as an adjunct to other services as opposed to standing on its own two feet as a business venture.

What Customers Really Want from Mobile Broadband

Mobile operators, equipment vendors, and customers themselves have many varying ideas about what the end user really requires from a mobile broadband solution. More than anything else, users want the ability to recreate the experience of being in the office or at home (with a broadband DSL or cable modem connection) and "plugged in"—even when they are on the road. That will require support for a variety of applications with the performance and security of a wired connection, which is definitely a tall order and one that existing solutions do not come close to meeting.

Email Is Just a Start

Although it is a "must have" and an important starting point, email alone is not the answer. Obviously the wired world has moved way beyond just text and attachments (which are not handled well by today's mobile data services anyway). POP or IMAP-based email systems are fine for consumer users, but most businesses use more full-featured productivity suites like Notes or Exchange, which include calendaring, group scheduling, and file databases. Access to corporate LAN-based services like Intranets or file servers are also vital to many businesses, as are other IP-based applications.

Always-on Is Key

Always-on communications are another important requirement for mobile business users. Connection-oriented services, often requiring a lengthy log-in procedure, are more than just a nuisance but are in fact counter-productive to mobile workers. A mobile data service should always "be there" for the user, allowing data to be pushed out to workers when required. If mobile workers require instruction and training on how to get connected, and it takes time and effort for them to do so, it is quite likely they will end up using their mobile data service much like they do existing dial-up Internet services. It will be back at the hotel at the end of the day, hours after the data they need was ready for them.

"Business-Class" Security Is Vital

IT personnel and corporations in general have learned a series of painful lessons over the past few years in the security arena. As a result, a huge amount of effort and money has been spent on installing firewalls, VPNs, and other measures to keep intruders out of their networks while continuing to allow access to remote users, partners, and customers. A mobile broadband solution will *never* be adopted by corporate users or fully supported by their IT staffs unless it is secure. Ensuring this security will require both secure connections between mobile users and the network service provider as well as support by the technology and the mobile operator of VPN standards like L2TP and IPSec. This will provide full authentication and encryption of the mobile user's connections back to the corporate network.

Performance that "Feels" On-Net

Existing mobile data solutions, which provide bandwidth performance below dial-up speeds, force users to behave differently than they do on an office or even home connection. The lower speeds prohibit large file transfers and use of multimedia applications. Additionally, the high latency of these services means that real-time applications like VoIP or even more basic messaging services like instant messaging are unwieldy at best.

True broadband mobile services require levels of bandwidth and latency that make customers "feel" as if they are still connected to the corporate LAN. That does not mean T1 speeds all the time (after all, an office T1 is typically shared among dozens or more users) but rather a minimum bandwidth of at least 384Kbps (about the same throughput that teleworkers using cable or DSL can expect). Additionally, low latency that allows interactive applications to work properly is a must.

The key metric of this performance is not a number, but rather more subjective criteria. Mobile users want to do the same things while mobile that they do while at their desktop. In other words, they want the ability to use all their common desktop applications anywhere they go, with the same level of subjective performance and without having to change their behavior to accommodate a mobile environment.

Support for Business AND Pleasure

Although business users have traditionally been and will likely remain the first adopters of wireless services, support for those applications typically considered "residential-only" is a key element of any broadband mobile technology. Not only do purely residential customers represent a large potential market, but business users may also behave like residential users during off-hours. An excellent example of this phenomenon can be seen in the wired world, where telecommuter DSL or cable modem connections are used for business purposes from 9 to 5, but become the portal to a variety of personal Internet services during evenings and on weekends.

This dual-use role means that the technology should support a wide range of IP-based, non-business applications and also provide support for multiple third-party service providers. The ability to authenticate and segregate traffic for multiple uses is also key, so that secure connections to the office remain secure while music downloads and other recreational uses of the service remain off the corporate network and are billed to the user separately.

Essential Business Applications

Determining which applications a broadband mobile service should support is an easy task—it is really just a large subset of all the applications that wired business broadband connections should support. A few applications can be ruled out, such as web hosting and ecommerce server hosting, but otherwise just about every IP application that a business user takes advantage of at his or her desktop should be supported.

Specifically, the following applications are essential:

- **Email/Calendaring/Scheduling.** Support for Exchange and Notes is essential to providing mobile users with connectivity to co-workers, partners, and customers. Bandwidth and end-user devices should allow for the receipt and viewing of applications to allow for true productivity when a user is in a mobile situation.

- **VPNs to Enable Secure Access to Intranet/Extranet.** Since the key focus of broadband mobile services is to provide data access to remote workers, support for IP VPN technologies is obviously an essential element. Standards-based VPN protocols such as L2TP and IPSec should be supported, which provide full authentication and encryption of connections of the mobile user back to the corporate network. Additionally, the broadband technology should enable the use of partnerships to deliver additional functionality to the enterprise customer.

- **CRM/ERP/Siebel.** Mobile work forces often include exactly those workers who need access to Customer Resource Management (CRM), Electronic Resource Planning (ERP), and other e-business IP applications.

- **Videoconferencing and Streaming Video.** Previously the domain of only the largest enterprises, videoconferencing has moved into the mainstream with widespread adoption of broadband and with the development of IP-based systems that move high-quality conferencing from expensive stand-alone systems to the PC. Streaming video downloads are a similar application, enabling IP video downloads for distance learning and remote training. These applications require significant bandwidth and a low-latency connection to perform correctly.

Lifestyle Applications

In many ways, residential applications can be just as demanding, if not more, on a broadband network than business applications. One need only think of Napster, which at its peak accounted for over 25% of the traffic on the backbones of residential service providers like @Home. Today's applications can be even more demanding than Napster, as many require not only broadband speeds but also low-latency connections to function properly. Low latencies are vital to support all forms of instant communication.

Some examples of these residential services include:

- **Gaming**. IP-based, online multiplayer gaming such as Quake has become incredibly popular, with substantial online communities growing around certain games. Many of the most widely played games have online user bases reaching into the millions. While bandwidth is important for online gaming, the most vital network characteristic is low latency. Latencies in the hundreds of milliseconds, common for many connections, cause a substantial and noticeable degradation of gaming quality online. Some residentially-oriented broadband service providers have found this situation to be a money-maker, hosting gaming servers on their own network infrastructure and charging customers additional monthly fees for access.

- **Audio/Video Downloads/Streaming.** Napster is a shadow of its former self, but Internet-based multimedia continues to grow as both peer-to-peer services and fee-based services proliferate. The increased penetration of wired broadband connections has helped to shift these applications from a model of downloading relatively small audio files for later playback towards a more network-intensive streaming model, with video joining audio on the menu.

- **Videoconferencing.** The videophone has long been a promise of the telecom industry but has never really taken off. Broadband has changed that equation to a degree by finally providing the bandwidth necessary for video-based communications. Online chat with video has gone mainstream, with applications like NetMeeting and Yahoo! Chat offering support for streaming video.

- **Ecommerce Enabled Through the Mobile Device.** The ability to use a mobile device to enable purchases has entered the marketplace in Europe and Asia but is still in early development in the US. This functionality allows a user to enable purchases based on charging directly back to the monthly mobile bill or by spending mobile "cash" charged to a mobile handset from a credit card. For example, this provides parents an opportunity to enable teen-spending in a controlled fashion.

Of course, beyond these "high-end" applications is a host of existing consumer applications like email, web surfing, chat, and instant messaging—all of which are enhanced by an always-on, high-bandwidth, low-latency connection.

Location Is Everything

So far, this paper has discussed the requirements of mobile broadband systems to do the same things that their wired cousins do—support high-speed, low-latency connectivity for a wide range of IP-based applications. Of course, there is one major difference, which is the fact that a mobile system must offer this performance and application support anywhere a user might be—in the airport, at a client's office, at home, in a hotel room, and while moving between these locations. The key to this mobile access and the area in which many existing systems fall short is that it should be both ubiquitous and consistent.

In other words, a mobile broadband system should have broad and deep customer coverage. Of course there will always be areas (profoundly rural locations, mountaintops, and the middle of the ocean) which will be off the network, but outside of these exceptional locations, customers desire and expect seamless coverage. Within coverage areas, users expect their coverage to provide them with a truly broadband, low-latency connection throughout the "cell." Transitions between cells should also be seamless, as they usually are for mobile voice services today. Additionally, users expect their mobile operator will offer service on a nationwide, or at least region-wide basis, so they do not have to make arrangements with multiple carriers to get service in different locations.

Pure Mobility

Pure mobility, in basic terms, means users can go anywhere and access anything at anytime. More specifically, it means that customers do not want to, and should not have to, change their behavior as they go about their business. For mobile broadband, this means the user can transition from the office to the road to home without losing their connection, reconfiguring their computer or handheld, or having to take any extraordinary steps to stay "online."

The network, and the CPE within customer devices that connects them to the network, should have a sufficient degree of intelligence and location awareness. This intelligence should have the ability to differentiate when the customer is in the office and should be connected to the 802.11b wireless LAN or when the customer is on the road and should be connected to the mobile broadband network. The network and the CPE should also automatically handle this transition and seamlessly "hand off" a customer to whichever connection is most appropriate, without user intervention.

A big part of this vision of mobility revolves around how services are billed. One failure of many existing mobile data services is their confusing billing with customers being charged usage charges per packet, per minute, or otherwise and also being charged different tiers of pricing based on location. These billing strategies can cause users to severely limit their usage, which both decreases the usefulness of the service to them and limits revenues to the mobile operator. A flat-rate billing scheme, which includes *all* access including handoffs to mobile LAN hotspots, is much more attractive to the customer.

Multiple Platform Support

Many existing mobile data solutions, typically mobile email systems, require users to purchase and use single-purpose hardware platforms like proprietary PDAs in order to use the service. For some users, this is an acceptable tradeoff today, as there is no other alternative. But in general, most business users already have a laptop, a PDA, and mobile phone and do not wish to add yet another piece of electronic gear to their briefcase.

A better solution for mobile broadband is a platform agnostic approach that utilizes standards-based customer hardware that can be used with a wide range of devices. The most common format for this type of hardware is the PC Card, which can be used in almost all laptops and in many PDAs. When the network is in place for mobile broadband—and at an affordable price, device prices will also come down due to economies of scale.

Solutions for an Underserved Market

So far this paper has discussed some shortcomings of existing mobile (narrowband) data systems and what potential customers look for in a broadband mobile data solution. Many mobile operators have no doubt already thought through these issues and, in fact, many have begun to acquire spectrum and testing systems they hope will help them transition today's voice-centric systems to tomorrow's data-centric networks.

Circuit-Switched Will Not Make the Transition

Unfortunately, many operators have begun to adopt solutions which build on their existing circuit-switched voice infrastructures (the so-called 2.5G and 3G technologies) rather than adopting new generations of packet-based mobile networking technologies. In the newer packet-based solutions, the Internet Protocol (IP) flows freely end-to-end (without requiring the rewriting of applications and content or a specialized device for access). Circuit switching does a great job of supporting voice transmission, as its connection-oriented nature can provide the low latency required to keep voice calls from sounding like a shortwave radio transmission. Circuit switching also does a good job of guaranteeing customers' bandwidth, but much like the circuit-switched analog telephone network, this bandwidth is usually limited to narrowband speeds.

Circuit-switched networks, however, run into several difficulties when scaling to broadband speeds:

- Circuit-switched networks inherently use bandwidth less efficiently than packet networks (like TCP/IP networks) because each user effectively "ties up" a portion of the overall bandwidth while connected. In a packet network, bandwidth is only used while a user is actively sending or receiving data, allowing the network to share bandwidth with a larger number of simultaneous users. Mobile operators are therefore required to build greater capacity (at a greater expense) to serve the same number of users on a circuit-switched network.

- Both circuit-switched mobile voice and existing data networks are built around a series of tradeoffs. For voice networks, low latency is designed from the beginning, but bandwidth to individual users is severely limited. Data networks, on the other hand, are designed with higher bandwidth capabilities but have not been optimized for the low latency required for instant communication.

- Support for TCP/IP applications requires an IP network overlay on the circuit-switched infrastructure. Because these IP applications, which make up the vast majority of both business and consumer data applications, are not natively handled by the circuit-switched infrastructure, the mobile operator must deploy a large number of network devices on top of the existing circuit-switched network. This adds significant complexity and expense to building a broadband data network and also adds significant processing overhead on the transmission of data, which can both limit throughput and increase latency.

The Benefits of Packet Networks

While mobile operators have been slow to transition from circuit-switched to packet networks, the wired world has been aggressively moving almost all its traffic from circuits to packets. Most data services have been moved to exclusively packet-based networks, and TCP/IP has been adopted as the standard for almost all data traffic. Even voice traffic is being transitioned to packet networks, as long distance carriers move towards adopting Voice over IP (VoIP) solutions on their backbone networks.

Packet networks also enable multicasting so that data destined for multiple users can be sent across the network one time, instead of being individually transmitted to each individual user. Despite these advantages, however, today's packet networks are not without shortcomings. The two biggest drawbacks of existing packet-switched implementations are a lack of built-in Quality of Service (QoS) mechanisms and increased latency compared to circuit-switched networks.

It is certainly possible to overcome both of these issues, but many packet networks like the public Internet have not been designed with these metrics in mind and can therefore offer users no guarantees regarding bandwidth, latency, or other service characteristics. Enterprises typically rely upon service providers to build their own networks using technologies such as MPLS, which can prioritize data packets according to their type and user characteristics, thus ensuring guaranteed bandwidth and low latency.

Oracle and Siebel are good examples of common applications that have been widely deployed and optimized for the IP-based networks used by most businesses. To work in today's mobile data networks, these applications require expensive rewrites of major system components to account for additional connection points, servers, and translation protocols in the network. A better solution is to utilize a low-latency, IP-friendly mobile network that can use these applications as is. The business case for rewriting applications to work with a cobbled-together legacy mobile data network is difficult to make if not impossible. Using today's existing applications, as is, on an optimized mobile data network takes no effort at all to justify.

Network Characteristic	Circuit-Switched Network	Packet Network
Bandwidth	Low	High
Latency	High	Low
QoS Support	Limited – bandwidth guaranteed due to connection orientation but no ability to prioritize between multiple connections	Offers support with additional extensions to the network protocol
Always-On	Have to connect for each use	Always connected to the network
Support of IP Applications	IP applications require translation	Nothing additional required
Security	Medium	Offers full support for end-to-end security with additional network points, servers and extensions

Table 1. Circuit-to-Packet Comparison

A Better Solution for Broadband Data

Instead of continuing to develop complex, costly, and non-scalable overlays to existing circuit-switched voice networks, mobile operators should investigate deploying packet-switched networks which can allow them to offer the broadband mobile services users want with lower Capex and a quicker return on their investment.

A purpose-built mobile broadband network is one way to go, as opposed to voice-centric, circuit-switched networks made to work for data. Much like the wireline service providers who made the move from circuit-switched to packet-based transport and IP services, many mobile operators may do the same.

One example of such a network option is Flarion Technologies' flash-OFDM (Orthogonal Frequency Division Multiplexing) packet-based wireless broadband technology. This technology brings high spectral efficiency, low latency, and support for any existing TCP/IP application together for mobile broadband operators.

Improved Spectral Utilization and Bandwidth

Compared to TDMA and CDMA systems used in circuit-switched cellular applications, flash-OFDM uses a spread spectrum frequency hopping approach. Along with the inherent decrease in interference offered by orthogonal multiplexing, it allows three times more efficient utilization of the frequency spectrum. Because it takes advantage of the frequency hopping of CDMA and the non-interference of TDMA, flash-OFDM reaps the benefits of both approaches to multiplexing. With this approach, flash-OFDM systems can offer users bursty speeds up to 3Mbps and can guarantee users symmetric speeds of 384Kbps anywhere in a cell.

- **Greatly Reduced Latency.** Because it has been designed from the ground up as a packet data system with no circuit-switched infrastructure to build on, no overhead is required to translate packet-based traffic to circuit-switched traffic. Therefore, extremely low-latency applications (as low as 5 milliseconds) such as latency-dependent applications like voice, video, and gaming can be supported.
- **Built-in Support for QoS.** flash-OFDM includes full and native support for IP QoS mechanisms such as MPLS. This enables traffic to be prioritized end-to-end and allows the mobile operator to create tiers of service for users based on their needs and willingness to pay for enhanced services.
- **Supports Voice.** Although designed to support packet data communications, the low-latency and built-in support for packet prioritization via QoS mechanisms of flash-OFDM means it can indeed support VoIP as a way of providing reliable and inexpensive voice services to users.
- **Supports Multiple Applications.** flash-OFDM is an IP-friendly, packet-based solution and will transparently carry TCP/IP traffic without the need for special gateways, compression, or packet-to-circuit translations. So any existing (or future) TCP/IP application will be seamlessly and natively supported.
- **Seamless Roaming On and Off Net.** Due to its low latency and guaranteed high bandwidth even at cell edges, flash-OFDM allows users to roam between cells on the network with no interruption in service. Additionally, customers can seamlessly transition between 802.11-based networks and the mobile broadband network without any interruption in service or any requirement to reconfigure their devices.

- **Smarter Network Edges.** The flash-OFDM base station is highly integrated and performs many network functions (like routing, authentication, and traffic prioritization) at the network edge rather than in separate servers at the core. This has the dual advantages of decreasing latency and also decreasing network complexity and associated capital expenses. Legacy networks typically apply QoS prioritization only within the network backbone, not at the edges. flash-OFDM networks can apply QoS end-to-end from the airlink to the network core. This greatly reduces the number of hops required for data to traverse as it crosses the network.

Summary: "Unwired" Business Broadband

Most business customers today use broadband in the office and use mobile for telephony. Few have begun to take advantage of today's limited mobile data offerings for basic services like email and text messaging. Unfortunately, a large disconnect exists between how workers use data applications in the office, and how they use them outside the office. Mobile operators realize their existing circuit-switched infrastructure will have a hard time bridging this gap between the wired and unwired worlds, and many have begun applying "Band-Aids" in the form of data service overlays to those networks.

These "Band-Aid" networks are inherently fraught with tradeoffs. Primarily, these networks do not natively support IP applications and instead require translation, rewriting of applications, and other stop-gap approaches—basically requiring a "rewriting" of the wired network to make it mobile with associated costs in terms of performance, complexity, and expense. IP is *the* common protocol for almost all business and consumer applications, and native IP support in a broadband wireless technology allows users to transparently use the same applications they already use in a wired environment.

Business users want a wireless data service that natively supports all the IP applications they use at their desktop. They want broadband bandwidth, low latency, instant communications, flat-rate billing, and a seamless handoff between various network technologies (such as between their in-office wireless LAN and the mobile operator's wireless network). In a nutshell, they want the same things when they are unwired that they have when they are wired.

Today's mobile data systems do not offer this. Their bandwidth is not broadband but rather is the same, or less than, dialup. Latency is high, and only a few applications are supported. Billing is confusing, pricing is high, and they must often pay multiple providers to go from office to road to a WiLAN hotspot in a hotel or airport. They must often use special-purpose, proprietary devices to access the network instead of using their existing PDA, laptop, or other data device. QoS, to allow prioritization of latency or bandwidth-dependent data, is not applied end-to-end but only within the network core.

A better approach is to realize that almost everything that happens in the data world (and voice is increasingly becoming just another data application) is based on packet-switched networks and on IP-based services. Instead of patching up the circuit-switched voice infrastructure to make these applications mobile, mobile operators would be wise to consider the benefits of moving to a truly broadband, packet-based mobile solution like Flarion's always-on, mobile broadband system based on flash-OFDM.