Mobile IP Technology Overview

3G Internet mobility

Mobility—it is the hallmark of 21st century communications, with mobile voice services having already transformed both business and personal interactions. But the full potential of mobile communications won't be realized until the capability extends to data. This next stage—extending seamless mobility to the Internet—has begun, and it will represent the true mobile communications revolution, empowering users with anywhere, anytime, anyway access to the world's greatest reservoir of information and entertainment, and the capability to instantly share this wealth with others.

The development of Third Generation (3G) networks, with their tremendous capabilities, will spur the creation of unprecedented amounts and types of content available on the Internet, including video, voice, and images. Combine that with the number of wireless subscribers—expected to reach 1 billion by 2004[1]—and the number of Internet users—projected to reach 600 million a year later[2]—and the demand for mobile Internet access is inevitable. So, too, will be the demand for convergent devices that provide both voice and data.

The communications industry already provides rudimentary mobile data services via Wireless Application Protocol (WAP) and General Packet Radio Service (GPRS) devices. On the horizon, though, are an exciting wave of mobile communications products and services made possible by a revolutionary new network-layer protocol called IPv6. For the communications industry, Mobile IP will indeed mean going new places. And Compaq Telecommunications will be there with the cutting-edge products and technology that make it possible.

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[1] Mobile Computing Forecast: 2000, Gartner Advisory, Dataquest, August 7, 2000.

[2] Third Generation Wireless: The Impact on Global Competition, ICM Global Intelligence, November 1999.

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Inspiration Technology

Mobile IP: Telecom challenges and opportunities

No telecom company needs to be convinced about the desirability or viability of mobile communications. In a very short time, mobile telephony has changed the world. Soon, the number of mobile handsets will overtake the number of fixed lines. For business, mobile communications today means that deals are hastened, products and services are more rapidly developed and delivered, and productivity is enhanced. On a personal level, mobile communications today provides the comfort and assurance that friends and family are immediately available.

The coming ascendance of mobility in the computing world will be just as revolutionary. Soon enough, we will live in a world where accessing e-mail, receiving sports scores or stock prices, playing games, or downloading critical information will be as easy with a data device as it is with a cellular one. *Indeed, these devices will be one and the same*.

After all, consumers will ask, why should mobile communications exclude the world of multimedia content that is data? Why not download information from someone and immediately discuss it with them on the same device, regardless of where you are or where they are or where either of you is going?

Compaq believes—and the historical development of the Internet confirms—that consumers will not just want more and better products and services, but that they'll also want to access these benefits as conveniently as possible. Until now in the computing world, that has meant tailoring information and devices. But as important as those steps have been, the next advance is even more impressive: making the instant information of the Internet available in a way that addresses today's mobile work and lifestyle demands.

For telecom companies, the opportunities are immense. One obvious advantage is the sheer traffic volume that will be enabled by Mobile IP. But Mobile IP will also make possible an astonishing new range of services, from gaming to global messaging services to home gateways that control your air conditioning or security. These new services will open the door for usage-based billing and other revenue streams for service providers. Even at this early stage, it's clear that consumers want these capabilities.

This new world of mobile communications, where voice and data join, will also challenge telecom companies. It will first and foremost require a mindset that recognizes the importance and viability of mobility as it pertains to the Internet. The rewards of Mobile IP won't be realized unless and until the new networking protocol known as IPv6 is embraced by the overall ecosystem of communications—the Internet, cellular, land-line, transport, and access networks.

Mobile IP will take all of us one step closer to realizing the true meaning and potential of mobile communications. Consumers and the businesses that serve them will reap the rewards of convergence, as telephony and network computing merge. For telecommunications companies, Internet service providers, and content developers, the time to prepare for this new world is *now*.

Mobile Internet access today: Limits and frustrations

Back in the days when the Internet was a data-sharing network for the military and a few research facilities, no one foresaw its growth as a communications powerhouse, and mobility was barely a concept. The current IP, Internet Protocol

Version 4 (IPv4), has been remarkably useful, as the growth of the Internet attests, but its limitations are now obvious.

The most pressing deficiency is a limited number of addresses allowed by IPv4's 32-bit address. Fortunately, the Internet Engineering Task Force (IETF) has developed IPv6—a next-generation protocol with a 128-bit address that not only resolves the address shortage and other issues (see sidebar), but also provides the foundation for greatly improved mobile access.

Because mobility was not a factor when IPv4 was developed, there was no need to distinguish between who you were and where you were; it was assumed that identity and location were one and the same. There is no information in the IPv4 address that indicates a new geographic point of attachment.

As a result, today's users have portable networking capability, but it's far from ideal. The correct delivery of packets requires a new IP address associated with the new point of attachment. One has to establish a new connection whether one moves 100 feet or 1,000 miles. As far too many people know, connecting to the Internet from different locations can be a very frustrating exercise.

It can be a costly exercise as well. Because mobility via IPv4 necessitates informing any agent in the routing process about a new location, additional infrastructure is required—something not always deployed in IPv4 nodes. A system has to be configured with a new address, a correct IP address mask, and a new default router every time one establishes a connection from a new location. Consequently, the time and effort benefits one might realize from having mobile Internet access can be dissipated because of the hardships required to attain that very access—hardly what today's time-pressed consumers expect or demand.

In designing IPv6, IETF added key functionality to the protocol so that Mobile IPv6 could take advantage of such features as Next Headers, Destination Options, Source Routing, and Neighbor Discovery. Then IETF was able to require key mandatory support elements in all IPv6 implementations to assist with those features.

Mobile IPv6: Reaching the Net anywhere, anytime, anyway

With Mobile IPv6, location is no longer an issue when connecting to the Internet. The mobile node sends information about its point of attachment to a home agent—a node on the home network that allows the mobile node to be reachable at its home address, regardless of its actual geographic location. Packets addressed to the mobile node are intercepted by the home agent and tunneled directly to the mobile node's current location.

Mobile IPv6 resolves the mobility issue by utilizing two addresses for a mobile node: a home address and a care-of address. The care-of address is created whenever the mobile node changes its point of attachment to the Internet and is no longer connected to its home network.

The care-of address can be assigned by a DHCP server, but one of the great advantages of IPv6 is stateless autoconfiguration, where the mobile node creates a unique IPv6 address by combining its LAN Medium Access Control (MAC) address with a prefix provided by the network router. There's no need for a manually configured server because no server has to approve or distribute an address. This reduces end-user costs because trained staff is no longer required at the receiving network for the mobile node.

Whenever the mobile node moves, its new care-of address is first registered with the home agent in a process known as "binding." It does this by sending a packet, called a Binding Update, that contains the mobile node's care-of address and registration lifetime, which dictates the length of time to use the binding, along with a Home Address destination option that contains the mobile node's home address. For authentication purposes, the home agent registers the binding and returns a binding acknowledgment to the mobile node.

With Mobile IPv6, the home agent automatically forwards data sent to the mobile node's home address to the care-of address, in a process known as *tunneling*. Mobile IPv6 also allows for route optimization, whereby data is sent directly from a correspondent node—a mobile or stationary node that directly communicates with the mobile node, utilizing such applications as e-mail, instant messaging, and streaming audio or video—to the mobile node. The mobile node accomplishes this by sending a Binding Update to inform the correspondent that it is no longer at home. The correspondent node then sends packets directly to the care-of address of the mobile node, with a routing header that contains the mobile node's home address.

When the mobile node sends packets to another node, its care-of address is set as the source address, and a home address destination option is included. This preserves the end-to-end model of TCP/IP, allowing mobility without interrupting any open connections.

For mobile users, location will no longer be an obstacle when connecting to the Internet. The additional time, infrastructure, and cost of today's mobile connection will no longer exist—factors that will certainly spur greater use of these connections.

The Mobile IP timetable

Mobile IP will one day become as commonplace as mobile telephony, but it won't happen overnight. To talk about the future of Mobile IP is to talk about the future of IPv6.

For some time, we will live in a dual-IP world with IPv4 and IPv6 coexisting. Fortunately, IPv6 was designed with such a transition in mind. IETF recognizes that upgraded hosts and routers will need to retain downward compatibility with IPv4 devices for many years. It's expected that we'll live in this dual-IP world for at least another decade.

The global benefits of IPv6—not just mobility, but also improved security, functionality, and quality of service—

Other advantages of IPv6

While IPv6 makes mobile Internet connections possible, that's only one of its benefits. It's not simply a new address; it provides for a "smarter packet" as well. IPv6 provides increased functionality in such commercially important areas as security and quality of service, and opens the door to new services.

With IPv6, necessary authentication, security encryption, and data integrity safeguards are an integral part of the protocol. The IPv6 standards-based authentication header extension assures that a packet is truly from its source address. End-to-end encryption at the network layer is provided by another standard header extension—the packet itself is never touched.

Quality of service (QoS) issues are also addressed by IPv6. This improved protocol enables differentiation between non-urgent communications and highly critical applications, such as video conferencing. While these capabilities can be constructed within the IPv4 framework, they're built-in with IPv6. A new traffic flow identification field lays the foundation for QoS functions as bandwidth reservation. In addition, traffic flows can be distinguished for best routing, and those labels can be set to assure a desired security level or cost. This capability opens the door to new services—and increased customer satisfaction as well.

IPv6 also advances the art of multicasting, important because there will be increased demand for streaming audio, video, and animated content. The improved address defines a large multicast address space, thereby limiting the degree to which multicast routing information is carried throughout an enterprise. IPv6 hosts and routers are required to support multicasting. And IPv6 also introduces the concept of "anycast" services, whereby a group of nodes can be designated as an anycast group, and a packet addressed to the group's address is delivered to only one of the nodes.

will only be realized when IPv6 is the dominant protocol. In essence, the weakest link determines the strength of the network, but many factors will work in favor of IPv6's ascendance. IPv6 has already been adopted as the protocol for next-generation networks by the Third Generation Partnership Project (3GPP), a worldwide standards-setting organization. This endorsement will greatly speed the adoption of IPv6 by future networks, beginning with 3G mobile networks.

Underlying factors also favor IPv6. The lack of addresses in developing and emerging economies; the increasing popularity of wireless in those lands and others; the continued rise of the Internet as the single most robust source of information; the need for anywhere, anytime, anyway access; the natural progression toward convergence—all these point to a bright future for IPv6.

Compaq expects IPv6 deployment to occur in stages, beginning with regional IPv6 networks. These networks will be deployed in order to launch new subscriber services and to gain competitive advantages. These regional IPv6 networks will interoperate with national and international IPv4 networks, thereby assuring global, end-to-end service delivery. Subsequent stages will feature the development and deployment of additional products and services made possible by the advanced features of the new infrastructure. In time, the entire national and global IPv4 infrastructure will migrate to the superior IPv6.

As the 3G infrastructure is built around the world, IPv6 is certain to be a core component. Just as surely, the vast improvements and capabilities of 3G networks will spur a multitude of innovative services accessed by an equally wide array of devices. Making it all possible will be IPv6.

Compaq and Mobile IP

While Mobile IP won't happen overnight, the process is already under way, and Compaq is committed to hastening its progress at every stage, from developing standards to bringing demonstration products to the telecom and computing industries and commercial products to the marketplace. Indeed, Compaq has been involved in the IPv6 story since its beginning.

Senior Compaq engineers fostered development of IPv6 within the IETF, contributing to its essential specifications, and their work is ongoing today. Compaq's lead IPv6 design engineer is a member of the IETF IP Next Generation Directorate and also chairs the IPv6 Forum Technical Directorate (www.ipv6forum.com/).

Compaq also provided one of the first implementations of IPv6 with a 1997 Early Adopter Kit, which was successfully used by enterprises such as ES, NET, UUNET, Mitre Corporation, NTT, and Netscape on the developmental 6bone, a worldwide IPv6 testing and preproduction deployment network (www.6bone.net). Altogether, more than 300 IPv6 early adopters used this kit.

Compaq is vigorously developing the products that will enable Mobile IP and is proud to have unveiled one of the first commercially available systems with production IPv6 support: the Compaq *Tru64*™ UNIX on *AlphaServer*™ system. The *Tru64* UNIX Version 5.1 operating system provides the Resource Reservation Protocol (RSVP), the first IP specification to use and define the IPv6 flow label—data that establishes a packet's priority, which is essential for quality of service within IPv6. Compaq provides RSVP for IPv6 for those who wish to manage their network's bandwidth within an intranet. We also offer an RSVP API that allows access to the IPv6 flow label, enabling resource reservation across a network.

A Compaq *OpenVMS*™ on *AlphaServer* system with production IPv6 support is also available.

In the summer of 2001, Compaq will showcase the *iPAQ*™ Pocket PC running Linux IPv6 in a Mobile IPv6 solution demonstration. This handheld development platform demonstration will be a boon to mobile operators, providing an IPv6 device for testing purposes and development environments. And in the fall of 2001, Compaq will have a Mobile IPv6 prototype kit available on the *Tru64* UNIX platform, initially targeting the telecom market.

These products will all be part of Compaq's Mobile IP solutions suite deployed in Compaq Wireless Competency Centers worldwide. At these centers, customers will be able to see demonstrations, personally sample mobile applications, and receive answers and support from our technical experts.

Compaq is committed to supporting the development of Mobile IP. Our product portfolio will continue to expand, covering today's and tomorrow's needs, from development of consumer devices and networking infrastructure to support of back-end billing and customer care. We are partnering with leading-edge solutions providers to create an exciting new world of communications, helping to integrate infrastructure solutions with end-user devices, and providing packaged solutions to the market.

For Compaq and its customers, anywhere, anytime, anyway Mobile IP is no longer a vision; it's today's mandate. Compaq and Mobile IP: We're ready when you are.

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