2

The Basic Political Economy of Identifiers

Certain aspects of the Internet governance debate are neither new nor unprecedented. We have decades of experience with the coordination of name and number spaces in other media such as the telephone system. Many of the policy and economic issues are analogous. This chapter attempts to put domain names and Internet addresses into a wider context by exploring some of the common economic and political features of address or name space management.

2.1 Uniqueness Requires Coordination

The fundamental starting point is that addresses must be unique. That is what makes it possible for them to guide the movement of data. Unique identifiers allow automated networks, such as telephone systems or the Internet, to distinguish among what may be millions of different parts.[1] The unique values needed by a large-scale public network cannot be created and assigned in a spontaneous and fully decentralized manner. Random or uncoordinated selection of values might lead to the selection of the same names or numbers by different people. Addressing thus requires some kind of coordinated action.

Coordination takes place at two distinct levels. First, a name space or address space representing a range of values must be defined and agreed upon as the basis for the identifiers. Second, individual values within that space must be assigned on an exclusive basis to specific devices or users. The first step in the process—defining the space—is basically a standardization process; it represents an agreement to use a specific architecture.

The second step—assigning values within the space to particular users or devices—is an ongoing responsibility and must be implemented by an organization.

2.2 Defining the Space

Name and number spaces are everywhere in our technology-saturated environment. Bank ATM cards and credit cards all have numbers assigned to them that must be unique within their particular technological system. Postal codes carve up countries into distinct, mutually exclusive regions. Bar codes in grocery stores are assigned to specific products. Books have their own international numbering standard (ISBN). Almost every durable good we buy has a unique serial number that is part of a number space defined by the manufacturer. The rise of the Internet and the digitization of all forms of information have fomented a great deal of research and experimentation on new ways of naming or identifying information content (Green and Bide 1997).

Depending on the technological, economic, and organizational circumstances, defining an address space can be very simple or very complex. Imagine a simple number space that starts with 1 and goes on to infinity. The first applicant would get the number 1, the next would be assigned the number 2, and so on indefinitely. Such a space would work like one of the "take a number" machines at a crowded delicatessen but with an infinitely large roll of tickets. Such an address space architecture makes it easy to assign values but imposes other costs. A few lucky people would get short, memorable, easy-to-use identifiers; those who came later would get increasingly long, unwieldy ones. In this hypothetical system, the identifier assigned to individuals would not yield information that was useful in running a communication network. All it would tell us is the particular sequence in which people received identifiers. It would tell us nothing about where they were located or how they might communicate with other people on the network. It would also make it difficult for computers or other automated methods to process such addresses efficiently, because they would never know exactly how long the number would be.

The hypothetical example is intended to illustrate some of the choices that must be made in defining a name or address space. Should the unique name or address merely *identify* an item, as a serial number does, or should it *locate* the item, as a Web URL (Uniform Resource Locator) or a telephone number does? Or should it try to do both? Should the address space be flat or hierarchical? A flat space may have difficulty adjusting to rapid growth, but a hierarchical space may impose limits on the mobility of the addressed objects and lead to less efficient use of the space. Should the address be purely arbitrary, or should it embed some intuitively accessible information about the object? There are operational advantages and disadvantages either way.

Table 2.1 provides a summary of some common name or address spaces and their basic features.

The structure of an identifier can be compared to a language that the network uses to talk to itself. The switches, routers, or other machinery on a network can "read" it to better handle the movement of information. A telephone number in North America, for example, has a syntax based on geography or function and the switching hierarchy. The number starts with a three-digit area code associated with a geographical region or special function. If the area code is 800, for example, the user knows that it is a toll-free call and the network knows to which database to go to find out how to connect the call. The area code is followed by a three-digit exchange number and a four-digit line number. The structure plays a vital role in telling the network how to route phone calls.

2.3 Assigning Unique Values

Once an address space has been defined, there must also be coordinated procedures for handing out unique values within that space and attaching them to users or objects. This process is known as assignment. Assigning unique values to individual users or machines can be viewed as an act of technical coordination. But it can have an economic and policy dimension as well. Figure 2.1 diagrams the relationship. Three distinct criteria that can be applied to the assignment of unique identifiers are represented as distinct layers. The first criterion is the technical coordination that ensures

Table 2.1
Summary of Common Name/Address Spaces and Their Features

Name	Owner/Root Administrator	Purpose	Capacity	Architecture
E-164	International Telecommunication Union (ITU), Geneva	To coordinate international telephone dialing	~1,110 country codes; permits 1 billion to 1 trillion national numbers per country	Recommends number prefixes for international calls (00) and domestic toll calls (0); assigns unique country codes (1–3 digits); fixes maximum digits for international numbers (15 digits, excl. international prefix)
"Handles" (Digital Object Identifiers)	Corporation for National Research Initiatives (CNRI), Virginia	To provide persistent unique identifiers for digital objects	No design limits on number of prefixes or suffixes	Two-part hierarchy: a prefix assigned by naming authority and a suffix created by user, separated by a slash "/"; separates location from identification to achieve permanent identifiers
Ethernet (EUI-64)	Institute of Electrical and Electronics Engineers (IEEE), Piscataway, New Jersey	To assign unique addresses for Ethernet Network Interface Cards (NICs)	16 million OUIs (Organizational Unique Identifiers); 1 trillion unique values per OUI	Two-part hierarchy: a 24-bit OUI and a 40-bit Ethernet Unique Identifier (EUI)
ISBN (International Standard Book Number)	International ISBN Agency, State Library, Berlin	To make processing and handling of books more efficient for publishers and booksellers	Number of unique IDs available depends on how much space is consumed by higher-level identifiers. Group ID max = 5 digits; publisher ID max = 7 digits; title ID max = 6 digits	10-digit number divided into 4 parts (separated by spaces or dashes) representing codes for group ID, publisher ID, title ID, and a check digit for error control Convertible into optical bar codes

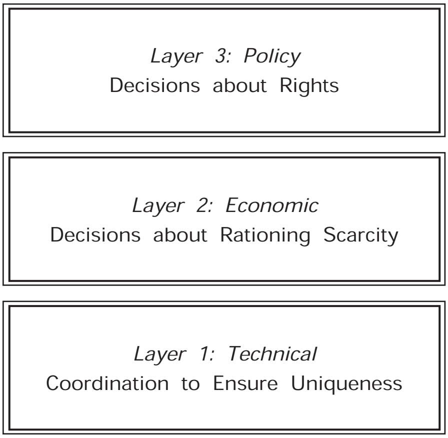

Figure 2.1
Three-layer model of assignment

the uniqueness of the assignments. The second layer is economic rationing, that is, the imposition of rules or procedures designed to conserve the resource space. The third layer consists of rules or policies defining or adjudicating rights to names.

2.3.1 The Technical Layer

Because of the uniqueness requirement, names and addresses in technological systems are almost always exclusive resources, that is, the assignment of a name or address to one thing necessarily prevents another thing from using the same name or address at the same time. Assignment processes must be organized to maintain this exclusivity. Two or three people cannot be given the same Social Security number without disastrous consequences. Multiple computers on the Internet cannot utilize the same IP address or domain name if they are to communicate reliably with the rest of the Internet. Thus, the assignment process must ensure that the process of giving out addresses or names to users is coordinated to preserve uniqueness and exclusivity.

2.3.2 The Economic Layer

An identifier space is a finite resource; it can be used up if it is not conserved properly. In addition to preserving the exclusivity of assignments, there may be a need to control the distribution of identifiers to make sure that the resource is not wasted. Are there enough to go around? Should prices or administrative methods be used to ration the resource space? These are important decisions that must be made by an assignment authority (or someone else). Let's call this the economic layer.

In many respects, decisions about economic rationing methods could also be considered policy decisions. Because the size of address spaces is fixed for a long time by standardization decisions that are costly to change, it is not easy to determine what conservation principles to use or how stringently they need to be applied. However, an economic rationing policy deals with a restricted set of issues. Machine-readable identifiers such as IP addresses, credit card numbers, or Ethernet addresses can be thought of as an undifferentiated pool—all the assignment authority needs to worry about is whether the supply of identifiers is sufficient to meet the quantity demanded for the foreseeable future.

As our society has become increasingly information- and communication-saturated, virtually all the major public network address spaces have had to be expanded. The size of the Ethernet address space (see section 2.5) is being expanded from 48 bits to 64 bits. Internet addresses are (we hope) being expanded from 32 bits to 128 bits. North America altered the syntax of its telephone number plan to make room for many new area codes.[2] Since 1996 the toll-free number space in North America has been given four new toll-free codes to keep pace with demand.[3] Many countries, including China, have moved to eight-digit local telephone numbers.

Often, the reason for expanding the supply of numbers is not that the available space is fully consumed but that assignment practices delegate large chunks of the space in an inefficient manner. U.S. telephone numbers provide a prime example of inefficient assignment practices. The United States was forced to add 119 new area codes between 1995 and 1999 despite the fact that only 5 percent of the 6.4 billion unique numbers supported by the numbering plan were actually assigned. The problem was that numbers were assigned to the telephone companies' geographic subdivisions in groups with a minimum size of 10,000, even when the areas had only a thousand or so telephone lines. Thus, it is difficult for most assignment authorities to avoid using economic criteria in their practices.

2.3.3 The Policy Layer

Assignment procedures may be designed to solve policy problems as well as economic and technical problems. If the identifiers are semantically meaningful, an assignment authority may need to make policy decisions about how to resolve competing claims for the same assignment.

The economics of assignment are profoundly affected by who uses the identifier: is it people or machines? As noted before, machine-readable identifiers such as IP addresses, credit card numbers, or Ethernet addresses are an undifferentiated pool. But when people directly interact with identifiers and when the values identifiers take can be meaningful, the market dynamics become far more complex. It is no longer just the quantity of identifiers but their *quality* that dominates the assignment process.

Think of the difference between two Internet domain names, *df5k67tlh.com* and *music.com*. Both are perfectly functional as Web site addresses, but the semantic features of the latter make it far more desirable. People will pay significant sums of money for vanity license plates on their cars. Businesses will sue each other over toll-free telephone numbers that spell words. Households prefer local telephone numbers that are easy to remember. In Hong Kong the Telecommunications Authority holds auctions for local phone numbers that contain lucky numbers. Domain names in the dot-com space based on common words have changed hands for millions of dollars. Semantics can produce huge variations in the economic value of different identifiers in the same space.

Meaning totally subverts the homogeneity of an address space. No two words or symbols mean exactly the same thing. Hence, no two identifiers are perfectly good substitutes for each other in an economic sense. Furthermore, meaning itself varies with the eye of the beholder. The domain name *df5k67tlh.com* does not seem very valuable, but this assumes that your company's name is not df5k67tlh or that df5-k67-tlh isn't the name of a new wonder drug or a leading rock band. Any apparently meaningless string of characters can become meaningful to some people or acquire secondary meaning through its association with something.

If identifiers are both public and meaningful, legal and policy issues surrounding consumer confusion, fraud, intellectual property, and freedom of speech cannot be avoided. Disputes over who "deserves" a name or who has a legal right to use it will arise. If you have registered the toll-free telephone number 1-800-COLLECT, and a new toll-free code, 888, is introduced, do you have a "right" to 1-888-COLLECT or should someone else be allowed to get it? Would the coexistence of these two numbers confuse customers? Similar issues arise in domain names. Is it legitimate for someone who is not French to register *france.com* or to run a top-level domain *.france*? Even if we agree that the domain should be limited to the French, how does the assignment authority decide which French organization or person "deserves" the name?

Or perhaps the technical coordinating body should not be involved in such decisions at all? In the toll-free number space, the U.S. Federal Communications Commission (FCC) decided *not* to impose trademark protection criteria on the assignments under new toll-free codes, instead leaving such protection to litigation under trademark law.[4]

A few technologists have proposed to solve the policy problems created by semantics by eliminating the meaningfulness of the identifiers. For example, proposals to replace meaningful, memorable Internet domain names with meaningless character strings occasionally are put forward in the domain name debate (Vixie 1995). Such "solutions" are attempts to avoid rather than to cope with the problem. People get involved in business and legal disputes over names because their meaning makes them valuable as identifiers. Eliminating the meaning eliminates the basis for disputes, true, but it also eliminates most of their value. It is like proposing to cure a headache by cutting off one's head.

2.3.4 Portability and Switching Costs

We have seen how the value of an address assignment can be affected by two economic factors: the scarcity of available unique values and the semantic features of a name or number. I now turn to a third economic factor, almost as important as semantics: the equity a user might have built up in a particular identifier. By *equity* I mean the investment a user makes in associating her business or organization with a particular public identifier.

Equity, like semantics, is only an issue when the address is part of the human interface. A business's telephone number or Internet domain name may appear on official stationery, business cards, and in directories or Web site links. Equally important, the name or number will be mentally associated with the business or become a part of the personal records of customers and other contacts. This association is economically valuable and tends to accumulate over time. A user who changes or loses an identifier may sacrifice some of that equity or put it at risk. Most of the money put into publicizing an identifier is a sunk cost; it cannot be recovered.

If an identifier is controlled by a service provider, users who want to change service providers will not only risk losing some or all of the equity in the old identifier; they will also have to promote the new address and compensate for temporary confusion and misdirection among their contacts. These are known as switching costs in economics (Shapiro and Varian, 1998). Switching costs may act as a deterrent to competition by making it more difficult for customers to switch service providers.[5]

Regulators and policymakers have tried to minimize consumer switching costs by promoting the portability of address assignments across service providers. Various forms of number portability are now being implemented in the telecommunication industry around the world (ITU 1999). Toll-free telephone service in North America was the pioneer of number portability.[6] Portability is not an absolute but a quality that is achieved in various degrees. Addresses can be portable across service providers but not across different geographic regions (e.g., you cannot use a North American toll-free number in Europe). Internet domain names have always been portable in the sense that the telecom industry is trying to achieve. That is, the addresses have always been entirely software-based, and assignments have been performed independently of the services provided by infrastructure providers. However, many consumers of Internet services get their domain names from Internet service providers (ISPs) instead of registering them themselves. In those cases, end users are burdened with major switching costs if they attempt to change ISPs. Every time they change their ISP, they must alter their email address, and notify friends and business associates.

2.3.5 Rationing Methods

How then does an assignment authority distribute identifier resources? The economic techniques that can be used to assign identifiers are the same as those that can be used to ration any resource. The economic literature on this issue is vast, but it is rarely applied specifically to name and address assignment, so it makes sense to recount the techniques here.

First-Come/First-Served One common rationing method is first-come/first-served: whoever gets there first can grab whatever he likes. That may seem unfair and inefficient, but it has the advantage of extremely low transaction costs. No one has to monitor behavior or enforce any rules (other than the exclusivity requirement, of course). Thus, first-come/first-served is a rational way to govern access to abundant, relatively low-value resources, such as parking positions in a suburban shopping mall or domain names back when the Internet was small and noncommercial. First-come/first-served is much less problematical when the assignments are homogeneous, that is, when they have no semantic properties. Lawsuits over which organization receives a particular Ethernet identifier are unlikely.

Administrative Fees Administrative fees are another form of rationing. They are charges for identifier assignments imposed on a periodic or one-time basis. The fee amount is basically arbitrary but is used by an assignment authority to discourage those who might consume too much if the assignments were free. The fees may also be used to support the operations of the assignment organization. First-come/first-served methods can be and often are combined with administrative fees.

Market Pricing Market pricing is another common rationing method. Auctions can be used in the initial assignment as a method of resolving contention for resources and to allow the price paid for the assignment to reflect its true scarcity value. A full-fledged market pricing regime goes beyond auctions and allows assignments or entire blocks of the identifier space to be owned and traded. This requires private ownership of parts of the resource space and the freedom of owners to trade those portions in a market. Trading allows the price of the resource to reflect continual variations in supply and demand, thereby creating incentives to use the resource efficiently. Higher (or lower) prices will not only encourage users to find ways to limit (or expand) their consumption but also induce those who might otherwise hoard assignments to release them when the price is right. The transaction costs of creating a market are much higher, but the efficiency characteristics are much better.

Administrative Rules Some assignment authorities will use administrative rules rather than markets to ration scarce number or name assignments. The use of administrative rationing criteria is easier for an assignment authority to implement and more controllable than a market, but it is less able to reflect and adjust to actual supply and demand conditions. As an example, applicants for address block assignments might submit information documenting their "need" for the assignments, and the assignment authority will evaluate that need. This assessment may be guided by simple administrative rules of thumb or by more complex criteria. At best, administrative rules are a low-transaction cost method of conserving a resource. At worst, they create a growing disconnection between the assignment authority and the actual needs and conditions of users. Some country domain name registrars, for example, imposed a rule that only one domain name should be assigned to an organization. That rule made life easy for the domain administrator but was very frustrating to domain name consumers and completely out of touch with the way domain names have come to be used on the Internet.

Merit Distribution Yet another rationing method is merit distribution. Merit-based assignments occur when the authority in control of the space takes it upon itself to base its assignments upon some extrinsic standard of worthiness. Merit assignment can be considered an extension of the administrative rules method. The authority reviews applicants and decides which ones will best fulfill some policy objective. Procedurally, it is a relatively costly method. It requires extensive documentation to accompany an application for an assignment. Competing, mutually exclusive applications may go through quasi-judicial hearings or be put before the public for comment and criticism. Determinations are more discretionary. The process is often referred to disparagingly as "beauty contests." Merit assignments were used by the FCC to assign local broadcasting licenses, and are used by localities to award cable television franchises. Regardless of the efficiency or desirability of merit-based assignment, political reality dictates that it is likely to be used when there are severe constraints on the supply of assignments. If there were only ten telephone numbers to be awarded in the entire world, for example, the process of deciding who got them would be intensely political. Political lobbying and jockeying for influence would almost certainly push the assignment authority into imposing some merit criteria on the awards.

2.4 Governance Arrangements

Assignment requires an ongoing organizational apparatus. Decisions must be made, the organization's full-time staff must be supported, and policies must be defined. This raises all the familiar governance issues: How should that organization be controlled and held accountable? Should it be private or public, profit or nonprofit, regulated or unregulated? Where will its money come from? There is no common pattern, but there is a marked difference between the ways the telecommunication world and the computer/Internet world have approached the governance arrangements surrounding identifier resources.

Traditionally, telephone number spaces were controlled by national post, telephone, and telegraph monopolies. As liberalization of the telecommunication industry introduces multiple telephone companies into most countries, the trend is to take control of the number space away from the telephone companies and make it a "national resource" under the administration of national regulators (ITU 1999). The purpose of nationalization is to equalize competition between incumbent telephone companies and new competitors. National regulators try to achieve numbering parity among the competitors and ensure that all competitors who enter the market have equal access to number blocks, without which they cannot function. Although frequently the actual administration of the number space will be delegated to industry-run self-regulatory agencies, such as the Association for Telecommunications Industry Solutions (ATIS) in the United States, the policies they must follow are defined by law and extensively regulated by public authorities.

There is a different tradition in data communication. Identifier spaces tend to be administered by private sector nonprofit standards organizations, such as the Institute of Electrical and Electronics Engineers (IEEE), the Internet Engineering Task Force (IETF), the World Wide Web consortium, or the regional address registries of the Internet. The policies of these organizations mostly are not subject to specific national laws and regulations regarding identifier policy. Furthermore, the data world tends to operate on a global basis. In the voice communication world, global coordination of numbering was conducted by a specialized international organization, the International Telecommunication Union (ITU). The ITU achieved global compatibility in a bottom-up fashion, interconnecting the otherwise incompatible number spaces of different nation-states by adding higher levels of hierarchy to the number space (e.g., country codes and special signals for international gateways) (Rutkowski 2001). The Internet and the Ethernet, on the other hand, started with a global address and name space; coordination was achieved top-down, through international acceptance of the same address space. Their standards have no territorial dimension.

2.5 An Example: The Ethernet Address Space

Thus far we have looked at the political economy of identifiers in the abstract, with a few examples thrown in for illustration. It might be helpful at this point to discuss a specific example in more detail. Most local area networks use what are commonly called Ethernet addresses. Compared to the political drama surrounding Internet names and numbers, Ethernet addressing has thrived in obscurity. Officially, Ethernet addresses are called Ethernet Unique Identifiers (EUIs).[7] These addresses are burned into the network interface hardware during manufacture.

Ethernet was a standard formalized by the IEEE's 802 Committee, so it is the IEEE that "owns" the Ethernet address space and takes responsibility for managing it. EUI addresses are divided into two parts. The first, 24-bit part is an Organizational Unique Identifier (OUI), a distinct code given to a manufacturer of the hardware in which the Ethernet address will be embedded. The second part is the 40-bit extension (24 bits in the older number space) that is assigned to a particular piece of hardware by the manufacturer. Address blocks are assigned to network component manufacturers by a one-person Registration Authority within the IEEE. The IEEE Registration Authority controls only the assignment of the company identification numbers. It imposes a one-time charge of US$1,250 for the OUI assignment. Once a company receives its own 24-bit identifier, it assigns the remaining 40 bits (or 24 bits in the older space) to hardware components. The full Ethernet address is thus formed from the concatenation of the unique company ID and the company-assigned value. It is a simple, two-part hierarchy.

The older, 48-bit Ethernet addresses gave manufacturers 16 million unique addresses for every organizational identifying number they received. The new EUI-64 space will give them 1 trillion (10^{12}) unique addresses. As a simple conservation rule, the IEEE Registration Authority requires that organizations must have used up at least 90 percent of the available numbers under an existing OUI before they will be assigned another one: "It is incumbent upon the manufacturer to ensure that large portions of the unique word block are not left unused in manufacturing."[8] IEEE does not explain how this rule is monitored and enforced.

The Registration Authority imposes few restrictions on the redistribution of EUI-64 values by third parties. The two most significant restrictions are that only one address value can be assigned to a physical component, and organizations that received OUIs must indemnify IEEE against any damages arising from duplicate number assignments. Other than that, anything goes.

The Ethernet addressing scheme is an organizationally lightweight, technically focused form of address management. The costs associated with using the address space are very low and nonrecurring. Policy for the Registration Authority is set by a Registration Authority Committee composed of about a dozen people, mostly delegates of manufacturers, within the IEEE's 802 Committee. The policy component attached to the assignment of numbers is minimal. Assignment policies are not designed to regulate the market for networking products or to control the behavior of users; they are driven entirely by the need to conserve identifiers, to properly identify the source and type of addresses, and to indemnify the assignment organization against ancillary damages.

Why is Ethernet addressing so uncomplicated? Because there is no human interface. Ethernet addresses are an undifferentiated lot of meaningless numbers. No manufacturer and no individual consumer of a Network Interface Card cares which particular numerical value is on it as long as it is unique. OUIs are addresses of and for machines. Along with this total absence of any human interface goes a near-total absence of politics.

2.6 Review of the Framework

The previous discussion was meant to identify a basic analytical framework for identifier resources. The coordination of unique identifiers takes places at two distinct levels: once when the address space is defined and then on an ongoing basis as specific values within the space are assigned to users. The assignment methods used by an organization can perform three essential tasks:

- Maintain the uniqueness of identifiers by making sure that assignments are exclusive (the technical layer)
- Prevent the resource from being consumed in an inefficient manner (the economic layer)
- In some cases, resolve competition or disputes around particular assignments (the policy layer)

The discussion introduced an important distinction between identifiers that are publicly visible and meaningful and those that are not. The combination of public visibility and semantics makes the policy layer decisions potentially contentious. It also allows end users to acquire equity in the name or address, raising issues of portability and switching costs. Various methods that assignment authorities might use to perform economic or policy functions were surveyed, briefly noting some general performance characteristics of each. Finally, some basic features of the governance arrangements that have been used to control assignment organizations were presented.

In subsequent chapters, the comparative framework will clarify two key questions in Internet governance: What was it about the process of assigning unique values to Internet identifiers that created a major global controversy? and Why did the organizational responsibility for the assignment process become such a ferocious point of contention?