POINT OF VIEW

Intelligent Infrastructure for the 21st Century

POINT OF VIEW

CONTENTS

Where it all comes together.™

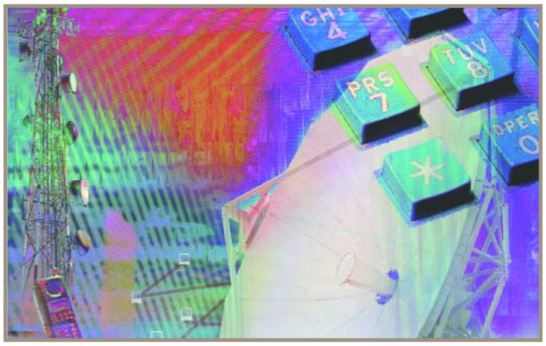
Intelligent Infrastructure for the 21st Century

+ Constructing Telegraph Lines Near Promontory Point, UT, 1869

Telegraph lines were built in parallel with rail lines, providing the intelligence necessary to coordinate the great rail networks.

+ Modern Day Air Traffic Control

Deployment of national air traffic control systems in the 1930s proved a prerequisite for commercial aviation.



+ Intelligent Signaling in Telephony Networks—System Y Deployment in UK, 1986

The deployment of the Signaling System 7 (SS7) networks around the world in the 1980s paved the way for rich services, mobility, and inter-carrier connectivity that characterize today's telecommunications.

+ Network Operations Center, 2004

Modern network operations center for the global Domain Name System (DNS). Currently, a constellation of worldwide servers provides coordination and direction for over 14 billion interactions each day across the global Internet.

Abstract

Throughout history, infrastructures for the transport of goods, services, and information (such as the rail system, electric utilities, air travel, and telephony) have had an enormous impact on society and the global economy. These infrastructures have helped to drive profound growth in productivity, incomes, and standards of living by reducing the barriers of time and distance and enabling people to interact, communicate, and conduct commerce in ways that were previously impossible.

This paper traces the development of such transport infrastructures, as well as the overlaid *intelligent infrastructures* (such as the telegraph, Supervisory Control and Data Acquisition systems, air traffic control, and telecom signaling systems) that have proven necessary for the transport infrastructures to reach their full potential. The authors use these historical examples to draw insights into the future development of the Internet and emerging digital infrastructures.

The authors observe that most *transport infrastructures* exhibit several common development trends. First, such infrastructures have traditionally taken about thirty years to build out. Second, at some point, generally ten years into deployment and broad-scale adoption, transport infrastructures reach a critical level of usage and complexity, requiring an overlay of intelligence for significantly improved communication, coordination, and fulfillment. The authors define the systems that provide this intelligence layer as "intelligent infrastructures." Third, once the intelligent infrastructure is deployed, growth in the underlying transport infrastructure generally accelerates through an inflection point, laying the foundation for several additional decades of growth in both the transport infrastructure and the overall economy. These gains almost always dwarf the gains made prior to the introduction of the intelligence layer.

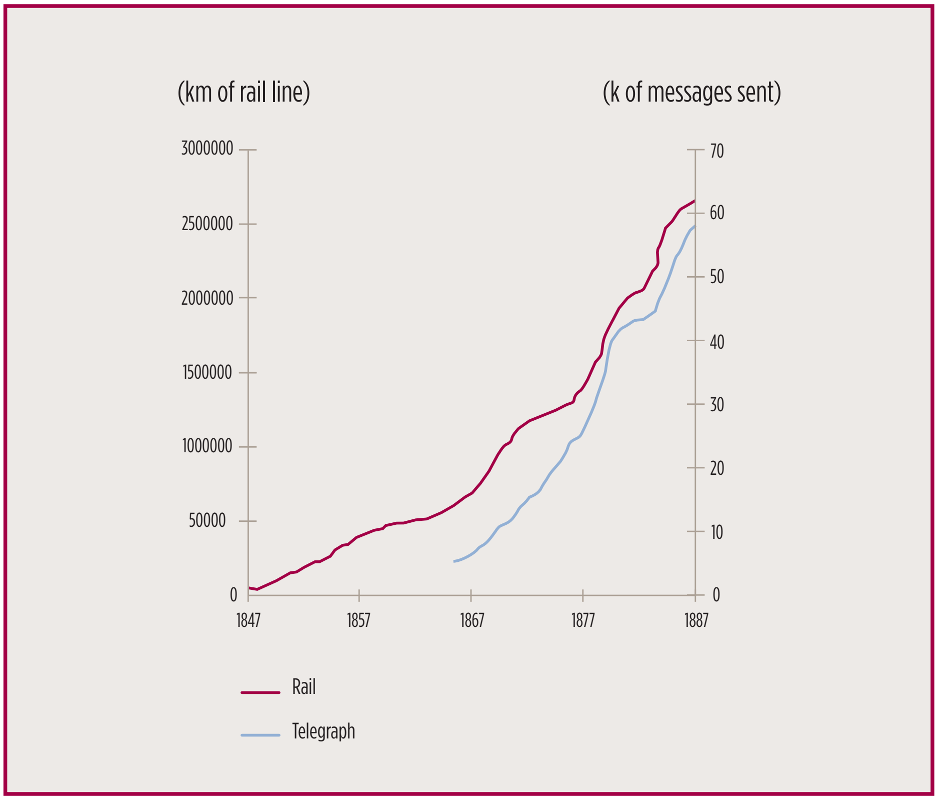
The authors then argue that we are about to reach a similar inflection point in the deployment of the emerging digital infrastructure. This is being driven both by the burgeoning usage of the infrastructure, and the corresponding issues of complexity associated with its broad adoption, including: a) the proliferation of applications, devices, and protocols; b) the use of the infrastructure for increasingly critical economic applications; c) the convergence of predecessor infrastructures; and d) a host of new security and regulatory concerns. The authors then posit that as a result there is a need for significantly enhanced intelligent infrastructure and introduce six critical characteristics that the new intelligent infrastructure must exhibit: scalability, interoperability, adaptability, reliability, security, and visibility. The paper concludes with illustrations of the role that Intelligent Infrastructure Services are playing—and will continue to play—in enabling such new applications as Voice-over-IP (VoIP), Radio Frequency Identification (RFID)-enabled supply chains, and digital content delivery systems.

I. Introduction: Intelligent Infrastructure through History

"It would occupy too much space to allude to all the practical purposes to which the telegraph is applied in working the railroad; and it may suffice to say, that without it, the business could not be conducted with anything like the same degree of economy, safety, regularity, or dispatch. The constantly increasing amount of business to be performed by it has rendered it necessary to put an additional wire over the Delaware division, for through messages, and I have no doubt the increase of traffic will soon compel its extension over every portion of the railroad."— *Daniel C. McCallum, Superintendent of the New York and Erie Railroad, in 1856.*[1]

In 1828, Charles Carroll, the last surviving signer of the Declaration of Independence, laid the final stone of the B&O Railroad, now widely regarded as the oldest railroad in the United States. While short-haul rails proliferated in the years that followed, it was not until nearly 30 years later that the Age of Rail truly began, when railroads were transformed from single, short-haul routes to interconnected, national transportation networks. The reason for this delay? Railroads had been using overland mail to convey the necessary

Figure 1: Parallel Growth of Rail and Telegraph in the U.S.[2]



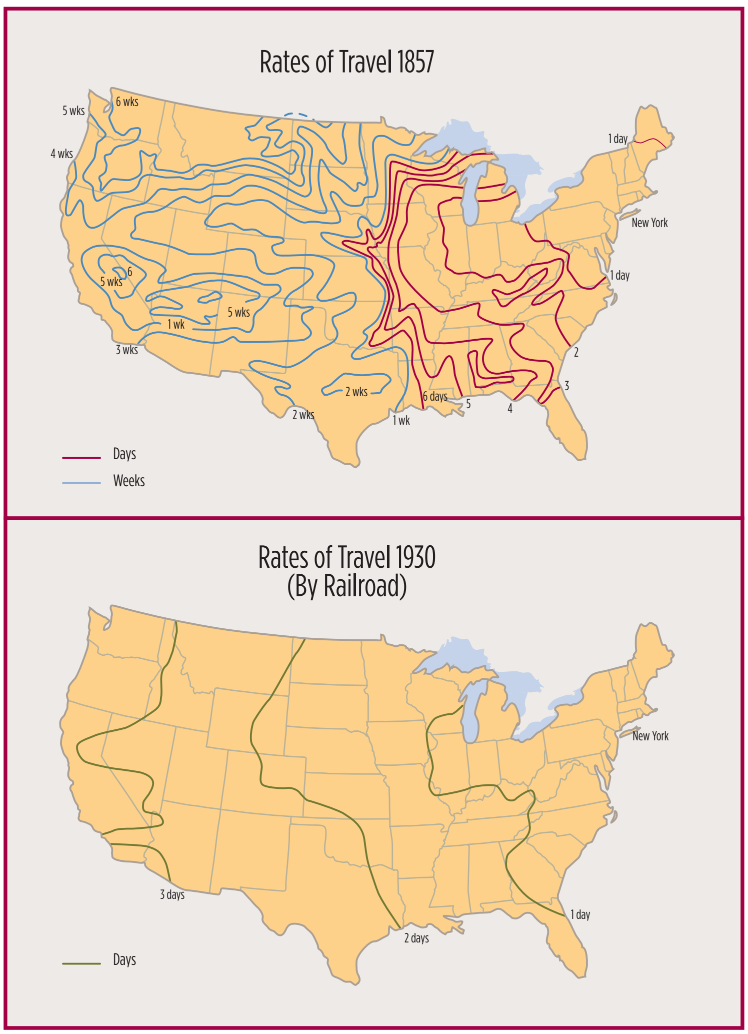
[1] From Daniel C. McCallum, "Superintendent's Report," March 25, 1856, in *Annual Report of the New York and Erie Railroad Company for 1855* (New York, 1856)

[2] Comin, D. and Hohijn B., "Cross-Country Technological Adoption: Making the Theories Face the Facts." Journal of Monetary Economics, January 2004, pp. 39-83.

information for adequate coordination, collaboration, and safety, but this system was unable to keep pace with the railroad's growing usage and complexity. It was not until the mid-19th century that the telegraph became available, and this technology proved a reliable and near-instantaneous mechanism for communicating operational intelligence. As seen in **Figure 1**, the adoption of the telegraph in rail marked a critical turning point, after which rail deployment soared, growing in parallel with the telegraph.

The history of the railroads and telegraph provides a useful analogy for examining the development of infrastructure through the present day. Great advancements in infrastructures for transport and delivery—be they for the transport of goods, services, power, or even information—have the potential to transform society by enabling people

Figure 2: Infrastructure Reduces Barriers of Time and Distance[3]

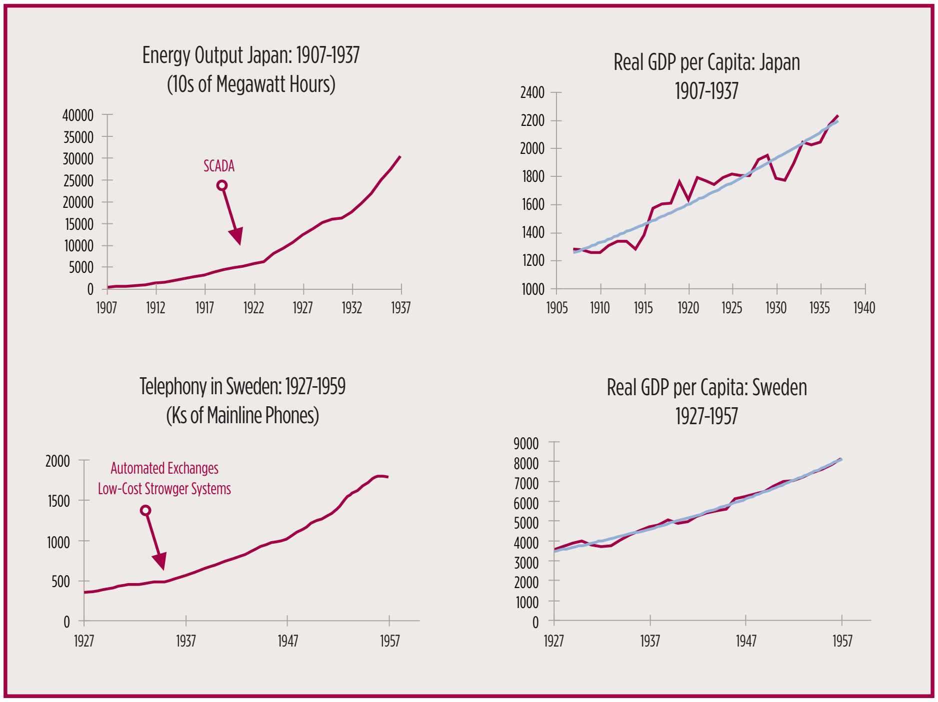


In 1857, it took roughly three days to reach St. Louis from New York, and six weeks to reach San Francisco. By 1930, these times were reduced to one and three days respectively.

[3] Paullin, Charles O., Carnegie Institution of Washington.
Atlas of the Historical Geography of the United States. Baltimore, MD: A. Hoen & Co., Inc., 1932.

to interact, communicate, and conduct commerce in ways that were previously impossible. However, at some point, most transport infrastructures approach a critical level of usage and complexity that threaten to limit their usefulness. At this point, the transport infrastructures require an overlay of intelligence to provide improved coordination, control, and functionality. For the purposes of this paper, we will call the systems that provide this intelligence overlay "intelligent infrastructures."

Figure 3: Intelligent Infrastructure and GDP Growth[4]



The pattern seen in the growth of rail and telegraph has held for most of the truly revolutionary infrastructure improvements of the 20th century. For example, by 1919, less than 15 years after the first powered air flight, nations around the world began laying the foundations of modern air traffic control systems. Having the systems to track, schedule, and control flights across the globe allowed the industry to move from barnstorming and crop dusting to becoming an integral component of commerce and transportation. Similarly, the advances brought about by electrical power grids would have been reduced significantly without the development of the overlaid Supervisory Control and Data Acquisition (SCADA) system that provides the basis for operational control across the world's utilities. Finally, while the technology for transporting voice was largely stabilized by the early 20th century, the deployment of electromechanical switching and signaling systems (e.g., Strowger systems and related automated exchanges) proved to be a prerequisite for the significant growth in telephony in the '30s, '40s, and '50s.

If we look closely at the development of these technologies, we see a sharper pattern still: most significant transport infrastructures need approximately 30 years from the time committed construction begins until the time they are fully deployed. At a certain point,

[4] Sources: Data published by the National Bureau of Economic Research.
Comin, D. and Hohijn B., "Cross-Country Technological Adoption: Making the Theories Face the Facts." Journal of Monetary Economics, January 2004, pp. 39-83.

the growth curve hits a sharp inflection point upward, corresponding with the adoption of the overlaid intelligent infrastructure (**Figure 3**). In most cases, intelligent infrastructure proves to be a key criterion for even more rapid expansion and use. By the time the intelligence layer is built out, we generally see great economic growth. (In the case of railroads, electrical grids, and telephony systems, Real GDP per capita nearly doubled during the brief period of infrastructure build out.) While there are many other contributing factors, intelligence proves to be a critical part of the mix in accelerating through the inflection point. Imagine, for example, the number of airplanes currently in the sky, and consider the task of coordinating their positions *without* the benefit of intelligent and connected air traffic control systems.

In modern times, intelligent infrastructures have also proved to be prerequisites for the blossoming of infrastructures used in the transport and delivery of information itself, such as telephony networks and the Internet. As a company that provides much of the intelligent infrastructure that supports both the Internet and telecommunications networks, VeriSign has a unique perspective on what is needed to enhance the transformational networks of the present day and the future.

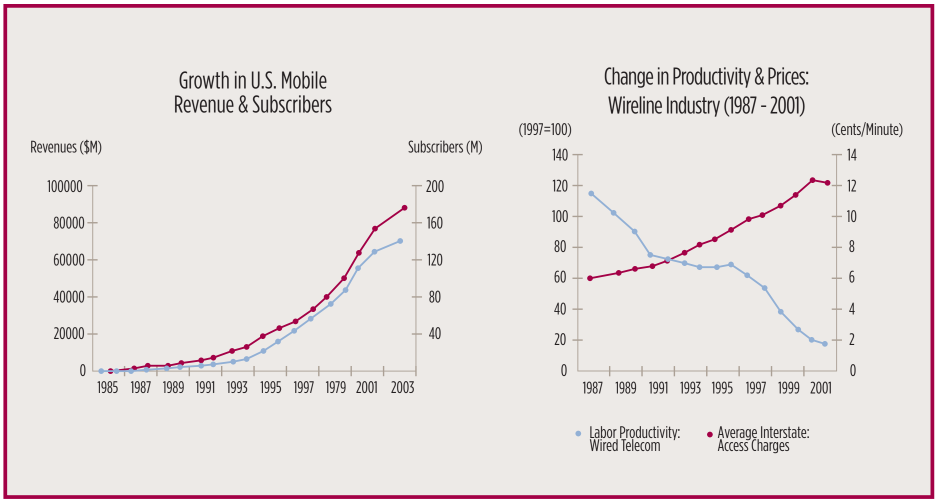
II. Intelligent Infrastructure for Telecommunications and the Internet

+ The Signaling System 7 (SS7) Network

As the case of the Public Switched Telephone Network (PSTN) demonstrates, even well-established transportation infrastructures with mature coordination and control systems can experience a second wave of growth and expansion when there is innovation at the core to deploy new intelligent infrastructures. By the early 1980s, telephony systems had developed to the point at which robust, reliable voice traffic could be conducted throughout much of the developed world. However, deregulation and denationalization, as well as the demand for new services, introduced a level of usage and complexity that the current system could not handle. The world's telecommunications providers responded by deploying an overlaid intelligent infrastructure called Signaling System 7 (SS7).

SS7 is a digital network designed to run on top of the PSTN. SS7 moved all of the signaling intelligence out of the PSTN itself, into a packet-switched network, mitigating the growing complexity of proliferating phone lines, and enabling much more efficient use of the underlying transport infrastructure. This move also allowed intelligence to be centralized, accelerated, distributed to multiple providers, and—most importantly—significantly enhanced. The intelligence provided by the SS7 network has proven to be a precondition for most of the recent telecommunications advances, such as Caller ID, voicemail, call blocking, pre-paid calling cards, and multi-party conferencing. SS7 also provided the signaling capability allowing mobile phones to move seamlessly between cells and providers, so that people can fly to a different city and immediately begin making calls, receiving voicemail, and even downloading email, video, games, and other types of rich content. As shown in **Figure 4**, this brought about an unprecedented period of growth in usage and productivity within the industry.

Figure 4: Changes in Telecom Usage and Economics in the Decades Following SS7 Deployment[5]



+ The Domain Name System (DNS)

Similarly, the expansion of networking from the Local Area Networks of the 1980s to the global Internet of today would have been impossible without the development of an overlaid intelligent infrastructure. When the Internet was comprised of only a handful of nodes, users could easily keep track of the available IP addresses. However, when the number of connected computers approached the thousands, the Internet reached its inflection point and became far too complex for most users to manage. Developed to provide an overlay of coordination and direction, the global DNS made it possible for emails and Web queries, sent from millions of devices across the world, to be routed to their correct destinations by using domain names to stand for IP addresses. Based on a distributed, global constellation of root servers providing information to hundreds of thousands of routers around the world, the DNS enables hundreds of billions of individual messages to be correctly routed every day.

Without this intelligent infrastructure, computing and communications today would be vastly different. Navigation and communication would be dependent on the use of complicated, numerical IP addresses. Transactions and communications would be limited to low-sensitivity information exchanges. In short, the Internet would look much more like the small, academic research network it was in the 1970s, rather than the ubiquitous information powerhouse that drives billions of dollars into the global economy each year.

These two examples also illustrate an important quality of intelligent infrastructures—they shield the end user from the issues of scale and complexity. People can turn on a light or plug an appliance into the wall without a second thought as to the massive amounts of coordination and safety measures required to deliver power reliably and safely to millions of consumers. Similarly, the intelligent infrastructures of today's Internet and telecommunication networks allow people to use mobile phones and calling cards, send email, and conduct online commerce in a way that—while not exactly as simple as turning on a light—largely shields them from the significant interoperability, coordination, and security concerns associated with delivering these services.

[5] Sources: U.S. Census Bureau, *Statistical Abstract of the United States: 2000.* Federal Communications Commission, *Trends in Telephone Service: May 2004.*

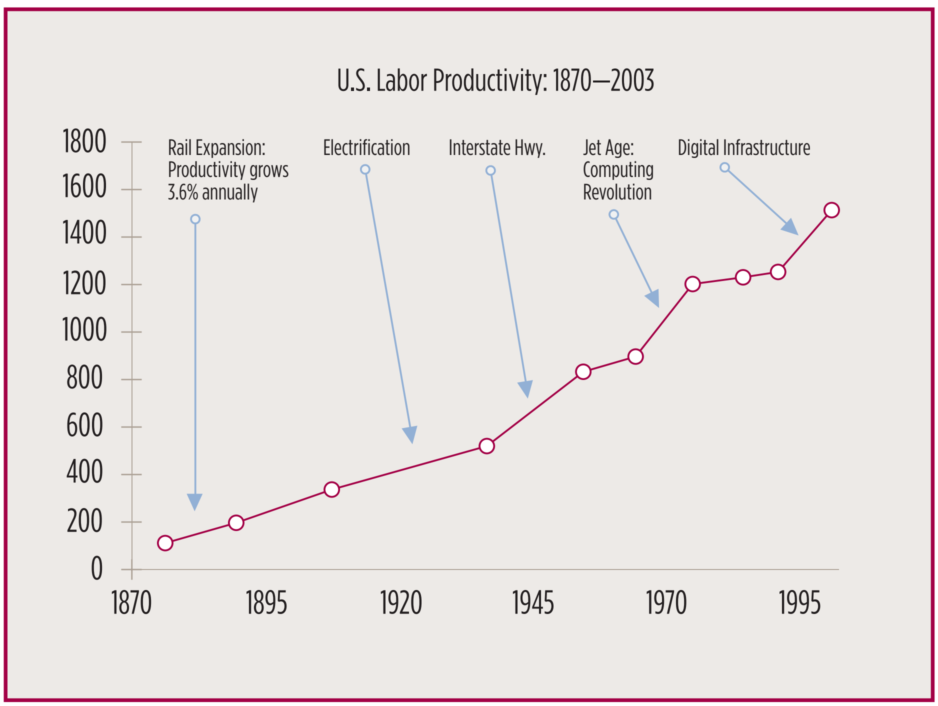
III. Are We at an Inflection Point in the New Digital Infrastructure?

We are about 10 years into a process through which the global economy is moving inexorably towards a multi-dimensional digital economy. As shown in **Figure 5**, this shift seems to be associated with the kinds of increases in productivity historically associated with other great infrastructural innovations.

However, there are also signs that we have reached a critical level of usage and complexity, indicating that, as in the past, there will be a need for significant innovation in intelligent infrastructure. We have seen usage of both the telecommunications and Internet networks increase at least a hundredfold in just the past few years,[6] resulting in a dramatic and often unforeseen impact on society and the economy. These trends have been accompanied by a massive increase in complexity, driven by:

- An increased, global demand requiring increases in scale
- The proliferation of applications, devices, and protocols
- The use of digital infrastructures for increasingly critical economic applications
- The convergence of predecessor infrastructures
- A host of new security and regulatory concerns

Figure 5: Productivity and Infrastructure[7]

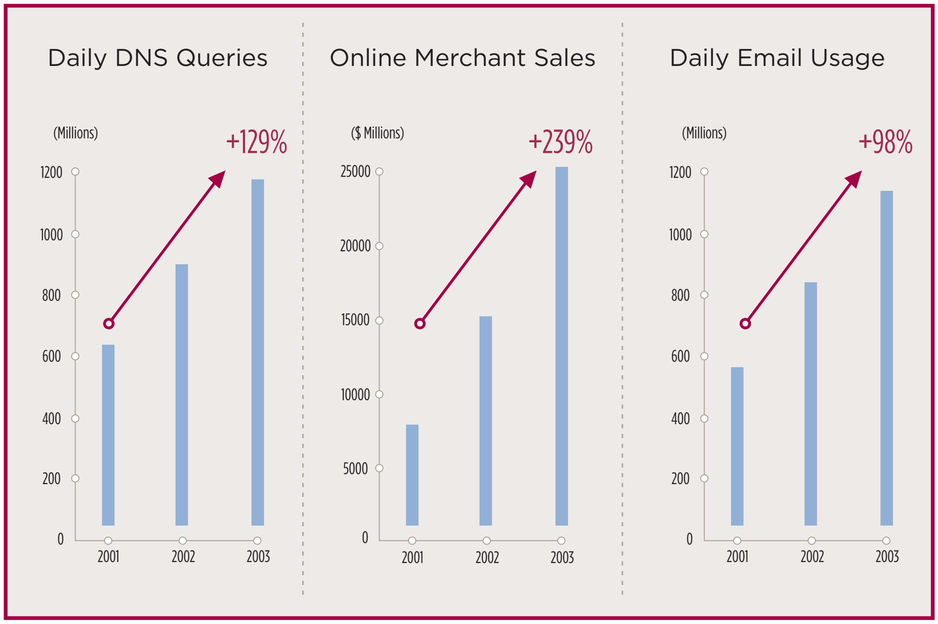


[6] Source: VeriSign, Inc.

[7] Great advancements in infrastructure have historically been correlated with increases in productivity. While productivity is driven by many factors (including capital deepening, education, non-infrastructure technical innovation, and other macro-economic factors, the patterns are nonetheless striking. The graph shows increases in real output per hour of labor input across the U.S. economy, using 1870 levels as an index of 100. Productivity data from 1948 on comes from the U.S. Bureau of Labor Statistics. Estimates prior to 1848 come from Abramovitz, M.A and David, P.A., "Two Centuries of American Macroeconomic Growth," Stanford Institute for Economic Policy Research, 2001.

If the past is any guide, for commerce and communications to reach their full potential, we must continuously strive to mitigate complexity through intelligent infrastructures. These infrastructures should support and enhance technology so it can enable people to find, connect, secure, and transact across today's complex global networks.

Figure 6: Internet Growth[8]



+ Increase in Usage

While no one doubts the dramatic increase in use of the new digital infrastructure in the late '90s, there is a widespread misperception that growth stalled with the bursting of the new economy stock market bubble. In fact, quite the opposite is true.

Given VeriSign's unique vantage point in operating much of the intelligent infrastructure overlaying the current Internet, we have observed and analyzed some of the more telling indicators of growth. As shown in **Figure 6**, rates of daily DNS queries, online merchant sales, and email usage[9] are up by 129 percent, 239 percent, and 98 percent respectively since the "bubble" supposedly "burst."

In light of the economic downturn that followed the '90s fervent speculation in the future of the Internet, such reports may inspire skepticism. However, it is instructive to note that many key predictions made in the late nineties were borne out, albeit in a slightly belated time frame than originally projected. Online sales and broadband deployment have both lagged the optimistic projections of the late '90s by only 12-18 months, while the number of Internet users is actually two years *ahead* of analysts' original expectations (**Figure 7**).

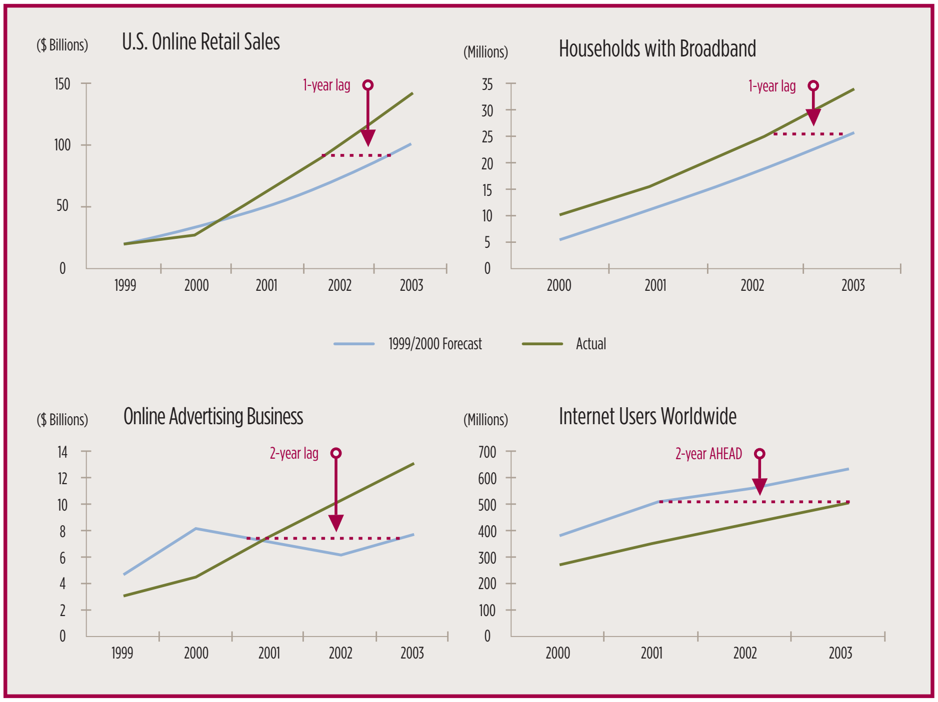
+ New Applications, Devices, and Protocols

The future of the Internet and telecommunications has been touted by many in the industry as a great "convergence." In fact, the rapid growth in demand usage and innovation have brought a significant "de-convergence" through the proliferation of numerous—and often incompatible—applications, devices, and protocols.

[8] Source: VeriSign, Inc.

[9] DNS look-ups for the *.com* and *.net* top-level domains are a proxy for global user interaction with a *.com* or *.net* top-level domain, be they a visit to a Web page, a download request to an FTP server, or the sending of a simple email. As such, they are an excellent indicator of Web use overall.

Figure 7: Actual Growth Relative to Original Analyst Estimates[10]



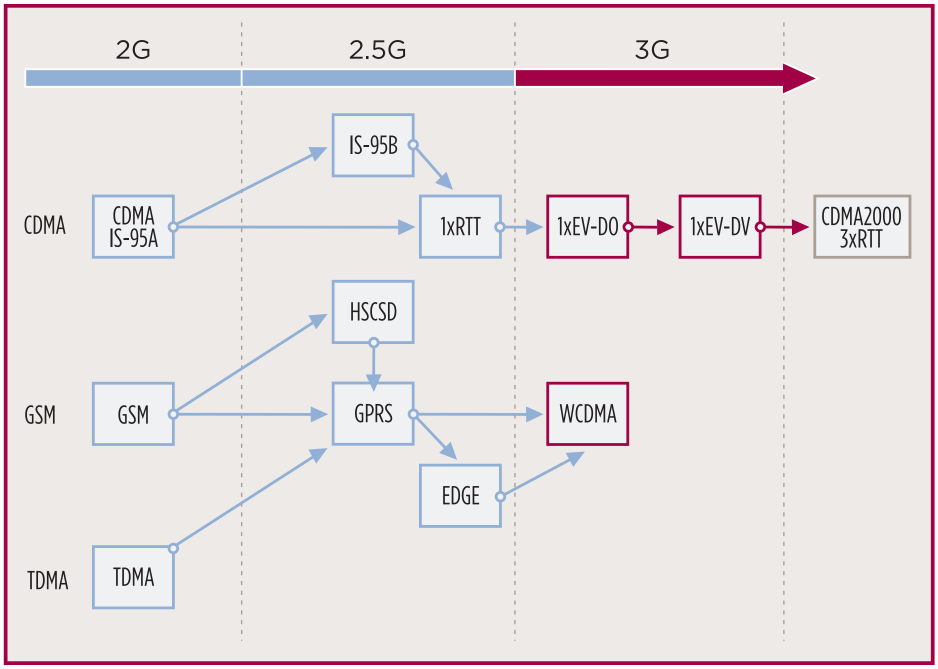
As shown in **Figure 8: De-Convergence in Mobile Communications**, the wireless communications industry continues to wrestle with an alphabet soup of standards along the road to convergence in a third-generation (3G) world. Add to that the bewildering number of paths for deploying wireless technologies to personal area networks and local area networks (as shown in **Figure 9: The Path to Wide Area Wireless**), and it becomes clear that some new intelligence will be necessary for existing and emerging networks to provide transparency, openness, and interoperability.

+ Digital Infrastructure's Role in Increasingly Critical Applications

The Internet and wireless networks are becoming the prime media for communicating sensitive information in such industries as aerospace, finance, medicine, law, utilities, and the military. As information-delivery systems are adopted for increasingly critical applications, they require increasing levels of performance and sophistication from the overlying infrastructure. For example, radio frequency identification (RFID) technology is currently being implemented as a tool for players in the global supply chain. To support this new commerce system, an Internet-based mechanism for global exchange of supply chain information called the EPCglobal Network™ is being deployed. While very promising in terms of the efficiencies it will add to the supply chain, this also promises to place the reliability and availability of much of the world's logistics on the shoulders of the new digital infrastructure.

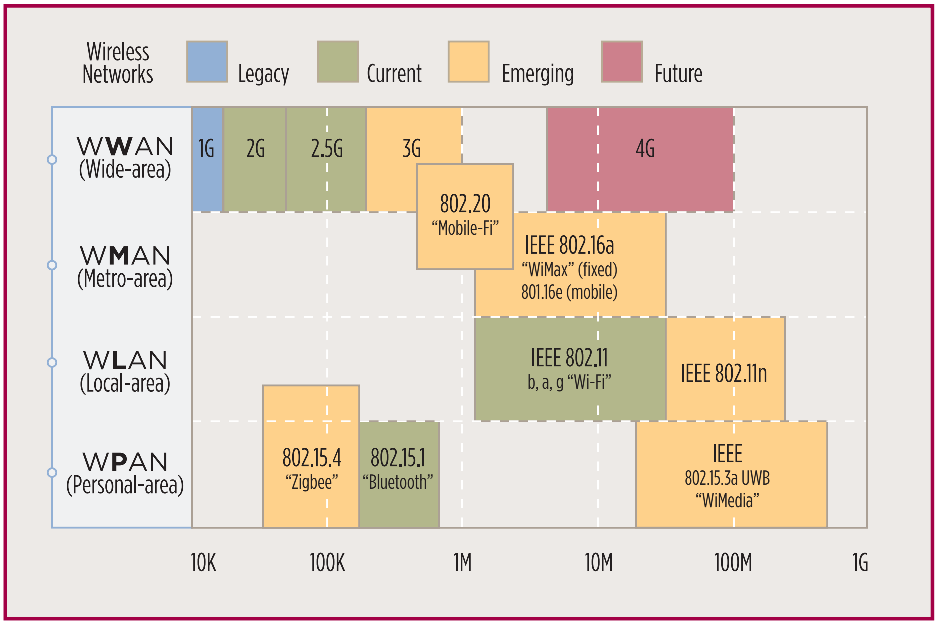
[10] Source: Tom Stein, *Wired*, March 2004

Figure 8: De-Convergence in Mobile Communications[11]



In the evolution toward 3G, telecommunications networks have brought on a proliferation of protocols.

Figure 9: The Path to Wide Area Wireless[12]



Consumers are demanding ubiquitous wireless LAN access, but providers must meet this demand using a variety of protocols.

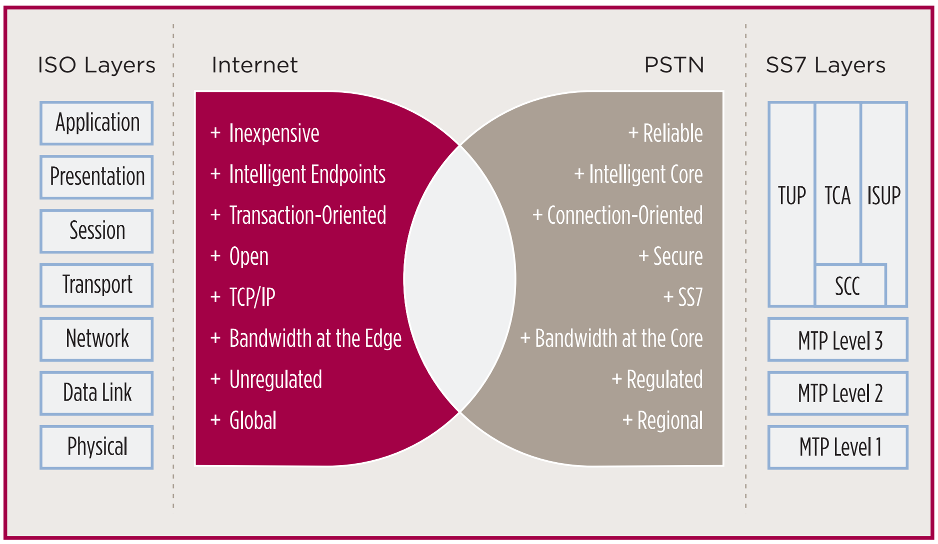
[11] Source: VeriSign, Inc.

[12] Source: VeriSign, Inc.

+ Convergence of Predecessor Infrastructures

We are also at the cusp of profound changes in the fundamental technological underpinnings that made the Digital Age possible. In 1993, cable television, the Internet, the public switched telephone network (PSTN), and cellular networks existed as discrete islands, offering differentiated services to their own customers. Today, consumers are demanding access to services that bridge these disparate technologies, such as VoIP, seamless text messaging, wireless gaming, and wireless Internet access. This increased demand provides unprecedented opportunities to communications service providers (CSPs) while also adding considerable complexity to their business practices.

Figure 10: Differences in the Internet and PSTN: Challenges and Opportunities from Convergence[13]



The Internet and telecommunications infrastructures were built on vastly different foundations with different features and benefits (see **Figure 10**). The approaches to the basic functions for finding, connecting, securing, and transacting were vastly different in the Internet and the PSTN. As a result, facilitating the interoperability between these two systems presents intricate challenges. If their attendant complexity can be mitigated, the technologies of the Digital Age will reach heights of success well beyond current expectations and a true "convergence" will come to pass.

+ Security and Regulatory Concerns in the Digital Age

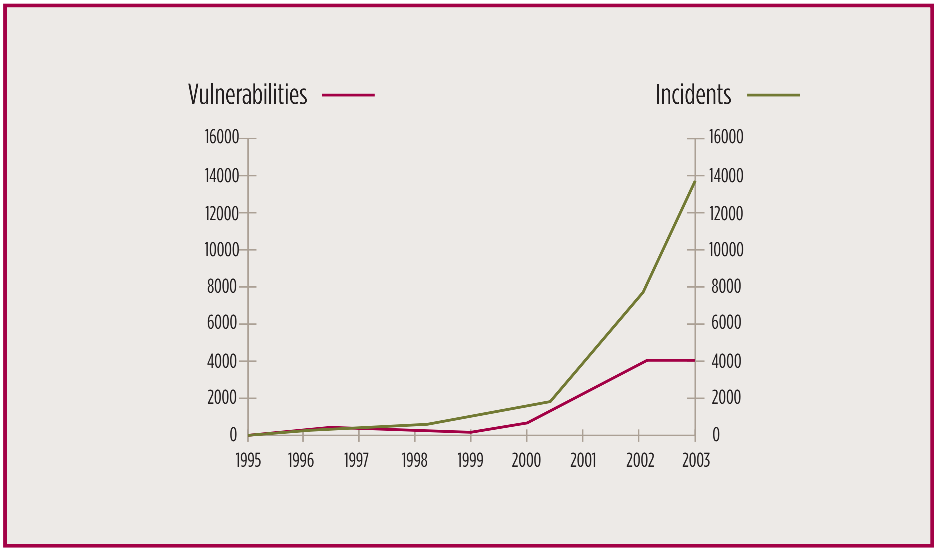
Security Concerns

In the Digital Age, organizations are becoming more globally interconnected, relying more on the Internet for communication, collaboration, and commerce. "Open" communication structures of this kind offer substantial opportunities to businesses and individuals, but also present new risks. As shown in **Figure 11**, security incidents and vulnerabilities continue to skyrocket as systems become more open and as more critical economic activity moves to these new open architectures.

[13] Source: VeriSign, Inc.

As organizations begin to rely on the Internet as a medium for facilitating communication and commerce, attacks on IT infrastructure are becoming more varied and sophisticated. Hackers, vandals, and others with criminal intent are mounting increasingly sophisticated attacks using email or applications running on simple, networked PCs. Each access point on a network presents a potential vulnerability for such an attack, and as networks expand to include more users, and widen to include Wi-Fi, virtual private network (VPN), and VoIP connectivity, all users are exposed to a higher level of risk. In a world where 1 billion handsets are connected to the network, with operating systems that are rarely patched once the phones are shipped, the possibility of 100-million-node distributed denial of service attacks becomes a very real possibility.

Figure 11: Growth in Reported Computer Security Events and Vulnerabilities[14]



Organizations have employed firewalls, network-based anti-virus software, access management, email gateways, intrusion detection systems (IDS), and other provisions to mitigate this risk. However, because of the highly unpredictable nature of such attacks, organizations must also employ comprehensive monitoring and analysis of network activity in order to deploy intrusion prevention measures and respond selectively to each specific instance. No longer will a single, unattended security device be flexible and intelligent enough to repel the number and variety of today's network intrusion attempts.

Regulatory Concerns

Organizations around the world are also struggling to keep pace with a new crop of regulatory initiatives. Financial institutions across Europe are rushing to maintain compliance with Basel II. In the United States, publicly traded companies must adhere to the reporting requirements of the Sarbanes-Oxley Act, while government agencies must answer to the Federal Information Security Management Act (FISMA).

Unfortunately, designing regulations for this new infrastructure is not easy. Geographically based concepts of jurisdiction break down when dealing with the global digital infrastructure, as do traditional notions of taxation or economics tied to time and distance. Legislatures around the world struggle to adapt 19th century legal codes to 21st century

[14] Source: The CERT Coordination Center (CERT/CC), Carnegie Mellon University, www.cert.org

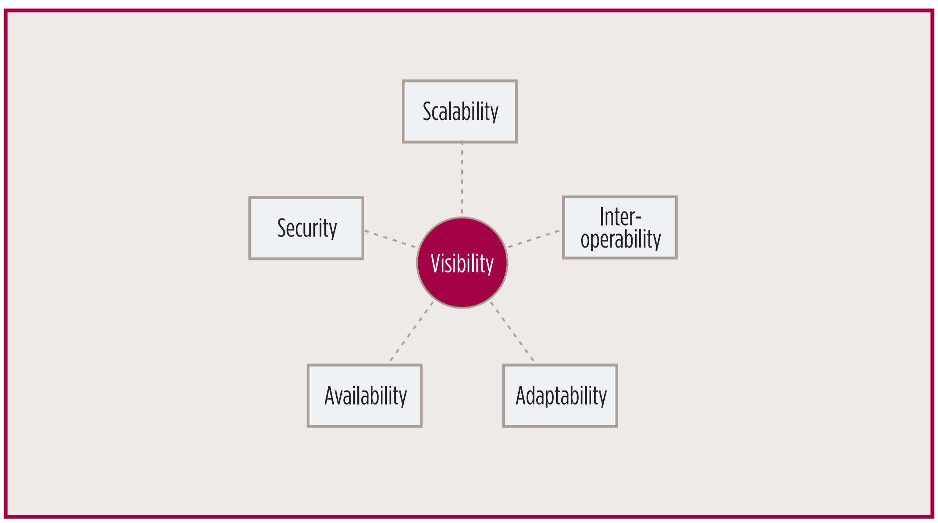
problems. Thorny issues arise in the application of laws such as the U.S. Communications Assistance for Law Enforcement Act (CALEA) and the Council of Europe's Convention on Cybercrime (both of which provide provisions for lawful intercept), enhanced 911, and Universal Service in an age of VoIP, embedded RFID chips, and un-tethered mobile communications.

This regulatory uncertainty has made long-term economic and technical planning difficult for many companies. Complying with existing regulations, preparing for an uncertain regulatory environment in the future, and taking advantage of new technologies create both an opportunity and a challenge for both existing service providers and new next-generation market entrants.

IV. Intelligent Infrastructure for the 21st Century

Just as intelligent infrastructure has played a critical role in mitigating the complexities of transport and communications infrastructures of the past, intelligent infrastructure is needed today to mitigate the complexities of our Digital Age. To do so, intelligent infrastructure for the 21st century must meet a set of six requirements.

Figure 12: Six Principles of Intelligent Infrastructure[15]



+ 1. Scalability

Dramatic increases in use have always been, and always will be, a source of complexity. The number of actual devices connected to the Internet is expected to climb from some 900 million at the end of 2003, to over 1.7 billion by 2005. The number of daily root DNS interactions across the Internet, already measured in the tens of billions, can be expected to increase over 100-fold once supply-chain interactions are added to the mix. Intelligent infrastructure must be capable of rising to the challenge of accommodating dramatically increasing usage.

[15] Source: VeriSign, Inc.

+ 2. Interoperability

Intelligent infrastructure must also be able to mediate between myriad technologies and protocols. As indicated above, "de-convergence"—not simplification—of protocols and standards has been a hallmark of the development of the digital infrastructure to date. Any useful intelligent infrastructure should enable mediation between different protocols, as well as mediation between multiple providers and devices. As noted in Section II, Intelligent Infrastructure for Telecommunications and the Internet, this must be provided in a manner that shields the end user from underlying complexity. If advanced services like the delivery of VoIP and digital content cannot be as simple for the user as making a mobile phone call is today, such services will be likely to fail.

+ 3. Adaptability

Intelligent infrastructure should not be *solely* aimed at mitigating present-day complexity. Rather, such infrastructure should be designed to adapt to new developments in commerce and communications as they occur. As we have seen over the last two decades, no one can accurately predict all the uses to which the new digital infrastructure will be put. In just one example, most wireless experts did not predict the use of small cellular phones for intensive text messaging, photography, or gaming. The design of the overlaid intelligent infrastructure must be flexible enough to meet the reality of constantly evolving form and functionality.

+ 4. Availability

As critical medical, legal, supply chain, and financial transactions are processed across the new digital infrastructure, and as that infrastructure becomes the basis for increasingly high-value and high-volume transactions, it must approach levels of reliability and availability superior to even the current wired telecommunications infrastructure. Since any system's overall availability is driven by the availability of its constituent parts, this will mean that the reliability and availability rates of intelligent infrastructure must exceed those we have come to expect from such utilities as the electrical grid or the current telephone networks. Given that design decisions to increase availability and reliability frequently come at the expense of adaptability (discussed above), this requirement will pose a significant challenge.

+ 5. Security

Given the central role that intelligent infrastructures play in coordination, control, and safety, they can make a target for criminals and others who have an interest in disrupting the underlying transport infrastructures. It almost goes without saying that the intelligent infrastructures of the 21st century will need to be built in a manner that makes them exceptionally resistant to physical, logical, network, and social engineering attacks.

+ 6. Visibility

The intelligent collection, correlation, and interpretation of data in myriad formats from multiple sources is at the heart of any intelligent infrastructure. Intelligent infrastructures must be able to provide visibility into usage, trends, and anomalies throughout an entire network as well as the larger Internet network of which they are a part.

V. Delivering Intelligent Infrastructure Services

Given the substantial requirements for effective intelligent infrastructure in the 21st century, it is not feasible for many organizations to develop and deploy such infrastructure on their own. Highly scalable infrastructure that provides consistent reliability and availability requires substantial investments in hardware, software, and other networking architecture, as well as the monitoring technology required to provide extensive visibility. In addition, developing intelligent infrastructure requires a level of expertise that only specialized organizations possess, including comprehensive knowledge of both Internet and telecommunications networks. This specialized knowledge is required to provide transparent mediation, reliable interoperability, and robust information security.

Not surprisingly, the intelligent infrastructures of the future, much like similar infrastructures of the past, are more likely to be provided by central providers rather than multiple, independent entities. The Internet, for example, simply would not be effective if each company operated their own authoritative, global DNS root system—comprehensive control requires at least one neutral, centralized, all-inclusive system. Beyond the issues of scale and expertise, the "visibility" requirement implies that intelligent infrastructure will always be less effective if it can only draw on data gathered from within the confines of a single organization.

The intelligent infrastructures of the 21st century must, like the digital infrastructure itself, be a set of "always on" services, broadly accessible to all individuals and providers who wish to plug into them.

+ Intelligent Infrastructure in Practice

Intelligent Infrastructure Services allow individuals and businesses to find, connect, secure, and transact across today's complex global networks. Here are just a few ways in which such services will be able to address the business challenges of the near future:

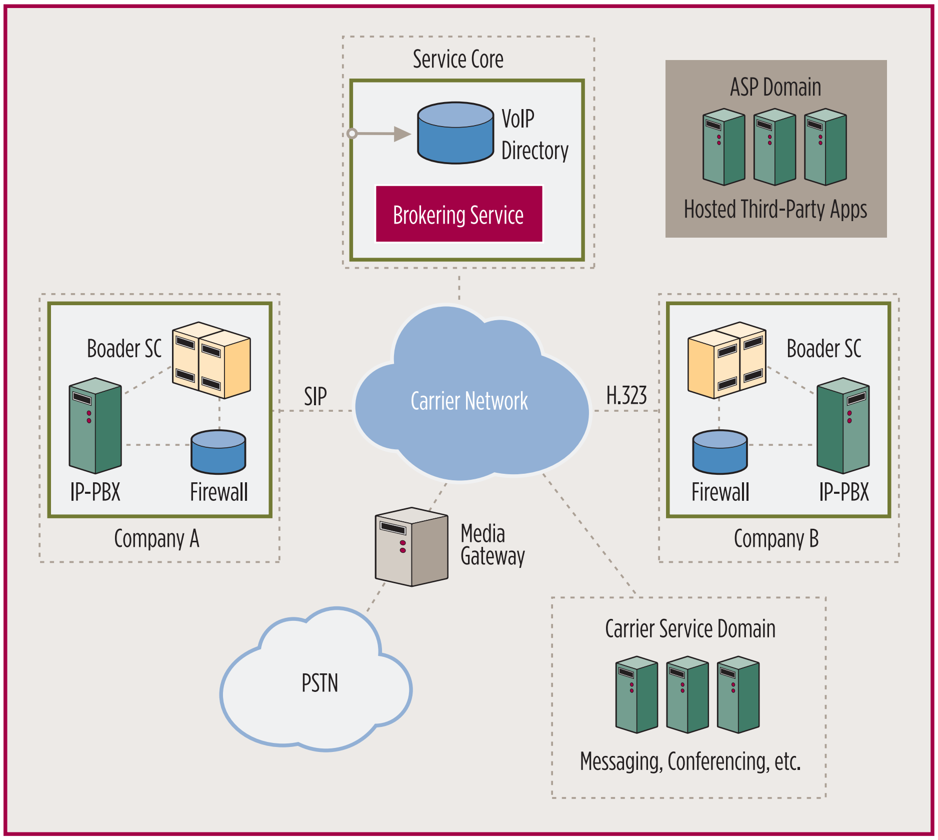
Voice-over-IP (VoIP) networks

Delivering voice over the Internet presents multiple challenges for service providers. To stay competitive, they must meet subscribers' considerable demands, while addressing their own needs to bridge Internet and telecommunications infrastructure. Intelligent Infrastructure Services will mitigate the complexities of providing this emerging service by mediating between the IP and telecommunications protocols.

Carriers need to connect seamlessly across SIP and H.323 protocols, as well as between VoIP networks and the PSTN. Using brokering services, next-generation providers will be able to allow for near-instantaneous mediation between these and other VoIP protocols.

Carriers also need to provide secure connections, despite the large number of ports that must be opened within a corporate firewall, to allow VoIP to pass through. And, given the strict latency requirements of voice, carriers must do so without introducing additional delays for stateful inspection. Communications providers will therefore need to partner with security experts that have considerable expertise in both Internet and telecommunications infrastructure. Also, all associated carriers, multiple system operators

Figure 13: Voice-over-IP (VoIP) Networks[16]



(MSOs) and other organizations need to transact business with partners. All partners in the "VoIP delivery chain" will turn to a central organization to facilitate a unified billing platform that will allow seamless settlement.

In addition to seamlessly connecting with other subscribers, regardless of protocol, subscribers will need to find important phone numbers at a moment's notice. Using the ENUM standard, which maps phone numbers with IP addresses, services will provide ready access to information across telephony and IP networks.

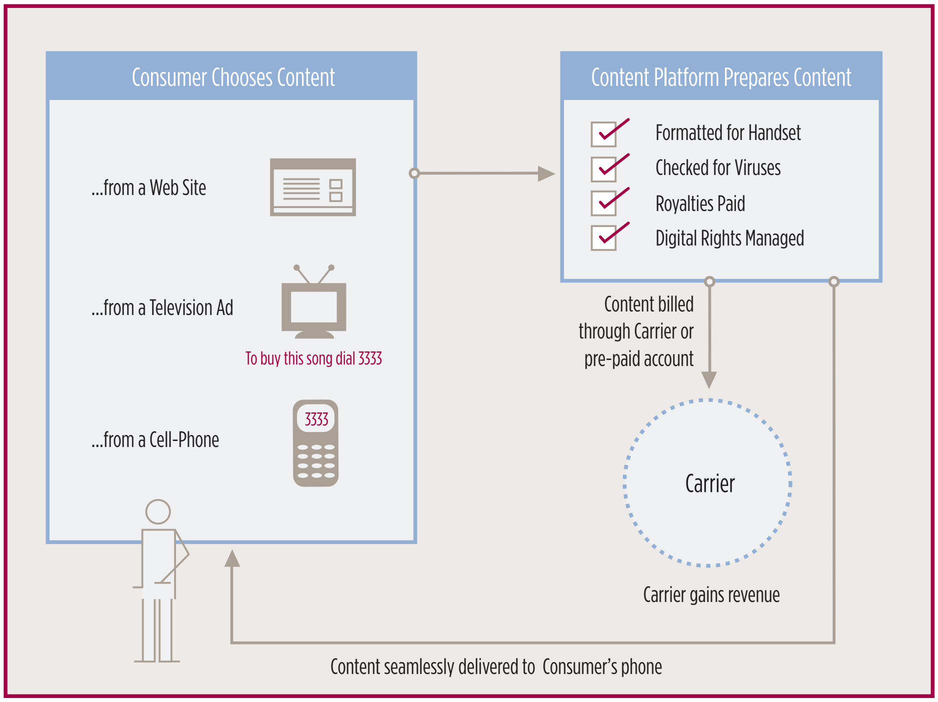
Digital Content Delivery Systems

Throughout many parts of the world, there is a booming business in enabling consumers to quickly and securely purchase digital content such as applications, games, and cell-phone ring tones, through their mobile devices. Not surprisingly, the industry is also looking to provide even richer media (such as video) on-demand, in the very near future. Behind the scenes, intelligent infrastructure is needed to mitigate much of the attendant complexity, allowing telecommunications carriers to provide these potentially lucrative services by collecting the content, verifying that it is free of viruses, matching the format to suit each device, enabling the seamless payment for these services, and mediating the digital rights of all parties and the payment of royalties.

Significantly, the growth of this market is driven by a young generation of consumers accustomed to receiving instant, seamless, on-demand services. Carriers that fail to leverage

[16] Source: VeriSign, Inc.

Figure 14: Digital Content Delivery Systems[17]

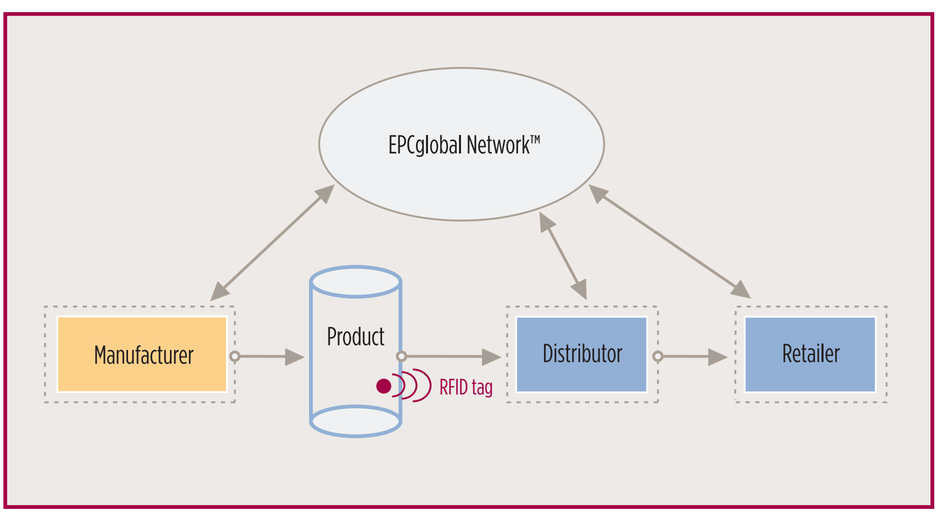


intelligent infrastructure to provide this level of immediate gratification—despite the underlying technical complexity—will see their market quickly move elsewhere.

Next-Generation Supply Chains Using RFID

RFID tags enable the technology that is poised to replace the current barcode system for printing encoded information on products. Unlike barcodes, RFID tags can be automatically read without the need for direct line of sight. This technology promises to

Figure 15: Next-Generation Supply Chains Using RFID[18]



[17] Source: VeriSign, Inc.

[18] Source: VeriSign, Inc.

+ MORE ABOUT VERISIGN

VeriSign, Inc., (NASDAQ: VRSN) operates Intelligent Infrastructure Services that enable businesses and individuals to find, connect, secure, and transact across today's complex global networks. Enterprises, carriers, governments, and individuals around the world turn to VeriSign to gain the benefits of the ongoing revolution in commerce and communications, by supporting new revenue streams and mitigating issues of cost, compliance, and complexity.

Every day, we operate the intelligent infrastructures that enable 14 billion Internet interactions, 2.7 billion telephony interactions, and $100 million of e-commerce transactions. We also provide the services that enable over 1,000 carriers, 3,000 enterprises, and 400,000 Web sites to operate securely, reliably, and efficiently. We provide the services that enable over 3 million mobile subscriber interactions per day, as carriers enable their customers to obtain ring tones, games, graphics, and community services.

As next-generation networks emerge, VeriSign is also leading the charge, deploying the intelligent infrastructure necessary for RFID-enabled supply chains, inter-enterprise VoIP, and mobile data and content distribution. VeriSign serves telecommunications carriers looking to rapidly deploy new services; Fortune 500 enterprises that need comprehensive, proactive security services; and e-commerce leaders wanting to securely process payments and reduce fraud. For many organizations worldwide, VeriSign is where it all comes together.™

instantly provide finer grained and more real-time inventory intelligence, replacing what today requires the efforts of multiple personnel working over several days. RFID tags will transmit electronic product codes (EPCs). Through querying the appropriate EPC directories and information services, retailers, manufacturers, distributors, and others throughout the supply chain will be able to gain fine-grained information about products, lots, expiration dates, inventory levels, shrinkage, etc., throughout the supply chain. This emerging technology will require an intelligent infrastructure so that such users can reliably find, connect, secure, and transact across this next-generation supply chain.

Store managers need to find the precise location of any shipment, en route from one country to another. RFID tags attached to products will transmit their information to readers as those products travel throughout the supply chain, and this information will be registered to appropriate directory and information services throughout the EPCglobal Network.™ These services will be connected via the Internet, and can be located via the Object Naming Service (ONS), a distributed global directory built to operate like (and, in fact, leverage) the global DNS.

Manufacturers, distributors, retailers, or any other party along the supply chain will need to connect with others along the supply chain, to exchange up-to-the-minute information about the shipment status. The EPCglobal Network will contain a comprehensive list of all parties involved, and will facilitate rapid communication.

While the supply chain data will be incredibly rich, there are natural security and privacy concerns that will arise as the EPCglobal Network is deployed. All parties will require that supply chain information be kept secure and out of reach from unauthorized users. Retailers, manufacturers, distributors, and network operators will need a reliable means of ensuring the confidentiality, integrity, and availability of supply chain information.

Consumers will want to streamline the purchasing process and accelerate transactions. Multiple RFID tags can be scanned simultaneously, reducing the need for cash registers and checkout clerks. Scanning devices mounted at store exits will instantly deduct the appropriate amount from customers' accounts.

VI. Intelligent Infrastructure and the Future

We find ourselves at a critical juncture where Intelligent Infrastructure Services are poised to catalyze information technology into its next phase of growth. At the Aspen Summit on "The Future of the Internet," keynote speaker and VeriSign Chairman and CEO, Stratton Sclavos, explained, "We are at that inflection point—that critical time, where without some intelligence, infrastructures that have been built and deployed, such as the Internet, cellular networks, or cable networks, are at risk of being swamped." While demand and adoption of technology grow at a blistering pace, security threats, inadequate capacity, and regulatory uncertainty stand as obstacles in the way of innovation. Now is the time for the technology industry to find *its* telegraph, to establish *its* air traffic control system—to develop that intelligent infrastructure that drives the transformation of these incredible networks from basic transport means, to ubiquitous systems that are indispensable to society. If history is any guide, this new intelligent infrastructure will not just mitigate cost, compliance, and complexity, but provide an impetus for untold economic and societal progress that will far eclipse the growth that we have seen thus far.

VeriSign, Inc.
487 EAST MIDDLEFIELD ROAD
MOUNTAIN VIEW, CA 94043
USA
www.VeriSign.com
P: 650-961-7500 F: 650-961-7300