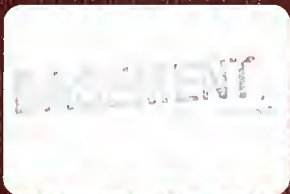
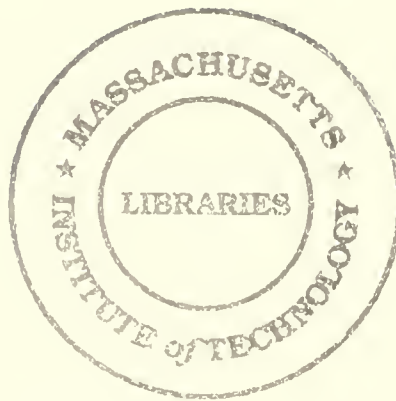


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ECONOMIC ISSUES IN COMPUTER INTERFACE STANDARDIZATION

Garth Saloner

WP2109-88

December 1988

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by

Garth Saloner*

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1. Introduction

Traditionally, computer vendors have provided a range of mutually incompatible systems, both in that machines manufactured by different vendors are not easily physically networked and in that peripherals and software written for one machine are not easily adapted to another. Recently however, there has been a major trend towards an alternative paradigm in which there are no proprietary boundaries between the product offerings of different vendors. The goal of the proponents of so-called "open systems" is to provide nonproprietary standards specifying how the components at the interfaces interact.

There are several facets to open systems. First, open systems will provide a standardized interface between applications software and any vendor's computer.^{1,2} This interface will provide "portability": the ability to transfer any software written to comply with that interface to any other computer system conforming to the standard. Importantly, this "applications environment" could be quite richly specified, including specifications of graphics and particulars of the user interface, including the "look and feel" of the display and windowing specifications.³ Second, standard networking protocols would be provided allowing seamless inter-computer communication between computers conforming to the communications interface. Finally, it would provide standard peripheral interfaces.

A major first step in the development of an open systems environment is standardization on an operating system around which the other elements of the open systems platform will be developed. The focal operating system has been Unix, a proprietary operating system of AT&T. By the end of 1987, there were 600 000 Unix installations worldwide of which 256 000 were added in 1987

1. We use the term "vendor's computer" somewhat loosely to denote both the vendor's hardware and software necessary to provide the interface with applications.

2. This interface is referred to variously as the Common Applications Interface (by the Open Software Foundation), the Applications Environment Specification (by X/OPEN), and as the Applications Portability Profile (by NIST).

3. Such specifications are contemplated within the OSF Common Applications

(a growth of 60% in a single year).⁴ By value of shipments, Unix accounted for 10% of the US market in 1987 and that is projected to grow to 20% by 1991.⁵ In 1987 DOS accounted for an additional 24% of the value of shipments, which is forecast to grow to 28% by 1991.⁶ Thus open systems could soon account for half of the market (measured by value of shipments).

In early 1988 AT&T entered into an agreement with Sun Microsystems to merge AT&T's Unix System V with parts of the UC Berkeley Unix 4.2 and to meld networking and graphics features of Version 4.2 already used by Sun.⁷ This move led to an outcry from vendors who expressed concern that AT&T would be able to lever its ownership of Unix into advantages for itself and Sun, and from rivals of Sun who feared that Sun would gain a competitive advantage as a result of their unique position as a co-developer of new interfaces.⁸

On May 17, 1988 seven major American and European computer companies (IBM, DEC, Hewlett-Packard, Apollo, Siemens, Nixdorf, and Groupe Bull) announced their sponsorship of the Open Software Foundation to provide a "common applications environment", with IBM's AIX version of Unix as the cornerstone of the foundation's offerings. Two other companies, Hitachi and Philips, have since joined as sponsor companies and many others have joined as members (including Data General, Intel, Silicon Graphics, Toshiba America, and Wang). The sponsors have each committed \$4.5m per year for three years (for a total of \$121.5m) and are each entitled to a seat on the board of directors. Members (who pay an annual fee of \$25 000 (\$5000 for not-for-profit organizations)) can participate in a variety of ways⁹. However, control is in

Environment.

4. "Open Systems: What Price Freedom?" Datamation, June 1, 1988, pg. 54.

5. ibid.

6. ibid.

7. "AT&T, Sun ink Unix Deal," Computerworld, March 2, 1988.

8. "Some of the strongest companies in the computer industry want to limit whatever advantages AT&T may gain through its ownership of Unix. DEC and HP complain that AT&T appears to be maneuvering to outflank them and other makers of Unix-based computer products ... The concern is that AT&T's new agreement ... with Sun ... will put other makers of Unix-related products perpetually behind AT&T and Sun in the race to market advanced Unix technology." (Thomas Hayes, "AT&T's Unix is a Hit at Last, and Other Companies are Wary," New York Times February 2, 1988, pg. 42.)

9. For example, they can contribute ideas on technical and policy matters ,

the hands of the Sponsor companies who comprise 75% of the membership of the board of directors.

While talks were held about the possibility of AT&T and OSF merging their efforts, on October 18, 1988 it was announced that a consortium of computer firms have formed an alliance (named the "Archer Group") around the AT&T effort. (This group includes Amdahl, Control Data, Fujitsu, Gould, ICL, Prime, SUN, NCR, Olivetti, and Unisys).¹⁰ AT&T announced that it would establish a separate software division which would be responsible for the development and licensing of Unix. There is thus the substantial possibility that not one, but two, sets of standards for open systems will be developed.

The adoption of open systems has important implications for interfirm competition and the economic performance of the computer industry. Moreover, the nature of the standards process and whether there is a unique or multiple development efforts has potentially far-reaching consequences. This set of issues is the focus of this paper.

In order to understand the effects of the development of open systems on competition and the motivations of the key players, we begin with a discussion of the effects of proprietary interfaces on competition (in Section 2) and contrast that with competition in an open systems environment (Section 3). We then investigate the implications of the adoption of open systems for the main classes of affected participants: large US, Japanese, and European systems vendors; small hardware component suppliers; independent software vendors; and end-users (Section 4). Finally, we examine considerations related to the standards process itself. These include both an evaluation of the novel features contained in the OSF approach to standard setting and a possible battle for dominance between two competing standards efforts.

participate in user groups, review specifications, etc. and can receive a variety of market and development data from OSF.

10. Stuart Zipper, "AT&T-Backed Group, OSF Clash on Unix V Hegemony," Electronic News, October 16, 1988, and Lawrence M. Fisher, "Plans for Single

2. The "Proprietary Systems" World; Large Vendors of Incompatible Systems

A useful starting point is the polar case in which there are several vendors of proprietary systems, each offering products (CPU's, software, and peripherals) that are compatible with its other offerings but which are incompatible with offerings of other vendors. This hypothetical characterization incorporates important abstractions which we relax later. In particular, in practice a systems vendor faces competition from manufacturers of compatible hardware and software and may itself offer products which are mutually incompatible.

(a) The significance of switching costs

In a market in which vendors provide mutually incompatible systems, the existence of the vendors' installed bases of equipment has important ramifications for competition. Consider first an end-user who is modifying an existing system. He may simply be adding additional computing power, storage, or peripheral devices. Alternatively he may be expanding the number of applications referencing an existing data base. Or, he could be "scaling up"; replacing his existing mainframe with a more powerful or modern version. Finally, he may be installing personal computers or workstations which will access a central data base and manipulate it.

Such a user has the option of purchasing compatible hardware or software from the existing vendor or switching his entire system to that of a rival vendor. The costs of switching to a new system endow the vendor of the installed base with a substantial advantage over incompatible vendors, and consequently with market power over its "locked-in" users.¹¹

Importantly, the switching costs and therefore the extent of "lock-in" can be far greater than would be suggested simply by examining the magnitude of the original hardware purchases. Over the years by adapting their accounting and other information systems to the idiosyncracies of the

Unix Standard Set Back," New York Times, October 19, 1988, pg. D-10.

11. See Klemperer (1987 a,b) and Farrell and Shapiro (1988) for models of

particular hardware, by writing their own software for it, and by training workers in system-specific skills, users add to the lock-in and their vulnerability to their vendor of choice.

Lock-in not only provides the vendor with the ability to charge supracompetitive prices for later purchases, but by judiciously setting the prices for the complementary products purchased later (such as software and peripherals) the vendor is able to price discriminate between customers, obtaining higher total profits.¹²

(b) Competition for "new" users

Every "locked-in" user was once a new user; uncommitted to any vendor, free to choose from the offerings of all. Moreover, a rational far-sighted user will anticipate the adverse affects of "lock-in", realizing that tomorrow's lack of freedom will translate into market power for his chosen vendor. Similarly the competing vendors will understand that today's sale will lead to profits tomorrow and they should, therefore, be willing to compete more vigorously today.

Suppose for example that a user is prepared to pay $\$x$ for a system today and is expected to desire to expand that system by purchasing an "add-on" to it the future for which he will be prepared to pay $\$y$. Suppose further that the costs to any vendor of providing the system and the add-on are $\$c$ and $\$d$ respectively ($\$y > \d and $\$(x+y) > \$(c+d)$). Looking forward the vendors will realize that the vendor who succeeds in supplying the basic system will be able to make a profit of $\$(y-d)$ tomorrow. Vigorous competition among the vendors for the provision of the basic system will therefore lead to deep

competition in the presence of consumer switching costs.

12. For example, suppose the vendor has two customers who have purchased systems from him and who later wish to add an additional disk drive. Suppose that one of the customers is willing to pay $\$a$ for the drive whereas the other is willing to pay $\$b$ ($< \$a$). If the vendor knows the respective willingnesses to pay he can charge $\$a$ for the disk drives and offer a "special discount" to the second customer of $\$(a-b)$. In this way he extracts the maximum revenue from the two. In order to accomplish this, however, he must be able to prevent competition from alternative peripheral suppliers who would be willing to undercut his price.

price competition today. In particular, if there is perfect competition in the vendor market, the basic system will sell for $\$(c+d-y)$ today.¹³ Although the user will be exploited tomorrow, he will be compensated in advance for that anticipated exploitation!

Unfortunately, however, competition for the original purchase does not guarantee that end-users are efficiently served. Suppose, for example, that there is a second user who values the basic system and the add-on at $\$x$ and $\$z$ respectively ($\$y > \$z > \$d$). Suppose further that vendors cannot tell the two users apart (they cannot tell which one who will value the add-on more highly tomorrow) and thus cannot charge them different prices for the same product.

A possible outcome is that the vendor sells the basic system to both purchasers today but only sells the add-on to the high-valuation user tomorrow. A vendor who has sold basic systems to both users earns $\$2(z-d)$ if he elects to sell add-ons to both, and $\$(y-d)$ if elects to sell an add-on only to the high-valuation user. Clearly he opts for the latter strategy if $y-d > 2(z-d)$. Since the vendor expects to earn profits of $\$(y-d)$ tomorrow, competition will force him to discount today's price to each user by $\$(y-d)/2$: the basic system will sell for $\$[c+(d-y)/2]$.

An unfortunate aspect of the overall outcome is that tomorrow's add-on is priced so high that only one of the users is prepared to purchase it even though the actual willingness to pay of both users exceeds the cost of providing it (i.e., $z > d$).

Therefore even if there is competition in advance, the inability of the firms to commit to competitive pricing later may introduce overall inefficiencies and distortions. In addition, however, there are several reasons to believe that competition for new users will not be as vigorous as portrayed above.

First, the relevant characteristic of a "new" user in the above analysis is not that he does not already own a computer system, but that in

13. This example ignores any difference in the value of $\$1$ received tomorrow versus $\$1$ received today.

considering his current purchase he is not "locked-in" to his installed base. Often, this means that he is a user who already has an existing computer system and is purchasing another for an unrelated (or distantly related) application. For example, a firm may have a computer system for its accounting function and require workstations for desktop publishing or computer aided design. Although the "new" system is ostensibly independent of the installed base, the provider of the "old" system may nevertheless be at an advantage over its rivals. For example, the user may be concerned that at a later date he will want to interconnect the now stand-alone systems. To the extent that such interconnection will be facilitated by using a single-vendor policy, the vendor of the old system will be at an advantage in providing the new. Finally, the vendor of the old system has the advantage that, as a result of a close working relationship with the customer, he has the "inside track": he learns of the customer's changing needs before his rival does and knows the particular customer needs.

Second, the presence of a relatively small number of complete systems vendors will tend to restrain price competition somewhat. Where the same few vendors compete with each other repeatedly over time, they are able to establish mutual understandings about "reasonable" price-performance offerings and to refrain from cutthroat competition. This is especially likely when product differentiation is important so that only a very small number of vendors offer products which are "close" to the desires of any particular end-user.

(c) Installed base as a barrier to entry

This discussion begs the question of what gives rise to the paucity of firms in the first place. While a large number of factors are relevant in determining industry structure¹⁴, the total installed base of each vendor is particularly important. An installed base is a source of a "demand-side

¹⁴. See Brock (1987) for a discussion of the determinants of industry structure in the computer industry.

economy of scale"¹⁵: a product is more valuable to a user the greater the number of other users who use compatible products.

The compatibility benefit arises here for several reasons. First, the larger that installed base, the greater the variety of software offerings is likely to be. Even abstracting from the provision of software by independent software vendors (ISV's) the systems supplier himself will find it worthwhile to provide more software when the cost of developing that software can be spread over a larger number of users. Second, applications can be shared ("ported") across machines. This means both that the same software can be used concurrently on different machines, and that a user who is contemplating upgrading his system at a later date knows he will be able to transfer his software. In the case of the personal computer, a substantial source of compatibility benefits is the ability of a user to transfer files between machines at different locations. Third, the size of the service network a large vendor is able to maintain is an important benefit of a large installed base: customers are particularly concerned with the ability of vendors to provide "mission critical" service and support.

Another source of demand side economies of scale arises from physical network size. As in the case of fax or telephone communications, the network is more valuable to each user the larger the size of the network. A network externality can arise from a large installed base on a vendor's system if a vendor's machines can be more readily interconnected (than machines of different vendors) so that they can readily share data bases and so that smaller workstations can make maximum use of large (remote) mainframes.

Because of the compatibility and network benefits, all else equal, a new user prefers a vendor with a larger total installed base of users. Thus installed bases have a tendency to be self-perpetuating: they provide the incentive for the provision of products (software and hardware) that is compatible with that in the installed base which in turn attracts new users to

15. This concept is developed, for example, in Katz and Shapiro (1985, 1986a) and Farrell and Saloner (1985, 1986a).

the installed base further swelling its ranks and increasing the incentive for the provision of even more complementary products.

Not only do vendors with large existing installed bases have an advantage, but so too do vendors whom it is believed will develop a large base of users. If it is widely believed that a vendor will develop a large base, users will find it attractive to adopt the vendor's product, thereby fulfilling their own prophesy. Thus if a vendor's offerings are somehow "focal", that vendor can succeed where others would fail.¹⁶ Conversely, if a vendor begins to lose market share and users believe the trend will continue, a "downward spiral" can be set in motion where the vendor continues to lose market share as independent software vendors and, consequently, users, shy away from the vendor. The "BETA" videocassette standard seems to have suffered this fate in its competition with VHS, for example.

This aspect of installed base is important because it means that de novo entry into a market occupied by vendors with large installed bases is exceedingly difficult. The successful vendors of the past can continue to prosper even if their product offerings fall behind the state of the art. They are able to exert their market power over their captive customers by setting high profit margins and by price discriminating between customers with differing willingnesses to pay for complementary products.

(d) Compatibility with proprietary interfaces

Vendors of proprietary systems face a dilemma. On the one hand they want to provide a range of hardware and software options so as to be able to serve a variety of user needs. However, in order to create compatibility and network benefits their own products must be compatible with one another and it must be easy to network the hardware together.

On the other hand, designing a set of compatible product offerings in

¹⁶. It is even possible that a product preannouncement can make the difference between success and failure. By encouraging users to wait for a new product, a product preannouncement can have the effect of swelling the user base that adopts the product early on and can slow the rate of growth of

this way means engineering interfaces between machines and between machines and applications software which incorporate a degree of standardization. This then introduces the possibility that "third-party" vendors will gain a sufficient understanding of those interfaces to be able to supply their own products meeting the interface standards. If that can successfully be achieved, the "installed base" advantage that the vendor has will be reduced as he faces competition from "compatible" software, peripheral, and CPU vendors. That is, the way the vendor exploits his installed base is by charging high prices to "locked in" users. He is unable to do that if he faces effective competition.

These issues arose in an important way for the first time in the case of IBM's System 360 product line, introduced in 1964. The System 360 provided a line of computers with a broad range of performances, where the most powerful model was almost a thousand times as powerful as the least powerful one,¹⁷ but which possessed a high degree of software compatibility so that applications running on one machine could easily be adapted to any other. Moreover, when it introduced the System 360, IBM took great pains to bring its current installed base (then on a variety of incompatible product offerings) with it, by making the System 360 somewhat compatible with its earlier machines.¹⁸

The System 360 was an enormous success for IBM, highlighting the importance and value inherent in a coherent set of product offerings. The success and the somewhat standardized interfaces attracted competition. In the late 1960's manufacturers of tape and disk drives introduced products which were "plug-compatible" with the System 360, i.e., they could be added to an IBM system without modification. Software had already become more adaptable than was previously the case with the movement away from assembly-language programs (which were highly tailored to specific hardware) to higher

a rival's installed base. (See Farrell and Saloner (1986b) for details.)

17. Flamm (1988) pg. 97.

18. "IBM made extensive use of microprogramming in certain processors of its 360 line: various 360 models could be reprogrammed to emulate the instruction

level standardized languages (such as FORTRAN and COBOL) which can be adapted to a variety of hardware provided the standard form of the code is used.¹⁹ With compatible peripherals and software in place all that remained was for independent vendors to provide CPU's compatible with those same peripherals and software on the "IBM-standard". In 1970 Gene Amdahl left IBM, received financial support from Fujitsu (1972), and introduced the first IBM-compatible system in 1975 delivering IBM performance at lower prices.²⁰

Given the importance of proprietary interfaces to IBM, one would expect IBM to have attempted to protect itself from competition from compatible manufacturers. Indeed books could (and have!) been written analyzing various allegations of IBM's behavior in this regard.²¹ We have no desire to revisit that controversy in its entirety here. Suffice it to say that many of the allegations go to the heart of the analysis we have conducted above. In particular, it is suggested that IBM tried to have its cake and eat it too. That is, it attempted to obtain the benefits of compatibility among its product offerings while simultaneously stifling competition by controlling the interfaces. Adams and Brock (1982) put it as follows: "By introducing ... undisclosed alterations in its components, the integrated monopolist can render the system - and the industry - "allergic" to rivals' components". The problem is that plug compatible manufacturers do not manufacture identical products but engineer products that they are able to get to work compatibly with the dominant vendor's products. However, by altering hardware in later releases in subtle ways it is possible for the vendor to ensure that his own line remains compatible but that rivals' ceases to be.

Similar issues arise in IBM's proposed Systems Application Architecture (SAA) which would provide a consistent interface for IBM products and would allow portability (the ability to move new and existing applications

sets of the older IBM machines they replaced," Flamm (1988) pg. 99.

19. Brock (1987), pg. 245.

20. Flamm op cit. pg 132.

21. See Fisher, McGowan, and Greenwood (1983) for an economic analysis from the IBM perspective, and DeLemarter (1986) for the view of someone involved in preparing the views of the Department of Justice.

with little effort from one computer to another²²) and, ultimately, would also lead to the ability to execute applications across a network of computers of different sizes. The successful implementation of such a system would increase the value of the installed base of IBM computers. On the other hand, if specifying the interface allows for increased competition from third-party vendors some of that advantage will be dissipated: "SAA, if it is open, could broaden most third-party vendors' markets ... On the other hand, if some interfaces turn out to be proprietary ... third-party vendors would find it virtually impossible to replace certain key IBM products ... Third-party vendors have sought written assurances from IBM that SAA will include no such hidden, internal interfaces. So far no such assurances have been forthcoming."²³

The "battle of the clones" in the PC market can be analyzed in these terms too. Since the first PC was built with off-the-shelf parts, it was easy for imitators to enter with compatible products. While this helped get the IBM-compatible bandwagon started, it created vigorous competition for IBM, depressing price margins. In the case of the PS/2, by contrast, IBM filled it "with its own technology - most notably the Micro Channel - and threatened to sue anyone copying it without paying steep royalties".²⁴ This was perceived by some as "a clone-killer, a club to beat back the legions of compatible machines that plundered market share from IBM's first PC."²⁵ Recently, however, so as to escape high royalties, nine of the leading clone manufacturers themselves banded together in an attempt to establish an independent standard of their own.

3. The "Open Systems" World

The power of the installed base in the proprietary systems world

²² Jeff Moad and Gary McWilliams, "SAA: The Yellow Brick Road to Cooperative Processing," Datamation, July 1, 1988.

²³ ibid.

²⁴ Paul Carroll and Michael Miller, "High Tech Wars," The Wall Street Journal, September 14, 1988, pg. 1.

²⁵ ibid. pg 28.

originates in the fact that "old" users are locked-in to the technology of specific vendors. Open systems have the promise of providing a market in which lock-in is avoided. Ideally in an open systems world new applications can be purchased from any software vendor supplying software compatible with the applications interface. For their part, independent software vendors have an enormous incentive to provide such software since their products can potentially be used on any computer without costly modifications.

Moreover, end-users are no longer limited in their choice of vendor if they wish to: "trade up" to a more powerful machine; add additional stand-alone machines but retain portability; ensure that their machines can be networked; add memory; or upgrade a part of the system. Other important advantages to end-users are that expenses incurred in training will be generalizable to the products of multiple vendors, and they will be able to "mix and match" hardware and software from different vendors.²⁶

In addition, the entry barrier which vendor's installed bases constitute in a proprietary world is greatly lessened here. A hardware vendor can enter knowing that his product will be judged on its virtues: the full set of applications software written for the common applications environment is the same across machines.

It is important to appreciate, however, that standardized interfaces do not imply homogeneous product offerings. To the contrary, competition among hardware vendors producing to a common interface typically results in a great degree of product differentiation along other dimensions. For example, stereo systems have standardized interconnect interfaces, compact disc players have standardized player/disc interfaces, automobiles have standardized gasoline/automobile interfaces, VCR's (within a given format) have standardized film/VCR interfaces, cameras (again within a given format) have standardized film/camera interfaces²⁷, etc.

In each of these examples manufacturers on both sides of the relevant

26. See Matutes and Regibeau (1988) for a model of the effect of mix-and-match possibilities on compatibility choices and pricing.

interface attempt to differentiate their product offerings as part of their competition for customers. Consider, for example, the variety of stereo systems, cameras, and automobiles that are available.

The applications interface has two other characteristics that are important in considering product differentiation. First, it is somewhat flexible: it can be modified by the purchaser to adapt to his special needs or equipment of the user. Second, it can incorporate the ability to take advantage of special features of the system on which it is being used. Thus, in the PC market, for example, we are used to seeing special versions of software for machines that have color monitors, graphic cards, math coprocessors, or other special features.

Thus while a "common applications environment" might enable an application to run on a wide variety of different systems, it will perform differently on them depending on the system's characteristics. Conversely, while any computer system may run a variety of software that performs a similar function, the software can be differentiated to offer a range of qualities and features. Consequently it will be possible for there to be a substantial amount of product differentiation.

Not only will the offerings of different vendors be differentiated in that they will offer different features and "selling points", the systems themselves will have different architectures. While the hardware offerings will be designed to conform to a standardized applications interface, competition to produce the best way of delivering product that meets that interface will result in machines with quite different internal compositions. The fact that all automobiles are designed to standard gasoline "interfaces" (and very similar "user interfaces") has not resulted in identical automobile designs. Indeed, the same manufacturer typically makes use of a variety of engines and chassis.

It is important to make this distinction between "open systems" and "open architectures": the first does not imply the second. In the case of the

IBM-compatible PC both were present (because IBM, in its haste to get the product to market, assembled their system largely from commercially available components). As a result, "clones" were easily able to replicate the IBM hardware offering and competition shifted over time to the provision of low-cost components and therefore to low cost "off-shore" producers. Such a trend is not inherent in the provision of open systems, however. If vendors are able to produce innovative products using proprietary technology to meet common interface specifications, their contributions will be protected from low-cost imitative competition.

Returning to the automobile analogy, very few auto components are standardized across different product lines. Because of the difficulty of arranging arms-length contracts for components which are idiosyncratic and specific to a particular purchaser, the largest automobile manufacturers produce many components in-house.²⁸ The issue of imitators putting together low-cost versions of the same products from available components does not arise. Of course, there may be less variation in user preferences for computers than for automobiles (consider "style", for example). However, the rate of technological change is greater in the computer industry and hence opportunities to differentiate are more frequent.

In summary, vendors will be able to produce differentiated products in the open systems environment. Their offerings are therefore unlikely to become standardized "commodity" items. Nonetheless, opening up the interfaces will alter the nature of competition through the reduction of switching costs and, hence, the reduction in the lock-in of installed bases.

4. Introducing Open Systems Into a Proprietary World

As is the case with the alteration of most economic regimes, with the introduction of open systems there are likely to be some winners and some losers. Who the winners are will depend on the way in which open systems are

27. But not camera/lens interfaces.

28. See Monteverde and Teece (1983) for an analysis of the determinants of

introduced and exactly how "open" they are. In this section we evaluate the outcomes for various classes of economic agents, in the light of the analysis of the previous sections, under the assumption that open systems are introduced, where by "open systems" here we mean a standardized applications and peripheral interfaces and network protocols, but not standardized architectures or product features. In the following section we comment on the process itself.

(a) U.S. vendors with large proprietary installed bases

The analysis of the previous sections suggests that these vendors should view the advent of open systems with some concern. Yet every major provider of a proprietary system is now participating in forums for the provision of open systems. This seemingly paradoxical behavior is discussed in the following section. Here we consider the likely effect of the emergence of a unique open systems standard on these vendors.

In contrast to any individual emerging rival, open systems can amass a large installed base of its own in a relatively short period of time. It has the advantage of being focal simply by virtue of not being proprietary to any vendor. Also, since an open system does not carry the threat of lock-in to any vendor, adoption of any vendor's open system offering is relatively risk-free: If that vendor encounters difficulties or falls behind the state of the art, the user is not doomed to remain with an obsolete system or to convert at great cost. Moreover, the open system's installed base is the union of the installed bases of all vendors' open systems installed bases. Thus the open system is an unusually viable rival to any vendor of a proprietary system.

As the open systems bandwagon grows, the largest proprietary installed bases will be less of an attraction to new users. The large proprietary vendors will have to be increasingly price competitive to attract new users to proprietary systems when those users have open systems alternatives.

This does not however signal the imminent disappearance of the

proprietary system. First, the existing installed bases on proprietary systems are not going to vanish. They will continue to constitute a considerable asset to their vendors who have a large incentive to provide proprietary add-ons, upgrades, and expansions. Those installed bases will gradually erode, however, as users move discretionary purchases (those that need not be compatible with the installed base) to open systems. In the meantime, however, the largest proprietary systems vendors (IBM and DEC in particular) will continue to offer proprietary systems in addition to any open systems offerings.

Second, in trying to be all things to all users, open systems will sometimes fail to provide the power of systems specifically designed for specialized tasks. In that case, "niche" producers will emerge whose products won't necessarily conform to open standards.

(b) European systems vendors

As the following table shows, the largest European systems vendors make the majority of their sales in Europe, and with one exception in their home country:

Table 1: Leading European Systems Producers, 1986²⁹

Company	Worldwide IS Revenues (\$m)	% in Europe	% in Home Market
Ericsson (Swe)	1344	89	n.a.
Groupe Bull (Fr)	2568	94	66
ICL (UK)	1756	81	63
Nixdorf (Ger)	2075	92	52
Olivetti (It)	3865	70	37
Philips (Neth)	1763	87	n.a.
Siemens (Ger)	4387	88	65

Despite the concentration of their business in Europe, the largest, Siemens, has less than a 10% share of the European IS market. In contrast IBM's share of the European IS market in 1986 was roughly 35%³⁰ and its share

vertical integration of components by Ford and General Motors.

29. Underwood and Tate, "The European 25," Datamation 33 (August 1, 1987), 58-9.

of the total installed base closer to 75%.³¹ To put things further into perspective, the combined worldwide IS revenues of these companies in 1987 (about \$22.3b) was not much larger than IBM's European IS revenues (about \$18.7b).

In assessing open systems these European vendors face a trade-off. The emergence of open systems will likely make each firm's domestic market more vulnerable to competition especially from the other European vendors on the list, but also from non-European competitors. On the other hand their existing levels of sales do not provide an installed base of sufficient magnitude to rival IBM. Open systems, by essentially enabling them to pool their installed bases, can make them a formidable combined rival. Moreover their existing national service networks and domestic reputations will stand them in good stead in open competition.

It is therefore not surprising, perhaps, that these vendors were among the earliest to embrace the idea of open systems and in 1985 formed the X/OPEN Group with the stated goal of "... increas(ing) the volume of applications available on its members' systems, and to maximize the return on investments in software development made by users and independent software vendors ... by ensuring portability of applications programs...".³²

Overall, these vendors are likely to be beneficiaries of the establishment of open systems standards.

(c) Japanese systems vendors

As in Europe, the bulk of Japan's IS revenues of domestic firms are earned in the domestic market:

30. ibid.

31. Gabel (1987), pg. 92. Moreover, in 1987, European sales contributed to 42% of net earnings and 37% of total revenue for IBM ("The Datamation 100," Datamation, June 15, 1988.)

32. X/OPEN promotional brochure cited in Gabel (1987).

Table 2: Leading Japanese Systems Producers, 1986³³

Company	Worldwide IS Revenues (\$m)	% in Japan
Fujitsu	6576	83
NEC	6325	81
Hitachi	4729	81
Toshiba	2605	76
Matsushita	1944	84

Unlike the European vendors, however, Japanese vendors have a strong hold on their own domestic market, accounting for about 80% of domestic sales with IBM accounting for much of the remainder.³⁴ Both Fujitsu and Hitachi produce IBM-compatible machines³⁵ and have maintained a strong position in the Japanese market in large part due to a variety of Government actions protecting the domestic industry.³⁶ Unless the advent of open systems is accompanied by a contemporaneous opening of Japanese markets, open systems are unlikely to alter the nature of competition in Japan.

In competing in the U.S. and Europe, Japanese IBM-compatible vendors have suffered a variety of disadvantages of the kind discussed in the latter part of Section 2. By producing a "leveling of the playing field" open systems will make it easier for the large Japanese vendors to compete in foreign markets if they choose to provide open systems offerings.

However a variety of institutional factors suggest that the Japanese are not particularly well poised to make major inroads into the foreign open systems market: they face relatively high labor costs, have tended to follow rather than to lead in innovation, and do not have the distributor or service networks that their foreign rivals possess. Moreover, in a country where central direction of the computer industry has played an important role, open systems have not been made a priority and Japanese vendors have not played a major role in standardization efforts.

33. Underwood and Tate, "The European 25," Datamation 33 (August 1, 1987), 58-9.

34. Flamm op. cit. pg. 201.

35. Indeed, both companies have been involved in litigation with IBM over intellectual property infringement claims. ("The Datamation 100", op. cit., pgs. 43 and 44.)

36. See Sobel (1986) for a discussion of the role of the Japanese Government

It is tempting to cite the PC experience as evidence of the difficulty Japanese firms will experience in competing abroad in an open systems environment. The three leading Japanese PC manufacturers NEC, Toshiba, and Fujitsu have respectively 4.0, 3.4, and 2.0 percent of the revenues of the PC revenues of the Datamation 100.³⁷ Moreover, with the exception of Toshiba, very few of those sales were made outside of Japan.

Yet this temptation should be resisted since the Japanese PC experience was atypical. First, Japanese vendors made the mistake of not producing IBM-compatible machines early on. Second, recent trends are distorted by the imposition of tariffs imposed by the US Government in retaliation for Japanese semiconductor agreement violations.³⁸

Japan faces a somewhat unique decision with respect to open systems. Because they have large domestic producers of IBM-compatible equipment, if they do not open the country up to open standards they can stay on the IBM standard and have a strong domestic computer industry. If, as argued above, IBM continues to support its standard to take advantage of its installed base, the Japanese market will continue to enjoy state of the art technology.

Adopting the strategy of remaining IBM-compatible at home, however, will likely preclude them from effectively competing in the foreign open systems markets since they will lose the opportunity to reap economies by producing for both markets. (They will, of course, continue to be able to compete in the IBM-compatible market abroad). It is therefore possible that they will not become significant open systems competitors until it is clear that the advantages of open systems justify abandoning the old standard at home.

Even then, however, Japanese computer vendors do not have the high quality/low cost edge that gave them dominance in other US electronics markets such as television sets.

in their computer industry.

37. "The Datamation 100", op. cit., pg. 160.

38. The successful Toshiba T1100 and T3100 laptop PC's, for example, were subject to a 100% import tariff.

In summary, while open systems will make it easier for any computer vendor to enter the world market, the Japanese vendors will not have a special advantage in this regard, and their dominance in their domestic IBM-compatible dominated market reduces their incentives to adopt open systems.

(d) Other hardware vendors

Smaller hardware vendors and low-cost producers (including those in the Pacific Rim) will be beneficiaries of open systems. Freed from the need to provide improved hardware complete with software offerings they will be able to bring their products to market more quickly and at lower cost than they now can.

Existing vendors who have fallen on hard times because their installed bases have dwindled as consumer confidence in their ability to gain market share has waned, will have a new lease on life. The ability to "plug into" a full range of software applications will provide them with the compatibility economies of a large installed base.

(e) Independent software vendors

For reasons already discussed, independent software vendors are another category of clear winners in the open systems world. The costs of developing any piece of software can be spread over sales to a far greater market without costly modifications to adapt to the idiosyncracies of particular proprietary systems. A wider variety of software will be supportable as a result: software which is marginal in a proprietary world will now be provided because there is a larger potential market. Moreover, software vendors will not face the difficulty of writing software for interfaces which can be changed at any moment by the hardware vendor.

Because developers of successful software products will make larger profits, competition among software developers will become correspondingly more intense. Overall, efficiency in this segment of the market is likely to be increased significantly as the substantial costs of making software

adaptations are eliminated.

(f) Users

The end-users themselves will be by far the greatest beneficiaries of open systems. First, competition unfettered by the users' allegiance to a proprietary system will lead to lower prices. This effect has already been felt in some markets. For example, Carlyle reports: "Aimed squarely at DEC are two beneficiaries of the open systems movement - Sun Microsystems and MIPS Computer ... The two are locked in a price/performance race that Gordon Bell, former DEC vp of engineering and leader of its VAX design team, says is undermining the pricing structure of the whole industry...[T]he two rivals have already achieved twice the performance level of today's leading pcs, and have moved several orders of magnitude beyond minis and mainframes..".³⁹

Second, users will be able to make hardware purchases without worrying about "backing the wrong horse". As Hamilton puts it: "With open systems, a customer could opt for a cheap divorce from an expensive supplier and switch brands."⁴⁰

Third, for the reasons outlined above, users will have a richer array of software to choose from.

Fourth, interconnectivity will be accomplished more easily.

Fifth, product differentiation and "niche seeking" by hardware vendors plus the elimination of installed base considerations will provide users with a more varied selection of hardware when they choose to expand or upgrade their existing systems.

There are, however, two sources of potential concern. First, a concern that often accompanies standardization is whether the pace of innovation will be adversely affected.⁴¹ Once an industry is bound together by the benefits of compatibility that accompanies standardization, it may be

39. "Open Systems: What Price Freedom?" Datamation, June 1, 1988, pg. 57.

40. Joan Hamilton, "Getting Computers to Dance to the Same Music," Business Week, May 23, 1986, pg. 112.

41. See Farrell and Saloner (1985) for a discussion.

difficult to coordinate a movement to a new, superior, standard if one comes along.⁴² In the current context, this could manifest itself in two ways: Improvements in the existing open systems interface could be implemented too slowly or it could become too difficult to move to a totally different interface. The importance of this concern depends on the way in which the open system interfaces are managed, if at all. This point is taken up in the following section.

The second source of concern is for some users with very large installed bases on proprietary systems. Although, as discussed above, the immobility of these users is exploited by the vendors of the proprietary system, some of them may paradoxically be better off if open systems don't take hold. If their installed bases are large compared to their probable future expansion, they may prefer to remain on their proprietary systems than to switch to open systems. Although their vendor of choice will continue to serve them for some time into the future, the installed base of users on their system will dwindle and, with it, future hardware and software support.

5. The Open Software Foundation in Context

Open systems are the focus of conflicting objectives and desires. On the one hand, for a candidate set of open systems specifications to succeed, it is necessary that there be a common perception that they will be adopted. The less confusion about which candidate will succeed the more likely one will be "focal", in which case it is more likely to be widely adopted, reinforcing the focalness. The more likely users believe a major vendor is to shift his attention from his proprietary system to the open system, the more likely it is that the open system bandwagon will take off.

On the other hand, several of the major players, in particular those with large vested interests in their installed bases of proprietary equipment, are likely to lose some of their market power if open systems are widely adopted. Moreover, if open systems ultimately become adopted, those vendors

will gain in the short run if the adoption of open systems is slowed.

If open systems constitute a threat to these vendors, why do they themselves have open systems offerings? Adoption of their open systems products only swells their rival installed base and their participation in the open systems venture increases its credibility and the bandwagon of adoption of the new standard. Why do these vendors participate in the open systems process? Is it merely the case, as some cynics suggest, that they do so only to "sabotage" the process itself by, inter alia, slowing agreement on specifications, sowing confusion, and by adopting an "on-again-off-again" attitude towards emerging standards?

To complicate matters even more, a vendor who is able to gain even a small degree of proprietary control on the "open" system that is adopted (for example, by being the licensor of a fundamental piece of the software code) has the potential to obtain extremely large profits later on if the open system becomes the industry standard, by holding licensees "hostage" at that time.

What are the prospects for an efficient process leading to the emergence of optimal open systems standards? The answer to this question depends in part on the answers to the following: (i) Do the vendors who formed OSF have a collective incentive to efficiently produce open systems?, and (ii) Is the conflict between the OSF and AT&T open systems camps conducive to economic efficiency?

We begin by briefly recounting background events leading to the formation of the Open Software Foundation and contrast the proposed operation of the OSF with other voluntary standard-setting bodies. We then examine each of the above questions in turn.

(a) A brief background

The open systems movement has its origin in the increasing overlap between the telecommunications and computer industries. With the falling

price of computer equipment, it became increasingly economical to digitize voice transmission on the telecommunications network so that the digital representations of voice could be switched electronically (thereby minimizing noise accumulation). Contemporaneous with that development came the desire by users to use the telecommunications network for data transmission between computers.⁴³

It was realized early on that it would be desirable to have some standardized computer interfaces in order to facilitate this communication. Standardization was foreign to computer manufacturers who, especially in the days when the mainframe reigned supreme, took advantage of proprietary lock-in to maximize profits. The culture of the telecommunications industry was quite different, however. Since Government-controlled or Government-regulated monopolies were responsible for providing telecommunications services within each country, and since there was therefore no fear of revenues being appropriated by rivals (the revenue issues related to the distribution of revenues between countries), standards were voluntarily and eagerly set in committees established for that purpose.⁴⁴

The International Organization for Standardization (ISO) seized the initiative and developed a seven-layered reference model known as the Open Systems Interconnection (OSI) reference model which provides a framework for structuring communication between separate end-users.

With the basic foundations for open systems thus laid, a number of organizations were formed, or existing organizations refocussed, to provide more detailed specifications for the interfaces. In the U.S. these include the National Bureau of Standards' effort with government agencies and others to develop an Applications Portability Profile (APP), the IEEE's development of an open forum to develop a new applications interface, POSIX (Portable Operating System Interface), and the Corporation for Open Systems which is a

42. See Farrell and Saloner (1986c, and 1987) for a discussion.

43. See Besen and Saloner (forthcoming) for a detailed discussion of this development and related standards issues.

44. See Besen and Saloner op cit for details.

US-based coalition developed to foster open networking standards.

Perhaps the most important open systems group in Europe was the X/OPEN Group formed in 1985 and discussed above. Of great significance in the formation of X/OPEN was the decision by the ten member firms to choose Unix as the operating system which was to provide the basis for their common applications environment. Unix is commonly used in scientific and technical applications. While regulated and not able to compete in the computer industry, AT&T was not much interested in Unix and essentially gave it away to several users. While "Unix" is a trademark of AT&T, a variety of proprietary operating systems based on Unix were developed: For example, Xenix (Microsoft), Ultrix (DEC), Sinix (Siemens) and, more recently, AIX (IBM). Evaluating Unix as a standard operating system in 1987, Gabel concludes: "... it has not yet established itself as a popular choice for commercial data processing, and its potential attractiveness is more its "openness" than any clear functional superiority as an operating system per se."

The significance of the X/OPEN adoption of AT&T's Unix version V was summarized by Gabel (1987) as follows: "One would have expected the X/OPEN Group to prefer a public standard given its basic objective of avoiding domination by a non-member's proprietary standard. Ironically, it chose Unix, a proprietary product of AT&T. The Group seems to have preferred risking being exploited by AT&T to running that same risk with IBM...". Somewhat prophetically, he continues: "The choice would be facilitated if AT&T's strategy in its use of its proprietary Unix were known, but it is not. The company could progressively restrict Unix purchase agreements and raise prices ... to extract rents, However, doing so would risk ... user group(s) abandoning AT&T's Unix...for a more open variant".

As discussed in the introduction, the next major event was the formation of the AT&T/Sun alliance in January 1988. Rivals were concerned with this development for a number of reasons. First, they believed that Sun and AT&T would derive an advantage in the product market from their leading position as developers of the standard: "Those involved ... said they had no

choice. They said AT&T was shutting them out of development work on Unix".⁴⁵ Second, they were concerned that AT&T was exerting proprietary control over Unix and "trying to wrest control of Unix from the marketplace"⁴⁶: "Rivals felt that AT&T was setting itself up as umpire and manager of the league's top team."⁴⁷ Third, they were concerned with the tightening of the restrictions that AT&T placed on its licensing of Release 3.0 of its Unix Version V, including compulsory compliance to SVID (System V Interface Definition) and restrictions on allowable modifications of the code.

Against this backdrop OSF was formed in May 1988 and the Archer group in October 1988.

(b) A comparison of OSF and conventional standard-setting processes

There are three main ways in which standards are established: they may be mandated by Governments, set by voluntary standards committees, or emerge from the independent actions of agents in the marketplace as de facto standards.⁴⁸

Typically, de facto standards emerge as more and more agents adopt a focal alternative. The bandwagon process builds on its own momentum as the set of adopters of the standard grows making it even more attractive for others. Eventually the standard is so widely adopted that it is self-enforcing: the benefits of going with the crowd become irresistible.

Voluntary standards are typically set by consensus decision-making.⁴⁹ As a result, by the time the standard is established, no participant has an incentive not to abide by it.

Propelled by the growing demand for standards in the telecommunications and computer industries, the voluntary standards endeavor

45. Paul Carroll, "IBM, Digital, Others Form Coalition on Unix System to Challenge AT&T, Sun," The Wall Street Journal, May 18, 1988.

46. Esther Dyson, "Why the Argument Over OSF?," Computerworld, May 30, 1988.

47. Nina G. Lytton, an analyst at Yankee Group in Boston, quoted in "Getting Computers to Dance to the Same Music," Business Week, May 23, 1988.

48. See Besen and Saloner op. cit., on which the first section of this section draws heavily, for details.

49. See Verman (1973) for a discussion of voluntary standards committees.

has mushroomed. It is estimated that the number of participants involved in voluntary standards committees of the ISO has grown from 50 000 in 1972⁵⁰ to over 100 000 today⁵¹. The number of standards that have been approved by the ISO grew from 2 000 in 1972 to 7 500 by 1985⁵².

A major advantage of the committee system over de facto standard setting is that the committee is more likely to lead to the adoption of a single standard whereas with de facto standardization, rival "standards" can battle out in the marketplace, diminishing the network externalities on both (the case of VHS vs. BETA is a case in point).⁵³ Moreover, committees are able to work out technical compromises, performing a useful design function in the process. On the other hand, committees are often criticized for their slowness: consensus building takes time and participants with a lot to lose if their preferred standard is not adopted may delay adoption of the rival standard.

Government standard-setting has the advantages of centralized control: standards can be enforced, and can be produced over the protestations of interested parties who hold a minority viewpoint. Despite these apparent advantages of mandated standard-setting, compatibility standards are overwhelmingly set in voluntary associations of industry members; most formed on their own initiative. There are several reasons for this.

First, Government agencies do not have the technical expertise required in many cases. Accordingly they must rely on the representations of industry participants. However, participants with vested interests have an incentive to exaggerate their positions. Of course they have the same incentive in voluntary standards committees. However there the claims are more easily evaluated by fellow experts and, knowing that decisions will only be made by consensus, participants will not cling to untenable positions if they favor early adoption of a standard. Moreover, since many of these

50. Sanders (1972) pg. 68.

51. Lohse (1985) pg. 20.

52. Besen and Saloner op. cit. pg. 20.

53. See Farrell and Saloner (1988) for a model of the relative efficiencies

players meet repeatedly, there is some "give-and-take" over different standards: a participant who compromises today can expect to "make it up" tomorrow.

Second, Government agencies are subject to "capture" by interested parties. The voluntary standards committees with representatives from interested parties (who often rotate back to their parent companies) are less vulnerable to this.

Third, in voluntary standards committees the incentives of the committee members are closely aligned with the incentives of the relevant economic agents. Thus they can be expected to respond to economic benefits. For example, they will "push" hard on a standard that is likely to yield important cost savings or benefits to their customers. Conversely, a bureaucratic agency responds more to the incentives of the bureaucrats and their political constituencies.

The charter of the OSF provides a bold attempt to reshape the nature of standard-setting in the computer industry. Its main innovations are twofold: First, OSF will not merely produce a list of specifications, conformance to which constitutes a standard, as voluntary standards committees typically do. Rather they will actually produce code embodying the standard. This code will be licensed to any interested user.

Second, OSF will not rely on consensus decision-making by all interested parties. Rather, OSF will issue "requests for technology" from the public domain, evaluate submissions (which will often be the previously proprietary product of individual vendors), and select that which they believe has the best features and performance characteristics.

There are several attractive features of this process. First, it has the potential to be much quicker than the voluntary standards process. Second, it eliminates ambiguity as to what the standard actually is. When standards are set by voluntary committees they either consist of (necessarily incomplete) written specifications, or there may also be a validation suite

against which a vendor can check his product for compliance to the standard. (In that case, the validation suite defines the standard in practice.) Third, the people responsible for making the selection are formally independent of interested vendors. Importantly, they do not have "parent companies" to which they return between standards meetings.⁵⁴ As a result they are more able to impose objectivity on their choice, and particular vendors cannot employ delaying tactics by instructing their representative to stick to unreasonable claims. Of course there is always the danger that the special relationship that the sponsor companies have with OSF will influence the outcomes of their deliberations.

(c) The motivation of large vendors

Still, the OSF venture contains several features which endanger its success. Standard setting is easiest to accomplish when all the participants are eager to establish a standard and do not have strong preferences as to the form that the standard takes.⁵⁵ Both of these features are lacking here. The first, stemming from large vendor's mixed attitudes towards open systems is discussed here. The other, dealing with the OSF/AT&T rivalry is discussed in the following subsection.

As discussed in Section 4, the vendors with large installed bases on proprietary technologies have ambivalent attitudes towards open systems. They would probably be better off if the open systems effort had never been launched. This appears contradictory with their recent interest in participating in the process. Indeed, as mentioned above, not everyone is convinced of their sincerity.

There is no contradiction, however. The relevant question is not whether IBM and DEC are happy about open systems, but whether, given a trend towards open systems, they are better off participating or not. By not

of committees versus bandwagons.

54. For awhile OSF will be composed of people "on loan" from participating companies. From January 1, however, OSF will have an independent staff.

55. See Besen and Saloner op. cit. for a framework for examining this

participating they might hope to prevent the widespread adoption of open systems, thereby protecting their proprietary technologies, or they might at least slow the process down. However, the longer they delay embracing open systems, the greater the extent to which they will be playing "catch up" if and when the open systems bandwagon becomes unstoppable. The history of their attitudes towards open systems is consistent with the view that early on the costs of promoting open systems outweighed the benefits whereas recently open systems achieved a level of acceptance where that situation no longer holds.

A particularly vivid illustration of the costs of shunning open systems was provided by the Government's ruling that the Air Force can specify a standard software system in its \$3.5b contract for equipment and services. In doing so the General Services Administration rejected the objections raised by DEC and others who wanted to be able to provide proprietary systems.⁵⁶

Of course explaining why large vendors eventually jump on the bandwagon doesn't explain how it gets going in the first place. However the seeds of the bandwagon are the preferences of those who get it going: small vendors or those with shrinking installed bases for whom the advantages of open systems way outweigh the benefits to be derived from proprietary installed bases.

An important implication is that those large vendors who have only recently found it worthwhile to enter the open systems standardization arena are probably close to indifferent about whether or not they participate. Accordingly, if a situation emerges which makes the open systems market less favorable to them than it now is, they could well withdraw. This is a disadvantage of the OSF process compared to standard setting by a voluntary committee. Consensus decision-making, although slow, guarantees the willingness of affected parties to implement the chosen standard. Although the OSF procedure allows for input by any member, ultimately the decision rests in the hands of the technical staff. If several important standards

argument.

56. Catherine Arnst, "Government supports Unix operating system," San

decisions put a large vendor at a disadvantage, he may find it preferable to shift resources back to proprietary systems.

Ironically, the stronger is competition from the AT&T open systems coalition, the more cohesive OSF will be since the focal alternative to vendors' own proprietary systems in the event OSF fails is not a disorganized diffuse open systems movement, but rather the AT&T alternative.

(d) Conflict on the open systems front

In considering merging with OSF in October 1988, AT&T faced the choice of not joining OSF and taking the chance that they would emerge the victors in a battle for market share with the OSF offerings, or throwing in their lot with OSF, probably thereby ensuring the success of that effort. In forming the Archer group they appear to have chosen the former strategy.

AT&T has a lot to gain by being the licensor of the standard operating system. In that position they are able to control what in practice will be an essential input to all computer suppliers if their standard is widely adopted. The power which AT&T is able to exert in that capacity, and which is the source of the concern of vendors discussed above, would grow enormously as the universality of their standard grew. The very factor that makes standards valuable - the compatibility and network benefits which they create - is also a potential source of profitability for any firm that can obtain control over them.

On the other hand, AT&T is only able to achieve that position if their standard is widely adopted. Seemingly paradoxical in this situation is the fact AT&T cannot achieve a powerful market position without the cooperation of those firms whom it will later have power over. However, here again there is no paradox. AT&T can afford to induce early adopters to opt for their standard on favorable terms. As the set of users on their standard grows it becomes increasingly attractive to additional adopters over whom AT&T can then exert their market power.⁵⁷

If, as we shall argue below, a unified standards effort for open systems would have larger benefits than the sum of two separate efforts it seems puzzling that the participants are unable to achieve a compromise. There are at least two reasons why the negotiating parties do not have the correct social incentives to combine their efforts. The first is the ambivalence of the large proprietary vendors towards open systems. While the open systems movement would benefit from a combined thrust, large vendors of proprietary systems will benefit from the disarray that results from a divided effort. Therefore the OSF sponsors have an incentive to insist on (perhaps unacceptably) favorable terms. The second is that users are important beneficiaries of open systems who are not involved in the negotiations.

A comparison between the relative economic efficiencies of a unified open systems effort and separate OSF/AT&T-coalition efforts requires assessing two main questions. First, would users be better served with two open systems offerings rather than one? Second, even if it would be better to end up with one, would it be better to have competition between two candidates so that the best can be selected from two alternatives?

The trade-off between standardization and variety is a delicate one. When standardization is left to the market there can in general be too much or too little standardization.⁵⁸ Incompatibility may be necessary to satisfy the idiosyncratic desires of different consumers. For example the different operating systems of the Apple and IBM-compatible PCs have features that appeal differently to different users. On the other hand, the are. Competition may also lead to greater development effort, attention to user needs, and speed with which the product innovations are brought to market.

Several of these usual virtues of competition are less important in the current context. First, OSF has been established as a not-for-profit corporation with a very large endowment.⁵⁹ Accordingly even if it were the

Francisco Sunday Examiner and Chronicle, Nov. 15, 1987.

57. Models in which networks are built by "penetration pricing" early on have been developed in a series of papers by Katz and Shapiro (1985, 1986 a,b).

58. See Farrell and Saloner (1986b).

sole open systems vendor it would not have the usual incentive to exploit its market power by high pricing. On the other hand, while the incentives of not-for-profit corporations to exert market power in their pricing strategies may be different from those of for-profit firms, the incentive to abuse that market power is not absent (for example, to obtain revenues for further growth or to improve working conditions for its employees). Moreover, issues of anticompetitive behavior may arise if some vendors (e.g., those who are sponsors of the organization) are given preferential treatment in their licensing terms.

Second, to the extent that the OSF internal environment mirrors that of the voluntary standards committee with its non-profit-maximizing, engineering-oriented goal of providing objectively "optimal" standards⁶⁰ there is no reason to suspect that such a standard-setting process would be obviously biased against the optimal timing of standardization. Moreover, since OSF would have no de jure status and, at best, de facto standard-setting power, they would still have to meet the market acceptance test of vendors and, ultimately, users.

On the other hand, there are reasons to believe that competition will have adverse consequences. Competition in markets characterized by demand-side economies of scale suffers from some serious shortcomings that competition in conventional markets does not. Battles for market dominance between two competing standards tend to have a "winners-take-all" nature. When the perception builds that one is dominating it grows even faster: the system tends to "tip" one way or another.⁶¹ Since the likelihood of success depends to a great degree on perceptions of the likelihood of success,

59. In addition to the \$4.5m per year over three years pledged by each of the first eight sponsors (for a total of \$108m) OSF could easily add additional sponsors. "Such a multiplicity of sponsors paying \$4.5m each would also rapidly inflate the size of the OSF budget, and the foundation could find itself in a quandary as to how to spend a more than \$100m annual budget which might result," Stuart Zipper, "AT&T-Backed Group, OSF Clash on Unix V Hegemony," Electronic News, October 16, 1988.

60. See Verman (1973) for a description of the engineering orientation of voluntary standards committees.

61. See Arthur (1985) for a model along these lines.

relatively insignificant events early on can lead to the success of one standard and the failure of the other.⁶²

Unfortunately, as a result, there is no guarantee that the "best" standard will triumph. Moreover, if it is later realized that an inferior standard has been adopted, it may be impossible to move away from the inferior standard because of the installed base on it.⁶³

In other cases, both rival standards achieve a large enough following to be able to survive, at least for quite some time. In that case, users suffer the loss of compatibility benefits from unnecessary nonstandardization. Besen and Johnson (1986), for example, describe the lack of widespread adoption of AM stereo because of nonstandardization and contrast that with the experience in FM where standardization was achieved early. The VHS/Beta conflict is another where early standardization would have been preferable. In addition, in that case many observers believe that the market, in choosing the VHS format, made the "wrong" long-term choice. The lack of standardization in US railroad gauges (finally standardized completely in the 1880s)⁶⁴ necessitated costly physical transferring of cargo or adjustments to rolling stock passing from one gauge to another.

It may seem that the costs involved in late standardization of a Unix base for open systems would not be very costly since software would be fairly easily adapted to move from one to the other. This perception is probably incorrect because the version of Unix selected will serve only as the base upon which other standards will be developed which, taken together, will constitute the common applications environment. Since software will be tailored to each of these many standards, conversion will be costly.

62. Arthur ibid. calls these "historical small events". He has developed some elegant probability theory to describe the behavior of systems with these characteristics. The interested reader is referred to his paper for references to that line of work.

63. David (1985) describes the factors that led to the adoption of the QWERTY keyboard and the lock-in to that system which is inferior to other later innovations, such as that developed by Dvorak.

64. See Nesmith (1985) for details.

6. Conclusions

Efforts aimed at the development of open systems seem to be coalescing into two camps. While the OSF camp is the stronger in terms of the combined market share of current worldwide revenues, the AT&T camp has a first-mover advantage in terms of having products on the market. A battle for market dominance between two extremely powerful coalitions is emerging.

End-users, who find themselves caught in the middle, are likely to be the victims of the split. First, the conflict will slow down open systems adoption as users take a wait-and-see attitude, not wanting to back the wrong horse. As noted above, ironically, the large vendors of proprietary systems will benefit from the resulting disarray. Second, some users who adopt early, may find that they have opted for the "losing" standard and that they are stranded on what has become an obsolete set of offerings. Finally, even if both standards maintain a strong following, the users on each will be deprived of the benefits of a unified installed base. While there are some countervailing benefits from additional competition, we have argued that they are swamped by the standardization benefits.

Unfortunately there do not exist particularly appropriate authority structures to correct the problem. First, voluntary standards committees operate under consensus and do not have the authority to impose unification on unwilling participants. Second, for reasons discussed above, national governments are not well suited to take on the standard-setting function themselves.

There are, however, steps that could be taken to help rationalize the process. First, national governments and large users influence the adoption process by their own adoption decisions. By organizing themselves early on and lending their weight to one effort or the other (by participating in the standards effort and by promising to adopt the offerings of their chosen group), they could influence the direction of future adoption. Second, such a coalition of users could at least agree that they will not adopt an "open" system which comes with proprietary strings attached. In particular, that

they would not adopt any common software platform unless it was licensed to vendors by a not-for-profit corporation. By doing that they will at least avoid the prospect of universal adoption of a standard over which a for-profit corporation will have an incentive to exercise its market power.

While we have concluded that government standard-setting is not a viable option here, there is the broader question of whether the US Government (or a coalition of several governments) could provide "groundrules" for the establishment of open systems standards. These would specify, for example, allowable restrictions, if any, on participation in the process, restrictions on licensing terms for final product (e.g. the extent to which members of the standard-setting body can be given preferential treatment in the licensing terms they receive), and requirements for "due process" before governments would endow an open systems offering with the status of de facto standard. Given the watershed that the computer industry has reached, this issues deserve further study.

REFERENCES

- Adams, Walter and James W. Brock, "Integrated Monopoly and Market Power: System Selling, Compatibility Standards, and market Control," Quarterly Review of Economics and Business, 22 (1982), 29-42.
- Arnst, Catherine, "Government supports Unix operating system," San Francisco Sunday Examiner and Chronicle, Nov. 15, 1987.
- Arthur, W. Brian, "Competing Technologies and Lockin by Historical Small Events: The Dynamics of Allocation under Increasing Returns," Center for Economic Policy Research Discussion Paper No. 43, stanford University, January 1985.
- Besen, Stanley M. and Leland L. Johnson, "Compatibility Standards, Competition, and Innovation in the Broadcasting Industry," The RAND Corporation, R-3453-NSF, November 1986.
- _____ and Garth Saloner, "The Economics of Telecommunications Standards," forthcoming in Technology and Government Policy in Computers and Telecommunications, R. Crandall and K. Flamm eds., The Brookings Institution.
- Carroll, Paul, "IBM, Digital, Others Form Coalition on Unix System to Challenge AT&T, Sun," The Wall Street Journal, May 18, 1988.
- Carroll Paul and Michael Miller, "High Tech Wars," The Wall Street Journal, September 14, 1988, pg. 1.
- Carlyle, Ralph E., "RISC and Unix: the Signs of Transitional Times," Datamation, September 1, 1988, pg.40.
- Carlyle, Ralph E., "Open Systems: What Price Freedom?" Datamation, June 1, 1988, 54-60.
- David, Paul A., "Clio and the Economics of QWERTY," American Economic Review, 75 (May 1985), 332-336.
- Dyson, E., "Why the Argument Over OSF?," Computerworld, May 30, 1988.
- Brock, Gerald W., The U.S. Computer Industry: A Study of Market Power, Cambridge, Ma: Ballinger Publishing Co., 1975.
- _____, "The Computer Industry," in The Structure of American Industry, Walter Adams ed., New York: Macmillan, 1987.
- DeLamarter, Richard Thomas, Big Blue, New York: Dodd, Mead & Co., 1986.
- Farrell, Joseph, and Nancy Gallini, "Second Sourcing as a Commitment," Quarterly Journal of Economics, forthcoming.
- Farrell, Joseph and Garth Saloner, "Standardization, Compatibility, and Innovation," Rand Journal of Economics, 16(1) (1985): 70-83.
- _____, "Installed Base and Compatibility: Predation, Product Preannouncements and Innovation," American Economic Review, 76 (5) (December 1986a) : 940-955.
- _____, "Standardization and Variety," Economics Letters, 20 (1986b): 71-74.
- _____, "Economic Issues in Standardization," in

Telecommunications and Equity: Policy Research Issues, edited by James Miller, North-Holland, 1986c, 165-178.

_____, "Competition, Compatibility and Standards: The Economics of Horses, Penguins and Lemmings," in Product Standardization as a Tool of Competitive Strategy, H. Landis Gabel, ed., New York: Elsevier Publishing Co., 1987, pp. 1-22.

_____, "Coordination through Committees and Markets," RAND Journal of Economics, 19 (Summer 1988).

Farrell, Joseph, and Carl Shapiro, "Dynamic Competition with Switching Costs," RAND Journal of Economics, 19 (Spring 1988), 123-137.

Fisher, Franklin M., John J. McGowan and Joen E. Greenwood, Folded, Spindled and Mutilated: Economic Analysis and U.S. v. IBM, Cambridge: The MIT Press, 1983.

Fisher, Lawrence M., "Plans for Single Unix Standard Set Back," New York Times, October 19, 1988, D-10.

Fishkind, Beth C., "Users Concerned Over Standards," Unix Today!, August 1988.

Flamm, Kenneth, Creating the Computer, Washington: The Brookings Institution, 1988.

Gabel, H. Landis, "Open Standards in the European Computer Industry: the Case of X/OPEN," in Product Standardization and Competitive Strategy, H. Landis Gabel ed., New York: Elsevier Publishing Co. 1987.

Hayes, Thomas C., "AT&T's Unix is a Hit at Last, and Other Companies are Wary," New York Times, February 24, 1988, pg. 42.

Kavner, Robert, "AT&T looks for common ground, not war, with OSF," Computerworld, August 29, 1988, 21.

Katz, Michael L. and Carl Shapiro, "Network Externalities, Competition and Compatibility," American Economic Review, 75 (1985), 424-440.

_____, "Technology Adoption in the Presence of Network Externalities," Journal of Political Economy, 94 (1986a), 822-841.

_____, "Product Compatibility Choice in a Market with Technological Progress," Oxford Economic Papers, 38 (1986b), 146-165.

Hamilton Joan, "Getting Computers to Dance to the Same Music," Business Week, May 23, 1986, pg. 112.

Hayes, Thomas, "AT&T's Unix is a Hit at Last, and Other Companies are Wary," New York Times February 2, 1988, 42.

Klemperer, Paul, "Markets with Consumer Switching Costs," Quarterly Journal of Economics, 102 (1987a), 375-394.

_____, "The Competitiveness of Markets with Consumer Switching Costs," RAND Journal of Economics, 18 (1987b), 138-150.

Lohse, Edward, "The Role of the ISO in Telecommunications and Information Systems Standardization," IEEE Communications Magazine, 23 (January 1985), 18-24.

Matutes, Carmen and Pierre Regibeau, " 'Mix and Match': Product Compatibility Without Network Externalities," RAND Journal of Economics, 19 (Summer 1988).

Moad, Jeff and Gary McWilliams, "SAA: The Yellow Brick Road to Cooperative Processing," Datamation, July 1, 1988.

Monteverde, Kirk and David Teece, "Supplier Switching Costs and Vertical Integration in the Automobile Industry," The Bell journal of Economics, 13 (Spring 1982), 206-213.

Nesmith, A., "A Long Arduous March Towards Standardization," Smithsonian, March 1985, 176-194.

Ordover, Janusz A. and Robert D. Willig, "An Economic Definition of Predation: Pricing and Product Innovation," Yale Law Journal, 91 (1981), 8-53.

Sanders, T.R.B., The Aims and Principles of Standardization, International Organization for Standardization, 1972.

Shepard, Andrea, "Licensing to Enhance Demand for New Technologies," RAND Journal of Economics, 18 (Autumn 1987), 360-368.

Sobel, Robert, IBM vs. Japan, New York: Stein and Day, 1986.

Underwood, Sarah and Paul Tate, "The European 25," Datamation, 33 (August 1, 1987), 58-9.

Verman, Lal Chand, Standardization, A New Discipline, Hamden: Ardon Books, 1973.

Zipper, Stuart, "AT&T-Backed Group, OSF Clash on Unix V Hegemony," Electronic News, October 16, 1988.

"AT&T, Sun ink Unix Deal," Computerworld, March 2, 1988.

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