Alternatives to Financing the Standards Development Process

Martin B.H. Weiss
Telecommunications Program
Department of Information Science
University of Pittsburgh
Pittsburgh PA 15260
mbw@tele.pitt.edu

Michael B. Spring
Department of Information Science
University of Pittsburgh
Pittsburgh PA 15260
spring@pitt.edu

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Abstract

Over the last several years, economists have studied the impact of standards on market dynamics. Recently, there has been increased attention to standards as barriers to free trade[1]. The Office of Technology Assessment [US Congress, Office of Technology Assessment, 1992] has suggested a variety of policy level concerns, including trade related matters, and suggests that in part the issues may be based on the U.S. approach to funding standards. Weiss and Toyofuku [Weiss and Toyofuku, 1993] examined the costs and benefits of standards development with an eye to determining who bears the majority of the costs and who derives the most significant benefits.

This paper proposes and demonstrates a framework for examining the financing of the standards process. This analysis examines the types of costs borne by different participants and the benefits they receive from participation. This qualitative analysis provides a framework for subsequent quantitative analysis. Thus, the primary objective of this paper is to set the stage for more detailed cost/benefit analyses. Subsequent research would include both theoretical analyses of the impact of alternative financing strategies on social welfare and empirical analyses of the present and alternative approaches.

The paper concludes with an analysis of current funding strategy and proposes alternative strategies for financing. In developing alternative funding strategies we seek to distinguish those aspects of the standards process that are best left to private financing from those aspects which will be under-provided by privately financed strategies suggesting some role for government.

[1] With the elimination of many of the traditional mechanisms used to restrict free trade as a result of the Uruguay round of GATT, standards – previously a minor barrier to free trade – become one of the significant remaining barriers to free trade.

1 Introduction

In the decade since scholarly work on standards began, the basic dynamics of standards in the marketplace have been reasonably well described[2]. Some empirical studies have been performed to examine the actual behavior of the marketplace and of committees[3] (even though this sampling is far short of what is necessary to fully understand standards), and preliminary attention has been paid to modelling the standards development process [Crane, 1979, Lehr, 1992]. Much anecdotal literature exists addressing changes in the standards process [Cargill, 1989], although little has been done to quantify this (see [Bonino, 1991, Weiss, 1991] for attempts at quantification). The properties, attributes, and related marketplace behavior of different kinds of standards, such as software standards *vs.* hardware standards, have not yet been researched.

The question of how to finance the standards process was been raised by the Office of Technology Assessment [US Congress, Office of Technology Assessment, 1992]. Additionally, Weiss and Spring [Weiss and Spring, 1992] began to address selected issues of financing in the context of intellectual property issues, and established a broad analytic framework for addressing financing issues through an examination of the specific, detailed pattern of costs and benefits of standards [Spring and Weiss, 1994].

This kind of study is pertinent in light of the numerous discussions that have occurred in recent years on restructuring the U.S. standards process. Several different kinds of standards are developed in the United States under the auspices of a multitude of professional and industrial organizations [Cargill, 1989, US Congress, Office of Technology Assessment, 1992]. Garcia [Garcia, 1993] shows that this approach developed in the early part of this century because of a policy preference for private enterprise over government-directed activity[4]. As a result, numerous Standards Development Organizations (SDOs) emerged, none with a clear, centralized authority. The situation is compounded today by the growing popularity of consortia [Weiss and Cargill, 1992] and the increasing use of public specifications developed by dominant producers such as Microsoft. Each SDO, consortium, and industrial organization has different rules, procedures, and motivations for developing standards.

The OTA report [US Congress, Office of Technology Assessment, 1992] suggests that the lack of a single authoritative SDO hampers United States efforts in the international standards arena. The report was critical of the market driven, decentralized process that is in place, particularly given the planned and organized approach used by our major trading partners. While there has been increased support for chartering the American National Standards Institute to serve as the official United States voice on standards, it is difficult to see how such a charter will improve the fundamental problems of funding the development of high quality standards that serve the interests of both the nation's industrial and commercial sectors and the nation as a whole. Even without considering the issue of external pressure, Weiss and Toyofuku [Weiss and Toyofuku, 1993] have raised questions about the sustainability of the current process in light of the "free riders" in the standards development process

[2]For surveys and summaries of this literature, see [David and Greenstein, 1990], [Greenstein, 1992], and [Besen and Farrell, 1994].

[3]The work of [Gandal, 1994], [Shurmer, 1993], and [Weiss and Sirbu, 1990] are examples.

[4]Garcia points out that the early predecessor to the National Institutes of Standards and Technology (NIST) was financially and politically crippled in the face of active lobbying and concern over government meddling in this "commercial" activity.

In terms of financing, the situation in the United States generally mirrors the situation internationally. In the International Telecommunications Union Telecommunications Standardization Sector (ITU-T),

> ". . . each organization bears the direct cost of participation of its experts in ITU-T meetings, including travel, hotel accommodations, etc. Such costs are quite substantial, particularly if one considers the costs arising from preparatory work (developing proposals, harmonizing them on a national and regional level, drafting the contributions, etc.). All this work prior to a meeting costs money, to be spent by each participating organization.
>
> "The costs incurred by TSB [Telecommunications Standardization Board] for providing logistical support, for translation, interpretation, printing, and mailing all paperwork, for salaries of TSB staff, etc., are covered by financial contributions by Administrations and other organizations admitted to take part in ITU-T activities [Irmer, 1994]

Private financing such as this is not the only funding strategy that is in use today. The European Telecommunications Standards Institute (ETSI) pays some standards developers in order to accelerate their work [Bernt and Weiss, 1993, Robin, 1994]. Colleen Preston, Deputy Undersecretary of Defense for Acquisition Reform, reported at the National Research Council Conference on Standards and Trade that as a part of acquisitions reform, DOD will be looking to pay for the development of public standards where none exist as an alternative to "Milspecs" and "Milstds". Similarly, the very high costs associated with some consortia may be viewed as upfront costs by the corporate sponsors to accelerate the standards development process.

Even though the free market approach seems to be gaining favor in Europe, there remain numerous examples of standards development that is more heavily government supported than is the case in the United States. While the private sector has resisted increased government involvement, even that limited to funding, there have been recent signs of a willingness on the part of some to accept government support so long as it does not imply increased regulation and bureaucracy [Oksala, 1994]. However, no analysis exists that provides a grounded explanation of what funding *should* be provided and how it should be provided.

To determine where funds should be directed, an analytic framework that articulates the costs and benefits accruing to the various stakeholders (such as the one developed by Spring and Weiss [Spring and Weiss, 1994]) is needed. This paper is directed more towards the alternative funding mechanisms and their analysis.

2 Framework for Analysis

At a global level, it is difficult to compare the costs and benefits of the 3.5 inch floppy disk standard with the costs and benefits of the TCP/IP standard. Even closely related standards such as IEEE 802.3 (Ethernet) and IEEE 802.3*i* (10BaseT) vary significantly in complexity, time required for development, cost of related product development, and length of use. All of these are factors in the cost of standardization. On the benefits side, the situation is equally complex. There are both direct and indirect benefits to the developers and users of a standard. This section provides a framework for the analysis of the costs and benefits of standards.

While any number of different dimensions might be selected as the basis for cost analysis, three stand out in the literature.

1. The type of standard
2. The nature of the development process
3. The scope of the standard

Types of Standards The costs (and benefits) of developing a standard before products are developed will be different–in distribution if not magnitude–from the costs of developing a standard based on existing products. Similarly, there are different costs and cost distributions for reference, base, syntax, and implementation standards. While different, the anticipatory–traditional and reference-base-syntax-implementation dimensions are not fully orthogonal. Reference models are almost always anticipatory. Similarly, derivative standards are frequently based on successful products. In contrast, base or syntax standards may be anticipatory (ISDN) or traditional (Ethernet). The qualified marriage of these two dimensions yields the following classification for standards by type:

Several previous authors have concerned themselves with typologies of standards[5]. Drawing from this work, [Spring and Weiss, 1994] suggested that the following typology of standard was appropriate for considering funding issues:

1. Reference
2. Anticipatory Syntax
3. Traditional Syntax
4. Anticipatory Base
5. Traditional Base
6. Implementation

Lacking accurate data, it is reasonable to assume that costs and benefits will be significantly different for each of these types of standards. Analyses that do not factor out the different costs and benefits will not provide a fair picture. Note that the following definitions apply:

1. Reference models serve to organize an area and serve to constrain and focus other standards. They are not implemented directly, but through the base standards they call for. Perhaps the most famous reference standard is International Standards Organization (ISO) 7498, The Open Systems Interconnection Reference Model.
2. Base standards form a measurable and implementable product or process description. These form the majority of the standards developed by traditional SDOs. IEEE 802.3 would be an example of such a standard.

[5]See [David, 1987], [Bonino and Spring, 1991], [Bonino, 1991], [Cargill, 1989], [Spring and Bearman, 1988], and [Spring, 1991]

3. Syntax standards specify a language or procedure that may be used to develop other standards. Thus while a computer language standard is a base standard (because programs developed in the language are not themselves standards), a standard such as ISO 8879 – Standard Generalized Markup Language (SGML) is intended to spawn implementations of the language that are themselves standards, such as CALS or Z39.59[6].

4. Implementation or derivative standards are standards developed from syntax standards or those with a significant dependence on a base standard. Clearly Z39.59 is an implementation of SGML.

As with typology, significant work has been done on the phases of standardization[7]. Drawing on these [Spring and Weiss, 1994] identified the following phases of standards development:

1. Requirements analysis
2. Document development
   (a) Objective setting
   (b) Development
   (c) Specification:
      i. of interface, characteristics, etc.
      ii. of conformance requirements
3. Standard approval
4. Document dissemination
5. Implementation:
   (a) of products
   (b) of conformance tests
   (c) of derivations of the base standards
6. Management
   (a) Maintenance of the standard
   (b) Establishment of certification procedures
   (c) Development of registry agents and conventions
7. Certification of products and registration of standards

[6] ISO 8824 – ASN.1 would be another example of a syntax standard.
[7] See [Weiss and Spring, 1994], [Standards Committee X3, 1993], and [Reilly, 1994].

Three points need to be made about this model. First, the phases are not necessarily linear. The use of formal description techniques (FDTs) in the specification phase may obviate the need for, or significantly reduce the cost of, the development of test suites in the implementation phase. At the same time, the use of an FDT is likely to increase the cost of the specification phase. Second, the expanded model defines a scope that spans organizational boundaries as they exist today. Third, not all phases apply to all standards types or to all the standards within a type. For example, it is generally meaningless to talk about conformance to a reference model. Standards that can generate conformance tests based on FDTs and that are subject to self certification will not have steps for review and certification of testing agencies. Similarly, a registration facility is only necessary where it is required by a base standard.[8]

Finally, [Spring and Weiss, 1994] proposed a classification based on the scope of a standard:

1. Community impacted:
   (a) General population–all or a large segment of the population
   (b) Population segment–only one group within the population, such as the publishing community, or the service sector
   (c) Development segment–a population segment that includes only the kinds of individuals involved in developing the standard
   (d) Developers–the standard affects only that group directly involved in the development of the standard
2. Scope of Agreement:
   (a) Industry or enterprise group defines the scope of agreement
   (b) National bounds define the scope of the agreement
   (c) A regional group of nations defines the scope of agreement
   (d) The global community defines the scope of agreement
3. Period of commitment:
   (a) The commitment is temporary for either political or technical reasons
   (b) The commitment is indeterminant, and while expiration is anticipated, no fixed time period is set
   (c) The commitment is considered to be indefinite, and no change is anticipated, or the commitment is made to observe the standard for a long period of time–more than 10 years from adoption, even if change might be desired

Combining these elements suggests Table 1, which provides a framework within which to assign costs for each kind of standard by its phase. This table crosses type of standard with phase of

[8]For example, since ISO8879–Standards Generalized Markup Language (SGML) assumes the development of shared Document Type Definitions (DTDs), it was necessary to specify Registration Procedures for Public Text Owner Identifiers–ISO 9070 to allow for the registry and availability of DTDs, which are in essence derivative standards or conventions.

	Reference	**Syntax**		**Base**		**Implmnt.**
		Anticip.	Trad.	Anticip.	Trad.	
Analysis						
Development *design* *specification*						
Approval						
Dissemination						
Implementation *products* *tests* *derivations*						
Management *maintenance* *certification* *registration*						
Certification						

Table 1: Cost Breakdown by Type of Standard

standardization. It is reasonable to expect that different costs can be expected in different phases for the different types. Areas of high cost will require careful examination and elaboration while areas of low or no cost may generally be ignored. Added to this analysis will be additional lost opportunity costs based upon an assessment of the scope of the standard. For limited scope standards, the costs are simply those of development. For standards that have significant scope in terms of impact, community, or period, additional direct costs or indirect costs must be added. The indirect costs will include lost opportunity, compromise, and commitment costs.

More relevant to the subject of this paper, however, is *who* bears the costs and receives the benefits of a standard. [Weiss and Toyofuku, 1993] proposed the categories of active developers shown in Table 2[9]. While all of these groups benefit from standards, Type 1 free riders incur no significant costs related to the development of the standard, as delineated in Table 2.

The direct costs to developers and Type 2 free riders can be significant. In their analysis of the 10BaseT Ethernet standard (IEEE 802.3*i*), Weiss and Toyofuku estimated the total direct development cost of this standard to be between \$8.7M and \$13M. From this, the *average* firm spent between \$125,000 and \$185,000 to develop the standard. Given the uncertainty in the data, they were unable to estimate what the active developers spent as opposed to the Type 2 free

[9] "Free Riders" are firms that benefit from standards but do not contribute to their development; hence they get a "free ride" from the developers of the standard. To be a free rider, a firm sells compatible products after the standard is developed. Type 1 free riders are firms that wait until the standard is complete before developing compatible products. Thus, they make *no* investment in the development of the standard. Type 2 free riders attend standards committee meetings, thereby incurring costs, and gain advance information on the standard. Other organizations attend standards meetings as well, and are typically called *observers* and *interested parties*. Typically, these consist of representatives from other SDOs and users who have an interest or a stake in a particular standard.

Participants	*Costs*
Developers	Time and Travel General R&D Product R&D Conformance/Interoperability Tests Product Marketing and Distribution
Type 2 Free Riders	Time and Travel Product R&D Conformance/Interoperability Tests Product Marketing and Distribution
Type 1 Free Riders	Product R&D Conformance/Interoperability Tests Product Marketing and Distribution
Standards Development Organizations	Time and Travel Publication and Mailing
Participating Users	Time and Travel

Table 2: Costs by Types of Participant

riders. Beyond these direct costs to participants, SDOs must also pay for various administrative support costs such as photocopying, mailing, meeting rooms, preparation of minutes, procedural support, and verification.

Similarly, conformance testing costs have to be calculated. The "classical" method for conducting a conformance test is to build an apparatus to which implementations of the standard (typically referred to as the Implementation Under Test, or IUT) are attached. The apparatus stimulates or "exercises" the IUT and observes its responses. The responses and their timing are measured by the conformance test apparatus and compared to those specified in the standard[10]. Alternatively, manufacturers can connect their implementations to existing implementations (normally from other vendors) in the marketplace. If they interoperate properly, then the new implementation is thought to conform to the standard[11]. This approach is sometimes called *interoperability testing* to distinguish it from conformance testing, since it focusses on product interoperability instead of conformance to the standard. This is arguably what end users want. Finally, there is *self certification* as a conformance test process. Here, vendors conduct their own conformance tests instead of relying on a third party to conduct them. An end user may challenge the conformance to the standard, and only at that time does the vendor have to produce the conformance test results.

From a cost distribution standpoint, each of these approaches to conformance testing have the following common feature: in each case, *any* organization that manufactures products conforming to the standard incurs these costs, regardless of the organization's participation strategy. There are some costs that might be borne by an SDO if it is involved in administering the conformance

[10] See [Linn, 1989, Linn, 1990] for a more detailed discussion of the technical aspects of conformance testing.

[11] Actually, the implementation conforms to those implementations of the standard. If an implementation of the standard is different from the standard but dominates the market, a *de facto* implementation of the standard could well emerge that may not conform to the actual standard.

test. It is assumed here that the development of the conformance test was part of the standards development process.

2.1 Analysis of Benefits

While any number of different dimensions might be selected as the basis for benefit analysis, we suggest that as with costs, benefits differ based on the type of standard being developed, its scope, and the group or stakeholder affected. While costs can best be analyzed by development phase, benefits are best analyzed by examining the groups to which the benefits accrue.

Three groups benefit from the development of a standard: the developers, the SDOs, and the users. Each of these groups may be further subdivided as shown below.

1. Developers
   (a) Active developers
   (b) Type 1 free riders
   (c) Type 2 free riders
2. Standards Development Organizations
   (a) Sponsoring SDO
   (b) Liaison SDO
3. Users
   (a) Producer users
   (b) Consumer users
   (c) Nation states

While it is theoretically straightforward, even if practically difficult[12], to attribute monetary costs for standards developers, it is more difficult to evaluate benefits.

For developers, gross revenues may be a reasonable metric of benefits[13]. For SDOs, gross revenues may also be a good metric[14]. For users, at the level of the nation state, the *existence* of a standard may meet some social goal and benefits may not be directly measurable in monetary terms.

[12]Studies by Weiss, Bonino, Toyofuku, have encountered tremendous difficulties in quantifying the costs associated with participation in the standardization process.

[13]Net revenues may have an advantage since it reflects the actual benefit a corporation gets. However, if "net revenues" is used as a measure, the costs are double-counted in the cost-benefit calculus.

[14]SDOs are frequently not-for-profit corporations, so gross revenues may be more appropriate. Shortfalls in gross revenues with respect to costs may be made up via other sources, such as membership dues, as long as the goals of the membership are satisfied.

Developers Developers have three major avenues for recovering their investment in the standards development process[15]:

1. Profits from products based on the standard
2. Consulting with other companies based on the expertise they developed in the development process
3. Royalties and licensing fees based on intellectual property owned by the developer that was incorporated into the standard[16]

In addition, developers may receive an indirect benefit associated with the prestige and industry leadership associated with active standards participation. There may also be some strategic benefits to actively participating even if the developer does not intend to manufacture and produce products conforming to the standard [Weiss, 1991, Besen and Farrell, 1994].

Simple analysis suggests that active developers must be able to recover their investment in the standard by being an early entrant to the market for compatible products[17], by building subcomponents (such as integrated circuits) that other product developers would likely use[18], or through other means. If the standard is delayed sufficiently to void their product leadership capability, it will be difficult for a firm to justify continued participation in the standards process, as it will be a money losing operation. The long term consequence of this is an under-supply of traditional, SDO sponsored standards. Of course, standards will still emerge where they are demanded by the marketplace, it is just that the emergence mechanisms will bypass the SDO process[Besen and Farrell, 1994]. Firms may find it more attractive to attempt the establishment of "proprietary standards" (such as MS-DOS) rather than to develop them cooperatively in committee if the free ridership losses are too high[19] Alternatively, firms could raise the cost of free ridership by developing the standard in a private group and leaving the details of the standard proprietary to the group members. After the details of the standard have been worked out, the information could be made public either in the context of a traditional SDO, or as a "public specification". Thus, developers would retain the market leadership advantage and still enjoy the coordination benefits. In fact, such groups (called *consortia*) have already emerged in information technology standardization [Weiss and Cargill, 1992]. Their high membership fees restrict participation to the most interested organizations. Consortia are not internationally recognized SDOs; however, since their members typically have a strong installed base and/or market share, their standards may have a large impact. Non-members of a consortium have a strategic interest in making small but significant changes to a consortia's standard should it be submitted to an SDO to blunt the market advantage of the consortium's members [Weiss, 1991].

[15] See [Besen and Farrell, 1994] for a more detailed discussion of this.

[16] This has been an area of some controversy. Firms are required to come up with fair and non-discriminatory terms for all intellectual property that they contributed to the committee. Different countries have had varying postures with respect to IP in standards.

[17] This assumes that early adopters are willing to pay a higher price for the product, and that difference between price and cost is high.

[18] For example, [Weiss and Toyofuku, 1993] found that semiconductor manufacturers, as opposed to developers of end products, were among the most active participants in the development of the IEEE 10BaseT standard.

[19] [Farrell and Saloner, 1988] address the choice of market rivalry *vs.* institutional standards development. Their analysis could be extended to include free-ridership losses.

Organization	*% Revenues*
American National Standards Institute	28%
American Society for Testing and Materials	80%
National Fire Protection Association	66%

Source: United States Congress, Office of Technology Assessment [US Congress, Office of Technology Assessment, 1992]

Table 3: Revenue from Sales for Selected SDOs

Standards Development Organizations The OTA has shown that many SDOs seek to recover the costs of standards development through the sale of standards documents. In fact, this revenue has become a significant fraction of their overall operating budget in some cases (See Table 3). Other revenues for these organizations are typically derived from membership dues and other sources. Thus, the administrative portion of the standards development process is supported by all who purchase standards documents. The other major source of revenues comes from the membership dues of the participating companies. As the OTA report pointed out, competition for revenues has led to hostilities within the standards development community [US Congress, Office of Technology Assessment, 1992].

Currently, many SDOs receive a portion of their operating funds from royalties derived from the sales of standards documents. [Weiss and Cargill, 1992] argued that many of these had relatively weak intellectual property protection because of the nature of the document – they describe facts – so this revenue stream is not reliable. They further suggest that royalties from conformance tests might be a more reliable strategy for recovering revenues.

Liaison SDOs also receive benefits from standards developed by other SDOs. They may benefit from not having to develop infrastructure standards, which may simply be referenced. More dramatically the development costs for other types of standards may be all but eliminated, particularly in the case of national standards adopted from the international arena or international standards based upon national standards. Adopting SDOs achieve all of the benefits of the sponsoring SDO with the caveat that their sales of the adopted standard will not be as high.

Users Three categories of users are suggested: producer users, consumer users, and nation states. Producer users provide products or services that are related to the products or services directly based upon the standard. Developers of test suites are a prime example of this category. Another example might be a developer of database systems who uses an SQL compliant front end, produced by a developer, to make their database system more attractive to potential customers. Consumer users make use of products that in some way depend upon the standard. Thus corporations that build client server database systems with SQL front ends derive benefits from the standard nature of the database interface. Similarly, many users derive significant benefits in terms of product cost and system design flexibility from reliance on products that use Postscript as the interchange standard between software and display devices. These consumer users may be small or large groups. They may be vertically integrated corporations or groups of corporations engaged in an enterprise; the largest single group is often the United States government.

The last category of user is the most difficult to define. By referring to it as the nation state we intend to suggest that it is the collection of individuals who benefit from a standard even if they don't make use of it, even indirectly. As a user, the government can play an important

	Reference		**Syntax**				**Base**				**Implmnt.**	
			Anticip.		Trad.		Anticip.		Trad.			
Participant	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.
Developers												
active	H	M/L					H	H				
T2 free riders	M	M/L					H	H				
T1 free riders	N/A	M/L					N/A	H				
SDOs												
sponsoring	H	M					H	H				
liaison	L	H					L	L				
adopting	L	H					L	H				
Users												
producer	N/A	N/A					L	M				
consumer	N/A	N/A					L	H				
nation state	H	H					L	M				

Table 4: Cost and Benefit Analysis by Type of Standard

role in supporting the emergence of a "bandwagon" around potentially strategic or important technologies [Anderson and Xie, 1991]. It can be argued that the United States government played this role with internetworking technologies by supporting the ARPAnet (and later the Internet) or by supporting other technologies such as commercial aircraft manufacturing. While the active picking of "winners" and "losers" is often decried as industrial policy, the United States has a tradition of doing this, albeit often for defense reasons[20]. Other countries are more open about their support for emerging standards and technologies.

3 Costs and Benefits

By carefully examining the costs incurred by each participant in each phase of the standards development process for different types of standards, and by comparing these to the benefits achieved by groups for each type of standard, we can assess how each group fares for each type of standard. This provides clues as to which phases of which types of standards are suitable for different standards funding methodologies. This analysis also allows for prediction of which standards with significant social benefits might be under-provided under the current funding scheme.

Table 4 is an initial attempt at constructing such a matrix. A portion of this table is completed using anticipatory base standards and reference standards as examples. While there is a considerable body of anecdotal evidence based on previous work by [Bonino, 1991, Weiss and Sirbu, 1990, Weiss, 1991, Weiss and Toyofuku, 1993], there is, as yet, no standard for of data collection to allow such a matrix to be filled in consistently for all standards.

[20] In the early days of telegraphy and railroads, the government actively supported the efforts of these new companies by granting them special privileges. The Post Roads Act (1866) gave Western Union the permission to use public rights of way and they could fell trees for poles at no charge [Horwitz, 1989].

It is also important to briefly discuss what is labelled as "benefits" in Table 4. The other factor that must be considered is the "specificity" of the benefits. That is, are the benefits of the standard easily identifiable to developers? An example of a specific benefit would be revenues and profits from the sale of a product based on a specific standard (*eg.* 10BaseT network interface cards and hubs). An example of a diffuse benefit would be the benefits attributable to a reference model. Firms that contributed to the development of the OSI reference model could not ship products containing the reference model. Benefits would exist, however, because the *structure* of different vendors' data communications systems would be similar, allowing for easier interoperation. Furthermore, if a developer of the reference model intended to develop subsequent base or syntax standards consistent with the reference model, presumably this development would be expedited because a framework for the base standards would exist. Hence, diffuse benefits do not imply absence of benefits; diffuse benefits merely imply difficulty in *measuring* benefits, which can reduce the *apparent* benefit.

3.1 Example 1: Anticipatory Base Standards

Returning to the case analyzed in [Weiss and Toyofuku, 1993] and introduced in Section 2, (page 7), it was found that, of the product manufacturers who were active developers of 10BaseT, only one (Hewlett-Packard) had a significant market share. The estimated collective market share of the Type 1 free riders dominated the market share of at least one of the developers. Thus, it would be fair to say that the Type 1 free riders benefitted significantly while not contributing to the cost. Similarly, some active developers (notably AT&T) never achieved a significant market share in the market for compatible end products. Thus, there is some evidence to suggest that at least one active developer may not have received an adequate return on their investment in the standards development from direct product sales.

Data were not available to identify the total revenues or profitability of the 10BaseT product line for each manufacturer, so it is impossible to determine whether they received a satisfactory return on their investment in the development of the 10BaseT standard. It is quite possible that the cost of developing the standard is dwarfed by the R&D cost of developing and marketing the products, so that it is essentially irrelevant. It is also possible that the market share of the the firms that actively developed the standard is steadily diminishing because their total costs are higher, and because the 10BaseT products are being reduced to commodities amenable to mass production in low-wage countries.

3.2 Example 2: Reference Standards

Unlike base standards, reference standards *per se* do not result in products; they are best understood as management or planning tools. For example, the OSI Reference Model, perhaps the best known of all reference models, by itself was never implemented in a product. Instead, the OSI Reference Model was used by the developers of subsequent base or syntax standards (such as HDLC, ASN.1, FTAM, and others) to organize the development of these standards.

It is difficult to measure the benefit to product developers of the OSI Reference Model by itself. It is possible that it helped reduce the development cost of subsequent base or syntax standards in that it clarified the interfaces between and required functionality of previously developed protocols. Despite the lack of general market acceptance of products conforming to OSI

standards, those that are successful in the market are often couched in terms of the OSI Reference Model.

We assert that the experience with the OSI Reference Model will be generalizable to reference models of all kinds. The essential economic feature of these kinds of standards is that their benefits are diffuse and cannot easily be referred to a product or even a group of products. Further, reference models make important statements about the architecture of future systems[21]. Since the development of reference models must necessarily consider future possibilities, information about the future will be valuable, scarce, and highly subject to individual vendor's market strategies. These attributes will most likely make for a costly development process for reference models[22].

An indirect measure of the benefit of reference models may be the frequency to which actual products shipped by a company refer to the reference model. If the sales and marketing efforts of companies actively promote consistency with a reference model, such as OSI, then the company is presumably gaining some benefit from it, since it perceives that buyers are interested in this feature.

4 Financing Standards Development

To identify areas that might be fruitful for alternative funding approaches, it is appropriate to examine those where the development costs exceed the net perceived benefits. Examining Table 4, it is clear that reference standards fit that category (others may fit as well). It is also clear that sponsoring SDOs must be provided some form of compensation for the development of high-benefit standards. These standards are likely candidates for adoption by other SDOs; while this is a good thing from the standpoint of public policy, it is something that must be addressed on the compensation side to ensure the continual development of high benefit standards.

4.1 An Analysis of the Present Approach to Standardization

Under the current system (in the United States), the costs are borne privately, but not necessarily in proportion to the benefits. It is possible for firms to free ride and still have access to the public good[23]. Nonetheless the current system attempts to recover administrative costs through profits on the sale of standards documents. Anyone who purchases the document subsidizes the system, even though those who incur the bulk of the cost – the developers – are not reimbursed directly for their investment except through the sale of products, licensing fees, and consulting fees, as discussed above.

The major advantage of this approach to financing standards is that those who stand to gain the most from a standard have the strongest incentive to contribute at the highest level. Thus,

[21] For example, the OSI Reference Model codified a *layered* approach to data communications. Other approaches to data communications exist as well, such as TCP/IP which uses a *hierarchical* approach.

[22] This need not be the case uniformly. Sometimes, vendors can be motivated to cooperate by a dominant firm. IBM may have provided the impetus for agreement on the OSI Reference Model with its Systems Network Architecture (SNA). Likewise, the fear of losing the workstation market to Microsoft's WindowsNT operating system motivated the vendors of competing Unix systems and standards to agree to the Common Operating Systems Environment (COSE)

[23] For example, a firm could refuse to pay membership fees to the SDOs and still participate in the process. SDOs are afraid of limiting participation because of the antitrust liabilities raised in the Hydrolevel vs. ASME case.

the system naturally allocates the development costs among the potential beneficiaries. The weaknesses of the current system include:

1. *Standards with diffuse benefits will be underdeveloped.* If no firm anticipates a significant benefit, then the standard will not be developed, despite the social benefit of having the standard. This is particularly problematic for standards or standards-related activities where the benefit is less tangible, such as reference standards, long range planning, and executive functions.

   The firms act on *expected* benefits. If their expectations are wrong because of delays in implementation of the standard (as with ISDN), because of free riders, or for other reasons, then the firm may be less willing to invest in standards development in the future.

   Perhaps more disturbing from a national point of view, dissemination of standards is driven by market demand. There is no coordinated effort to "sell" a given approach. This is particularly important for anticipatory standards, which are at heart marketing devices. This attitude is changing, and one sees encouraging developments in the telecommunications field (see [Matute, 1994]). At the same time, important standards in the IT arena continue to languish in part for lack of marketing effort. SGML serves as one example in this area (for a discussion of SGML's development and adoption, see [Adler, 1992]).

2. *Standards with specific benefits will be overdeveloped.* When there is a great interest in standards and multiple implementation approaches exist, multiple standards may emerge (as is the case in local area networks).

   Recovering the cost of standards development via document sales leads to competition among SDOs instead of coordination [US Congress, Office of Technology Assessment, 1992]. As the cost of the standards documents increase, the dissemination of the standard decreases. Thus, it is not clear that the benefits of standards are completely realized[24].

   There is no central authority for coordinating the efforts of the various SDOs. While the Information Systems Standards Board of ANSI makes an effort to avoid and resolve disputes between various SDOs, this does not coordinate strategic planning for the various SDOs, nor does it serve to coordinate submissions to the various SDOs. Thus, planning and requirements analysis are carried out in a vacuum.

3. *Only as much of the standard is developed as is needed by the beneficiary will be developed.* The conformance test development, certification, and registry functions are not directly accounted for in the model. While an SDO produces the standard, other organizations are responsible for developing test suites. For example, in the case of POSIX, while the base standard is developed by the IEEE, conformance tests have been developed by National Institute for Standards and Technology and X/OPEN. The situation is complicated further by the fact that certification of conformance in accord with the suites may be by the developer under self certification, or by yet another party–an accredited certification agency such as Corporation for Open Systems. In a simple world, such an arrangement might be workable. In the real world, the development of conformance test suites may uncover errors

[24] A common argument in the Internet community today is that the success of IETF standards is at least in part attributable to the low cost of obtaining these standards.

in the standard, and the certification process may mandate changes to both the standard and the conformance tests. All of this requires cross-organizational communication under the current model and greatly increases the total cost (see [Cashin, 1994]).

These shortcomings may be overcome in part by establishing additional mechanisms for funding standards. By imposing a "standards fee" or tax, those using products that rely on the standard would finance its development. In some ways, this approach attempts to recoup the cost of intellectual property embodied in the standards. While this may be conceptually sensible, significant distributional problems exist. A more extreme approach recognizes that standards are a public good, and would use public funds collected through general taxation to pay for the process, as is done in some countries. This approach relies on the taxation system for fairness and appropriate cost allocation.

4.2 A "Standards Fee"

In the standards fee approach, each product conforming to a standard would be subject to a surcharge to assist in the recovery of the cost of developing the standard(s) on which it is based. The fee would be collected and distributed to all developers of the standard until the costs that they incurred in developing the standard were covered. Thus, standards development is funded directly by users, as it is today, except that free riders' products would not be exempt from the cost of developing the standard. Thus, the cost differential of developers' and free riders' products would be based solely on the underlying production costs and not on the existence or absence of standards development costs.

While this addresses the issue of the free ridership directly, it is not without problems. There are some technical issues as well as incentive issues that emerge, for example:

1. Disbursement mechanisms would be required to ensure that the revenues from the fees are distributed in an equitable fashion to the developers based on their costs.

2. The fee should be in place only until the development costs of the standard are recovered.

3. The promise of revenues could distort firms' incentives to develop standards, so that standards may end up being over produced, or that the "wrong" kinds of standard might be over produced (*eg.* standards that might have been produced anyway, regardless of the existence of a "standards fee").

4. Firms having revenues that are below expectations for legitimate engineering or marketing reasons might shift more of their resources to standards development in hopes of bolstering their net corporate revenue, which would ultimately raise the price of their stock.

4.3 Direct Governement Subsidies

One can also make a case for direct government financing. The role of government in standards has been studied at some length by [Garcia, 1992, Garcia, 1993]. In [Garcia, 1992], she argued that the current standards process had its roots in the early 1900s, and reflects the market realities of that time, as well as the pluralistic tradition of the United States. In [Garcia, 1993],

she argued for the rationality of a stronger government role in U.S. standards setting given the present market realities. In particular, she pointed out that:

- It is well known that all economic transactions have *transaction costs* associated with them [Williamson, 1975]. Standards can reduce transaction costs, so government involvement to ensure an adequate supply of standards (that is, to ensure that they are not under-provided by our current market-based approach) results in increased economic efficiency, which generally meets economic and social goals.

- The lack of an active, coordinated standards development strategy could be a disadvantage vis-a-vis our competitors who have such a strategy. By failing to set the standards-setting agenda, we can be at a disadvantage in global markets, which reduces our overall competitiveness as a nation.

- The failure to support standards development processes in emerging economies, such as Mexico, India, and China, even as our most significant trading partners are doing so, leaves the United States at a significant future disadvantage in potentially important markets.

None of this addresses the role of government as a *financier* of the standards process, however. Garcia tends to argue that government should take a more active role in coordinating the activities of various organizations, and perhaps in setting the agenda for them, but stops short of proposing and analyzing a government-funded standards development process.

In this approach, standards are viewed as a public good, and broadly based government revenues are used to reimburse the developers of standards. This can be done either through direct payments or through tax credits. A critique of this approach would include:

1. While this is the standard approach to financing public goods, it is potentially distortive because it is not sector specific. That is, everyone's taxes contribute to finance standards even if someone never makes use of a standard, either directly or indirectly.

2. By hiring individuals instead of firms to do the work, ETSI avoids some of the incentive distortion problems that resulted from the standards fee. But individuals are often not as sensitive to cost and peformance tradeoffs as firms are, as the individuals would not ultimately be responsible for developing products conforming to the standard.

This approach has precedents in the information technology industry. The European Telecommunications Standards Institute (ETSI) uses *paid* standards developers are used to accelerate the development of a standard. The money for this expense comes from member countries, hence from a general tax levied on the citizens for the standards development process. In the U.S. the Department of Defense (through its Advanced Projects Research Agency) and later the National Science Foundation (NSF) directly funded the development of the TCP/IP protocol suite, which now enjoys considerable marketplace success. The funds to support this were drawn from the general tax revenues.

Direct government financing of selected standards activities seems to be beset by fewer distributional problems, even if it is somewhat distortive. If the efforts to finance standards development were focussed on the types of standards that were likely to be under-provided (such as reference models) then this distortion would be minimized

5 Summary

We have presented a preliminary framework for considering standards financing. Clearly much work must still be done in this area, particularly to establish an empirical basis for the conclusions. Nonetheless, it seems that some alternative financing mechanism must be found for some types of standards, lest they be under-provided. We have proposed two alternative financing mechanisms as a basis for the continuing discussion in this area. While the details must still be worked out for both of the alternatives, we believe that they would solve the under-provision problem, even though they might raise other problems.

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