



WHITE PAPER

Wi-Fi VoIP and Cellular Network Integration

The Power of Dual-Mode Handsets and Wi-Fi
to Cellular Roaming



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CONTENTS

+ Introduction	3
+ Current State of the Mobile and Landline Markets	3
+ Market Opportunity	6
+ Proposed Technology Solution	9
+ VeriSign Wireless IP Connect: Benefits of a Managed Solution	11



Due to increased convenience, wireless service is displacing landline service both at work and at home.

Introduction

This white paper, which addresses the opportunity to provide an integrated voice-over-internet-protocol (VoIP)/cellular service, will discuss the growth in mobility users, advances in cellular and Wi-Fi technologies, and the introduction of dual-mode handsets and how this combination of mobility growth and technology advancements presents an opportunity for landline mobility services. It will also discuss how VeriSign is addressing the converged opportunity with the VeriSign® Wireless IP Connect Service currently available for customer evaluation and testing.

The Current State of Mobile and Landline Markets

This section provides an overview of the current state of the mobile and landline markets and identifies voice-over-Wi-Fi enablers, market barriers, and market opportunities.

+ Move to Mobility

Within the course of a day, the population has certain telecommunication needs categorized and served based on presence (at home, at work, and in motion). Traditionally, landline and cellular operators have predominantly served this finite demand for telecom services with wire-based access (at home and at work); however, recent advancements in wireless technologies and mass-market adoption of cellular services have created economic conditions that are enticing a growing number of people to migrate toward the convenience of wireless communications.

Inexpensive rate plans that include unlimited night and weekend service and bundled long distance have allowed cellular operators to move beyond the population's mobility needs, growing revenues through increased indoor use. According to a Yankee Group report released in March 2005, in more than 70 percent of U.S. households, at least one person has a wireless phone. These households report that an estimated 60 percent of long distance calls and 36 percent of local calls take place on a wireless phone.

Whether by providing users with a single point of contact where they may be reached at all times or by enabling them to remain productive while in motion, wireless services have become an indispensable part of most peoples' lives. On average, cell phone penetration in the enterprise is above 35 percent, and 14 percent of consumers now use cell phones as their primary line; many more are ready to switch should their in-home cellular coverage improve.

This is good news for cellular operators but is a serious threat to landline operators.

+ Introduction of Dual-Mode Handsets

Believing Wi-Fi-enabled cell phones command significant market potential, handset vendors, along with their semiconductor suppliers, are actively investing in dual-mode cellular/Wi-Fi technologies, which allow wireless handsets to switch between the licensed spectrum of the public cellular network and the unlicensed spectrum of wireless LANs (WLANs).

Operators are investing in technologies to extend mobile service to the home and office—unlicensed spectrum and VoIP backhaul are significantly reducing airtime costs.

To date, market demand for such solutions has remained relatively low, due largely to the comparably high cost of Wi-Fi-enabled handsets and outstanding battery/talk time and quality-of-service (QoS) issues. Nevertheless, the introduction in mid-2003 of TI's low-power trimode 802.11a/b/g cell phone chip and Motorola's Global System for Mobile communications (GSM)/802.11a dual-mode handset represented a milestone in the industry that signaled its confidence in the emergent market opportunity. Since the announcements, virtually every major handset and semiconductor vendor has announced plans to invest in technologies that will eliminate the remaining market barriers to widespread cellular/Wi-Fi convergence.

Taking into account traditional early-adoption rates of new technologies and their associated compound annual growth rates (CAGR), market conditions are not expected to support a significant cellular/Wi-Fi convergence opportunity this year or the next. However, if the CAGR for Wi-Fi-enabled cell phones tracks to Wi-Fi Access Points and Network Interface Cards (1999 to 2002 CAGR 199 percent), a sufficient amount of handset shipments (more than 1 percent of all shipments, which will represent 54 million handsets, about 0.3 percent of the worldwide subscriber base) is expected to commence FY2007.

+ Impacts of Wi-Fi Unlicensed Spectrum on Cellular Service

Cellular networks essentially consist of two parts: the Radio Access Network (RAN), which controls transmission and reception of radio signals, and the Core Network, which provides switching, transport, and enhanced services for traffic emanating from and directed to the cellular network's RAN. The typical operating cost per minute of use (about \$0.03 per minute) is equally divided across the core network and the licensed RAN (code division multiple access [CDMA], and GSM), a significant fact when considering the effect the delivery of mobile service over the inexpensive, licensed-exempt spectrum of Wi-Fi networks will have on cellular operators' ability to compete. In fact, today most cellular operators are pursuing cellular/Wi-Fi convergent technologies, such as Wi-Fi-enabled cell phones, which will permit extension of core network services to locations served by Wi-Fi networks, most notably the home and office.

When superimposed on the Internet protocol (IP), the voice services of cellular operators' core network become yet another service delivered over the data-network infrastructure. Functioning as an unlicensed RAN, Wi-Fi networks and VoIP transport change the cost structure of mobile telecom services, which in turn furnish cellular operators with an inexpensive means of reducing airtime costs and improving in-building coverage.

Essentially, cellular/Wi-Fi-convergent technologies arm cellular operators with a means of eliminating the remaining market barrier (dead spots) to widespread wireless substitution of landline services.

+ Landline to Add Mobility Value Proposition

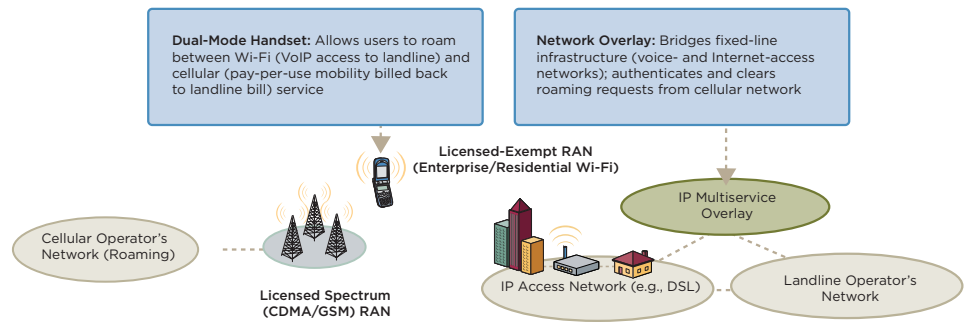
Services delivered over the fixed-line infrastructure of the public telephone network enjoy cost and performance characteristics superior to those of the licensed cellular infrastructure of the public mobile network. However, the cell phone's address book, and a single telephone number reachable anytime, anywhere, grant cellular service a competitive advantage, which is fueling the use of cell phones indoors, estimated to be more than 30 percent of all use today.

Recognizing the effect VoIP, Wi-Fi, and Wi-Fi-enabled cell phones will have on business, many landline operators are converging on IP multimedia subsystem (IMS) network

Subscribers want one device, one telephone number, one address book, and one bill with ubiquitous service—anytime, anywhere.

architecture. As mobility services continue to draw closer to the Internet environment and the demand for multimedia services broadens, a multiservice network architecture empowers operators with the ability to integrate cellular and landline services with each other as well as with rich media services (see Figure 1).

Figure 1:



The main functions in a cellular network that enable mobility are the home location register (HLR) and the visitor location register (VLR). Through an overlay of these functions on the landline network, in the form of a third-generation partnership project (3GPP)-compliant IMS network environment, operators are able to offer subscribers possessing a Wi-Fi-enabled cell phone access to less expensive fixed-line services from virtually any location served by a broadband wireless network.

Increasingly, tight integration of cellular air interfaces with closed proprietary handsets, which provided cellular operators with a de facto monopoly, will come under threat by Wi-Fi-capable cell phones that unbundle access from network services.

+ Meeting Subscriber Expectations

If you were to ask cellular subscribers, “How should voice over Wi-Fi complement your cell phone service?” they would most likely respond with a desire for an inexpensive, flat-rate, anytime unlimited calling plan that features clear voice quality.

Ironically, this is a market expectation for which the fixed-line infrastructure of the public telephone network is best positioned to satisfy.

Mobility enabling of the landline network will allow landline users to roam onto Wi-Fi networks with dual-mode handsets capable of automatically sensing the presence of Wi-Fi and establishing service with the fixed-line infrastructure over an existing cable plant that utilizes access technologies such as voice over DSL. This technology enables a mobility service that features superior indoor quality of service subject to landline rate plans. In other words, it provides a primary or secondary line service delivered over DSL, which is complemented by cellular roaming service.

Through roaming agreements between landline and wireless operators, subscribers can be offered a hybrid service bundle that includes ubiquitous mobility within the public cellular network.



The subscriber value propositions for such a service bundle include the ability to preserve anytime cellular minutes for use outside the home or office as well as the value of device consolidation, which includes a wireless device featuring a mobile address book and single telephone number reachable anytime, anywhere.

A recent report cited that 14.4 percent of U.S. consumers now use a cell phone as their primary phone. The report found that among those still using a landline as their primary phone, 26.4 percent would consider replacing it with cellular service should there be an improvement to their in-home coverage. The use of Wi-Fi-enabled cell phones and VoIP transport as an inexpensive solution to indoor dead spots effectively removes a key barrier to cell phone use.

+ Broadband-Access Technologies Holds Strategy Advantage

In modern broadband-access technologies, the separation of access, transport, and applications has a critical effect on how services can be offered and on which carriers can offer these services. Dual-mode mobile phones enable a consolidated device scheme in which mobility can be unbundled from voice services.

When competing technologies threaten a subscriber base, the most desirable defense is the introduction of new value propositions and service bundling, which strengthen the incumbent's ties with subscribers. Separating access from services changes the traditional cost structure of the telecommunications industry, which in turn furnishes operators with the greatest cost advantage—a means of defending their subscriber base. By dividing subscribers' telecom bills into access, services, and roaming components, service providers are able to entice subscribers to substitute-in whole or part-the use of competitors' services.

Market Opportunity

This subsection covers the product description, the customer profile, and the potential market size.

+ Wi-Fi/Cellular Product Description and Model

This technology would enable a landline subscriber possessing a dual-mode cell phone and a landline telephone number to roam from home or office, incurring roaming charges only when the phone is used in transit and enjoying the benefits of a landline service's unlimited calling plan when not roaming, while eliminating the hassle of signing contracts and receiving multiple bills.

Most cellular rate plans involve purchase of a "bucket" of anytime minutes (at an average cost of \$0.10 a minute) and include a large or unlimited number of night and weekend minutes. However, most subscribers use only 60 percent of purchased minutes. According to J.D. Power & Associates, only 72 percent of anytime minutes and 51 percent of night and weekend minutes ever get used, for an average of 61 percent of total minutes. In other words, subscribers pay for nearly twice as many minutes as they use. Many observers attribute this fact to subscribers' fear of going over the minutes contracted, because going over by 10 percent typically doubles the cost.

Wi-Fi-enabled cell phones create new pay-per-use opportunity, particularly for security-use subscribers.

Intermittent users, a significant segment of the subscriber base, use a low number of peak minutes. Divide their bills by the number of minutes actually used, and you will see that these users would be best served by a pay-as-you-go plan. Yes, the minutes on a pay-as-you-go plan look more expensive—an average of \$0.24 per minute—but in most cases such a plan better suits intermittent users' needs.

+ Low-Tier, Pay-per-Use Cellular Market Opportunity

Pay-per-use services are not new to landline operators. In fact, prior to widespread cellular usage, most realized substantial revenues from pay-per-use calling features such as collect calling and postpaid calling cards, which do not require a monthly commitment and can be paid for as used. Today, with the emergence of Wi-Fi-enabled cell phones, nothing prevents landline operators from extending an alternative to the billing scheme for roaming. Operators could enhance pay-per-use service with cellular phones in which users pay an airtime premium for use outside the home or office.

In the third quarter of 2003, the Yankee Group announced that cellular usage had overtaken landline usage; the average cell phone subscriber logged 490 minutes per month. Assuming a 60/40 split between daytime and night/weekend minutes and factoring in a 72 percent usage rate, the average subscriber requires a cellular plan including about 400 anytime minutes. Today, a bucket of 400 anytime minutes costs an average of \$3995 per month (including unlimited nights and weekends). Based on the actual number of anytime minutes used (only 72 percent), the end cost of anytime minutes is in reality \$0.14 per minute.

Roaming agreements charge \$0.15 to \$0.35 per minute, so it is safe to conclude that a service bundle including pay-per-use roaming is not an attractive offering for the average user in medium- and high-tier markets. For the low-tier or security subscriber markets, however, in which the primary reason for purchasing cellular phone service is emergency use, a landline service featuring pay-per-use cellular roaming is an attractive alternative to a contract or prepaid cellular subscription.

Low-tier subscriber markets typically opt for rate plans that include a nominal number of anytime minutes (250 minutes at \$30 per month or less or 150 minutes at \$25 per month), the cost of which (factoring 72 percent usage) ranges from \$0.17 to \$0.24 per minute. Moreover, many users that fall within the security/emergency-market segment opt for a prepaid plan in which the anytime cost is \$0.25 to \$0.35 per minute.

+ Potential Market Size

The U.S. cellular market consists of a few basic segments: high-end business users, local or regional business users, high-end consumers, medium-use consumers, and safety/security subscribers (see Figure 2).

The high- to mid-tier consumer and business segments, the focus of most operators, are relatively mature, with limited growth potential. Consuming high to medium peak and off-peak minutes of use, subscribers within these market segments are unlikely to substitute their bucket-rate plan in favor of a pay-per-use mobility-rate plan unless a significant amount of their minutes are consumed indoors (as is the case in many international markets, such as Japan).

The low-tier consumer and business segments, however, are relatively immature and therefore offer the opportunity for growth. Peak usage in this segment is low and can be addressed by pay-on-demand services. Although cellular operators have serviced the emergency and

security market to some degree, it is still an immature segment with high costs and low revenue. The goal of many operators, to date, has been to either transition these subscribers to other consumer segments or to force them to other operators' networks (including mobile virtual network operators [MVNOs] that have wholesale agreements with mobile operators).

Figure 2:

Wireless and Mobile Market Segment Metrics							
Segment	Typical Usage	ARPU		Acquisition Cost		Operating Cost	
		Current	Future	Current	Future	Current	Future
High-tier Consumer	Medium peak MOU High off-peak MOU Contract	\$50-\$70	\$40-\$60	\$300-\$350	\$200-\$250	\$30-\$35	\$30-\$35
Med-tier Consumer	Low peak MOU Medium off-peak MOU Contract	\$35-\$50	\$30-\$40	\$300-\$350	\$150-\$200	\$30-\$35	\$25-\$30
Low-tier Consumer	Very low peak MOU Low off-peak MOU Prepaid/pay-on-demand	\$25-\$35	\$20-\$30	\$300-\$350	<\$100	\$30-\$35	\$20-\$25

Wireless and Mobile Market Segment Metrics							
Segment	Typical Usage	ARPU		Acquisition Cost		Operating Cost	
		Current	Future	Current	Future	Current	Future
High-tier Business	National/International travel High peak MOU Contract/corporate acct.	\$100+	\$100+	\$300-\$350	\$200-\$250	\$35-\$40	\$40-\$45
Med-tier Business	Local/regional High peak MOU Contract/prepaid	\$70-\$100	\$50-\$100	\$300-\$350	\$150-\$200	\$30-\$35	\$30-\$35
Low-tier Business	Local Low peak MOU Prepaid/pay-on-demand	\$30-\$70	\$20-\$50	\$300-\$350	<\$100	\$30-\$35	\$25-\$30
Emergency/Security	Extremely low usage	\$25	\$20	\$300-\$350	<\$100	\$30-\$35	\$15-\$18

The addressable markets for landline bundled pay-per-user cellular service, typified by infrequent or low peak usage, include low-tier consumer (10 percent), low-tier business (18 percent), and emergency/security (10 percent), representing 38 percent of the U.S. subscriber base, or 479 million people.

When calculating the cellular penetration rate based on current service provider sales methods, primarily contracture sales, and youth and non-credit worthy consumers are taken out of the addressable market (which then factors to 182 million), penetration actually rises to 69 percent (126 million), leaving 31 percent, or 56 million credit-worthy people without service.

Seamless cellular-to-Wi-Fi roaming can be accomplished with an overlay network using 3GPP Multimedia Subsystem technology.

A mature market is forcing operators to pursue lower revenue consumer and business market segments, including users for whom a subscription is not an option. These remaining market segments will return lower average revenue per user than previous segments, forcing operators to reduce acquisition and operating costs to maintain profitability.

+ A Vehicle to Increase Cellular Penetration

Clearly, to grow the market and increase penetration, the industry needs to sell more services to more people. However, simply offering more services under the current postpaid, contractual sales model is not the answer—penetrating new segments with services that those users will find attractive and compelling is. Through a new landline channel, the largely untapped intermittent-use cellular markets benefit greatly. Landline operators offering their subscribers the ability to port home and office phone numbers to a VoIP service featuring pay-per-use roaming introduces a new business model for acquiring low-revenue users. For example, a secondary line service, derived from broadband, which features pay-per-use mobility is an ideal tool for tapping the preteen, teen, and college markets, which represent more than 35 million people.

Growth in the cellular market as a whole will unquestionably be mainly due to consumer-segment expansion. The addressable market of almost 100 million users ensures that the potential of the security/emergency market is high. Specifically, consumer growth in the next five years will be in the preteen, teen, college, and lower-income segments. These are the prime consumer market segments for cellular operators to sell blocks of service time to landline operators, who, through service bundling, can create a compelling offer to a large untapped market.

The dilution of customer acquisition and ongoing subscriber-maintenance costs across service bundles that include broadband, voice, and mobility service will ultimately create economics that will fuel landline operators' broadband penetration rates and the cellular operators' revenue derived from those lucrative roaming minutes of use.

Cultivating this channel means a change in business model for today's cellular operators, including roaming costs/agreements. The operators' margins will be increasingly squeezed, and those employing this channel to target lower-revenue segments will need to remove an equivalent amount of acquisition (including handset subsidy), activation, and provisioning costs from wholesale roaming charges. This strategy will have an immediate, dramatic impact on landline operators' ability to market an appealing service bundle to these market segments.

Proposed Technology Solution

This subsection discusses the proposed technology solution (the VeriSign 3GPP IMS-compliant signaling overlay).

+ Wi-Fi to Cellular Roaming

VeriSign is developing a technology solution for enabling seamless roaming between cellular and Wi-Fi networks (the VeriSign® Wireless IP Connect Service) leveraging a 3GPP IMS-compliant signaling overlay that enables landline operators to offer subscribers the ability to port their home or business telephone numbers to a fixed-mobile service.

CALL SCENARIO

- + When on traditional mobile network, handset registers to mobile switching center (MSC) and HLR
- + When subscriber gets home, Wi-Fi is detected and device obtains IP address from IP network
- + Device registers to VeriSign® WMG—it is now online to make and receive calls
- + VeriSign WMG registers to the HLR in carrier network—mobile network now knows to send calls to VeriSign WMG

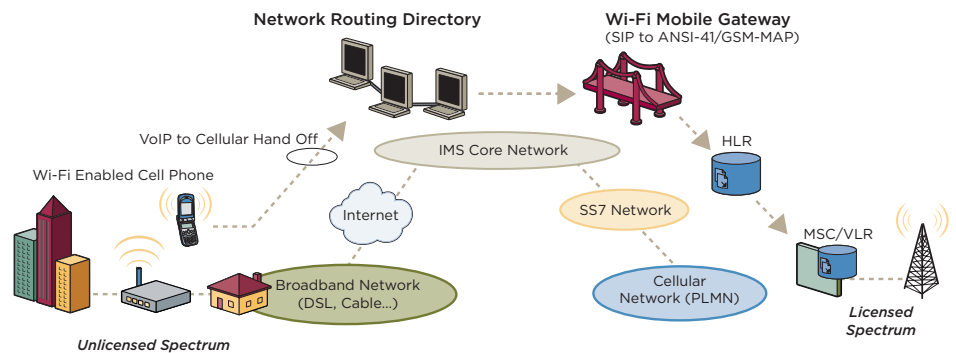
The VeriSign® NRD provides authentication and routing information, enabling the integration of wireline and wireless network technologies.

With such a solution, subscribers are able to move seamlessly between their Wi-Fi-enabled broadband service (for example, DSL) and wide-area cellular service, using a single telephone number anchored to a landline operator’s network.

The VeriSign overlay consists of three network functions: the Network Routing Directory (NRD), the Wi-Fi-mobility gateway (WMG), and the media gateway controller function (MGCF) (see Figure 3). The NRD hosts the subscriber-registry functions that perform device authentication and maintain the device’s current location (in the IP network and cellular networks). The WMG provides ANSI-41/GSM-MAP to session initiation protocol (SIP) interworking, handling SIP call control, ANSI-41/GSM signaling mediation, and enhanced service delivery to the dual-mode handset when on the IP network. The MGCF provides integrated services digital network user port (ISUP) to SIP interworking, acting as the bridge between landline and IP networks, and interfaces with the NRD to discover the user’s current location.

All incoming calls to the subscriber’s telephone number are routed to the landline operator’s network (anchor-end office), which directs incoming calls to the MGCF. The MGCF, in turn, queries the NRD, which directs the MGCF to the subscriber’s current location within the landline operator’s IP-connectivity network or the cellular network.

Figure 3:

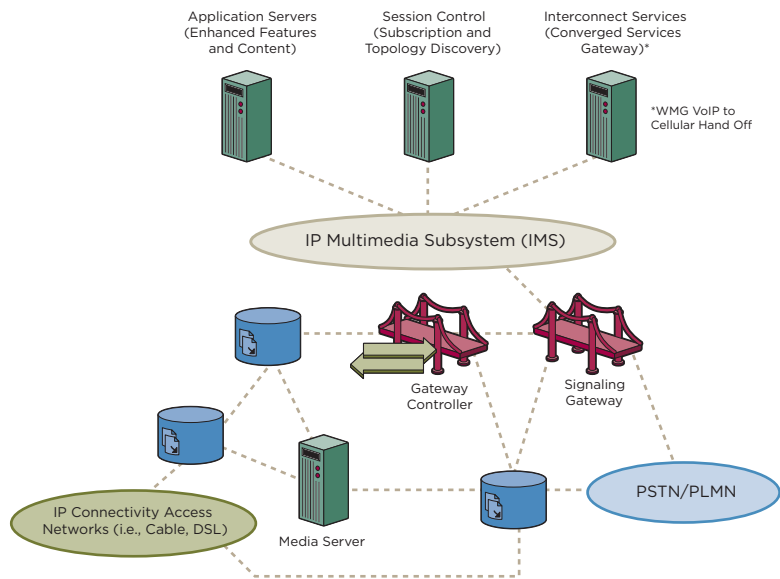


+ The Functionality of the VeriSign® NRD

The VeriSign® NRD is the core element of the VeriSign technology solution. As a common multiservice registry, the directory supports VoIP (SIP and electronic numbering [ENUM]) as well as cellular-based (ANSI-41 and GSM-MAP) location-discovery services, providing authentication and routing information that may be used to establish connectivity across various wireline and wireless network technologies (see Figure 4).

The NRD’s authentication, authorization, and location services may be applied to sessions originated by subscribers explicitly registered within the NRD registry (dynamic location services) and/or those subscribers registered within trusted foreign domains or peer registries (inter-domain routing services across various networks).

Figure 4:



User-identification information can be provisioned to allow for dynamic updating of location information. Static user-location information at the inter-domain level can be provisioned to facilitate routing of traffic to and from the network-demarkation points of foreign domains. If required, network-address-translation (NAT) services and protocol interworking functions may be co-located at the inter-domain mediation points to hide configuration, capacity, and network topology from the outside world. Optionally, user-security information may be provisioned to arm network-access control logic, enforcing subscriber authentication and network-access authorization policies. User-profile information may be provisioned to allow the NRD to detect and broker service interactions between subscribed network services such as Unified Messaging and IP Centrex.

VeriSign® Wireless IP Connect: Benefits of a Managed Solution

The VeriSign® Wireless IP Connect Service will allow operators to offer full VoIP-to-cellular roaming to subscribers, who benefit from the ability to port home or business numbers to a fixed mobile service and move seamlessly between their Wi-Fi-enabled broadband service and wide-area cellular service using a single telephone number anchored to a landline operator's network.

VeriSign Wireless IP Connect provides a cost-effective means of integrating Wi-Fi-enabled cell phones with the existing Signaling System 7 (SS7) network, allowing interconnection between IP networks and the public cellular network. In addition to the largest independent SS7 network in the world, with direct connectivity to hundreds of carriers, VeriSign brings more than 20 years of successful experience in core signaling, roaming,

intelligent-network, wireless billing, clearing, and settlement services that directly apply to your service vision. VeriSign has provided the Cellular Telecommunications Industry Association (CTIA)-endorsed ANSI-41 roaming backbone since its inception. One connection to the VeriSign SS7 network provides seamless roaming and quick launch of new plans and features to subscribers.

+ VeriSign: Experienced Network-Solutions Provider

VeriSign has been providing ANSI-41 signaling since 1993, with the distinction of being the CTIA cellular backbone provider. In 1999, VeriSign deployed GSM-MAP signaling and today has added SIP, supporting American National Standards Institute (ANSI), International Telecommunications Union (ITU), and Internet Engineering Task Force (IETF) protocols and the conversion between them to enable roaming across all wireless network technologies within the licensed and unlicensed spectrums.

VeriSign access to any cellular VLR database via direct connectivity to major cellular operators and gateway access to other GSM and ANSI-41 networks enables wireless operators' subscribers to roam freely into the public cellular network. The VeriSign seamless roaming service enables authentication of subscribers on both the licensed cellular spectrum and the unlicensed Wi-Fi spectrum, identifying the appropriate destination for routing through the VeriSign SS7 network for MSC/VLR validation and the IP network for VoIP validation, and accepts the handset requests to complete registration of location updates.

VeriSign supplements carriers' existing infrastructure, helping them realize savings in capital investments and operating expenses. Our service-bureau approach assists our customers in getting to market quickly with high-quality services. Our industry leadership and commitment to the highest level of efficiency and innovation means you work with a partner you can trust.

In support of the VeriSign nationwide SS7 network, the company's Network Surveillance Control Center (NSCC), staffed 24/7, provides maximum performance, efficiency, and reliability for our customers' signaling traffic. VeriSign achieves nationwide coverage by utilizing 16 geographically and physically diverse signaling-transfer-point (STP) pairs and more than 300 signaling points of interconnection (SPOIs) to allow greater flexibility and cost efficiency.

Operating the largest independent SS7 network in the world, VeriSign has connectivity arrangements and direct access to carriers throughout the Americas. Customers experience virtually instant connections and have access to ISUP, ANSI-41, and GSM-MAP transport services, the cornerstones of seamless roaming. The VeriSign default roaming services for calls from unregistered phones allow carriers to offer roaming services to subscribers roaming within the cellular network across 25 countries.

The VeriSign® Wireless Messaging suite offers integrated solutions for intercarrier messaging to a global network of 500 mobile carriers. Leading the industry in establishing peering agreements, VeriSign handles routing and protocol conversions necessary to complete delivery between incompatible networks.

VeriSign® Mobile Commerce and Content Services drive new revenue opportunities, where VeriSign provides the trusted middleware that absorbs the complexity of managing critical aspects of the mobile content-value chain, including distribution, rights management, copyright clearing, and financial settlement.

Visit us at www.Verisign.com for more information.

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