

The Changing Role of Telephone Numbers: Do They Provide Incumbent Advantages?

Timothy Denton, BA,BCL
Masters Program, Law and Technology
University of Ottawa

The Changing Role of Telephone Numbers:	1
Do They Provide Incumbent Advantages?	1
1. Theses and Scope of the Paper.....	2
2. The Law and Institutional Arrangements governing Numbers.....	4
a) The Telecommunications Act	4
b) What are telephone numbers?.....	7
c) The Management of Canadian Telephone Numbers	10
d) The Canadian Numbering Administrator.....	12
d) CISC and the Canadian Steering Committee on Numbering.....	13
e) Dissociating the functions of telephone numbers	19
f) Observations on Code, Architecture and Law	21
3. The Genesis and Development of ENUM	23
a) The basic idea	23
b) What issues are being addressed?.....	26
c) Genesis	27
d) Into the world of telephone numbering.....	28
e) Levels and hierarchy in ENUM	30
f) The flavours of ENUM	31
g) The experience in Country Code 1	33
4. Conclusions.....	39

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

1. Theses and Scope of the Paper

This paper explores the implications for telecommunications competition of the current arrangements for the management of telephone numbers. In part, the paper inquires into the effect of these arrangements on competition, and in particular, whether they provide the managers of these numbers with advantages of any importance.

The paper also tries to describe the effect on the telephone numbering system of rival naming and addressing systems, particularly the domain name system (DNS), which has arisen with the Internet. In this latter regard the theme is simple and unequivocal. As technology has advanced and borrowed ideas made possible by computer-based communications, the formerly integrated functions of telephone numbers have been dissociated into three: identifiers of users, locaters of end points, and instructions to switches.

The question I ask about telephone numbers is whether they will retain and augment their value as identifiers of humans, even as their technical functions as locaters of end points and instructions to switches are superseded. The discussion of that point is framed in terms of the technology called ENUM, which translates telephone numbers into domain names.

Telecommunications are in transition to an all-IP infrastructure, and this involves what for telephone companies is a rapid change to new architectures and business models. As stated previously, circuit switching is giving way to packet-routed signal transport. The

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

business model of reciprocal compensation is giving way to bill-and-keep. Telephone numbers may follow circuit switching into obsolescence, or they may be preserved as identifiers, even as the machinery they used to direct is scrapped.

There are important reasons to preserve the use of telephone numbers. They are non-linguistic, international, compatible with existing and future technologies, convenient, and memorable. They serve a significantly larger installed base of machinery than personal computers. The question I ask, and for which the answer is not yet clear, is whether the ways they are managed will respond rapidly enough to allow for their continued use, or whether they will eventually join milk bottles and rotary dial telephones as artifacts of a bygone era.

The opportunity to preserve the value of telephone numbers is inherently of limited duration, in my opinion. The Internet has a notorious ability to move around obstacles in unforeseen ways. Rivals systems of identifier, especially the domain name system, function well now and could easily supersede telephone numbers entirely in the future. The governance of these newer systems of identifier is independent of that of the telephone numbering system. For example, the domain name system is the principal, though by no means the only, rival to the telephone numbering system. It was devised in the more free-wheeling atmosphere of the Internet, and has grown rapidly in popular acceptance. The final question, as yet unanswered, is whether the governance of the telephone numbering system will adapt fast enough to preserve the usefulness of telephone numbers as the underlying signal transport systems are replaced. The premise

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

of my argument is that telephone numbers, however important they are today, will decline in relative importance if they remain tightly bound to a signal transport system that fails to adapt to the architecture of the Internet. Such a decline may seem a far-fetched idea, but we should recall that Morse code was in its time the ubiquitous signal protocol of the telegraph age.

The more likely outcome, in my view, is that rivals to the telephone system, mainly the cable industry, seeing the value of telephone numbers, will accelerate deployment of network architectures that use telephone numbers to find end-points, but which pass through telephone company equipment as little as possible on the way between customers.

2. *The Law and Institutional Arrangements governing Numbers*

a) The Telecommunications Act

In Canada's *Telecommunications Act*¹, carriers have certain privileges which are generally not available to other enterprises. They include special powers to break up roads and highways, and to cross land for the purpose of building their transmission infrastructure. Those concerning roads are found in the *Telecommunications Act*.

¹Telecommunications Act (1993, c. 38)

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

43. (1) In this section and section 44, “distribution undertaking” has the same meaning as in subsection 2(1) of the *Broadcasting Act*.

(2) Subject to subsections (3) and (4) and section 44, a Canadian carrier or distribution undertaking may enter on and break up any highway or other public place for the purpose of constructing, maintaining or operating its transmission lines and may remain there for as long as is necessary for that purpose, but shall not unduly interfere with the public use and enjoyment of the highway or other public place.

In further subsections of section 43 the CRTC may be called upon to adjudicate the terms on which the carrier may proceed. Likewise, in section 46, provision is made for carriers to proceed with expropriations.

46. (1) If, in the opinion of a Canadian carrier, the taking or acquisition by the carrier of any land, an interest or, in the Province of Quebec, a right in any land without the consent of the owner is required for the purpose of providing telecommunications services to the public, the carrier may, with the approval of the Commission, so advise the appropriate Minister in relation to Part I of the *Expropriation Act*.

Further subsections of s.46 elaborate on the process to be followed. These legal privileges are extremely important in the construction of facilities. It is at the physical level that network owners have their principle economic advantages over potential rivals. Few

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

private agencies in society have comparable powers: electrical and natural gas distribution undertakings are among the very few who do.

Our concern is with telephone numbers and their governance. Section 46.1 of the Act sets forth the law on the subject. By amendment passed in 1998², numbering was passed from the Department of Industry to the CRTC.

46.1 The Commission may, if it determines that to do so would facilitate the interoperation of Canadian telecommunications networks,

(a) administer

(i) databases or information, administrative or operational systems related to the functioning of telecommunications networks, or

(ii) numbering resources used in the functioning of telecommunications networks, including the portion of the North American Numbering Plan resources that relates to Canadian telecommunications networks; and

(b) determine any matter and make any order with respect to the databases, information, administrative or operational systems or numbering resources.

² 1998, c. 8, s. 6.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

46.2 (1) The Commission may, in writing and on specified terms, delegate any of its powers under section 46.1 to any person, including any body created by the Commission for that purpose.

2) For the purposes of sections 62 and 63, a decision of a delegate is deemed to be a decision of the Commission.

46.3 (1) Subject to subsection (2), a delegate may charge rates for exercising delegated powers.

2) The Commission may regulate the rates charged by a delegate, whether by requiring pre-approval of the rates or otherwise.

(3) Notwithstanding the *Financial Administration Act*, money collected by a delegate is deemed not to be public money.

46.4 The Commission may regulate

(a) the manner in which any person provides services relating to any of the matters referred to in paragraph 46.1(a); and

(b) the rates, whether by requiring pre-approval of the rates or otherwise, charged by the person.

b) What are telephone numbers?

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Canada is part of Country Code 1 and participates in the [North American Number Plan \(NANP\)](#)³ with the USA and 17 Caribbean nations. In the North American Numbering

Plan, telephone numbers take the characteristic form

1-nxx-nxx-xxx, where

- 1 is the digit representing the whole plan to the rest of the world,
- n is any number between 2 and 9, and
- x is any number between 0 and 9.

The first nxx is known as the area code, known to telephone number administrators as the Number Planning Area (NPA), and the second nxx is the central office code, known as the CO code.

As section 46.1 of the *Telecommunications Act* makes clear, the regulatory powers of the Commission over the arrangements to manage telephone numbers are complete. But what are telephone numbers, legally?

Discussion of the legal nature of telephone numbers is sparse. They are treated as a finite public resource, like letters of the alphabet, or the system of numbering itself, and so incapable of appropriation. A review of the documents and practices relating to telephone number management indicates that various rights or interests may be held by carriers and users in telephone numbers, but that these rights or interests do not amount to appropriation, either by users, who hold them for a while on conditions and for payment,

³ <http://www.nanpa.com/>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

or by carriers, who manage them under a system sanctioned by law and by treaty, in the case of the International Telecommunications Union.

One administrative document governing number assignments in Canada is “The Canadian Central Office Code Assignment Guidelines”⁴. It deals with the arrangements for the management of the North American Numbering Plan, called NANP, the telephone numbering system in North America.

The document states⁵:

“2.1 The NANP resources are considered a public resource and are not owned by the assignees. Consequently, the resources cannot be sold, brokered, bartered, or leased by the assignee for a fee or other consideration except in a manner consistent with Commission direction. (e.g., a Commission-approved tariff)

“If a resource is sold, brokered, bartered, or leased for a fee in a manner inconsistent with Commission direction, the resource is subject to reclamation by the administrator.

2.2 “NANP numbering resources shall be assigned to permit the most effective and efficient use of a finite numbering resource in order to prevent premature exhaust of the NANP and delay the need to develop and implement costly new numbering plans.

⁴ Version 7, Approved by Telecom Decision CRTC 2006-4, 26 January 2006, found at <http://www.crtc.gc.ca/public/cisc/cn/CNODGL0002A.doc>

⁵ Ibid., at pp 1-2

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

“2.7 Administrative assignment of the CO Code public resource does not imply ownership of the resource by the CO Code Administrator nor the CO Code Holder to which it is assigned.”

Telephone numbers are managed as a *public resource*. As we shall see in the administrative arrangements for assigning and recovering telephone numbers, no one, not even the managers of telephone numbers, claims untrammelled property rights to assign, dispose, hold, or own outside of agreed procedures, managed under the supervision of the national regulator, and coordinated in an international system which looks to the North American Numbering Plan for area codes and eventually, to the International Telecommunications Union for ultimate questions.

c) The Management of Canadian Telephone Numbers

There are three levels to the management of the telephone numbering system.

1. **The International Telecommunications Union (ITU)**, a treaty-based international organization for telecommunications, which sets the standards for telephone numbering plans. The standard is referred to as Recommendation E.164, and in the jargon of the trade, E.164 numbers are telephone numbers conforming to the ITU recommendation for numbering plans. Recommendation E.164 involves the assignment of number prefixes to each country code administrator.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Wikipedia⁶ defines E.164 as

“**E.164** is an [ITU-T](#) recommendation which defines the international public [telecommunication numbering plan](#) used in the [PSTN](#) and some other data [networks](#). It also defines the format of [telephone numbers](#). E.164 numbers can have a maximum of 15 digits and are usually written with a + prefix.”

2. **The North American Numbering Plan Administration**, or NANPA, which creates and assigns area codes (Number Planning Areas) for North America and the Caribbean.

The NANP describes itself as⁷:

“The North American Numbering Plan (NANP) is an integrated telephone numbering plan serving 19 North American countries that share its resources. These countries include the United States and its territories, Canada, Bermuda, Anguilla, Antigua & Barbuda, the Bahamas, Barbados, the British Virgin Islands, the Cayman Islands, Dominica, the Dominican Republic, Grenada, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks & Caicos.

“[Regulatory authorities](#) in each participating country have plenary authority over numbering resources, but the participating countries share numbering resources cooperatively.

⁶ <http://en.wikipedia.org/wiki/E.164>

⁷ http://www.nanpa.com/about_us/abt_nanp.html

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

“AT&T developed the North American Numbering Plan in 1947 to simplify and facilitate direct dialing of long distance calls. Implementation of the plan began in 1951.”

The North American Numbering Plan Administrator (NANPA) is the agency that carries out the directives of the US federal regulator, the FCC, to manage the numbering system in a competitively neutral manner. The contract to perform this function is let by the FCC. The company that has won this contract to carry out the functions of the NANPA is Neustar. Numbering resources that have been assigned to Canada are managed by the arrangements described below.

3. Canada has both a policy advisory body for numbering and an administrator of numbering resources. The Canadian Steering Committee on Numbering (CSCN)⁸ sets policy for numbering under the general supervision of the CRTC. The Canadian Numbering Administrator (CNA)⁹ executes numbering assignment and recovery functions on behalf of the carriers who compose the consortium to which the Administrator is contracted.

d) The Canadian Numbering Administrator

“The mandate of the CNA (Canadian Number Administrator) is to provide a numbering administration [service](#) to the Canadian telecommunications industry under contract to the Canadian Numbering Administration Consortium Inc.”¹⁰

⁸ <http://www.cnac.ca/cscn/cscn.htm>

⁹ <http://www.cnac.ca/about/mandate.htm>

¹⁰ <http://www.cnac.ca/about/mandate.htm>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The Consortium that lets the contract to the CNA is composed of certain types of carrier only. The CNA website describes the qualifications as follows:

“The CNAC operates under a Unanimous Shareholder Agreement (USA) which defines the mandate, governance and operation of the corporation. Any entity that is an Incumbent Local Exchange Carrier (ILEC), a Competitive Local Exchange Carrier (CLEC), an Independent Telephone Company, a Canadian International Carrier, an Interexchange Carrier or a Wireless Service Provider (WSP) may voluntarily choose to become a shareholder of the CNAC. Internet Service Providers, Paging Service Providers, Resellers and End-Customers are not currently eligible to be shareholders unless they otherwise satisfy the shareholder eligibility criteria.”¹¹

The functions and procedures of the CNAC are set forth in a document called “Canadian Adjunct to the 900 NXX Code Assignment Guidelines”, which is found as hyperlink from the main CISC procedures and documents page at the CRTC website.¹²

d) CISC and the Canadian Steering Committee on Numbering

The policy advisory function for numbering is carried out by the Canadian Steering Committee on Numbering (CSCN). This is a committee on which all those who are

¹¹ http://www.cnac.ca/cnac/cna_consortium.htm

¹² <http://www.crtc.gc.ca/public/cisc/cn/CNODGL0006A.doc>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

interested in numbering issues may participate. The CSCN operates as a subcommittee of the general industry forum, called the CRTC Interconnection Steering Committee, or CISC. The CISC was a creative response to the eruption of technical issues that followed the decisions of the CRTC to permit interconnection, and therefore competition, between carriers. We shall discuss the working style of the CISC and then explore further the work of the CSCN.

The CISC

The Mandate of the CISC is described in its Administrative Guidelines¹³:

“The mandate of the CISC is to undertake tasks related to technological, administrative and operational issues on matters assigned by the Canadian Radio-television and Telecommunications Commission (CRTC) or originated by the public, that fall within the CRTC's jurisdiction.”

The CISC was called into being by the CRTC. It was

“established pursuant to Implementation of Regulatory Framework - Development of Carrier Interfaces and Other Procedures, Telecom Public Notice CRTC 96-28, 1 August 1996, to identify issues and propose solutions for consideration by the Commission.”¹⁴

The CRTC found that

¹³ Administrative Guidelines, version 1.1, 31 March 2001, at <http://www.crtc.gc.ca/public/cisc/c-docs/CISC2001-03-31.doc>

¹⁴ Telecom decision CRTC 97-8, at paragraph 9

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

“the input and assistance of the CISC and its working groups to be of great value. The CISC brings together participants of the industry in working groups under the guidance of the Commission.”¹⁵

The *Administrative Guidelines* describe a consensus process of decision making:

“broad and consistent achievement of a consensus resolution is a fundamental expectation and the reason for the existence of the CISC.”¹⁶

While the Commission is the ultimate arbiter of disputes arising from CISC sub-committees, the general pattern of work is

- the production of papers by a sponsoring organization, called “contributions”
- the careful commentary upon and going over of the paper “contribution” in established committees,
- the sending of a consensus report upwards to through the full CISC committee to the CRTC.

The telecommunications industry, like other technically complex industries, is characterized by a relatively benign and cooperative approach to the setting of standards and procedures by which their markets can be made to work. Competition can and does take place in standards-setting, but the process itself is characterized by rational discussion and consensus seeking, wherever possible. The CISC was created to allow interested parties in the industry to work out technical issues attendant upon the CRTC’s decision to allow local voice competition.¹⁷

¹⁵ Ibid., at paragraph 10

¹⁶ Operating Principles of the Administrative Guidelines, page 1, note 12 *supra*.

¹⁷ <http://www.enac.ca/cscn/cscn.htm>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The CSCN

The Canadian Steering Committee on Numbering works under the general *Guidelines* for the CISC, and has a few rules and procedures of its own. The mandate of the CSCN is described in the CRTC's relevant webpage¹⁸ as follows.

“The CSCN is a Working Group of the CISC and addresses numbering issues that fall under the jurisdiction of the CRTC. The CSCN establishes numbering administration guidelines which the Canadian Numbering Administrator (CNA) follows to provide numbering administration functions for the Canadian telecommunications industry. SAIC Canada currently performs the CNA role under contract to the Canadian Numbering Administration Consortium (CNAC), which is authorized by the CRTC to hire a contractor to perform the CNA function. The CNA works cooperatively with the North American Numbering Plan Administrator (NANPA) to ensure effective and efficient use of North American Numbering Plan (NANP) resources.”

Pro-competitive decisions of the regulator have set the agenda for the CSCN, first as regards local number portability¹⁹, and then later wireless number portability²⁰. While the CSCN's regular work consists of the husbanding of numbering resources, major

¹⁸ <http://www.crtc.gc.ca/cisc/eng/cisf3f.htm>

¹⁹ Telecom Decision CRTC 97-8 of May 1, 1997 mandated local number portability between LECs and CLECs, at paragraph 282.

²⁰ Telecom Decision CRTC 2005-72 of 20 December 2005

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

innovations set by the federal regulator, such as wireless number portability, have prevailed over routine administration.

In its wireless number portability decision, the Commission reversed its earlier opposition to wireless number portability, citing the following:

“The Commission considers that permitting wireless carriers to access LNP systems would expand the benefits of number portability to wireless customers and to those wishing to switch from wireline to wireless and vice versa. The Commission considers that allowing subscribers to retain their current telephone numbers when they switch service providers is a key element in minimizing the inconvenience and, in the case of businesses, avoiding potential loss of business and unnecessary costs of having to change stationery, letterhead and advertising materials. In the Commission's view, customers should be given the widest possible choice of service providers to meet their needs, and there should be minimal inconvenience, risk and related costs when changing service providers.”²¹

The Commission further directed²² wireless providers to become voting shareholders of the Canadian Local Number Portability Consortium, the industry group that manages local number portability.²³

²¹ Ibid., at paragraph 30 of the Decision

²² Ibid., at paragraph 41 of the Decision

²³ Its website is <http://www.clnpc.ca/>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Decisions of this nature reinforce the impression gained from a reading of the *Telecommunications Act* that the major policy decisions affecting numbering are implicit in the CRTC's regulatory powers and are not hidden away in obscure technical procedures manuals. Nevertheless, the fact that only certain kinds of carrier have rights to be assigned telephone numbers, biases policy towards those who are so privileged. The privileges are subtle. Those who do not enjoy them may be denied numbering resources if regulation breaks down. This could happen in two ways:

- the market is completely deregulated and the incumbents find it not in their self-interest to lease numbering resources at any affordable price; or
- the actual administrator of numbers ceases to act impartially according to public rules and acts capriciously towards certain parties.

From my observations of the process over the past year and a half as co-chair of the CSCN working group on ENUM, coupled with observations made in a different capacity in the mid-1990s, I see no biases which are not simply result of public, approved and legal institutional arrangements already described.

There is much evidence that telephone numbers are, on the whole, managed in a technically neutral way and without bias towards competitors. In conversation with Doug Birdwise, Chairman of the CSCN, I asked him about the neutrality of the CSCN as regards all participants.²⁴ He replied, "*At the present time* we try to address issues as the CRTC directs". He alluded to some past restrictive or unfair behaviour of previous CSCN administrations after emphasizing "at the present time".

²⁴ Telephone conversation December 4, 2006. Mr. Birdwise has been quoted with his permission.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Numbers are made available to competitors within the confines of publicly known rules, the administration of which is mainly concerned with the rational management of a finite resource. Canadian regulation has directed number policy to accommodate the convenience of the public, and this has led to the increasing portability of numbers in both the fixed and wireless markets. Our limited human memory means that people want to keep telephone numbers even when we change locations, and most importantly, service providers. The federal regulatory agency has directed the regulated entities to accommodate this desire, even if it has meant considerable inconvenience for the carriers to adapt.

Nevertheless, telephone numbers are a scarce resource managed by a consortium of certain kinds of carriers, and not others. Those carriers who do not own facilities are inevitably placed in a subordinate position in that they have no rights to numbers apart from commercial arrangements made with those who are endowed with the legal right to numbers. Thus Vonage and other upstarts must lease their numbering resources in conjunction with tariffs for various kinds of interconnection. Should these tariffs disappear, or become cost-ineffective, non-facilities providers would have no capacity to compete using telephone numbers.

e) Dissociating the functions of telephone numbers

Before number portability, the telephone number served as

- The identifier of the user
- The location of the end point

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

- Instructions as to how to reach the end point

The telephone number was originally a geographical concept, identifying the user by a particular location. With the advent of number portability, a complex series of changes have been made necessary. The changes required the development of databases, where the telephone number would remain fixed, but the underlying data would be found in a look-up. Today, telephone communications requires the location routing number (LRN), which actually directs the call to the end point. The customer keeps his identifier, the telephone number, while the underlying machinery is directed by the LRN.

Number portability is maintained under contract to the FCC in the United States and Canada by Neustar, which runs the Number Portability Administration Center, or NPAC. The LRN in principle will also support service provider mobility.

The analogy of telephone numbers to domain names and of LRNs to IP addresses is apt. The domain name remains fixed, while the end point is found by an IP address. The IP address can be dynamically assigned, so that the numerical value of the address need not stay fixed. Nevertheless the domain name system (DNS) manages to locate the IP address of the end user through a series of look-ups, which are organized in a distributed system of nameservers under different management in various locations.

A quick look into one's email program will show that changing one's IP address and service provider is a process controlled from the end point – your computer. The nature of the computer system developed on the basis of IP and the DNS moves these decisions

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

to the end user. In the telephone system, implementing these capacities takes much more central coordination, and though the user may call for service or number portability, he is powerless to effect it from his telephone set. The system we shall shortly examine, ENUM, inherently makes possible some of the same sorts of empowerment of the end user, and this was part of its attraction to early enthusiasts. It may also be fairly said that such making service portability easier is not to the immediate advantage of carriers.

f) Observations on Code, Architecture and Law

The use of committees to sort out complex technical issues is increasingly pervasive in the telecommunications and Internet fields. The work frequently involves the creation and specification of markets themselves. In a software-driven industry, where lines of code can determine what the products or services are, how signals can move, and who can move signals, technical specification of procedures is essential to making the goal of interoperability real.

The exhaustive specification of procedures and results in these various documents are characteristic of engineering organizations. There can be no tolerance for underspecifying results if the slightest failure in this regard results in calls not being completed.

The growth of these forums for the resolution of technical questions is consistent with the analysis of Lawrence Lessig, which he developed in *Code and other Laws of*

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

*Cyberspace*²⁵ and *Free Culture*²⁶. In this view there are four different modalities of regulation: law, markets, architecture, and norms. Lawyers are by training most familiar with the law as the supreme organizing principle of them all. By directing our attention to the other forces at work in a market society, Lessig has assisted lawyers to think more broadly about the subject of regulation.

These modalities interact. Laws and regulations derive from the state. Norms derive from society, though they may also be enforced by the state as well as society. “The market imposes a simultaneous constraint upon how an individual of group might behave,”²⁷ even though the market is ultimately a creation of laws and norms. Architecture likewise acts as a simultaneous constraint upon the regulated subject and the other modalities, says Lessig.

In the subject matter that we shall now turn to, ENUM, it is possible to see that innovators are creating technical arrangements that constitute *architecture* in the sense in which Lessig is using the term. If this technical architecture solves problems for carriers or consumers, it is possible that it will be introduced in the carrier market for the resolution of calls in an IP environment, or directly for consumers, in a similar manner to domain names.

²⁵ Lawrence Lessig, *Code and Other Laws of Cyberspace*, New York, Basic Books, 1999, ISBN0-465-03913-8

²⁶ Lawrence Lessig, *Free Culture*, New York, Penguin Press, 2004, ISBN 1-59420-006-8

²⁷ *Free Culture*, op.cit, page 122

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The development of ENUM illustrates the influence of existing legal and regulatory arrangements on the development and testing of the architecture. In this we are enabled to see how the different legal arrangements (including treaty-based institutions) governing telephone numbers have influenced the emergence of ENUM, which has its origins in the world of the Internet, which is governed by different structures of authority and informed by different ideas.

3. The Genesis and Development of ENUM

a) The basic idea

As we transition to VoIP, it becomes more and more important for devices to be able to interconnect from the world of IP addressing to that of telephone number addressing, and back. In order to interconnect, a device needs both an IP address, so that it can be found on the Internet, and a telephone number, so that it can be found through the PSTN. One way to do this would be to load each gateway between the Internet and the PSTN with the both addresses. But if the IP device is numbered dynamically, that is, it gets a temporary IP address, or if the subscriber changes location, or service provider, or the primary gateway fails, the call cannot be completed. Clearly a more dynamic system of location must be available.

The second feature that must be built into such a translation system is adaptability to the various services that a telephone number will support. These include faxing, paging, and text messaging, and special numbers such as 1-800. A set of services associated with the

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

same telephone number must be able to be mapped to a set of IP servers, rather than a single server with a single IP address.

On the side of the DNS, a number of records can be associated with the same domain name. Each record can specify what is to be done with a voice call, a fax and so forth. ENUM uses the DNS to map a telephone number onto a collection of service-specific *Uniform Resource Identifiers (URIs)*²⁸.

At its simplest, ENUM is a protocol of the Internet Engineering Task Force (IETF) that turns E.164 telephone numbers into fully qualified domain names. These domain names allow one to reach a Uniform Resource Indicator (URI). This is a location on the Internet, or in a private network, where a variety of information may be stored, the effect of which allows the calling party to reach the called party by one or more paths, using one or more service providers.

In the original idea of ENUM, called *public* ENUM, the called party could specify what paths could be used to reach him according to various criteria, such as time of day, or by which device. The main point of convenience was that only one number would be necessary to reach all the called party's devices.

²⁸ This explanation follows that of Geoff Huston, "ENUM – Mapping the E.164 Number Space into the DNS", in the *Internet Protocol Journal*, www.cisco.com/warp/public/759/ipj_5-2.pdf

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

I shall try to reduce the technical terms to an absolute minimum necessary to convey the themes of this paper. Unfortunately, an irreducible minimum of terms must be introduced.

The basket of information containing the URIs is called a Naming Authority Pointer²⁹, inelegantly rendered as the NAPTR. NAPTR records would define the services a person had subscribed to, and the carrier or carriers that would be used. The services would be pointed to by the URIs in question.

Immense numbers of articles and technical presentations have discussed ENUM. It is very easy to get lost in the detail. For the moment I want to make a simple point about its implications.

Very basically, the use of ENUM and other protocols approved by the IETF would, if used

- Unite the address spaces of the domain name system with that of the telephone system;
- Allow carriers or customers to shift calling, and any other form of signal transmission, such as video or text, to an Internet-based architecture, thereby avoiding the public switched telephone network for much or all of the signal path. Thus costs associated with the PSTN could be avoided if the signal path did not need to pass through the PSTN at any point.

²⁹ Specified at <http://www.rfc-archive.org/getrfc.php?rfc=2915>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

- Rely on architectures, principles, and protocols arising from the Internet and its governing bodies, the Internet Engineering Task Force (IETF)³⁰, the Internet Architecture Board (IAB)³¹, and the domain name governance organization, the Internet Corporation for Assigned Names and Numbers (ICANN).³²

In other words, ENUM envisaged, at least in principle, and in its original *public* form, something of a power reversal between the carrier and the user. For reasons we shall explain, the *public* form of ENUM is unlikely to see the light of day. We can speculate on the power of resistance of carriers to any such idea. Nevertheless, there are profound reasons why a carrier would not want to have exposed in the totally public DNS, records pertaining to customers. These reasons are of privacy, on the one hand, and exposure to the various forms of cyber-attack that characterize operations in the DNS. Governments and the public would likewise have cause to be concerned.

b) What issues are being addressed?

In the following sections, I will attempt to trace out two important features of the development of ENUM of relevance to the questions asked in this paper.

- Are legal privileges held by certain classes of carrier over numbering resources significant for competition?

³⁰ Paul Hoffman and Scott Bradner defined the IETF in RFC 3233. “The Internet Engineering Task Force (IETF) is an open global community of network designers, operators, vendors, and researchers producing technical specifications for the evolution of the Internet architecture and the smooth operation of the Internet.” It is unincorporated, and works on rough consensus and running code. Essentially it is an elite of network engineers. See RFC 3233 at <http://www.rfc-archive.org/getrfc.php?rfc=3233>

³¹ The Internet Architecture Board (IAB) is the even more senior set of network architects who supervise the IETF and manage the editorship of RFCs. See <http://www.iab.org/>

³² ICANN is the governing body for the domain name system. See www.icann.org

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

- Does the state-oriented nature of telephone numbering administration produce a demonstrable effect on innovation in numbering and addressing concepts?

In the course of this paper I hope also to illustrate that the very technical complexity of the subject matter has limited the number of people who can participate in the development of ENUM. Many issues are of similar complexity in science, technology or medicine. Here however we are talking about a merging of two enormous technical constructs, the telephone number system and the domain name system, that have practical consequences for people in real life. The effect of this rather small number of participants capable of making original contributions to the subject has, in my view, had certain consequences. It took longer to create consensus about who benefits from ENUM, and how to fix the defects of the original *public* flavour of ENUM, than if broader discussion had been possible.

c) Genesis

The technical specification for the ENUM protocol was devised by Patrik Fällström of Cisco in an IETF document, known as Request for Comments (RFC) 2916, “E.164 Number and DNS”. The RFC has since been updated to RFC 3761.³³

“This document discusses the use of the Domain Name System (DNS) for storage of E.164 numbers. More specifically, how DNS can be used for identifying available services connected to one E.164 number.”

³³ RFC 3761, *The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)* April 2004, at <http://www.ietf.org/rfc/rfc3761.txt> The original RFC 2916 dates from September 2000.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The basic idea was to apply the decentralized and distributed system of the DNS, which is already known to map domain names to IP addresses, and which works world-wide in a hierarchy of look-ups, to the telephone numbering system.

The fact that the idea was first expressed in 2000, and that ENUM is not yet broadly deployed in 2006, indicates that the institutional barriers associated with the use of telephone numbers may have some role to play.

d) Into the world of telephone numbering

From the moment that the Internet engineers sought to bridge the gap between the world of the Internet and the DNS, to the world of telephone numbers, they committed to dealing with certain features of the telephone numbering world. These are distinct from the Internet's characteristic less formal modes of operation, decentralized architecture, and self-organizing governance through the IETF.

- The ITU

The highest level of authority over telephone numbers is the treaty-based ITU, whose recommendation E164 authorizes international and national numbering plans. The ITU is the creation of treaty, and therefore states, not companies, are the primary constituents of the organization. The use of telephone plans inevitably required the authorization of officials of the ITU. The process is called *delegation*. Authority to use E.164 numbers for the purpose of ENUM experiments is delegated from the ITU to states.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The original IETF engineers who produced ENUM entered into negotiation with representatives of the ITU-T for the creation of a name that would designate the root which would lie at the top of the hierarchy of ENUM look-ups. The name of this root showed the union of authorities belonging to the IETF and the ITU – *e164.arpa*. E.164 derives from the ITU plan for telephone numbering schemes; *arpa* derives from “advanced research and projects area”, which is a domain name owned by the Internet Architecture Board.³⁴

- States

The setting up of ENUM trials involves states seeking permission of the ITU to use E.164 numbers. The seeking and the granting of permissions takes place on a state-by-state basis. This is perfectly normal for matters subject to the authority of states, but quite strange by comparison with the launch of technology in markets. It is often remarked that Tim Berners-Lee did not need permission of carriers to launch the protocols that gave rise to the World Wide Web. Nor did Steve Jobs or Bill Gates seek permission state by state to launch their operating systems. The launch of new technologies is normally wholly outside the purview of states, save insofar as intellectual property may be more or less protected. The DNS is known to work on a global scale. Yet the authority structure of telephone numbering follows that of states. Thus delegation of authority to experiment with E.164 numbers has required diplomatic activity with the participating state and the ITU.

³⁴ Learned in conversation between the author and Scott Bradner, chief Privacy Officer for Harvard University and former regional director of the IETF, September 2003, at Wood’s Hole, Massachusetts..

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

e) Levels and hierarchy in ENUM

ENUM look ups would be arranged in a series of tiers, corresponding to levels of authority over the telephone numbering system. The basic functioning of any globally distributed naming system requires levels or tiers, so that a call or inquiry can be bounced to higher levels if the particular number or domain name cannot be found in a particular nameserver or country. Like the country codes in the DNS³⁵, ENUM look-ups would be organized nationally in the following manner.

Tier 0- this is the root of the ENUM look-up system, legally controlled by the ITU. The particular nameserver for the root, *e164.arpa* is managed by the European manager of the country codes, whose name is RIPE-NCC (which stands for *réseau IP européen- network control centre*) in a fine conflation of English and French. RIPE-NCC is located in The Netherlands. Tier 0 would point to country codes, so that if an inquiry bounced up to this level, and the number prefix was 44, say, the inquiry would be directed to the United Kingdom.

Tier 1 – corresponds to the E.164 country code, or a portion of an integrated numbering plan that is assigned to an individual country. Delegations are made by the ITU-TSB (telecommunications services branch) to the entities designated by each country as responsible for the domain corresponding with their country code. In the case of country code 1, which is international, a delegation would be made to an entity selected to manage *1.e164.arpa*.

³⁵ .ca is the country code for Canada, .fr for France, and so forth

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Tier 2 – this level corresponds to the E.164 number itself. The number of service providers at this level is a matter of national administration, and depends on the particular country's competition policies in telecommunications services.

f) The flavours of ENUM

The thinking on ENUM is confined to a small group of people who combine DNS and telephone company experience. It might be reasonable to suppose that, in an environment so technically complex, different policy ideas are expressed in technical language. What is surprising is that there is no agreement on the whom ENUM is intended to benefit.

Following a number of ENUM trials in Austria, Ireland and the United Kingdom, which were concluded in and around 2002, it began to be clear that

- Users would have very little incentive to pay extra for a domain name representing their telephone number, the beneficiaries of which service people trying to reach him.
- The scale problem was insurmountable. That is, in any system where people would opt-in to ENUM, the number of subscribers would be so small that no apparent benefit would accrue to early subscribers. It would be like a universe of a few dozen fax machines. In the words of Richard Stastny, Austria's pre-eminent ENUM guru, the only people who would

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

be interested in using public- subscription based ENUM would be “freaks”.³⁶

- Carriers would not wish to expose information in the public DNS about their customers. By definition, all end-points in the DNS are fully exposed to the public
- Governments continued to be skeptical that the personal information stored in NAPTR records, equally exposed in the DNS, could be made secure from unauthorized prying.

This has led to discussion of what sort of ENUM would ever be successful. Richard Shockey, Neustar’s ENUM evangelist, has for considerable time maintained that large enterprises would benefit from ENUM by diverting traffic off the PSTN³⁷. However, as time marches on, it has become clear that only two flavours of ENUM, private and carrier, are still under serious consideration. Public ENUM will continue to be experimented with, but unless the opt-in problem can be solved, its future is dim. There are also technical issues having to do with whether VoIP providers give their customers a SIP URI. If they do not, then ENUM cannot be used to avoid termination charges, thus reducing the principal economic incentive to subscribe to ENUM-enabled services.

Here is a table showing the attributes of the flavours of ENUM: public, carrier, and infrastructure.

³⁶ Richard Stastny has made this observation at the London ENUM Conference, in June 2005 and earlier in his presentation to VON Europe May 2005, at [http://enum.nic.at/documents/AETP/Presentations/Austria/0053-2005-05_VON_Europe/200505_VON_Europe_ENUM_Update_RStastny.ppt#473.6.VoIP on the Internet](http://enum.nic.at/documents/AETP/Presentations/Austria/0053-2005-05_VON_Europe/200505_VON_Europe_ENUM_Update_RStastny.ppt#473.6.VoIP%20on%20the%20Internet)

³⁷ Mr. Shockey speaks extensively on ENUM. A useful sample is found at http://enum.nic.at/documents/AETP/Presentations/Other/0035-Canada_Shockey_IETF_ENUMForum.ppt

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

	Root	Records	Regulation
public	E164.arpa	One set of customer records	Fully subject to national regulation
carrier	E164.arpa	Two sets of customer records, one the end-user's, the other the carrier's	Fully subject in principle to national regulation
infrastructure	Anything agreed upon	One set of records controlled by the carrier	Outside of regulatory notice or control

g) The experience in Country Code 1

This section deals with the development of a trial framework for ENUM in Country Code 1, and the early stages of conducting a user ENUM trial. The experience on Country Code 1 is unique insofar as special arrangements had to be made for delegation to occur to an entity in Country Code 1 from the ITU, in a manner that could be acceptable to the United States and Canada, as well as the other countries belonging to it.

Chronology

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

- On 27 October 2004, the Country Code 1 (CC1) ENUM Limited Liability Corporation (LLC) was created in the USA by AT&T, Bell South, GoDaddy.com, MCI, SBC Laboratories, Sprint and Verizon to implement ENUM in CC1 and the USA.
- The LLC is seeking to build a commercial implementation consistent with the relevant open standards of the Internet Engineering Task Force (IETF) and the International Telecommunication Union (ITU) upon which ENUM is based.
- On 12 February 2003, the USA Department of Commerce endorsed USA participation in ENUM and established guidelines for implementation (see: www.ntia.doc.gov/ntiahome/ntiageneral/enum/enum_02122003.htm).
- On 9 February 2005, CIRA and the US ENUM LLC signed [a memorandum of understanding \(MoU\)](#) regarding the terms under which CIRA would act, during the trial period, as the Tier 1A registry for ENUM for participating countries in Country Code 1. The establishment of a Tier1A registry allows for the national registry in Canada and the United States to be different, and this registry would be known as Tier1B.

The NTIA's guidelines

The guidelines for implementation were set out by the Department of Commerce, whose telecommunications policy section is the National Telecommunications and Information Administration (NTIA). The head of the NTIA at the time, Nancy Victory, set forth the goals that were to be achieved. They were:

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

6. **Preserve national sovereignty:** Any participation by the United States in a coordinated, global approach must preserve the United States' national sovereignty. That is, the United States and every other participating nation should have the right to determine whether and in what manner ENUM or any alternative is implemented domestically.
7. **Support competition:** Domestic implementation of ENUM must also allow for competition among providers and operators on as many levels as feasible.
8. **Promote innovation:** Adoption of ENUM or ENUM alternatives must encourage innovation and promote advanced voice and data services through new products, services, and vendors.
9. **Protect users' security and privacy:** Domestic implementation of ENUM must be done in a manner that maximizes the privacy and security of user data entered in the ENUM DNS domain. For example, ENUM providers should develop systems to ensure the authentication and authorization of users who enter and update their personal information.
10. **Minimize regulation:** Governance of ENUM on the international and national level must be accomplished through the least regulatory means possible. For example, a coordinated, global approach to ENUM should not give rise to a new regulatory apparatus to govern international and domestic implementation.
11. **Preserve opportunity for alternative deployments:** The implementation of ENUM within the United States must not preclude alternative deployments of ENUM or other solutions that may provide competitive alternatives to ENUM.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

12. **Allow for interoperability:** In order to support competition and the emergence of alternative technologies and networks, the implementation of ENUM within the United States should accommodate alternative deployments' interconnection with the ENUM tree.
13. **Preserve stability and security:** Any implementation of ENUM must not diminish the stability and security of the Internet or telecommunications systems.

On 30 Sept 2005, the CC1 ENUM LLC sent a letter to the 18 other nations in CC1 requesting CC1 Governments to approve the request for temporary delegation of the ENUM CC1 domain to the CC1 ENUM LLC for the CC1 ENUM Trial. This temporary delegation has been achieved. The term of the delegation expires in March 2006, unless renewed, which will require the approval of both the United States and Canada.

Permissions and Conditions Concerning Numbers

On 2 Sept 2005, the US Department of State issued a letter to the CC1 ENUM LLC encouraging the corporation to proceed with requesting other NANP area nations to request the ITU to temporarily delegate the CC1 domain to the CC1 ENUM LLC for the purpose of conducting an ENUM trial. In this letter, the USA Government also established terms and conditions for a US trial of ENUM.³⁸ The CC1 ENUM LLC has

³⁸ <http://www.enumllc.com/USGDeILetter.pdf>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

developed and agreed upon a Framework Document for a US/CC1 ENUM Trials Program.³⁹

The conditions laid down by the United States' Government (USG) in the letter to the ENUM LLC of 2 September 2005 are of particular interest. They illustrate the caution with which the government has approached the whole concept of public ENUM. They also illustrate the plenary authority of government over the issue of access to telephone numbers.

In addition to the requirement to submit to the USG a detailed trial plan, as well as monthly and other reports, the conditions also required the ENUM LLC to seek the permission of the FCC to use numbers dedicated to the trial from available NPA's (area codes). In addition, the trial was not concern itself with carrier or infrastructure ENUM. Only trial participants could use these numbers.

On March 28, 2006, the ENUM LLC submitted what is called a waiver request to the FCC to obtain permission to have appropriate numbers assigned to the trial. At the same time, the participants in the trial organized themselves into what is called the Trial Participants' Advisory Committee (TPAC), which is under the ultimate direction of the ENUM LLC. The TPAC held its weekly meetings and reported to the ENUM LLC on the progress made in developing test cases for the trial.

³⁹ <http://www.enumllc.com/cc1trials.html>

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

No decision has yet been made at the FCC to issue numbers to the US public ENUM trial. All attempts to find out what was going on and why were unsuccessful.⁴⁰ There are two theories why the FCC never acted to supply numbers to the trial. One conjecture, based on the opinion climate in Washington telecom circles, was that institutionally, the new Chairman of the FCC, Kevin Martin, had gutted the section concerning itself with telephone numbers and that responsible people were not available inside the FCC to take up the work of issuing the waiver order. The other was that certain sections of the USG were so concerned for privacy in ENUM that intra-bureaucratic fighting prevented any action on this low-priority item.

In the event the ENUM LLC was finally forced to act. On September 30th, 2006, the ENUM LLC wrote to the US government telling it that the terms of the trial would have to be changed unilaterally by the ENUM LLC to allow trial participants to use their own numbers in the trial.⁴¹ No objection has been raised by any element of the USG to date.

The US public ENUM trial continues. At the same time, a trial of carrier ENUM has also been launched by the ENUM LLC⁴².

In Canada

⁴⁰ As Project Executive of the US public ENUM trial I have learned of these matters through conversations with members of the ENUM LLC and through work activities.

⁴¹ September 30, 2006 *Progress report*, at <http://ustrial.enumllc.com/>

⁴² Its terms of reference are found at http://www.enumllc.com/provider-enum-trial-framework-1_0.doc

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

In Canada a parallel process of development of trial documents has been completed. This work was conducted in the CSCN working group on ENUM over the space of about 18 months. Its final report was delivered to the CRTC on May 16, 2006, and no action has yet been taken by the CRTC. In part this is attributable to the work being conducted on wireless number portability, which occupies the same people in the CRTC as ENUM.

The Working Group's report to the CSCN and the CRTC is found at TIF report #58 at <http://www.enumorg.ca/docs/trials/CNRE058ATrialFramework.doc> . The report called for the creation of a Canadian trial, but the numbering resources to be used would be different from those in the US trials. The Canadian trial would use, if the CRTC approves, a new non-geographic NPA assigned for the purpose of the Canadian ENUM trial framework, that is NPA 688. The use of a special NPA for the purpose avoids some of the concerns associated with using numbers already in use. As for most of the text of the Trial Framework Document, it was borrowed *en bloc* from the US "Framework Document for a US-CC1 ENUM trial"⁴³ and adapted at various places to suit the needs of Canadian participants.

The lack of progress in ENUM in Canada has prompted the Canadian registry, CIRA, to offer a carrier-type address resolution service to cable and other interests. This would still leave the root in e164.arpa, and thereby leave some room for governmental oversight, but would allow rival carriers to have a neutral peering point for the exchange of VoIP traffic.⁴⁴

4. Conclusions

⁴³ http://www.enumf.org/documents/6003_1_0.pdf

⁴⁴ See the announcement of August 2006 by Bernard Turcotte, President of CIRA, on this issue at www.enumorg.ca

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

The paper began with an inquiry as to whether the legal privileges associated with certain kinds of carrier over number were competitively significant. On the whole, it was found that the domestic regulator drives the major policy decisions regarding telephone numbering, such as local number portability and wireless portability. While there could be opportunities for abuse in the current arrangements for obtaining numbering resources, and the head of the CSCN, Doug Birdwise, admitted that competitive gaming had occurred in the past⁴⁵, the work of Canadian numbering administration has settled into a dispassionate execution of assigning, conserving, and re-using a limited resource. Things might be different under different management and policy direction.

At the same time, non-facilities carriers are always at a disadvantage. They have no rights to numbers; they must obtain them at tariffed rates from those who are endowed with the right to be assigned them, the facilities-based carriers. If government policy were to change, and less supervision were exercised over access to numbers by the regulator, then the current arrangements would be unlikely to be sustained.

Thus, in any discussion of opening markets to more competition, and lessening controls over discriminatory practices, it is vital to keep an eye on the possibilities for anti-competitive conduct in various subtle or obvious ways. A policy that did not take account of the legal privileges of some kinds of enterprise over others would discourage investment and innovation in the field. Though competition may be a dynamic discovery process, investors would look with less favour on competing in an industry where legal privileges assisted one kind of enterprise over another. This is clearly the case now in

⁴⁵ Conversation with Doug Birdwise with the author, quoted with permission.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

Canadian telecommunications, and for this reason anti-discrimination measures are to be found in our *Telecommunications Act*.

If a new set of arrangements for addressing and numbering were to be recreated in Canada, would the government find it in the public interest to assign authority over the telephone address space to a closed consortium of facilities-based providers? Or would it not be more advantageous to open the management of numbers to a broader set of enterprises who were able to satisfy some reasonable criteria, such as is the case with registrars in the DNS, who must qualify under rules established by ICANN?

I have maintained that the addressing-identifier system of telephone numbers has strong advantages of language-independence, huge installed base, public comprehension of how to use them, reliability for carriers and global connectivity. The DNS cannot boast of the same advantages to the same degree. Therefore it would seem imperative to the public interest that telephone numbers should be saved, and not pass into obsolescence, like Morse code.

The experience with ENUM is not encouraging in this regard, nor is it a cause for despair. ENUM illustrates, as perhaps nothing else could, that once a technical idea moves into the domain of telephone numbering, a series of consequences is entailed that slows the rate of progress, relative to what would happen if state involvement were not present. At every stage of delegation of authority over telephone numbers, governments have been active. The root e164.arpa had to be negotiated between the IETF and the ITU.

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

National regulatory or foreign policy authorities had to be invoked to get permission to delegate authority to experiment with numbers in e164.arpa, and they must be asked for their assistance again if delegations for the purpose of trials need to be extended.

Oversight of trials is predicated on the notion that user data is insecure in the public DNS.

In the short run, some of those seeking to offer registry services for the telephone numbering system are finding it advantageous to slip out of sight of government regulation. They do so by offering a purely private ENUM service. It is no secret that CableLabs, the US cable research organization, has recently accepted bids for a peering service that would employ ENUM in purely private manner.

Finally, ENUM has not been assisted by the fact that it took at least five years from its inception before it became apparent that public ENUM, the user opt-in kind, as it was first conceived, was likely be a non-starter. In some measure this difficulty of appreciating how ENUM would work in practice has been the result of the very small universe of people actually capable of contributing meaningfully to the subject, technical abstruseness, and the limited opportunities to converse about it with a knowledgeable audience. From my observations over the past several years, even some quite informed people have difficulty with understanding the full technical complexity of the subject and anticipating the problems associated with it for carriers and users.

I conclude that at this stage it is not possible to tell whether telephone numbers will successfully transit to an all-IP era, but the public interest in their doing so is strong, and

The Changing Role of Telephone Numbers: Do they provide incumbent advantages?

this gives me confidence that eventually the technologies, business practices, and institutional arrangements will be found to allow this.