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Delocalization in Telecommunications Networks

Douglas C. Sicker*

1. Introduction

Lawyers, economists and policymakers have long debated what role states should play versus the federal government in regulating modern communications networks.[1, 2] The typical argument takes place, on one side, with those who believe deferring to the states leads to a disparate patchwork of laws not well suited to modern communications. On the other side, there are those who believe that the regulatory authority should lie with the states, presumably closer to the people it affects.[3, 4]

This debate is not new. As far back as 1969, then-Circuit Judge, later Chief Justice, Burger showed strong support for federal preeminence in stating that:

> Any other determination would tend to fragment the regulation of a communications activity, which cannot be regulated on any realistic basis except by the central authority. Fifty states and myriad local authorities cannot effectively deal with bits and pieces of what is really a unified system of communications.[5]

More recently, Federal Communications Commission (FCC) Chairman Michael Powell echoed a similar perspective in a statement concerning the 'Triennial Review' Order. Chairman Powell remarked that, "[t]he nation will now embark on fifty-one major state proceedings to evaluate what elements will be unbundled and made available to CLECs. These fifty-one cases will likely be decisions in multiple ways —some

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* Douglas C. Sicker is Adjunct Fellow at the Progress & Freedom Foundation and assistant professor in computer science and telecommunications at the University of Colorado at Boulder. The views expressed are his own and do not necessarily reflect those of the foundation, its officers, or Board of Directors. Professor Sicker would like to thank the following individuals for their assistance with this paper: Lisa Blumensaadt, Dale Hatfield, Phil Weiser, Jon Peterson and Adam Peters.

[1] *See* R. Noll, *Managing the Transition to Competition in Telecommunications*, A working paper, Stanford University, (1986) [hereinafter Noll].

[2] *See* P. Teske, *American Regulatory Federalism and Telecommunications Infrastructure* (1995).

[3] *See id*.

[4] This simplifies a rather complex debate, which includes numerous arguments on both sides of the debate. It is not my intention to explore this debate, but rather to describe how technology is influencing one aspect.

[5] *General Telephone Co. v. FCC*, 413 F.2d 390 (D.C. Cir. 1969), *cert. denied*, 396 U.S. 888 (1969) (opinion by Burger, J.).

upholding the state, some overturning the state and little chance of regulatory and legal harmony among them at the end of the day."[6]

However, no one within this debate has critically examined this issue with respect to the technical evolution of the network; nor have they considered the impact of these laws on the subsequent operations of the network. Although Noll points out that technical and economic distinctions between federal and state jurisdictions are a fiction,[7] his work does not provide the analytical assessment to indicate the nature of that fiction. This paper articulates these issues and the trends associated with the evolution of technology and the associated network and service architectures. While this paper does focus on technology, it is not my intention to trivialize the complex interplay of technology, economics and policy, but rather to demonstrate how technology is making jurisdictional distinctions less tenable.

This paper considers a number of well-known technology trends that are influencing the evolution of the network, six of which are particularly pertinent to the thesis of this paper:

(1) the cost of 'communicating' is becoming more distance insensitive;

(2) the networks and the services that ride on these networks are becoming more modular;

(3) packet-routed networks are becoming more prevalent than circuit-switched networks;

(4) the application (e.g., voice) is becoming more independent and separate from the network;

(5) geographic boundaries are irrelevant to emerging technology; and,

(6) intelligence and functions are migrating away from the central office (the delocalization of the central office).

These trends are continuing to have a profound impact on the evolution of the network and especially the services and applications provided over these networks. As I will later describe in detail, voice over packet service differs substantially from traditional voice service, and these differences are causing (and will continue to cause) substantial regulatory difficulty.

The primary thesis of this paper is that modern telecommunications networks are evolving in ways that render local and state authority over many telecommunications policy decisions less justifiable. Networks, and the services offered over the network, are delocalizing in design, operations, traffic and cost characteristics. Further, the benefits from a modernized network are undermined by policies that attempt to make a

[6] *See Implementation of the Local Competition Provisions of the Telecommunications Act of 1996* (CC Docket No. 96-98) (August 21, 2003) (Chairman Powell, dissenting).
[7] *See* Noll, *supra* note 1.

distinction between local and non-local aspects of the network, particularly as this relates to the services carried on these networks.[8]

To analyze this issue, I examine the evolution of the Public Switched Telecommunications Network (PSTN), as well as the development of packet-based networks (including the Internet).[9] To begin this examination, I consider the evolution of these networks' design, operation, traffic and cost characteristics. The goal of this review is to understand the general evolution of these networks, with a particular focus on architecture, cost and operations. I then examine how these characteristics have influenced: (1) jurisdictional issues; (2) network configuration, and (3) network economics.

Through this analysis, I demonstrate that the historic rationales for local authority over telecommunications are much less valid today than in the early days of the PSTN. Moreover, the persistence of traditional state/federal jurisdictional categories will, in fact, inhibit optimal network design.[10] I also demonstrate why we should move away from a "dual federalism model" where states may clash with the federal government over a jurisdictional divide toward "cooperative federalism" where states may act as labs, within limits, and the federal government leads the policy directive.[11] Lastly, I demonstrate that a more deregulatory regime is appropriate, particularly as it relates to the technical evolution of the network.[12]

2. The Historic Telephone Network

This section of the paper offers a general description of the historic telephone network, including its architecture, operations, traffic, and cost, as well as the influence of regulation on its evolution.

The highly local and hierarchical nature of the early telephone network, with particular regard to its design and operation, went highly unchanged for decades. Arguably the service -- voice -- experienced no change whatsoever. And while the technology (switching and transmission) evolved, there was minimal reflection in pricing because of the regulatory structures applied to this market.

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[8] Even more artificial (and problematic) are the distinctions created by intralata and interlata designations, as well as the distinctions between intrastate and interstate, and arguably national versus international distinctions.

[9] It is important to recognize that the PSTN is evolving away from a circuit-switched model. For example, access over DSL is based on packet architectures and long-distance services are now traveling over packet-routed networks. Therefore, care must be taken to indicate what is meant when discussing the modern PSTN, since it is clearly not the circuit-switched network of yesteryear.

[10] While this paper focuses on the PSTN, a similar argument could be made for other networks (e.g., cable and wireless).

[11] *See* Philip J. Weiser, *Cooperative Federalism and Its Challenges*, Michigan State DCL L. Rev. 1 (2003).

[12] This paper does not assert that regulation is unnecessary; indeed, in several areas regulation (be that local, state, national and international) should continue to have a positive impact on consumer welfare.

For most of the twentieth century, both the federal and state governments regulated the telephone network as a natural monopoly. The value of the network was in the number of subscribers, or ubiquity of service.[13] Efficient pricing was sublimated to how many people could be reached on the network. Thus, the notion of competitors overbuilding to current customers of the dominant provider was seen as redundant and a waste of capital. Building out the dominant network added value, and the dominant provider had little economic or regulatory reason to interconnect with networks of other providers.

As such, initial regulatory oversight consisted of rate-of-return or right-of-way regulation. At this early point in network development, it was sensible for states to be involved. The design and traffic of the network was such that many of its elements had a local physical presence and served a clearly local function; i.e., carrying and controlling largely local traffic. This traffic stayed within a limited geographic area bounded traditionally by the city, town or community that the communications network served.

As the network developed, the traffic became less local, and the intelligence and control of the network likewise became less local. The design of the network has progressed from relatively noncomplex switches hierarchically connected, where most all intelligence and control resided locally, to more complex switches handling many more functions, and ultimately to a design wherein much of the intelligence and control has migrated away from the local switch into the network and network endpoints. It is this delocalization of the network, including the migration of intelligence and control away from the local switch, that raises jurisdictional uncertainty.

2.1. Network Operations and Design — of the Historic Telephone Network

Early network operations will be considered first. As depicted in the figure below, the PSTN has a star configuration with the central office at the center and the lines radiating out to the customers, with control and intelligence localized at the central office. In the early days of telephony, when a customer placed a call, it was received at a local central office (also known as an end-office or later as a Class 5 office). Within the central office was the switch, whose role was to process the call based on logic that resided in the switch.[14] In simple terms, a switch provided a connection (and subsequent disconnection) between the calling and called parties.[15] Initially, this 'switch' was a human that operated a patch panel to interconnect calls. When a call arrived at the central office, the operator would make a connection between the calling and the called party by physically plugging a cord between the two parties. The operator was the intelligence of the network, providing information to the customer, as well as making the actual connection. However, as telephony grew in popularity, the

[13] *See* Brands and Leo, *The Law and Regulation of Telecommunications Carriers* (1999). The technical economic description of this is that the telephone network exhibited positive network externalities.
[14] This is not to imply that the switch is the only equipment within a central office; there are many other elements including distribution frames, cross connects, power supplies, optical equipment and so on.
[15] *See Engineering and Operations in the Bell System*, Bell Laboratories, Inc. (1990), and *Telecommunications Transmission Engineering*, Vol. 3, Bell Communications Research (1990).

task of making the connection eventually passed to electromechanical switches. These electromechanical switches were eventually replaced by subsequent generations of more modern switches.

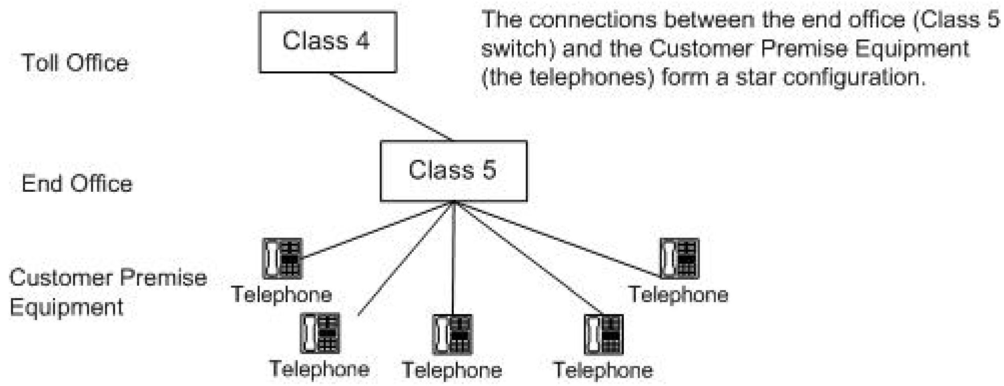

Figure 1. The Historic Telephone Network Star Architecture[16]

The telephone network was based on a design where simple endpoints (i.e., telephones) would signal a limited amount of information (e.g., dialing, on-hook and off-hook) to a relatively complex switch.[17] The switch maintained the logic for completing a call, and later for services such as call forwarding, and for many other management and billing operations. In other words, the switch was the intelligence of the PSTN. Regardless of the technology, the early switch maintained a pivotal role in the operation and services provided to the customer. The central office played *the* major role in the operations of the early telephone network.

Several major technical advances altered the design and operation of the telephone network, including the advent of digital switching, the development of modern signaling systems and the introduction of optical technology.

The advent of the digital switch changed the basic operation of the PSTN drastically. Now, not only was the network controlled digitally, but the voice data was digital within the network. However, the architecture was still circuit-switched, whereby the digital data was still carried over a dedicated circuit from end-to-end. Yet, the digitization of the network led to a more general-purpose computing platform, which provided the basis for subsequent advances. In the late 1970's, American Telephone and Telegraph (AT&T) started to implement a new signaling and control technology, referred to as Common Channel Interoffice Signaling. This approach made use of a separate data network to transmit call routing, signaling and supervisory information among the toll offices.[18] This technology eventually led to the now pervasive (packet-based) Signaling System 7 (SS7) networks.[19] This technology delocalized the control and signaling of

[16] *See id*.
[17] *See id*.
[18] A toll office can be thought of as simply a central office used for switching toll calls.
[19] Signaling System 7 defines the protocols used in call establishment, modification, teardown and management.

the network. Finally, optical networks based on Synchronous Optical Network (SONET) technology provided a substantial improvement in the reliability of the network, both at the bit level, as well as in the ability of the network to recover from certain outages. This technology supported large quantities of calls with high reliability (and at an improved price point), thereby supporting the growth of long-distance and data traffic.

The legal rules governing the network served as a lagging indicator of the technological change. *Carterfone v. AT&T*[20] was pivotal in the modularization and delocalization of the network. In *Carterfone*, the FCC invalidated AT&T's restriction on the attachment of foreign equipment as unreasonable and unjustifiably discriminatory.[21] This allowed customers to purchase equipment from other manufacturers and attach it to AT&T's network. Thus, monopoly control over endpoint devices was broken, creating a new market and shifting some power from the local provider (almost invariably AT&T) to the customer and other manufacturers. This modularization of control allowed end devices to hold more intelligence and possess more features.

Carterfone also led to strong competition in the PBX field.[22] End users, such as large manufacturing and transportation companies, constructed extensive local (on-premises) and long-distance private line networks using PBXs and leased lines or private microwave facilities. Like the central office switches, these devices became increasingly computer-like and offered a host of services, such as abbreviated dialing, least cost routing and a host of other services that were not always available on a central office (CO) switch. Some of the motivation for the long-distance private line networks was to reduce long-distance charges by avoiding access charges.[23] Similar functionality could be provided through a CO-based solution, namely CENTREX, and large private networks were created using leased switching services as well. At divestiture, AT&T (and others) offered PBX-based solutions. The divested Bell Operating Companies (BOCs), however, fought back using CENTREX to compete. This is a classic example of 'where does the intelligence reside'. It also demonstrates how divestiture facilitated (through separation, competition and falling prices) the further migration of intelligence to different parts of the circuit-switched network.

[20] *Carterfone v. AT&T*, 13 F.C.C.2d 420, *reconsideration denied*, 14 F.C.C.2d 571 (1968).
[21] *See id*.
[22] A PBX (Private Branch Exchange) can be thought of as a telephone switch deployed on a customer's premise.
[23] Each long-distance telephone call you make includes per-minute fees that your long-distance carrier pays to the originating and terminating local telephone companies over whose facilities that call also traveled. Those fees, which are designed to recover the costs to local telephone companies for use of their facilities, are referred to as "access charges." Access charges — both state (intra-) and federal (inter-)—were traditionally set by regulators to be above cost, thus artificially inflating the costs of inter- and intra-state long distance. As a general matter, these inflated charges were used to cross-subsidize below cost rates for rural and residential subscribers. Despite being set above-cost and thus being uneconomic, they rates were set to allow local phone companies to recover regulatorily legitimized costs. *See* http://www.fcc.gov/Bureaus/Common_Carrier/Factsheets/ispfact.html

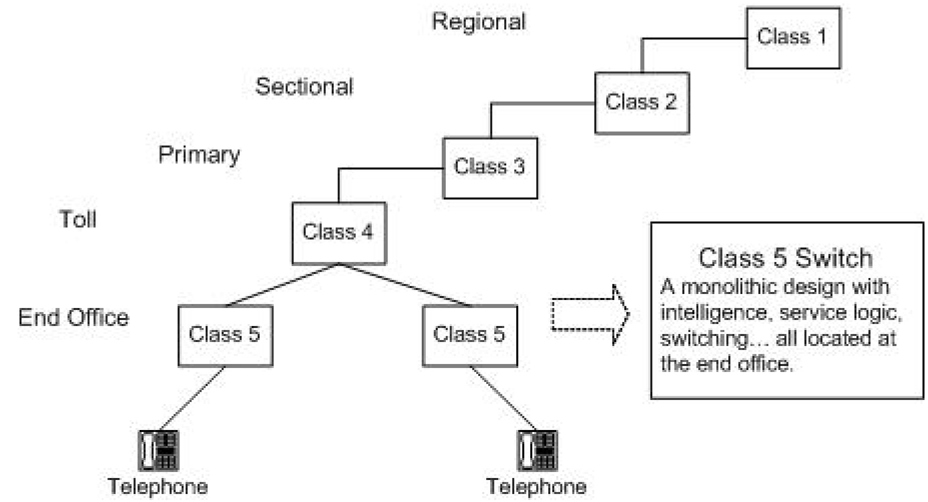

Figure 2. The Historic Telephone Network Hierarchy[24]

The design of the early telephone network was based on a hierarchical architecture, where the need to rise up the hierarchy generally correlated to the distance of the call. As depicted in Figure 2, the Class 5 office served to terminate the customer loop. Customers served off of the same Class 5 switch were connected directly through that switch. However, customers served off of different Class 5 switches still needed to be connected. Since it would be impractical and inefficient directly to connect all of the switches across the country (as the traffic between these switches would not warrant the expense), these switches relied on other switches higher up the hierarchy to provide the interconnection.[25] As a call progressed up the hierarchy, it would hit the Class 4 switch (the toll center). If this switch could not provide a connection, the call would pass up the hierarchy to the Class 3 switch, and so on. This approach was very practical, as most calls were local and the hierarchical design scaled well with network growth. Local networks in large urban areas were sometimes based upon a two level hierarchy – with the end offices and local tandem(s) forming the two levels. Large, flat-rate local calling areas meant that these two-level local networks handled considerable amounts of traffic.[26]

Delocalization and decentralization are not recent phenomena. Even during the 1970s and 1980s, the network trended toward delocalization. New switches were based on computer technology, which would support new network control models such as packet-based signaling systems. These systems allowed the network to operate in a more efficient, coordinated and secure manner. The operation of these packet-based signaling systems included the control and intelligence of completing a call.[27] Thus, the intelligence and control, which formerly resided in the local switch, migrated into the

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[24] *See Telecommunications Transmission Engineering*, *supra* note 15.
[25] Some Class 5 switches were directly interconnected when traffic between the two warranted a dedicated connection.
[26] One of the interesting things that happened with the falling cost of transmission and the ability to build larger switches is the flattening of the hierarchical design of the network
[27] Calls that originated and terminated on the same switch may not require this signaling system.

network through the packet-based signaling systems. This shift toward computer-based switches helped usher in the shift of control and intelligence into the network and away from the local switch.

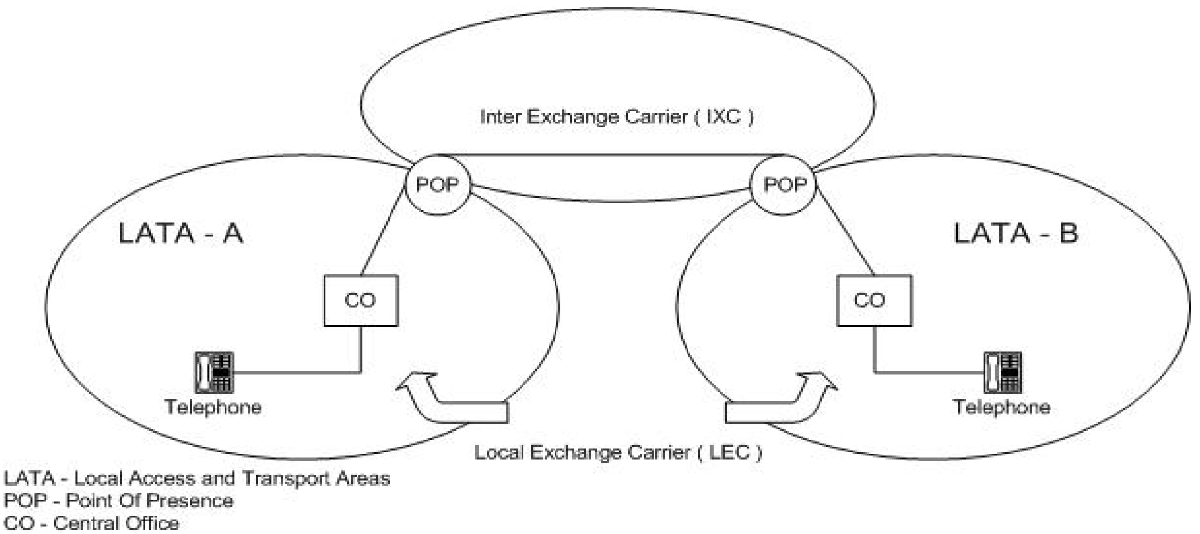

Figure 3. The Historic Telephone Network (Post Divestiture)[28]

In addition to being shaped by legislation and administrative regulations, the telephone network has also been shaped by intervening federal antitrust actions. In 1974, the U.S. Department of Justice (DOJ) brought suit against AT&T for maintaining its monopoly power through anticompetitive conduct, in violation of the Sherman Act.[29] Trial eventually commenced in 1981 and ended with AT&T and the DOJ settling with the Modification of Final Judgment (MFJ) in 1982.[30] This led to the separation of the local network from the long-distance network, creation of the Local Access and Transport Areas (LATA)[31] and prohibition against Bell Operating Companies' (BOCs') provision of long-distance service.[32] LATAs defined the area in which the BOC could provide local services.[33] Points of Presence (POPs) were created by long-distance carriers as a point of interconnection to the Local Exchange Carrier (LEC), where they terminated and originated traffic to or from the LECs' networks.[34] The corresponding network point

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[28] *See Engineering and Operations in the Bell System*, *supra* note 15.
[29] *See U.S. v. AT&T*, 524 F. Supp. 1336 (D.D.C. 1981).
[30] *See AT&T Consent Decree*, 1982 [Modification of Final Judgment, or MFJ.] This agreement was termed such because it was considered a modification of the original 1956 decree terminating an antitrust action against Western Electric. *See also, U.S. v. American Telephone & Telegraph Company*, 552 F. Supp. 131 (D.D.C. 1982) [court approval of MFJ].
[31] *See U.S. v. Western Elec. Co.*, 569 F. Supp. 990 (D.D.C. 1983).
[32] *See generally*, the MFJ, *supra* note 29.
[33] *See AT&T Consent Decree* at § IV(G), *supra* note 27. Most states were divided into several LATAs, but some were single-LATA states, and some LATAs crossed state boundaries.
[34] The service provided by the LECs to long-distance carriers is referred to as exchange access service and includes transport, switching and access functionality.

for the LEC is the Point of Interconnection (POI). Due to equal access obligations BOCs could not discriminate in favor of any particular long-distance carrier.[35, 36]

Divestiture dissolved the monolithic telephone system into a number of distinct and competitive business entities.[37] The BOCs were now interested in the local operations, while AT&T (and the other long-distance companies) sought to make long distance as attractive as possible by reducing previously artificially inflated rates. The long-distance providers paid the local service providers an access charge for calls carried over the local network. With very high per-minute access charges, large companies were paying many times more than the cost of their loops to access the long-distance carriers. Thus, there was a great amount of incentive to move that traffic to dedicated (non-switched) facilities, where there were no per-minute charges. If dedicated facilities were provided by the local phone company, it was called service bypass; and if dedicated facilities were provided by another local carrier (called Alternative Local Transport Service Provider or Competitive Access Provider), it was called facilities bypass. The threat of bypass from these two sources forced the local carriers' per minute access charges down, with some of the loss in revenue being compensated for by an increase in end-user fixed monthly charges. Interestingly, with the sharp drop in per-minute access charges, there was less need for large users to construct private line networks and much of that traffic migrated back to the PSTN as virtual private networks. The marked decrease of the BOCs' implicit local rate subsidy from interstate traffic pricing coupled with concurrent long-distance competition drastically changed pricing and traffic characteristics, as described in detail in the following subsection.

The implication is that, just as the MFJ and previous regulation significantly influenced the architecture and evolution of the network at the time (by determining who connects and how), so will various state and federal regulation influence the technical evolution of the current (and future) network. The MFJ's clear effects on network design and operation confirm how the regulatory environment impacts the subsequent operations of the network.

2.2. Traffic and Cost Characteristics — of the Historic Telephone Network

Traffic on the early telephone network was predominately local. Flat rates on local calling encouraged the use and adoption of the local telephone service. The network was designed to accommodate traffic patterns premised on local calling. Indeed, the pricing reinforced the network use. Low local flat rates encouraged local calling and thus this local design nature of the network. In contrast, long-distance rates remained high and charged on a per-minute basis. Consequently, long-distance usage remained

[35] Equal access also required dialing parity, where all carriers had one-touch dialing.
[36] *See* http://myphliputil.pearsoncmg.com/student/bp_stamper_bdc_6/48.
[37] Note that the CPE, inside wiring and long-distance segments were pushed to become competitive segments by FCC decisions prior to the MFJ, however the MFJ made the long-distance and local segments' interests much more polar as their operations were now completely separate business/financial entities.

relatively low (particularly in the residential market).[38] Therefore, the communications network needed comparatively little long-distance infrastructure compared to local infrastructure. Artificially low cost local service and artificially high cost long-distance service saw to that.

It is interesting to consider that a few decades ago, a long-distance call was generally considered as something special — worthy of the interruption. Where long-distance calls were once priced so that they were reserved for important business or somewhat of a luxury indulged in only occasionally by most customers, today's long-distance rates are readily affordable to most and have made long-distance calls a frequent occurrence. Indeed, calling plans with "unlimited" long-distance calling (or large bundles of minutes) have made long-distance calls a commonplace occurrence. This demonstrates the obvious: pricing greatly influences traffic, which in turn, shapes architecture and network evolution.

As described by FCC statistics, while there was a steady growth in long-distance, it was not until the divestiture of the Bell System (and again after the Telecommunications Act of 1996) that long-distance growth increased substantially.[39] The high cost of long-distance is well-understood as being the factor that suppressed demand.[40] Again, it was not until the introduction of competition that rates fell sufficiently to stimulate demand. The subsidy of local rates by long-distance and business charges complicated network traffic and cost characteristic. While it kept rates low ostensibly to spur adoption, it also distorted the market.

Following divestiture and the concurrent decrease of subsidized local rates, there was a significant increase in both long-distance and local traffic and penetration rates. Based on FCC data, local usage increased 25% and long-distance increased over 100% during the four-year period following divestiture. Interestingly, this increase in local traffic occurred even though rates had increased. Also, contrary to state regulatory concerns at the time, local telephone penetration rates continued to increase.[41]

2.3. Implications

Benefiting from close federal regulation on new entrants, pre-divestiture AT&T operated in a stable environment, where it could strictly control network evolution. For the network, this resulted in fairly slow and steady progress, hallmarked by reliability and availability.[42]

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[38] It is important to recognize that while rates did fall for long-distance service pre-divestiture, it was not until after divestiture that we saw sufficient price decreases to stimulate substantial increase in use.
[39] FCC data adapted from http://www.fcc.gov/wcb/iatd/lec.html.
[40] *See* Remarks of FCC at http://www.fcc.gov/speeches/chong/sprbc506.txt.
[41] *See* Remarks of FCC at http://www.fcc.gov/speeches/chong/sprbc506.txt.
[42] *See* Steffen Blaschke, *The Organization of AT&T – A Historical Contingency Approach* (2001), at http://www.students.uni-marburg.de/~Blaschke/arbeit/ATT.pdf.

Considering the development of the early telephone network, it is easy to see how regulators made such a strong distinction between the local network and the long-distance network. Aside from regulatory influence, there was a strong local nature to the network's technology, design, operations and traffic patterns. The design and technology were such that calls were locally controlled through a human operator and later through an electromechanical switch; and the traffic was also predominantly local, partly due to local subsidization using high long-distance and business rates to keep local residential rates artificially low. The policy to subsidize local rates had a substantial impact on maintaining the local and static nature of the U.S. telephony system. While it might be argued that this approach served us well to establish a highly-deployed and highly-reliable network, it is clear that the consequence was to minimize the use of long-distance, keeping the network localized in that aspect.

In conclusion, the early telephone network had a local nature, particularly with respect to switching, services, operations, traffic and cost. While the advent of divestiture resulted in a decrease in prices and an increase in volume of long-distance traffic, the local nature of the network remained substantially the same; particularly in terms of design (control, intelligence and service provision maintaining a physical local presence).[43] However, with the introduction of new signaling technology, control and intelligence migrated away from the local switch and deeper into the network. This migration away from the highly localized structure of the network marked the beginning of radical changes soon to come to the PSTN. These changes included the introduction of the Intelligent Network (IN) and the merging of the PSTN with Internet Protocol (IP)-based network(s). Thus, divestiture resulted in delocalization through the introduction of new players and through changes in costs and traffic patterns, while new technology resulted in delocalization by removing control from the local switch and bringing it deeper into the network and out into end-devices.

3. The Present Telephone Network

This section of the paper provides a generalized description of the present telephone network. As with the last section, this includes an examination of the architecture, operations, traffic and cost. This discussion will demonstrate how the telephone network has become increasingly delocalized, and the consequences of this delocalization. Finally, this section highlights the substantial increase in traffic, the decrease in cost and corresponding drop in consumer and business rates that occurred during this period.

3.1. Network Design and Operations — of the Present Telephone Network

The introduction of new signaling systems and fiber technology predominated in the post-divestiture evolution of the PSTN.[44] This new signaling system, Signaling System

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[43] As previously described, there was some migration of control and function toward the network edge through PBXs.

[44] Various, and nearly simultaneous, technical improvements have driven the decrease in communications costs, including new and improved fiber production, compression, and digital signal processing techniques, to name a few.

7 (SS7), represented a substantial change in the operation of telephone systems. As indicated in the figure below, control of resources shifted away from the local switch and into the signaling network. Notably, the switch was now better able to communicate with other switches and devices for the completion of calls, rather than relying on the local switch to maintain all or most of the intelligence and control. In the 1990's, the telephone carriers introduced an extension to the SS7, the Intelligent Network (IN). The IN represented another significant change in how and where service and associated intelligence existed in the network. While the SS7 provided a means of querying other switches for the connection and management of calls, the IN provided the intelligence necessary to make novel (and profitable) services available to customers, such as 800 service (free to caller), calling card services and voicemail.

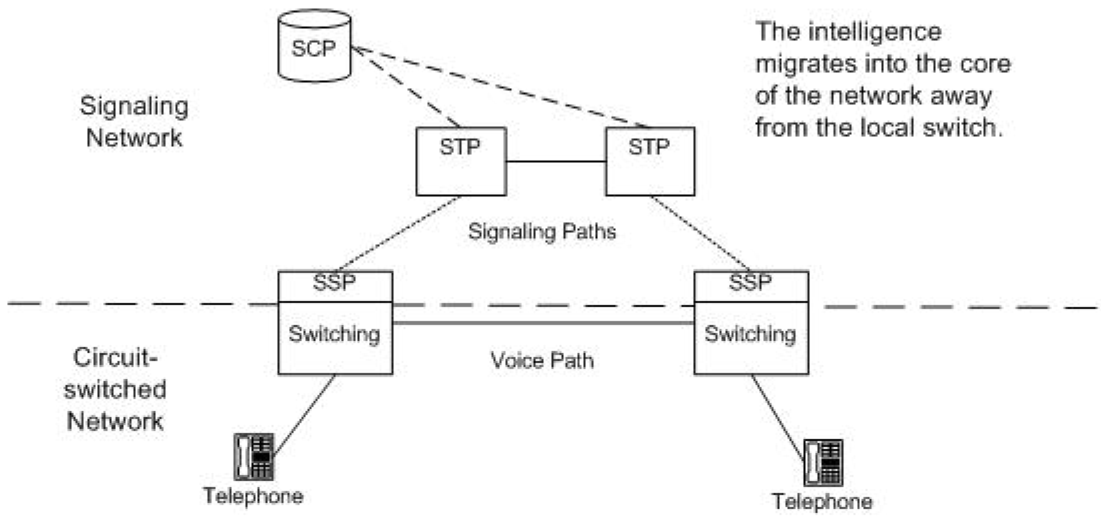

Figure 4. A Simplified View of the Present Telephone Network[45]

Thus, the introduction of the SS7 and the IN profoundly impacted the location of services and functions. Part of the call control that traditionally existed within the switch was off-loaded to an SS7 component within the network referred to as a Service Signaling Point (SSP). As depicted above, this SSP would communicate with other SSPs (associated with other switches) through Signal Transfer Points (STPs).[46] The STP combined high-rate routing with some basic translation services. Additionally, the introduction of the IN extended the SS7 to provide such capabilities as database lookup, announcements and credit card verification through a Service Control Point (SCP).[47] Where intelligence was once housed substantially within the local switch, the SS7 and

[45] *See* Douglas Sicker and Martin Weiss, *Cost Issues of AIN-based Local Number Portability Solutions*, 6th Intl. Telecommunication Systems Performance and Modeling Conference, Vanderbilt University, (1998) [hereinafter Sicker and Weiss].

[46] An SSP is a signaling component in the SS7 that originates, modifies and terminates the calls. They are associated with a telephone switch and contain the software and connections necessary to communicate with other SS7 components. An STP provides the routing of signaling requests among SSPs and SCPs. An SCP provides a database function necessary for call processing, such as number translations.

[47] *See* Sicker and Weiss, *supra* note 45.

the IN operated on a packet-based network to allow for the introduction of profitable services outside of the local switch.

Another fundamental network design change occurred with the passage of the Telecommunications Act of 1996 (Act).[48] The Act obligated the incumbent local exchange carrier (ILEC) to provide a variety of means whereby competitive local exchange carriers (CLECs) could gain access to facilities or services associated with the ILEC's access network.[49] The most notable of these obligations is the availability of the unbundled network element (UNE). UNEs are defined as "a facility or equipment used in the provision of a telecommunications service . . . include[ing] features, functions, and capabilities that are provided by means of such facilities or equipment, including subscriber numbers, databases, signaling systems, and information sufficient for billing and collection or used in the transmission, routing or other provision of a telecommunications service."[50] UNEs initially included local loops, local and tandem switches (including all vertical switching features provided by the switches), interoffice transmission facilities, network interface devices, signaling and call-related databases facilities, operations support systems functions, and operator and directory assistance facilities.[51]

The Act allowed for the unbundling of the local telephone network[52] with the intent that competitors gain access to facilities without which they would be "impaired" operationally or economically, or where an element was "necessary," when considering alternative elements outside an ILEC's network, lack of access to that element would preclude a carrier from providing a particular service.[53] The FCC subsequently interpreted this to include the features, functions and capabilities used in the provision of a telecommunications service.[54] This included physical elements such as the loop or subloop, and logical features such as operator services. Various rulings have changed the original set of UNEs to include (1) the loop and subloop;[55] (2) transport;[56] (3) switching;[57] (4) signaling networks;[58] (5) call-related databases;[59] (6) OSS functions;[60] and (7) Enhanced Extended Links (EELS).

[48] Pub. L. No. 104-104, 110 Stat. 56 (1996) (codified at scattered sections of 47 U.S.C.).
[49] *See id* at §251..
[50] *See* 47 U.S.C. §153(29).
[51] *See Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, First Report & Order*, 11 FCC Rcd. 15,499 (1996).
[52] *See* 47 U.S.C. §251(c)(3).
[53] *See* 47 U.S.C. §251 (d)(2)(A) & (B).
[54] *See Implementation of the Local Competition Provisions of the Telecommunications Act of 1996* (CC Docket No. 96-98) (August 21, 2003).
[55] In particular, mass market loops –e.g., stand-alone copper loop, including x-DSL capable copper loop; narrowband/voice grade portion of FTTH loops *only if* copper loop is retired due to overbuild; hybrid loops –narrowband/non-packetized/voice-grade portion only *or* copper loop alternative; enterprise market loops –dark fiber loops, DS1 loops and some DS3 loops; subloops for multi-unit premises access; and inside wire subloops and NIDS. *See id*.
[56] Specifically, dedicated transport –dark fiber, DS3, DS1 and shared transport –*if* state determined. *See id*.
[57] Note, UNE-P *only for* mass market. *See id*.
[58] Note, *only if* purchasing signaling as a UNE. *See id*.

It is notable that New York, a progressive state in the communications arena, had been developing unbundling plans prior to federal development of UNEs. However, although UNEs had beginnings within a few progressive states, the fact that UNEs were adopted nation-wide under a federal initiative has led to a national (non-local) implementation; whereas UNE adoption on a state-by-state initiative would have potentially led to localization of policy and technology. As described by Weiser, "In this instance cooperative federalism was effectively realized with the states, New York in this case, acting as a laboratory and the federal government stepping in with a cohesive national directive."[61] Management of this plan in fifty-one different ways by the states and the District of Columbia would lead to inconsistencies that could very well thwart the implementation and intended effects of the plan, frustrating the efforts of the intended beneficiaries, the CLECs, and ultimately consumers.

Several UNEs have been deleted from the list because they no longer meet the necessary and impair standard, e.g., operator, database and directory services. When we look at the nature of these elements, we see that some of these services do not exist at the local switch. For example, operator services can be (and are) provided from remote locations in the network. The non-local nature of these services explains, in part, why they do not meet the 'necessary and impair' standard, in that such services can be provided elsewhere in the network by the competitor. Since these services can now be obtained by a provider other than the incumbent, it pushes them away from meeting the "necessary" standard.[62] It is also worth pointing out that some of these elements (e.g., directory services) are following the same path of delocalization as the network is in general.

The creation of UNEs modularized and delocalized the network by segmenting portions of the network and by parsing out service functions to make them available to competitive providers.[63] UNE creation had a secondary effect of further delocalization by pushing some services to be offered outside the local office, within the network by alternative providers (non-ILECs).

At the same time, several forces seem drive the reluctance of incumbent phone companies to invest in new technology. First, the constant introduction of new

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[59] Note, *only* 911 and E911 databases *unless* unbundled switching is purchased. *See id*.

[60] Specifically, pre-ordering, ordering, provisioning, maintenance and repair, billing functions and loop qualification information. *See id*.

[61] *See* Weiser, *supra* note 11.

[62] It may be that the 'Iowa Utilities Board decision' led to the proliferation of these services being offered within the network as the court ruled that, "[t]he FCC cannot, consistent with the statute, blind itself to the availability of elements outside the incumbent's network. In addition, the FCC's assumption that *any* increase in cost (or decrease in quality) imposed by denial of a network element renders access to that element "necessary," and causes the failure to provide that element to "impair" the entrant's ability to furnish its desired services . . ." *See AT&T Corp. et al. v. Iowa Utilities Board et al.* (1999). This may have spurred alternative providers to create these services within the network, knowing that CLECs would have to look to them as a provider, and not solely rely on the FCC to give them blanket access to the ILEC's UNEs.

[63] Future work will examine the costs of UNEs, including the cost of the loop, switching, signaling and databases.

technology creates an environment with short technology life spans. This short technology life span is well recognized with personal computers, where consumers commonly replace their computer every 2 years. This same phenomenon now exists (or will soon) in the telecommunications world, where new access technology, such as new generations of digital subscriber line (DSL), emerges every 3 to 5 years. For companies, this means continuously making costly investment decisions in an attempt to track this change, possibly replacing existing technology too soon to recoup a return on that investment. However, the incumbent may be reluctant to invest in high-cost technology that must be shared with its competitor.[64]

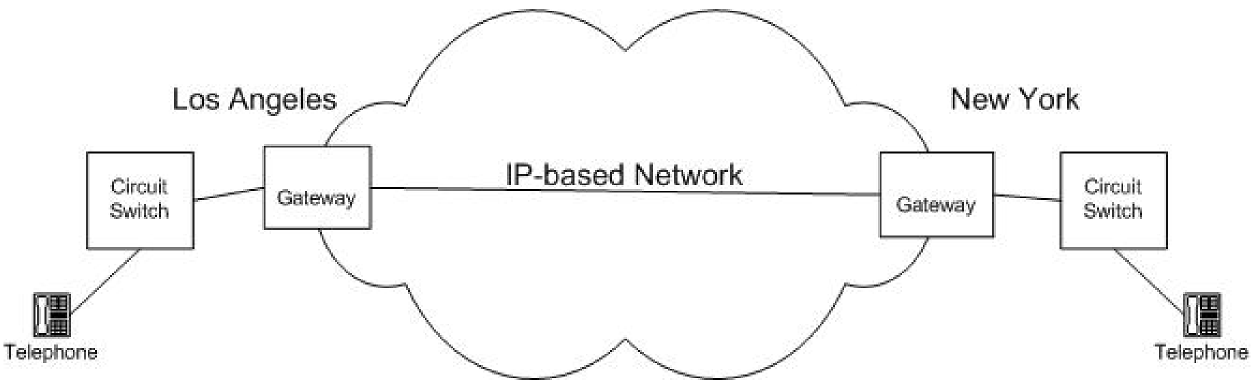

Figure 5. An example of IP-based long-distance bypass

Another substantial network change arrived with the introduction of long-distance bypass through the use of Internet Protocol (IP) based networks. In this model, customers would place a local call to a local telephone number, which would terminate on an IP gateway. This ingress gateway would make use of the carrier's IP-based network to carry the call to a gateway local to the called customer. This gateway would then complete a local call to the called customer. Partial motivation for this technology change was the ability of the carrier to bypass access charges. In this situation, seemingly local calls are actually not local, making jurisdictional tracking difficult and local regulation less logical.[65] As I will discuss, while this arbitrage-based use of new technology is a theme that continues with us today, it should be realized that bypass and arbitrage are not new concepts. Arguably, PBX, private line and enhanced service provider models all 'exploited' regulation.[66] For example, enhanced service providers such as Tymnet and Compuserve offered public packet-switched services, such as electronic mail and content, before the public had access to the Internet. The Enhanced Service Exemption arose in the context of whether a dial-up connection to a packet network (e.g., to Tymnet) was an exchange call or an exchange access (long-distance)

[64] *See U.S. Telecom Ass'n v. FCC*, 290 F.3d 415, 424, stating, "If parties who have not shared the risks are able to come in as equal partners on the successes, and avoid payment for the losers, the incentive to invest plainly declines."

[65] This type of bypass also offered cost savings, in that lower quality (and cost) facilities could be used to transport the traffic.

[66] There were also cases where long-distance carriers used regular flat rate lines to avoid payment; this is similar to recent accusations against some long-distance carriers.

call.[67] The enhanced service providers designed their networks so that users could make local calls to gain access to the enhanced service provider's network and thereby avoid exchange access. This exemption – and hence avoidance of access charges -- formed the basis for much of the subsequent policy regarding access to the Internet.

3.2. Traffic and Cost Characteristics — of the Present Telephone Network

Above, we discussed a number of technology and regulatory influences on the design and operation of the network. All of these influences have had an impact on the traffic and cost characteristics of the present network. With this said, traffic in long-distance and local calls continued to increase at significant rates as prices continued to drop. The same cycle of more efficient technology, increased competition and increased volume continues to fuel these decreasing prices.[68]

3.3. Implications

Unlike the stable, slow technology change of the traditional telephone network, the present telephone network is changing in a much more rapid and less predictable manner. This is being driven by the introduction of new technologies, the competitive pressure to deploy this new technology, and the need for faster depreciation rates on existing technology. An implication of this change is that providers must be able to readily upgrade their networks as technology advances. A regulatory model that creates inconsistencies in how a carrier must deploy its network based on innumerable local requirements will hamper the ability of the carrier to rapidly deploy new technology.

For example, a national carrier decides to deploy a new IP-based voice service that implements a particular design strategy. If one state allows this implementation and another does not, it creates a migration and deployment dilemma for the carrier. For economic efficiency, a carrier would want to deploy a single technology nationally, or across a broad region, but this deployment could be hampered if the technology must go through fifty-one separate compliance reviews. Although the best technical solution may emerge from different regulatory experiments in different states, we must recognize the benefits of uniformity and move toward a cooperative federalism model where a federal directive emerges to create a uniform environment. In other words, while it may be advantageous to allow states to serve as regulatory laboratories, the federal

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[67] *In re* Amendment of Section 64,702 of the Commission's Rules and Regulations, *Final Decision*, 77 F.C.C.2d 384 (1980), *reconsidered*, *Mem. Op. and Order*, 84 F.C.C.2d 50 (1980), *and further reconsidered*, *Mem. Op. and Order on Further Recons.*, 88 F.C.C.2d 512 (1981), *and aff'd*, Computer and Communications Indus. Ass'n. v. FCC, 693 F.2d 198 (D.C. Cir. 1982), *and cert. denied*, 461 U.S. 938 (1983) [hereinafter Computer II Order]. The Computer II Order distinguished between "basic" and "enhanced" services. It defined basic services as "pure transmission capability over a communications path that is virtually transparent in terms of its interaction with customer supplied information," and enhanced services as "any offering over the telecommunications network, which is more than a basic transmission service." *See id*. at 420, para. 96. It further found that it has jurisdiction over enhanced services, but would forbear from regulating them. *See id*. at 428, para. 114. Thus, a dial-up connection to a packet network would fall under enhanced service and would not be regulated.
[68] Other factors such as regulatory arbitrage have also influenced this price/demand curve; however, such factors account for a minor part of the total traffic.

government must ensure that a uniform environment emerges that supports rapid technology adoption and deployment.[69]

In conclusion, the last decade has been marked by a significant increase in the traffic of both local and long-distance calling, with the most marked increase in long-distance calling. Further, the network has continued to delocalize through the heavy deployment of various new technologies: SS7 has shifted control away from the local switch into the network; IN has allowed profitable service provisioning outside the local switch, within the network; and UNEs have segmented portions of the network, parsed out service functions and secondarily pushed services to be offered outside the local office, from within the network.

4. The Internet

This section examines the architectural and operational characteristics of the Internet. As shown below, these characteristics depart substantially from the traditional telephone network, particularly with regard to how the network operates, how a service is provided, and who might control that service. These aspects of the Internet are particularly relevant because they reflect a broader trend for the PSTN and voice service. It is in current Internet characteristics that we can see future trends of even further delocalization in today's PSTN.

4.1. Network Design and Operations

One might think of the design philosophy of the Internet as the inverse of the PSTN. Where the PSTN traditionally places the intelligence in the network, the Internet places the intelligence at the end-point.[70] This design difference is quite substantial when one considers the where, what and how of modern packet services. While many of the characteristics that distinguish the circuit-switched networks from packet-routed networks will be addressed, this will not be an exhaustive review.[71] Rather, this paper describes how packet networks are changing the operation of the PSTN, as the PSTN comes to incorporate features of packet networks more and more.

As depicted in the figure below, the Internet is based on a design philosophy wherein intelligence and control is located at the end points of the network.

[69] *Ibid*., at fn 61.
[70] *See* Jerome H. Saltzer, David P. Reed and David D. Clark *End-to-End Arguments in System Design*, ACM Transactions on Computer Systems at 277-288 (November 1984) at ftp://ftp.isi.edu/in-notes/rfc1958.txt.
[71] Circuit-switched technology is more typical of the PSTN, while packet-switched technology exemplifies the Internet. This is not to imply that all packet networks are based on the Internet Protocol suite.

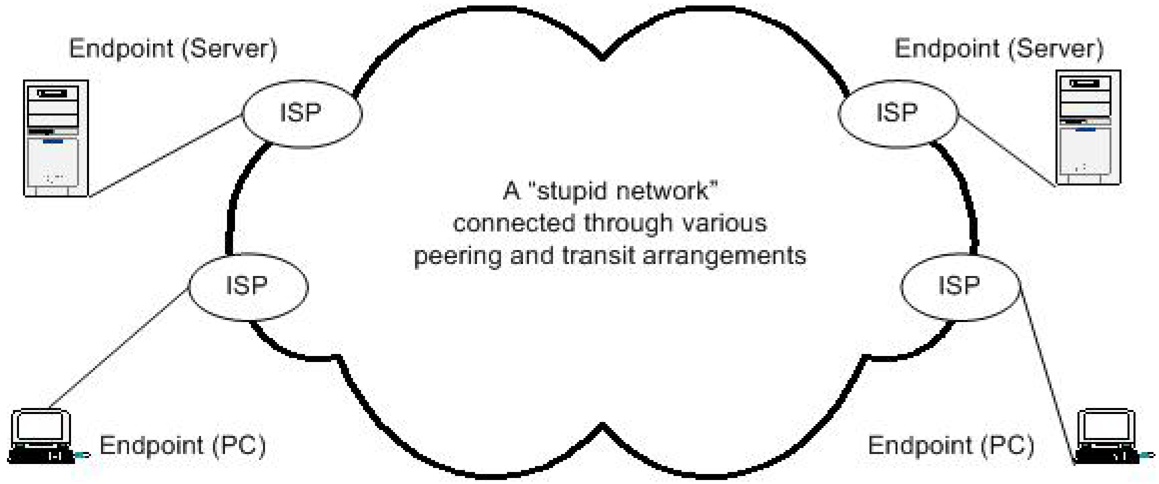

Figure 6. A Simplified Representation of the Internet[72]

Unlike the design of the traditional PSTN where intelligence resides at the local office or within the network, IP-based networks push the intelligence to the endpoints; essentially serving only to route packets among the end points. It is this type of attribute that distinguishes IP-based networks from circuit-switched networks. For example, IP networks are based on routing of packets in a connectionless mode, wherein the data does not travel on dedicated paths as in the connection-oriented circuit-switched network.

The current Internet also operates on the premise of "best efforts," meaning that a packet may be dropped because of congestion within the network. This is fundamentally different from circuit-switched networks, where the call depends on the intelligence of the network to control the connection. In the PSTN a "dedicated circuit" is established by network intelligence and the same route is used exclusively and uninterrupted for the entire session, or duration of the call. While information is not dropped due to congestion in the circuit-switched PSTN, a price is paid in terms of efficiency.[73] IP networks do not rely as heavily on the network to control the connection of "sessions" as is the case in the circuit-switched network establishing dedicated circuits. Rather, each packet is dynamically routed through the network based on information that the packet provides to the network. In a packet network, bandwidth is allocated as needed by the packets entering the network, connections are not dedicated and each packet may use different routes although they are part of the same session/transmission. As described in figure 6, the Internet is based on a "stupid

[72] Adapted from I. Faynberg *et al*, *Converged Networks and Services*, Wiley Computer Publishing (2000) [hereinafter Faynberg]; and D. Isenberg, *Rise of the Stupid Network*, Computer Telephony, at 16-26 (August 1997).

[73] This is not to imply that packet is always more efficient than circuit switching. To understand this efficiency one would have to consider the trade-off of overheads in each technology (e.g., packet headers versus circuit setup and dedicated circuits).

network" concept, where the network provides the minimum of functions, specifically transporting packets.[74]

Further, IP networks push the intelligence and applications (e.g., web browsing, email or instant messaging) out to the endpoints, whether that is the user's computer or a server somewhere out in the network.[75] It is this separation of the application from the network and the distribution of control that hastens the delocalization of the network. If applications are separated from the network and performed by endpoint devices, the need for intelligence and control to lie within the network core is removed.

The packet-based network wreaks havoc with traditional jurisdictional analysis. Whereas with a circuit-switched network, a call traveled a dedicated path along a foreordained geographic path; a packet-based network observes no such constraints. The "best efforts" nature of a packet-based network follows no pre-set pattern of observing hierarchical paths. For instance, a packet-based communication may or may not observe state boundaries, depending on the network conditions of the moment. Thus an intrastate packet-based call may or may not be, in fact, interstate – but the network operator and certainly the regulator cannot tell in advance. At most, with a packet-based network, one can say that a communication may remain intrastate, but not always and not necessarily. Traditional state jurisdictional boundaries simply will not be observed in a packet-switched world.

Another characteristic of the Internet, while not inherent in its design, is its growth. Internet growth is still nearly doubling every year.[76] This growth has implications for technology, innovation, economics and policy, the most obvious of which is how to regulate it, or not, so as not to retard its growth.

Interestingly, some of these differences (between circuit and packet) are what make carrying voice over an IP network (VoIP) difficult. While these difficulties have for the most part been resolved, it does raise a fundamental point. As discussed below, the PSTN essentially evolved with one purpose, to carry voice traffic. The Internet evolved as a data network not tied to any one application. Providing voice service over the Internet in a way that emulates our expectations of 'phone service' has required the development of a variety of new protocols. However, one should not think of VoIP as recreating traditional telephony service. First, the outcome in terms of design and operations is considerably different. Second, the potential for additional IP-based services far outweighs those that could be provided over traditional telephone networks. It is also interesting to consider what is motivating the move toward VoIP. While some claim technical advantage (e.g., lower data rates and increased flexibility), this does not appear to be the true initial motivator. Rather, it appears that cost and regulation (or the lack thereof) are more likely the initial motivators. With this said, I do believe that in the long run, VoIP's true advantages (e.g., integrated networks and flexible service platforms) will be what drives its success.

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[74] *See* Isenberg, *supra* note 72 at 16-26.
[75] *See* Saltzer, Reed and Clark, *supra* note 70.
[76] *See*: http://www.research.att.com/areas/transport_evolution/oft.internet.growth.pdf

As stated, in the Internet model, the network does not specify or control the services that are provided, as is the case for the traditional phone network; rather this control and specification resides in the endpoints. The Internet model's relevance to this discussion has to do with what this means for locally provided services, i.e., services provided by the central office. Clearly, as service specification and control moves out of the network and toward the endpoints, the role of the central office changes. Specifically, it becomes more simplified. For example, the local switch (or whatever it evolves into) might no longer be involved in the call other than to route or transport packets. This is not to imply that the voice service will exist solely at the user's endpoint. Rather, it is more likely that a variety of models will exist, with various service functions provided throughout the network, maintained and controlled in various ways by either the user or network provider(s). Practical operational constraints (for both the user and the network provider) as well as profit models will motivate and influence the outcome.

4.2. Implications

In the traditional circuit-switched network, the voice service and the transport service coevolved. Transport was tailored for the movement of voice traffic and the assumptions that went into the design of the network were based on the requirements of carrying voice. In the PSTN design, the service was provided and controlled by the local switch (in the local exchange office). As the network evolved, new service capabilities were introduced to the network. For example, the advent of the IN brought a number of new capabilities. The trend that this represents is the pushing of network intelligence deeper into the network, and away from the local switch. This is quite different than the design of the Internet. Like the PSTN, the Internet model allows intelligence to migrate. However, in the case of the Internet, the intelligence migrates out of the network and into the endpoints, rather than from the central office into the network. The important difference is that the Internet model distributes this functionality to the endpoints whereas the IN model pushes it further within the network.[77]

The revolution in telecommunications is being driven by the rapid rate of technical innovation and adaptation. This has led to a significant decrease in costs, which only fuels the fires of change. Policy decisions at the federal level to leave enhanced services unregulated opened the door for the rapid and radical development of Internet-based services. The unexpected growth and direction of "all things Internet" shares this technical and economic cycle. As is recognized by a number of commenters, it is difficult for regulation to keep pace with the dynamic world of technology and if it tried, it would only retard that pace.[78] However, the Internet is more than technology — it is the adaptive and flexible services, business models and growth that provide the engine for a vibrant market. It is also the opportunity to move away from the long history of regulation. In fact, attributing too much to the technology of Internet Protocols can lead to irrational conclusions about why and how it differs from other technology. For

[77] There were discussions among carriers and regulators regarding an SS7/IN architecture that provided more control to the end user (essentially distributing functionality), but this never came to fruition.
[78] *See* Jason Oxman, *The FCC and the Unregulation of the Internet* (1999), at www.fcc.gov/Bureaus/OPP/working_papers/oppwp31.pdf.

example, differing the regulatory treatment of two services that operate in nearly identical ways simply because one service runs over a particular technology does not suggest sound or rationale policy. Further, it is far from being technology neutral. Moreover, it misses more important issues, such as concern over market power and support of socially desirable services (e.g., E911).

The fact that voice services defined basic telecommunications points to the narrow nature of the technology and policy. Voice has merely become another application in the IP space, and this has caused an appreciable regulatory quandary. The implications are best realized when we consider how the PSTN and the Internet are interconnecting to provide voice service. Initially (and as described earlier in the long-distance bypass example), the Internet (or an IP-based network) provides an alternate technology (and an alternate regulatory) path for the carriage of voice traffic. However, this simple 'data carriage model' is evolving to include a much broader set of services (e.g., multimedia content) and functions (e.g., user-specified operations), which are at the heart of the Internet model. The consequence of this design, as we will discuss in the next section, is that the future networks based on Internet Protocols will provide voice (or more aptly communication) services in ways quite different from the PSTN. While the traditional Internet model, as I have just described, may not remain unaltered through this period of convergence, it is likely that voice service providers will adopt many aspects of this model.[79]

In conclusion, the Internet model is a highly distributed, application independent approach to moving or using data. It does not respect traditional state/federal jurisdictional boundaries. Indeed, the Internet architecture precludes honoring the geographical bounds upon which the federalist regulatory approach has been historitcally premised. Further, as we have discussed, the differences between this approach and the approach used within the traditional PSTN are numerous. While the specific implications of Internet design on the future network are still uncertain, it is certain that carriers will adopt many aspects of the Internet model. Further, it is certain that this model will result in a continued delocalization of the network.

5. Future Networks

This section examines what future networks will look like, focusing on their likely architecture, operations, traffic and cost characteristics. Much of this examination focuses on the service architectures, not the physical infrastructure. It also addresses a rather interesting conundrum, defining 'voice service' in future networks. This section then considers the potential difficulties that might arise in a poorly regulated environment.

[79] As I will later elaborate, the concept of what constitutes a voice service provider in the future is open to debate, just as what constitutes a voice service. The distribution of the service (and the associated service providers) creates a variety of potential service models.

5.1. Network Design and Operations

In the future, voice service will be highly distributed, and applications, functions and services will exist throughout the network.[80]

There are a variety of trends emerging in the proposed design of future networks. One that stands out in contradiction to the Internet model is the effort by various carriers and vendors to emulate traditional telephony service over IP; this emulation includes the use of standard telephones as the end device. This approach is not surprising given that most users are presumably most comfortable with this end device. In these models, call control and services exist within the provider's network and not in the end device. However, as we will discuss, even these models rely on the distributed nature of IP networks in the manner that they will offer such services. In fact, one could argue that these models continue the trend of delocalization by limiting the intelligence of the customer end point, maintaining intelligence within the network. Unlike the traditional Class 5 switch (the switch that exists in the local end office of the PSTN), the emerging Softswitch technology (defined and described below) divides the call processing from the call transport in a way that supports a highly distributed control model.

Protocols that interface the Internet with the PSTN are being used to create Class 4 and Class 5 replacements.[81] This technology, based on Softswitch architectures,[82] is the next step in the evolution of the circuit-switched network to packet voice networks. Some of the early implementations of Softswitches were for the offloading of Internet bound dialup traffic. This implementation grew out of a need to reduce the load on the PSTN switches created by the long holding times of Internet users.

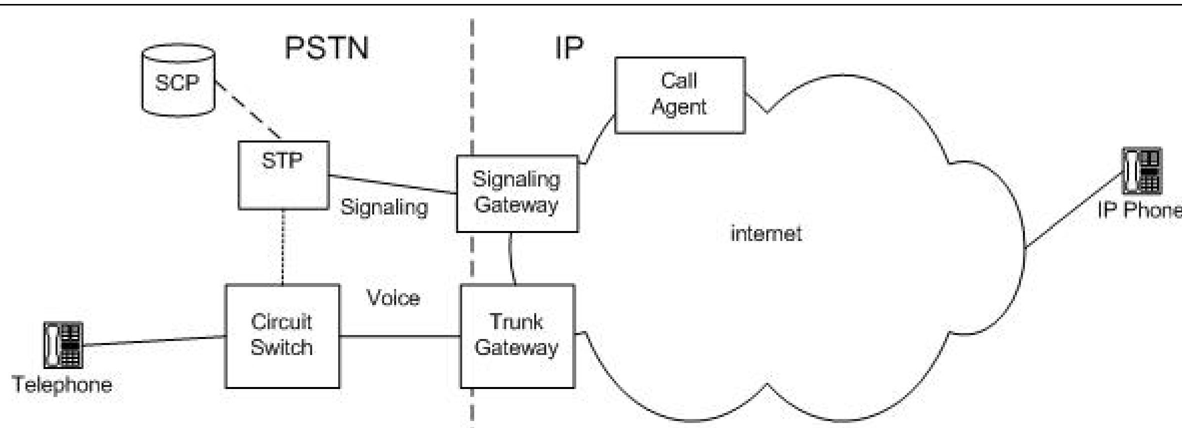

Figure 7. Future voice over packet model based on Softswitch architecture

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[80] Most all networks are experiencing the transformation toward packet technologies. As these various networks evolve to carry converged traffic (e.g., voice, video and data), an interesting design convergence is occurring. For example, the architectures of cable and telephone networks are beginning to resemble each other ever more closely.

[81] *See* Faynberg, *supra* note 72.

[82] A Softswitch can be thought of as a decomposed and distributed central office switch and generally refers to the call logic associated with a call or connection.

The evolution of voice services within the modern network provides insight into the delocalization of the network. Again, the term Voice over Internet Protocol (VoIP) describes the use of IP-based networks to carry voice conversations.[83] In this example of VoIP, we consider a particular architecture for voice over broadband networks.[84] It is important to recognize that there are many models for carrying voice over IP and that this approach represents only one of many.

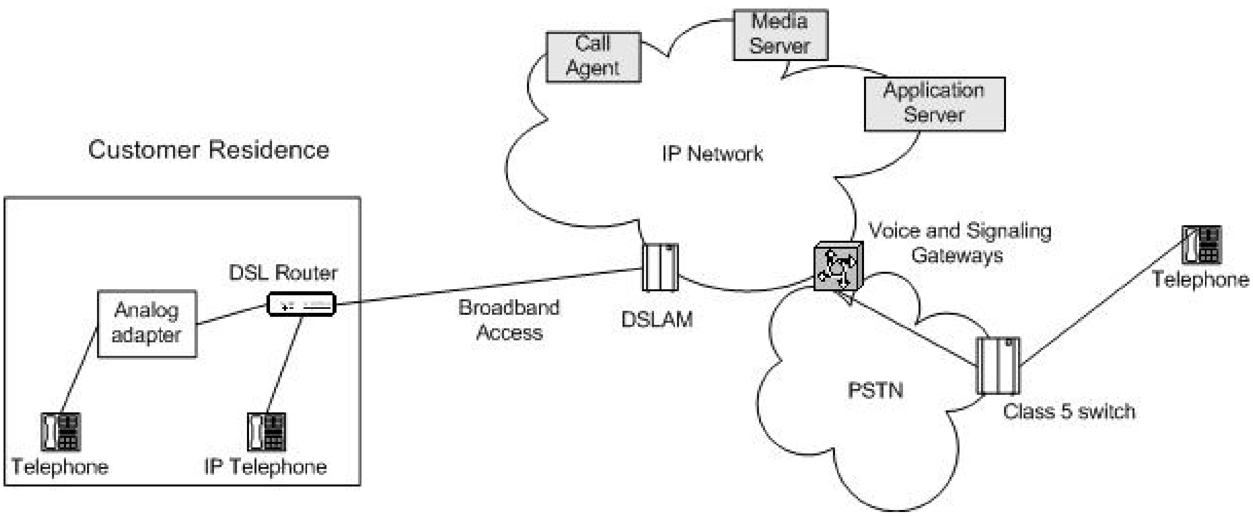

Figure 8. A Future Voice Network[85]

This model does not require an IP-enabled telephone; rather the consumer could use either a traditional telephone or an "IP telephone". As depicted above, the phone would plug into an analog telephone adaptor, which allows the telephone voice and signaling to be translated into formats appropriate for IP-based networks. The communications from the telephone pass through the DSL modem/router and onto the broadband access segment of the network. However, rather than terminating at the central office on a switch for call processing, the call passes through the DSLAM into the IP network, where the actual voice service is provided by a number of elements including the Call Agent, Media Server and Application Server. These various servers (and the associated service) could be provided by a variety of providers. The point is simply that the voice service now exists in a highly distributed manner with functionality throughout the network.[86]

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[83] Note that IP does not necessary mean the "public" Internet; in fact, a great deal of VoIP is carried over "private" IP-based networks. By private, we mean networks that are not publicly reachable (addressable) over the Internet.

[84] *See* Michael Kende and Douglas Sicker, *Real-time Services and the Fragmentation of the Internet*, Telecommunications Policy Research Conference (2000).

[85] *See* NGN Migration Strategies at http://www.metaswitch.com/news/whitepapers.htm.

[86] The description above is a gross simplification of the operations of such a network and is only intended to demonstrate the delocalized nature of future voice services. In more detailed terms, the call continues through the network to an access gateway (AGW). This gateway provides a variety of functions, the first of which may be to ensure that the call is authorized to be on this network. It also can connect calls to other customers on that network. The AGW connects to the media server, which provides such functions

The above discussion highlights the difficulty of actually defining what constitutes a voice service in a future network. The service can now be offered in a highly distributed manner, wherein the various functions could be cobbled together by the end user or by a service aggregator. Access to this service could vary across devices as users transition among locations throughout their day (in other words, it is not the access device that necessarily dictates the service provider). Now, the voice service is a number of decomposed functions that are assembled in a variety of manners by a variety of entities. The non-local, highly distributed nature of future voice service makes local regulation of such a service much less logical.

5.2. Traffic and Cost Characteristics

Increasing distance and location insensitivity has been a strong trend in telephony and data networking. The cost of transmission (the distance sensitive component) of making long-distance calls continually becomes a smaller fraction of the total cost of the call.[87, 88] Ignoring regulatory compensation obligations, a local and a long-distance call incur similar costs. The recent wave of bundled, flat-rate local and long-distance calling plans best reflects this condition. These plans, which are being offered by both local (e.g., Qwest's "Unlimited Possibilities") and long-distance (e.g., MCI's "The Neighborhood") providers, are usage and distance insensitive.[89] This same model is being offered to customers through a broadband VoIP service, the best known of which (at present) is the Vonage model.[90]

5.3. Implications

The first point to consider is that the networks of the future are already here. A variety of next-generation networks (or service architectures) already exist and providers will steadily deploy more of these networks in the near future. However, there is also a huge installed base of traditional telephony, cable and wireless networks that will not go away anytime soon. Rather, these networks will likely evolve toward a variety of new packet-based models. While these models may not necessarily reflect the end-to-end aspirations of the Internet, they will certainly alter how services are provided and where the intelligence for these services exists.

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as dial tone and message announcements. Again, these gateways may reside anywhere on the network. Another element to consider is the Signaling Gateway (SG), which might translate between IP-based signaling and SS7 messages. The call agent (CA), also called a Media Gateway Controller (MGC), provides the call logic and control of the GW(s). It provides the intelligence that would typically reside in the switch. The CA actually controls the GWs that would interconnect the IP network with the PSTN. Finally, the application server provides service logic for specific applications such as voicemail. The application server provides the VoIP network with the ability to quickly add new services to the network. *See id*.

[87] Morten Falch, *Cost and Demand Characteristics of Telecom Networks*, http://www.lirne.net/resources/tr/chapter09.pdf.

[88] It could also be reasoned that the cost of access networks is also dropping, particularly when considered in terms of bits per second per dollar of new high rate access technology.

[89] *See* Peter Grant and Almar Latour, *Once a Minor Player, Service Captures Growing Share of Home, Business Market*, Wall Street Journal, Oct. 9, 2003.

[90] *See* www.vonage.com.

The model of future networks will resemble the layers of the Internet Protocol suite, with access and transport layers moving data, a control layer providing session and other control, and an application layer providing features, services and applications. As networks evolve, there will be a number of architectural issues to consider. The first will be the location of the service intelligence, which can now reside anywhere in the network. The second is the converged nature of these networks. Various services and applications will ride together over the same access and transport networks. It is important to realize that these trends (in some shape or form) are occurring in all networks. For example, cable and wireless networks are moving toward IP-based architectures, and with this transition they are embracing most, if not all, of the characteristics discussed previously.[91] The third and final issue to consider will be the integration of the new systems with the legacy systems. This last issue raises a number of interesting regulatory issues that are, however, outside of the scope of this paper.

As previously described, the design of future voice services is becoming increasingly more distributed and delocalized. One of the most relevant of these architectural changes is the decomposition of the telephone switch and the subsequent distribution of these functions throughout the network. The functions and services (e.g., call control, features, and functions) no longer need to be provided at the central office as they were in the traditional PSTN. Rather, services will exist as applications provided within the network. Indeed a single service such as voice becomes highly distributed with various aspects potentially provided by multiple providers. The consequence of these trends goes to the thesis of this paper; the delocalization of the networks and services demonstrates the need to move away from local regulatory jurisdiction.

The penultimate consideration is whether consumers will be better off, but an underlying issue is whether regulation will interfere negatively with the technical development of future networks. Below, this issue is examined on two levels —state actions and general regulatory or deregulatory directions.

6. Trends and Consequences

This section of the paper reviews the technology trends occurring in networks and then considers the consequences and implications of this evolution on related policy issues.

6.1. Technology Trends

This paper considers a number of well-recognized technology trends that are influencing the evolution of the network. Of these trends, six are particularly pertinent to the thesis of this paper.

- The first is that the cost of a call is becoming even more insensitive to the distance of that call.

[91] *See* examples at www.packetcable.com.

- The second is the increasing modularity of the network.
- The third is the shift from circuit-switched networking to packet-routed networks.
- The fourth is the separation and independence of the application (voice) from the network.
- The fifth is the irrelevance of geographic boundaries for emerging technology.
- The sixth and final trend is the movement of intelligence and function away from the central office, or the delocalization of the central office.

These trends then end up with the central office of the future being little more than a node that connects users to the core of the network and through that core to services existing throughout the network.

6.1.1. Distance Insensitive Cost

The ever-decreasing impact of distance on the cost of the call cannot be overstated. The cost of transmission continues to become less of the total cost. The actual cost percentage of the call that comes from transmission is now a small part of the total cost, which has the inevitable result of making distance less relevant. Accordingly, the network architecture no longer needs to be optimized on distance, as was the case with the traditional hierarchical design of the PSTN. This distance insensitivity has also led to a network design that is less hierarchical.

6.1.2. Modularity

The divestiture of the Bell System and the *Carterfone* decision began a trend wherein the network became more divided and segmented and subsequently more modular. By modularity, we mean that the network was broken down into components and segments, allowing devices and services to be obtained from numerous providers. This modularity has continued through various technical and policy advancements with the introduction of IP technology being the most recent. However, these modules do not fit well within geographic boundaries because functions and services may now exist anywhere in the network.

6.1.3. Network Digitization and Packetization

The PSTN has been moving toward digital and packet technology for decades. In fact, the core network is based on some type of digital and/or packet technology. More recently, we have seen the introduction of digital and packet technologies into the local loop in the form of various Digital Subscriber Line (DSL) technologies. These technologies will push the packet nature of the network out to the customer's device, which will usher new architectures and services into the PSTN network, locating more control and intelligence outside the local office. The routing functions of communications will likewise become more difficult to trace and will not necessarily follow state boundaries.

6.1.4. Independence of the Application

The trend of separating the application from the network is well understood within the technical community and this separation forms the basis of how applications are developed within the Internet community. The result of this separation is that the control and intelligence of an application can reside entirely on the end device, with no dependence on the network other than to transport bits between sender and receiver. This design approach also allows functions traditionally deployed within the network to migrate to the endpoint, a trend that is paralleled by the migration of applications, thus control and intelligence, from the PSTN local office into the network — delocalization of telephony.

6.1.5. Blurring of Network Boundaries

Eli Noam has described how transmission, switching and networks are blurring the relevance of state borders.[92] This delocalization distinctly applies to switching and to call control. Consider soft switch architectures, where the control and services exist not at the central office but at various points in the network, and where calls are readily moved onto private networks. It has been common (predating the Internet) for a company to route calls over its private network with no deference to state or national borders. It is also known that carriers are routing traffic over longer distances to avoid intrastate settlement charges.[93] Arguably, this type of arbitrage is what voice over the Internet has mirrored. Returning to the VoIP model, software services that control or aid your call setup could exist far from the origin of the call (unlike traditional telephony where the call was controlled from the local central office). In such a model, there is little meaning to geographic boundaries, e.g., LATAs and state borders. Further, in order to avoid certain regulatory obligations a service provider may purposely move components of their network into other states or countries.

6.1.6. Central Office Delocalized

The final trend to consider is the movement of intelligence and function away from the central office, the delocalization of the central office. One might argue that this movement is actually the consequence of the aforementioned trends, which allow the function and intelligence to migrate. Regardless, most carriers are in the process of delocalizing, with softswitch deployment being a prime example. It should be mentioned that there are other versions of VoIP emerging, which also remove the traditional notion of the central office. For example, the recent peer-to-peer Skype service allows end users to communicate directly with each other over the Internet.[94]

[92] *See* Teske, *supra* at note 2.
[93] Various carriers are accusing one another of routing calls in a manner that avoids intrastate settlements. *See Telecom Tangle*, The Wall Street Journal (July 29, 2003).
[94] *See* www.skype.com.

Another service is Free World Dialup, a SIP-based[95] VoIP service that has a substantial number of subscribers.[96]

6.2. Consequences

An interesting consequence of these trends is the difficulty of defining what constitutes future voice services and voice service providers. The service is becoming an increasingly more decomposed and distributed gathering of functions and services potentially provided by numerous entities. In terms of operation, design and function, this barely resembles traditional PSTN voice service.

At this point, it should be rather clear that technical trends are eroding jurisdictional distinctions at all levels. Policymakers who ignore these trends could regulate and unwittingly cut across the evolution of this technology. Misguided or misapplied regulatory mandates could stop innovative service providers, influence or impede network efficiency, or add to the costs for consumers with no concomitant benefit.[97] For example, regulating end-to-end voice over broadband service as a traditional telecommunications service with the concurrent obligations, rather than as a data service, would force costly telecommunications obligations such as access charges, taxation and other contributions (e.g., E911 and number portability) onto a fledgling technology.[98] When adding these costly regulatory obligations to high initial investment costs it may not be profitable enough to continue offering the service. Thus an innovative service would be lost and an alternative provider eliminated.

It would have the additional effect of impeding network efficiency, as it may be the case that the path to a more efficient future network is to shift voice traffic to broadband (packet-based) channels. Lastly, there may not be a benefit to consumers in saddling a start-up, non-traditional provider with traditional telecommunications service obligations in that their portion of the contributions to the regulatory obligations as a whole would be a small portion of the total. Further, it may force the new provider to increase the cost of their service to the point that they could not motivate consumers to switch to their service, or force them to decrease their revenues to the point that this model would not produce enough profit. Thus, misunderstanding the consequence of these trends could potentially have a profound impact on the developing technology.

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[95] Session Initiation Protocol allows for users to directly (or with minimal network assistance) connect with each other over the Internet to establish a session or 'call'.

[96] *See* www.pulver.com/fwd.

[97] It could be argued that small-scale regulatory failures at the state level have limited impact while providing valuable experience without jeopardizing the entire network. However, this ignores the longer-term problems that might arise with a variety of differing state requirements.

[98] This is not to imply that all such obligations are undesirable. However, regulators need to investigate the transition to VoIP with a close eye on which obligations should remain, which should change and which should be removed. It could be logically argued that the exemption of VoIP from access charges would have to go in tandem with deregulating incumbents' so that they have other avenues to regain the lost revenue from the lost access.

6.2.1. Consequences on Jurisdictional Issues

Few functions viewed as local (including some unbundled network elements) are unambiguously local any more.[99] For example, the same facilities are used for accessing local as well as national and international services. However, what is now occurring is a clear trend to migrate the services and functions that ride on these facilities. This trend continues to erode the traditional local nature of telephony service. Further, usage trends continue to reflect increasingly more non-local (long-distance) use. These phenomena continue to evolve over time in a manner that renders the traditional interstate/intrastate (and interLATA/intraLATA) jurisdictional distinction less applicable. Beyond the technical difficulties associated with promoting a localized policy agenda, there are numerous non-technical concerns. Take, for example, the national scope of network operations and planning that most major telecommunications companies wish to undertake. These companies could be forced to implement numerous disparate network designs depending on the desire of each state, leading to longer deployment times (slowing technological advance) and increased costs, and therefore less incentive to deploy new technology.

6.2.2. Consequences on Policy

In contemplating telecommunications policy, market, economic, technical, and policy issues must be considered in unison, recognizing the unique characteristics of each. A market evolves and is defined by the players in that market. The network evolves and is defined by its technology. Policy evolves and is defined by the regulation (or lack thereof).

These elements all evolve, but technology evolves the fastest and in the most unpredictable manner. As such, there are certain benefits to moving towards a deregulatory regime. Noll argues that federal and state regulators are in conflict over the issue of deregulation.[100] He states that whereas a state regulator's motivation is to maintain low local telephony rates through subsidies, federal regulators have a statutory mandate to introduce competition and eliminate those subsidies. While this might be viewed as an oversimplification of motivations, it seems prudent to rely on federal regulators to continue to lead the policy directive of deregulating the network and the services that ride on these networks.

Further, deregulation should continue to be a goal for all regulators. While there may be benefits in the states serving as regulatory laboratories, the federal government should have a vigilant deregulatory posture and preempt when necessary. That said,

[99] The only element that is tangibly tied to being local is the loop (with the possible inclusion of transport). The local loop facilities remain as the one item that maintains this local nature, merely by the fact that it is tied to the local area by a physical presence. Nonetheless, there are numerous arguments that suggest the local/non-local nature of these facilities; this includes the fact that these facilities are used for communications that are outside of the local area (e.g., traditional long distance and access to the Internet). However, clearly, control over the local loop still has significant implications, particularly when market power is considered.

[100] *See* Teske, *supra* note 2.

complete deregulation is politically impossible, as the market simply does not serve certain societal goals such as universal service subsidies.[101]

7. The Conclusion

In this paper, I have examined the evolution of communications networks with a particular focus on design, operations, traffic and cost. The consequence of these observations is that jurisdictional separation becomes increasingly dubious, particularly as services are increasingly no longer provided locally.

As a result of these trends and observations, I see two high-level policy implications emerging as sensible choices given the technical evolution previously described. The first is the need for a more uniform national policy.[102] The second is the need to more actively pursue deregulatory policies.

As the network becomes increasingly more distance and location insensitive and services are more highly distributed throughout the network, local policies could hamstring the deployment of new technology. As voice becomes a more generalized network service, we should seek a more generalized and uniform policy. Several motivations favor a national deregulatory position as the best choice considering the technical evolution we have just described. First, the federal government currently has the mandate and momentum to deregulate. Second, technology trends are rapid, while policy/law is slow to change. Third, the technology is becoming more distributed and this distribution does not follow geographically imposed boundaries or jurisdictional claims. Clearly, certain regulatory decisions should remain at the local or state level; however, the federal government should serve to guide this process. What needs to be realized is that the services that ride on these networks no longer have the same local significance or characteristics.

Modern communications networks have evolved in diverse and distinct environments, as reflected by the diverse and distinct regulatory, economic and technical influences exerted on these networks. These influences have had profound impact on the subsequent development. As technology continues to evolve in ways that eradicate the distinctions between local and non-local communications, so should the policy. This paper demonstrates that, from a technological perspective, the historical rationales for state versus federal distinctions are less valid today than they were for the traditional PSTN, and that traditional notions of jurisdiction could inhibit the emergence and adoption of new technology.

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[101] This is not meant to imply that the states have not served well as laboratories in the past, nor that they should have no say in the regulatory process, but that they should focus on matters that are of a local nature. As this paper illustrates, those local matters are becoming a smaller and smaller part of the communications landscape.

[102] Again, some might extend this argument to indicate a need for uniform *international* policy.

The Progress & Freedom Foundation ■ 1401 H Street, NW ■ Suite 1075 ■ Washington, DC 20005
voice: 202/289-8928 ■ fax: 202/289-6079 ■ e-mail: mail@pff.org ■ web: www.pff.org