Transitioning the PSTN to IP: What's in a Number?

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On the Road to IP

For more than a hundred years we have relied on the telephone network to connect us. Within the next 10 years, most of our TDM-based network will transition to a network based on Internet Protocol (IP). This new IP network offers us unlimited possibilities in terms of applications. It will connect not only people but things—cars, streetlights, refrigerators—whatever or wherever the benefits of connectivity are found. Between the present state of the public switched telephone network (PSTN) and the future state of the IP network, there is no one clear path. Standards organizations, regulatory groups, vendors, operators and customers are all working on the transition challenge. All have their suggestions and their reservations. Among these groups, however, there is agreement regarding a handful of key concerns—issues that lie at the core of the transition and that must be addressed as an industry. One of these is numbering. In this whitepaper we look at the challenges and opportunities presented by the evolution of the PSTN to an IP network and the central role that numbering and the Number Portability Administration Center (NPAC) play in this transition.

Say Goodbye to Your Land Line

The evolution of the PSTN from TDM to IP is happening today. The number of traditional switched access lines in the U.S. declined by 25 percent between 2009 and 2012, according to operator data reported by the FCC. Yankee Group's survey of more than 15,000 consumers in the U.S. shows that more than a quarter of U.S. households no longer even have a land line (see Exhibit 1 on the next page). What is driving this flight from the TDM-based PSTN? As suggested in Exhibit 2 on the next page, switched access connections are being squeezed out by two key trends:

- Consumers are turning to their mobile phones as their primary source of connectivity
- Service providers are gradually rolling out VoIP, frequently as part of a multiplay broadband service offering

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Exhibit 1: Mobile Takes Over: More than a Quarter of Survey Respondents Do Not Have a Land Line
Source: Yankee Group's 2013 US Consumer Survey, September

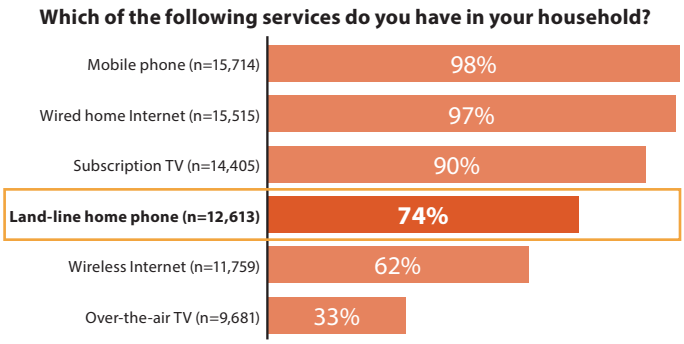
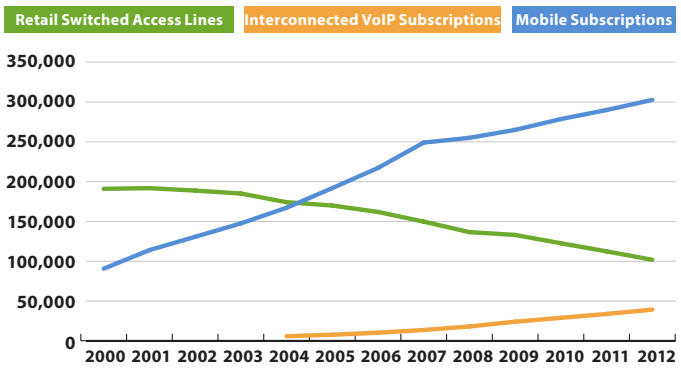


Exhibit 2: 12-Year Trend Paints a Clear Picture
Source: FCC, 2013 and Yankee Group, 2014



The PSTN Will Be With Us for Years to Come; So Will IP

As dramatic as these changes are, the TDM-based PSTN is not disappearing as rapidly as previously predicted by the FCC Technological Advisory Council (TAC), which in early 2011 forecasted that by 2014 we would have fewer than 42 million access lines. At that time the FCC TAC also recommended that the transition of the PSTN to all-IP technology be accelerated so as to be completed by 2018. Service provider reaction to this recommendation, noted at the time in interviews with Yankee Group, was uniformly negative, ranging from a matter-of-fact "It's not going to happen" to a chastising "Irresponsible and out of touch with consumer customers. They would not appreciate it nor would they be ready to pay for it." It is not surprising, therefore, to learn that as of the first quarter of 2014, Yankee Group research shows that there are still more than 10,000 digital TDM switches in the U.S. and even about 20 analog switches. Service providers have been gradually swapping out TDM switches for IP voice infrastructure on an opportunistic basis, driven by specific enterprise customer requirements or by switch failures due to flood, fire, parts failure, etc. However, up until today, there have been few widespread planned conversions to IP infrastructure in the U.S. apart from fiber-based broadband projects; one notable is Verizon's FiOS, which passes about 18 million U.S. homes. To put it in the words of one operator interview from 2012: "To say that we have a plan in place and that we are stepping through that plan—no."

As the TDM switches age, however, the price to support each PSTN user, in terms of facilities costs alone (i.e., power and space), increases and the advantages to IP infrastructure become more difficult to ignore (see Exhibits 3 below and 4 on the next page). Today we are finally seeing operators accelerate their PSTN migration plans. However, while life after transition is looking more appealing, operators still face the same challenge of migration that made them so skeptical three years ago. In order to maintain services to the end-user, the transition is handled on a per-line basis. This is reflected in the way many IP softswitch vendors price their equipment—on a per-line basis. Capex represents only half the cost; the other half is the cost of transition. To quote one operator: "When you do a complete switch collapse you have to look at it as a cost per line—because you have to move them line by line by line, and that is time consuming."

Exhibit 3: The Cost of Maintaining the PSTN Will Increase by 70 Percent per Line Between 2013 and 2020
Source: Yankee Group, 2014

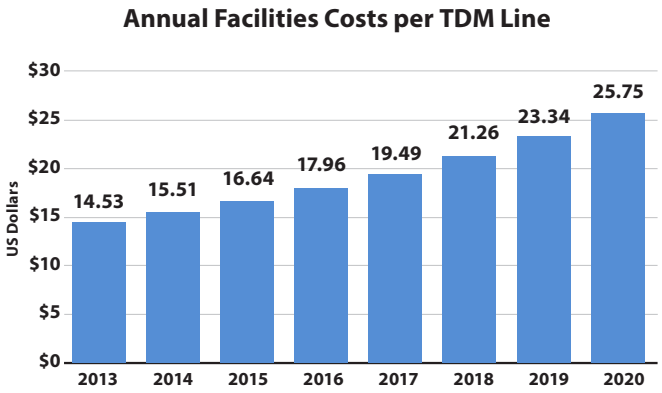


Exhibit 4: Reasons for PSTN Transition Combine Cost, Functionality and Operational Necessity
Source: Yankee Group, 2014

	TDM	IP
Capital cost	Fully depreciated	Capex hit (Regardless of lower price per port than "new" TDM switch)
Facilities costs	Averages 10 times more power and cooling	10% of the power and cooling
	Averages 10 times more floor space	10% of the floor space
Ability to deploy new services	EOL	Frequent upgrades
	Legacy features and services only	Multimedia/multi-device services
Operational costs	High OSS costs via legacy interfaces	Low OSS costs via Web-based GUIs and modern APIs
	Aging support personnel	Growing support community
	Lack of spare parts for repairs	No scarcity of spare parts
	Parts aging out even with no malfunction	

You Have To Move More Than the Line

To identify and assess the key challenges associated with the PSTN to IP transition, the Alliance for Telecommunications Industry Solutions (ATIS) established the PSTN Transition Focus Group (PSTN TFG). ATIS is a Washington, D.C.-based organization that develops technical and operational standards and solutions for the telecommunications industry. It has 225 members drawn from both the vendor and operator communities. ATIS is the North American partner to the 3GPP and is accredited by the American National Standards Institute (ANSI). The goal of the PSTN TFG is to establish a set of standards and best practices that will help service providers in their evolution from TDM to IP. The pivotal role that numbering plays in this evolution can be seen from the list of key areas into which the PSTN TFG divides PSTN-IP network transition:

- Application Services
- Access
- Transport
- Numbering

Transitioning the core or transport network can be accomplished completely transparently to the end-user, although it creates the potential for a variety of new services once completed. Moving user lines (access) establishes connectivity. However, all of the PSTN applications associated with that specific line must also be transitioned accurately. Both of these transitions (that of the line and that of its associated applications) must be accomplished without disruption to the end-user. The only element of the network that logically associates the application with the line and both the line and its applications to an end-user is a telephone number. The telephone number is therefore critical to maintaining continuity and avoiding disruption of services. Before you transition the line and the applications, you have to port the number.

Unravelling the PSTN

An all-IP network holds the promise of infinite applications in infinite combinations. Before we can get there, however, we must be able to transition existing PSTN applications to an IP environment. The PSTN may not be known for its wealth of applications, but in fact dozens of PSTN applications have existed for decades and are woven deep into emergency services, public safety and business revenues (see Exhibit 5 on the next page). This makes the task of transitioning technologies far from trivial. All of these applications are critical in maintaining social policies and commercial programs:

- **Core voice services/regulatory services** are essential to public safety and homeland security.
- **Advanced communication services** are used extensively by enterprises in revenue-generating and support applications.
- **Media services/Customer premise equipment-dependent services** span a wide range of enterprise services including alarm systems and fax machines.
- **Accessibility/assistance services** are critical to the elderly and persons with disabilities.

The PSTN FTG analyzed the current set of PSTN applications and divided them into three categories:

- **Sunset services are services** that will not be transitioned. These services were built on outdated technology and will be or have been replaced by alternate solutions providing superior functionality.
- **Transitional services are services** that, due to market penetration, will be supported until it makes commercial sense to transition.
- **Successor network services** are services supported in successor networks owing to demand from regulatory, social policy or market forces.

Exhibit 5: Providing Application Continuity Will Be a Major Transition Hurdle
Source: ATIS, 2013 and Yankee Group, 2014

Service Category	Service	Successor network services	Transitional services	Sunset services	Drivers
Core voice services/ regulatory services	Dual-tone multifrequency signaling (DTMF)				Market
	Emergency services				Regulatory
	Lawful intercept				Regulatory
	Priority services				Public safety
	Malicious call trace				Regulatory/public safety
	Portability				Regulatory
Advanced communication services	CLASSSM				Regulatory
	Database services				Regulatory
	Automatic call distributor (ACD)				Market
	IVR (interactive voice response)				Market
	Intelligent network (IN) services				Market
	Voice mail				Market
	Voice conferencing				Market
Media services/ CPE dependent services	Fax				Market/legal
	Alarm system				Market
	BRI services				Market
	PRI services				Market
	Channel associated signaling (CAS) trunk services				Market
	Analog loop signaling dependent services				Market
Accessibility/ assistance services	Emergency hot line				Market
	Coin (public interest payphone)	Alternate implementation			Regulatory
	Emergency alerts				Regulatory
	Operator assisted communications				Regulatory
	Telecommunications relay services (TRS)				Regulatory
	Video relay service (VRS)				Regulatory
	IP relay service				Regulatory

Legacy applications may not be supported on the new switch or there may be functional parity in the IP environment, but the user must be transitioned to the IP version of the application. Even with this transition, the IP version of an application is unlikely to have full feature parity with its predecessor, expanding on some capabilities and obsoleting others.

Forget about feature/function parity—in some cases TDM services are not even fully defined in an IP environment: for example, telemetry, alarms, auto-dialers, 911 and the Communications Assistance for Law Enforcement Act (CALEA). Operators inevitably point to these first three applications as reasons they cannot fully transition enterprises and consumers to IP. The regulatory role and operator responsibilities for 911 and CALEA in an IP environment have to be codified before these applications can be transitioned to the new network.

The Role of NPAC

The one characteristic uniting all of these applications is that they are identified and addressed by a telephone number. In order to maintain public safety, business continuity and consumer satisfaction, each number has to be ported over the IP environment. The NPAC, currently administered by Neustar, processed more than 540 million local number portability (LNP) adds, changes and deletions in 2013—by far the largest number in the world. This translates to 1.48 million real-time broadcasts of adds, changes and deletions every day. Less than 10 percent of these changes, however, are associated with individual consumer porting requests. The remainder—90-plus percent—are generated by merger and acquisition activity and technology migrations such as TDM to IP switching. The NPAC has enabled every technology transition and merger/acquisition on the fixed and mobile networks since its inception in 1997, including 2G to 3G, VoLTE and VoIP. It is clear that the migration to an all-IP network will drive an even greater volume of activity and that LNP will be a critical lynchpin of the transition.

As we transition to an all-IP network (i.e., for the next decade and likely beyond), PSTN and interconnected VoIP services will continue to be addressed via today's North American Number Plan (NANP) and be subject to number portability. An IP SIP server can associate any string of text and/or numbers with an IP address. However, the TDM and IP networks must be able to send, receive and route calls to each other, and for this they have to rely on a common naming scheme administered by a central body, i.e., the NANP and NPAC.

Number portability uses a Location Routing Number (LRN) to associate telephone numbers in the NPAC with a specific service provider switch. A ported number is assigned that LRN when one service provider wins over a customer from a competitor or when a service provider acquires another operator or adds/moves a switch. The donor network (i.e., original service provider or switch) and the recipient network (i.e., new service provider or switch) then use the NPAC and the LRN to determine the new route to the customer. Because the NPAC is connected to service provider networks in real time, and because the NANP is used by all service providers for the purpose of portability, NPAC is the logical facility for:

- Enabling service providers with TDM only, IP only, or a mix of TDM and IP technology to all interconnect
- Sharing IP routing addresses
- Maintaining consistency with regards to TDM and IP routes
- Synchronizing with NPAC for VoIP and all things that can be reached by a telephone number
- Preserving the role of telecommunications industry: The institutional knowledge and oversight of NPAC is currently entirely under service provider control rather than controlled by the government.

The Future State of NPAC

Local and wireless number portability were mandated to encourage competition and improve the customer experience; NPAC was formed around this mandate. However, the transition to IP opens up a new world of opportunity and a new set of challenges. The challenges of numbering in an increasingly IP world include not only the porting of numbers but also the effective administration and conservation of numbers. The opportunities are virtually unlimited. As we examine these challenges and opportunities, two points become increasingly clear:

- **The telephone number will continue as the unifying factor for PSTN to IP conversion.** It will remain the key identifier for called and calling parties and will remain central to today's transitional and tomorrow's successor services.
- **To execute this transition without disruption to the enterprise or consumer, it is critical that these changes are implemented in a highly controlled manner from a centralized registry,** with industry participation and oversight already in place and neutrality guaranteed.

I Don't Know Where You Are: Freedom From Location

Today's NANP is based on 10-digit telephone numbers that tie an area code and exchange to a specific switch in a specific location. As we move through the PSTN transition, this will continue to be the case—calls between TDM and IP switches will be routed through the switches associated with those numbers. However, in a mobile world, supported by a virtualized IP infrastructure, the concepts of location and even "switch" become nebulous and increasingly meaningless.

Telephone numbers are also associated with a specific geography or local access and transport area (LATA). Your LATA defines the limits of number portability. If you change carriers but not houses or if you move to a new house within the same LATA, the regulations surrounding number portability allow you to retain your number. If you move outside the LATA, you are given a new telephone number. IP does not have a requirement for hierarchy of LATAs, so this distinction becomes largely arbitrary. What becomes of LATAs in an all-IP world? Will any boundaries to number portability remain or will you be able to move from Virginia to California with the same telephone number? Interconnected VoIP providers today actually allow you to choose an area code that is different from that of your place of residence. However, when you dial that number from the PSTN, the call is routed to the LATA associated with the area code/exchange combination and from there the call is routed to the user via the VoIP provider network.

What we should expect in an IP environment are numbers that are non-geographic: identifying the country with a nationwide area code, but nothing more granular. To simplify traffic routing and management, we will need points of interconnect (POIs). Today we have 225 LATAs and each LATA is a POI. In an IP environment we will be able to reduce this number to a handful of POIs.

During the next decade the NPAC administrator will be grappling with the issue of separating location from individual and providing sensible routing that does not backhaul traffic to arbitrary locations based on the LRN number of a switch. While there are emerging protocols that can help enable this, we have not even begun to transition today's fixed numbering plan to accommodate tomorrow's virtualized and mobile environment.

We Can't Count that High: Conserving Numbers

To support the Internet of Things (IoT) where not only people, but a wide variety of devices, from cars and alarm systems to thermostats and refrigerators, are connected over the Internet, the global IP community is in the midst of a migration from IPv4 to IPv6. IPv4 supports 3.4 billion addresses and we have, for all intents and purposes, run through all of them. IPv6 supports about 3.4×10^{38} addresses. Similarly, as we transition the PSTN to IP we will want the ability to associate a variety of devices and applications with a telephone number, making the allocation and conservation of telephone numbers increasingly important (unless we want to memorize telephone numbers that are 38 digits long).

The FCC allocates telephone numbers to U.S. service providers in blocks of 10,000 numbers—basically all of the numbers pertaining to a specific area code and exchange (NPA-NXX). While easy to understand and administrate, this is not the most efficient use of telephone numbers; a large percentage of these mega-blocks are unassigned, unused and mothballed. To optimize the use of telephone numbers, the FCC approved the National Number Pooling plan in 1998. Under the pooling plan, service providers return unused blocks of 1,000 numbers (NPA-XXX-X) to a centrally administrated pool. The Pooling Administrator (also Neustar) can then allocate these blocks to other service providers offering telecom service in the same location. The conservation of numbers afforded by number pooling will be critical to enabling enhanced IP telephony services, given the continued demand for telephone numbers associated with those services.

I've Got Your Number: Giving Number Allocation Control to the User

National Number Pooling allows for a more conservative use of numbers; however, the allocation of numbers is still under control of the service provider and the end-user must petition the service provider for each telephone number. Why shouldn't this change in an all-IP environment? Online applications to allocate telephone numbers immediately and directly to the end-users (e.g., a consumer or business) can certainly be developed along with the ability to have the order flow through to the provisioning management and billing systems. This is the manner in which domain names are allocated and administered. There is no reason, from the user perspective, that this direct, just-in-time provisioning should not apply to telephone numbers as well. This is yet another capability currently under investigation by the service providers and their vendors as part of the transition to IP networks.

Is that Really You? Number Authentication

The Wild West-like, unregulated environment of the Internet of the past decade, paralleled by the rise in VoIP, has resulted in a growing set of problems. Because there exists no embedded security mechanism for verifying the origin of a VoIP call, we have seen a dramatic rise in real-time communication fraud including:

- **Robocalling:** Bulk unsolicited commercial communications
- **Vishing:** Voicemail hacking and impersonating financial and insurance institutions or even the IRS
- **Swatting:** Fraudulent calls to emergency services in order to precipitate the large-scale, unwarranted deployment of law enforcement and emergency personnel

Yankee Group believes that to address these issues the industry will move to an authoritative registry of numbers, similar to existing Internet domains and authoritative DNS registries (such as those administered by companies including Verisign and Neustar). These registries will assign digital credentials to allocated telephone numbers, creating a type of digital certificate for VoIP numbers.

Beyond the Transition

NPAC and LNP impact much more than competition. They are critical elements of the U.S. telecommunications infrastructure today and, as the industry accelerates toward highly individualized services, they become even more essential.

LNP is a harbinger of the Network of One—the personalized, consumer-centric communications economy. Today the consumer can take his or her telephone number with him/her when changing service providers—but what other services can be associated with that telephone number, and who will bill for them? Myriad applications for security, distance learning, geo-fencing, health services, etc., can be delivered via the broadband or mobile network, and the service provider is ideally positioned to bundle these offerings with existing products and provide third-party billing for them. The ability to interface the NANP with IP addressing will open the door to an even richer set of applications and service capabilities. However, these enhanced personalized services depend on accurate and reliable numbering information; they demand that service providers have the tools to detect missing or redundant LNP records and cross-platform provisioned attributes (e.g., services provided via exchanges and intelligent network platforms).

LNP and National Pooling together will ease the growing pains of a PSTN to IP migration, but it is the ability to provide increasingly selective and personalized services that we believe will place increased emphasis on number portability during the next two to five years. Service providers are facing an opportunity to take their robust number portability infrastructure and leverage it to offer their consumer and enterprise customers the flexibility, security and rich portfolio of services they are looking for. The bottom line is that we can either spend the next two years reinventing the past or we can move to the future, leveraging today's number administration and assignment in an environment of personalized, tailored services with full integration between our telephone numbers and our online experience.

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Jennifer Pigg is a vice president of research on Yankee Group's Mobile Broadband team. Her area of expertise is network carrier infrastructure, examining the challenges facing service providers in provisioning the edge and core network, and the solutions and technology that will meet the demands of cloud computing, Web 2.0 mobile data networking and LTE. Her areas of research include Software Defined Networking (SDN), Network Functions Virtualization (NFV), network policy management, Diameter Routing, IPv6, DNS, mobile backhaul and the Evolved Packet Core.

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