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History and Impact of Computer Standards

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***Abstract**: Standards are especially important to a young and quickly changing industry like the computer industry: They stabilize technology and encourage investment.*

A computer trade publication recently devoted a column in one of its issues to complaints about the uselessness of standards developing organizations and, by extension, of standards. Despite those complaints, the author of the column probably saved a great deal of time and effort by composing it on a computer system made possible only through standards. Without such standards, the author probably would have been using a manual typewriter with a proprietary keyboard, paper, and ribbon.

There are many other examples of how important standards are to the computer industry and to many other industries. For example, various sources estimate that US industry spends between $17 billion and $30 billion each year on standards. The computer industry contributes its share to that total.

In fact, as we will see, standards are especially important to a young and quickly changing industry like the computer industry.

About Standards

Many aspects of industrialized society, including some that we take for granted, have some form of standardization. For example, notebook paper in the US is 8-1/2 inches wide and 11 inches long. There are also standards for flashlight batteries, light bulbs, paper clips, and tires. The list goes on. The computer industry is no exception, with standards for everything from bus structure to disk form factors to object-oriented programming. In fact, information technology is so complex, it is particularly dependent on standards.

Standards for a technology are presented as specifications that developers and manufacturers of the technology follow. There can be

- formal standards, developed by official standards developing organizations (see the sidebar “Standards organizations”) such as the IEEE;
- public specifications, developed by a consortium of companies that use a technology, such as TCP/IP developed by the IETF; and
- de facto standards, developed by one company whose implementation of a technology has been accepted in the marketplace, such as Microsoft Windows 95.

Key example

One of the most interesting examples of an industry standard which, years later, also affected information technology is the typewriter keyboard.

After the typewriter was introduced, the concept was quickly picked up by other manufacturers, who put forward dozens of designs, including dissimilar keyboard configurations. In 1878, the Remington typewriter company patented our current QWERTY configuration (named after the first five letters on the left in the top row of letter keys), which emerged as the industry standard.

The QWERTY layout was designed to ensure that no one could type fast enough to jam a manual typewriter’s keys. QWERTY is not the most efficient design. Other layouts permit faster typing. However,

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Standards organizations

Standards developing organizations (SDOs) generate formal standards, generally through an established process that lets all interested parties participate and that strives to reach a consensus among participants.

There are international SDOs (such as the International Organization for Standardization and the International Electrotechnical Commission) and national SDOs that generate standards for use within countries (such as the British Standards Institute (BSI) and Deutsches Institut für Normung (DIN) in Germany).

ISO

The International Organization for Standardization, founded in 1946, is the world's premier standards organization. ISO, which has about 5,000 participants, is made up of standards organizations from throughout the world.

ISO develops international standards for all areas except the electrical and electronics fields. International standards are developed for those areas by the International Electrotechnical Commission. This means ISO has standards for such diverse items as screw threads, ornamental garden rocks, earthmoving equipment, and global information systems.

ISO and the International Electrotechnical Commission, both based in Geneva, have formed the Joint Technical Committee 1 for developing IT standards.

ANSI

The American National Standards Institute, which was founded in 1918, does not develop standards but instead develops guidelines for procedures that SDOs should follow. SDOs in the US that follow these procedures are accredited, which means their standards can be called American National Standards. This gives the standards more credibility within their industries.

SDOs in the US

The New York-based ANSI considers accredited SDOs to be either accredited standards committees, which only develop standards, or accredited organizations, which also have other activities. For example, in the field of information technology, ANSI considers X3, which develops all types of IT standards, to be an accredited standards committee. The institute considers the IEEE, which is primarily a professional engineers organization, to be an accredited organization.

ANSI procedures

ANSI's recommended procedures and accreditation process are designed to ensure that SDOs open their development process to all interested parties and seek the consensus of all participants in the adoption of standards. This is designed to keep a few powerful companies in a field from getting together and developing standards that would unfairly shut out their competition and let them take over their market. SDOs that follow ANSI's recommended procedures can avoid charges that they have violated federal antitrust and restraint-of-trade laws.

QWERTY is still the standard (the International Organization for Standardization made it a formal standard in 1991) because everyone is used to the configuration and because the cost of change probably outweighs the marginal benefits of a more efficient layout.

Computers and Standards

About 50 years ago, scientists completed ENIAC, the first operational electronic digital computer. For about 10 years, each computer was a unique design, a one-of-a-kind laboratory experiment. The cost of each unit was tremendous. Few people understood the computers, and even fewer could use them. This was the time of the famous "I think there is a world market for maybe five computers" comment ascribed, probably apocryphally, to IBM President Thomas Watson Sr. in 1943.

When mainframes were born, in the late 1950s, the world of computing changed. Mainframes were less expensive and were produced in quantity. Watson's estimate was quickly proven wrong.

Because each manufacturer built a complete system, each developed its own proprietary standards, such as control and programming methods. Because each

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manufacturer wanted to get people to buy only its brand of computer, no one tried to develop heterogeneous interconnections or data portability.

Once computers entered the commercial mainstream, they began to get smaller and more powerful. They have since increased exponentially in number. And the growth in the way computers are used has been even more phenomenal. Standards have been a key reason for this.

In reading about some of the key standards in computer history, it is interesting to note how technologies specified by the standards changed from their original intent to their current usage. In many cases, it is as if someone specified a horse-drawn wagon but an airplane emerged. For example, the IEEE began developing LAN standards so users could share computer resources, but LANs ended up enabling the PC and workstation revolution. In some cases, this has worked out well. In others, it hasn't.

Important Computer Standards

In the beginning, a computer used lights and switches as control and feedback mechanisms. Manufacturers rapidly turned to the keyboard, a simpler device that more people could use. There have been many other standards that have advanced the computer industry.

Hollerith card

Probably the earliest modern computer standard was the Hollerith punched card, which had 80 columns, 12 rows, and rectangular holes. Other computer manufacturers used their own proprietary punched-card systems. However, IBM's card became the standard card because the company was the dominant seller of card-input devices.

As computers became more widespread, the card became even more common and thus became a de facto standard. The American National Standards Institute (ANSI) finally made the Hollerith card a formal standard in the mid-1960s.

The card advanced the computer industry by providing a common vehicle, or medium, for transporting data, initially between types of equipment (for example, between the keypunch machine and the computer) and subsequently between types of systems (for example, between computers and sorters). The punched card was followed by punched paper tape, magnetic tape, and disks.

ASCII

ASCII, the American Standard Code for Information Interchange, was released in 1963. This was the first true IT standard, designed in a formal, consensus-based standards committee.

ASCII was not based on a major manufacturer's proprietary design, and it was not a legacy handed down from earlier equipment, as was the case with the Hollerith card and the QWERTY keyboard layout. Instead, ASCII was based on worldwide input and was developed to meet a need of the telecommunications industry.

The telecommunications industry needed a standard character set to transport information over a serial telephone line. The standard in use before ASCII was a very limited 5-bit coded character set with one shift for letters and another for numbers.

The committee that developed ASCII had representatives from all over the world, but the character set they generated was limited to the 26 letters of the Latin alphabet, as well as numbers, grammatical characters, and some special control characters.

Nations that didn't use the Latin alphabet accepted ASCII because at the time, most programming languages were developed in the US and used a Latin character set with comments and commands that were in English or based on English. Thus, ASCII was all that was needed to program and control computers.

COBOL

Cobol was an attempt to standardize a language so that people could write programs for any machine and be understood by anyone else who knew the language. Cobol has been revised and improved over time and is still an important standard. In fact, it is the world's most heavily used language for business applications. About 17 billion lines are in use today.

Early computer programming was difficult. The earliest computers used patch cords and were difficult and time-consuming to program. The punch/patch board, a large piece of hardware that could be swapped, let people change programming wires more easily. Eventually, people could use an input device (such as punched cards, punched paper tape, or a keyboard) to enter a program into memory.

Few people had the skill necessary to program computers, which could be programmed only in machine language, not human-readable language. To make matters worse, each machine language could be used with only one type of computer. As computers became increasingly available, it became increasingly difficult to find programmers.

It also became obvious that the computer industry needed a human-readable programming language that could be used on various computer systems. The language would have to follow a carefully defined syntax so that it would be unambiguous and could be dependably translated into machine language.

On May 28, 1959, the US Department of Defense convened a meeting of computer manufacturers and users, and other interested people to develop such a language for business applications. The meeting was later called Codasyl (conference on data systems languages). Participants wanted to develop a language that was like a natural language (for example, English), not one that was symbolic, like Fortran.

Interestingly, some of the people who were managing the effort originally didn't want to fund the committee's work, because they didn't see its value. To win them over, committee members said they could program in French as well as English with their new language. One evening, they simply translated some of the compiler's tables from English to French. This was an inconsequential effort but convinced their opponents to support their work.

Codasyl published its specification for the new language, called Cobol (common business oriented language), in April 1960. ANSI used this specification as the basis of the formal Cobol standard, which it approved in 1968.

The International Organization for Standardization (ISO) adopted ANSI's Cobol standard in 1972. There have been two revisions of the language and a fourth version is being developed for release in 1997.

RS-232

RS-232, the standard for the serial port on the back of the PC, is particularly important because it marked the first time hardware standards were used to merge the interests of the telecommunications and information technology industries, a process that now seems commonplace.

The effort that led to RS-232 began in the late 1950s. As computer technology advanced and people found the need to connect computers to keyboards and printers, Bell Telephone Laboratories developed the modem.

Until RS- 232, people used hardwired teletype connections with modems. Teletypes used motors, wheels, and electromagnets to convert analog signals on a telephone line into printed characters. The effort that led to RS-232 began in the late 1950s. As computer technology advanced and people found the need to connect computers to keyboards and printers, Bell Telephone Laboratories developed the modem. Until RS- 232, people used hardwired teletype connections with modems. Teletypes used motors, wheels, and electromagnets to convert analog signals on a telephone line into printed characters.

In the early 1960s, Bell Telephone Laboratories developed a different interface to connect its modems to such devices as computers, keyboards, and printers. RS-232, the original standard for this interface was developed by the Electronics Industries Association (EIA) and addressed only voltage levels, timing, and line definitions. The 25-pin D connector, which was almost always used with the modem signal set, was not included in the standard until the EIA published the EIA-232D revision in 1987.

In 1991, the EIA and the Telecommunications Industry Association approved a new standard for the interface, called EIA/TIA-232E. It includes all of the interface components that are currently used but that were not included in previous RS-232 versions.

The IEEE has approved a new standard that would replace current PC serial and parallel ports with a new type of port.

Local area networks

Ethernet and token ring are the best known LAN standards. LAN standards are also known as IEEE 802 standards because they were created in the IEEE Computer Society's P802 Standards Committee. They are now also ISO and ANSI standards.

Previously, standards had been tools that documented and legitimized existing product designs. However, the LAN standards changed the way computing is done and created a market for LAN products, and thus represented a landmark in IT standards development.

In the early 1980s, there were a few expensive LAN designs and products available, but they did not interconnect, and the small market was fragmenting into vendor-based camps.

Project 802, as the IEEE called the LAN standards development effort, stabilized the technology. This let developers focus on specific LAN technologies and permitted interoperability within technologies. These factors led to LANs that were more useful and affordable, and permitted today's multibillion-dollar LAN market.

GREAT INTEREST IN LAN STANDARDS. By early 1980, when the IEEE began Project 802, many people had heard about the LAN concept but few people really understood it. In addition, many people had heard rumors (which turned out to be true) about a new LAN product that Digital, Intel, and Xerox were going to release. This sparked a lot of interest in Project 802.

When the project started, there were about 300 participants. This was impressive because, at the time, the average standards meeting attracted only about 20 participants. The number and diversity of attendees led to

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a lively exchange of ideas and the presentation of many potential solutions.

BATTLE LINES. When Project 802 began, there were three architectural camps. Digital, Intel, and Xerox supported their CSMA/CD (carrier sense multiple access with collision detection) scheme. A group headed by IBM favored a scheme called token ring, and a third group, consisting mostly of small independent companies, preferred a scheme called token bus.

In addition to architecture, participants battled over address length, bit order, byte order, error detection codes, start-of-frame delimiters, and so on. Some of these arguments were made simply to obstruct people with opposing views, and some were actually attempts to improve the standard.

Each contributor wanted Project 802 participants to adopt only its original specification proposal, with no changes, which made it impossible to reach consensus on one set of standards. After three years, participants finally agreed to work on multiple LAN standards for multiple access methods that satisfied multiple types of user demands and multiple provider capabilities.

COMPROMISE. Project 802 was subsequently reorganized into five working groups, and work progressed swiftly on what we now know as Ethernet (CSMA/CD) and token ring standards. Participants also approved a token bus standard, but it was never widely accepted. Deployment occurred rapidly after the standards were approved, prices dropped, and today, the LAN is an accepted computing strategy.

CD-ROM

The standardization of the CD-ROM was significant because it demonstrated users' power to force the development of one product standard and thus make the market meet their needs.

Most of the computer industry's early data-storage standards, such as the magnetic tape standard, were adopted easily during the industry's less contentious days. The CD-ROM, however, was not adopted quickly, even though the industry knew it would be a good data-storage medium and even though the technology was available to develop it for several years.

CD-ROMs were not adopted in the computer industry because they cost too much. They cost too much because users and suppliers could not agree on a common data-labeling format that would let everyone's computer read CD-ROMs. With many labeling formats, manufacturers could not produce the product volumes necessary to bring down costs and make the technology practical for widespread use.

In the mid-1980s, suppliers funded a small group of technical experts to work on the problem, and they produced a CD-ROM standard, which eventually led to the ISO 9660 standard. Users and producers accepted the standard, and the CD-ROM became a viable medium that also helped create the multimedia market.

USERS DRIVE STANDARDIZATION. As CD-ROM technology advanced, manufacturers created a new optical digital disk, which is smaller and contains more data than previous versions. However, there were two competing and mutually exclusive designs. Before the designs hit the market, the computer industry, which did not want to be forced to build machines to accommodate both standards, threatened to boycott the two designs if a single one wasn't adopted as a standard.

As a result, the ISO and the ECMA (formerly called the European Computer Manufacturers Association) is developing one standard. In this case, the users, not the manufacturers, drove the standardization effort.

Elements of Successful Standards

The successful computer standards have used technology to meet business needs without inhibiting innovation and competition.

History shows that the best way to accomplish this is to limit standardization to the specifications that are necessary either to specify essential functions or to define such important matters as data-interchange methods and interfaces.

A good standard in any industry is generally a solution to an interface problem. Standards should not address the implementation of a product. In that way, they can encourage competition in the way a product is used.

For example, the standard for screw threads sets their pitch, width, and other physical dimensions. It does not require manufacturers to use stainless steel, aluminum, or wood. The standard specifies only the interface, which is where parts meet and must interact. The more implementation-specific details we include in a standard, the less open, acceptable, and viable it will be. And complete standardization reduces or eliminates innovation, and thus hurts competition.

Information technology standards, going back to the Hollerith punched card and ASCII, helped the computer industry grow rapidly because they were designed with these concepts in mind. The industry thus developed standards for the media and cables that permit interchange but not for the way these products are used and produced. The industry also standardized media formats and character sets but not the way the media should be used in a computer. In other words, the industry left room for competition and innovation.

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Standards for the Future

The next level of computing will involve high-resolution, full-motion video, as well as faster communication and more data storage. Data compression standards such as MPEG and JPEG will probably be very important. The new standards for optical digital data disks will also support this evolution. Larger disks will permit more data storage, which will lead to better visual and audio applications, which will lead to faster processors, faster buses, better communications, and more memory.

Conclusion

In this article, we have touched on computer standards that have been milestones in the industry. We omitted some important standards, such as the Open Systems Interconnect (OSI) and Posix, because the jury is still out on their historical significance.

In general, however, computer standards have had a significant impact on the market. The PC, the modem, and the telephone lines we use for communications are commercially viable largely because someone standardized the underlying infrastructure and allowed innovations to take place. This has been a key to the computer industry's past success and will be important to the industry in the future. In general, however, computer standards have had a significant impact on the market. The PC, the modem, and the telephone lines we use for communications are commercially viable largely because someone standardized the underlying infrastructure and allowed innovations to take place. This has been a key to the computer industry's past success and will be important to the industry in the future.

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