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## *Manipulating interface standards as an anticompetitive strategy*

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### **Abstract**

The creation of interface standards enables competition at the level of components, rather than in complete systems, and consumers often benefit from component competition. Nevertheless, the standard setting process can be manipulated to achieve anticompetitive ends. The authors consider the conditions under which a standards consortium could impose anticompetitive burdens on the market and examine several strategies such a consortium might employ to achieve anticompetitive objectives. They present a new strategy – one-way interface standards – and discuss the conditions under which it can be anticompetitive.

### **1 Introduction**

Complementary devices in a complex technological system must communicate through interfaces to interoperate successfully. In systems that involve communications and computing functions, interfaces are connections through which signals pass. The devices on both sides of an interface (e.g., the microprocessors and a disk drive, or the PBX [that is, the private branch exchange] and the central office switch) must be designed so that they make the correct physical connection, send the correct signals to each other, and correctly interpret the signals received. We refer to the formal physical and signaling details as the *interface specification*.

Communications and computing functions are featured in a much wider variety of systems than those we think of as primarily telecommunications or computers. For example, automobiles have sophisticated controller systems in which multiple components communicate with each other. Medical devices often perform sophisticated computation. At the least, our analysis applies to any system through which information flows through electrical, photonic, or other electromagnetic

signaling. We also expect the general principles to apply to interfaces in other (non-signaling) technologies, though we have not studied such systems.

An interface stands (physically or logically) between two (or more) separate components. Thus, for an interface specification to succeed, it must be adopted by at least one manufacturer of the components on each side of the interface. When an interface specification is published, adopted, and implemented by at least one different firm manufacturing each of the affected components, we refer to it as an *interface standard*.<sup>1</sup>

In this article, we develop three related ideas: (1) technologies can compete as individual components or as complete systems; (2) interface standards are important determinants of component-level competition; and (3) the standard setting process can be manipulated to distort component competition. Our primary original contribution is to identify a specific strategy – which we call *one-way interface standards* – that standards consortia can use to manipulate a standard setting process to achieve anticompetitive ends.

Competition and consumers often – but not always – benefit when interface specifications are standardized and openly published. For example, if competing firms can design and manufacture system components that correctly interoperate, then consumers (or systems integrators that then sell to consumers) can mix and match components from different manufacturers to get the set of components that offers the best combination of price and performance. Nevertheless, consumers also may benefit when competition is for complete, incompatible systems, because there may be more incentive for innovation or more efficient adoption and rejection of new technologies.

Most interface specifications are developed by firms participating in the relevant industries. There are several different configurations of industry participants that might work together to create a standard. For example,

- A group may be composed of several manufacturers of each component. In some such cases, a relatively open process is used, in which a membership organization (with or without government sanctioning) accepts any qualified participant that manufactures either (or both)

<sup>1</sup> Terms such as “standards” and “open” are used in various ways in the literature. In this article, we use “standard” for a specification that is published, and we use “open” to refer to the public nature of the standard. We specifically do not use “open” to describe the copyright or licensing status of the standard, such as it is often used when discussing open source technologies.

of the complementary components and through a formal process the organization jointly develops the specification. In other cases, membership is limited.

- A group may be composed of firms that manufacture the component on one side of the interface. For example, automobile manufacturers might agree on a specification for attaching tires to wheels without the participation of tire manufacturers.
- A single firm that manufactures products on one or both sides of the interface may specify a standard. For example, once required to do so by the Federal Communications Commission, AT&T announced specifications for attaching customer premises equipment (CPE) to its network.<sup>2</sup> Microsoft also unilaterally announces the specifications of applications programming interfaces (APIs) for software programs to communicate with its operating systems.

It is conventionally assumed that openly published standards lower the barriers to entry in a market because potential entrants can design components that interoperate with existing complements if they adhere to the standard. The standard setting process, however, can be manipulated to *create or raise* barriers to entry. Just as with a price-setting consortium (that is, a cartel), a standards consortium may be able to harm competition when its membership characteristics satisfy conditions for market power and barriers to entry.<sup>3</sup> There are two conditions sufficient to anticompetitively manipulate a standards process: (1) the consortium must include firms with sufficient market power to ensure industry adoption of the standard, and (2) membership and decision-making control must be restricted in a manner that excludes viable potential competitors.<sup>4</sup>

<sup>2</sup> The rules requiring AT&T to permit others to attach CPE to its network and to publish the interface specifications necessary to do so, were developed by the courts and the Federal Communications Commission in a series of landmark decisions: *Hush-A-Phone Corp. v. United States* (1957); *Use of the Carterfone Device in Message Toll Telephone Service* (1968); *Second Computer Inquiry Decisions* (1980 and 1981); and *Computer & Communications Industry Association v. Federal Communications Commission* (1982, 1983, 1984).

<sup>3</sup> The European Commission (1987) recognized these characteristics in *X/Open Group*.

<sup>4</sup> Many standard setting groups have two levels or groups of membership. One group controls (sets) the standard and the other group has an advisory and/or testing role. For example, the USB 2.0 Implementers Forum has Promoter Members, who are allowed to vote on decisions, and Participant Members, who

When a standards consortium has the potential to exercise market power, various strategies may have anticompetitive consequences. These strategies include delaying publication of the standard to gain a first-mover advantage; creating standards that require other firms to use royalty-bearing intellectual property (e.g., a patent owned by a firm in the standards consortium); and creating one-way interface standards.<sup>5</sup>

To the best of our knowledge, the last strategy – one-way interface standards – has not previously been described in the economics literature. In an industry with complementary system components that interoperate, component manufacturers on *both* sides of the interface require specifications for the physical and/or logical connections that enable the components to interoperate. In general, it is necessary to publish the specification of both sides of the interface protocol for manufacturers on either side to use the standard. However, through creating a blind or a cut-out – in the form of an extra technology layer – a consortium can publish the information necessary to manufacture compliant components on one side of the interface without releasing the information necessary to manufacture components on the other side. We name this strategy one-way interface standards. Such standards facilitate competition for one component, but harm competition for the other, complementary component.

Whether one-way interface standards harm consumers overall turns on the same issues well known in the trade-off between mix-and-match and systems competition. Our contribution is to show how an interface standards consortium can move the boundary that separates systems from mix-and-match competition.

are allowed to participate in the discussions but are not allowed to vote. See the group's bylaws at [www.usb.org/data/retail/usbif\\_bylaws.pdf](http://www.usb.org/data/retail/usbif_bylaws.pdf).

<sup>5</sup> In the penultimate section of this paper, we present three detailed examples of standards consortia that apparently have employed these tactics to use standard setting processes for anticompetitive gain. One example involves the JEDEC consortium and its creation of a DRAM standard subject to the patents of Rambus, which participated in JEDEC; another is Intel's specification of the Accelerated Graphics Port (AGP) advanced graphics standard; and the third is the development of the Universal Serial Bus (USB) 2.0 and EHCI (Enhanced Host Controller Interface) interface specifications to implement high-speed serial communications with desktop computer peripherals.

## 2 Benefits and costs of component competition

When interface specifications are standardized and non-proprietary, component competition – that is, competition between multiple manufacturers of a given component in a system – can thrive. However, it is not given that component competition is necessarily superior to systems competition. We briefly describe the benefits and costs of component competition.

### 2.1 *Benefits from component competition*

#### **Competition on price and performance**

When interface specifications are published, more firms can enter the markets for individual components, and the greater entry results in more competition on price, performance, and quality of the component in question (Economides 1988; Matutes and Regibeau 1988). In contrast, when interfaces are not public, competition is between incompatible systems (i.e., combinations of components), rather than between mix-and-match components. Systems competition results in increased product differentiation among components of a particular type: they are compatible with different systems. If there is not much demand for the ensuing variety, it may serve primarily to divide the market. Thus, spurious differentiation can lead to higher prices and may not provide offsetting gain from variety (Farrell and Saloner 1986a). Component competition avoids such spurious product differentiation, and thus can lead to lower prices and higher quality.

#### **Scale efficiencies and lower production costs**

By increasing the size of the potential market, public interface standards may enable firms to realize efficient scale and learning economies (Hemenway 1975). This may explain why Apple Macintosh hardware typically costs more than comparably performing PC (personal computer) hardware.<sup>6</sup>

<sup>6</sup> Scale economies might explain the price difference for some components that use different interfaces even if the interfaces adhere to published standards. For example, in 2001, PC Connection (a leading component retailer) listed eighty-seven add-in video cards for Intel-based PCs. Mac Connection (owned by the same company) listed only five add-in video cards for Apple Macintosh

**Network externalities**

For many products, consumers benefit the more other users there are of the same (or a compatible) product. For example, several standards for mobile telephones are in use. Telephone companies in the United States largely adopted TDMA (Time Division Multiple Access) multiplexing, but some adopted CDMA (Code-Division Multiple Access) technology. Europe and most of the rest of the world adopted GSM (Global System for Mobile Communications), which uses TDMA. Consumers with GSM phones benefit from being able to use their phones as they move from country to country.<sup>7</sup> Some US users have started to benefit from this network externality, as providers deploy new GSM networks. To do so, however, customers typically must first purchase more expensive multi-mode phones to make domestic calls outside the rather limited footprint of the GSM networks and then use the different frequencies for GSM that are employed by other nations. If there is a single standard with component competition, then the number of users will be larger and consumers may obtain greater benefits from the network externalities.

**More innovation and variety for components**

When interfaces between complementary components are standardized, a firm making one component in a system faces a larger potential market than in a market with multiple proprietary interfaces. If interfaces are proprietary, a firm that innovates can only sell its component to the portion of the market that uses the particular system with which its component works. When the potential payoffs are larger, it is worthwhile for small, innovative, new firms to incur the risks and costs of entry, thereby enhancing competition. For example, while maintaining compatibility with the x86 architecture interface standards, firms other than Intel pioneered low-power microprocessors for mobile computers; Cyrix's MediaGX microprocessor spawned

computers. In addition, prices for the PC components were lower. For example, the ATI Tech Radeon 32MB DDR (double data rate) video board for a PC was \$166 with an AGP interface. See [http://www.pcconnection.com/scripts/productdetail.asp?product\\_id=214468](http://www.pcconnection.com/scripts/productdetail.asp?product_id=214468). The same card for the Macintosh is \$209–\$240 with an AGP interface. See [http://www.macconnection.com/scripts/productdetail.asp?product\\_id=219741](http://www.macconnection.com/scripts/productdetail.asp?product_id=219741).

<sup>7</sup> One of the authors observed Martin Cave, while in Australia, use his UK phone to call someone with an Australian phone who was sitting in a cubicle 10 feet away.

the sub-\$1,000 PC market;<sup>8</sup> AMD (Advanced Micro Devices) and Intel have been leapfrogging each other in a race for the fastest processors; and so forth.

### **Reduced risk of stranded investments**

When interfaces are standardized, consumers will have confidence that they can buy upgraded components that will work with their systems and that these components will continue to work if they purchase a new base system. For example, consumers can add larger and faster hard drives, improved monitors, scanners, and other devices to their base computers (Porter 1985).

## *2.2 Costs from component competition*

There are also some potential costs to consumers from component competition based on open standards. The costs we discuss in this section are not (necessarily) associated with anticompetitive behavior: They can occur in competitive markets. These costs are a consequence of the complementarities inherent in complex technological systems. With complementarities, consumers may be better off with production of systems consisting of components that connect through proprietary interfaces. In such cases, there may be sufficient benefits from competition between systems to outweigh the foregone benefits of component-wise competition.

### **Reduction in system design variety**

Systems competition, with the resulting differentiation between system architectures, may provide benefits by increasing variety. When interfaces are proprietary, a firm that wishes to enter with a new, innovative design in one component may find it necessary to develop an entire system. The result may be an increase in variety of systems. The entry of the NeXT computer in the late 1980s may be an example. NeXT introduced a new operating system that took greater advantage of the

<sup>8</sup> The MediaGX combined a microprocessor, memory controller, graphics accelerator, and PCI (peripheral component interconnect) interface on a single chip. At the time, competing offerings would have required at least a processor plus the north bridge of a chipset to match this functionality. *Microprocessor Report* (1997a) attributes the MediaGX's success with driving Intel to finally breach the \$106 price floor it had long maintained for its mainstream processors.

object-oriented programming model than did any other desktop operating system. NeXT also produced its own hardware on which to run this operating system, introducing innovations in digital signal processing, raster-oriented (Display Postscript) screen output, mass storage (magneto-optical drives), and other features.<sup>9</sup>

### Network externalities

When network externalities are significant, socially undesirable outcomes may occur in a market with open standards and component, rather than systems, competition. For example, when there are already many users of a given standardized system, the incentives to innovate and develop a better system may be insufficient. Even if a firm does develop a better system, consumers may find it too costly to switch (in part because they do not believe that enough other users will switch). In a market with competition among several incompatible systems, entry by a new, innovative system may be easier than in a market with a single common set of standards. This problem, which can lead to sub-optimal innovation, is known as *excess inertia* (Farrell and Saloner 1986a; Katz and Shapiro 1994).

### 2.3 Summary: systems versus mix-and-match competition

Manufacturers of complementary components need to know interface specifications in a system so that their components correctly connect and communicate with the other components. With open interface standards, many firms can make compatible components on both sides of the interface, and thus component competition will be viable. As was previously described, there are both benefits of component competition for consumers and, in some situations, offsetting costs. In some industries, these offsetting costs are sufficient enough that consumers are better served by systems competition, which is marked by proprietary interfaces and components that work only with specific matching complements.

For the most part, the history of the x86-compatible PC industry has been marked by component-based competition; the availability of open

<sup>9</sup> The NeXT operating system became the basis for Apple's OS/X operating system, and thus has contributed substantially to Apple's ongoing ability to put some competitive pressure on Microsoft and Intel.



standards has been credited with the high rate of innovation, the variety of low-cost, high-performance products, and the overwhelming success of the PC architecture against closed systems, such as the Apple Macintosh and various RISC-based (reduced instruction set computer-based) systems. Both systems and component competition have been dominant in different parts of the telecommunications industry.

On the basis of economic theory alone, we cannot conclude that component-based competition and open interface standards are always best for consumers and the economy. Yet, when open standards are preferred, it is usually on the assumption that they benefit component competition. We now identify strategies through which the standard setting process can be manipulated to harm competition and consumers.

### 3 Anticompetitive manipulation of interface standards

Collusive agreements between competitors to fix prices or divide markets are generally illegal. Indeed, under the Sherman Antitrust Act, collusion is *per se* illegal: it is not necessary to prove that the agreement causes harm to consumers; rather, harm is presumed. However, collusive agreements among competitors to establish interface standards are not *per se* prohibited, and in fact are both common and encouraged by policymakers.

The different stance toward standards agreements follows from the presumption that their effects are primarily pro-competitive. Yet, when there is a combination of firms that together have power in at least one of the markets for components on the two sides of an interface, they may be able to use the process of setting interface standards to increase or maintain market power. Doing so can ultimately harm consumers and society.

To harm competition, a standards consortium must satisfy the two usual conditions. First, it must have market power and be protected by barriers to entry in order to successfully exercise that market power. Thus, for it to be *possible* to harm competition, a consortium needs to include firms with sufficient market power in one or both of the component markets to ensure widespread adoption of the standard. Second, to protect against competitive dilution, the consortium needs to restrict membership and decision-making control in a manner that excludes viable potential competitors. If not – that is, if any competent

and interested firm could participate and if the decision process was not biased so that a subset of the members could exert effective control – then it would be hard for the consortium to implement anticompetitive strategies.<sup>10</sup>

The European Union antitrust body discussed precisely these conditions in its *X/Open Group* decision (European Commission 1987). It was concerned with market power because the case involved a standard setting group of computer firms that were each of considerable size. The Commission also noted that it was possible for the members to exclude competing firms from membership. The Commission concluded that “an appreciable distortion of competition . . . may result from future decisions of the Group” (¶34).

Of course, that a consortium of firms with the *potential* to exclude competition agrees to set standards does not imply that consumers and competition will be harmed. We now describe some strategies with anticompetitive effects that such consortia might employ.

### 3.1 Charging a toll

One way in which an interface specification consortium can harm component competition is to design royalty-bearing intellectual property into the standard. Suppose one firm in the consortium holds a patent on a technology that is useful but not essential for the interface. That is, the interface could be designed without the patented technology and be equally efficient. The patent holder, however, might induce the consortium to specify that the patented technology be used for the interface, and, as a result, would be paid royalties for its use. As an inducement, the patent holder might share the rents by offering consortium members a reduced or zero royalty, ensuring that rivals of the consortium’s members will have higher costs than consortium members.

Sometimes a patent holder might be able to deceive a consortium unilaterally into including its patented technology in a specification. Often there are long delays between the date a firm files a claim and the

<sup>10</sup> Although restricted voting can enable a consortium to harm competition, it may not be necessary to force democratic participation and fair voting rules to protect competition. It may be sufficient to require that all information shared by consortium members be made simultaneously available to all other competent and interested firms.

grant of the patent. The consortium may not realize that a technology written into a specification is covered by such a “submarine” patent.<sup>11</sup> If the patent is granted after the specification is released and adopted as a standard by the industry, the patent holder may successfully raise its rivals’ costs through the royalties it demands. Later, we will discuss the Rambus cases, in which its rivals claimed Rambus employed this strategy.

### 3.2 *Withholding or delaying information*

A second strategy through which an interface specification consortium can harm component competition is by withholding necessary interface information from potential rivals for a short or long period, thereby rendering a so-called open standard effectively proprietary (Farrell and Saloner 1992). Withholding necessary information raises rivals’ costs (thus raising the prices to end users) and may deter entry (or hasten exit) altogether (Matutes and Regibeau 1996). In particular, if crucial interface information is withheld for long enough, a potential rival will be forced to develop a complete system, in which it controls the interfaces, and then to compete on a systems basis. Thus, the consortium may have colluded to exclude component competition. The creation of the Universal Serial Bus (USB) 2.0 standard, which we describe below, is a possible example of this strategy.

### 3.3 *One-way interface standards*

Another potentially anticompetitive strategy is for a consortium to design a standard to facilitate competition in components on one side of an interface while restricting competition in components on the

<sup>11</sup> There are many cases in which patent claimants exploited Patent Office rules to intentionally delay the granting and publication of their patents. The Lemelson machine vision patents are a well-known example, in which delays were created by filing a series of continuation and divisional patent applications that claim priority from the initial patent application. The Federal Circuit recently ruled that a patent may be unenforceable if the patent applicant unreasonably delays prosecuting the patent (*Symbol Technologies Inc. v. Lemelson Medical, Educational & Research Foundation* 2002).

US patent law was recently amended by the American Inventors Protection Act of 1999 to limit submarine patents. Claims filed after November 29, 2000 will automatically be published eighteen months after they are filed, even if the review process is not complete.

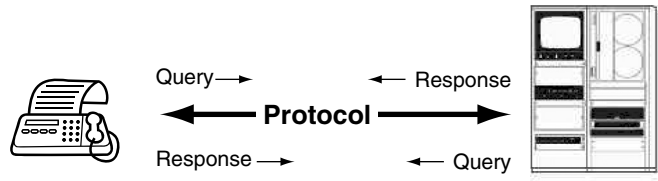


Figure 7.1. Telecom interface protocol.

other side of the interface. We call this a *one-way interface standard*. As we noted earlier, we have not seen this strategy previously identified in the literature.

Implementing a one-way interface standard is not straightforward. Since a standard specifies both sides of an interface, it might seem that the consortium need merely withhold the specification information for one side of the interface. In fact, it is the nature of interface standards that manufacturers of components on both sides need all of the information about both sides of the interface. To understand this requires a bit more detail about interface standards.

Consider a simple interface (see Figure 7.1). We have illustrated the communications part of an interface standard, known as the *protocol*. An enormous variety of technologies (including any system that employs communications or computing) depends on interfaces that send signals between components. The protocol specifies the language for the signaling, including a syntax and vocabulary. In Figure 7.1 we show a piece of CPE and a communications switch. The CPE sends queries and directives to the switch; the switch responds. Likewise, the switch queries the CPE, which in turn responds. The protocol specifies the permissible queries and the responses that can be generated to each query. If the CPE complies with the specification, it knows what messages it can send and what responses the switch can give. If the CPE did not know the responses the switch could give, then it could not be programmed to make use of those responses. Likewise, a compliant CPE knows what queries it can receive and what responses it is expected to give.

From the example, it should be evident that the components on both sides of the interface must know the full specification. The CPE must know not only its own permissible queries and responses to the switch, but also the switch's permissible responses and queries. It is not



Figure 7.2. Telecom interface with translator.

possible to publish only one side of the specification and design components on that side.

How, then, can a standards consortium design a one-way interface standard? The basic idea is to create a “cut-out” or a “blind” – to insert an additional structure between the two components. We call this structure a *translator*. Now the interface specification between one component and the translator can be published, but the interface specification between the translator and the other component is treated as proprietary and is not published. Manufacturers on the open side can manufacture compliant components that communicate with the translator, but non-member manufacturers on the other side cannot make their components communicate with the translator.

To illustrate, consider the following example of how the protocol in Figure 7.1 would break down if both sides were not published. Imagine that the CPE is programmed to communicate in English. However, the switch is programmed to communicate in another language, and the CPE does not know what language the switch is using, nor how to speak it. Clearly, the CPE and the switch cannot interoperate successfully.

Now introduce a translator (Figure 7.2). The interface protocol between the CPE and the translator can specify that they speak English to each other. The language spoken between the translator and the switch can be kept secret. Anyone can manufacture compliant CPE, but only those consortium members who know the secret language spoken by the translator can manufacture switches.

There is a simple and reasonably familiar way to implement a one-way interface standard, at least conceptually. The standard could specify that the two components communicate via public key cryptography (PKC). In PKC communications, keys are created in pairs, one called “public” and the other “private.” A message encrypted with the public key can only be decrypted with the private key; likewise, a

message encrypted with the private key can only be decrypted with the public key.<sup>12</sup>

The following example illustrates how PKC can be used to implement one-way interface standards. The standard would publish a public key and an algorithm that components on the public side could use to encrypt messages sent to the private side, and to decrypt messages arriving from the private side. Components on the private side would need the corresponding private key to decrypt messages encrypted with the public key and to encrypt messages that could be decrypted with the public key. As long as the component manufacturers on the protected side of the interface kept the private key secret, no other manufacturer could make a component that could communicate with the public side components.<sup>13</sup>

The effect of a one-way interface standard is to extend the boundary of systems competition. Continuing with the example, the switch in Figure 7.1 is a system. That is, the switch is a set of complementary components that communicate with each other to collectively perform services for users. To compete in switches, manufacturers need to implement all of the features that switch users expect – in particular, the ability to communicate with external components through specified interfaces. Thus, there is systems competition in switches. Suppose that when a one-way interface standard is imposed, as in Figure 7.2, the switch is on the proprietary side. Now, a potential competitor that previously would have designed complete switch systems to compete must design both the switch and the translator. That is, since the specification between the CPE and the translator is public, potential switch competitors can connect to CPE if they develop their own translators that conform to the public CPE-translator standard. The system boundary has expanded to include the translator device.<sup>14</sup>

<sup>12</sup> Diffie and Hellman (1976) first proposed the PKC; the most widely used implementation is the RSA algorithm (Rivest et al. 1978).

<sup>13</sup> It is unlikely that PKC would actually be used for this purpose for at least two reasons. First, the private key would need to be hard-coded into the physical components, and then it would likely be a straightforward matter for competing firms to discover it. Second, PKC imposes substantial computational overhead, and hence would not be practical for the many very fast, very short messages that communications and computing devices exchange.

<sup>14</sup> Notice that this strategy is similar to tying as a foreclosure strategy: A firm with monopoly power over Good A requires consumers to purchase Good B if they

Expanding the system boundary is a variation on raising rivals' costs. It may be possible to design and market expanded systems (that include proprietary translators), but it takes time and money to do so. If the translator design is sufficiently costly or time-consuming, or if it is protected by intellectual property, then firms excluded from the standards consortium may find it very difficult to compete effectively.

### *3.4 Timing is critical*

Timing is a crucial element in the above strategies. In the communications and computing industries, technological innovation is so constant and rapid that significant delays in time to market can mean the difference between vibrant, successful competition and a persistent pattern of dominance with minor fringe competition. Thus, none of the strategies needs to be leak-proof or permanent. If the dominant firm can impose the competitive disadvantages for as little as a few months or a year, the effects on competition can be devastating. This is particularly so because the ongoing cycle of innovation gives the dominant firm the opportunity to put its competitors "on the treadmill." For example, with one-way interface standards, a dominant firm could introduce one translator after another, for each new or revised interface that arises. Potential competitors would bear an ongoing stream of higher costs and delays in getting to market.

The US Federal Trade Commission (hereafter, FTC 1999) makes this point quite forcefully in its analysis of Intel's conduct published along with the consent decree entered into by Intel and the FTC:

The computer industry is characterized by short, dynamic product cycles, which are generally measured in months. Time to market is crucial. Indeed, the denial of advance product information is virtually tantamount to a denial of actual parts, because an OEM [original equipment manufacturer] customer lacking such information simply cannot design new computer systems on a competitive schedule with other OEMs. An OEM who [sic] suffers denial of such information over a period of months will lose much of the profits it

want to get Good A. If demand is sufficient for Good A, this may harm competition in the market for Good B. For a Good B producer to effectively compete, it may have to develop its own version of Good A so that it can offer consumers a complete package of Goods A and B.

might otherwise have earned even from a successful new computer model. Continued denial of advance technical information to an OEM by a dominant supplier can make a customer's very existence as an OEM untenable.

The European Commission (1987, ¶32) noted the same concern in the context of a standards consortium:

In an industry where lead time can be a factor of considerable importance, membership of the group may thus confer an appreciable competitive advantage on the members vis-à-vis their hardware and software competitors . . . this advantage in lead time directly affects the market entry possibilities of non-members.

That is, it is not necessary for a standard setting consortium to withhold the interface specification standard forever for competition to be harmed. If the member firms have advance knowledge of the standard, they can bring compliant products to market before non-members, and even a few months of lead-time can spell the difference between market success and failure.

#### **4 Examples of possible anticompetitive interface specifications**

In this section, we examine three examples of possibly anticompetitive interface standards in the computer industry. In one example, the consortium incorporated patented information in a memory standard; in another, a monopolist established a one-way interface standard for graphics processors; and in the third, a consortium imposed a one-way interface standard and gained competitive advantage by delaying the release of necessary specification details for a peripheral standard.

Before discussing the examples of standards consortia in the computer industry, we briefly describe some relevant technological and economic characteristics of microprocessors. By themselves, microprocessors have little or no value to end users. Microprocessors can process computational instructions, but they need software to deliver the instructions. They also need a variety of other devices that assist in performing the tasks that end users desire. For example, microprocessors need memory to hold data and instructions (which end users demand in a variety of configurations, e.g., DRAM [dynamic random access memory], hard disks, floppy disks, CD-ROM [compact disc-read-only memory], etc.). Microprocessors need input and output



devices (keyboards, scanners, microphones, cameras, printers, monitors, voice and data network lines, etc.). For all of the above, the microprocessors need communications pathways and devices that manage the vast variety of complex and extremely fast high-speed signals flowing among all of the various devices. In short, end users demand computer systems, of which microprocessors are but one component. The systems, in turn, are comprised of numerous components. Between these components are a variety of interfaces.

In the microprocessor industry, many consortia exist to create standards for the interfaces between hardware devices that connect to a PC's microprocessor or to the microprocessor's associated chipset. Many of these consortia have closed membership, and the members of the consortia both control the details of the interface standards and have advance knowledge of the interface details, which provides consortia members substantial lead-time in developing compatible products.

Both systems and component competition occur in the computer industry. When standards are proprietary, competition must take place on a systems basis. An example is the current technology for microprocessors and chipsets. In the mid-1990s Intel made the bus that connects its microprocessor to chipsets proprietary. Since then, Intel-compatible microprocessors and chipsets compete as a system against AMD-compatible microprocessors and chipsets.<sup>15</sup>

When interface specifications are open and standardized, it is possible for multiple firms to compete for the manufacture of a given component for use in the same system. This is known as component competition. An example is the competition among Maxtor, Seagate, IBM, Fujitsu, and others to make and sell hard drives that are used in PCs manufactured by Dell, Compaq, Vobis, Groupe Bull, and others.

<sup>15</sup> Intel making the bus proprietary and thus expanding the boundary of its microprocessor system to include chipsets is an example of a one-way interface standard. While the specifications to connect to the chipset from components other than the microprocessor are publicly available, the specifications to connect the chipset to the microprocessor are not publicly available and are also protected by intellectual property subject to restrictive licensing.

#### 4.1 Inserting patents in standards: JEDEC and Rambus<sup>16</sup>

A possible example of using standard setting for anticompetitive gain concerns standards for computer memory.<sup>17</sup> The parties include

- JEDEC Solid State Technology Association, a standard setting organization. Membership is open to any company that manufactures products or provides services related to electronics. One of its subcommittees, JC-42.3, the Subcommittee on RAM Devices, develops standards related to RAM. It published standards in November 1993 and again in 1999 (Alban 2004).
- Rambus, a designer/developer of “high-speed chip-connection technology.” This chip-connection technology is incorporated in memory chips. Rambus licenses technology; it does not manufacture memory chips.
- Manufacturers of computer memory, including Hitachi, Hynix, Infineon, Micron Technology, Samsung, and Toshiba.

The actions of Rambus, described in some detail below, have led to many lawsuits. Rambus has been accused by the FTC of unreasonably restraining trade, attempting to monopolize, monopolizing, and engaging in unfair methods of competition in the market for SDRAM technology in violation of Section 5 of the FTC Act.<sup>18</sup> Memory manufacturers have sued Rambus, with allegations of fraud and antitrust violations (Miles and Shankland 2000). Rambus has filed suits against most of the major memory makers alleging patent infringement (Infineon, Micron, and Hyundai, which is now Hynix). A group of standard setting bodies filed an amicus brief in support of Infineon, arguing that Rambus concealed its intellectual property (Kanellos 2003a). Many of the cases are still active, but the most recent rulings have tended to be in Rambus’ favor, interpreting the JEDEC bylaws as

<sup>16</sup> The information in this section is primarily from the complaint filed by the FTC in 2002, Fried 2001, Kanellos 2001, and Miles and Shankland 2000.

<sup>17</sup> In particular, this incident involves the move from asynchronous DRAM (dynamic random access memory) to synchronous DRAM (often called SDRAM) that occurred during the 1990s. Some form of SDRAM is the most common memory in computers today. RDRAM (or Rambus DRAM) and DDR DRAM (or double data rate DRAM) are both forms of SDRAM.

<sup>18</sup> In February 2004, an FTC administrative law judge dismissed the case; the FTC is appealing the case (FTC 2004).

not requiring disclosure on Rambus' part.<sup>19</sup> Of course, whether or not JEDEC bylaws specifically required disclosure is immaterial to whether Rambus actually concealed information in the standard setting process with anticompetitive effects.

The allegations against Rambus are that they used participation in the standard setting process to write their patents in such a way as to ensure that the JEDEC-adopted SDRAM standards infringed on Rambus' patents. Rambus filed its first patent April 18, 1990. It attended its first JEDEC meeting in December 1991, and joined JEDEC in February 1992. Business documents show that as early as 1992, Rambus believed that SDRAMs infringed on its patents (Alban 2004). The JEDEC bylaws call for all participants "to inform the meeting [of the standards-setting committee] of any knowledge they may have of any patents, or pending patents, that might be involved in the work they are undertaking" (JEDEC 2002, 18). When asked by JEDEC representatives if Rambus had disclosures to make, in one instance Rambus declined to make any such disclosures and in another made limited disclosures regarding a single patent relating to a clocking technology that differed from anything JEDEC was considering.<sup>20</sup>

Rambus stopped attending JC-42.3 meetings in December 1995, and formally left the organization in June 1996. The letter formally withdrawing its membership included a list of Rambus' patents. Infineon accused Rambus of using "informants" after Rambus withdrew from JEDEC to learn of discussions of DRAM standards in order to rewrite its patents to cover JEDEC standards (Kanellos 2001). Rambus filed amended patent applications in 1997 to cover SDRAM technology; these patents were awarded in 1999 and 2000. At that point, Rambus began enforcing its patent rights against memory manufacturers.

Rather than using restricted membership as a means to achieve anticompetitive ends, in the Rambus cases, the standard setting group had open membership to anyone involved commercially in the industry. Although restricted membership is sufficient for the potential to manipulate, this condition is not the only one necessary to enable

<sup>19</sup> In particular, the Administrative Law Judge dismissed the FTC case against Rambus (FTC 2004) and the Federal Circuit ruled largely in Rambus' favor in *Rambus v. Infineon* (Alban 2004).

<sup>20</sup> In its defense, "Rambus has maintained that competitors knew about its patents and product plans while SDRAM-related standards talks were going on at JEDEC" (Kawamoto 2004).

anticompetitive behavior. In the Rambus situation, the seller of the technology allegedly withheld vital information about its intellectual property throughout the standard setting process, adjusted its patent filings to reflect the standards adopted by the group, and then enforced its patents against the buyers of the technology once they had adopted the standards that Rambus claimed infringed on its patents.<sup>21</sup> Open membership may not protect the standards process if one firm can successfully deceive the other members about crucial property rights.

#### 4.2 *One-way interface standards: Accelerated Graphics Port*

The Accelerated Graphics Port (AGP) is an example of a one-way interface standard.<sup>22</sup> The AGP has electrical specifications on one side, between the AGP and the peripherals, and software specifications on the other side, between the AGP and the chipset.

The AGP specification<sup>23</sup> was developed by Intel with input from various industry participants, including ATI Technologies (a leading

<sup>21</sup> It is possible that, even had JEDEC known about Rambus' intellectual property, it would have adopted the same standards. However, JEDEC does have as one of its goals to avoid using patented technology.

JEDEC standards . . . that require the use of patented items should be considered with great care. (For the purpose of this policy, the term 'patented items' includes items and processes for which a patent has been applied.) While there is no restriction against drafting a proposed standard in terms that include the use of a patented item if technical reasons justify the inclusion, committees should avoid standardization that refers to a product on which there is a known patent unless all the relevant technical information covered by the patent is known to the formulating committee, subcommittee, or task group.

If the committee member indicates that the standard requires the use of patented items, then the committee chairperson must receive a written assurance from the organization holding rights to such patents that a license will be made available to applicants desiring to implement the standard either without compensation or under reasonable terms and conditions that are demonstrably free of any unfair discrimination. (JEDEC 2002, Section 8)

<sup>22</sup> The AGP Forum web page, which is no longer available, describes the AGP interface as "a new platform bus specification that enables high performance graphics capabilities especially 3D, on PCs at mainstream price points" (<http://www.agpforum.org/>, accessed September 1, 2002).

<sup>23</sup> The information and quotations in this paragraph are from the AGP Forum's website, at <http://www.agpforum.org/>. The AGP Forum existed until at least late 2002. As of today, the AGP forum web page is no longer available, and a search of Intel's web page does not find anything on the forum. We do not know the exact date between late 2002 and mid-2004 when the forum became defunct.

developer and manufacturer of graphics chips) and Cirrus Logic (“a premier supplier of high-performance analog, digital signal processing [DSP] and mixed-signal chip solutions for consumer electronics”). In May 1996, Intel created “an open industry group,” the Accelerated Graphics Port Implementors Forum. The goal of the forum was to “foster design and production of graphics hardware products and PC systems” which comply with the AGP interface specification. Firms could become members for \$2,500 a year, with the benefits of “participation in events and technical support subject to availability.” Intel had the right to limit the number of participants or to discontinue the program altogether and maintained unilateral control over the standard. As far as we could determine, no microprocessor or chipset manufacturer other than Intel was part of the forum. This is a case in which the standards consortium that implemented the one-way interface standard is essentially a single firm (with input from others).

Intel made the electrical specifications public, which means that firms can manufacture peripherals that will interoperate with AGP.<sup>24</sup> “[T]he AGP 1.0 specification consists of the necessary electrical and signal information that will enable graphics hardware developers and system OEMs to both design and use graphics controllers on the graphics port” (Intel 1996). AGP-compliant PCs and graphics hardware products were available by March 1997. Competition for these products has been vital, in large part because the specification was freely available.<sup>25</sup>

Innovation and competition on the chipset/chip interface side of AGP (i.e., the interface that was not published) has not been so dynamic. Intel, the owner of the specification, had AGP-capable chipsets out in mid-1997 that were compatible with Pentium II processors. Other chip and chipset makers could not immediately manufacture on their side of the standard because the software specifications were not public. Instead, they had to invent around the software specifications.

Although it appeared that parties other than Intel were offering AGP-compliant chipsets within about six months of Intel’s introduction

<sup>24</sup> The AGP V3.0 Interface Specification, revision 1.0, September 2002, contains a chapter on the physical layer specification, but not the software layer. See [http://developer.intel.com/technology/agp/downloads/agp30\\_final\\_10.pdf](http://developer.intel.com/technology/agp/downloads/agp30_final_10.pdf) (accessed May 11, 2004).

<sup>25</sup> More precisely, “[t]he AGP specification will be licensed on a royalty-free, reciprocal basis” (Intel 1996).

of an AGP-compliant chipset, the appearances were deceiving. First, the chipsets offered by third parties were not compatible with Pentium II chips, which at the time were the high-end microprocessors and were introduced in May 1997. Second, the chipsets did not work properly. VIA Technologies and ALI offered chipsets that were compatible with Socket 7 Pentium chips by late 1997 or early 1998; these chipsets were not compatible with Pentium Pro, Pentium II, and beyond. VIA's first supposedly AGP-compliant chipset crashed with Cyrix microprocessors and the AGP 2x mode did not work (Tom's Hardware 1997).

As late as May 1999, HardwareCentral, an online news source "for in-depth computer hardware info,"<sup>26</sup> reported that to use AGP required a "motherboard with Intel's 440LX PCI/AGP chipset," a chipset for Pentium II microprocessors (Risley 1999a). It was expected that the 440LX chipset would be made available for non-Intel processors, and it was reported that Socket 7 motherboards that offer AGP support using the VIA Apollo VP3 and the ALI Aladdin V chipsets were "beginning" to appear. HardwareCentral also reported in May 1999 that AGP was "on the road to becoming non-exclusive to the Intel Pentium II and 440LS chipset" and that Cyrix was "working on the MXi, which will . . . support AGP" (Risley 1999b). Not long after that, however, Cyrix indefinitely postponed development of the MXi (Slater 1999).

AMD offered an AGP-compliant chipset in August 1999 (AMD 1999), and VIA Technologies offered Pentium II-compatible chipsets that were AGP compatible about the same time (Shimpi 1999). Thus, Intel was the only supplier of AGP-compatible and Pentium II-compatible chipsets for over two years after the AGP standard was published. Transmeta x86-compatible microprocessor chips did not support AGP until October 2003, and the chips were not marketed in the United States until April 2004 (Sharma 2004), over seven years after the AGP interface was developed. This lack of functionality was something that "prevented the company from getting into the mainstream notebook market" (Kanellos 2003b).<sup>27</sup> In addition,

<sup>26</sup> See [www.hardwarecentral.com](http://www.hardwarecentral.com).

<sup>27</sup> Nvidia produced the chipsets for Transmeta's Efficeon processor (Kanellos 2003a).

Transmeta's ability to support AGP came at a time when AGP was beginning to be replaced by PCI Express.

By implementing a one-way interface standard, Intel had a significant time-to-market advantage. For over two years, it was the only company offering chipsets that were AGP-compatible and Pentium II-compatible, and the supposedly AGP-compliant and Socket 7-compatible chipsets that were offered by third parties had essentially no impact on the market. On the other side of the interface, competition was vibrant and immediate, with AGP-compatible products becoming available in the market by March 1997, just a few months after the standard was published. In this example, standard setting encouraged component competition on just one side of the interface.

#### 4.3 *One-way interface standards and publication delay: USB 2.0*<sup>28</sup>

In this last example, we describe a consortium that has behaved in a way that is consistent with two of our anticompetitive strategies: Implementing a one-way interface standard and delaying the release of information about the standard.

The USB is a standard for the microprocessor to communicate with slow- and medium-speed peripherals such as mice, keyboards, printers, scanners, and digital cameras. It defines an interface between a host controller and the peripherals. The host controller, which can be an independent physical device or be integrated onto the chipset, speaks with the system software via the host controller interface. Thus, there are two interfaces working together: the USB interface between the peripherals and the host controller, and the host controller interface between the host controller and the system software. As was previously described, this is a situation with two devices – the peripherals and the microprocessor (and system software) – separated by a “translator,” the host controller (see Figure 7.2).

USB 1.1 was originally developed in 1995. Two host controller interfaces, OHCI (Open Host Controller Interface) and UHCI (Universal Host Controller Interface), work with USB 1.1. UHCI is Intel's proprietary interface, and is available via a royalty-free, reciprocal license for adopters of USB. Jointly developed by Compaq,

<sup>28</sup> USB 2.0 is also marketed as Hi-Speed USB (see *CNET News.com* Staff 2001).

Microsoft, and National Semiconductor, OHCI is an open standard, available for download at <http://www.compaq.com/productinfo/development/openhci.html> (Compaq 1997).

USB 2.0, which increases the speed of the peripheral-to-PC connection by forty times relative to USB 1.1, was completed in April 2000.<sup>29</sup> USB 2.0 is compatible only with a new host controller interface, EHCI (Enhanced Host Controller Interface), which is proprietary to Intel. Version 0.95 of the EHCI was made public in November 2000, but Version 1.0 was not released until April 2002, a full two years after the USB 2.0 specification was published. The EHCI interface is not freely available: Intel licenses it only in exchange for the grant of a royalty-free license to Intel on the licensee's related intellectual property.

A one-way interface standard was implemented because the host controller interface, EHCI, is proprietary to Intel, while the USB 2.0 interface is an open interface. Peripheral manufacturers have the information they need to produce USB 2.0-compliant peripherals and consortium members have the information they need to produce USB 2.0-compliant chipsets and stand-alone host controllers. That is, the consortium released the specification information necessary for makers of complementary peripherals to implement their side of the USB 2.0 interfaces. The EHCI is required to implement the chipset/motherboard side of the USB 2.0 interface. Only non-member chipset and microprocessor firms are denied the information necessary to design their products to meet the USB 2.0 interface specification.

The consortium has the characteristics that allow it to develop standards with an anticompetitive impact. The USB Implementers Forum has two membership classes: Promoter Members, who have voting rights, and Participant Members, who do not.<sup>30</sup> Promoter Members must be engaged in research and development of the USB specifications. The Board of Directors, made up of employees of Promoter Members, has sole discretion to accept or reject applications from other firms to become a voting member.<sup>31</sup> To become a Promoter Member, one must receive unanimous approval of the Promoter

<sup>29</sup> A beta version was published in October 1999.

<sup>30</sup> The USB Implementers Forum was incorporated as a non-profit organization on January 18, 1999.

<sup>31</sup> Jeff Ravencraft of Intel currently serves as Chairman and President of the Board of Directors of the USB Implementers Forum; before him, the Chairman was Jason Ziller, also Intel's technology initiatives manager. Email communication



Members; any individual Promoter Member has veto power over a Promoter Membership application. Thus, the consortium satisfies one of the criteria that enable a consortium to behave anticompetitively: Membership is limited and current members control which firms can become a member.

The voting members of the consortium are Intel, Compaq, Hewlett-Packard, Lucent, Microsoft, NEC Technologies, and Philips.<sup>32</sup> These members created and controlled the interface specification standard for USB 2.0.<sup>33</sup> The consortium does not include any firms that produce chipsets or microprocessors except for Intel. Intel has an opportunity, then, to manipulate the standard setting process in such a way as to advantage itself against other microprocessor firms (chiefly AMD) and other chipset firms (e.g., VIA Technologies). The second criterion for a standards consortium to have the potential to manipulate a standard anticompetitively is that it must include firms with sufficient influence to ensure that the standard is adopted. In this case, Intel and Microsoft together have the ability to ensure industry-wide adoption of a standard.

In addition to the one-way nature of the interface standard, consortium members had a competitive advantage through early access to the USB 2.0 and EHCI specifications. That is, any firm has been able to build a peripheral that is USB 2.0-compliant, but only consortium members have been able to build the system-side hardware. For example, NEC Technologies announced that it had developed the world's first USB 2.0 and EHCI-compliant host controller on April 12, 2000, fifteen days before the USB 2.0 interface was released and six months before the preliminary version of the EHCI interface was released. In August 2000, Lucent announced a host controller;<sup>34</sup> and in May 2001, Philips announced a host controller. Until May 2002, implementation of USB 2.0 required the use of a host controller, a separate add-on piece to the chipset. In May 2002, the first chipsets with integrated host

to the authors from Traci Donnell, USB-IF Administration, dated June 2, 2004, and Intel 2002a.

<sup>32</sup> The formation of the USB 2.0 Promoter Group was announced at the Intel Developer Forum in Spring 1999. For USB 2.0, Hewlett-Packard, Lucent, and Philips joined the original core firm behind USB 1.1 – Compaq, Intel, Microsoft, and NEC Technologies.

<sup>33</sup> The bylaws are available from [http://www.usb.org/data/retail/usbif\\_bylaws.pdf](http://www.usb.org/data/retail/usbif_bylaws.pdf).

<sup>34</sup> We believe that Lucent did not succeed in manufacturing this host controller until at least May 2001.

controllers were announced. It was at this point that a non-member of the consortium announced implementation of a USB 2.0 compliant chipset or host controller.<sup>35</sup>

## 5 Conclusion

We have described the circumstances under which firms can use the standard setting process in an anticompetitive manner. Anticompetitive strategies include manipulating standards to include a firm's patented intellectual property; using information gained from within the consortium to gain a time-to-market advantage; and creating one-way interface standards. We believe our discussion of one-way interface standards is new to the literature.

Each of these strategies can have the effect of reducing component-based competition, and thus has the potential to harm consumer welfare. Since systems competition can in some circumstances be better for social welfare than component competition, it generally would be prudent to examine the specific facts and economic conditions relevant to a particular interface standard before concluding that the use of these strategies by a standards consortium is harmful. Nevertheless, recognizing the availability of these strategies to consortia demonstrates that standard setting does not guarantee vital component-based competition.

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<sup>35</sup> In May 2002, VIA announced a chipset that integrates a USB 2.0 host controller. Intel, however, challenged VIA's legal right to produce a Pentium 4 chipset.

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