The Art of Standards Wars

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Standards wars—battles for market dominance between incompatible technologies—are a fixture of the information age. Based on our study of historical standards wars, we have identified several generic strategies, along with a number of winning tactics, to help companies fighting today's—and tomorrow's—battles.

There is no doubt about the significance of standards battles in today's economy. Public attention is currently focused on the Browser War between Microsoft and Netscape (oops, America On-Line). Even as Judge Jackson evaluates the legality of Microsoft's tactics in the Browser War, the Audio and Video Streaming Battle is heating up between Microsoft and RealNetworks over software to deliver audio and video over the Internet. The 56k Modem War of 1997 pitted 3Com against Rockwell and Lucent. Microsoft's Word and Excel have vanquished WordPerfect and Lotus 1-2-3 respectively. Most everyone remembers the Video-Cassette Recorder Duel of the 1980s, in which Matsushita's VHS format triumphed over Sony's Betamax format. However, few recall how Philips's digital compact cassette and Sony's minidisk format both flopped in the early 1990s. This year, it's DVD versus Divx in the battle to replace both VCRs and CDs.

Virtually every high-tech company has some role to play in these battles, perhaps as a primary combatant, more likely as a member of a coalition or

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alliance supporting one side, and certainly as a customer seeking to pick a winner when adopting new technology. The outcome of a standards war can determine the very survival of the companies involved. How do you win one?

Historical Examples

Happily, companies heading off to fight a standards war do not have to reinvent the wheel. The fact is, standards wars are *not* unique to the information age. Unlike technology, the economics underlying such battles changes little, if at all, over time. We begin with three instructive standards battles of old. From these and many more historical episodes we have distilled the battle manual for standards wars that follows.

North vs. South in Railroad Gauges[1]

As railroads began to be built in the early 19th century, tracks of varying widths (gauges) were employed in the United States. By 1860, seven different gauges were in use in America. Just over half of the total mileage was of the 4 8½ standard. The next most popular was the 5 gauge concentrated in the South. Despite clear benefits, railroad gauge standardization faced three major obstacles: it was costly to change the width of existing tracks; each group wanted the others to make the move; and workers whose livelihoods depended upon the incompatibilities resisted the proposed changes, in fact to the point of rioting. Nonetheless, standardization was gradually achieved between 1860 and 1890. How?

The Westward expansion provided part of the answer. The big eastern railroads wanted to move western grain to the East, and pushed for new lines to the West to be at standard gauge. Since the majority of the Eastbound traffic terminated on their lines, they got their way. The Civil War played a role, too. The Union military had pressing needs for efficient East-West transportation, giving further impetus for new western lines to be built at standard gauge. In 1862, when Congress specified the standard gauge for the transcontinental railroads, the Southern states had seceded, leaving no one to push for the 5 gauge. After the war, the Southern railroads found themselves increasingly in the minority. For the next twenty years, they relied upon various imperfect interconnections with the North and West: cars with a sliding wheel base, hoists to lift cars from one wheel base to another, and, most commonly, building a third rail.

Southern railroad interests finally threw in the towel and adopted the standard gauge in 1886. On two days during the Spring of 1886, the gauges were changed, converting 5 gauge into the now-standard 4 8½ gauge on more than 11,000 miles of track in the South to match the Northern standard—a belated victory for the North.

Many of the lessons from this experience are very relevant today:

Incompatibilities can arise almost by accident, yet persist for many years.

Network markets tend to tip towards the leading player, unless the other players coordinate to act quickly and decisively.

Seceding from the standard-setting process can leave you in a weak market position in the future.

A large buyer (in this case the U.S. government) can have more influence than suppliers in tipping the balance.

Those left with the less popular technology will find a way to cut their losses, either by employing adapters or by writing off existing assets and joining the bandwagon.

Edison vs. Westinghouse in Electric Power: The Battle of the Systems[2]

Another classic 19th century standards battle concerned the distribution of electricity. Thomas Edison promoted a direct current (DC) system of electrical power generation and distribution. Edison was the pioneer in building power systems, beginning in New York City in 1882. Edison's direct current system was challenged by the alternating current (AC) technology developed and deployed in the U.S. by George Westinghouse.

Thus was joined the "Battle of the Systems." Each technology had pros and cons. Direct current had, for practical purposes relating to voltage drop, a one-mile limit between the generating station and the user, but was more efficient at generating power. Direct current had also had two significant commercial advantages: a head start and Edison's imprimatur.

Unlike railroads, however, standardization was less of an imperative in electricity. Indeed, the two technologies initially did not compete directly, but were deployed in regions suited to their relative strengths. DC was most attractive in densely populated urban areas, while AC made inroads in small towns. Nonetheless, a battle royal ensued in the 1887-1892 period, a struggle that was by no means confined to competition in the marketplace, but rather extended to the courtroom, the political arena, public relations, and academia. We can learn much today from the tactics followed by the rival camps.

The Edison group moved first with infringement actions against the Westinghouse forces, which forced Westinghouse to invent around Edison patents, including patents involving the Edison lamp. Edison also went to great lengths to convince the public that the AC system was unsafe, going so far as to patent the electric chair. Edison first demonstrated the electric chair using alternating current to electrocute a large dog, and then persuaded the State of New York to execute condemned criminals "by administration of an alternating current." The Edison group even used the term "to Westinghouse" to refer to electrocution by alternating current.

Ultimately, three factors ended the Battle of the Systems. First and foremost, advances in polyphase AC made it increasingly clear that AC was the superior alternative. Second, the rotary converter introduced in 1892 allowed existing DC stations to be integrated into AC systems, facilitating a graceful retreat for DC. Third, by 1890 Edison had sold his interests, leading to the formation of the General Electric Company in 1892, which was no longer a DC-only manufacturing entity.[3] By 1893, both General Electric and Westinghouse were offering AC systems and the battle was over.

The battle between Edison and Westinghouse illustrates several key aspects of strategy in standards wars:

Edison fought hard to convince consumers that DC was safer, in no small part because consumer expectations can easily become self-fulfilling in standards battles.

Technologies can seek well-suited niches if the forces towards standardization are not overwhelming.

Ongoing innovation (here, polyphase AC) can lead to victory in a standards war.

A first-mover advantage (of DC) can be overcome by a superior technology (of AC), if the performance advantage is sufficient and users are not overly entrenched.

Adapters can be the salvation of the losing technology and can help to ultimately defuse a standards war.

RCA vs. CBS in Color Television[4]

Our third historical example is considerably more recent: the adoption of color television in the United States fifty years ago. Television is perhaps the biggest bandwagon of them all. Some 99% of American homes have at least one television, making TV sets more ubiquitous than telephones or flush toilets.

We begin our story with the inauguration of commercial black and white television transmission in the United States on July 1, 1941. At that time, RCA—the owner of NBC and a leading manufacturer of black and white sets—was a powerful force in the radio and television world. However, the future of television was clearly to be color, which had first been demonstrated in America by Bell Labs in 1929.

Throughout the 1940s, CBS, the leading television network, was pushing for the adoption of the mechanical color television system it was developing. During this time RCA was busy selling black and white sets, improving its technology, and, under the legendary leadership of David Sarnoff, working on its own all-electronic color television system. As the CBS system took the lead in performance, RCA urged the FCC to wait for an electronic system. A major obstacle for the CBS system was that it was not backward-compatible: color

sets of the CBS-type would not be able to receive existing black and white broadcasts without a special attachment.

Despite this drawback, the FCC adopted the CBS system in October 1950, after a test between the two color systems. The RCA system was just not ready. As David Sarnoff himself said, "The monkeys were green, the bananas were blue, and everyone had a good laugh." This was a political triumph of major proportions for CBS.

The market outcome was another story. RCA and Sarnoff refused to throw in the towel. To the contrary, they re-doubled their efforts, on three fronts. First, RCA continued to criticize the CBS system in an attempt to slow its adoption. Second, RCA intensified its efforts to place black and white sets and thus build up an installed base of users whose equipment would be incompatible with the CBS technology. "Every set we get out there makes it that much tougher on CBS," said Sarnoff at the time. Third, Sarnoff intensified RCA's research and development on its color television system, with around-the-clock teams working in the lab.

CBS was poorly placed to take advantage of its political victory. To begin with, CBS had no manufacturing capability at the time, and had not readied a manufacturing ally to move promptly into production. As a result, the official premier of CBS color broadcasting, on June 25, 1951, featuring Ed Sullivan among others, was largely invisible, only seen at special studio parties. There were about 12 million TV sets in America at the time, but only a few dozen could receive CBS color. Luck, of a sort, entered into the picture, too. With the onset of the Korean War, the U.S. government said that the materials needed for production of color sets were critical instead for the war effort and ordered a suspension of the manufacture of color sets.

By the time the ban was modified in June 1952, the RCA system was ready for prime time. A consensus in support of the RCA system had formed at the National Television Systems Committee (NTSC). This became known as the NTSC system, despite the fact that RCA owned most of the hundreds of patents controlling it. This re-labeling was a face-saving device for the FCC, which could be seen to be following the industry consortium rather than RCA. In March 1953, Frank Stanton, the President of CBS, raised the white flag, noting that with 23 million black and white sets in place in American homes, compatibility was rather important. In December 1953, the FCC officially reversed its 1950 decision.

However, yet again, political victory did not lead so easily to success in the market. In 1954, Sarnoff predicted that that RCA would sell 75,000 sets. In fact, only 5,000 sets were purchased, perhaps because few customers were willing to pay $1000 for the 12½ color set rather than $300 for a 21 black-and-white set. With hindsight, this does not seem surprising, especially since color sets would offer little added value until broadcasters invested in color capability and color

programming became widespread. All this takes time. The chicken-and-egg problem had to be settled before the NBC peacock could prevail.

As it turned out, NBC and CBS affiliates invested in color transmission equipment quite quickly: 106 of 158 stations in the top 40 cities had the ability to transmit color programs by 1957. This was of little import to viewers, since the networks were far slower in offering color programming. By 1965, NBC offered 4000 hours of color, but CBS still showed only 800 color hours, and ABC 600. The upshot: by 1963, only about 3% of TV households had color sets, which remained three to five times as expensive as black and white sets.

As brilliant as Sarnoff and RCA had been in getting their technology established as the standard, they, like CBS, were unable to put into place all the necessary components of the system to obtain profitability during the 1950s. As a result, by 1959, RCA had spent $130 million to develop color TV with no profit to show for it. The missing pieces were the creation and distribution of the programming itself: content. Then, as now, a "killer app" was needed to get households to invest in color television sets. The killer app of 1960 was "Walt Disney's Wonderful World of Color," which Sarnoff obtained from ABC in 1960. RCA's first operating profit from color television sales came in 1960, and RCA started selling picture tubes to Zenith and others. The rest is history: color sets got better and cheaper, and the NBC peacock became famous.

We can all learn a great deal from this episode, ancient though it is by Internet time.

> Adoption of a new technology can be painfully slow if the price/performance ratio is unattractive and if it requires adoption by a number of different players.[5]
>
> First-mover advantages need not be decisive, even in markets strongly subject to tipping.
>
> Victory in a standards war often requires building an alliance.
>
> A dominant position in one generation of technology (such as RCA enjoyed in the sale of black-and-white sets) does not necessarily translate into dominance in the next generation of technology.

War or Peace?

Standards wars are especially bitter—and especially crucial to business success—in markets with strong *network effects* that cause consumers to play high value on compatibility.[6] We do not consider it a coincidence that there is a single worldwide standard for fax machines and for modems (for which compatibility is crucial), while multiple formats persist for cellular telephones and digital television (for which compatibility across regions is far less important).

We do not mean to suggest that every new information technology must endure a standards war. Take the compact disk (CD) technology, for instance.

Sony and Philips pooled together and openly licensed their CD patents as a means to establish their new CD technology. While CDs were completely incompatible with the existing audio technologies of phonographs, cassette players, and reel-to-reel tapes, Sony and Philips were not in a battle with another new technology. They "merely" had to convince consumers to take a leap and invest in a CD player and compact disks.

What is distinct about standards wars is that there are *two* firms, or more commonly alliances, vying for dominance. In some cases, one of the combatants may be an incumbent that controls a significant base of customers who use an older technology, as when Nintendo battled Sony in the video game market in the mid-1990s. Nintendo had a large installed base from the previous generation when both companies introduced 64-bit systems. In other instances, both sides may be starting from scratch, as in the battle between Sony and Matsushita in videotape machines as well as in the browser war between Netscape and Microsoft.

Standards wars can end in: a *truce*, as happened in 56k modems and color television where a common standard was ultimately adopted; a *duopoly*, as we see in video games today with Nintendo and Sony battling toe-to-toe; or a *fight to the death*, as with railroad gauges, AC versus DC electric power, and videotape players. True fight-to-the-death standards wars are unique to markets with powerful positive feedback based on strong network effects. Thus, traditional principles of strategy, while helpful, need to be supplemented to account for the peculiar economics of networks.

Before entering into a standards battle, would-be combatants are well-advised to consider a peaceful solution.[7] Unlike many other aspects of competition, where coordination among rivals would be branded as illegal collusion, declaring an early truce in a standards war can benefit *consumers* as well as vendors, and thus pass antitrust muster.[8]

Even bitter enemies such as Microsoft and Netscape have repeatedly been able to cooperate to establish standards when compatibility is crucial for market growth. First, when it appeared that a battle might ensue over standards for protecting privacy on the Internet, Microsoft announced its support for Netscape's *Open Profiling Standard*, which subsequently became part of the *Platform for Privacy Preferences* being developed by the Word Wide Web Consortium. Second, Microsoft and Netscape were able to reach agreement on standards for viewing 3-D images over the Internet. In August 1997, they decided to support compatible versions of *Virtual Reality Modeling Language*, a 3-D viewing technology, in their browsers. Again, Microsoft was pragmatic rather than proud, adopting a language invented at Silicon Graphics. Third, Microsoft and Netscape teamed up (along with Visa and MasterCard as well as IBM) to support the *Secure Electronic Transactions* standard for protecting the security of electronic payments by encrypting credit card numbers sent to online merchants. Cooperative standard-setting often takes place through the auspices of formal standard-

setting organizations such as the American National Standards Institute or the International Telecommunications Union.[9]

We must note, however, the clear analogy between technology battles and military battles: the more costly a battle is to both sides, the greater are the pressures to negotiate a truce; and one's strength in battle is an overriding consideration when meeting to conduct truce talks. Whether you are planning to negotiate a product standard or fight to the death, you will benefit from understanding the art (read: economics and strategy) of standards wars.

Classification of Standards Wars

Not all standards wars are alike. Standards battles come in three distinct flavors. The starting point for strategy in a standards battle is to understand which type of war you are fighting. The critical distinguishing feature of the battle is the magnitude of the switching costs, or more generally the adoption costs, for each rival technology. We classify standards wars depending on how compatible each player's proposed new technology is with the current technology.

When a company or alliance introduces new technology that is *compatible* with the old, we say that they have adopted an "Evolution" strategy. Evolutionary strategies are based on offering superior performance with minimal consumer switching or adoption costs. The NTSC color television system selected by the FCC in 1953 was evolutionary: NTSC signals could be received by black-and-white sets, and the new color sets could receive black-and-white signals, making adoption of color far easier for both television stations and households. In contrast, the CBS system that the FCC had first endorsed in 1950 was not backward compatible.

When a company or alliance introduces new technology that is *incompatible* with the old, we say that they have adopted a "Revolution" strategy. Revolutionary strategies are based on offering such compelling performance that consumers are willing to incur significant switching or adoption costs.

If both your technology and your rival's technology are compatible with the older, established technology, but incompatible with each other we say the battle is one of "Rival Evolutions." Competition between DVD and Divx (both of which will play CDs), the 56k modem battle (both types communicate with slower modems), and competition between various flavors of Unix (which can run programs written for older versions of plain vanilla Unix) all fit this pattern.

If your technology offers backward compatibility and your rival's does not, we have "Evolution versus Revolution." The "Evolution versus Revolution" war is a contest between the backward compatibility of Evolution and the superior performance of Revolution. Evolution versus Revolution includes the important case of an upstart fighting against an established technology that is offering compatible upgrades. The struggle in the late 1980s between Ashton Tate's dBase IV and Paradox in the market for desktop database software fit this

pattern. (The mirror image of this occurs if your rival offers backward compatibility but you do not: "Revolution versus Evolution.")

Finally, if neither technology is backward compatible we have "Rival Revolutions." The contest between Nintendo 64 and the Sony Playstation, and the historical example of AC versus DC in electrical systems, follow this pattern.

These four types of standards battles are described in Table 1.

Key Assets in Network Markets

In our view, successful strategy generally must harness a firm's resources in a manner that harmonizes with the underlying competitive environment. In a standards battle, the competitive environment is usefully characterized by locating the battle in Table 1. What about the firms' resources?

TABLE 1. Types of Standards Wars

		Rival Technology: Compatible	Rival Technology: Incompatible
Your Technology	Compatible	Rival Evolutions	Evolution *versus* Revolution
Your Technology	Incompatible	Revolution *versus* Evolution	Rival Revolutions

Your ability to successfully wage a standards war depends on your ownership of seven key assets:

- control over an installed base of users;
- intellectual property rights;
- ability to innovate;
- first-mover advantages;
- manufacturing capabilities;
- strength in complements; and
- brand name and reputation.

What these assets have in common in that they place you in a potentially unique position to contribute to the adoption of a new technology. If you own these assets, your value-added to other players is high. Some assets, however, such as the ability to innovate or manufacturing capabilities, may even be more valuable in peace than in war.

No one asset is decisive. For example, control over an older generation of technology does not necessarily confer the ability to pick the next generation. Sony and Philips controlled CDs but could not move unilaterally into DVDs. Atari had a huge installed base of first-generation video games in 1983, but Nintendo's superior technology and hot new games caught Atari flat-footed. The early leader in modems, Hayes, tried to buck the crowd when modems operating at 9600 kbps were introduced, and ended up in Chapter 11.

Don't forget that *customers* as well as technology suppliers can control key assets, too. A big customer is automatically in "control" of at least part of the installed base. America Online recognized this in the recent 56k modem standards battle. Content providers played a key role in the DVD standards battle. IBM was pivotal in moving the industry from 5¼ diskettes to 3½ disks. Most recently, TCI has not been shy about flexing its muscle in the battle over the technology used in TV set-top boxes.

Control over an Installed Base of Customers

An incumbent firm, like Microsoft, that has a large base of loyal or locked-in customers is uniquely placed to pursue an Evolution strategy offering backward compatibility. Control over an installed base can be used to block cooperative standard setting and force a standards war. Control can also be used to block rivals from offering compatible products, thus forcing them to play the more risky Revolution strategy.

Intellectual Property Rights

Firms with patents and copyrights controlling valuable new technology or interfaces are clearly in a strong position. Qualcomm's primary asset in the digital wireless telephone battle was its patent portfolio. The core assets of Sony and Philips in the CD and DVD areas were their respective patents. Usually, patents are stronger than copyrights, but computer software copyrights that can be used to block compatibility can be highly valuable. This is why Lotus fought Borland all the way to the Supreme Court to try to block Borland's use of the Lotus command structure (see below), and why Microsoft watched the trial intently to protect Excel's ability to read macros originally written for Lotus 1-2-3.

Ability to Innovate

Beyond your existing intellectual property, the ability to make proprietary extensions in the future puts you in a strong position today. In the color TV battle, NBC's R&D capabilities were crucial after the FCC initially adopted the CBS color system. NBC's engineers quickly developed a color system that was compatible with the existing black-and-white sets, a system which the FCC then accepted. Hewlett-Packard's engineering skills are legendary in Silicon Valley; it is often in their interest to compromise on standards since they can out-engineer their competition once the standard has been defined, even if they have to play some initial catch up.

First-Mover Advantages

If you already have done a lot of product development work and are farther down the learning curve than the competition, you are in a strong position. Netscape obtained stunning market capitalization based on a their ability to bring new technology to market quickly. RealNetworks currently has a big lead on Microsoft in audio and video streaming.

Manufacturing Capabilities

If you are a low-cost producer, due to either scale economies or manufacturing competence, you are in a strong position. Cost advantages can help you survive a standards war, or capture share competing to sell a standardized product. Compaq and Dell both have pushed hard on driving down their manufacturing costs, which gives them a strong competitive advantage in the PC market. Rockwell has lower costs than its competitors in making chipsets for modems. HP has long been a team player in Silicon Valley, welcoming standards because of their engineering and manufacturing skills. These companies benefit from open standards, which emphasize the importance of efficient production.

Strength in Complements

If you produce a product that is a significant complement for the market in question, you will be strongly motivated to get the bandwagon rolling. This, too, puts you in a natural leadership position, since acceptance of the new technology will stimulate sales of the other products you produce. This force is stronger, the larger are your gross margins on your established products. Intel's thirst to sell more CPUs has been a key driver in their efforts to promote new standards for other PC components, including interfaces between motherboards and CPUs, busses, chipsets, and graphics controllers.

Reputation and Brand Name

A brand-name premium in any large market is highly valuable. But reputation and brand name are especially valuable in network markets, where expectations are pivotal. It's not enough to have the best product; you have to convince consumers that you will win. Previous victories and a recognized name count for a lot in this battle. Microsoft, HP, Intel, Sony, and Sun each have powerful reputations in their respective domains, giving them instant credibility.[10]

Preemption

Preemption is one of two crucial marketplace tactics that arise over and over again in standards battles. The logic of preemption is straightforward: build an early lead, so positive feedback works for you and against your rival. The same principle applies in markets with strong learning-by-doing: the first firm to gain significant experience will have lower costs and can pull even further ahead. Either way, the trick is to exploit positive feedback. With learning-by-doing, the positive feedback is through lower costs. With network externalities, the positive feedback comes on the demand side; the leader offers a more valuable product or service.

One way to preempt is simply to be first to market. Product development and design skills can be critical to gaining a first-mover advantage. But watch out: early introduction also can entail compromises in quality and a greater risk

of bugs, either of which can doom your product. This was the fate of the color television system promoted by CBS and of Japan's HDTV system. The race belongs to the swift, but speed must come from superior product design, not by marketing an inferior system.

In addition to launching your product early, you need to be aggressive early on to build an installed base of customers. Find the "pioneers" (a.k.a. gadget freaks) who are most keen to try new technology and sign them up swiftly. Pricing below cost (i.e., *penetration pricing*) is a common tactic to build an installed base. Discounting to attract large, visible, or influential customers is virtually unavoidable in a standards war.

In some cases, especially for software with a zero marginal cost, you can go beyond free samples and actually *pay* people to take your product. As we see it, there is nothing special about zero as a price, as long as you have multiple revenue streams to recover costs. Some cable television programmers pay cable operators to distribute their programming, knowing that a larger audience will augment their advertising revenues. In the same fashion, Netscape is prepared to give away its browser for free, or even pay OEMs (original equipment manufacturers) to load it on new machines, in order to increase the usage of Navigator and thus direct more traffic to the Netscape Web site.

The big danger with negative prices is that someone will accept payment for "using" your product and then not really use it. This problem is easily solved in the cable television context, because programmers simply insist that cable operators actually carry their programming once they are paid to do so. Likewise, Netscape can check that an OEM loads Navigator (in a specified way) on new machines, and can conduct surveys to see just how the OEM configuration affects usage of Navigator.[11]

Before you go overboard giving your product away, or paying customers to take it, you need to ask three questions. First, if you pay someone to take your product, will they really use it and generate network externalities for other, paying customers? Second, how much is it really worth to you to build up your installed base? Where is the offsetting revenue stream, and when will it arrive? Third, are you fooling yourself? Beware the well-known "Winner's Curse": the tendency of the most optimistic participant to win in a bidding war, only to find that they were overly optimistic and other bidders were more realistic.

Penetration pricing may be difficult to implement if you are building a coalition around an "open" standard. The sponsor of a proprietary standard can hope to recoup the losses incurred during penetration pricing once it controls an established technology. Without a sponsor, no single supplier will be willing to make the necessary investments to preempt using penetration pricing. For precisely this reason, penetration pricing can be particularly effective when used by a company with a proprietary system against a rival touting its openness.

Another implication is that the player in a standards battle with the largest profit streams from related products stands to win the war. We have seen this

with smart cards in Europe. They were introduced with a single application—public telephone service—but soon were expanded to other transactions involving small purchases. Eventually, many more applications such as identification and authentication will be introduced. Visa, MasterCard, and American Express are already jockeying for position in the smart card wars. Whichever player can figure out the most effective way to generate multiple revenue streams from an installed base of smart card holders will be able to bid most aggressively, but still profitably, to build up the largest base of customers.

Expectations Management

The second key tactic in standards wars is the management of expectations. Expectations are a major factor in consumer decisions about whether or not to purchase a new technology, so make sure that you do your best to manage those expectations. Just as incumbents will try to knock down the viability of new technologies that emerge, so will those very entrants strive to establish credibility.

Vaporware is a classic tactic aimed at influencing expectations: announce an upcoming product so as to freeze your rival's sales. In the 1994 antitrust case brought by the Justice Department against Microsoft, Judge Sporkin cited vaporware as one reason why he found the proposed consent decree insufficient. In an earlier era, IBM was accused of the same tactic. Of course, drawing the line between "predatory product pre-announcements" and simply being late bringing a product to market is not so easy to draw, especially in the delay-prone software market. Look at what happened to Lotus in spreadsheets and Ashton-Tate and database software. After both of these companies repeatedly missed launch dates, industry wags said they should be merged and use the stock ticker symbol "LATE." We must note with some irony that Microsoft's stock took a 5.3% nosedive in late 1997 after Microsoft announced a delay in the launch of Windows 98 from the first to the second quarter of 1998.

The most direct way to manage expectations is by assembling allies and by making grand claims about your product's current or future popularity. Sun has been highly visible in gathering allies in support of Java, including taking out full-page advertisements listing the companies in the Java coalition. Indicative of how important expectations management is in markets with strong network externalities, WordPerfect even filed a court complaint against Microsoft to block Microsoft from claiming that its word processing software was the most popular in the world. Barnes & Noble did the same thing to Amazon, arguing that their claim to being the "world's largest bookstore" was misleading.

Once You've Won

Moving on from war to the spoils of victory, let's consider how best to proceed once you have actually *won* a standards war. Probably you made some concessions to achieve victory, such as promises of openness or deals with various allies. Of course, you have to live with those, but there is still a great deal of room for strategy. In today's high-tech world, the battle never really ends. So, take a deep breath and be ready to keep moving.

Staying on Your Guard

Technology marches forward. You have to keep looking out for the next generation of technology, which can come from unexpected directions. Microsoft, with all its foresight and savvy, has had to scurry to deal with the Internet phenomenon and try to defuse any threat to their core business.

You may be especially vulnerable if you were victorious in one generation of technology through a preemption strategy. Going early usually means making technical compromises, which gives that much more room for others to execute an incompatible Revolution strategy against you. Apple pioneered the market for personal digital assistants, but U.S. Robotics perfected the idea with their Palm Pilot. If your rivals attract the power users, your market position and the value of your network may begin to erode.

The hazards of moving early and then lacking flexibility can be seen in the case of the French Minitel system. Back in the 1980s, the French were world leaders in on-line transactions with the extensive Minitel computer network, which was sponsored and controlled by France Telecom. Before the Internet was widely known, much less used, million of French subscribers used the Minitel system to obtain information and conduct secure on-line transactions. Today, Minitel boasts more than 35 million French subscribers and 25,000 vendors. One reason Minitel has attracted so many suppliers is that users pay a fee to France Telecom each time they visit a commercial site, and a portion of these fees are passed along to vendors. Needless to say, this is quite a different business model than we see on the Web.

Now, however, the Minitel systems is seen as inflexible, and France is lagging behind in moving onto the Internet. Just as companies that invested in dedicated word processing systems in the 1970s were slow to move to more generalized personal computers in the 1980s, the French have been slow to invest in equipment that can access the Internet. Only about 3% of the French population uses the Internet, far short of the estimated 20% in the U.S. and 9% is the U.K. and Germany. Roughly 15% of French companies have a Web site, versus nearly 35% of U.S. businesses. Only in August 1997 did the French government admit that the Internet, not Minitel, was the way of the future rather than an instrument of American cultural imperialism. France Telecom is now in the planning stages to introduce next-generation Minitel terminals that will access the Internet as well as Minitel.

What is the lesson here? The French sluggishness to move to the Internet stems from two causes that are present in many other settings. First, France Telecom and the vendors had an incentive to preserve the revenue streams they were earning from Minitel. This is understandable, but it should be recognized as a choice to harvest an installed base, with adverse implications for the future. Milking the installed base is sometimes the right thing to do, but make this a calculated choice, not a default decision. Second, moving to the Internet presents substantial collective switching costs—and less incremental value—to French consumers in contrast with, say, American consumers. Precisely because Minitel was a success, it reduced the attractiveness of the Internet.

The strategic implication is that you need a migration path or roadmap for your technology. If you cannot improve your technology with time, while offering substantial compatibility with older versions, you will be overtaken sooner or later. Rigidity is death, unless you build a really big installed base, and even this will fade eventually without improvements.

Offer Customers a Migration Path

To fend off challenges from upstarts, you need to make it hard for rivals to execute a revolution strategy. The key is to anticipate the next generation of technology and co-opt it. Look in all directions for the next threat and take advantage of the fact that consumers will not switch to a new incompatibility technology unless it offers a marked improvement in performance. Microsoft has been the master of this strategy with its "Embrace and Extend" philosophy of anticipating or imitating improvements and incorporating them into its flagship products.[12] Avoid being frozen in place by your own success. If you cater too closely to your installed base by emphasizing backward compatibility, you open the door to a Revolution strategy by an upstart. This is precisely what happened to Ashton-Tate in databases, allowing Borland and later Microsoft to offer far superior performance with their Paradox and FoxPro products. Your product road map has to offer your customers a smooth migration path to ever-improving technology, and it must stay close to, if not on, the cutting edge.

One way to avoid being dragged down by the need to retain compatibility is to give older members of your installed base free or inexpensive upgrades to a recent but not current version of your product. This is worth doing for many reasons: users of much older versions have revealed that they do not need the latest bells and whistles and thus are less likely to actually buy the latest version; the free "partial" upgrade can restore some lost customer loyalty; you can save on support costs by avoiding "version-creep"; and you can avoid being hamstrung in designing your latest products by a customer-relations need to maintain compatibility with older and older versions. To compromise the performance of your latest version in the name of compatibility with ancient versions presents an opening for a rival to build an installed base among more demanding users. Happily, this "lagged upgrade" approach is easier and easier with distribution so cheap over the Internet.

Microsoft did a good job with this problem with migration to Windows 95. Politely put, Windows 95 is a kludge, with all sorts of special workarounds to allow DOS programs to execute in the Windows environment, thereby maintaining compatibility with customers' earlier programs. Microsoft's plan with Windows 98 is to move the consumer version of Windows closer to the professional version, Windows NT, eventually ending up with only one product, or at least only one user interface.

Commoditize Complementary Products

Once you've won, you want to keep your network alive and healthy. This means that you've got to attend not only to your own products, but to the products produced by your complementors as well. Your goal should be to retain your franchise as the market leader, but have a vibrant and competitive market for complements to your product.

This can be tricky. Apple has flipped back and forth on its developer relations over the years. First they wanted to just be in the computer business, and let others develop applications. Then they established a subsidiary, Claris, to do applications development. When this soured relations with other developers they spun Claris off. And so it went—a back-and-forth dance.

Microsoft faced the same problem, but with a somewhat different strategy. If an applications developer became successful, Microsoft just bought them (or tried to—Microsoft's intended purchase of Intuit was blocked by the Department of Justice). Nowadays a lot of new business plans in the software industry have the same structure: "Produce product, capture emerging market, be bought by Microsoft."

Our view is that you should try to maintain a competitive market in complementary products and avoid the temptation to meddle. Enter into these markets only if integration of your core product with adjacent products adds value to consumers, or if you can inject significant additional competition to keep prices low. If you are truly successful, like Intel, you will need to spur innovation in complementary products to continue to grow, both by capturing revenues from new complementary products and by stimulating demand for your core product.

Competing Against Your Own Installed Base

You may need to improve performance just to compete against your installed base, even without an external threat. How can you continue to grow when your information product or technology starts to reach market saturation? One answer is to drive innovation ever faster. Intel is pushing to improve hardware performance of complementary products (such as graphics chips and chipsets) and helping develop applications that crave processing power so as to drive the hardware upgrade cycle. Competition with one's own installed base is

not a new problem for companies selling durable goods. The stiffest competition faced by Steinway in selling pianos is from used Steinways.

One way to grow even after you have a large installed base is to start discounting as a means of attracting the remaining customers who have demonstrated (by waiting) that they have a relatively low willingness-to-pay for your product. This is a good instinct, but be careful. First, discounting established products is at odds with a penetration pricing strategy to win a standards war. Second, if you regularly discount products once they are well established, consumers may learn to wait for the discounts. The key question: Can you expand the market and not spoil your margins for traditional customers?

Economists have long recognized this as the "durable-goods monopoly" problem. Ronald Coase, recent winner of the Nobel Prize in Economics, wrote 35 years ago about the temptation of a company selling a durable product to offer lower and lower prices to expand the market once many consumers already purchased the durable good. He conjectured that consumers would come to anticipate these price reductions and hold off buying until prices fall. Since then, economists have studied a variety of strategies designed to prevent the resulting erosion of profits. The problem raised by Coase is especially severe for highly durable products such as information and software.

One of the prescriptions for solving the durable-goods monopoly problem is to *rent* your product rather than sell it. This will not work for a microprocessor or a printer, but rapid technological change can achieve the same end. If a product becomes obsolete in two or three years, used versions won't pose much of a threat to new sales down the line. This is a great spur for companies like Intel to rush ahead as fast as possible increasing the speed of their microprocessors. The same is true on the software side, where even vendors who are dominant in their category (such as Autodesk in computer-aided design) are forced to improve their programs to generate a steady stream of revenues.

Protecting Your Position

A variety of defensive tactics can help secure your position. This is where antitrust limits come in most sharply, however, since it is illegal to "maintain a monopoly" by anticompetitive means.

One tactic is to offer ongoing attractive terms to important complementors. For example, Nintendo worked aggressively to attract developers of hit games and used its popularity to gain very strong distribution. This tactic can, however, cross the legal line if you insist that your suppliers, or distributors, deal with you to the exclusion of your rivals. For example, FTD, the floral network, under pressure from the Justice Department, had to cancel its program giving discounts to florists who used FTD exclusively. Since FTD had the lion's share of the floral delivery network business, this quasi-exclusivity provision was seen as protecting FTD's near-monopoly position. Ticketmaster was subjected to an extensive investigation for adopting exclusivity provisions in its contracts with

stadiums, concert halls, and other venues. The Justice Department in 1994 attacked Microsoft's contracts with OEMs for having an effect similar to that of exclusive licenses.

A less controversial way to protect your position is to take steps to avoid being held up by others who claim that your product infringes their patents or copyrights. Obviously, there is no risk-free way to do this. However, it makes a great deal of sense to ask those seeking access to your network to agree not to bring the whole network down in an infringement action. Microsoft took steps along these lines when it launched Windows 95, including a provision in the Windows 95 license for OEMs that prevented Microsoft licensees from attempting to use certain software patents to block Microsoft from shipping Windows 95. Intel regularly asks companies taking licenses to its open specifications to agree to offer royalty-free licenses to other participants for any patents that would block the specified technology. This "two-sided openness" strategy prevents *ex post* hold-up problems and helps safely launch a new specification.

Leveraging Your Installed Base

Once you have a strong installed base, basic principles of competitive strategy dictate that you seek to leverage into adjacent product spaces, exploiting the key assets that give you a unique ability to create value for consumers in those spaces. In some cases, control over an interface can be used to extend leadership from one side of the interface to the other.

But don't get carried away. You may be better off encouraging healthy competition in complementary products, which stimulates demand for your core product, rather than trying to dominate adjacent spaces. Acquisitions of companies selling neighboring products should be driven by true synergies of bringing both products into the same company, not simply by a desire to expand your empire. Again, legal limits on both "leveraging" and on vertical acquisitions can come into play. For example, the FTC forced Time Warner to agree to carry a rival news channel on its cable systems when Time Warner acquired CNN in its merger with Turner.

Geographic expansion is yet another way to leverage your installed base. This is true for traditional goods and services, but with a new twist for network products: when expanding the geographic scope of your network, make sure your installed base in one region becomes a competitive advantage in another region. But careful: don't build a two-way bridge to another region where you face an even stronger rival; in that case, more troops will come across the bridge attacking you than you can send to gain new territory.

Geographic effects were powerful in the FCC auctions of spectrum space for PCS services, the successor to the older cellular telephone technology. If you provide Personal Digital Assistance (PDA) wireless services in Minneapolis, you have a big advantage if you also provide such services in St. Paul. The market leader in one town would therefore be willing to outbid rivals in neighboring

locations. In the PCS auctions, bidders allegedly "signaled" their most-preferred territories by encoding them into their bids as an attempt to avoid a mutually unprofitable bidding war. The Department of Justice is investigating these complaints. Our point is not to offer bidding strategy, but to remind you that geographic expansion of a network can be highly profitable. Network growth generates new customers and offers more value to existing customers at the same time.

Staying a Leader

How can you secure a competitive advantage for yourself short of maintaining direct control over the technology, e.g., through patent or copyright protection? Even without direct control over the installed base or ownership of key patents, you may be able to make the other factors work for you, while garnering enough external support to set the standards you want.

If you have a good development team, you can build a bandwagon using an "openness" approach of ceding current control over the technology (e.g., through licenses at low or nominal royalties) while keeping tight control over improvements and extensions. If you know better than others how the technology is likely to evolve, you can use this informational advantage to preserve important future rights without losing the support of your allies. IBM chose to open up the PC, but then they lost control because they did not see what the key assets would be in the future. Besides the now-obvious ones (the design of the operating system and manufacturing of the underlying microprocessor), consider the example of interface standards between the PC and the monitor. During the 1980s, IBM set the first four standards: the Monochrome Graphics Adapters (MGA), the Color Graphics Adapter (CGA), the Enhanced Graphics Adapter (EGA), and the Video Graphics Adapter (VGA), the last in 1987. But by the time of the VGA, IBM was losing control, and the standard started to splinter with the Super VGA around 1988. Soon, with the arrival of the VESA interface, standard-setting passed out of IBM's hands altogether. By anticipating advances in the resolution of monitors, IBM could have done more to preserve its power to set these interface standards, without jeopardizing the initial launch of the PC.

Developing proprietary extensions is a valuable tactic to recapture at least partial control over your own technology. You may not be able to exert strong control at the outset, but you may gain some control later if you launch a technology that takes off and you can be first to market with valuable improvements and extensions.

One difficulty with such an approach is that your new technology may be *too* successful. If the demand for your product grows too fast, many of your resources may end up being devoted to meeting current demand rather than investing in R&D for the future. This happened to Cisco. All of their energies were devoted to the next generation of networking gear, leaving them little time for long-run research. If you are lucky enough to be in Cisco's position, do what they did: use all the profits you are making to identify and purchase firms that

are producing the next-generation products. As Cisco's CEO, John Chambers, puts it: "We don't do research—we buy research!"

Allow complementors, and even rivals, to participate in developing standards, but under *your* terms. Clones are fine, so long as you set the terms under which they can operate. Don't flip-flop in your policies, as Apple did with its clone manufacturers: stay open, but make sure that you charge enough for access to your network (e.g., in the form of licensing fees) that your bottom line does not suffer when rivals displace your own sales. Build the opportunity costs of lost sales into your access prices or licensing fees.

Rear-Guard Actions

What happens if you fall behind? Can you ever recover?

That depends upon what you mean by "recover." Usually it is not possible to wrest leadership from another technology that is equally good and more established, unless your rival slips up badly. However, if the network externalities are not crushing, you may be able to protect a niche in the market. And you can always position yourself to make a run at leadership in the next generation of technology.

Atari, Nintendo, Sega, and Sony present a good example. Atari was dominant in 8-bit systems, Nintendo in 16-bit systems, Sega made inroads by being first-to-market with 32-bit systems, and Sony is giving Nintendo a run for their money in 64-bit systems. Losing one round does not mean you should give up, especially if backward compatibility is not paramount.

This leaves a set of tricky issues of how to manage your customers if you have done poorly in one round of the competition. Stranding even a small installed base of customers can have lasting reputational effects. IBM was concerned about this when they dropped the PC Jr. in the mid-1980s. Apart from consumer goodwill, retaining a presence in the market can be vital to keeping up customer relations and brand identity, even if you have little prospect of making major sales until you introduce a new generation of products. Apple faces this problem with their new operating system, Rhapsody. How do they maintain compatibility with their loyal followers while still building a path to what they hope will be a dramatic improvement in the operating environment?

Adapters and Interconnection

A tried and true tactic when falling behind is to add an adapter, or to somehow interconnect with the larger network. This can be a sign of weakness, but one worth bearing if the enhanced network externalities of plugging into a far larger network are substantial. We touched on this in our discussion of how to negotiate a truce; if you are negotiating from weakness, you may simply seek the right to interconnect with the larger network.

The first question to ask is whether you even have the right to build an adapter. Sometimes the large network can keep you out. Atari lacked the intellectual property rights to include an adapter in their machines to play Nintendo cartridges, because of Nintendo's lock-out chip. In other cases, you may be able to break down the door, or at least try. The dominant ATM network in Canada, Interac, was compelled to let non-member banks interconnect. In the telephone area, the FCC is implementing elaborate rules that will allow competitive local exchange carriers to interconnect with the incumbent monopoly telephone networks.

The most famous legal case of a less-popular network product maneuvering to achieve compatibility is the battle between Borland and Lotus in spreadsheets. To promote its QuattroPro spreadsheet as an alternative to the dominant spreadsheet of the day, Lotus 1-2-3, Borland not only made sure than QuattroPro could import Lotus files, but copied part of the menu structure used by Lotus. Lotus sued Borland for copyright infringement. The case went all the way to the Supreme Court; the vote was deadlocked so Borland prevailed based on its victory in the First Circuit Court of Appeals. This case highlights the presence of legal uncertainty over what degree of imitation is permissible; the courts are still working out the limits on how patents and copyrights can be used in network industries.

There are many diverse examples of "adapters." Conversion of data from another program is a type of adapter. Translators and emulators can serve the same function when more complex code is involved. Converters can be one-way or two-way, with very different strategic implications. Think about WordPerfect and Microsoft Word today. WordPerfect is small and unlikely to gain much share, so they benefit from two-way compatibility. Consumers will be more willing to buy or upgrade WordPerfect if they can import files in Word format and export files in a format that is readable by users of Word. So far, Word will import files in WordPerfect format, but if Microsoft ever eliminates this feature of Word, WordPerfect should attempt to offer an export capability that preserves as much information as possible.

The biggest problem with adapters, when they are technically and legally possible, is performance degradation. Early hopes that improved processing power would make emulation easy have proven false. Tasks become more complex.

Digital's efforts with its Alpha microprocessor illustrate some of the ways in which less popular technologies seek compatibility. The Alpha chip has been consistently faster than the fastest Intel chips on the market. Digital sells systems with Alpha chips into the server market, a far smaller market than the desktop and workstation markets. And Digital's systems are far more expensive than systems using Intel chips. As a result, despite its technical superiority, the Alpha sold only 300,000 chips in 1996 compared to 65 million sold by Intel. This leaves Digital in the frustrating position of having a superior product but suffering from a small network. Recognizing that Alpha is in a precarious position, Digital has

been looking for ways to interconnect with the Intel (virtual) network. Digital offers an emulator to let its Alpha chip run like an Intel architecture chip, but most of the performance advantages that Alpha offers are neutralized by the emulator. Hoping to improve the performance of systems using the Alpha chip, Digital and Microsoft announced in January 1998 an enhanced Alliance for Enterprise Computing, under which Windows NT server-based products will be released concurrently for Alpha- and Intel-based systems. Digital also has secured a commitment from Microsoft that Microsoft will cooperate to provide source-code compatibility between Alpha- and Intel-based systems for Windows NT application developers, making it far easier for them to develop applications to run on Alpha-based systems in native mode.

Adapters and converters among software programs are also highly imperfect. Converting files from WordStar to WordPerfect, and now from WordPerfect to Word, is notoriously buggy. Whatever the example, consumers are rightly wary of translators and emulators, in part because of raw performance concerns and in part because of lurking concerns over just how compatible the conversion really is: consider the problems that users have faced with Intel to Motorola architectures, or dBase to Paradox databases.

Apple offers a good example of a company that responded to eroding market share by adding adapters. Apple put in disk drives that could read floppy disks formatted on DOS and Windows machines in the mid-eighties. In 1993, Apple introduced a machine that included an Intel 486 chip and could run DOS and Windows software along with Macintosh software. But Apple's case also exposes the deep tension underlying an adapter strategy: the adapter adds (some) value, but undermines confidence in the smaller network itself.

Finally, be careful about the large network changing interface specifications to avoid compatibility. IBM was accused of this in mainframe computers. Indeed, we suggested this very tactic in the section above on strategies for winners, so long as the new specifications are truly superior, not merely an attempt to exclude competitors.

Survival Pricing

The marginal cost of producing information goods is close to zero. This means that you can cut your price very low and still cover (incremental) costs. Hence, when you find yourself falling behind in a network industry, it is tempting to cut price in order to spur sales, a tactic we call *survival pricing*.

However, the temptation should be resisted. Survival pricing is unlikely to work. It shows weakness, and it is hard to find examples where it made much difference. Computer Associates gave away "Simply Money" (for a $6.95 shipping and handling fee), but this didn't matter. Simply Money still did not take off in its battle against Quicken and Money. On the other hand, Computer Associates got the name and vital statistics of each buyer, which was worth something in the mail list market, so it wasn't a total loss. IBM offered OS/2 for as

little as $50, but look where it got them. Borland priced QuattroPro very aggressively when squeezed between Lotus1-2-3 and Microsoft Excel back in 1993.

The problem is that the purchase price of software is minor in comparison with the costs of deployment, training, and support. Corporate purchasers, and even individual consumers, were much more worried about picking the winner of the spreadsheet wars than they were in whether their spreadsheet cost $49.95 or $99.95. At the time of the cut-throat pricing, Borland was a distant third in the spreadsheet market. Lotus and Microsoft both said they would not respond to the low price. Frank Ingari, Lotus's vice president for marketing, dismissed Borland as a "fringe player" and said the $49 price was a "last gasp move."

Survival pricing—cutting your price after the tide has moved against you—should be distinguished from penetration pricing, which is offering a low price to invade another market. Borland used penetration pricing very cleverly in the early 1980s with its Turbo Pascal product. Microsoft, along with other compiler companies, ignored Turbo Pascal, much to their dismay later on.

Legal Approaches

If all else fails, sue. No, really. If the dominant firm has promised to be open and has reneged on that promise, you should attack its bait-and-switch approach. The Supreme Court in the landmark *Kodak* case opened the door to antitrust attacks along these lines, and many companies have taken up the invitation. The key is that a company may be found to be a "monopolist" over its own installed base of users, even if it faces strong competition to attract such users in the first place. Although the economics behind the *Kodak* case are murky and muddled, it can offer a valuable lever to gain compatibility or interconnection with a dominant firm.

Conclusions and Lessons

Before you can craft standards strategy, you first need to understand what type of standards war you are waging. The single most important factor to track is the compatibility between the dueling new technologies and established products. Standards wars come in three types: Rival Evolutions, Rival Revolutions, and Revolution versus Evolution.

Strength in the standards game is determined by ownership of seven critical assets:

control of an installed base

intellectual property rights

ability to innovate

first-mover advantages

manufacturing abilities

presence in complementary products

brand name and reputation

Our main lessons for strategy and tactics, drawn from dozens of standards wars over the past century and more, are these:

Before you go to war, assemble allies. You'll need the support of consumers, suppliers of complements, and even your competitors. Not even the strongest companies can afford to go it alone in a standards war.

Preemption is a critical tactic during a standards war. Rapid design cycles, early deals with pivotal customers, and penetration pricing are the building blocks of a preemption strategy.

Managing consumer expectations is crucial in network markets. Your goal is to convince customers—and your complementors—that you will emerge as the victor. Such expectations can easily become a self-fulfilling prophecy when network effects are strong. To manage expectations you should engage in aggressive marketing, make early announcements of new products, assemble allies, and make visible commitments to your technology.

When you've won your war, don't rest easy. Cater to your own installed base and avoid complacency. Don't let the desire for backward compatibility hobble your ability to improve your product; doing so will leave you open to an entrant offering less compatibility but superior performance. Commoditize complementary products to make your systems more attractive for consumers.

If you fall behind, avoid survival pricing; it just signals weakness. A better tactic is to establish a compelling performance advantage, or to interconnect with the prevailing standard using converters and adapters.

Notes

1. For a lengthy discussion of railroad gauge standardization, see Amy Friedlander, *Emerging Infrastructure: The Growth of Railroads* (Reston, VA: Corporation for National Research Initiatives, 1995).
2. For further details on the Battle of the Systems, see Julie Ann Bunn and Paul David, "The Economics of Gateway Technologies and Network Evolution: Lessons from Electricity Supply History," *Information Economics and Policy*, 3/2 (1988).
3. In this context, Edison's efforts can be seen as an attempt to prevent or delay tipping towards AC, perhaps to obtain the most money in selling his DC interests.
4. A very nice recounting of the color television story can be found in David Fisher and Marshall Fisher, "The Color War," *Invention & Technology*, 3/3 (1997). See, also, Joseph Farrell and Carl Shapiro, "Standard Setting in High-Definition Television," *Brookings Papers on Economic Activity: Microeconomics* (1992).
5. For color TV to truly offer value to viewers, it was not enough to get set manufacturers and networks to agree on a standard; they had to produce sets that performed well at reasonable cost, they had to create compelling content, and they had to induce broadcasters to invest in transmission gear. The technology was just not ready for the mass market in 1953, much less 1950. Interestingly, the Euro-

peans, by waiting another decade before the adoption of PAL and SECAM, ended up with a better system. The same leapfrogging is now taking place in reverse: the digital HDTV system being adopted in the U.S. is superior to the system selected years before by the Japanese.

6. For a fuller discussion of positive feedback, network effects, and network externalities, see Chapter 7 of Carl Shapiro and Hal R. Varian, *Information Rules: A Strategic Guide to the Network Economy* (Boston, MA: Harvard Business School Press, 1998). See, also, Michael Katz and Carl Shapiro, "Systems Competition and Network Effects," *Journal of Economic Perspectives*, 8/2 (1994); Brian Arthur, *Increasing Returns and Path Dependence in the Economy* (Ann Arbor, MI: University of Michigan Press, 1994).
7. We recognize, indeed emphasize, that building an alliance of customers, suppliers, and complementors to support one technology over another in a standards battle can be the single most important tactic in such a struggle. We explore alliances and cooperative strategies to achieve compatibility separately in Chapter 8 of *Information Rules* [Shapiro and Varian, op. cit.]. See, also, David B. Yoffie, "Competing in the Age of Digital Convergence," *California Management Review*, 38/4 (1996).
8. For a discussion of the antitrust treatment of standards, see the Federal Trade Commission Staff Report, *Competition Policy in the New High-Tech, Global Marketplace*, Chapter 9, "Networks and Standards"; Joel Klein, "Cross-Licensing and Antitrust Law," 1997, available at www.usdoj.gov/atr/public/speeches/1123.htm; Carl Shapiro, "Antitrust in Network Industries," 1996, available at www.usdoj.gov/atr/public/speeches/shapir.mar; Carl Shapiro, "Setting Compatibility Standards: Cooperation or Collusion?" Working Paper, University of California, Berkeley, 1998.
9. We cannot explore cooperation and compatibility tactics in any depth here. We discuss tactics for participation in formal standard setting in Chapter 8 of *Information Rules* [Shapiro and Varian, op. cit.].
10. Even these companies have had losers, too, such as Microsoft's Bob, Intel's original Celeron chip, and Sun's 386 platform. Credibility and brand name recognition without allies and a sound product are not enough.
11. Manufacturers do the same thing when they pay "slotting allowances" to supermarkets for shelf space by checking that their products are actually displayed where they are supposed to be displayed.
12. Indeed, the strategy has been so successful that some have amended the name to "Embrace, Extend and Eliminate."