TELNYX | WHITEPAPER

Twilight of the PSTN

From wireline to cloud communications, the industry is amid a tectonic shift to internet-centric voice and messaging.

Contents

Don't keep forever on the public road, going only where others have gone. Leave the beaten track occasionally and dive into the woods. You will be certain to find something you have never seen before. Of course it will be a little thing, but do not ignore it. One discovery will lead to another, and before you know it, you will have something worth thinking about to occupy your mind, and really big discoveries are the result of thought.

- Alexander Graham Bell

Anyone who's been paying attention has noticed that when we communicate today, we use the internet, probably on a smartphone. A landline phone has become more novelty than daily device. Wireless networks and the internet are the site of modern collaboration and conversation.

Internet communications have matured, wireless has become ubiquitous and the Public Switched Telephone Network is on the verge of being displaced forever. But, universal communications still has problems left to solve: the internet's lack of security or reliability; the unique regulatory environment of hundreds of countries; making network services programmatic and plug-and-play.

Twilight of the PSTN charts this moment in the communications market as it leaves wireline services behind and embraces programmatic internet communications as its new standard. We'll track the PSTN's late conversion to IP, VoIP's meteoric rise and the industry settling into a new configuration of network operators, communication platforms and application-embedded communications. We'll also explore the implications of this new configuration and the unanticipated innovation being built on that foundation.

The PSTN Today

The Public Switched Telephone Network (PSTN) has been around for more than a century. It provides the wireline telephone services that were part and parcel of most 20th century American households. However, over the last few years, there has been a gradual paradigm shift in the consumption of telephone services from PSTN to wireless and Voice over Internet Protocol (VoIP) technologies. Between 2004 and 2018, the fraction of U.S. households with an operational landline has fallen from 90% to less than 50%.[1] At the same time, more than 49% of U.S. households have embraced wireless,[2] and households are relying more on wireless and non-landline technologies for their connectivity solutions.[3]

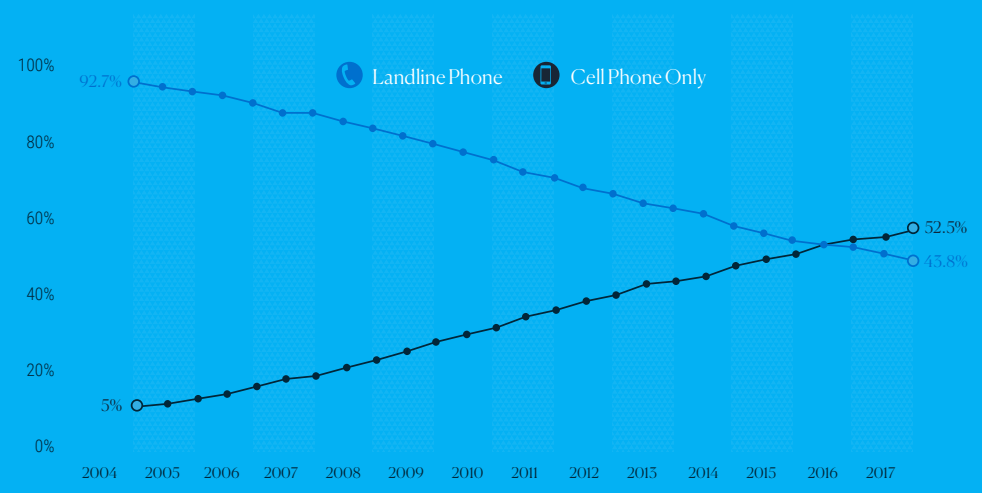
This changing landscape presents a major challenge to incumbent carriers such as AT&T and Verizon who risk losing substantial revenues centered around voice traffic tied to the PSTN networks. The situation is further exacerbated by a falling subscriber base and rising operational costs for maintaining the legacy PSTN networks.[4,5] According to AudioCodes, the cost of maintaining the PSTN will increase by 70% per line between 2013 and 2020.[6]

The carriers are aware of this dire scenario and want to keep themselves relevant by switching off the legacy voice-only PSTN networks and migrating to an IP-based infrastructure that can carry voice, video and data as part of a unified infrastructure.

However, services offered by the telecommunication carriers are governed by the Federal Communications Commission (FCC), and prior approval is required before turning off or making disruptive changes to existing solutions. Consequently, in 2009, AT&T submitted a petition with the FCC recommending steps for migrating to a broadband-based network, remarking that the PSTN and the plain old telephone system (POTS) are “relics of a by-gone era.”[7] The report also highlighted the fact that maintaining and operating the legacy POTS and PSTN networks "are diverting critically needed funds that could be used for broadband deployment."

The Landline Phone Dwindles

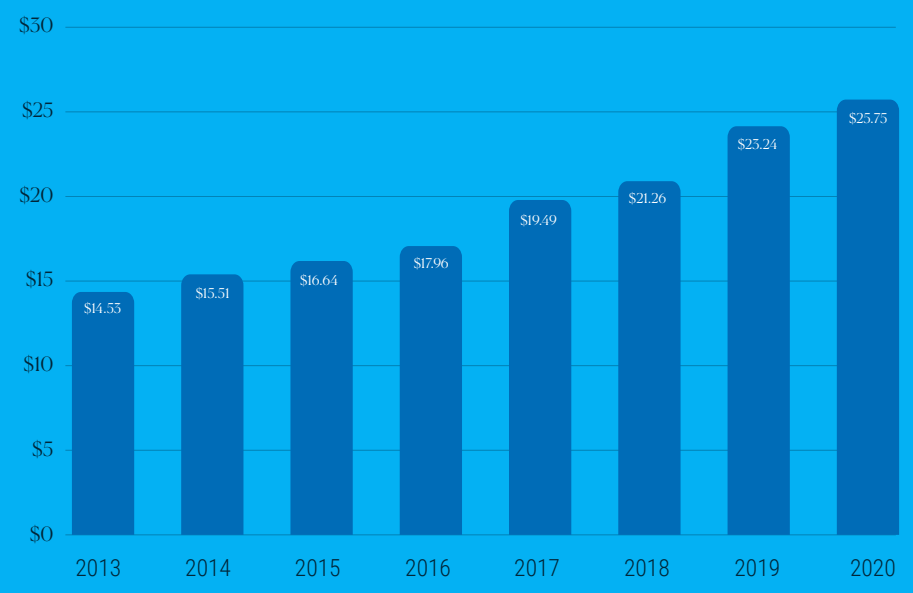
Percentage of US Households with and without a working landline telephone*



Based on the biannual National Health Interview Survey of 15,000+ US households. Source: CDC

The Cost of the PSTN Rises

The cost of maintaing the PSTN will increase by 70% per line between 2013 and 2020.



Annual facilities costs per TDM line. Source: Yankee Group, 2014

In response to the AT&T petition, the FCC created a Technical Advisory Council (TAC) to investigate what it will take to turn off the PSTN networks. In 2012, AT&T again submitted a petition with the FCC[8] to retire their PSTN network. The primary reason mentioned was the rising maintenance cost of the copper wires of the PSTN network. TAC supported the transition effort[9], and in 2014, AT&T announced plans to start trials to migrate their customers to an all IP network starting with Alabama and Florida.[10] In 2017, AT&T announced that voluntary customer transitions have increased by 72% in Alabama and 59% in Florida, and PSTN usage declined by 36% and 38% respectively in those areas.[11]

Legacy TDM-based networks are relics of a bygone era.

- AT&T FCC filing, 2009

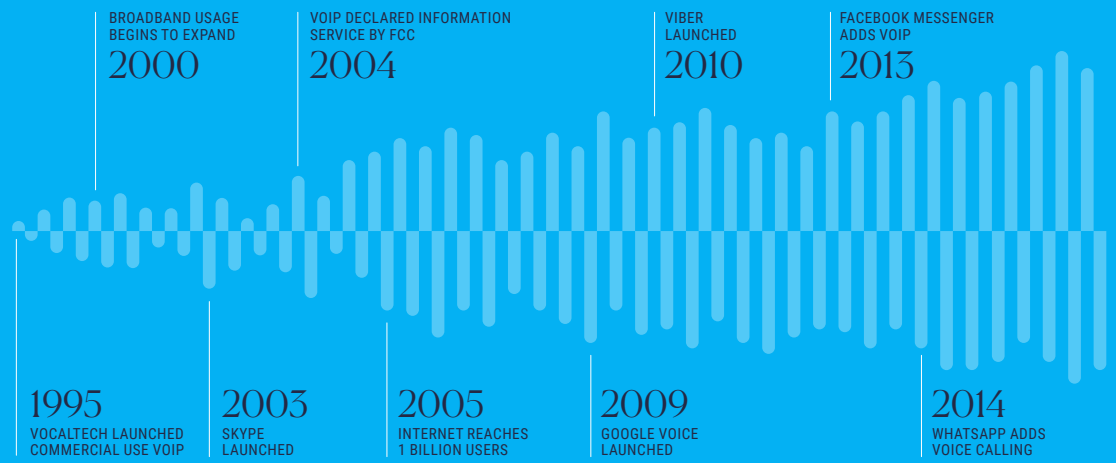
The bottom line is that the move to sunset the PSTN has already started, and it is only a matter of time before the telecommunication carriers migrate their customers and services to an IP-only infrastructure. At least 19 worldwide operators have announced plans to migrate to an all-IP network.[12]

Dawn of VoIP

VoIP was first developed in the early '90s, and after more than two decades, has revolutionized the world of communication. Unlike traditional circuit-based PSTN landlines, the technology works by using the ubiquitous IP protocol—made popular by the internet—for receiving and transmitting information.

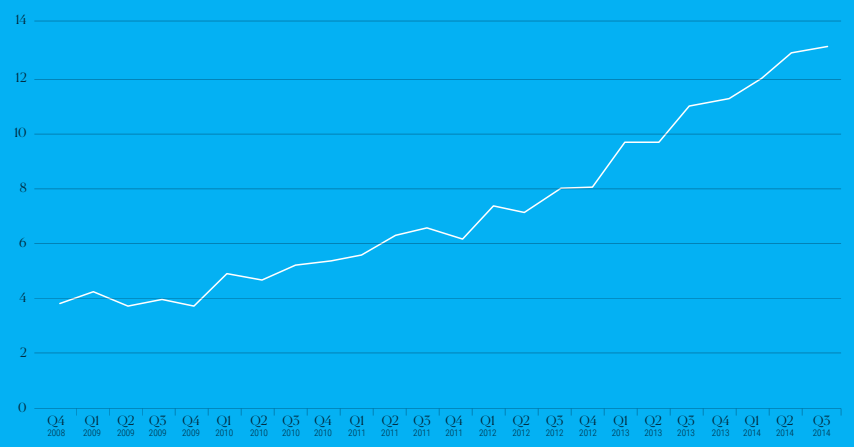
The Events that Shaped VoIP

The initial VoIP systems started as a cheaper alternative for making long distance calls by leveraging existing internet connectivity. It allowed users to freely call each other using the computer's speakers and a microphone. However, during the initial days, internet connectivity was primarily over leased lines or dial-up connections, which used the PSTN network to send VoIP data. This resulted in poor call quality since the dial-up lines were not built to handle data connections, and leased lines didn't allow for simultaneous transmission of data and voice calls.



The Internet Accelerates

Improved internet speeds sparked the growth of VoIP technology.



**Average US internet connection speed (Mbps) Source: Akamai, State of the Internet*

However, between 2000 and 2001, broadband subscriptions increased 40% and saw another 48% increase in 2003.[13] This allowed VoIP systems to take advantage of increased bandwidth associated with high-speed internet access that was always on.

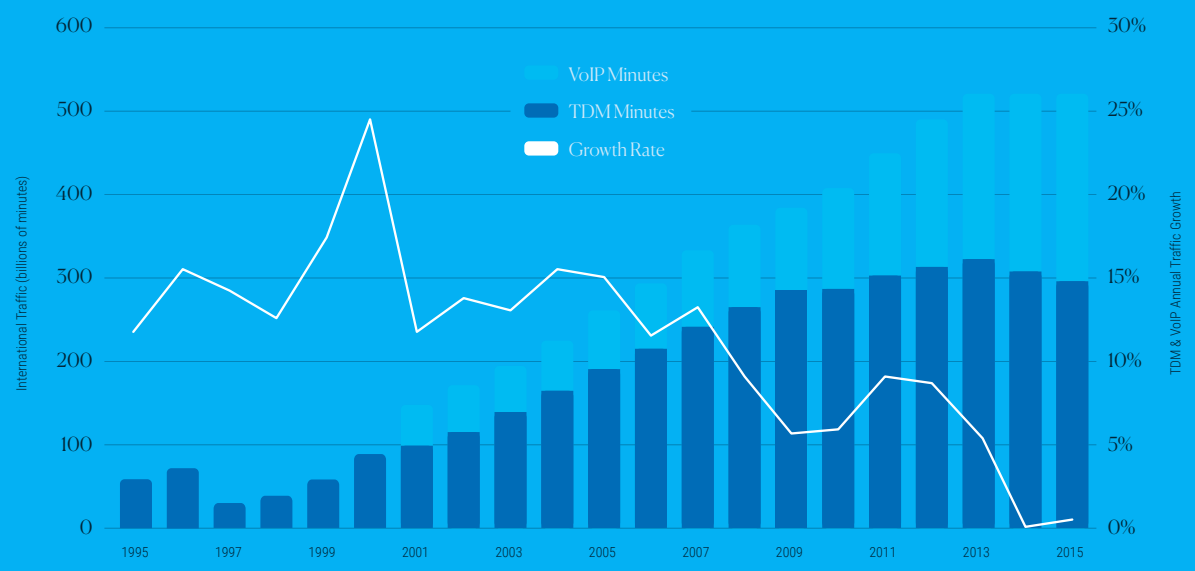
Until 2003, most VoIP calls were used as a replacement for traditional PSTN-based voice calls. With the launch of Skype in 2003, the market experienced a disruption with greatly improved call quality and the ability to simultaneously make video calls for free.

For a small fee, users could even make calls to landlines and mobiles phone to almost any part of the world. Also in 2003, Vonage launched the first VoIP service platform to offer 911 calls.

More than 100 VoIP companies operate in the US today.

VoIP Goes Global

VoIP grew to two-thirds of total international traffic by 2015.



Source: TeleGeography

In 2004, FCC declared VoIP to be an information service rather than a telephonic service. This was a landmark decision and immediately put VoIP systems outside the regulation of individual states. It also resulted in lower taxes for VoIP customers than landline or mobile phones.

Since then, VoIP has enjoyed a steady increase over the years, with companies adding VoIP features to their popular applications. Google launched Google Voice in 2009 and integrated VoIP and video calling to their Google+ social app. Facebook expanded its Facebook Messenger to support VoIP in 2014. In 2015, WhatsApp, which was acquired by Facebook in 2014, added mobile VoIP and video calls to its messaging app.

Today, the global VoIP services market is estimated to grow by 10% between 2017 and 2021[14] to an estimated value of USD 140 billion.[15] The market is not regulated by the FCC and consequently has a low barrier to entry. This has allowed multiple competitors to thrive. According to voip-info.org, today there are more than 100 active VoIP companies in the US.[16]

skype Vonage Google facebook WhatsApp

The global VoIP services market is estimated to grow by 10% between 2017 and 2021 to an estimated value of $140 billion.

What's Driving the VoIP Market?

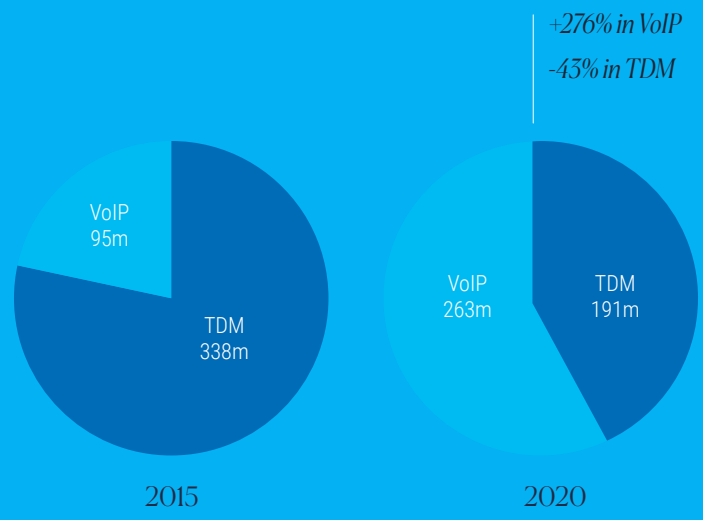
Cost is still the primary driver for migrating to VoIP from TDM for businesses. Small businesses can save as much as 45% each month[17] over TDM by switching to a VoIP system with a host of features such as voicemail, call waiting, toll-free numbers and call forwarding included.[18]

VoIP Overtakes TDM

Between 2015 and 2020, VoIP users will grow by 276% while TDM will fall by 43%.

While cost is an important driver, VoIP adoption is also being accelerated by a major transformation of the workplace and the rise of smartphones. According to IDC, 72% of the U.S. workforce is expected to be mobile by 2020, implying that traditional offices with tethered phones may cease to exist, and workers will communicate more frequently through a combination of VoIP and wireless.[19]

Smartphones are being embraced at an increasingly fast rate. Just over 36% of the world's population is projected to use a smartphone by 2018, up from about 10% in 2011.[20] The adoption rate of smartphones among US millennials is as high as 98%[21], and 67% of them don't have landlines.[22] This new generation of people use collaboration tools that utilize VoIP technology to stay connected.

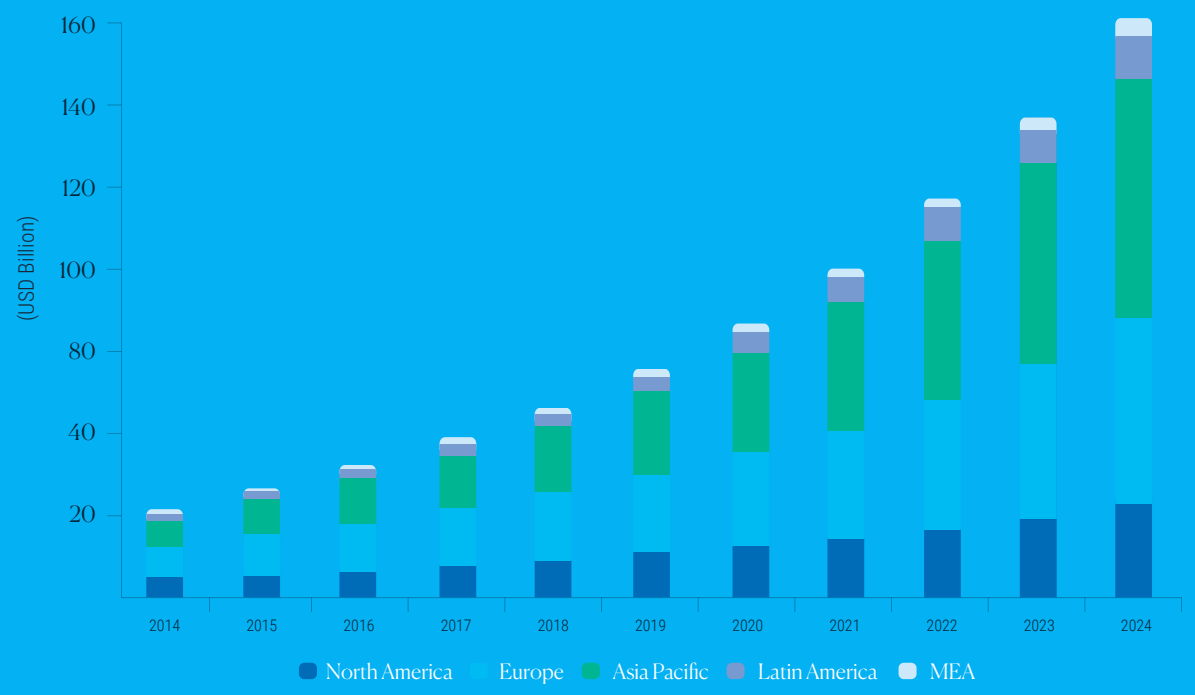


72% of the U.S. workforce is expected to be mobile by 2020.

**Global business voice seats. Source: AudioCodes*

Mobile VoIP Chases Smartphones

Countries without strong broadband coverage are seeing major growth in mobile VoIP.



Mobile VoIP markets by region. Source: Grand View Research, 2016

Growth in smartphones has resulted in an explosive growth of network traffic. Infrastructure providers have responded by making significant improvements to their global network infrastructure. It is now possible to initiate VoIP calls over Wi-Fi and cellular networks (voice over LTE). This means that VoIP calls are no longer tethered to a physical internet connection and can be initiated anywhere that has a mobile or Wi-Fi connection.

Mobile VoIP market has grown alongside the growing subscriber base in emerging economies such as India and China where traditional phone calls are heavily taxed and regulated. As a result, people are increasingly using instant communication platforms such as Skype and WhatsApp to make voice and video calls across both consumer and business segments. According to Grand View Research, the Asia Pacific region is expected to be the region that adopts mobile VoIP technology the fastest, rising at a CAGR of over 23% from 2016 to 2024.[23]

VoIP & PSTN Interoperability

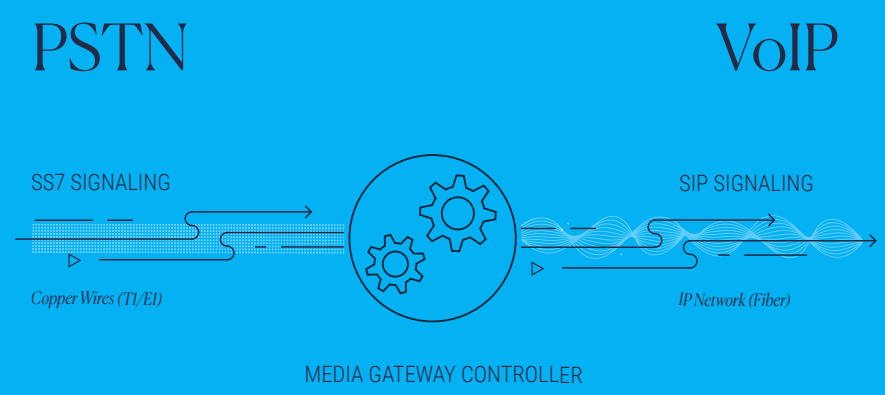
VoIP calls made between two IP-enabled endpoints do not cross PSTN boundaries. However, in some instances, one of the endpoints happens to be a landline. This is true for both consumers and businesses where calls are made to families or business contacts that still rely on landlines on PSTN networks. In such scenarios, a portion of the call traverses the PSTN network, incurring charges from those operators.

The interface between PSTN and IP networks happens via an adapter that seamlessly converts voice calls between the two technology stacks. This adapter is commonly referred to as the VoIP gateway or Media Gateway Controller (MGC) and plays a crucial role in making the two domains interoperate. This is also the place where most problems and complexities exist as calls are transported between the two networks.

To begin with, PSTN uses the signaling protocol called ISDN User Part (ISUP) to setup calls between the two parties and T1/E1 trunks for transporting the digitized voice. On the other hand, signaling in the VoIP domain is based on the Session Initiation Protocol (SIP) and Real-time Transport Protocol (RTP) for carrying the voice packets over IP. Consequently, when a user in the PSTN domain places a call, the gateway has to translate ISUP messages to equivalent SIP messages and the voice streams to equivalent RTP packets.[24]

Unfortunately, several different standards exist that map between ISUP and SIP messages. This means deviations exist across vendor implementations, which can cause errors and service degradation. It can also result in an erroneous call detail record (CDR). This, in turn, can affect the accuracy of VoIP billing since calls that traverse PSTN networks incur access charges.[25] Such discrepancies happen more often in international carrier domains where countries use their own choice of preferred vendors for implementing MGC functionalities.[26]

VoIP systems also have to support multiple voice codecs as they interface with legacy PSTN based networks. One of the key advantages of a VoIP system is the availability of a wide variety of codecs that can support high-definition voice quality over broadband internet. However, bandwidth in PSTN is limited, and the MGC has to support codecs in the G-series recommended by the International Telecommunication Union (ITU). Examples of such codes include G.711 and G.729 that can encode at 64Kbps and 8Kbps respectively.



VoIP systems often must account for different types of traffic such as Dual-Tone Multi-Frequency (DTMF) responses or fax. When a user dials a number or presses a button, the telephone generates a tone called DTMF. This tone has a different frequency than human voice and is used by carriers to understand when a button is pressed. The preferred approach in VoIP is to send DTMF as out-of-band IP packets using call signaling protocol.[27] However, packet loss in IP networks can cause DTMF tones to be lost or incorrectly detected. To prevent such losses, the MGC border agent sends DTMF packets over redundant paths.[28] Similar loss resilient systems have been developed to support fax machines over IP networks.

Phone number portability in both landline and VoIP connections is facilitated by assigning a local routing number (LRN) to identify the infrastructure that the telephone number is associated with. The number to be ported along with the associated LRN is registered to a database called the Number Portability Administration Center (NPAC). When PSTN calls traverse VoIP networks (and vice-versa), the intermediate MGC gateway queries the NPAC database to determine the location of the downstream servers for routing the call.

Why Does the PSTN Persist?

Although migrating to an all IP network is the ultimate goal of carriers, regulators and consumers, turning off the PSTN faces various structural, policy, reliability and coverage issues. To begin with, communications on PSTN networks just work.[29] Many basic consumer services such as 911, fire alarms, fax machines, medical alert and security systems today rely on the PSTN network to function reliably. It's inconceivable as a consumer to dial emergency services and not get a response due to poor call quality or coverage issues.

For example, after Hurricane Sandy, Verizon applied to the FCC asking for permission to replace damaged copper lines with residential wireless services called Voice Link. However, unlike traditional copper-wire based phone services, customers were expected to provide backup battery power for emergency services such as 911 to work in case of power failures.[30] (Legacy phone lines supply their own power to the phones in addition to voice connectivity.) This degradation of service has invited a lawsuit from the New York Attorney General[31] and has also received negative coverage[32] from the media–examples of the challenges inherent in turning off the PSTN.

How did PSTN become so ubiquitous? The answer to that question lies in an FCC regulation called Universal Service.[33] As part of the requirement, telephone services must be made available in all parts of the country. This has forced PSTN operators to deploy infrastructure to even remote and unprofitable parts of the country.

While both AT&T and Verizon intend to sunset their PSTN networks and replace them with IP-based broadband services, the carriers have to ensure that there is a viable and acceptable alternative to public services, especially in rural areas. However, many parts of rural America still do not have wireless coverage and almost 39% lack broadband access.[34] As a result, approximately 24% of businesses still rely on PSTN phone lines that serve nothing but basic voice services.[35]

Another hurdle that needs to be addressed before a VoIP system can universally replace landlines is security. A gap still exists in security enforcement for many VoIP systems.[36] VoIP systems installed on smartphones via apps have the potential of becoming compromised via software vulnerabilities. In recent times, there has been a marked increase in the incidence of robocalling, voicemail hacking and swatting.[37] VoIP security issues are similar to cybersecurity issues, and careful considerations must be made before moving critical systems from PSTN-based communication to a VoIP-based network.[38]

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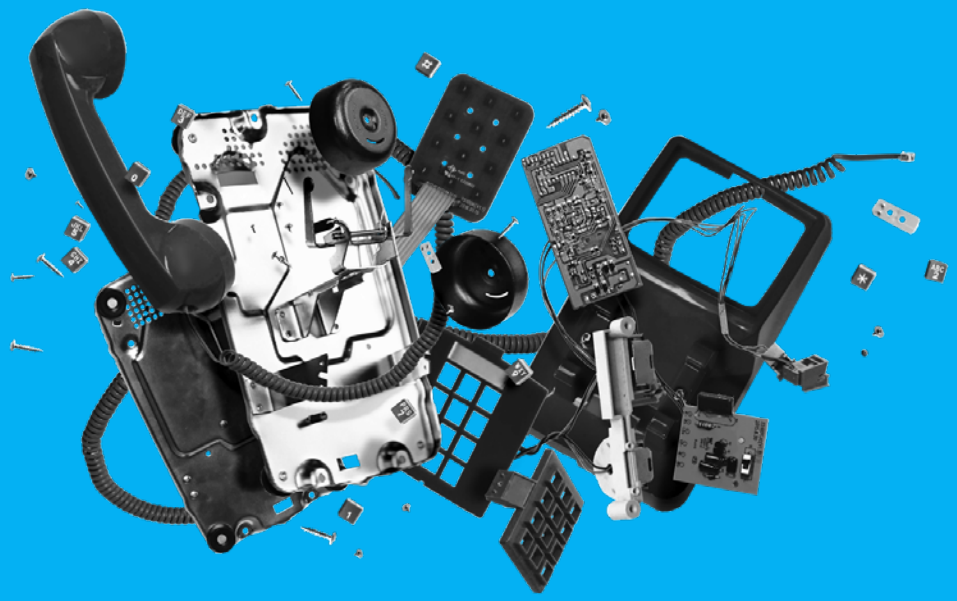
And finally, there's the reality of transformation.

While the TAC had envisioned that the transition to an all-IP technology would be complete by 2018, the PSTN still persists. One of the reasons is the cost of the transition. To make the switch seamless without disrupting services to the end-user, the migration has to be handled line-by-line. This is time-consuming and must be handled carefully, strategically and accurately.

Additionally, the transition has to ensure feature parity exists between old and new services. As a matter of fact, there are a host of transitional services such as telemetry, alarms, auto-dialers and 911 that need to be maintained due to market penetration and regulatory requirements.[39]

So, while an all-IP network is the eventual end state, the PSTN will remain while VoIP and wireless-based solutions are conceived and built to cover these baseline needs.



Moving to an IP-only PSTN

An all-IP network can easily handle the scale of the PSTN—the internet being the best example. And as we have seen, the movement to migrate to an all-IP network is already afoot. Some telecom operators—such as British Telecom (BT) by 2025—have already publicly announced their intention to replace their PSTN.[40] However, there are still open questions around network reliability, voice quality and price schedules that need to be addressed as part of the design of next-generation commercial-grade IP networks before PSTN systems can be sunsetted.[41]

The new generation of VoIP systems will have the ability to discover and fix breakdowns before they happen—think self-healing networks and predictive maintenance.

PSTN Holdovers

For example, in legacy PSTN, the transmission medium is copper. Copper does not require external power for transmitting information, and voice calls can be made in the event of an extended power outage. However, fiber-based optical systems used in IP networks require external power systems for exchanging information. This means systems built over fiber networks must take into consideration the availability and design of backup power sources to handle extended power outages. Also, existing PSTN numbers are associated with an area code, exchange and location. However, an all-IP network has no concept of location and lacks hierarchy. Consequently, the new system has to handle the concept of a fixed numbering plan in a virtualized IP world.

Artificial Intelligence

While network operators are working towards closing such technological gaps between legacy PSTN and VoIP, the new generation of VoIP systems will benefit from the rise and popularity of artificial intelligence (AI), data science and cloud computing. By mining data and connecting the dots using AI and pattern-seeking algorithms, the new generation of VoIP systems will have the ability to discover and fix breakdowns before they happen—think self-healing networks and predictive maintenance. Systems with integrated real-time language translation and speech recognition capabilities will also be able to break down language barriers in multi-country conference calls.

Networking

Software-defined networking (SDN) and network functions virtualization (NFV) will enable VoIP systems to integrate with SaaS-based business models and also help virtualize the voice infrastructure. NFV promises to reduce total cost of ownership (TCO) by eliminating proprietary hardware, consolidating equipment and lowering operating costs.[42] The next generation of VoIP systems will be born of automation, agile software engineering concepts and the blurring of lines between traditional infrastructure operators and software providers.

Internet of Things

The Internet of Things (IoT) market is growing at the rate of 5.5 million devices each day.[43] By 2020, the total number of IoT devices is projected to reach 20.8 billion.

In an IoT-centric ecosystem, any embedded device can send data over the network. Popular IoT devices include thermostats that can self-adjust based on ambient conditions, power switches that can be remotely controlled and security systems that can intelligently identify objects and stream data for real-time computing. These IoT devices belong to the category of home automation. Similarly, there are IoT devices in manufacturing, farming, energy management, transportation, healthcare, etc. All of these devices are natively IP-enabled or require an IP enabled gateway to communicate with the central command center—similar to VoIP systems that use the IP stack for communication. In fact, VoIP is expected to facilitate the transmission of the collected IoT data to remote cloud-based services.[44]

On the other hand, IoT systems generate mountains of data and require a reliable communication medium to ensure those data are not lost in transit. With the internet being a best-effort transport medium and PSTN systems being sunsetted, it's important for next-generation communication systems to be able to handle such high volume data transmissions reliably. Telecommunication companies are already aware of the new requirements and are eager to tap into the the business opportunities that IoT devices are expected to create. For example, Verizon has already announced plans to rollout 5G fixed wireless access over the next few years to support the massive growth of IoT devices.[45]

Internet-centric communication platforms have deployed facilities-based IP infrastructure that addresses the need for high-fidelity communications as well. We are gradually moving to a communication structure where every endpoint is expected to be connected over an extensible and scalable infrastructure but without the complex stack of signalling protocols and messaging systems prevalent in PSTN networks.

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After the PSTN

Because of sunsetted technologies and the combined efficiency of a single network for voice and data, the process of converting core telephony infrastructure to IP fiber has already begun for most legacy telecom carriers, but this is only part of the story. The internet, cloud computing, the rapid introduction of new communication channels and the rise of platform-as-a-service have caused early tectonic shifts in the way telecommunications are supported, purchased, delivered and consumed.

The next PSTN—that is, the eventual stable configuration of internet, private networks and the companies, organizations and regulatory environment that support entirely IP-based telecommunications—**will be very different.**

For one, as the public internet becomes more sophisticated and more secure, that bulk share of communications that already relies on the internet will continue to grow. Legacy telecom and legacy PSTN infrastructure (once converted to IP) will remain to fulfill functions like providing access to residential markets and remote locations, while internet-centric communication platforms are already entering markets to support the next generation of use cases arising from SaaS services, IoT and social trends like an increasingly mobile workforce.[46]

Cloud communications, communication platforms and CPaaS all refer to this new market of programmatic internet carriers. The qualities that define a CPaaS provider are:

Internet-Centric Communication Engines

- *Providing some combination of voice, messaging/SMS, phone numbers and routing metadata, browser-based communications, wireless and networking.*
- *While PSTN interoperability is necessary now, CPaaS functions independently of legacy telecom infrastructure.*

Embeddable & Configurable

- *API-powered functionality designed for drop-in implementation by modern applications.*
- *Granular configurability is required to service a market with diverse use cases and technical specifications.*

The internet is the fabric that connects disparate devices, browsers, applications and clouds where communications originate today. Within this, Communication Platform as a Service (CPaaS) provides the technical means for programmable communication connectivity—that is, API-powered communications that are configurable to various internet use cases and embeddable into applications and browsers. CPaaS built on private, facilities-based infrastructure can also provide connectivity that is more reliable, more secure and more global than what the public internet can support.[47]

CPaaS growth will accelerate as scale reduces cost, and centralizing the function leads to greater innovation and faster development. Scale markedly reduces costs for communication companies once on-net calls become a significant portion of business. From there, network effects, incumbency and mergers will likely lead to a small set of ascendant CPaaS winners much like our existing telecom landscape or other technology markets.[48]

These trends have only just begun.

Modern communications will continue to be absorbed into work applications, social media and wireless devices. IoT will explode the number of connected devices, including those that support real-time communications and those that require the type of secure, programmable connectivity to cloud systems that CPaaS is well-situated to provide.[49]

The Future of Communications

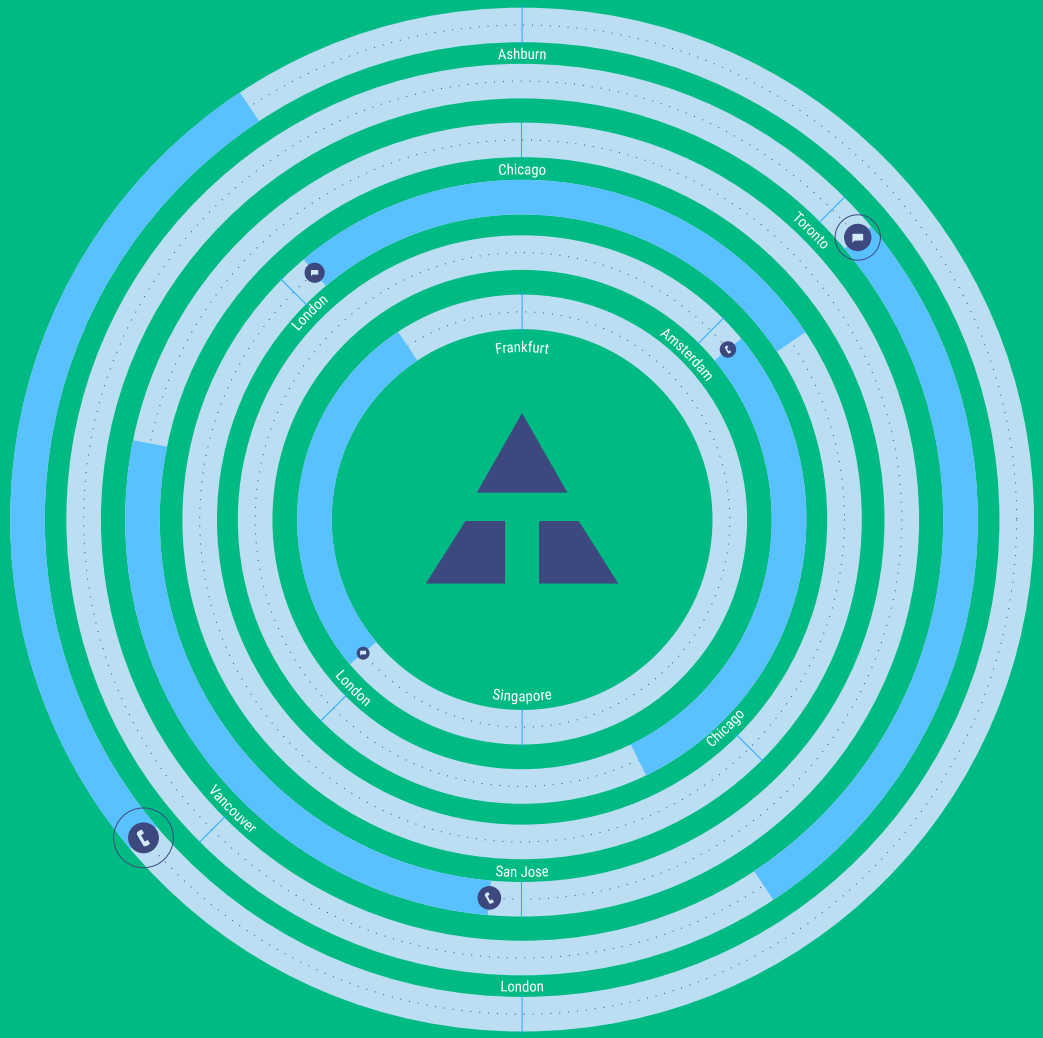
This unique moment in communications, carried along by the technology and social trends described before, has major implications for the future of the world economy. Communications are a bedrock service that facilitate coordination in every industry and underpin the life of a population that is increasingly dispersed and online. The technical details and commercial preferences hashed out in the CPaaS market today will serve as the framework for this coming generation of all-IP communications.

Telnyx is among this vanguard of CPaaS pioneers building the communication network of tomorrow. More than 4,000 next-generation applications and services rely on our network today for reliable, innovative internet RTC. We've built a high-performance network and PSTN-agnostic communication engine, and some of our current projects address major impending communication needs *that barely exist today.*

Network

Telnyx has deployed facilities-based IP infrastructure throughout North America, Europe, Asia and Australia that we continue to expand. Points-of-presence at major internet exchanges scoop communications off the public internet and route them along our direct, private fiber backbone.

While Telnyx has local interoperability with the PSTN in many countries, the Telnyx network is fully functional for on-net calls even during a full PSTN outage. For organizations that connect directly to our communication environment through cloud peering or wireless networks, even the internet is an unnecessary component.



Self-Service and API

In order to service the sheer diversity of use cases for modern internet communications, Telnyx has implemented granular configuration control. System administrators can access that control through the self-service Mission Control portal, and applications can manage their configuration via API.

More importantly, the full functionality of the Telnyx platform is exposed in our RESTful API. So, any application can embed high-fidelity communications backended by a straightforward HTTP interface.

Communications Expertise

As an organization, we've brought together world-class network engineers, application developers, telecom veterans and wireless experts to design the PSTN of the future, discover the potential technology the internet community is dreaming up and working with them to make those dreams a practical reality.

Communications Engine

Our service is designed with a microservice architecture that operationalizes RTC technologies like SIP, Kamailio and FreeSWITCH. Our network architecture eliminates points of failure through diversity and redundancy in order to reproduce the reliability and security of legacy telecom. And, we've achieved truly massive, global scale through the use of distributed cloud computing and automated scaling.

Beyond Dial Tone

Because our communication engine is natively internet-centric and built on a proprietary network, we can offer features and services that PSTN-centric or over-the-top services could never support:

- *Virtual cross connects provide private connectivity between cloud systems and the Telnyx environment, avoiding the public internet altogether.*
- *Programmatic call control enables native call flow manipulation via API. An application can manage complex IVR workflows or multi-part caller experiences through simple system commands.*
- *Call media forking supports transcription and voice analysis services by delivering a duplicated audio stream to a secondary IP address.*
- *SMS IP transit provides highly secure and reliable data connectivity between cloud environments, even between different cloud service providers and different continents.*

This is just the beginning.

As the value of baking communications into applications becomes more apparent, and as the market grows, CPaaS vendors will gain larger networks of users with a wider set of communication needs. Customer demand and expanded organizational capacity will accelerate market differentiation, CPaaS innovation and the PSTN's demise. Likely, much of the CPaaS functionality that will be considered commonplace by the time the PSTN has been fully migrated to an all-IP infrastructure has yet to be conceived.

But, the foundation is being laid today.

About the Author

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Joshua is the content manager at Telnyx, focused on evangelizing the unbounded potential of cloud communications and the impending internet RTC revolution. Prior to Telnyx, he built online audiences as a technology writer and researcher.

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18 Time Business Systems
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20 Statista
21 Nielsen
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