EURAS Yearbook of Standardization, Vol. 5
Homo Oeconomicus XX1(4) (ACCEDO, Munich 2004)

Maintaining the Integrity of Standards: No Passage East of Java

by
Tineke M. Egyedi* and John Hudson**

Abstract: This paper explores how best to protect the integrity of standards. The context is the attempts by Sun to transform Java from a *de facto* to a *de jure* standard. We show that where the *de facto* standard is already in existence, control of the standard's evolution can be optimally placed in the hands of a single firm, possibly the one developing it, provided (i) the firm has no other products the profits of which however indirectly are linked to that standard and (ii) measures, such as the enforcement of non-discriminatory licensing, are taken to prevent the exploitation of a monopoly position. A *de jure* standard is unlikely to do this because firms take their competitive interests into standards committees. Sun's experience with Java illustrates this. Together with Sun's own reluctance to relinquish control of the standard, it explains the failure, to date, in making Java a *de jure* standard. Whilst Sun's legal dispute with Microsoft suggests that the law does not place sufficient emphasis on the importance of maintaining a standard's integrity.

1. Introduction

This papers seeks to explore a new area of standardization, that of maintaining a standard's integrity. We take as given that a standard, *de jure* or *de facto*, has emerged and examine issues of who will best maintain the integrity of that standard. By integrity is meant the consistency or compatibility of the standard

---

*Delft University of Technology Faculty of Systems Engineering, Policy Analysis and Management Information and Communications Technology, T.M.Egyedi@tbm.tudelft.nl.
**Department of Economics and International Development, University of Bath, Bath, BA2 7AY, UK, J.R.Hudson@bath.ac.uk. We gratefully acknowledge the contribution of the European Commission (DG Enterprise/ Standardisation Unit) and Verdonck Holding B.V. towards funding the research on which this paper has been based. Furthermore, we thank Manfred Holler and the two anonymous reviewers for their helpful comments. However, the views expressed in the paper are the sole responsibility of the authors.

across users and different versions. In many cases standards need to evolve. They have been developed within a specific context or state of the world. As the latter changes then so should an optimal standard. But which institutional framework is best suited to ensure the optimal evolution of the standard given the conflicting needs between maintaining integrity and ensuring it adapts to meet changing circumstances? We will examine these issues within the specific context of Sun's Java.

Java is one of the key technologies for developing cross-platform software.[1] The core technology is owned by Sun Microsystems. However, the issue of standard integrity is a general one and our analysis has wider relevance than simply Java. The Unix standard, for example, fragmented into proprietary versions that were only partially compatible such as IBM's AIX, HP's UX and Sun's Solaris, etc.[2] In the future Linux runs this risk and efforts are currently under way to ensure that this does not happen. Moreover, many standards are updated and if for this reason alone risk being fragmented.

This is, as we have said, a new area of research. However, we build on a relevant and substantial body of literature relating to compatibility or interoperability standards (Holler and Thisse, 1996 and previous issues of this yearbook and David, 1987). Kindleberger (1983, p. 395) argues that this kind of standardization of goods "...has two main purposes: to reduce transactions costs and to achieve economies of scale through product interchangeability...". He further argues that standards reduce transactions costs"...because both parties to a deal mutually recognize what is being dealt in..." (p. 378). Given the complexity and uncertainty associated with the consumption of many goods and services, it is not unusual for consumers to find themselves at an asymmetrical information disadvantage relative to producers which standards redress (Leland, 1979, Hudson and Jones, 1997 and Jones and Hudson, 1996).

In general compatibility is sought *ex ante* by developing standards recognized and administered by one of the major formal national or international agencies such as the International Standards Organization (ISO), or by standards consortia and other multi-party standards bodies (e.g. Internet Engineering Task Force and the World Wide Web Consortium). However, compatibility can also develop *ex post* as a result of market dominance. In those cases we speak of *de facto* standards. For example, we may try to avoid compatibility problems by using the same software. An example would the way IBM earlier set the

[1]Cross platform relates to software that runs on different platforms. An example of a platform is Windows, see also Bresnahan and Greenstein (1999).

[2]See De Palma, Leruth and Regibeau (1999) and Katz and Shapiro (1985) for a discussion of partial compatibility.

standard for PCs.[3] Its position was achieved not by consensus and discussion but by its market dominance, a dominance which in itself became a positive attribute for buyers partly because of the compatibility implied.

The literature on *de facto* standards has mainly been concerned with their evolution and to what extent they are optimal. An important strand of this literature has analyzed the market process generating *de facto* compatibility standards (David, 1985; Farrell and Saloner, 1985; Katz and Shapiro, 1985). This has shown that if the process of standardization is left to the market alone the outcome may be unsatisfactory in several respects. Under conditions of positive network externalities "bandwagon" phenomena can result in premature commitment to standards that will inhibit innovation and lock-into inferior technologies. Network externalities occur when, e.g., the value of goods to a user depends upon the number of other users and compatibility between products (Katz and Shapiro, 1985).

Apart from this there is of course the problem of monopoly power if one firm gains control of a standard. Anti-competitiveness effects may arise from one or more incumbent firms being able to impose differentially higher costs on their rivals, which may even deny them market access (David and Steinmueller, 1994).

Some economists hold that standards generated by the complex interplay of market/competitive forces are better than those resulting from the standards committees of SDOs and industry consortia because they have the advantage of being arrived at swiftly (Farrell and Saloner, 1988). However, quality may suffer for speed's sake and there is no guarantee that the outcome will be optimal. In addition, where *de facto* market mediated processes of standardization are involved bandwagon momentum and installed base effects (which induce consumers to conform to the preponderant choices of previous buyers) may entrench a dominant firm that will thereby acquire a much greater measure of market power than would be warranted by its having proprietary control over one among many in an array of alternative technological solutions (David and Steinmueller, 1994).

The cooperative way of arriving at standards is consensus - i.e. where interested parties undertake to choose a standard by reaching explicit agreement (Farrell, 1993). However, the general problem of the organization of a commit-

[3]The IBM compatible PC standard (Metcalfe and Miles, 1994) became the norm for PCs in the 1980s. As suppliers recognized that their markets could only be secured if they represented their products as industry standard it became commonplace to claim that a computer was IBM compatible. In practice the application of IBM operating principles was not always complete: users encountered problems when running software, although suppliers would not advertise this. Bresnahan and Greenstein (1999) review the evolution of standards within the computer industry.

tee can be understood on the basis of the concept of collective decision logic, using the development suggested by Arrow (1963).[4] If all the participants do not have the same preference or objective function then there are no perfectly satisfactory choice procedures.

In addition committees are open to capture by large, producer interests as these can provide the technical expertise to write the standards. Major vendors have an advantage when it comes to undertaking the background R&D and providing expert personnel to work on the committees. Moreover, they can use the voluntary standards organizations to issue product specifications that impose cost burdens upon rivals and potential users. They may circumscribe potential future competition by writing anticipatory standards that have the effect of channeling innovation into areas where they have control of complementary or basic technology through patents or other devices (David and Steinmueller, 1994).

To a considerable extent this literature, as illustrated above, relates to the development of a standard rather than the maintenance of an existing standard. Nonetheless some of it does touch on aspects which are relevant to our analysis. Hence, Choi (1996) analyzes a situation where there is experimentation between different technologies before ex-post standardization. He argues that the market outcome will tend to generate too little standardization. Such experimentation can result in benefits but does jeopardize compatibility. This trade-off between compatibility and new developments can also be found in De Bijl and Goyal's (1995) analysis of the process by which Philips upgraded the compact cassette into the digital compact cassette in a way which was backwards compatible, whereas Sony's upgrade was not.

The paper will proceed as follows. In the next section we will discuss Java and Sun's problems with preserving the integrity of Java. This discussion will raise several important questions. One of these questions is which parties have an incentive to harm standards integrity, and under what conditions. To increase our understanding we shall look at the theoretical issues involved. Finally, in the conclusion, we will consider among other issues the optimal institutional framework to govern the administration and evolution of existing standards, and propose some alternatives for the way forward.

2. Java

Java started as a programming language. One of Sun's maxims was *Write Once Run Anywhere* (WORA). That is, a Java programmer should not need to rewrite software to make it run on the proprietary platforms of different vendors. Java

---

[4] The problems of committees in the standardization arena are discussed in Werle (2001).

programs were to be portable and scaleable. In order to achieve this degree of cross-platform compatibility, Sun created a standardized programming environment.[5] Each system and browser provider had to fully implement it if WORA was to be achieved. Large system providers such as IBM and Hewlett-Packard did so. The platform independence of Java allowed small Java programs to be downloaded and executed by web browsers. These moving, colorful applets triggered its breakthrough on the Internet.

2.1 Controlling its evolution or maintaining standard integrity?

The evolution of Java proceeded with much input from the Java community. Already at an early stage Sun provided access to the Java source code and invited interested parties to comment on, experiment with and improve it. Sun used different strategies to co-ordinate this process.[6] Until the late 1990s, Sun essentially retained control over decisions regarding the Java-core and the changes to be included in new updates. However, pressed by the developers and business community, Sun issued *The Java Community Process Program Manual: The formal procedures for using Java specification development process* (1998). The intent was to develop a formal process for developing Java specifications based on an "inclusive, consensus building approach". However, participation in drafting the new specification required signing the Java Specification Participation Agreement (JSPA) which in effect confirmed Sun's control. Sun attempted to readdress criticisms in a document issued in April 2000. This initiative was, however, outshone by an initiative to formally standardize Java, an effort which we will discuss later on.

With a view to maintaining the integrity of the de facto standard, one of Sun's main strategies was its licensing policy. Test suites were used to certify compatible Java products as well as use of the *Java compatible* logo. These instruments of control were backed up by trademarks (Java™, Java-compatible logo), patents (software algorithms) and copyright (primarily copyright on specifications). The *company license* for commercial use of Java posed most constraints on Java use. The *research use license* was the least restrictive.

---

[5] The standardised application programming environment includes the specifications of the Java Virtual Machine (JVM; i.e. software that runs on proprietary operating systems and is capable of interpreting compiled Java byte code) and Application Programming Interfaces (APIs). APIs comprise the standard packages, classes, methods and fields made available to software developers to write programs.

[6] For example, the instruction manuals which Sun and others wrote on Java and the training programs that led to certified Java developers supplemented a coordinated development of the Java platform.

Usually licenses for commercial use are strictly confidential. However, as part of the court case between Sun and Microsoft, which we discuss later, details of the Technology License and Distribution Agreement became known. Therein Sun makes explicit its interest in maintaining compatibility among Java language based products and in protecting and promoting its Java compatibility logo. Sun expects Microsoft's products to conform to the latest developments of the Java platform and offers Microsoft its test suites free of charge. If the products pass these tests Microsoft may use the Java-compatible logo. A key aspect of the license relates to use of the latter. The Java logo gives third parties confidence in the product's compatibility. Microsoft is requested to refrain from actions that degrade the integrity of the standard and thus harm the reputation and goodwill associated with the logo.

Pressed by its licensees to develop a more liberal licensing regime, Sun developed the Community Source License Principles in 1998 (Gabriel and Joy, 1998). Therein community members are given broad access to the Java source code and are encouraged to participate in its development. The research license, which is free of charge and open to all, grants "broad experimentation and evaluation rights". The commercial license grants developers considerable modification rights.[7] However, Sun continues to charge fees for companies that want to sell products based on modified source code, among other things.[8] That is, the new license still allowed Sun to retain control.

From the outset, Sun indicated that it was keen on getting Java formally standardized by ISO because this would give added confidence to customers, partners and developers about investing in Java. Becoming a Publicly Available Specification (PAS) submitter to ISO would allow Sun to shortcut the normal standardization process and if approved become an international standard. After an initial rejection in November 1997, and with reservations about the openness of the Java specification process, Sun was accepted as an authorized PAS submitter. However, Sun never submitted Java as a PAS. Box 1 discusses the reasons not to do so. Instead, Sun approached ECMA, an industry association for standardizing information and communications systems, to discuss *de jure* Java standardization. Once approved as an ECMA standard, ECMA's liaison with ISO would allow Sun to make Java an international standard via ISO's Fast Track procedure, a procedure very similar to the PAS procedure. However, Sun

---

[7] That is to modify the Code, but subsequently the modified Code must pass the test suites provided by Sun.

[8] In addition, products distributed under the Commercial Use License must be branded with the appropriate Sun logo which requires a separate trademark license from Sun. Sun still owns the infrastructure part of the original code and upgrades and provides test suites to ensure compatibility.

soon also withdrew from this route (i.e., to ISO via ECMA). Why Java was not standardized twice is discussed in Egyedi (2001b).

Box 1. Standard integrity issues in Sun's withdrawal from ISO

When Sun approached ISO to formalize Java one of its goals was to "preserve industry's substantial investment in Java". This was a way of sying that Java should not undergo serious changes during the PAS review process. Sun further expected to retain control over the standards maintenance process by securing the role of the Java community during ISO standardization, whose inmput was coordinated by Sun itself. Sun further upheld its essential Intellectual Property Rights (IPR), and retai8ned its patents (although no fees were asked), its copyright (joint-copyright ownership was suggested, no fees asked), and trademarkds (e.g., control over compatibility logo). The revenues from IPR were forfeited in exchange for enlargeing and stabilizing the Java market - without compromising control over cross-platform compatibility (e.g. by means of the Java compatible logo and the test suited). ISO's role was to codify and ratify the specification development activities supervised by Sun.

Sun withdrew from the PAS process allegedly because ISO changed tha PAS procedure. The new procedures, according to Sun, implied that Sun would have had to turn the maintenance and evolution of Java over to ISO. Moreover, standard maintenance would not be restricted to minor adjustments such as bug fixing. To Sun, the changes signaled that it would encounter problems when submitting the Java specification. For example, a Java Study Groupd had been installedin ISO and people were discussimng how they were going to change the JAVA specification.

In addition, there were market developments that threated Sun's position, occurrences that increased Sun's desire to keep a grip on Java developments. Firstly, Microsoft did not abide by the Java licensing agreement, and posed a threat to cross-platform compatibility. A lawsuit followed. Secondly, there were disquieting developments in the area of real-time embedded Java. In 1998, workshops were organized to develop specification requirements for real-time Java. This led to the formation of the Real-Time Java Working Group (RTJWG) led by Microsoft and Hewlett-Packard. The RTJWG activities were disquieting to Sun, because real-time Java draws on the base specifiocation of Sun's Java. The working greoup could not write real-time speicifications in a useful way without making changes to the base specifications. There was therefore a risk that competitive developments in the field opf real-time Java would affect the work done on Java^{TM} within Sun's Java Community Process and thus endanger the integrity of the Java platform.

2.2 The Sun-Microsoft lawsuit and its implications

In 1997, Sun filed a complaint against Microsoft for copyright infringement. Microsoft had developed a software toolkit for Java, the use of which could lead to platform dependent Java programs. Microsoft further falsely advertised its Java implementation as the 'official reference implementation' and made other misleading claims suggesting compliance to Sun's specs. This challenged the standard's integrity. Microsoft's market power could lead to an incompatible and unauthorized version of Java Technology becoming the *de facto* standard within the market.

The outcome of the lawsuit was largely in Sun's favor, but on the grounds of breach of contract and not copyright infringement as Sun had hoped. This reflects not only the relative sophistication of the American legal system in areas of market competition, but also its relative reluctance to recognize the gains from *de facto* standardization. This is a critically important point. It forces companies such as Sun who want to maintain the integrity of a *de facto* standard to devise elaborate, and therefore more expensive and probably less effective, intellectual property rights (IPR) systems and devices. The default legal regime simply does not give them sufficient protection from users wishing to modify the standard.[9]

Sun was also having difficulties in maintaining the integrity of the Java platform in the real-time market of small devices (e.g., the Barbie doll, cruise missiles and telephone switches (Gage, 1999). In 1998, the US National Institute of Standards and Technology organized a series of workshops to specify requirements for real-time Java (see Box 1). This led to a working group (RTJWG) and eventually to the establishment of the Java Consortium. The consortium tried to take over control for the evolution of real-time embedded Java. In response, Sun started its own group. (For more details on this struggle we refer to Egyedi, 2001c.) Whereas a different platform for small devices already posed a threat to (the scalability of) the Java platform, these two competing groups for standardizing real-time Java aggravated the problem of the standard's integrity.

This pattern of events raises several questions. Firstly, should the Courts give greater emphasis to the needs for standardization and compatibility in its judgments?[10] Secondly, do companies need legal protection when the option is open to them to have the *de facto* standard made official by one of the standards' organizations? Thirdly, is there some internal dynamic leading standard users to

---

[9] The European Union is discussing a Directive on Software Patenting. At the time of writing, Autumn 2003, the European Parliament opposes the idea to follow America's lead in this respect.

[10] This question is also addressed in Egyedi (2001a).

dilute the integrity of the standard despite the obvious benefits from maintaining that integrity? In order to help answer these questions we first turn to theoretical considerations of the processes surrounding *de facto* standardization.

3. The firm's problems

We assume firms operate at three levels. Level 1 (L1) denotes firms operating at the level of the platform. It sells only to firms operating at the second level. These use the platform to produce products they sell to other firms (and consumers). The latter use the products of the industry but are not (in general) part of that industry. Within the context of the previous discussion, Sun is a L1 firm, Microsoft and IBM level two (L2) firms and anybody who buys their products level three (L3) firms. The network is characterized by a vector of characteristics, **Z**, the L1 firm chooses that combination (**Z*)** which maximizes its profits. This will be linked to the vector which promotes greatest usage amongst L2 firms, and depending upon the licensing agreements perhaps amongst level three (L3) firms as well. In doing this it is possible that the L1 firm will consider the possibility that some L2 firms will find the standard so far away from their desired specification that they abandon the standard altogether in favor of some alternative. This may, despite the loss from decreased network effects, prove inevitable and is not necessarily sub-optimal. For simplicity we will assume that **Z** can be represented by just a single characteristic Z. We will analyze the implications of allowing a L2 firm to move away from the provider's standard Z^* even though this reduces the integrity of the standard. In our analysis L1's decisions are predicated on the assumption that the integrity of the standard will be maintained.

An alternative possibility, which we shall not explore in this paper, is that L1 might permit limited adaptations of the standard by L2 firms. This opens up interesting issues of when and under what conditions it is profitable to do so and may also help illuminate how far a firm such as Sun should go in enforcing the integrity of the standard. One such approach would be a two period dynamic model. In period 1 the innovator chooses Z^* and licenses the technology to interested adopters without making changes to it. In period 2, the adopters may adapt Z^* to their own needs. 'Local adaptations' will have two effects: (1) the use of the technology increases and so do L1's licensing revenues and (2) compatibility among the adopters diminishes into partial compatibility. Partial compatibility may reduce the utility of the technology for the adopter's users and thus diminish their willingness to pay for the products of the adopter's users (L2) who face this trade-off themselves with the innovator remaining passive in this second period.

3.1 Level one firms: Which standard?

We first focus on what standard each L2 firm would wish to see prior to the standard being set and where it bears none of the costs of developing the standard. The *i*'th level 2 firms maximization problem is:

(1) $$\text{Max } \pi_{2i} = p_{2i}q_{2i} - c_{2i}q_{2i} = (p_{2i} - c_{2i})q_{2i}$$

(2) $$q_{2i} = f_{2i}(C, Z^*)$$

where, at this point, we ignore the impact of p_{2i} on q_{2i}. c_{2i} represents both marginal and average costs of production. These are standard costs relating to labor and capital and are assumed to be independent of Z^*. $C \in [0,1]$ is an index of standard or platform integrity, i.e. the extent to which a product developed on one machine can be carried over to work on another. In this hypothetical case, we assume $C = 1$, i.e. we are interested in what level of standard the *i*'th firm would wish to see employed, given everyone adheres to it, i.e. complete integrity. The optimal solution implies:

(3) $$\partial\pi_{2i} / \partial Z^* = (p_{2i} - c_{2i})\partial f_{2i} / \partial Z^* = 0$$

The above implies some optimal level of Z for the firm (Z_i^*). A relatively simple functional form which captures this is

(4) $$q_{2i} = A_i C^{\alpha i} - \beta_i (Z^* - Z_i^*)^2$$

$A_i C^{\alpha i}$ represents potential demand for the *i*'th firm's product when the standard is at the firm's preferred level. Deviations of the standard from this preferred level result in lower sales in a symmetric manner. As $|Z^* - Z_i^*|$ increases so demand falls at increasing rates. In this case with $C = 1$, profit maximization subject to (4) results, not surprisingly, in a preference for $Z^* - Z_i^*$.

We turn now to a L1 firm which will seek to produce a standard Z^* which meets the wishes of its (potential) customers. First we focus on what license fee (γ_i), levied on the *i*'th L2 firm's profits, it will seek to charge from L2 firms for use of the platform. This involves maximizing:

(5) $$\begin{aligned} Max\ \pi_1 &= \sum \gamma_i \pi_{2i} + (1 - \gamma_1)\pi_{21} \\ &= \sum_{i \neq 1} \gamma_i \pi_{2i} + \pi_{21} \end{aligned}$$

subject to

(6) $$q_{2i} = f_{2i}(C, Z^*, p_{21}, \boldsymbol{p_{2j}})$$

where $\boldsymbol{p_{2j}}$ includes all L2 prices except *i*. We include in (5) the possibility that the L1 firm is also a L2 user of its own platform - hence the term $(1-\gamma_1)\pi_{21}$. The solution implies:

(7) $$\partial\pi_1 / \partial\gamma_i = \pi_{2i} + \gamma_i \partial\pi_{2i} / \partial\gamma_i + \partial\pi_{21} / \partial\gamma_i + \sum \gamma_j \partial\pi_{2j} / \partial\gamma_i = 0$$
$$\gamma_i = -\left\{\pi_{2i} + \partial\pi_{21} / \partial\gamma_i + \sum \gamma_j \partial\pi_{2j} / \partial\gamma_i\right\} / \left(\partial\pi_{2i} / \partial\gamma_i\right)$$

That is, the L1 firm will seek to extract monopoly profits by charging a differential fee to different L2 firms, an example of first degree price discrimination. But this particular exercise of monopoly power goes further because the L1 firm is also a L2 firm, i.e. it uses its own platform in other goods it produces. Thus it will also set γ_i to raise the fee it charges to L2 competitors and lower it to those, if any, who produce complementary goods to its own (the term $\partial\pi_{21} / \partial\gamma_i$ in (7)). *This abuse of monopoly power can be mitigated by ensuring that the L1 firm charges a fixed fee γ to all L2 firms.*[11] However, this does not fully solve the problem of monopoly power as the L1 firm will also seek to set the standard in such a way as to maximize its own, rather than the community's, benefit. It is to this problem that we now turn.

We first examine the case of revenue maximization, where the L1 firm again chooses to maximize its fixed share of L2 firms' profits. The optimal solution involves the following maximization:

(8) $$Max \sum \gamma\pi_{2i} = \sum \gamma(p_{2i} p_{2i} - c_{2i} q_{2i}) + (1-\gamma)(p_{21} q_{21} - c_{21} q_{21})$$

We assume that the fixed license fee (γ) has already been set, hence again we focus solely on the optimal choice of standard specification, abstracting from the impact of p_{2i} on q_{2i}.

(9) $$q_{2i} = f_{2i}(C, Z^*)$$

which results in the following marginal equivalence condition:

---

[11]See Lemley and McGowan (1998) for both a discussion of and examples of non-discriminatory licensing.

(10) $\gamma\sum\partial\pi_{2i}/\partial Z^{*}=\gamma\sum(p_{2i}-c_{2i})\partial f_{2i}/\partial Z^{*}+(1-\gamma)(p_{21}-c_{21})\partial f_{21}/\partial Z^{*}=0$

where we have assumed $(p_{2i}-c_{21})$ is independent of output. When the demand function is as in (4) this becomes:

(11) $$\gamma\sum\pi_{2i}\partial f_{2i}/\partial Z^{*}$$
$$=2\gamma\sum(p_{2i}-c_{2i})\beta_i(Z^{*}-Z_i^{*})+2(p_{21}-c_{21})(1-\gamma)\beta_1(Z^{*}-Z_1^{*})=0$$

and hence

(12) $$Z^{*}=\left[\gamma\sum(p_{2i}-c_{2i})\beta_iZ_i^{*}+(p_{21}-c_{21})(1-\gamma)\beta_1Z_1^{*}\right]/\left[\gamma\sum(p_{2i}-c_{2i})\beta_i+(p_{21}-c_{21})(1-\gamma)\beta_1\right]$$

Where the L1 firm is also the only L2 firm this simplifies to $Z^{*}=Z_1^{*}$. In the more general case, where the L1 firm has no direct L2 interest this simplifies to:

(13) $$Z^{*}=\sum(p_{2i}-c_{2i})\beta_iZ_i^{*}/\sum(p_{2i}-c_{2i})\beta_i$$

i.e., in (13), Z^{*} is a weighted average of $Z_i^{*}(\forall i)$ where the weights depend upon the impact of changing the standard on the *i*'th firm's profits. Hence Z^{*} will, reasonably enough, favor the larger firms with larger sales, who other things being equal will have larger β_i,. However, when the L1 firm has a direct interest as a L2 firm, in setting Z^{*}, greater weight will be given to its own preferred option (Z_i^{*}) as in (12). The standard will no longer be set optimally from the point of view of all users. We made the simplifying assumption that there is just one characteristic to the standard. However, provided the characteristics are independent of one another and in their impact on demand, then we can use (12) and (13) to determine the optimal value for each of a vector of characteristics in turn.[12]

In the case where the platform provider is attempting to maximize usage (i.e. the volume of sales of all L2 firms) rather than profits (or indeed revenue) the optimal condition for Z^{*} becomes

(14) $$Z^{*}=\sum\beta_iZ_i^{*}/\sum\beta_i$$

---

[12]In (12), Z^{*} depends upon γ. In reality, it is possible that the optimal values for these variables are decided upon simultaneously by the firm.

3.2 Level two firms

We now focus on the maximization problem of the L2 firm once the standard has been set. There will be a tendency for it to deviate from the standard. Its maximization problem is now:

(15) $$Max\ \pi_{2i} = p_{2i}q_{2i} - c_{2i}q_{2i} - k_{2i}$$

(16) $$q_{2i} = f_{2i}(C, Z_i, p_{2i})$$

(17) $$C = h(Z_i - Z^*)^2$$

(18) $$k_{2i} = k(Z_i - Z^*)^2$$

The optimal characteristic vector (Z_i^*) will vary between L2 firms, clearly a Barbie Doll is likely to require different characteristic to a Cruise missile. Because of this the quality of its product will, unless the two coincide, be enhanced if it deviates from Z^* and moves towards Z_i^*. Thus, e.g., Microsoft's version of Java was optimized for Windows in a way which made it more attractive for its users (Gilbert and Katz, 2001). In addition, given the heterogeneity of L3 firms and final users, there will also be an incentive for a L2 firm to attempt to slightly move away from the agreed standard, thus making itself more attractive to a significant sector of the market and hence tending to pick up many of the sales from that sector. However, any move away from Z^* will reduce *C*, the integrity of the standard. Changing the platform provided by the L1 firm will involve costs (k_{2i}) which we assume to be an increasing function of the distance $\left|Z^* - Z_i^*\right|$, but fixed with respect to output. These costs may include the expected legal costs if the platform provider seeks to protect the standard by taking legal action.

There are a number of factors which are exogenous to the problem. These include what other firms, e.g. the *j*'th, are doing with respect to Z_j (impacting on integrity) and the underlying level of demand for L3 firms and hence L2 firm's products (impacting on the functional form (f_{2i})).

Optimizing (15) with respect to Z_i gives

(19) $$(p_{2i} - c_{2i})\left[\partial f_{2i} / \partial Z_i + (\partial f_{2i} / \partial C)(\partial C / \partial Z_i)\right] = \partial k_{2i} / \partial Z_i$$

The left-hand side term represents the financial rewards (if any) from moving the standard. It consists of the gains in having a standard better suited to the firm's needs balanced against the losses from diluting the integrity of the standard. The right-hand side represents the direct costs associated with changing the standard. *The costs tend to be the same for all firms whereas the advantages tend to increase for larger firms and hence we would expect the greatest impetus from standard dilution to come from larger firms.* Using (4), (17), (18) and (19) we get:

(20) $Z_i =$

$$\left\{(p_{2i} - c_{2i})\beta_i Z_i^* + (k - \alpha_i A_i C^{\alpha i - 1} h) Z^*\right\} / \left\{(p_{2i} - c_{2i})\beta_i + k - \alpha_i A_i C^{\alpha i - 1} h\right\}$$

That is the standard the user will adopt is a weighted average of Z^* (the provider's standard) and Z_i^* (the standard the user would ideally like). The greater the impact of the standard specification on sales the greater the weight on Z_i^*. Conversely, the greater the costs of changing the standard, the greater the emphasis on Z^*.

Using (19), the total gain to the firm from moving away from the standard Z^* is approximately[13] equal to

(21) $$\left\{(p_{2i} - c_{2i})\left[\partial f_{2i} / \partial Z_i + \partial f_{2i} / \partial C(\partial C / \partial Z_I)\right] - \partial k_{2i} / \partial Z_i\right\}(Z^* - Z_i)$$

The total cost to all Java users is approximately:

(22) $$\sum\left\{(p_{2m} - c_{2m})\left[\partial f_{2m} / \partial C(\partial C / \partial Z_I)\right]\right\} - \partial k_{2i} / \partial Z_i (Z^* - Z_i)$$

This total cost is likely to exceed any advantage to the *i*'th firm for two reasons. Firstly, the integrity of the standard will have been damaged by approximately $(Z^* - Z_i)\partial C / \partial Z_i$. Secondly, in shifting away from the agreed standard the *i*'th firm incurs costs approximately equal to $\partial k_{2i} / \partial Z_i (Z^* - Z_i)$.

However, in those cases where $\left|\partial C / \partial Z_i\right|$ *is small then there may be gains in letting individual firms deviate from the standard.* This might be the case with, e.g., the Barbie Doll, where any change to the Java code might be supposed to have little impact on other users at any level. This is not, of course, the case with Microsoft. Any damage it inflicted on the integrity of the standard would have a substantial impact on other users. There is, however, a fundamental difference in Microsoft's actions compared to those of other potential L2 firms. It stood to gain directly by "polluting" the integrity of the Java standard inasmuch as, in contrast to most other L2 firms, $\partial q_{2i} / \partial C < 0$.

[13] Approximately, because we are using partial derivatives.

The WORA feature of Java posed a direct threat to the dominance of the Windows operating system where network effects operated to form an entry barrier to new operating systems. Java offered a standard which would allow creators of programs to write without regard for the underlying operating system. Hence new operating systems would become exchangeable with Windows.

4. Conclusions: Return to Java

The issues which this paper has focused on, namely the integrity and evolution of *de facto* standards, are relatively new to literature. We believe that these are important issues and hope that the paper will stimulate further research. We are not so much interested in how *de facto* standards emerge, although our analysis may have implications for this, but in whether private companies, formal standard setting organizations[14] or some combination of the two can be expected to administer standards optimally. This is particularly important where standards need to evolve over time. Our analysis has highlighted that this may well be an area of conflict. For example, we have seen that whilst the standard provider has an incentive to protect the integrity of its standard, the standard user may have an incentive to modify it in certain key areas. For example, the user's optimal configuration may differ from the current standard, which is almost certainly a compromise between the requirements of the different users. The user company might gain sales if it could modify the standard to meet its own requirements more closely. Such a modification could be termed a 'benign' case of standard dilution. In addition, there is the possibility that firms might want to dilute or acquire control over a standard for anti-competitive reasons.

Of course, there is a trade-off involved here. In diluting the standard its value it also reduced. Hence, the extent to which a firm deviates from the standard, if indeed it does deviate, will itself be a compromise. It should be emphasized that the standard user does not bear the full costs of deviating from the standard, there are also costs to other standard users as well as to the standard provider. Because of the fixed nature of the set-up costs in modifying a standard, it is perhaps more likely that large firms with a large client base will dilute the standard. On the other hand, we have also seen that it is likely that the standard will be developed with their needs in mind more than those of small firms. All of these developments are in evidence when looking at the history of Java.

The standard provider has an incentive to protect the integrity of the standard and L2 firms have an incentive to deviate from the standard. If the integrity of

[14] Implementing a *de jure* standard where decisions are taken in some form of collective manner.

the *de facto* standard is upheld by the courts, then the provider simply needs to make this explicit in any licensing agreement and be prepared to sue licensees who depart from the standard. If the courts are not prepared to fully recognize such clauses the process becomes much more complex. The standard provider needs to make IPR clauses as diverse as possible and to supplement them with any other instruments under its control. In part this is to increase the likelihood of the courts finding some reason to declare in their favor, in part it raises the (legal) costs of deviation from the standard thus making it more unlikely that user firms will do so.[15]

Alternatively, as with Java, the firm can seek to make its *de facto* standard an official or *de jure* standard. The problem with this is that the firm will lose some, and possibly all, control over the standard. Committees are open to capture by special interest groups. If there is a potential problem of monopoly abuse of power, the use of formal committees does not solve this problem, it merely transfers the battleground from the market place to the committee room.

This brings us directly to consider what institutional structure can be depended upon to administer existing standards optimally. Within the context of a platform standard such as Java, the problems of private control are the problems of monopoly abuse of power. That is, the standard provider may adopt a differential pricing strategy if not explicitly to harm rivals then at least in a manner which is not welfare maximizing. For example, a standard user may agree with the provider to price its competitors out of the market in return for a share of the monopoly profits. This can be overcome by outlawing such practices and the legal requirement that all contracts are publicly accessible. But pricing policy is only part of the administrator's task: the second part concerns control over the evolution of the standard, something which is particularly important in the case of Java.

Hence, we can apparently neither depend upon *de jure* or *de facto* processes to administer a standard optimally. Superficially, the Java Community Process offers a potential way forward. It might, e.g., provide a framework which makes the innovator more aware of users' needs and even permit some local modifications to the standard, whilst still maintaining control of the standard's integrity. However, this would have to be looked into. We would not expect this process to differ much from the formal standards process since the Java Community Process does nothing to reduce the inherent differences between firms, in

---

[15] In this sense IPR is a tool for the firm to maintain control over its standard. It is however possible, as suggested by an anonymous referee, that IPR may also be used to threaten the integrity of the standard. One motive for adopters to fragment the standard could be to innovate extensions on the technology. If they get IPR on these extensions they may earn money from licensing these to other adopters of the technology (see Wallace, 1997).

particular between the innovator and the different users of the standard. It is in effect a form of committee, with Sun taking the lead role. Yet our analysis does suggest a way in which the conundrum may be solved. The first part of the solution is, as before, open contracts so that the possibility of discriminatory pricing is negated. Only if the provider publishes the details of its licensing agreements can we be certain that it is not abusing its monopoly position in this way. To deal then with the possibility of distorting the future development of the standard to meet the platform provider's wider interests, we rule those wider interest out of the equation.

If the standard provider has no other business interest than to administer the standard, and if openness is a prerequisite of the administration process then our analysis has shown that it is in the provider's interest to administer the standard in such a way as to maximize the overall profits/sales of user firms. Under certain assumptions this will simultaneously maximize social welfare. If the existing platform provider satisfies these conditions then they can continue administering the standard. If not, then control of the standard should be passed over to a firm whose sole interest lies with administering the standard. This firm could then pay a share of its revenue to the innovator firm.

This is currently not the case, and as such our analysis has relevance for several policy and theoretical issues. Firstly should the courts be more ready to recognize infringement of a *de facto* standard as a legal issue? On the one hand, the provider of a *de facto* standard is a monopolist with the potential and incentive of all monopolists to distort competition to its own advantage and to the public's eventual disadvantage. On the other hand, maintaining the integrity of the standard, benefits both user firms and eventually consumers in providing a consistent working environment, hence reducing transactions costs and enhancing external economies of scale. However, just as there is an incentive for the standard provider to distort competition so there is an incentive for users of the standard to fragment it; and because of the fixed costs associated with changing the platform this probably applies to large firms more than small ones. These two tendencies suggest that the courts should be concerned with both ensuring fair competition and maintaining the integrity of the standard, whereas at the moment they are more concerned with the former.

Lemley and McGowan (1998) in a comprehensive review of the law's position on network effects, whilst at times recognizing the advantage of strong standards, suggest that the courts should favor legal solutions that open standards to 'competition'. Part of the basis for this argument is that this will reduce the lock-in effects which strong standards induce. This argument, of course, completely misses the point that one cannot have standard competition between rival L1 firms and simultaneously maintain the integrity of the standard.

This is a more general reflection of what is at best an ambiguous and confused attitude by the law and legal scholarship to this concept.[16]

Finally, the fact that there is a public interest in preserving the integrity of the platform does not necessarily translate into arguing for legal protection for the standard provider's rights. Apart from the monopoly arguments we have been analyzing, the development of the standard is frequently, as in the case of Java, carried on by other users. It is a community development with the provider certainly taking the initial and perhaps subsequently the major role, but the involvement of others (i.e., users and programmers) in its development gives them an ethical case for having their views considered on how the standard should develop. Even if they do not influence the development of the standard, they use it and thus contribute to its success and this too gives them ethical rights, particularly if, as in the case of a *de facto* standard, there is no alternative for them to use.

References

Arrow, K. (1963), *Social Choice and Individual Values*, New Haven: Yale University Press.

Bresnahan, T.F. and S. Greenstein (1999), "Technological competition and the structure of the computer industry", *The Journal of Industrial Economics*, 47, 1-40.

Choi, J.P. (1996), "Standardization and experimentation: ex ante vs. ex post standardization", *European Journal of Political Economy*, 12, 273-290.

David, P. (1985), "Clio and the economics of QWERTY", *American Economic Review, P&P*, 75, 332-336

David, P.A. (1987), "Some new standards for the economics of standardization in the information age", in: P. Dasgupta and P. Stoneman (eds.), *Economic Policy and Technical Performance,* Cambridge: Cambridge University Press.

David, P.A., and W.E. Steinmueller (1994), "Economics of compatibility standards and competition in telecommunications networks", *Information Economics and Policy*, 6, 317-341.

De Bijl, P.W.J and S. Goyal (1995), "Technological change in markets with network externalities", *International Journal of Industrial Organization*, 13, 307-325.

De Palma, A., L. Leruth and P. Regibeau (1999), "Partial compatibility with network externalities and double purchases", *Information Economics and Policy*, 11, 209-227.

Egyedi, T.M. (2001a), "IPR paralysis in standardization: is regulatory symmetry desirable?", *IEEE Communications Magazine,* April.

---

[16] This is a reflection of the difficulties the law has in dealing with network effects in general (Lemley and McGowan, 1998). In the context of our paper there are some difficult issues. For example, how should a court decide whether a standard has been violated? It might be argued that in some cases modifying the standard is desirable and preventing violations runs the danger of stifling innovation. Nonetheless, the law cannot simply avoid areas because they present difficulties in implementation.

Egyedi, T.M. (2001b), "Why Java™ was -not- standardized twice", *Computer Standards & Interfaces*, 23, 253-265.

Egyedi, T. (2001c), "Strategies for *de facto* compatibility: standardization, proprietary and open source approaches to Java", *Knowledge, Technology, and Policy*, 14, 113-128.

Farrell, J. (1993), *Choosing the Rules for Formal Standardization, NBER Conference: Cooperation, Coordination and Collusion among Firms*, Cambridge, Mass.

Farrell, J. and G. Saloner (1985), "Standardization, compatibility and innovation", *RAND Journal of Economics*, 16, 70-83.

Farrell, J. and G. Saloner (1988), "Coordination through committees and markets", *RAND Journal of Economics*, 19, 235-252.

Gabriel, R.P. and W.N. Joy (1998), *Sun Community Source License' Principles (SCSL)*, ***place of publishing***, ***publisher***.

Gage, D. (1999), *Real-Time Java Dispute Comes to a Head this Week*, www.Znet.com/pcweek.

Gilbert, R.J. and M.L. Katz (2001), "An economist's guide to U.S. v. Microsoft", *Journal of Economic Perspectives*, 15, 25-44.

Holler, M.J and J.-F. Thisse (eds.) (1996), *The Economics of Standardization* (Special Issue of the *European Journal of Political Economy*, 12), Amsterdam: North-Holland.

Hudson, J. and P. Jones (1997), "The gains of standardization from reduced search costs", *EURAS Yearbook of Standardization,* Volume I (*Homo Oeconomicus* 14), Munich: Accedo-Verlag.

Jones, P. and J. Hudson (1996), "Standardization and the costs of assessing quality", *European Journal of Political Economy*, 12, 355-361.

Katz, M.L. and C. Shapiro (1985), "Network externalities, competition and compatibility", *American Economic Review*, 75, 424-440.

Kindleberger, C.P. (1983), "Standards as public, collective and private goods", *Kyklos*, 36, 377-396.

Leland, H.E. (1979), "Quacks lemons and licensing: a theory of minimum quality standards", *Journal of Political Economy*, 87, 1328-1346.

Lemley, M.A. and D. McGowan (1998), "Legal implications of network economic effects", *California Law Review*, 86, 479-611.

Metcalfe, J.S. and I. Miles (1994), "Standards, selection and variety: an evolutionary approach", *Information Economics and Policy*, 6, 243-268.

Wallace, J. (1997), *Overdrive: Bill Gates and the Race to Control Cyberspace*, New York: John Wiley and Sons.

Werle, R. (2001), "Institutional aspects of standardization - jurisdictional conflicts and the choice of standardization organizations", *Journal of European Public Policy*, 8, 392-410.