THE SIX DIMENSIONS OF STANDARDS:
CONTRIBUTION TOWARDS A THEORY OF STANDARDIZATION

E. Baskin*, K. Krechmer* and M. H. Sherif+
* Communications Standards Review Palo Alto, CA, USA.
+ AT&T Labs, Paris, France.

Paper presented at the Seventh International Conference on Management of Technology, February 20, 1998, and published in Management of Technology, Sustainable Development and Eco-Efficiency, Edited by Louis A. Lefebvre, Robert M. Mason and Tarek Khalil, Elsevier Press, Amsterdam, 1998, p. 53.

Abstract: This paper offers the beginnings of a framework for standards so that standards development organizations, commercial organizations, and individuals can more clearly plan their standard strategy. First, we review the different approaches to multimedia communications to understand how this could affect standardization. Then we identify the range of stakeholders from standards creators to standards seekers. We then present the framework for standardization in terms of answers to six questions: Why? What? When? Which? How? and Where?

Keywords: Standards, compatibility, etiquette, standards seekers, standards creators

Introduction

Standards, and the regulations that use them, are essential for commerce. While not necessary in all fields of human endeavor, the standardization of interfaces is necessary for connectivity. Furthermore, as markets expand beyond the reach of individual governments, the importance of standardization increases. There are many instances where the lack of a single standard has added a heavy burden in telecommunications. For example, different color TV standards, the transcoding law for Pulse Code Modulation (PCM) voice coding, and individual country homologation systems have increased costs for service providers, equipment manufacturers, and end users alike. Standards specify the methods for interaction, the measures of equivalence, the limits of performance, quality, or degrees of compatibility. They may also include safety, reliability and test methods.

Multimedia Communications

A communications network can be viewed as a pipe that transports the bits of information transparently, while all the intelligence needed for processing resides in the end-user terminal or computer. Traditional roadway engineers as well as the designers of end-user equipment (modems, personal computers, work stations, browsers, word processors, etc.) share this view of a decentralized network with atomic elements. In this case, and because of short product life cycles, intense rivalry among suppliers and constantly emerging substitutes, the aim of standardization is to provide the lowest common denominator.

According to another view, the telecommunications networks should have enough intelligence to match its offerings with the needs of the end-users at all times. The deployment of such intelligence requires long-term planning to ensure the integration of compatible systems. This view, once peculiar to the practitioners of traditional telephony (i.e., PT&Ts), is being adopted gradually whenever long range interoperability is required, such as in the design of intelligent roadway systems.

2

The uniformity and coherence of the Switched Telephone Network (STN[1]) was based on the understanding that, to further public interests, the terminals and networks were to be coordinated to allow the transparent flow of voice traffic. The commonality of digital processing of signals, digital transmission, and digital switching among phone systems and local area networks (LANs) offers the promise of access "anywhere any time" for many traffic types. Today, the design and engineering activities of all these emerging services and terminals are scattered across many disciplines and organizations without any explicit regulatory mechanism that could ensure and maintain end-to-end compatibility. Different offerings are emerging: digital, wireless, and multimedia communications with new capabilities and new services.

Multimedia communication straddles the traditions of both telecommunications and information technologies. The overlap of technologies in multimedia communications has caused many standards groups to address the issues independently and with little coordination leading to application-specific approaches. Various bodies have adopted competing standards (for example, the many voice coding algorithms for wireless, cellular and conferencing applications), leaving to others the thankless task of networking these different algorithms. In such a fragmented environment, a better understanding of the theory of standards becomes more important, to focus resources in an productive way.

Standard Creators and Standards Seekers

Stand-alone terminal and computer equipment (VCRs, early computer systems, etc.) operate more or less independently. Thus, the early terminal and computer manufacturers attempted to dominate markets with their unique products. That is, they wished to make their own "standards" rather than accept other'. Standards creators believe that they can or should create their own unique product or service. In contrast, standards seekers consider outsiders as stakeholders while creating a new product or service.

One reason for this difference lies in the market segment that each set is trying to address. For example, the market for intelligent end-user terminals is characterized by polychronic activities ("multitasking"), short product life cycles, and the need for differentiation. In contrast, the world of communications relies on long-term planning, cooperation, orderly integration, and homogeneity. As a consequence, the number of STN providers, while increasing, is much less than the number of participants in the field of intelligent terminals or those offering non-real time communications through the Internet. This is because it is much simpler and less costly to modify the software configuration of a computer or terminal than to change the network infrastructure that supports such devices.

Over the product continuum shown in Figure 1, the interests of standard seekers and standards creators are at opposite ends.

[1]The term Switched Telephone Network includes the existing world-wide telephone system, both public and private, as defined in International Telecommunications Union (ITU) Recommendations

3

Unique No externalities			Uniform Maximum externalities
one-of-a-kind products	stand alone manufactured products	products/services with private interfaces	public communications products and services, commodities
Standards creators			Standards seekers

Figure 1. The product continuum.

Standards creators and standards seekers represent competing paradigms in the sort battle that cannot be resolved by proofs, where the proponents of each of the competing paradigms "practice their trades in different worlds." [2]

Economists[3]use the term "network externalities" to describe the value of specific external relationships to a communications product or service. A unique product has no defined externalities; a uniform product has many. Communications networks are examples of services where the value of the externalities increases with the number of users.
However, even standards seekers desire product differentiation. Communications service providers attempt to differentiate their service via pricing, quality, coverage, or range ofservice options. In the same time, as computer networks grow, computer equipment makers, that once were only standards creators, are becoming standards seekers as well. The question of why to standardize has become more important and also more difficult to answer, as the value of externalities in a globally interconnected society increases.

The Internet itself, can be seen from both perspectives. From the standards creators view point, it is a network of autonomous loosely-coupled data networks scattered around the globe. The standard seekers' perspective reminds us that this network needs, at the very least, a synchronization plan to lock the transmitting and receiving network multiplexers to the same source frequency. Dexterity in moving from one view to another is becoming more common, and more necessary, as more ideas and participants are shared among the traditional organizations and the Internet Engineering Task Force (IETF).

A Framework for Standards

Technical standards, like all other forms of human activity, may be described reasonably completely by answering six questions in *The Just So Stories* (1902), "The Elephant's Child" by Rudyard Kipling[4]These questions will help us define a framework to approach standardization.

---

[2]Thomas S. Kuhn, The structure of scientific revolutions, 2nd ed., The University of Chicago Press, 1970, pp. 148-150.
[3]M. L. Katz and C. Shapiro "Network Externalities, Competition and Compatibility", The American Economic Review, Vol. 75(3) pp. 424-440, 1985.
[4]"I keep six honest serving men/(They taught me all I knew);/their names are What and Why and When/And How and Where and Who"

The first three questions relate to planning the development of a standard - the strategy. The second three questions relate to developing a standard - the tactics.

The strategic questions are:

- Why seek a standard?
- What is the category of product or service to be standardized?
- When in the product cycle to standardize?

The tactical questions are:

- Which is the appropriate Standards Development Organization (SDO)?
- How will consensus be reached?
- Where will the standard be used?

The answers to each set of three questions interrelate because strategy and tactics affect one anotherSuccessful decision-making requires several iterations, first to understand each question and then, to re-evaluate the answers in light of all the other answers. We will be discussing each question separately.

Why seek a standard?

The purpose of this question is to position the product or service under consideration in the continuum from the unique to the uniform.

- In a technologically mature field, where competition is basically on price, there may be no real incentive to reveal technical information. In this case, a commercial organization "will accept and use standards only if it believes that it cannot expand the market directly and that standards can."[5]
- In an emerging field, the risks may be so high that firms may share their knowledge selectively to stimulate the market and/or discover unanticipated applications.
- Standardization may also be a competitive strategy for new entrants to oppose the dominant firms[6]. This helps legitimize the new technology and allows the organization owning or mastering the new technology to have a central position[7].

The commercial decision not to standardize implies a decision to seek a unique, possibly controllable, market. This is probably the correct decision when a product or service has few interfaces to other products or services. Conversely, a decision to standardize suggests the desire

---

[5]C. F. Cargill, *Information Technology Standardization: Theory, Process and Organizations*,p. 42, Digital Press, 1989.

[6]H. L Gabel, "Open standards in computers: The case of X/OPEN," *Product Standardization and Competitive Strategy*,H. L. Gabel, Ed., pp. 91-123, North-Holland, Amsterdam, 1987.

[7]V. Mangematin and M. Callon, "Technological competition,: strategies of the firm and the choice of the first users: The case of road guidance technologies," *Colloquium Mngmt of Tech: Implications for Enterprise Management and Public Policy*,Paris, France, May 27-28, 1991.

---

to address markets with some commonality. It also relates to the understanding that there will be competition but that there is value in supporting common interfaces.

What Categories?

Figure 2 depicts a layered taxonomy of technical standards into four strata based on an economic perspective described by David, 1987 [8]. He proposed the first three levels, to which we add the next layer.

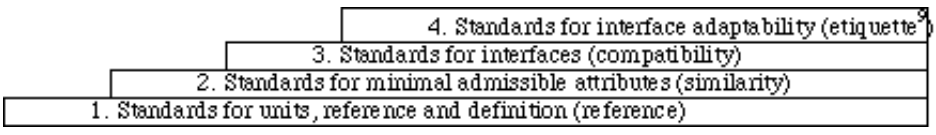

Figure 2. The strata of technical standards.

Stratum 1. Reference Standards..

Reference standards include unit standards which define measurable physical qualities, e.g., ohm, volt, watt, dBm, etc. Reference standards also allow other entities to be compared to a reference. Examples include the ASCII character set, the Open System Interconnect (OSI) model, and E.163 (The numbering plan for international telephone service).

Stratum 2. Similarity Standards.

Similarity standards define the nominal value and the allowed variation for a set of similar entities. A proper similarity standard is closed form, meaning all practical variations are defined in the standard. Most communications standards are similarity standards.

---

[8]David, Paul A. Some New Standards for the Economics of Standardization in the Information Age, Economic Policy and Technological Performance, Editors: P. Dasgupta & P. Stoneman, Cambridge University Press, 1987

[9]The term etiquette was first used in a similar manner by the Wireless Information Network (WIN) Forum which was followed in the US FCC Personal Communications System (PCS) requirements. In this case it described a means to identify pre-existing wireless users in the same band and back-off (similar to the Aloha protocol). The first use of the term as defined here is in K. Krechmer, Technical Standards: Foundations for the Future, pp. 4-8, *StandardView*, Vol. 4, No.1, March 1996.

Figure 3 describes the components and interfaces in a typical communication systems.

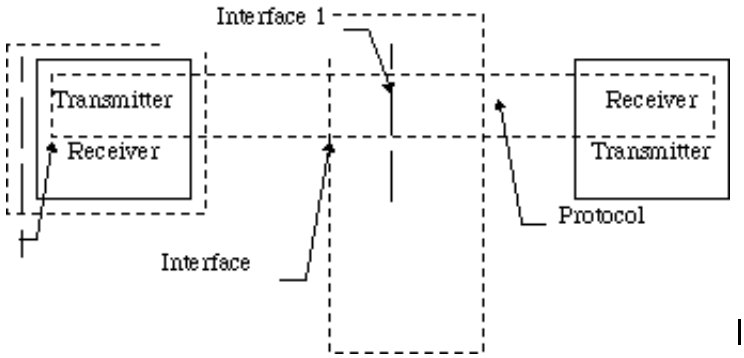

Figure 3. Device, protocol and interface standards.

The transmitter and the receiver are enclosed in a device. The two devices communicate across an interface using a set of protocols. Device standards are similarity standards. Protocol standards, which define transmitting and receiving pairs, are usually similarity standards. In this paper the term protocol is used to describe functions that terminate an OSI layer, to distinguish it from functions that do not terminate an OSI layer: etiquettes (discussed below).

In general, it is a good practice to separate similarity and compatibility standards. In wireless communications, similarity standards, usually referred to as minimum base station and minimum mobile station standards, are distinct from compatibility standards, often termed the air-interface.

Stratum 3. Compatibility Standards.

According to Q.300,"compatibility....implies a degree of transparency sufficient to support an acceptable grade of service with respect to a connection.... Full compatibility implies full transparency."Thus compatibility standards define the "transparency" of an interface between two or more mating elements that communicate with each others. Modem recommendations (V.32, V.34, etc.) or the packet switching recommendation X.25 are examples of compatibility standards: they define interfaces, sufficient aspects of the transmitter and the receiver pairs necessary to ensure communication. These are not similarity standards as they don't define all aspects of a device or protocol.

Protocol standards today often consist of a core portion and many negotiated options. The effect of such options often has been to create the need for additional standards, which are compatibility standards, sometimes termed interfaces, templates, or agreements. Q.921 and Q.931 are examples of protocol standards so complex that it is not easy to ascertain whether two implementations will interwork. In this case, a compatibility standard is also needed. These compatibility standards define the allowed range of options necessary for compatibility for

---

7

defined applications. The NIUF[10]ISDN User Agreements provide compatibility standards for Q.931 and Q.921.

Compatibility in a communications system is a necessity. Users that purchase communications systems of significant size (US Government, General Motors, etc.) can also impose requirements to achieve compatible interfaces to reduce their costs or increase their flexibility. While manufacturers may prefer more general requirements that allow for future flexibility of their products or prevent direct competition, large users with specific needs may force standards creators to become standards seekers.

Some of the difficulties experienced in deploying Integrated Services Digital Network (ISDN) was the complexity of the similarity standards. A counter example is the rapid acceptance of Advanced Mobile Phone System (AMPS) cellular telephone standards in North America. AMPS standards, from Telecommunications Industry Association standards committee TR-45.1, first developed compatibility standards, which they termed air interfaces.

Compatibility itself has multiple dimensions, including multi-vendor compatibility, upgrade and backward (multi-vintage) compatibility, product line compatibility, revision level compatibility, etc. Maintaining compatibility as standards evolve requires an etiquette to negotiate extensions not yet defined.

Stratum 4. Etiquette Standards.

Etiquette standards define the range and open ended variability of protocols. These standards are becoming important due to the widespread use of programmable processors. As example, the IETF Internet draft[11], Protocol Extension Protocol (PEP) is designed to accommodate extensions of applications such as HTTP clients, servers and proxies.

Etiquettes provide the framework for bilateral and multilateral negotiations to specify areas left for further study, future revisions or manufacturer specific options - any open ended requirements. As such proper etiquettes support negotiation between protocols not within a protocol. Although etiquette like functions often are included (buried) in protocols, there are sound reasons (extensibility) for defining them separately.

Currently proper etiquettes are most often used to support physical node change (Ethernet CSMA/CD),

backward compatibility (automode supporting V.32, V.22bis, V.22 handshaking, V.8 and V.8bis supporting V.34 modems and other negotiation) and wireless access (WINForum spectrum etiquette). In these cases, the etiquette negotiates variable aspects of the physical layer process. V.8 and V.8bis are also capable of negotiating aspects above the physical layer and supporting proprietary implementations.

Maintaining such evolutionary compatibility (openness) in standards requires care. A protocol defined by a similarity standard specifiesall supported functions. When a protocol implies or requires functions outside its scope, transparency may be affected. For example, the protocol may terminate in an intermediate device (e.g., a network element or a gateway) without informing that device of what functions that are needed from outside entities. As example, in

[10]NIUF, National Institute of Science and Technology (NIST) ISDN User Forum
[11](was originally) Available at http://www.w3.org/TR-WD-http-pep

Group 3 facsimile, T.30 (a combination of a compatibility standards and etiquette functions) negotiates, among other things, non-standard facilities (NSF), an open ended function. This is a problem when a demodulation/remodulation function (gateway) occurs in the network. The gateway is not capable of negotiating NSF. This example identifies the value of separating compatibility standards from etiquette standards.

Etiquettes are a new class of standards with which product developers are not yet familiar. Often they require considerable development and testing effort due to the range of possible variation in an actual system. Such effort is only desirable when the considerable advantages of etiquettes in extending product and market life cycles are understood.

Review of the model.

In this model, each stratum is the foundation for the next stratum. As technology advances, the associated standards can be on several strata. Consider for example, two of the recommendationsfor Group 3 facsimile, T.4 and T.30. T.4 specifies the format of the page to be sent and the modem used. The T.30 describes the operating modes between two facsimile terminals. Accordingly, T.4 is a similarity standard, while T.30 is a compatibility standard that includes some etiquette to accommodate technological changes.

This model helps us to see how to structure a series of standards for a technological system. Given today's rapid pace of technology, similarity standards that are not structured to evolve, often have limited value.

When in the product cycle to standardize?

The understanding of a product or service commences with understanding a need, which is an entrepreneurial activity. Precursor products or services provide sufficient proof of the technology or market interest to stimulate work on standards. Currently proprietary PCM modems from US Robotics and Rockwell are good examples of precursor products coming in advance of the V.pcm modem recommendation from the ITU.

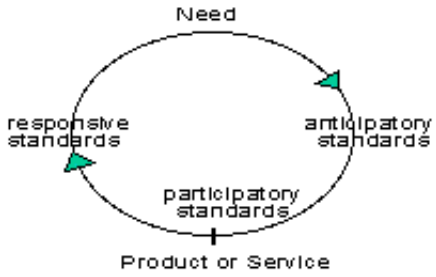

Figure 4. Standardization position in the product cycle.

In terms of its position in the product cycle, standards can be one of the following:

1.Anticipatory standards
2.Participatory standard
3.Responsive standards.

This is shown in Figure 4.

Anticipatory standardsare those standards that must be created before widespread acceptance of the device or services. They can emerge from the cooperation among existing competitors, or by new entrants that offer a precursor of the potential standard product or service.

Anticipatory standards (e.g., V.32 modem, X.25 packet interface, ISDN, TCP/IP, the H.series recommendations for video communications or SET[12]) may be developed by any interested standards development organization (SDO). The studies that precede the adoption of an anticipatory standard should, ideally, involve all interested parties. In this way, the standards provide a more formal way for sharing innovations among firms. This incidental benefit can be an important factor in spurring innovation (for example, the development of G.728 CCITT/ITU- T 16 kbit/s speech coding algorithm led to a major breakthrough in voice coding[13]).

Participatory standardsare developed, tested and used in an interactive environment. Some of the participatory standards are the voice coding algorithms of G.728 and G.729. However, prior to the Internet, a widespread interactive standards development environment did

[12]SET Secure Electronic Transactions a protocol for secure electronics payments, Electronic Payment Systems, D. O'Mahony et al., Artech House, 1997, pp. 101-121.

[13]M. H. Sherif and D. K. Sparrell, "Standards and innovations in telecommunications," IEEE Communications Magazine, July 1992, pp. 22-29.

not exist. Internet applications above the TCP layer may be considered participatory standards (e.g., MBONE, MMUSIC, etc.).

Responsive standardsoccur to codify a product or service that has been sold with some success. When a product is well entrenched (e.g., Microsoft Windows), there may be no incentive to standardize, particularly in the terminal or computer endpoint business. In the telecommunications field, however, a manufacturer,

even with a large market share, may want to formalize their product or service through a standards organization to expand their market because of network externalities (e.g., Microcom MNP protocol[14], AT&T RJ jacks, IBM HDLC, DataBeam data conferencing protocol which evolved to become T.120). Alternatively, a formal standards committee may wish to standardize a useful technology to codify the reality that it is widely used (e.g., modem AT command sets, UNIX operating system, programming languages, etc.) and allow its reference in future work.

Responsive standards offer a systematic way of distilling scientific information and available data into useful technical constructs. They expedite the consolidation of knowledge and provide avenues for sharing technical know-how.

Responsive standards mean however, that the initial manufacturer will have to contribute to the standards development, in addition to developing a product. They may have to release technical information earlier than anticipated or modify future product plans. In addition, product differentiation will have to shift to areas not covered by the standard. The options available to the initial manufacturer who chooses to support a responsive standard are:

- Achieve the maximum market penetration prior to supporting a responsive standard.
- Enhance the product beyond the standardized levels of functionality.
- Differentiate the product based on quality, customer support, or services.

Usually initial manufacturers attempt to do all three. However, the long term success of the innovator will depend on whether they can introduce additional desirable levels of functionality and how well they maintain backward and forward compatibility to/from these new levels of functionality. The Hayes modems using the proprietary standard AT command set dominated the initial personal computer modem market[15]. However, Hayes was not able to introduce additional desirable level of functionality and maintain compatibility. This allowed Microcom to successfully introduce the MNP error control protocol which required new AT commands, and Hayes lost control of the AT command set in the marketplace. Hayes continued to dominate the modem market for some time by virtue of market strength and a patent on a key aspect of the AT command set. This indicates that an initial manufacturer's continued market success does not depend only on standards, but will also be dependent on marketing and sales skills, financial strength and manufacturing capabilities.

One way to deny a competitor an advantage is to delay the issuance of a responsive standard. This may be possible when numerous interest groups are involved and there is no way to achieve consensus. However, delaying a standard often results in incompatible approaches

[14]Microcom Networking ProtocolMNP-4 was included in the ITU Recommendation V.42

[15]K. Krechmer, "Autodialing Modems are Improving Response Capabilities", Electronic Products magazine,April 1, 1985 , pp. 73-76.

11

and may delay the whole market: a current example is digital television. On the other extreme, premature standards (e.g., OSI management, applications programming interfaces, Group 4 facsimile) may be ignored or may force a whole industry to inefficiencies.

Based on the above consideration, we can classify current work on conferencing and related multimedia standards as follows:

Organization	Standards	Classification
ITU-T	T.120, H.323 and H.324	Anticipatory
IETF	MBONE, MMUSIC	Participatory
ISO	MPEG (video and audio compression)	Anticipatory
Company proprietary	Intel ProShare, Microsoft NetMeeting, Lotus Notes	possible precursors to Responsive standards

The success of these different standards all used for conferencing is likely to indicate which approach was most appropriate. Most likely a combination of aspects of the different standards will gain market acceptance.

Which Standards Development Organization (SDO)?

The expanding use of technology and the interconnection of needs commercial activities have increased the number of SDOs. The operating procedures of an SDO may affect the way a company could contribute to the standards process. Formal SDOs have more rigorous rules that others. In all cases however, contribution to a standardization process implies a policy of knowledge management in a company, i.e., that of generating, keeping, and/or releasing information. Many companies may not give much attention to the issue of knowledge management which they mistake as secrecy. In such cases, participation in formal SDOs, which expect an organized and on-going involvement, can be more difficult. Other companies may prefer less formal SDOs to avoid formalism, even if this choice is not the most effective to attain the company's goals.

The range of classification of SDOs is always changing, as new variations of standards committees continue to emerge. As example, the IETF (Internet Engineering Task Force) currently falls between the accredited committees and industry committees concepts. As the IETF achieves more success, it may eventually move closer to an accredited standards committee, which may require changes to some of its operating procedures. But all SDOs support, in one way or another, a consensus-based process.

How consensus is reached?

Consensus based standards rely on the positive self-interest of the parties involved. Their self-interest directly relates to the benefits of the network externalities. This encourages mutual agreements among competing organizations to support the creation of a standard. The nature of the agreement, however, will depend on the activities of those participating in the consensus.

12

For example, the consensus of terminal manufacturers might be different than the consensus of network operators or service providers. It is important that a telecommunications standard takes into account the views and interests of the various stakeholders so that the collective resources become focused on its implementation. In the best case, all views are understood and taken into account to allow more flexibility in the application with fewer revisions and modifications to meet unforeseen needs.

The drawback of the consensus-based approach is that it may not always be achieved. The reasons are many; nevertheless, disagreements can split a standard committee to the point that dual or multiple agreements result. When political compromise is not practical, technology can offer alternative solutions. In such cases etiquettes are one mechanism to achieve functionality between multiple similar standards.

Where will the standard be used?

The applicability of a standard can be assessed in terms of market, industry or geography. Traditionally, standards use has been associated with governmental or supra-governmental requirements which are enforced over a defined geographic area. Increasing international trade is reducing the value of single country standards, but regional technical standards developing organizations (e.g., ATIS, ETSI) are certainly expanding their influence. Industry groups may also develop standards that relate to a specific industry or market.

Summary

We have proposed a framework for defining standardization activities. In choosing whether to be a standards seeker or a standards creator, it is suggested that an organization attempt to answer the above six questions and define the strata in which they operate.

Telecommunications services were once only for the transport of voice. Now, at the end of the 20th Century, the world's network providers are becoming private, for profit organizations, and the standardization of multi-media communications is too large a task for any single standards making organization.

In the last decade, standards activities and policy discussions have centered on reducing the legal and technical barriers for new communications network entrants, technological substitutions, and perhaps also, the exit of major participants in the older coalitions. Diversification of the network environment has thus far been attained at the price of potential bottlenecks, instabilities and conflicts.

Standards are the only realistic means of maintaining compatibility in increasingly complex multi-media communications. Therefore, governments, standards practitioners and commercial communications organizations of the 21st Century need to comprehend the rationale behind standards development.

Go to the directory of Ken's lectures, published articles and book reviews

This page was last updated March 9, 1998.

Return to CSR Home Page