

Thinking About Openness in the Telecommunications Policy Context

Ashish Shah
Engineering and Public Policy
Carnegie Mellon University
ashishs@andrew.cmu.edu

Douglas C. Sicker
Department of Computer Science
University of Colorado at Boulder
douglas.sicker@colorado.edu

Dale N. Hatfield
Interdisciplinary Telecommunications Program
University of Colorado at Boulder
dale.hatfield@colorado.edu

Abstract

In recent years, issues associated with “openness” have taken on increased importance in the development of telecommunications policy. For example, the concept of Open Network Architecture was hotly debated in the context of the Federal Communications Commission’s Computer Inquiry III proceeding. The phenomenal success of the Internet is often attributed to its reliance upon open, non-proprietary standards. Recently, open access has been a contentious topic in terms of cable television company provision of Internet access services. Despite its importance, the term “open” is often not clearly defined, is often taken to mean different things in different contexts and has vastly different implications depending upon what level of the protocol stack is being considered.

It is not our purpose in this paper to advocate any particular degree of openness or to critique past commercial and regulatory decisions dealing with the topic. Rather, in this paper, we seek to explain and to offer a clearer, more unified and consistent definition of what constitutes openness. We do so in the context of the different levels of the protocol stacks that comprise modern data communications networks. We focus particular attention on the Internet suite of protocols (e.g., TCP/IP) and its relationship to the other layers. Where applicable, we identify and describe recent changes in network architectures that impact on the openness in different layers. We also discuss the changing commercial, technological and regulatory developments that might motivate these changes.

1. Introduction

In recent years, issues associated with “openness” have taken on increased importance in the development of telecommunications policy. For example, the concept of Open Network Architecture was hotly debated in the context of the Federal Communications Commission’s Computer Inquiry III proceeding. The phenomenal success of the Internet is often attributed to its reliance upon open, non-proprietary standards. Recently, open access has been a contentious topic in terms of cable television company provision of Internet access services. Despite its importance, the term “open” is often not clearly defined, is often taken to mean different things in different contexts and has vastly different implications depending upon what level of the protocol stack is being considered. Sicker and Mindel point out the broad and varied use of openness in such areas as standards, architectures, interconnection, interoperability, software, and content.¹

It is not our purpose in this paper to advocate any particular degree of openness or to critique past commercial and regulatory decisions dealing with the topic. Rather, in this paper, we seek to explain and to offer a clearer, more unified and consistent definition of what constitutes openness. We do so in the context of the different levels of the protocol stacks that comprises modern data communications networks. We focus particular attention on the Internet suite of protocols (e.g., TCP/IP) and its relationship to the other layers. In undertaking this layer-based analysis, we assess “openness” by asking two questions: (1) can the information be delivered and/or (2) is there discrimination against the delivery of this information? Where applicable, we also identify and describe recent changes in network architectures that affect openness in different layers. Changing commercial, technological, and regulatory developments may also affect openness. For example, an otherwise open network may be closed or partially closed by the use of content filters deployed in response to security threats; by content filters designed to protect a user against spam; or by content filters designed to exclude a competitor’s traffic. In this case, the choice may be prompted by sound security policies, by an individual’s email preference, or by a competitive pressure. The point is that the openness of a system may be altered for various reasons.

We begin this paper with a survey examining the use of the term openness as it applies to telecommunications. The purpose of this survey is twofold. First, it allows us to point out the broad, liberal and sometimes inconsistent use of the term. Second, it allows us to extract some common concepts for what defines openness. Next, we describe existing layered network protocol models and then propose a layered model for examining the issue of openness. Lastly, we apply this model to examine different examples of openness at various layers of the model.

2. A Survey of Openness

In this section, we provide a survey of how the term openness has been used and defined in the worlds of telecommunications and information technology. As we will show, the definition of openness differs substantially across (and within) various domains. Our goals are to:

- Highlight the broad, liberal and sometimes inconsistent use of the term, and
- Attempt to extract some common principles.

While this latter goal may not be possible given the hotly debated nature of the topic, we will nonetheless attempt to identify some common concepts.

¹ See - Sicker, Douglas and Joshua Mindel, “Refinements of a Layered Model for Telecommunications Policy” - Journal on Telecommunications and High Technology Law, Volume 1, Pages 69-94.

2.1. Perspectives on Openness

In this section, we examine the various definitions and perspectives applied to the term openness. We examine openness in terms of other important, related concepts including Open Network Architectures, interoperability, open access, open source, open standards, unbundled network elements, interconnection, proprietary/non-proprietary, and the “end-to-end” design principle.

2.1.1. Open Network Architectures and Interoperability

We first consider the FCC Open Network Architecture requirements. In May 1986, in its Third Computer Inquiry, also known as the Computer III Decision², the Federal Communications Commission (FCC) introduced the concept of an Open Network Architecture (ONA), which represents an attempt to create free market conditions within the telecommunications industry through regulation.

In the Commission’s words: “ONA is the overall design of a carrier’s basic network services to permit all users of the basic network, including the information services operations of the carrier and its competitors, to interconnect to specific basic network functions and interfaces on an unbundled and equal-access basis. The BOCs and GTE through ONA must unbundle key components, or elements, of their basic services and make them available under tariff, regardless of whether their information services operations utilize the unbundled components. Such unbundling ensures that competitors of the carrier’s information services operations can develop information services that utilize the carrier’s network on an economical and efficient basis.”

According to the Open Network Architecture mandate, the carriers were required to provide the independent Enhanced Service Providers (ESPs) access to basic communications services on an equal basis and at an equal cost to those enjoyed by the carriers’ own Enhanced Service operations. Such an architecture was perceived as a means of creating an open market, allowing various service providers to compete on an equal basis.

Hence, in this example, openness refers to access to network elements, interoperability and design. As such, this is a broad application of the term openness in that it includes functional elements (unbundled services), pricing (tariffs) and design specifications. The motivation behind this model of openness was to provide competitors the elements perceived as necessary to build information services.

2.1.2. Unbundled Network Elements

Unbundled network elements or UNEs have important open access implications. Unbundled network elements refer to the parts of the incumbent telecommunication provider’s network that can be leased by competitive local exchange carriers (CLECs). This allowed the CLECs to compete with the incumbent without building or using their own facilities.

The FCC identified certain network elements that must be unbundled, without which the requesting carriers would be impaired.³ These network elements (loops, subloops, network interface devices, local circuit switching, interoffice transmission facilities, operations support system and so on) were

² Computer III Order 1999, 14 FCC Rcd at 4298, ¶ 8 n. 15. See also Computer III Remand 1995, 10 FCC Rcd 8366, ¶¶ 15-16.

³ See – Third Report and Order and Fourth Further Notice of Proposed Rulemaking, In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, released Nov 05, 1999.

required to be unbundled by the ILECs at the request of the CLECs who wished to offer their own service as an alternative to the incumbent's services.⁴

The FCC perceived that access to UNEs would allow new entrants to compete in the market and provide customers with the choice of an alternative service provider. Unlike resale, these new entrants would compete with the ILECs by offering differentiated services and lower price packages.⁵

In this example of openness, the focus is on architectural choice and regulatory obligations, wherein a competitor could openly access elements of the incumbent's network. As in the example of open network architecture, the motivation behind this mandate was to provide competitors the elements necessary to build information services.

2.1.3. Open Access

We next examine open access. Cable open access requires the cable companies to provide multiple ISPs access to their systems. This would enable the competing ISPs to offer their service to customers on the cable platform. However, cable companies are not required by law to open their systems to such competition, unlike the telephone companies, which are subject to regulation as specified under Title II of the Telecommunications Act.⁶ The cable industry is not regulated as a Title II common carrier.

The recent FCC declaratory ruling and notice of proposed rulemaking concludes, "the cable modem service, as it is currently offered, is properly classified as an interstate information service, not as a cable service, and that there is no separate offering of telecommunications service."⁷ Hence, although cable and telephone companies both provide almost substitutable broadband services, they are regulated differently. This issue continues to be a source of great contention. Cable companies deploying broadband technology are bundling ISP services along with their access facilities. This prevents their users from selecting an Internet Service Provider (ISP) of their choice (without also using and paying for the cable ISP). According to Lemley and Lessig, the explanation for adopting such a single-ISP architecture could be that "only by fully controlling content and traffic over the

⁴ Later, the high frequency component of the loop was also added as an element that must be unbundled on a national basis. See - Deployment of Wireline Services Offering Advanced Telecommunications Capability and Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, Third Report and Order in CC Docket No. 98-147 and Fourth Report and Order in CC Docket No. 96-98, 14 FCC Rcd 20912 (1999) (Line Sharing Order). The Commission addressed line-sharing issues in a separate proceeding so that it could more fully develop a record on specific technical and operational issues relating to such unbundling.

⁵ Cable modem and Digital Subscriber Line (DSL) are the two most popular and widely deployed broadband technologies, while other technologies, such as wireless, satellite and power line are still in nascent stage of deployment. Although DSL and cable modem have an almost identical broadband offering, they differ greatly in the way they are regulated. Telephone companies are common carriers and are subject to regulation as specified under Title II of the Telecommunications Act of 1996. Title II requires common carriers to allow other telecommunications carriers to interconnect with their facilities, and it requires them to sell their telecommunications services to other telecommunications carriers for a reasonable price.

⁶ Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (codified as amended in scattered sections of 15, 18 and 47 U.S.C.) [hereinafter 1996 Act]. The 1996 Act amends the Communications Act of 1934, 47 U.S.C. §§151 et. seq.

⁷ See - FCC Notice of Proposed Rulemaking; 'In the Matter of Inquiry Concerning High-Speed Access to the Internet Over Cable and Other Facilities.' CS Docket No. 02-52, March 15, 2002.

network can they reap the profits necessary to finance the upgrade of their infrastructure”.⁸ It makes sense to give the cable operators incentives that would encourage them to invest in broadband infrastructure. However, some may argue allowing them to have monopoly power over a competitive ISP market may not be the best way to provide these incentives.⁹

The FCC has so far adopted a Wait-and-Watch approach in this matter. They indicated that broadband services should exist in a minimum regulatory environment that promotes investment and innovation in a competitive market. However, they also indicated that the Commission must be alert and ready to act against anticompetitive risks and discriminatory provisioning by dominant providers that result in consumer harm.¹⁰ Again, while it is not our purpose here to critique the approach adopted by the FCC (or the industry), such regulatory restraint could come at a price, as it is very difficult to reverse an already adopted technical architecture once the infrastructure is built and investment is made.

In December 2001, Columbia Telecommunications Corporation prepared a report for the American Civil Liberties Union (ACLU) defining cable open access, stating the following.¹¹

This report uses the term "open access" to refer to the ability of competing Internet Service Providers to offer services over cable systems, assuming both of the following essential technical requirements are met:

(1) the technical architecture or its configuration enable ISPs to offer the services they wish without constraints imposed by the cable company for non-technical reasons; and (2) the technical architecture or its configuration precludes the cable company from manipulating or monitoring the content of the data transmissions sent and received by the ISPs' customers. Under this definition, simple access by multiple ISPs (as in the "rebranding" scenario favored by some cable operators) is not open access because the cable company controls the services the ISP can offer and is able to manipulate and monitor data.

In this example (and from one side of the debate), much like unbundled network elements, openness refers to an architectural design choice; one that is linked to the competitive provision of ISP services. Obviously, this architectural choice can be influenced by a commercial motivation or regulation. In the DSL space, open access is driven by regulation. However, since the cable operators are not subject to such regulation, their choice of architecture is mainly driven by technical and commercial motivations or business arrangements.

⁸ See Mark Lemley and Lawrence Lessig: "The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era."

⁹ The consequence of such bundling practices could effectively reduce competition among ISP's serving residential broadband cable. Further, the services offered to the consumers would be determined by the few ISP's either owned or affiliated with the cable company. These ISP's could then have the power to discriminate in the choice of Internet services they allow and the customers would have to accept their choice. This would empower the ISP's and hence the cable companies to control the content and services to which their customers have access. Giving such power to discriminate to the owner of the actual network infrastructure may be viewed as inconsistent with the end-to-end philosophy of the Internet.

¹⁰ In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities: FCC Notice of Proposed Rulemaking, CC Docket No. 02-33.

¹¹ See – "Technological Analysis of Cable Open Access and Cable Television Systems": Columbia Telecommunications Corporation; http://archive.aclu.org/issues/cyber/broadband_report.pdf

2.1.4. End-to-End Design Principle

In this section, we consider the end-to-end network design principle. The success of the Internet is often attributed to its reliance upon non-proprietary standards and open architectures. Part of the open architecture is the notion of the end-to-end design principle. The end-to-end argument is a set of architectural principles that characterize how the Internet has been designed. Specifically, it describes a network design where intelligence resides at the end devices and the network does not impede communications between the end devices. In this section, we describe the underlying concept of the end-to-end design principle and discuss its benefits. Jerome Saltzer, David Clark and David Reed were the first to articulate the end-to-end design principle. According to RFC 1958:

The basic argument is that, as a first principle, certain required end-to-end functions can only be performed correctly by the end-systems themselves. A specific case is that any network, however carefully designed, will be subject to failures of transmission at some statistically determined rate. The best way to cope with this is to accept it, and give responsibility for the integrity of communication to the end systems.¹²

Blumenthal and Clark revisited the issue and described the benefits of the end-to-end design as the following:¹³

- Lower cost in core of network
- User control and power
- Conducive to innovation
- Greater flexibility
- Facilitates competition
- Better reliability

Several of these benefits may be perceived as relating to openness. In terms of user control, rather than relying upon the creativity of a small group of innovators who might work for the companies that control the network, the end-to-end design enables anyone with an Internet connection to design and implement a better way to use the Internet. According to the end-to-end design principle, the network is kept neutral and intelligence resides at the end nodes, users should have the freedom to design any sort of Internet applications as long as they run on the underlying network. The end-to-end principle is still very relevant today and continues to guide technical development of Internet standards.¹⁴

Hence, in end-to-end design, openness refers to the ability to communicate end-to-end and includes a broad range of concepts such as design principles and element behavior. Arguably, the end-to-end design is the broadest application of openness.

2.1.5. Internet Interconnection

In this section, we consider interconnection. While interconnection is itself a broad topic, we focus here on Internet interconnection. One of the most important values of the Internet lies in its ability to connect a user to all other users, independent of their geographical location. This can happen only

¹² See – Request for Comments: 1958, “Architectural Principles of the Internet” available at <http://www.faqs.org/rfcs/rfc1958.html> visited 07/22/2003.

¹³ See – “Rethinking the design of the Internet: The end to end arguments vs. the brave new world”: David Clark and Marjory Blumenthal available at <http://www.ngi-supernet.org/NGI-PI-2000/Clark.PDF> visited 07/22/2003

¹⁴ See – Kempf, James and Rob Austein, “The Rise of the Middle and the Future of End to End: Reflections of the Evolution of the Internet Architecture”, Internet Draft, April 2003 – available at <http://www.iab.org/drafts/draft-iab-e2e-futures-03.txt> visited 08/07/2003

when the huge numbers of networks (LAN, WAN, backbone, etc.) are interconnected to each other through proper interconnection agreements. However, unlike the telcos, an Internet service provider is not regulated under Title II interconnection obligations. Therefore, an Internet service provider must seek commercially based interconnection agreements, which then form the basis for the price, quality and reliability of its connection to the rest of the Internet. As such, this interconnection process is a complex blend of technical and business matters. Two types of interconnection arrangements are common: the peering arrangement and the transit arrangement. In the peering arrangement, the peering partners exchange traffic on a settlement-free basis.¹⁵ In a transit arrangement, one network pays another network to carry its traffic.

Peering arrangements generally take place between equal sized networks with a comparable geographical presence. A large network is less likely to peer with a smaller network since it would not benefit much from the other network's infrastructure and would have to carry a large amount of traffic of the smaller network. In a transit arrangement, the network charging the customer network for interconnection is not only responsible for carrying traffic destined for its network, but also has to carry traffic destined for any of its peering partners. It is common practice for a network to have peering and transit arrangements with other networks. For example, it would make sense for a low tier network to peer with the other local low tier networks and get into transit arrangements with a tier 1-backbone network in order to obtain access to not only those tier 1 networks, but also their peering partners.

The process of gaining a tier one peering agreement (peering with the big backbone providers) was a topic of considerable debate a few years ago; however, this issue has not received much attention lately. Nonetheless, this type of interconnection holds the same potential for abuse as any other interconnection process, wherein discrimination, market abuse and collusion might occur.

In this example, openness refers the ability to negotiate interconnection through a peering arrangement or a transit agreement with another network provider. This process can be driven by regulation or by the market.

2.1.6. Network Neutrality

In this section, we consider network neutrality. An open network typically refers to an architectural arrangement or design, particularly as it relates to access technology. Network neutrality on the other hand is the ability to choose among Internet-based information, products and services. Wu recently addressed the relationship among concepts like open-access, network neutrality and broadband discrimination.¹⁶ According to Wu, a network is said to be neutral if it does not favor one application over another. Amazon.com positioned network neutrality as the freedom of choice in information, products and services. In its comments to the FCC Amazon.com stated, "Amazon.com believes that the most important freedom of choice to preserve and protect in this proceeding (CS Docket No. 02-52) is unimpeded consumer access to all Internet-based information, products and services."¹⁷ They

¹⁵ "The Digital Handshake: Connecting Internet Backbones": Michael Kende: Working Paper – Office of Plans and Policy, Federal Communications Commission.

¹⁶ See – "Network Neutrality and Broadband Discrimination," Tim Wu – available at <http://faculty.virginia.edu/timwu/bbd.pdf> visited 08/07/2003.

¹⁷ See Comments by amazon.com to FCC Notice of Proposed Rulemaking - In the Matter of Inquiry Concerning High-Speed Access to the Internet Over Cable and Other Facilities. CS Docket No. 02-52, March 15, 2002, available at http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513198055 visited 08/03/2003

described various ways in which ISPs may impede consumer access (blocking or redirecting addresses, adopting differing quality of service mechanisms and so on.). Finally, amazon.com stated that network neutrality could be realized by adopting an open-access architecture, a philosophy different from that of Wu. Again referring to their comments, "...if only one ISP were available for broadband access, it would have many economic incentives, and no competition-based disincentives, to impede consumer access to select information, products and services."

Hence, in the context of network neutrality, openness may be defined as nondiscriminatory access to services and products on the Internet.

2.1.7. Open Source Initiative

We next examine open source software. Generally, open source refers to access to source code, made available for use to the public. Open source software is generally developed as a public collaboration and made freely available. "The basic idea behind open source is very simple: When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it, people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing."¹⁸ The concept relies on peer review to find and eliminate bugs in the program code, a process that commercially developed and packaged programs do not utilize. Users/programmers on the Internet read, redistribute and modify the source code, forcing an evolution of the product.

However, open source might not only mean access to source code. Open Source Initiative (OSI) dictates that in order to be considered "OSI Certified" a product must meet certain specific criteria. A few of them are mentioned below:¹⁹

- Free Redistribution
- Source code must be made available and its free distribution must be permitted. Also, the source code should be in a format in which it can be easily modified.
- No discrimination against persons or groups
- No person, group or field of endeavor can be denied access to the program.
- License must not be specific to a product.
- The licensed software should not place restrictions on other software that is distributed with it.
- The license must be technology-neutral.
- The author must allow modifications and derivations of the work under the program's original name.²⁰

The history of the GNU/UNIX operating system is an example that meets the above-mentioned criteria. Although GNU had no technical advantage over UNIX, its principal advantage and selling point was that it was free software. The terms free software and open-source software are often interchangeably used. According to Richard Stallman, "Free software and Open Source describe the same category of software, more or less, but say different things about the software and about values. The GNU project continues to use the term free software to express the idea that freedom, not just

¹⁸ www.opensource.org – 06/25/2003

¹⁹ For a complete list of these criteria and the definition of 'Open Source', see the open source website at www.opensource.com

²⁰ http://www.webopedia.com/TERM/o/open_source.html - 06/27/2003.

technology, is important.”²¹ According to Stallman, the term “free software” is sometimes misunderstood and linked to price. Stallman argues that “free” refers to freedom not in price, but in:

- The freedom to run the program, for any purpose
- The freedom to modify the program to suit your needs (To make this freedom effective in practice, you must have access to the source code, since making changes in a program without having the source code is exceedingly difficult.)
- The freedom to redistribute copies, either gratis or for a fee
- The freedom to distribute modified versions of the program, so that the community can benefit from your improvements

Hence, in this example openness refers to the access to source code and the ability to review, use, modify and distribute it.

2.1.8. Open Standards and Reference Models

We next consider standards bodies. We consider a number of ‘open’ standards bodies, each with a slightly different perspective on what embodies an open standards process.

2.1.8.1. ISO

The International Organization for Standardization (ISO) created the Reference Model of Open System Interconnection consisting of seven layers to describe networked systems. One can think of a reference model or a set of protocols as being open, much like open source.²² The Open System Interconnection defines a reference model for data communication that provides a layered approach to the functions. This ensures that the whole process is divided into manageable pieces, and not one single layer is too complex. Natural boundaries between the functions are used to determine the layers i.e., similar or associated functions are grouped together in one layer. It also ensures that easy changes can be made within one layer, as need arises, without affecting other layers.

Various principles were applied to arrive at the seven layers. The RAD data communications website lists a few of these principles:²³

- A layer should be created where a different level of abstraction is needed.
- Each layer should perform a well-defined function.
- The function of each layer should be chosen with an eye toward defining internationally standardized protocols.
- The layer boundaries should be chosen to minimize the information flow across the interfaces.
- The number of layers should be large enough that distinct functions need not be thrown together in the same layer out of necessity, and small enough that the architecture does not become unwieldy.

²¹ See Richard Stallman, *The GNU Operating System and the Free Software Movement*, in *OPEN SOURCES—VOICES FROM THE OPEN SOURCE REVOLUTION*, available at <http://www.oreilly.com/catalog/opensources/book/stallman.html> visited 07/23/2003.

²² A protocol (or a set of protocols) can be considered to be open if its specifications (source – in the case of code) are open or freely available to the public.

²³ See – “The OSI Reference Model”, available at <http://www2.rad.com/networks/1994/osi/osi.htm> visited 08/29/2003.

Hence, in this example, openness is defined as well-specified interfaces between each layer. This allows different network operating systems and protocols to work together by having each manufacturer adhere to the standard interfaces. This ‘open’ approach is well recognized and applied by most standards bodies, including the two that follow.

2.1.8.2. IETF

The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual.²⁴ The IETF working groups defined and created the routing, management, transport and security standards, which define the Transmission Control Protocol/Internet Protocol (TCP/IP) Suite. The TCP/IP suite is a set of communication protocols used to connect devices on the Internet. As such, it has become the de facto standard for transmitting data over networks. The TCP/IP protocol uses a whole family of protocols, two of which being TCP (a transport control protocol) and IP (a network protocol). The TCP/IP protocol is a layered protocol with each layer corresponding to a different facet of communications. Such an approach allows a single complex job to be broken down in to simpler manageable tasks. The set of protocols used by the TCP/IP suite are public and their details are freely available. Any computer manufacturer or software developer is free to produce software that takes advantage of or uses these protocols. Furthermore, anyone can participate in the process of changing the protocols, through the IETF.

According to Scott Bradner:

The IETF and its standards have succeeded for the same sorts of reasons that the Open Source community is taking off. IETF standards are developed in an open, all-inclusive process in which any interested individual can participate. All IETF documents are freely available over the Internet and can be reproduced at will. In fact, the IETF's open document process is a case study in the potential of the Open Source movement.²⁵

All of the IETF documents are openly available. Even IETF mailing lists and meetings are open, not limited only to members and not requiring a fee. In order to meet the needs of the user and the vendor community, active participation from these communities is encouraged during the standards development process. This open participation allows even students or developers from small startups to understand, and thus make use of, the standards.

Hence, openness is defined to mean open participation, free and widely available documentations, and non-proprietary.

2.1.8.3. IEEE

The Institute of Electrical and Electronics Engineers, Inc., (IEEE) is a non-profit, technical professional association of more than 380,000 individual members in 150 countries.²⁶ IEEE is an organization comprised of engineers, scientists and students. The IEEE is best known for developing standards for the computer and electronics industry. IEEE standards follow a well-defined path from concept to completion, guided by a set of five basic principles: due process, openness, consensus,

²⁴ See - <http://www.ietf.org/overview.html> visited 08/05/2003

²⁵ See – Essay by Scott Bradner, “The Internet Engineering Task Force” – available at <http://www.openresources.com/documents/open-sources/node35.html> visited 08/05/2003

²⁶ See – www.ieee.org visited 08/05/2003.

balance and right of appeal. The IEEE addresses at least two types of openness. One ensures that all interested parties can participate actively in the IEEE standards development process.²⁷ For example, all meetings of IEEE 802 are open to individuals who wish to participate in the standards development, and balance is achieved by encouraging wide points of view from different areas of technology.²⁸ A second type defines an open system, “An open system provides capabilities that enable properly implemented applications to run on a variety of platforms from multiple vendors, interoperate with other systems applications, and present a consistent style of interaction with the user.”²⁹

2.1.8.4. Summary

In this example, openness refers to the variety of perspectives within several open standards bodies. For example, the OSI model stresses the importance of open communication between systems, irrespective of type and manufacturer, by virtue of their mutual adherence to a set of standards. The IETF stresses bottom-up organization, participation and access; where anyone can participate in the development process and all aspects of the process are free and publicly available. Finally, the IEEE stresses that the underlying standard must be vendor neutral, consensus driven and distributed widely. Much of what differentiates these bodies lies in the philosophical differences in the approach to the problem, and is worthy of separate examination.

2.1.9. Proprietary Standards

In this section, we examine proprietary standards. Proprietary standards are common in the market and co-exist along with open standards. In the telecommunications and computer industry, the term proprietary is very often used to mean the opposite of open. Anything proprietary is viewed as one that is owned by a company or an individual. It also implies that the owner of the proprietary content/code/design has not divulged specifications that would allow others to have access.³⁰ While open standards help customers avoid being locked into goods and services from a particular firm, vendors often see themselves as more likely to profit if their proprietary standard is adopted in the market place.

In regards to proprietary standards, openness refers to the degree in which the specifications of a standard are made readily available.

²⁷ See - <http://standards.ieee.org/announcements/backgroundunder.html> visited 08/05/2003

²⁸ The IEEE 802 Local and Metropolitan Area Network (LAN/MAN) Standards Committee has a basic charter to create, maintain and encourage the use of IEEE standards primarily within layers 1 and 2 of the Open System Interconnection (OSI) Reference Model. See “802 perspectives” – available at <http://www.comsoc.org/ni/Public/2001/May/ni802.html> visited 08/07/2003

²⁹ See – 1003.0-1995 IEEE Guide to the POSIX Open System Environment (ANSI/IEEE), ISBN No.0-7381-3138-5

³⁰ However, as Maxwell points out, something that is proprietary can be incorporated into open standards. He states, “Firms have also pressed to have their proprietary elements included in open standards such as those established by the World Wide Web Consortium (W3C) and other standards-setting bodies. Many open standards include material that has been previously patented, but has either been “donated” or is made available on a royalty free basis or on “reasonable and non-discriminatory” terms.” This gives a twist to the term proprietary. Maxwell, Elliot, a talk entitled, “Openness and the Digital Economy: Building on the Past, Shaping the Future,” 2002.

2.2. Common Principles

From the selection of perspectives presented above, one can see the broad application of the term openness. We can reduce the above perspectives to a more limited set of items, including open access to:

- physical elements (e.g., poles, spectrum, UNEs)
- content and resources (e.g., network neutrality, UNEs)
- code (e.g., software)
- specifications (e.g., standards)
- interconnection (e.g., peering or transit)
- participation (e.g., standards)

These items might further be reduced to unimpeded or freely available access to:

- resources
- processes

While recognizing that the above items do not represent all aspects of openness, they do provide an initial point for considering what is common to these items. Further, from this list we can think about what constitutes a reasonable perspective to take when considering openness in the context of telecommunications. As described above, the nature of this openness might vary depending on perspective, situation and element. It is an inherently subjective concept, and as such, it is unlikely that one definition will suffice for all. Nonetheless, we can consider ways of approaching or considering the general concept of openness. To do this, we considered what concepts might transcend the individual application of openness, particularly one that might place it in terms relevant to public policy.

As we survey the above definitions of openness, we find that non-discriminatory access is an integral aspect defining openness in the context of UNEs, cable open access and interconnection. However, this concept only makes sense in terms of a scarce resource. In other words, if there are alternatives to this resource or process, then the issue of discrimination is less concerning. Thus, we can draw these two broad commonalities for a general assessment of openness, as they are shared elements in defining openness across these discrete contexts.

Therefore, the two concepts that stand out in terms of assessing the openness of a resource or process include:

1. Is there discrimination in accessing the resource or process?
2. Is there an alternative to the resource or process?

Therefore, as part of our examination, we consider these questions in assessing the degree of openness of a system. A third concept to consider would be:

3. Is participation in determining the future design or operation of telecommunications being impaired?

We see that the third is just another form of discrimination. In the following section, we describe a model one could apply when making this assessment.

3. Layered Models

Our model of analysis uses the layered protocol model as a lens or framework for analyzing openness. Thus in this section, we provide a brief tutorial on the basic ideas behind protocols and protocol layering. We also describe the Open System Interconnection (OSI) and Transmission Control

Protocol/Internet Protocol (TCP/IP) model and highlight the significance of the layered approach and its impact on openness. We then propose our model for examining openness.

3.1. Protocol Layering

A computer network can be conceived as a series of connections between computers that allow them to communicate. The content, scope, size, speed, and reliability of the network vary depending on its protocols and implementation. Protocols are a pre-established means of communication. They are nothing but a set of valid messages, a set of rules and formats that govern the communication between two communicating peers.³¹ Protocol layering is a common technique to simplify networking designs by dividing them into functional layers, and assigning protocols to perform each layer's task. Protocol layering produces simple protocols, each with a few well-defined tasks. The concept of layering relies on breaking a complex task into smaller subsets, each of which addresses a specific issue. Each layer provides a well-defined set of services to the layers above it and depends on lower layers for its own foundation.³²

The Internet protocols are arranged in essentially independent, unbundled layers with the Internet Protocol (IP) itself at the “waist” of the stack. The protocol stack broadens above the waist to support a wide range of transport and application layers including email, the Worldwide Web, file transfer protocols, remote login, etc. The protocol stack broadens below the waist to ride on a wide range of underlying networks using a variety of technologies including frame relay, ATM, ADSI, fiber optic systems, and so on. Modularity promotes fair and open competition between and among providers of the different layers by allowing competitors to compete with products that will interoperate. The modularity/stratification coupled with openness facilitates the introduction of new transmission technologies and new applications thereby stimulating innovation.

3.2. Open System Interconnection (OSI) Stack

As previously described, the International Organization for Standardization (ISO) created the seven layer Reference Model of Open System Interconnection to describe networked systems. This now familiar model can be depicted as follows:

³¹ For a detailed explanation of protocol Layering, see – “Protocol Layering: An Engineering Approach to Computer Networking” by S Keshav available at http://www.cs.cornell.edu/skeshav/book/slides/protocol_layering/ppframe.htm visited 07/22/2003.

³² See - <http://www.freesoft.org/CIE/Course/Section1/4.htm> : “Protocol Layering,” visited 08/10/2003.

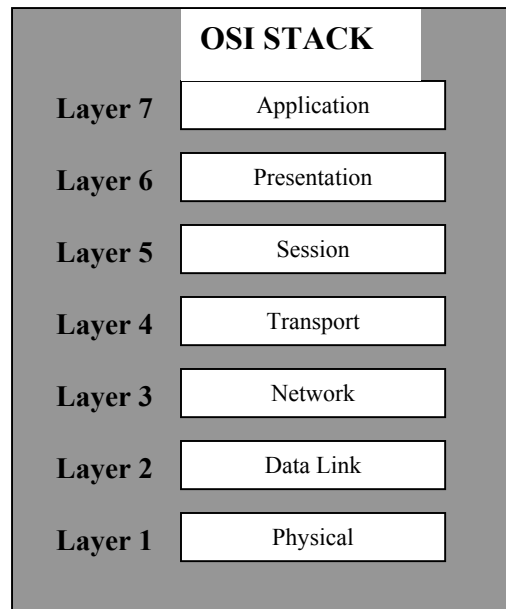


Figure 1: OSI Reference Model

Each of these layers has a set of specific functions associated with it. Starting at the bottom of the stack.³³

Physical: covers the network hardware, physical cabling or a wireless electromagnetic connection. It also deals with electrical specifications, collision control and other low-level functions.

Data Link: attempts to make the physical link reliable and provides the means to activate, maintain and deactivate the link.

Network: provides for transfer of packets between end systems across a communications network.

Transport: provides a mechanism for the reliable, transparent exchange of data between end-points across a network.

Session: provides the mechanism for controlling the dialogue between applications in end systems, such as starting and terminating sessions.

Presentation: defines the format of the data to be exchanged between different applications and offers application programs a set of data transformation services.

Application: Provides entry points for user programs to control transmission of data to and from other machines. It contains management functions and generally useful mechanisms to support distributed applications.

³³ For a detailed explanation on the OSI reference model and description of each layer, see – Stallings, William, “Data and Computer Communications”, Sixth Edition, Pages 51-54 – ISBN no. 81-7808-442-2.

3.3. Transmission Control Protocol/Internet Protocol (TCP/IP) Suite

As mentioned earlier, the term TCP/IP (Transmission Control Protocol/Internet Protocol) actually refers to a whole family of protocols, of which TCP and IP are just two. TCP/IP, developed in 1969 by the U.S Department of Defense Advanced Research Projects Agency (DARPA), is an industry-standard suite of protocols designed to provide high-speed communication network links. TCP/IP protocols map to a four-layer conceptual model known as the DARPA model, named after the U.S. government agency that initially developed TCP/IP. The four layers of the TCP/IP suite are: Application, Transport, Internet, and Network Interface. Each layer in the TCP/IP suite corresponds to one or more layers of the seven-layer Open Systems Interconnection (OSI) model.³⁴

Network Interface Layer: The network interface layer is the lowest layer in the Internet reference model. It corresponds to the physical and data link layers of the OSI model. This layer contains the protocols used to deliver data to the other computers and devices that are attached to the network. TCP/IP was designed to be independent of the network access platform. In this way, TCP/IP can be used to connect differing network technologies such as Ethernet, ATM or Frame Relay. Independence from any specific network technology gives TCP/IP the ability to be adapted to new technologies.

Internet Layer: This layer is responsible for routing messages through networks. The Internet layer is similar to the Network layer of the OSI stack explained earlier.

Transport Layer: The protocol layer just above the Internet layer is the transport layer. It is responsible for the reliability and integrity of the communications. It is similar to the transport layer of the OSI stack mentioned earlier.

Application Layer: The application layer is the highest layer of the TCP/IP protocol stack. It maps to the upper three layers of the OSI model. It provides applications the ability to access the services of the other layers and defines the protocols that applications use to exchange data.³⁵

The TCP/IP protocol suite is quite similar to the OSI reference model and both contributed to the other. The main differences between the OSI architecture and that of TCP/IP relate to the layers above the transport layer (layer 4) and those below the network layer (layer 3). OSI has both, the session layer and the presentation layer, whereas TCP/IP combines them into the application layer. Also, TCP/IP combines OSI's physical layer and data link layer into a network interface level. The figure below shows the basic layering approach in both the schemes.

³⁴ See – Microsoft white paper, “Introduction to TCP/IP” – available at <http://www.microsoft.com/ntserver/zipdocs/TCPIntrowp.doc> visited 08/05/2003.

³⁵ See – Cisco Documentation, “Understanding TCP/IP” – available at <http://www.cisco.com/univercd/cc/td/doc/product/iaabu/centri4/user/scf4ap1.pdf> visited 08/05/2003.

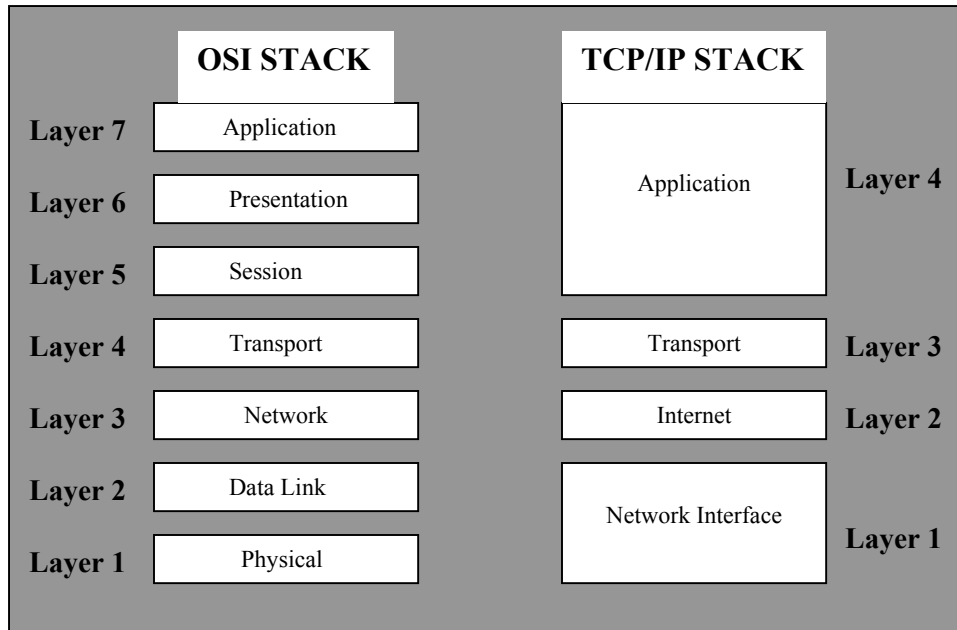


Figure 2: OSI versus TCP/IP

3.4. Our Model

Several authors have examined the application of layered models to the analysis of the policy and technology issues.³⁶ These models substantially modify traditional protocol layered models to provide a tool for market and policy analysis. Since the analysis undertaken in this paper is more closely tied to technology, we propose a model that closely resembles a traditional protocol stack. We model our analysis roughly around the OSI reference model and TCP/IP protocol suite. As such, we examine technology and business aspects of openness associated with each layer of the model. We add a Layer 0 to represent the physical and power related issues not generally captured in layer 1. We also add a Layer 6, which includes issues beyond the layered model and other non-conforming topics. This includes process related issues, such as standards participation and interconnection negotiations.

³⁶ See F. M. Bar, *Configuring the Telecommunications Infrastructure for the Computer Age: The Economics of Network Control* (1990) (Ph.D. thesis, University of California, Berkeley); Sicker, D.C., and Mindel, J., "Refinements of a Layered Model for Telecommunications Policy," *Journal of Telecommunications and High Technology Law*, vol.1, issue 1, 2002.; J. Weinberg, *The Internet and Telecommunications Services, Universal Service Mechanisms, Access Charges and Other Flotsam of the Regulatory System*, Telecommunications Policy Research Conference (1998), available at <http://www.law.wayne.edu/weinberg/FLOTSAM.a04.PDF>.

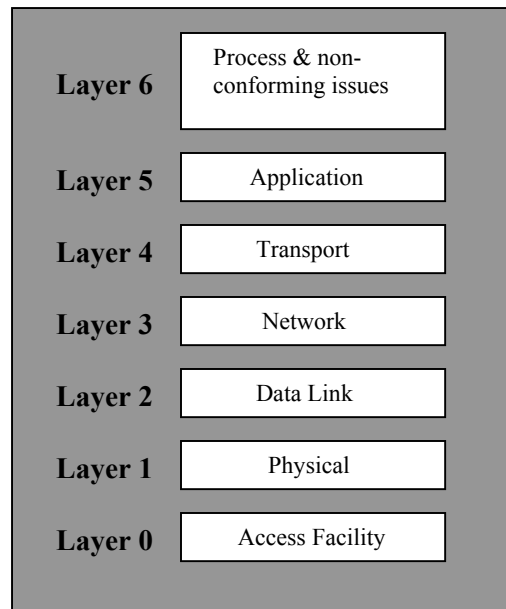


Figure 3: Our Model

In undertaking this layer-based analysis, we assess “openness” by asking the question: if the resource or process is closed because of discrimination, are there alternatives? Where applicable, we also identify and describe recent changes in network architectures that affect openness in different layers. Again, it is not our purpose in this paper to advocate any particular degree of openness or to critique past commercial and regulatory decisions dealing with the topic. Rather, in this paper, we seek to explain and to offer a clearer, more unified and consistent definition of what constitutes openness. In other words, just because we find an element as “closed” does not mean that we believe regulatory or court action is required.

4. Layered Analysis

In this section, we examine openness at each layer of our model. We also present a possible method for examining market related issues. The intention of this examination is not to exhaustively cover every technology at every layer, but to provide a number of examples to indicate how we might consider openness within each layer.

Unfortunately, this part of the analysis is still a work-in-progress. We will have it completed and available at the TPRC presentation.

5. Conclusion

In examining the issue of openness, we have tried not to advocate any particular degree of openness or to critique past commercial and regulatory decisions dealing with the topic. Rather, we have sought to explain and to offer a clearer, more unified and consistent definition of what constitutes openness. We did so in the context of the different levels of the protocol stacks that comprises modern data communications networks. We focused particular attention on the Internet suite of protocols (e.g., TCP/IP) and its relationship to the other layers. In undertaking this layer-based analysis, we assessed the “openness” by asking two questions: can the information be delivered and/or is there discrimination against the delivery of this information? Where applicable, we also identified and described recent changes in network architectures that affect the openness in different

layers. Changing commercial, technological, and regulatory developments may motivate such changes. For example, an otherwise open network may be closed or partially closed by the use of content filters deployed in response to security threats; by content filters designed to protect a user against spam; or by content filters designed to exclude a competitor's traffic. In this case, the choice may be prompted by sound security policies, by an individual's email preference, or by a competitive pressure. The point here is that the openness of a system may be compromised for various reasons.

6. References

Ad Hoc Group of the 706 Federal/State Joint Conference on Advanced Services, "POLE ATTCHMENTS" - Presented at the 2001 NARUC Summer Meetings, in Seattle – July 2001.

Bailey, Joseph, "Economics and Internet Interconnection Agreements", Presented at MIT Workshop on internet Economics, March 1995 – available at <http://www.press.umich.edu/jep/works/BailEconAg.html> visited 08/07/2003

Blumenthal, Marjory and David Clark, "Rethinking the design of the Internet: The end to end arguments vs. the brave new world"- available at <http://www.ngi-supernet.org/NGI-PI-2000/Clark.PDF>

Carlo, Jim, "802 perspectives" - available at <http://www.comsoc.org/ni/Public/2001/May/ni802.html> visited 08/07/2003.

Center for Democracy and Technology, "Broadband Backgrounder: Public Policy issues raised by Broadband Technology" - December 2000, available at http://www.cdt.org/digi_infra/broadband/backgrounder.shtml, visited 07/12/2003.

Chapter 31 - Microsoft TCP/IP Architecture available at <http://www.microsoft.com/technet/treeview/default.asp?url=/technet/prodtechnol/ntwrkstn/reskit/rktcp02.asp> visited 07/23/2003.

Cisco Documentation, "Understanding TCP/IP" – available at <http://www.cisco.com/univercd/cc/td/doc/product/iaabu/centri4/user/scf4ap1.pdf> visited 08/05/2003.

Columbia Telecommunications Corporation, "Technological Analysis of Cable Open Access and Cable Television Systems"- available at http://archive.aclu.org/issues/cyber/broadband_report.pdf

Comments by amazon.com to FCC Notice of Proposed Rulemaking - In the Matter of Inquiry Concerning High-Speed Access to the Internet over Cable and Other Facilities. CS Docket No. 02-52, March 15, 2002, available at http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513198055 visited 08/03/2003

Computer III Order 1999, 14 FCC Rcd at 4298, ¶ 8 n. 15. See also Computer III Remand 1995, 10 FCC Rcd 8366, ¶¶ 15-16.

Cooper, Mark and Christopher Murray, “Technology, Economics and Public Policy to Create an Open Broadband Internet.” – The Policy Implications of End-to-End, Stanford Law School; December 1, 2000

Covad Communications Company; Working Paper Series, No. 1, “Defining ‘Digital’ Loops – Avoiding Re-monopolization in a Digital World”, available at <http://www.covad.com/PDF/DigitalLoop.pdf> visited 07/28/2003

Esbin, Barbara “Internet over Cable: Defining the future in terms of the past”, OPP Working paper Series 30, Federal Communications Commission.

FCC Notice of Proposed Rulemaking, CC Docket No. 02-33, “In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities”

FCC Notice of Proposed Rulemaking; CS Docket No. 02-52, March 15, 2002, “In the Matter of Inquiry Concerning High-Speed Access to the Internet over Cable and Other Facilities”

Gulf Power, 112 S.Ct. at 786, 787-88,789.

Kende, Michael, “The Digital Handshake: Connecting Internet Backbones” - Working Paper – Office of Plans and Policy, Federal Communications Commission.

Keshav, S, “Protocol Layering: An Engineering Approach to Computer Networking” available at http://www.cs.cornell.edu/skeshav/book/slides/protocol_layering/ppframe.htm visited 07/22/2003.

Kriete, Debra, Esquire, Rhoads and Sinon LLP, “Shining a Light on Dark Fiber” –Presentation to NARUC Staff Subcommittee on Telecommunications, July 27, 2002 available at <http://www.naruc.org/Committees/telecom/kriete.pdf> visited 07/28/2003

Kurose, James and Keith Ross, “COMPUTER NETWORKING: A Top Down Approach Featuring the Internet”

Lemley, Mark and Lawrence Lessig: “The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era”

McCrea, Philip, Bob Smart and Mark Andrews, “Blocking Content on the Internet: A Technical Perspective” – available at <http://www.cmis.csiro.au/projects+sectors/blocking.pdf>

Microsoft white paper, “Introduction to TCP/IP” – available at <http://www.microsoft.com/ntserver/zipdocs/TCPIntrowp.doc> visited 08/05/2003

National Research Council, Committee on Broadband Last Mile Technology, Computer Science and Telecommunications Board, Division of Engineering and Physical Sciences, “Broadband: Bringing Home the Bits”

Office of Telecommunications (OfTel), “DUCT AND POLE SHARING”, available at http://www.oftel.gov.uk/publications/1995_98/competition/ductpole.htm visited 07/28/2003.

Qwest Communications 2001, “Process requirements to accessing Poles, Ducts and Rights-of-Way for CLECs” available at

http://www.qwest.com/wholesale/downloads/2002/020613/Access_to_PDR_Course.doc visited 07/28/2003.

RAD Data Communications Website at <http://www2.rad.com/networks/1994/osi/osi.htm> visited 08/29/2003

Remarks by Nancy J. Victory Assistant Secretary of Commerce for Information and Communications, and Administrator of the National Telecommunications and Information Administration, as prepared for deliver to the FCC Forum on Rights-of-Way, October 16, 2002, “Rights-of-Way Management -- A Key Piece of the Broadband Puzzle”– available at http://www.ntia.doc.gov/ntiahome/speeches/2002/fccrow_10162002.htm visited 07/25/2003

Request for Comments: 1631 – “The IP Network Address Translator (NAT)”

Request for Comments: 1958, “Architectural Principles of the Internet” available at <http://www.faqs.org/rfcs/rfc1958.html> visited 07/22/2003

“Rights-of-Way (ROW), Conduits, Pole Attachments, Attachment 6” available at http://www22.verizon.com/About/publicpolicies/pdfs/CO_Att_6_ROW.doc visited 07/25/2003

Section 224 of the Communications Act of 1934, as amended, 47 USC 224.

Sicker, “Further Defining a Layered Model for Telecommunications Policy,” 30th TPRC, 2002.

Sicker, D.C., and Mindel, J., “Refinements of a Layered Model for Telecommunications Policy,” Journal of Telecommunications and High Technology Law, vol.1, issue 1, 2002.

Stallings, William, “Data and Computer Communications”, Sixth Edition

Stallman, Richard, The GNU Operating System and the Free Software Movement, in OPEN SOURCES—VOICES FROM THE OPEN SOURCE REVOLUTION, available at <http://www.oreilly.com/catalog/opensources/book/stallman.html> visited 07/23/2003

Telecommunications Act of 1996, Section 251.

Wu, Tim, “Network Neutrality and Broadband Discrimination”– available at <http://faculty.virginia.edu/timwu/bbd.pdf> visited 08/02/2003

www.opensource.org – 06/25/2003

www.opensource.com

www.webopedia.com/TERM/o/open_source.html - 06/27/2003