The Mobile Enterprise: From Isolated LAN to Always-On Mobile WAN

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1. Introduction: The Clamor for Mobility and Speed

There can be no doubt that the economy in general, and the high technology marketplace in particular, has recently experienced considerable contraction after years of meteoric growth. This contraction places added pressure on all segments of the economy, including enterprise IT organizations and the mobile operators that provide service to them. The pressure is on enterprise IT organizations to understand what new services they will be able to provide in order to enable their companies to better compete in these challenging times. The pressure is on mobile operators to identify and deploy profitable services that correspond to the shifting enterprise requirements.

The encouraging news is that there are some specific components of the high-technology marketplace that are doing quite well, in spite of the downturn in the broader high technology market. Understanding what is driving these specific market segments provides powerful insight into how enterprise IT organizations can better enable their company's competitiveness, as well as how mobile operators can respond to the changing enterprise marketplace.

One component of the high technology marketplace that is expected to experience tremendous growth is the wireless LAN marketplace. A report written by the Dell'Oro Group in late 2001 predicted that the marketplace for 802.11b products will grow by 35% in 2002. Greg Collins, a director at the Dell'Oro Group was quoted in a recent press release as saying that "The growing acceptance and adoption of 802.11b in homes and universities bodes well for the long-term prospects of wireless LANs, as more and more people come to rely upon the convenience of mobile network connections."

The rapid growth of wireless LANs underscores a simple, but powerful principle that applies to the broader high technology marketplace.

Principle: *People around the globe are mobile, and they want all of their communications to support that mobility.*

Another component of the high technology marketplace that is doing extremely well is broadband. For example, a recent article [1] documented the growth of DSL. That article concluded that the total number of DSL access lines worldwide grew from 7.8 million lines as of March 31, 2001,

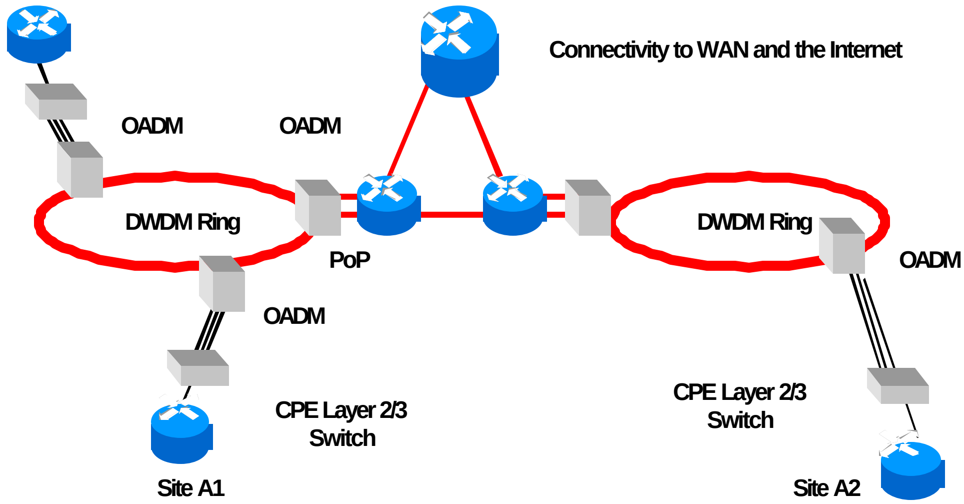
[1] DSL Subscriber Numbers Analysis: 2nd Quarter 2001 Worldwide, August 30, 2001, Point-Topic

to just over 10.2 million lines as of June 30, 2001. The article also stated that the total number of DSL lines in the world has doubled in less than 9 months.

The growth of DSL clearly demonstrates that there is a huge latent interest on the part of customers for higher speed access. However, DSL has some significant deployment issues. One of the DSL deployment issues is the high cost and complexity of provisioning DSL. For example, AT&T recently announced a service whereby they would use DSL as an access technology into their Frame Relay network. As part of their service announcement, AT&T stated that customers could expect an average provisioning interval of up to 45 calendar days. Another of the DSL deployment issues is the lack of coverage. In the afore mentioned AT&T service announcement, they pointed out that customers should expect that no more than half of their locations would qualify for DSL. They also pointed out that between twenty and forty percent of those sites that did indeed qualify are likely to fail to perform as expected.

While they are relatively new to the market, there has also been a very significant interest in both using and deploying Metropolitan Area Network (MAN) services. For example, a recent IDC report predicts that U.S. MAN services revenues will soar from more than $155 million in 2001 to more than $740 million in 2006. That represents a Compound Annual Growth Rate of over 35%.

Adding validity to the projections made in the IDC report is the breadth of providers who are aggressively deploying networks to allow them to offer MAN services. These networks are typically based on IP, Ethernet, and fiber optics as shown in Figure 1.



MAN Based on IP over DWDM Rings
Figure 1

Among the providers who are offering MAN services are the emerging Ethernet Local Exchange Carriers (ELECs) such as Yipes, Telseon, and Cogent, as well as venerable incumbents such as AT&T. In addition, fixed wireless providers, such as Advanced Radio Telecom, have announced wireless MAN broadband services that address one of the primary weaknesses in the architecture depicted in Figure 1. That weakness being that it is often impractical or even impossible to deploy fiber optics out to the people who need access to the MAN services. Note that wireless services in general, and mobile wireless services in particular, are well suited to address this weakness.

The phenomenal growth in broadband services such as DSL and Metropolitan Ethernet services highlights the following principle.

Principle: *There is currently a strong need for speed. This need will only accelerate as content becomes increasingly rich.*

2. The Mantra of the Enterprise Marketplace: Ubiquitous Access to Applications and Services

The previous section of this paper discussed both the need for mobility and the need for speed in somewhat of an abstract fashion. This section of the paper will discuss these needs both in the context of today's mobile networks as well as today's business critical applications.

Whether we refer to the network as being 2G, 2.5G, or 3G, today's mobile networks have one element in common – they are slow. In particular, most of the current wireless networks have a maximum speed of 14.4 Kbps. As the current wireless networks evolve, and as new wireless networks get deployed, their top speed will certainly increase beyond 14.4 Kbps. The key question is will these networks evolve in a way that allow them to support the need for speed? Regrettably, the top speed that most mobile operators talk about supporting make these networks seem more appropriate for supporting services such as SMS (Short Messaging Service) than business critical applications of the type discussed below.

For example, in November of 2001, VoiceStream announced a series of new services based on a technology referred to as General Packet Radio Service (GPRS). These new services from VoiceStream will be among the fastest mobile data services available in the U.S. However, these services are designed to allow users to surf the Internet at speeds that only average 40 Kbps, and have a maximum speed of only 56 Kbps. While these services represent a small step forward, the speed associated with these services resemble the dial-up services that have been in place for over five years, and which continue to frustrate users.

Principle: *Today's mobile networks are designed for voice and low speed data*

Many applications qualify as being business critical. For example, to a professional services organization, applications such as Intranet access and email are business critical. That follows because the consultants who work for professional services organizations are typically offsite, and require timely access to information. What also follows is that the volume of information that these consultants need access to increases dramatically over time.

A second class of widely deployed applications that has become business critical is the suite of Oracle applications. Oracle claims that their technology can be found in 98 of the Fortune 100 companies. They further claim that they are the first software company to develop and deploy 100% Internet-enabled enterprise software across its entire product line. However, to make Oracle applications work well given the high latency associated with today's wireless services requires a re-write of the applications. While this is one possible approach, a better long term approach is to reduce the overall latency associated with wireless services, for applications such as Oracle, as well as SAP (see below).

A third class of application that has become both pervasive and business critical over the last few years is Enterprise Resource Planning (ERP) applications. SAP, one of the leading providers of ERP applications, claims to have 10 million users and 36,000 installations.

Regrettably, the bandwidth requirements of applications such as SAP R/3 have precluded these applications from being widely deployed in a mobile environment. Those bandwidth requirements were quantified in a report written by the Netigy Corporation.[2] That report documented tests that Netigy performed in order to both quantify the network throughput requirements of SAP's R/3 Release 4.6 as well as to test the effect of implementing Quality of Service (QoS) on the performance of the application.

In particular, Netigy tested the VA01 Create Sales Order Transaction. What is particularly interesting about this test is that the Create Sales Order Transaction is clearly the type of transaction that a mobile sales person would want to use.

Among the observations that were made in the report were:

1. Using the SAP GUI for HTML resulted in bursts of traffic at speeds of roughly 140,000 bps. These bursts lasted for 10 seconds or more. Note that this is significantly more bandwidth than the recently announced VoiceStream services will support.

2. The SAP R/3 Release 4.6C SAP GUI for HTML produced more than 30 times the volume of traffic when compared to a Release 3.x client for the same Create Sales Order transaction.

3. In a congested network, implementing QoS functionality reduced the SAP transaction time by approximately 75%.

Principle: *Many business critical applications require an ever-increasing amount of bandwidth that has precluded their being widely deployed in a mobile environment to date.*

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[2] Evaluation of Application Network Performance for SAP Sales and Distribution R/3 Release 4.6, November 2000, the Netigy Corporation

3. Enabling Technologies: IP and QoS

Now that we have demonstrated the marketplace requirements for speed and mobility, this section of the paper will discuss two key enablers of high-speed mobile services: IP and QoS. In order to be as relevant as possible to marketplace realities, this discussion will involve identifying factors that drive technologies to either be successful or non-successful in the marketplace.

As previously mentioned, the emerging Metropolitan Area Network services are typically based on IP, Ethernet, and fiber optics (Figure 1). What is interesting about this observation is that until recently the high technology industry was engaged in heated discussions about both Layer 3 protocols as well as MAN and LAN transmission technologies.

For example, it was only a few years ago that SNA and DECNET were widely deployed. At the same time, numerous articles in the press announced that IPX would soon be more prevalent than IP. In today's enterprise networks, protocols such as SNA, DECNET, and IPX certainly still exist. However, they increasingly constitute a smaller and smaller portion of the overall infrastructure. IP currently is, and will remain, the protocol of choice in the vast majority of enterprise networks, whether they are traditional wired networks, or an emerging 3G or 4G mobile network.

A similar story applies to MAN and LAN technologies. In the late 1980s, FDDI was widely advocated as a MAN technology. In the mid 1990s, a number of service providers deployed Transparent LAN Services based on ATM. While it certainly is possible to find some MAN services based on ATM, it would be very difficult to find any that are based on FDDI.

The amount of coalescing that has occurred in the LAN marketplace dwarfs what has happened in the MAN marketplace. For example, until recently there were heated debates over the use of a wide range of LAN technologies, including Ethernet, 100 VGAnyLAN, FDDI, Token Ring, and ATM 25. Today these debates are over. Some variant of Ethernet is clearly the technology choice in the LAN.

Principle: *The high technology marketplace tends to coalesce on a small number of tested technologies, such as IP. In order to be successful, new networking services need to work seamlessly with these key technologies.*

Both enterprise IT organizations and mobile operators need to understand which technologies are most likely to survive the inevitable contractions that occur in the high technology marketplace. While there are many factors that influence the success of a given technology, two key factors are complexity and longevity.

To demonstrate how complexity and longevity impact the likely success of a technology, consider how ATM 25 did in the marketplace. A few years ago ATM 25 was heralded as the obvious successor to shared Ethernet LANs. The argument was made that ATM 25 offered considerable functionality and was an important step on the path to driving higher speed LAN technologies to the desktop.

However, virtually no enterprise ever deployed ATM 25. One of the factors that kept ATM 25 from being successful is that the complexity of the technology far outweighed the functionality that it offered. Another factor that kept ATM 25 from being successful is that it few organizations wanted to deploy a technology that clearly had a short life cycle. The combination of high complexity and short life cycle doomed ATM 25 to obscurity.

A newer technology that has similar characteristics to ATM 25 is WAP (Wireless Application Protocol). The primary WAP protocols are listed in Table 1. One conclusion that can be drawn from Table 1 is that WAP is clearly complex.

Protocol	Description
Wireless Datagram Protocol (WDP)	A datagram protocol, somewhat similar to UDP, but with segmentation and reassembly functionality
Wireless Markup Language (WML)	This is an XML based language for describing WAP content
Wireless Markup Language Compressed (WMLC)	This is used to compress WML before it is sent to the user's browser
Wireless Markup Language Script (WMLS)	This is a scripting language based on ECMAscript
Wireless Session Protocol (WSP)	This is equivalent to HTTP 1.1
Wireless Telephony Application Interface (WTAI)	This is an Application Programming Interface (API) to the telephony capabilities in a mobile phone
Wireless Transport Layer Security (WTLS)	This protocol is based on Transport Layer Security (TLS)

Wireless Transaction Protocol (WTP)	This is used in conjunction with WSP

Primary WAP Protocols
Table 1

Cisco authored a paper [3] that describes WAP functionality in detail. In the paper, Cisco makes the following comments about the likely longevity of WAP. "Proponents of WAP believe that the high bit error rate (BER), low processor power, limited battery lifetime, small display, and so on all require special treatment. In fact, as the hardware technology develops, it is likely that a new version of WAP will move towards a more conventional use of WWW protocols."

WAP is clearly a very complex protocol suite that was designed for cellular phones and an early generation of PDAs. The use of WAP also requires that applications be re-written to run in a WAP environment. The combination of all of this complexity, as well as the projection for a short life cycle, makes it unlikely that WAP will be widely deployed.

Principle: *Complex technologies with a short life cycle tend to have very limited deployment*

QoS refers to the ability of the network to provide preferential treatment to certain classes of traffic. The most common reason that enterprises deploy QoS functionality is that they have one or more delay sensitive, business critical applications that they want to ensure performs well.

A previous section of this document gave examples such applications: Oracle and SAP. That section of this document also presented test data that demonstrated that by implementing QoS functionality, the transaction time associated with the SAP sales order transaction was reduced by 75%.

Another widely deployed application driving the need for low, predictable network latency is Voice over IP (VoIP). In recent market research conducted by Ashton, Metzler & Associates, twenty one percent of the respondents indicated that their company had already deployed VoIP. The survey respondents also indicated that within a year, roughly fifty percent of their companies will have deployed VoIP. Successful VoIP deployment requires very stringent limits on the end to end network delay.

The need for QoS in the WAN to protect business critical applications is well recognized by enterprise IT organizations. To demonstrate that awareness, Ashton, Metzler & Associates (AM&A) recently surveyed

[3] WAP White Paper, www.cisco.com/warp/public/cc/pd/iosw/prodlit/iwarp_wp.htm.

over two hundred network professionals. Twenty-six percent of these professionals indicated that their company had already widely implemented QoS in their WAN infrastructure.

AM&A also asked these network professionals whether or not their company would make significant use of QoS in their WAN infrastructure a year from now. Their responses are depicted in Table 2.

Response	**Percent of Marketplace**
Will make significant us of QoS mainly from services acquired from Service Providers	10%
Will make significant use of QoS mainly in a private WAN infrastructure	27%
Will make significant use of QoS by leveraging service provider offerings and a private infrastructure	24%
Will not make significant use of QoS functionality in the WAN	39%

Enterprise Organization's Interest in QoS in the WAN
Table 2

As can be seen in Table 2, sixty-one percent of the respondents expect to make significant use of QoS in their WAN infrastructures a year from now. It is interesting to note that these network professionals expect to both deploy QoS functionality in their private WAN infrastructures as well as to have it be a part of services that they acquire from service providers.

Principle: *The majority of enterprises require QoS in their wide area networks, whether they are traditional wired networks, or an emerging 3G or 4G mobile network. This requirement will grow over time as businesses continue to deploy delay sensitive, business critical applications.*

However, in order for QoS to be effective, it must be deployed end-to-end. That follows because the goal of deploying QoS is to guarantee that delay sensitive applications (i.e., Oracle, SAP, Voice) perform well. The only way to provide that guarantee is to manage the latency on each segment of the end-to-end path.

Principle: *The success of wireless networks will increasingly depend on implementing both IP and QoS at the customer's first connection point.*

4. Complimentary Technologies: Bluetooth and 802.11

The previous section of this paper discussed technologies (i.e., IP and QoS) that are a necessary component within the vast majority of networks, whether that is a traditional wired network, or an emerging 3G or 4G mobile network. This section of the paper discusses technologies, such as Bluetooth and 802.11, which are complimentary to the emerging 3G and 4G networks.

Bluetooth technology has been submitted to the IEEE 802.15 committee for consideration as the standard for Wireless Personal Area Networks (WPAN). The underlying technology has a very narrow focus. In particular, Bluetooth technology is defined for small-form factor, low power links supporting up to eight total mobile devices such as PCs, PDAs, or cell phones. Key emerging applications for Bluetooth are to enable the use of a wireless keyboard or a wireless mouse.

The IEEE 802.11 set of standards defines the protocols between a wireless station and an access point, which acts as a bridge between wired and wireless networks. The initial 802.11 standard was released in 1997 and was intended to enable wireless networks running at either 1 Mbps or 2 Mbps.

The first section of this document described the rapidly growing deployment of wireless products based on the second generation of 802.11 protocols; i.e., 802.11b. The 802.11b standard was released in 1999. The current 802.11b standard added to the existing 802.11 standard the support for wireless networks running at either 5.5 Mbps or 11 Mbps.

The third generation of 802.11 protocols is 802.11a. The standard defines basic speeds of 6 Mbps, 12 Mbps, and 24 Mbps, which every 802.11a compliant device must be able to support. However, it is anticipated that 802.11a devices running at speeds as high as 108 Mbps will soon be operational.

One of the reasons that 802.11a can achieve these higher data rates is because it employs an encoding scheme that is a variant of Orthogonal Frequency Division Multiplexing (OFDM). This sophisticated encoding scheme enables higher speed communications by dividing a single high-speed carrier into several lower speed sub-channels, and using some of these channels for error correction.

Principle: *The ability to support higher mobile data rates will require the use of technologies such as Orthogonal Frequency Division Multiplexing (OFDM).*

One of the many uses for high-speed wireless LANs is to provide for connectivity in public locations. As shown in Table 3, Wireless LAN (WLAN) technologies have already been deployed in a number of public locations, often referred to as Hot Spots.

Public Domains	**Total Number in the United States**	**Deployment Case**
Airports	19,098	San Jose Airport, Vancouver Airport, AA lounges
Automotive Dealerships and Service Stations	200,935	Shell and Hertz
Colleges and Universities	4,064	Carnegie Mellon University, Columbia University
Eating and Drinking Establishments	478,635	Starbucks
Elementary and Secondary Schools	116,910	Multiple examples
Hospital Facilities	6,201	St. Luke's Hospital (Texas)
Hotel and Lodging Establishments	59,212	Four Seasons, Hilton Hotels
Local and Interurban Passenger Transit Establishments	19,821	High-speed trains (Japan), Underground trains (UK)
Motion Picture Establishments	46,420	Multiple examples
Shopping Centers	45,000	MSC, Simon Properties
Total Target Locations	996,296	

Source: the Yankee Group

US Wireless LAN Hot Spots
Table 3

While Hot Spots provide a valuable service, they are only a small part of a total solution. Today's mobile worker requires the ability to supplement WLAN services, where they are available, with 3G and 4G cellular services.

Principle: *The requirements of mobile professionals require that a number of technologies be deployed. Some of these technologies are focused on enabling connectivity within a building or a campus, while others are focused on enabling connectivity either within or between campus locations.*

It is very encouraging to see that companies are beginning to appear in the marketplace with solutions that address the afore mentioned requirements of the emerging wireless marketplace. One such company is Flarion, a privately funded company that is headquartered in New Jersey.

Flarion is likely to be successful in the marketplace for three key reasons. The first reason is that Flarion recognizes that IP has won the protocol wars, and that in order for wireless operators to be successful that they must deploy a purpose-built mobile broadband network that is packet based. The second reason is that Flarion also understands that our industry is littered with companies that attempted to require that IP be changed in order for their value proposition to be fully realized. Because of this, the Flarion approach requires no changes to the IP protocol, applications, devices, or content. The third reason is that with their development of flash-OFDM™, Flarion is clearly leveraging the power of OFDM technology.

5. Summary and Conclusions

This document discussed the evolution of wireless networks in general and of business critical, delay sensitive applications in particular. Relative to that evolution, this document established a number of principles. Those principles are:

1. People around the globe are mobile, and they want all of their communications to support that mobility.

2. There is currently a strong need for speed. This need will only accelerate as content becomes increasingly rich.

3. Today's mobile networks are designed for voice and low speed data

4. Many business critical applications require an ever-increasing amount of bandwidth that has precluded their being widely deployed in a mobile environment to date.

5. The high technology marketplace tends to coalesce on a small number of tested technologies, such as IP. In order to be successful, new network technologies must work seamlessly with these key technologies.

6. Complex technologies with a short life cycle tend to have very limited deployment

7. The majority of enterprises require QoS in their wide area networks, whether they are traditional wired networks, or an emerging 3G or 4G mobile network. This requirement will grow over time as businesses continue to deploy delay sensitive, business critical applications.

8. The success of wireless networks will increasingly depend on implementing both IP and QoS at the customer's first connection point.

9. The ability to support higher mobile data rates will require a packet-switched technology with support for end-to-end IP. In order to be successful in the marketplace, these packet-switched solutions need to run over technologies, such as Flarion Technologies flash-OFDM, that do not require any changes to IP.

10. The requirements of mobile professionals require that a number of technologies be deployed. Some of these technologies are focused on enabling connectivity within a building or a campus, while others are focused on enabling connectivity either within or between campus locations.

In order to be successful in these challenging times, mobile operators must deploy services that reflect the preceding principals. In particular, mobile operators need to deploy a new class of high-speed services that allow enterprise customers ubiquitous access to all applications and services (i.e., SAP R/3) and not just SMS, email, and stock quotes.

In order to be widely adopted, these new services must provide support that is both seamless and universal for key enterprise requirements such as IP and QoS. And, in order to control their costs, mobile operators must make some key technology choices. These technology choices must be made in a way to ensure that mobile operators minimize their deployment of interim technologies, and focus on deploying technologies that maximize the amount of bandwidth that can be derived from a given amount of spectrum.