What are Open Standards?
Implications for Adoption, Competition and Policy

Joel West
Associate Professor, Technology Management
College of Business
San José State University
San Jose, CA 95192-0070
Joel.West@sjsu.edu
http://www.cob.sjsu.edu/west_j

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Abstract

"Open" product compatibility standards are prized as an ideal by many buyers and policymakers. The belief is that such standards lead to superior outcomes for societal welfare, while preventing the worst abuses of proprietary lock-in.

The reality is that all "open" standards are not created equal, in that some are more open than others. It is possible to discern several dimensions of openness, and different levels for each dimensions. Also, different participants in the value chain — customers, complementers and competitors — will value different aspects of openness.

This paper suggests measures for assessing the openness of a standard, and possible policy applications of these measures.

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Introduction

During the past two decades, information technology buyers and policymakers have largely agreed that, *ceteris paribus,* "open" standards are preferable to "closed" or "proprietary" standards. I.T. vendors have complied by delivering standards that they call "open." Meanwhile, regulators (and courts) were forced to evaluate whether the actual openness delivered by "open" standards from dominant firms comply with national policies such as antitrust laws.

Unfortunately, such increasing stakes for open standards obfuscated any rigorous definition of the term, leading to Orwellian examples of proprietary technology being proclaimed as "open". For example, many supporters of the Wintel PC architecture have referred to it as an "open" standard; on the other hand, then-Sony CEO Nobuyuki Idei charged that "With Microsoft, open architecture means Microsoft architecture" (Auletta 2001: 166). Even standards that are nominally open (such as MPEG for video and GSM for mobile phones) may be based upon royalty-bearing IPR that confers advantages to their sponsor(s) over other economic actors.

In fact, even the most proprietary standard is at least partially open to enable a supply of complementary products. Standards are not bifurcated between "open" and "closed", but instead encompass multiple shades of gray in between. There are also multiple dimensions of openness, each of which may have different impacts on different economic actors in different contexts. And such openness varies by industry, by firm and even by technology generations.

Finally, the definition of an "open" standard has often been confused with the consequences of openness — such as the availability of multiple implementations or the reduction in vendor power. Thus, more specific ways to operationalize the concept of an "open" standard would make it possible both to design openness into the standardization process, and also for policymakers to *ex ante* assess whether a given standardization effort met overall policy goals.

This paper reviews different concepts of open I.T. standards in management research and practice. Beginning from a fundamental definition of openness — rights provided by the sponsor of a standards to other economic actors — it offers a framework incorporating the who, what, how and why of open standards. Finally, it concludes with a discussion of how more precise gradations of the economic value of open standards can be applied to policy decisions.

Defining Open Standards

> "The concept of 'open systems' has become an icon to conveniently express all that is good about computing." (Cargill 1994: 3)

As Cargill notes, the term "open" in conjunction with information technology compatibility standards has been embraced by buyers who intuitively believe such technology will give them more choices. This preference is more often based on philosophy than rigorous analysis; "open" advocates have not done a careful calculation of whether such openness results in underinvestment in R&D, and many have even ignored whether specific solutions based on "open" standards provide less utility than the "closed" alternative.

In response, some vendors have wholeheartedly embraced "open" standards. Others have supported open standards but layered proprietary components to maintain at least partial competitive advantage and lock-in. And still others have sought to reposition their proprietary offerings in the market by attaching the open label: for example, after complying with open systems API standards, Digital Equipment Corp. rebranded its flagship proprietary operating system as "OpenVMS" (Duffy 1992).[1]

[1] In addition to OpenVMS, Grove (1996) assets that the horizontally specialized PC platform architecture (with proprietary quasi-monopolists controlling two layers and multiple choices of system vendors) is "open" compared to mainframe platforms, where buyers have a choice of proprietary architectures from vertically integrated vendors.

So what is an "open standard"? It first would be helpful to agree upon a common definition of "standard", to discuss the general characteristics of what makes a standard open, and to draw the crucial distinction between a standard's openness and the consequences of that openness. The remainder of the paper then discusses various dimensions of openness and their associated consequences.

Standards, Specifications and Implementations

Compatibility standards "enhance or make possible technical coordination among different components of a technological system" (Antonelli 1994: 197). Such a system may, for example, be a computer, a layed architecture of software products, a voice or data network.

The specific rules for interconnection between two components are referred to as interfaces or protocols. The interfaces may be peer to peer and symmetric, as with TCP/IP communication protocols between two Internet devices. Or they may be hierarchical and thus asymmetric, as with application programming interfaces between an operating system and application. These interfaces allow for a modular decomposition of systems development between multiple implementers; these implementers may be within a single organization, or between organizations (Schilling 2000). And there may be a single implementation for one side of an interface (as is common for the operating system layer), or multiple competing implementations (as with communication devices).

Standards are typically considered in economics and policy studies in terms of their formal specification. However, this neglects the inherent role of the implementation of a standard in both defining and promulgating that standard.

In some cases, multiple conforming implementations of the same specification may be mutually incompatible, as happened with the Open Systems Interconnect protocol standards.

While some bemoan such incompatibility as a symptom of incomplete specification, the reality is that for complex digital systems standards, the formal specification is inherently incomplete and the actual standard is defined both through the written specification and through actual implementations (West 2004). To reduce such problems, for years the Internet Engineering Task Force has adhered to a philosophy of "rough consensus and running code," using multiple independent implementations prior to formalizing the definition of any IETF standard (Bradner 1999).

Certainly for any firm trying to implement a standard, knowledge of both the formal specification and existing implementations is valuable. Otherwise, the implementer faces an extended trial-and-error process as it seeks to discover how other firms have resolved specification ambiguities.[2] So a typology of openness must consider the openness both of the specification and implementation.

Open Standards

> open: … 5. not restricted to a particular group or category of participants
> (Merriam-Webster Online Dictionary)

Under the laws of developed countries, both the specification and implementation of a standard may have associated intellectual property rights. Rights such as copyright and trade secret will accrue to the standards sponsor(s) by default, while unique innovations may also be protectable using patent laws.[3] When there is strong legal and technical appropriability for such IPR, its owner can expect to profit either through licensing or sale of its own products (Teece 1986).

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[2] This does not apply to those few organizations which have the dominant market power necessary to unilaterally impose their interpretations (and implementations) of standards as the marketplace *de facto* standard.

The sponsors' default ownership of such rights is what enables a distinction between open and closed standards. If no such rights exists, and knowledge diffused equally to all economic actors everywhere, then all standards would be equally and inherently "open".

So here we define "open" for a standard as meaning rights to the standard made available to economic actors other than the sponsor. These rights may be licensed by the sponsor to other organizations under contract, as with a standard software end-user license agreement (EULA). They may be rights waived or ceded to other groups (such as when IPR is donated to the I.T. "community"). Or the standard may contain elements that are inherently unprotectable, such that the sponsor gains little or no competitive advantage for hoarding rights to the standard.

Open Standards and their Consequences

The goals of open standards are often defined in terms of a consequence or outcome of the openness of a standard, rather than any measurable trait of the standard or standardization process itself. So for many buyers and policymakers, an "open" standard is one that reduces vendor power over buyers, usually due to multivendor competition between implementations of the standard. But such a definition is tautological in its claims — a open standard that enables competition is one where competition is enabled — and thus does not lend itself to *ex ante* adjudications of a standard's openness.

Here I develop a series of attributes of standards, how they are created and implemented, that can be used as metrics for assessing the openness of standards. These are then used to discuss the policy implications of the various types of open (or closed) standards.

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[3] Here I use "sponsored" standard in a broader sense than David & Greenstein (1990) to include cases where the sponsor is a private firm, a group of firms, a non-profit organization (e.g. ANSI) or a government agency (e.g. the FCC).

Metrics for Open Standards

Even if a sponsor makes rights available to a standard, there are multiple dimensions and degrees of openness. One standard may be available to a handful of organizations under onerous restrictions and payment terms, while another may be available to all comers upon signing a simple acknowledgement of the sponsors' trademark rights.

This section considers three dimensions of openness:

- who has access to the standard;
- goals for opening a standard; and
- what access is provided to the standard

It also discusses the potential for proprietary gain from nominally open standards: if the goal is to create a "level playing field" through open standards, then these common tactics must also be considered.

Open to Whom?

If one asserts that a standard is "open," then the first question that must be answered is "to whom is it open?" Organizations will have different views of what aspect of openness is most important, depending on their role in product value chain.

Customers, Complementers and Competitors

A key issue in defining rights to open standards is in defining what parties would benefit from openness. This can be considered in terms of the role of the prospective beneficiary: customer, complementer or competitor.

When an I.T. vendor sponsors standards, its business model usually involves the sale of the implementation to its customers.[4] For a physical good (e.g. a router or PC), the vendor's compensation is assured through the product purchase. For an information good (e.g. software), to assure payment the customer's rights will normally be restricted by license terms that prohibit redistribution or reuse.

In most cases, the sponsor will seek other firms to support its (standardized) product through production of complementary products, which Katz & Shapiro (1985) term the "hardware-software paradigm." To obtain such products, the firm will need to release some portion of the definition of the standard to potential complementers. The sponsor of necessity shares some of the economic returns from the standard with the "software" developers, particularly if (as per Teece 1986) the "software" requires specializing investments that only can be reclaimed through software sales to the installed base of "hardware" owners. In many cases, the sponsor actively courts complementers and applies resources to widely disseminate the specifications, as with the third party software "evangelism" departments of systems vendors.

Finally, there is the attitude of the standard sponsor towards makers of competing implementations. Potential competitors will typically have access to the standards specification — if through no other means, through information broadly disseminated to complementers. But to protect the R&D investment of the sponsor(s)' implementation, proprietary sponsors usually withhold additional information that would be useful in constructing implementations, such as additional specification information and implementation tricks. In these cases, reverse engineering of an existing implementation is often essential for making an interoperable

[4] User driven standardization will have the opposite goal — making implementations available as cheaply as possible. Meanwhile, IPR-only companies participate in standardization to monetize the value of their patents rather than to create or sell products.

competing implementation (West 1995). Conversely, non-proprietary sponsors often proliferate implementations to spur adoption of a standard.

Joining the Standards Club

The discussion of standards openness is typically cast as a choice between multivendor nonprofit standards development organizations (SDOs) —such as ANSI or the ITU — and a single firm developing proprietary *de facto* standards within the boundaries of the firm. But few firms have the power to unilaterally impose standards upon the marketplace, while formal SDOs are widely seen as being too slow and unresponsive to provide anticipatory standards in industries with rapidly changing technologies.[5] In response, many of the most important I.T. standards of the past 20 years have been developed by private standards consortia (David & Shurmer 1996; Krechmer 2000).

Unlike single-firm *de facto* standards, such consortia standards result in multiple implementations from multiple vendors. However, in most other ways consortia serve proprietary goals, functioning as a private, members-only club, favoring the interests of the members over any societal welfare, adoption or other metric for success. In this regard, the single-firm standards sponsor most closely resembles a 1-firm consortium.

Consortia are not the only standardization groups that make such insider/outsider distinction. Bilateral alliances (such as the April 2004 agreement between Microsoft and Sun) may share standards specification and implementation information not available to third parties. Even formal SDOs (such as the ITU) often favor their members for access to information and participation in standards development. Whether as an incentive to obtain funding, or a way to

[5] This criticism of SDOs is rejected by many who participate in formal standardization efforts. For an opposing interpretation of the relative speed of SDO and consortia standardization, see Sherif (2003).

limit the number of organizations entitled to participate in standardization, such discrimination is evidence that SDOs may vary greatly in their degree of openness.

Thus, a key measure of openness for any group of firms creating standards (whether an SDO, consortium or informal alliance) is the access provided to non-members. If non-members have the same use rights as members, then the standard itself is a public good available to all (Kindleberger 1983).[6] If non-members have little or no rights, then the standard is a collective good (per Berg 1989) for the benefit of its members.

A related issue is whether an interested party can join the standardization group: membership policies can range from completely closed to completely open. In some cases, participation in the standardization efforts is a closed group (the "Wintel" duoopoly). In other cases, the group may require formal membership with pre-defined eligibility requirements, as is common in trade associations such as the Telecommunications Industry Association. In a few cases, the process is available to any interested party, as with the IETF.

Why is it Open?

Under what conditions will a standard be open? Firms generally open technology for two reasons: because of buyer pressure, or because they need other firms (such as makers of complementary products) to support their business ecosystem.

Why Customers Want Open Standards

Buyers making capital investments with high switching costs recognize the risks of "lock-in," and, in particular, the potential for vendors to use that lock-in to extract rents from buyers who have no reasonable alternative. Thus, buyers seek both to reduce such lock-in through

[6] I this case, the only firms that need to become members are those who have a direct concern with the standardization decisions being made, rather than those who merely need access to the standardization group's eventual output.

multiple suppliers, and also (where possible) to use the threat of such suppliers to bargain down prices prior to accepting lock-in (Shapiro & Varian, 1999).

The modern history of I.T. vendor lock-in dates to IBM's 1964 introduction of the System/360. By providing a common set of platform standards across a wide range of prices and capabilities, the S/360 mainframe product family proved extremely popular in the 1960s and 1970s and attracted dominant market share in the U.S., Europe and Japan (Moschella 1997; Bresnahan & Greenstein, 1999).

IBM's dominance sparked the initial push for "open" standards in Europe during the 1980. Buyers objecting to proprietary lock-in allied with second-tier domestic manufacturers to promote a series of multi-vendor standards in what became known as the "open systems" movement. The two best known responses were:

- For mainframe computer platforms, the "Open Systems" operating system standards movement began with the 1985 launch of the X/OPEN Group, an alliance of systems vendors and users who endorsed interfaces based on AT&T's Unix System V (Gabel 1987). X/OPEN was followed by the Open Software Foundation and Unix International, who together engaged in the "Unix wars" (Cargill 1997). The efforts succeeded in part, as buyers valued the choices offered by multivendor standards (Bresnahan and Saloner, 1997). However, these systems were less open than later Unix-compatible platforms built on free and open source operating systems such as Linux (West & Dedrick, 2001; West, 2003).
- For computer networking, the Open Systems Interconnect reference model was developed by the ISO and CCITT international standards bodies, in reaction to the proprietary SNA standard of the vertically integrated IBM. While the OSI protocols

won considerable official support in the 1980s, delays and ambiguities introduced by the politicized standardization process made the standard hard to implement and generally ignored by computer buyers when it finally became available. It (like most other networking standards) was displaced by the TCP/IP Internet standard (Miller 1981; Egyedi 1999).

Both efforts showed the potential for multivendor standards to reduce vendor lock-in. But both also demonstrated that inferior implementations (no matter how small the lock-in) would have trouble attracting adopters in significant numbers.

Why Vendors Do Not

Since the IBM System/360, many I.T. vendors have developed proprietary *de facto* I.T. standards. Most have chosen to make their standards only partially open.

The proprietary sponsorship of a standard allows the sponsor to justify the up front investment necessary to bootstrap standard adoption (Katz & Shapiro, 1994:101). While the rents from the lock-in for such proprietary standards are among the most attractive available to IT vendors, these returns also provide incentives to keep a technology up-to-date to attract buyers afraid of vendor lock-in (Morris & Ferguson, 1993).

For *de facto* standards conforming to the hardware-software paradigm, the investments by "hardware" vendors including creating or attracting a large supply of "software" to make their standard and products more valuable. The larger supply of software creates a competitive advantage. Through analysis of a quasi-experiment in the PC industry, West & Dedrick (2000) demonstrated that a shift in control of the interfaces between a computer platform and its associated software also resulted in a shift in the associated rents.

But such attempts to create advantage and lock-in are far from limited to the sponsors of *de facto* standards. Sponsors of *de jure* and consortia standards also gain advantage from attracting adopters and creating lock-in, if such standards are encumbered by private patent claims, as are standards such as W-CDMA, MPEG-4 and DVD.[7]

Knowing the potential for exploitation of proprietary lock-in, buyers of standardized products will try to force the sponsor to commit to sharing these rents with adopters (Shapiro & Varian, 1999). Proprietary single-vendor standards enjoy a few efficiency advantages that are easily passed on to buyers. One is time to market, as intraorganizational resolution of standardization conflicts are more quickly resolved than those that arise in formal inter-organizational standards efforts. Another is superior integration of various components of a solution, due in part to the simplification of testing requirements when compared to the combinatoric complexity of a true multivendor solution.

Certainly buyers continue to buy proprietary solutions in the face of open alternatives, as both Gabel (1987) and Bresnahan & Saloner (1996) attest in the case of IBM and its "open systems" rivals. These provide an existence proof that, in some cases, proprietary solutions will also be preferable for customers.

Why Vendors Open Up

The owner of a standard may assign certain rights, in exchange for an explicit (or implicit) quid pro quo. Typically, under the hardware/software paradigm, the sponsors of most standards release rights to other firms to develop complementary products, to make their product more attractive to prospective customers.

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[7] As will be discussed later, normally such standards are developed to read on essential patents through the involvement of the benefiting party in the standards-development process.

More generally, West (2003: 1259) argues that strategies for proprietary firms opening their technology

> …reflect the essential tension of *de facto* standards creation: that between appropriability and adoption. To recoup the costs of developing a platform, its sponsor must be able to appropriate for itself some portion of the economic benefits of that platform. But to obtain any returns at all, the sponsor must get the platform adopted, which requires sharing the economic returns with buyers and other members of the value chain.

In fact, openness is often used to win adoption in competition with sponsors of more proprietary standards. Members of the X/OPEN group sought to win adoption from customers that wanted to weaken IBM's market power (Gabel 1987). In the workstation market during the 1980s, Sun used a more open systems architecture to win customers away from Apollo, which used a vertically integrated proprietary strategy (Garud & Kumaraswamy 1993). Apple incorporated open source implementations into its operating system, in hopes of making the platform more attractive both to customers and complementers (West 2003).

Finally, a sponsor may release rights (opening up a standard) in cases where it cannot protect the standard indefinitely, and hopes to gain goodwill (or perhaps even reduced costs) by releasing rights prior to the expiration of its advantage.

When Standards are Open From the Start

In some cases, proprietary vendors cooperate to create standards that are open from the start. As with *ex poste* openness, such *ex ante* openness may be intended to attract customers or makers of complementary products.

In some cases, the IPR is deliberately waived by the sponsor in hopes of selling related products. The original authors of the Apache http server were employed to deliver Internet services such as web hosting. They later received major financial support from IBM, which used the Apache architecture and APIs as the basis for building its proprietary WebSphere product

(West 2003). Similarly, IBM's release of the Jikes compiler as an implementation of the Java standard was widely seen as helping establish the Java standard, on which it hoped to build other products (Gonsalves and Coffee 1998).

In other cases, the nominally open standards may be available to all, but carries economic rents for its sponsors. In this regard, the proprietary Intel microprocessor standard is comparable to the royalty-bearing GSM and MPEG-4 multivendor standards: in all three cases the technology can be incorporated into proprietary products, but not without paying fees that favor one or more of the standards' sponsors.

What Rights are Provided?

With the possible exception of internal corporate information system or military encryption system, all standards holders of necessity assign certain rights to other organizations. What sort of rights are essential for an "open" standard? The question has been considered before. Among the examples:

- The open source community offers its own definition of what is "open" in terms of software. Richard Stallman and his colleagues define "free software" as having four freedoms: the rights to run, see the source code, redistribute software, prepare derivative works with asking permission or paying for these rights (FSF 2003). To this list, "open source" software adds a clause preventing the code from placing restrictions on derivative works (Perens 1997).
- Based on both open systems and open source typologies, West (2003) proposes a multi-attribute scale of operating systems standards openness, measuring factors such as multiple hardware vendors, multiple implementations and the availability of source code. He concluded that the most open standards were those which included

unrestricted source code implementations, such as provided by a BSD-style open source license.

- Approaching the problem from the perspective of the communications industry, Krechmer (1998) offers a list of 10 principles for open standards. Eight specify the process by which the standards are created, a ninth allows for extensibility of standards while providing backward compatibility, while the tenth encourages the reduction or elimination of patent royalties for standards.

Here we consider three basic categories of standards access: access to the process creating the standards specification, access to the resulting specification, and access to implementations of the specification.

Creating the Specification

The first group of rights valuable to firms is the ability to participate in creating the specification for a standard, i.e. to become a sponsor. This may be valuable to a firm because it wants to control the direction the standard takes, so that it will enable the sponsoring firm to use the standard in its products. The company may want to direct the standard in a way that's most compatible with its existing investments, as with *post hoc* V.90 standardization of 56K modems. It may wish to influence the standard to intersect the company's strengths, including royalty-bearing IPR. Or it may wish to gain the tacit knowledge that accrues from being part of the discussion, creation and evolution of an essential standard.

Finally, organizations may wish to control the rate of change in the standard. Proprietary systems and component vendors — whether IBM, DEC, Sun, Intel or Microsoft — have always used dynamic standards as a source of competitive advantage: the more the standard changes, the harder it is to maintain commercially viable competing implementations. So an important

distinction between single-firm and multivendor standardization is that the former naturally favors a higher rate of change so that one implementation has competitive advantage over another.

What possibilities face the prospective sponsor of a standard? There are four typical scenarios of how the sponsor can join the standardization effort, in order of increasing openness:

- *fixed group,* i.e. "no new members". In this case, new entrants are not allowed to participate in the standardization effort, as typically happens in most single-firm proprietary standards.
- *members with qualifications* ("country club"). The existing members get to decide what firms can be come new members, typically using some combination of subjectively interpreted criteria.
- *non-discretionary membership* ("fitness club"). In these, upon filing a form (and, in most cases, paying dues) nearly all firms can become members.
- *non-member organizations* ("town meeting"). The Internet Engineering Task Force prides itself on not requiring membership to participate in its standards creation:

> The IETF is not a membership organization …The IETF is a large open international community… open to any interested individual.
>
> The actual technical work of the IETF is done in its working groups . To become a participant in the IETF, one merely becomes active in one or more working groups by asking to be added to the WG's mailing list. (IETF 2004)

Finally, there is the question of how conflicting goals and interpretations are resolved by the various members. The organization literature makes a distinction between process fairness and outcome fairness (e.g. Greenberg 1987). In the former case, decision-making rules become paramount; in the latter, everyone is happy (whether they participate or not) if the outcome matches their goals. Even though process fairness would be expected to lead to outcome fairness,

because research suggests participants may use either metric to evaluate the fairness of an outcome, any attempt to measure the openness of the standardization process must consider both metrics.

Using the Specification

Two groups use a standard's specification: the complementers (making products that work with the standardized technology), and competitors (who wish to make competing implementations).In some cases, customers may be their own complementers, if, for example, they are authoring in-house software packages that work with a given OS or communications standard.

The categories of access parallel those for participating in standardization:

- fixed club: no new members.
- discriminatory access to IPR: all or some of the members have preferential terms over nonmembers for access to the intellectual property of the project.
- rights are available to all: the best example of this is when the spec is posted in HTML or PDF format on the Internet, for all interested parties to download without registering for membership.

Rada & Berg (1995) note that an important issue in some cases is whether the standard definition itself is available without charge. Proprietary firms (such as Microsoft) that can assure themselves of revenues from selling an implementation are more likely to give away their specification; non-proprietary organizations (such as the IEEE or ISO) that depend on standardization revenues are more likely to sell their specification, making it less widely available.

Some organizations will not be allowed to join the standardization club, or will choose not to. In these cases, there is the question as to whether non-members (or even some members) will have access to the same specification information as the standards' primary authors, as will be discussed later.

Using an Implementation

Some rights to implementations are inherent in any standard created to support commercially distributed products. Typically, a customer gets rights to use a standard as part of purchasing the rights to a product that incorporates that standard, rights that also can be enjoyed by complementers.

A key difference for implementations is the availability of the reference implementation to organizations developing a competing implementation. For competitors, the ideal case would be access to the design of the implementation, such as source code for a software standard. An example of this was the TCP/IP networking standard, whose specifications were always freely available on the ARPAnet, the direct forerunner of today's Internet (Postel 1981a, 1981b). At the same time, the DARPA-funded Berkeley Unix implementation of TCP/IP was freely available to all, forming the basis for implementations of the protocol in most proprietary and nonproprietary operating systems.[8]

And all three groups — customers, complementers and competitors — face the question of whether their use of the technology is encumbered by patent royalties, or other restrictive IPR.

[8] The use of the BSD TCP/IP by Microsoft still rankled author Bill Joy almost two decades later (Kim 1999). However, a former Microsoft executive noted that the distribution of the implementation both assured its widespread adoption and facilitated interoperability, two top goals of any public standardization effort (interview, December 2003).

Is it Really Open?

Even if a standard meets the preceding criteria for openness, there are still other avenues for sponsors to create barriers to entry and imitation against non-sponsors.

Must Open Be Free?

Advocates of free and open source software have repeatedly emphasized that the important aspect of openness and freedom is "'free' as in 'free speech,' not as in 'free beer'" (FSF 2003). And yet human nature suggests that free beer can be a powerful motivator. Certainly charging for access to a standard (no matter how nominal) tends to hinder diffusion of the standard and its associated knowledge (Rada and Berg 1995).

More seriously, the use of proprietary IPR (notably patents) on even nominally "open" standards perpetuates the barriers between sponsors and non-sponsors of a standard. Such tactics have been used against competitors, complementers and even customers. For example:

- *Competitors.* The patent portfolio of the European-developed GSM mobile phone standard was deliberately crafted to keep out Japanese competitors (Bekkers et al 2002). Even in 2004, more than 20 years after deployment of the first GSM system, acquiring the patent portfolio of one of the original GSM sponsors provided an attractive way for a foreign firm to reduce entry barriers to the European market (Ramstad and Pringle, 2004).
- *Complementers.* While video game console makers such as Nintendo encourage third parties to make complementary products (software), a fundamental basis of their business model is that they charge royalties on all third party products shipped (Gallagher and Park 2002).

- *Customers*. The MPEG-4 video compression standard is the first audio-visual standard that not only charges royalty fees on encoding and decoding tools (complements), but also charges a royalty for commercial content distributed in the MPEG-4 format.

Standardization groups today adopt IPR policies that largely determine the ability of sponsors and other interested parties to profit from the incorporation of their IPR in a standard. These policies may range from mandatory disclosure to royalty-free licensing. However, most approaches make a distinction between standardization participants contributing essential IPR and all others, whether their IPR is formally pooled among sponsors or whether informal policies lead to cross-licensing arrangements that favor sponsors over outsiders.

The two most common used royalty approaches for standards-related patents are RAND (reasonable and non-discriminatory) and royalty free. While RAND can be royalty free, in practice it allows a specific subset of standards sponsors (the patent-holders) to create an exclusive club whose members (through cross-licensing) generally have a superior cost structure to non-members.

The royalty free approach, as its name suggests, is the free (as in beer) alternative. It is the approach strongly preferred by open source developers (and others) who consider such royalties — not matter how nondiscriminatory — to be not open enough (Festa 2002).

Incomplete Disclosure

Even if all parties have access to the published specification of a standard, this does not assure a level playing field. Proprietary firms with high market share may also add hidden (i.e. nonpublic) interfaces to their implementation. This does not create switching costs, but the implications are more pernicious. It implies that some application writers have preferential

access to platform capabilities over others. While such preferential treatment might be used to reward strategic allies, the more likely example would be for a vertically integrated software vendor seeking to link sales of one layer of the software "stack" to another.

When the vendor holds monopoly power in one layer, such linking is potentially a violation of national competition laws. This was one of the allegations covered by the 1995 consent degree resolving the first *US v. Microsoft* case (Sheremata 1997)

Finally, even with full disclosure of all formal interfaces, there are still opportunities for sponsors to gain advantage through their knowledge of tacit information gleaned through the creation of a standard.

For example, Sun Microsystems developed and disseminated numerous industry *de facto* standards that were made available to customers, complementers and competitors. However — much as with a fully proprietary standard such as IBM's MVS or Microsoft's Windows — Sun's control and knowledge of the technology gave it the quickest access to specifications and thus a time advantage in creating implementations. Finally, it benefited from a pool of tacit knowledge built up through learning by doing (Garud and Kumaraswamy 1993: 360).

Discussion

Policy Implications

Government has many technology policy responsibilities in which it has an interest in open standards. The aforementioned criteria, as summarized by Table 1, provide metrics for how open standards are. How might these be applied? Below we consider four policy areas: direct regulation, government procurement, intellectual property law and antitrust (competition) policy.

Standards Regulation

In some cases, the government will play a direct role in developing or selecting a standard. This is most often found in regulated industries, such as telecommunications. For example, for 2nd generation digital mobile phone standards, the European Commission mandated a single standard for all EC countries, while in the U.S. the FCC gave carriers in the 1.9 GHz band to choose from among a list of seven standards (of which three were widely adopted).

The government may also find a policy rationale in developing common infrastructure standards, whether or not they arise in regulated industries. The government's role may lie in encouraging common outcomes from a wide range of interests groups. For example, standardization of EDI and other business-to-business commerce standards can improve the efficiency of the overall economy.

In a few cases, the political economy of a given country assumes a greater government role in key decisions than in market-based economies. For example, to help local manufacturers in 2003 the Chinese government proposed mandating a domestically-developed WiFi (802.11) encryption standard (Chen 2003), a policy it later abandoned in the face of protests from foreign trade officials.

The government's role in creating or selecting standards may also change the process of creating standards. If a standard is to be imposed by the government, then there is a greater requirement for process openness — at least in a democratic society with the expectation of transparency and public access to the decision process.

Procurement

National governments have influence upon the direction of the I.T. industry as a major buyer of the industry's outputs.

As a buyer, the government has the same concerns as any other buyer: encouraging multivendor competition to reduce lock-in and prices, and maximize choices through an I.T. system. As one U.S. government I.T. manager observed, "The IT industry has problems when a single powerful and well-capitalized provider … refuses to release its application program interface specifications to obtain a public consensus" (Royster 1996: 104).

Intellectual Property Law

Either by statute or (under English common law) judicial interpretation, the importance of open standards often conflicts with the rights granted under intellectual property law.

This has come to the fore in the treatment of reverse engineering of *de facto* standards implementations in order to obtain interoperability, either by direct competitors or by makers of complementary products. Examples of this include

- In 1991, the European Community passed its Software Directive unifying law throughout the community, which allowed reverse engineering to achieve compatibility (McManis 1993).
- In two 1992 U.S. appeals court decisions, *Sega v. Accolade* and *Atari v. Nintendo,* ruled that the necessity of complementers achieving compatibility (in this case, makers of videogames) outweighed the copyright rights of the standards holder.
- From 1993-1994, the Japanese copyright authority considered arguments by domestic and foreign I.T. producers that claimed reverse engineering was necessary to prevent vendor lock-in; opponents (successfully) argued that allowing broad reverse engineering by competitors would reduce the incentives for innovation (West 1995).

Competition Policy

The role of proprietary standards as a barrier to market competition has been a central issue in regulatory and legal actions against dominant I.T. firms, in both the U.S. and Europe. In such cases, the government has asserted that the network effects of dominant *de facto* standards create quasi-monopoly power which is subject to abuse. For example, Rubinfeld (1998: 875) notes that "having substantial market power can provide an opportunity for a firm to pursue anticompetitive strategies that raise rivals' costs and effectively foreclose opportunities."

One of the central issues of the 1998 *US v. Microsoft* case was the differences between Microsoft and Netscape in *de facto* extensions to the Internet HTML 4.0 standards, and Microsoft's use of its Windows market power to win adoption of its proprietary extensions (see, for example, Gilbert and Katz 2001). Although the base standard was an open standard, Microsoft's extensions were proprietary; the shift of web authors to use Microsoft's browser implementation as their standard for creating web content gave Microsoft at least a transient advantage over competing browser implementations of the HTML standard.

In a parallel case, the Federal Trade Commission filed suit in 1998 against Intel for denying one of its customers (Intergraph) access to its implementation of the dominant microprocessor standard, in retaliation for Intergraph seeking to assert patent claims against Intel and other firms. In a 1999 settlement with the FTC, Intel agreed to provide implementations to customers filing patent suites in most exceptions (Shapiro 2003). Intel later agreed to pay $300 million in damages to Intergraph to settle a private lawsuit (Clark 2002).

Single-vendor standards are not the only area of interest for antitrust officials. The action of SDOs could be considered anti-competitive for some cases of excluding potential participants. However, the most recent (and heated) antitrust actions involving SDOs have been against

outside participants trying to hijack open standardization efforts, specifically through the use of undeclared IPR. In the most famous case, *Rambus v. Infineon,* a combination of SDO policies and court actions have sought to discourage such actions by setting disclosure standards for standards creation efforts (Alban 2004).

While the above examples reflect U.S. regulatory and judicial decisions, with the increased centralization of European Union authority, EU regulators have increasingly influenced what is and is not allowable openness for dominant standards. In an early case, Gable (1987) notes that the European Commission required IBM disclose its mainframe interfaces to makers of competing plug-compatible products. In the 1998 *US vs. Microsoft,* EU regulators pursued parallel allegations after U.S. Federal and state attorneys general settled their action, eventually levying a $600 million fine (Kanter et al, 2004). And in the Rambus case, in 2004 the European Patent Office revoked a Rambus patent that still remained valid in the United states (Hering 2004).

Conclusions

In areas where standards intersect public policy concerns, understanding the openness of standards plays an inherent role in monitoring and achieving the associated policy goals. Whether openness is considered from a technical, organizational or financial standpoint, it is important to be able to measure the openness necessary to support those goals.

This paper has outlined several criteria for gauging such openness, and offers examples of how these criteria related to desired outcomes such as multivendor availability of and free market competition between implementations. This conceptual approach suggests avenues for further empirical research to establish the appropriate constructs and measures that best predict which form of openness is important for achieving specific goals.

Figures and Tables

Locus	Question	Most Open	Most Closed
Who	Is it open to customers?	open to all	closed except to sponsors
Who	Is it open to complementers?		
Who	Is it open to competitors?		
Who	What are rights of non-sponsors?	same as sponsors	none
What	Can others help create the specification?	open to all	closed except to sponsors
What	Can others use the specification?		
What	Can others use an implementation?		
How	How hard is it to get access to the standard?	no permission required	not allowed
How	How hard is it to get rights to use the standard?		
How	How much do rights cost?	free	prohibitively expensive
How	How many interfaces are non-public?	none	many
How	How accessible is tacit knowledge?	all have equal footing	proprietary knowledge resides in a single sponsor

Table 1: Test questions for measuring standards openness

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