Chapter 2
A Context for the Study:
Using the Literature to Develop a Preliminary Conceptual Model

2.1. Introduction

Chapter 1 introduced the research study. This chapter locates Z39.50 development in the broader context of standards and standards development and introduces the preliminary conceptual model that guided the research. Since this is a research study on standards development, it is important to identify connections between this study and previous research on the topic. As noted in Chapter 1, there has been little empirical research on the development of information technology standards. There is, however, an extensive literature on standards and standards development.

This chapter has several objectives. One is to provide additional context and background for the research. Another objective of the chapter is to provide evidence and support from the literature for the preliminary conceptual model that guided this study. The support takes the form of identifying the complex of entities, activities, and processes involved with standards development as discussed in the literature on standards. An examination of the various models and frameworks related to standards development provides this support. The chapter also provides a basis for developing the tentative definitions and concepts underlying the model and framework. This review identifies selected research on and approaches to understanding the standards development process. Finally, this chapter indicates how this complex arena is most adequately studied using the research approach and methods described in Chapter 3.

While there are apparent differences in how the literature review should be used in a qualitative study such as reported here, there is agreement that the literature review does not serve the same function as it does in a conventional, hypothesis–testing study (see Glaser, 1978; Marshall and Rossman, 1989; Merriam, 1988). In those studies, the researcher uses the literature review to identify the theoretical basis for the research so as to identify and operationalize variables, determine measures for the variables, and so forth.

The guidance that informs this literature review comes from Glaser (1978, p. 3) who warns the qualitative/naturalistic researcher to enter the research setting with "as few predetermined ideas as possible—especially logically deducted, *a priori* hypotheses" so that the researcher can see and record data without having filtered them through these hypotheses and biases. Glaser suggests, however, that the theoretical sensitivity of the researcher "is necessarily increased by being steeped in the literature that deals with both the kinds of variables and their associated general ideas that will be used" (p. 3). Strauss and Corbin (1990, p. 42) describe theoretical sensitivity as an "attribute of having insight, the ability to give meaning to data, the capacity to understand, and capability to separate the pertinent from that which isn't." They claim that the literature is one source for developing theoretical sensitivity.

Reviewing the literature served several purposes. First, it examined how others described and assessed standards development processes to provide background for this study, and to increase the researcher's theoretical sensitivity, and to corroborate certain assumptions and conclusions the researcher reached through his previous involvement in standards development projects (e.g., standards development is a multifaceted and complex social process). Second, it confirmed that few empirical and analytical studies have been conducted on standards and standards development. The previous studies were not directed at producing a holistic understanding of standards development, which was a primary goal of this study. Third, the review revealed a number of models and frameworks that address one or more aspects of the development of standards. These models influenced the researcher's choice of the preliminary conceptual model (see Section 2.6) and suggested components to include in that model.

This chapter first reviews the literature on standards to discuss definitions and categorization schemes for standards. Next, the chapter describes several standards development processes. It explores the special characteristics of information technology and associated standards that challenge the existing standards processes. The latter half of the chapter highlights various models of standards development offered by several writers. This lays the groundwork for introduction of the preliminary conceptual model that guided this research.

2.2. Introduction to the Literature

The literature on information technology standards, standardization, and standards development has grown in recent years, but specific research studies are relatively rare. One finds many discussions of particular standards, descriptions of the formal mechanisms of standards developers, and descriptions of the organizations that are developing information technology standards. Descriptions of the standards developers, organizations, and their work help identify some of the players in information technology standards. Awareness of the formal procedures is necessary in understanding one of the contexts for standards development. In addition, the literature includes speculations, sometimes written by people actively involved in standards work, that offer important perspectives on the many issues and challenges of information technology standards.

The existing writings on standards and standards development relevant to this research fall into several categories:

- General overviews on standards development, with a focus on the organizations responsible for developing standards
- Conceptual and speculative approaches that describe models, issues, and problems related to information technology standards and standards development
- Analytical and theoretically based approaches that attempt to explain behaviors and activities involved in information technology standards and standards development
- Research–based approaches that discuss and describe standards development
- Information on Z39.50, the specific standard of interest in this research.

This review uses the literature from all five categories to accomplish the objectives of this chapter. Of particular interest, however, was identifying the extent of previous research that provides a basis for understanding standards development.
Spring (1991), in a major review of research on standards, concludes that "little empirical research exists on the standardization process itself" (p. 99), but adds that "there is a growing number of studies

of standards and the standardization process" (p. 92). His review suggests that researchers have generally been interested in three basic questions (pp. 92–93):

- How do we know when a standard needs to be developed?
- What factors affect the choice of a given process or product as a standard?
- What is the best way to develop a standard?

The conceptual work on frameworks for standards development or standardization by Cargill (1989), Spring and Bearman (1988), and others can be understood as partially addressing the first question posed. There is little evidence of existing research that addresses the third question.

The body of literature that this researcher refers to as "analytical" writings primarily addresses the second question. Most of this literature comes from the discipline of economics, particularly microeconomics and game theoretic approaches to the questions about technology choice and the development of standards for compatibility. For example, using a theoretical model, Katz and Shapiro (1985) examine the effects of network externalities on the installed base of the technology and the choices to move to a new technology. Farrell and Saloner have contributed a number of important works (1985,1986, 1987,1988). One investigation (1988) examines how standards committees serve the purpose to coordinate stakeholders, and Farrell and Saloner use game theory to compare the performance of standards committees with the market in terms of coordination. They suggest that the "careful and explicit cooperation" found in standards committees is a "natural response to the need for coordination" (p. 236).

The economics literature was of limited use in this research. This is due in part to an almost exclusive focus on market–mediated activities *vis a vis* standards, especially in the ***use*** of standards (e.g., to achieve competitive advantage), rather than a focus on standards ***development***. It contributed minimally to the development of the preliminary conceptual model.

In the category of empirically based research reports on standards, only a small number are evident in the literature. Spring, et al. (1995) report on a survey of members from various standards committees to identify ways to improve the traditional standards development process. Specifically, the study focuses on possible interventions in the standards process through the training of chairpersons and members. Weiss and Sirbu (1990) report on a research study to test whether the outcome of a standards process is random. Through an empirical investigation they hypothesize that firms participate in voluntary standards processes because they want their technology adopted in the standard to gain competitive advantage. In another study, Weiss (1989) investigates data modem standards development to identify the relationship of timing of product release with approval or publication of a standard; this was intended to explore the issue of anticipatory standards.

Another group of reports on standards is based on case studies of one or more standards (Besen & Johnson, 1986; Crane, 1979; David, 1985; Sirbu & Zwimpfer, 1985). While providing important historical information about some of the forces at work in the development of standards ranging from color television standards and communications standards to the QWERTY keyboard, there is little evidence that the case studies were guided by or developed conceptual or analytical models of standards development.

Research studies on information technology standards are not plentiful. However, there is an increased awareness that standards development processes present important problems in need of research. Weiss and Spring, in particular, and others have undertaken important initiatives to conduct systematic research on standards development. The Office of Technology Assessment (OTA) in a major study on standards and their role in the increasingly global marketplace, suggests that the Federal government consider funding research on standards because of the relative lack of understanding of this vital area (Office of Technology Assessment, 1992). OTA (p. 26) states that much of the research takes a relatively narrow economic focus and added that there are much broader concerns that affect standards including: the role of standards organizations and their relationships to one another; the full range of motivations for participation in standards processes; and the impact of globalization of the standards process. They concluded that "there is almost no current work being done to anticipate future standardization problems or standards needs."

2.3. Definitions of Standards

It may appear as a striking irony that there is no one "standard" definition of a standard! Cerni (1984, p. 8) states:

> The term 'standards' suffers from centuries of use and misuse. The meaning of the term can be vague and amorphous, even though standards have become an essential, all–pervasive element of modern society….Not only is the term used in a variety of contexts (e.g., various industries, economics, medicine, law) with different connotations, but the voluntary and/or regulatory aspects of standards are often misunderstood and misconstrued.

A rudimentary and commonsense definition of a standard might be:

> *An agreement among people to do certain things in certain ways to achieve desired and expected ends*.

This definition of a standard does not specifically address how people develop a standard. The statement suggests that the standard is an agreement, and, thus, implies a set of activities that may be involved:

- Identifying the problem or topic
- Communicating information on the problem or topic
- Sharing perspectives on the problem or topic
- Discussing various and possibly conflicting approaches to solving the problem
- Negotiating and compromising to develop an agreement
- Deciding (e.g., unilaterally, by majority vote, by building consensus) what the agreement covers and the specifics of the agreement.

Portraying standards development in this way highlights the social aspect of these activities. This commonsense inventory of standards development activities provides a suitable, albeit tentative, framework for thinking, in general, about the development of standards. It can be expanded to include some of the elements reflected in the definitions offered by a number of writers and organizations. Table 2–1 presents a selection of definitions of "standard" found in the literature.

Table 2–1
Definitions of Standards

Standards generally describe, define, or document an already existing reality (or problem solution) so that others can easily reproduce this reality (or solve a similar problem), thereby avoiding a duplication of effort. (Cerni, 1984, p. 9).

A prescribed set of rules, conditions, or requirements concerning the definition of terms; classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices. (Definition offered in the National Policy on Standards for the United States, 1979, quoted in Cerni, 1984, p. 10).

A technical specification or other document available to the public, drawn up with the cooperation and consensus or general approval of all interests affected by it, based on the consolidated results of science, technology, and experience, aimed at the promotion of optimum community benefits, and approved by a body recognized in the national, regional, or international level. (Definition offered by Kemmler, "Codes, Standards, Accreditation, and Certification." ASTM Standardization News, quoted in Cerni, 1984, p. 10.)

A standard is the deliberate acceptance by a group of people having common interests or background of a quantifiable metric that influences their behavior and activities by permitting a common interchange. (Cargill, 1989, p. 13)

An explicit definition that can be communicated, that is not subject to unilateral change without notice, and that, if properly followed, will yield predictable and consistent results. (Crawford, 1991, p. 8)

A document, established by consensus and approved by a recognized body, that provides for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. (Definition offered by the International Organization for Standardization (ISO) in Spivak & Winsell, 1991, p. 319.)

A prescribed set of rules, conditions, or requirements concerned with the definition of terms; classification of components; delineation of procedures, specification of dimensions, materials, performance, design, or operations; measurement of quality and quantity in describing materials, products, systems, services, or practices; or descriptions of fit and measurement of size. (Office of Management and Budget, 1993, p. 57645)

Abstracting from the definitions in Table 2–1 and other definitions, the researcher proposes the following working definition of a standard for purposes of this study:

> *A standard represents an agreed upon response to a recurring problem—perceived, anticipated, or "real," and codifies the response for the purpose of communication. The standard is the result of a problem–solving process. It involves agreements among stakeholders who have an interest in adopting specific responses to the problem. Conformant use of the standard leads to predictable results and a reduction of uncertainty.*

Some of the assumptions upon which this definition is based are corroborated by terms and phrases used in the literature:

- “However the issue is viewed by the participants, the standard should represent the industry response to a real problem, and assuming that the problem was analyzed correctly, the standard should provide a valid solution” (Cargill, 1989, p. 28)
- “… a standard is a workaday solution to a problem and not the ultimate technical response” (Cargill, 1989, p. 71)
- “Standards are, after all, a method of codifying information” (Cargill, 1989, p. 56)
- “…standards are agreements or conventions about the substance or form of some product or service. From this perspective, standards may be viewed as simple instruments for cooperation that are forged as needed” (Spring, 1991, p. 92)
- “Many, in some sense most, standards are merely definitions, or more accurately, agreements on definitions” (Hemenway, 1975, p. 57)
- “Standards are developed in response to a common recurring problem” (Wood, 1989, p. 67)

A focus on the problem–solving nature of standards allows one to assume that various stakeholders in the standards development process may have differing views on the nature, scope, and shape of the problem and the potential solutions to the problem.

The terms “standards development,” “standards setting,” “standards making,” and “standardization” are used in the literature to refer to the process of creating a standard, yet these terms are seldom defined uniformly. Cerni (1984, p. 14) suggests that standardization is:

> process of formulating and applying rules for an orderly approach to a specific activity for the benefit and with the cooperation of all concerned. It is based on the consolidated results of science, technique, and experience. It determines the basis not only for the present, but also for future development and it should keep pace with progress.

Cargill (1990, p. 8) distinguishes between standards development and standardization:

- *Standards Development*: “the act of creating a standard—understanding how or why something (a thing, process, or activity) works, and describing this in a manner that others (individuals, groups, organizations) can reproduce. It is an act that requires considerable understanding of the thing, process, or activity being described. It requires an understanding of the application of the thing, or the intent of the process or activity, and an ability to convert this understanding into unambiguous language. The end result is a standard, which is a description of how something is supposed to happen, and how to make it happen in essentially the same fashion time after time.”
- *Standardization*: “the act of managing a standards program—includes standards development, a definition of what needs to be standardized, when it is necessary to adhere to a standard, the nature of the adherence, what benefits will accrue, and what penalties will be avoided.”

For the purposes of this research, the term standards development refers to the broad set of activities and processes by which a standard is developed including:

- Identification of a problem to be addressed by a standard
- Standards project initiation
- Standards writing

- Approval of standard
- Implementation
- Evaluation.

This set of activities has similarly been described as stages in the standards life cycle (see X3, 1993). While it is possible to identify existing formal procedures that govern the initiation, writing, and approval for standards, no such formal rules and procedures exist for the entire process of standards development as defined for this research.

A key component of standards development is the work of the group of individuals involved in "standards writing." That term, however, does not reflect the range of activities the group may be engaged in. To highlight this component of standards development, the researcher uses the term *standards work*. This term refers to activities of participants in determining the problem they will address and arriving at the agreements that they subsequently documents in the standard.

2.4. Taxonomies of Standards: Categories and Classification Schemes

Although there is no accepted definition of a "standard," the literature provides several approaches to categorizing standards and provides definitions of the categories albeit without defining "standard."

Standards can be classified according to a number of criteria. These criteria include type of standard, area of jurisdiction, and how the standards are developed. For example, writers often refer to types of standards such as *de facto*, government (sometimes called *de jure*) and voluntary standards. These types of standards are related to the processes by which they are developed (see below Section 2.5). Spivak & Winsell (1991, pp. 320–321) offer definitions for these three categories of standards:

- *De facto standards*: Standards that have not been promulgated and adopted but have come into use by general acceptance, custom, or convention; may or may not be described in a published document.
- *Government standards (de jure)*: Standards developed, adopted, or promulgated by a federal, state, or local government agency. A government standard is generally mandatory as applied to government procurements or when adopted as a code, regulation, or rule by a regulatory authority.

- *Voluntary standards*: Established generally by private sector bodies and available for use by any person or organization, private or governmental. These are usually developed by a consensus process for voluntary use and with which there is no obligation to comply. However, a voluntary standard may become quasi–mandatory or mandatory as a result of its use, reference, or adoption by a regulatory authority.

These categories are not necessarily exclusive since a *de facto* standard can be adopted as a voluntary standard, and voluntary standards can be adopted as a *de jure* or government standard. Voluntary standards developed through a formal standards process are at times referred to as formal standards or *de jure* standards. The descriptor "formal" may be acceptable, but for this research "*de jure*" is reserved for referring to standards that have the force of law or other governmental authority behind them. According to this classification, Z39.50 is a voluntary standard.

Cerni (1984, p. 10) describes the following levels of applicability or jurisdiction of a standard:

- Company
- Industry
- Inter–Industry
- National
- Government (Regulating)
- Regional
- International.

The same standard can be adopted at one or more these levels. For example, Z39.50 is an American National Standard, that is, it has been approved for use as a national standard. There were also companion international standards for information retrieval of which Z39.50 was a compatible superset. Even though Z39.50 is an American National Standard, implementors in other countries are free to use it. This occurred in Canada, the Netherlands, and elsewhere. (Although outside of the scope of this study, it is important to note that in 1996, the International Organization for Standardization has accepted Z39.50 as an international standard, ISO 23950.)

Categorizing a standard in terms of its level of applicability using Cerni's scheme indicates the pool of potential stakeholders of the standard and the interaction between jurisdictions and stakeholders regarding a particular standard.

Verman (1973, p. 32–34) identifies three dimensions or facets by which to define a "standardization space." These three facets are:

- *Subject*: the topical area and sub–areas of the standard (e.g., engineering, textiles)
- *Aspect*: the aspect of the subject the standard covers (e.g., specification, grading & classification, forms & contracts)
- *Level*: the domain to which a standard may be applicable (e.g., individual, association, national, international.

Verman does not address specifically standards for information technology. None of his main categories for "subject" deals directly with communication or computing. Yet his standardization space may be used to locate a standard such as Z39.50 by adding the subject "computer communications" and an aspect for "protocol specification." The facet "level" echoes that of Cerni's level of applicability.

Hemenway (1975) presents a useful dyadic classification for thinking about standards. He categorized standards as those concerned with quality and those concerned with uniformity. Standards for quality categorize products as "superior" (meeting the standard) or "inferior" (not meeting it). Standards for uniformity can help regulate the sameness of products and simplifies the number of products, which promotes economies of scale and facilitates price comparisons. Uniformity enhances interchangeability, compatibility, and interoperability for two or more products. Interchangeability allows for wider markets, increases alternative sources of supply and thereby promotes competition. While the interchangeability of products has been an important consideration in industrial and consumer products, the concept of interoperability inherent in the idea of standards for uniformity is particularly relevant for Z39.50.

The literature on standards provides a number of interesting categorizations for standards. The reason to discuss classification of standards in terms of this study are to: 1) understand in which categories Z39.50 can be fit, and 2) identify some of the forces that might be at work in developing standards of a particular category. For example, by understanding the level of its applicability, it is possible to tentatively identify potential stakeholders. Using the categories discussed so far, Z39.50 is standard interoperability adopted at a national level as a voluntary standard.

2.5. Overview of Standards Development Processes

The previous section discussed definitions and categories of standards. In several cases, the category of a standard is a reflection of the standards processes used to create a standard. This section discusses some of the standards organizations relevant to information technology and their role in standards production.

Cargill (1989) emphasizes the need to understand the context from which standards emerge. To understand the development of Z39.50, it is necessary to understand the context within which its development occurred. The section begins by providing a detailed look at the American National Standards Institute (ANSI) process of voluntary consensus standards development and, thus, helps to place Z39.50 in its specific standards organizational context. The voluntary consensus standards process, however, is not the only one by which standards can be developed. The section also addresses alternative approaches for standards development including:

- *De facto* standards processes
- *De jure* standards processes
- Consortia standards processes.

In particular, *de facto* and consortia standards are playing increasingly important roles in the evolving information infrastructures technology in part because of the perceived failure of the ANSI–accredited process to address the specific challenges presented by information technology standards and the perceived successes of the Internet standards process.

2.5.1. Voluntary Consensus Standards

Over the years, individuals and organizations formalized the ways in which to develop industrial and technical standards (for an historical overview of the evolution of U. S. standards activities see Cerni, 1984, pp. 17–27). A primary mechanism that emerged to develop standards was the voluntary consensus standards development process (also called the voluntary standards system). Standards developed through this system are voluntary in the sense that there is no law or regulation that mandates compliance. Consensus refers to the level of agreement that is required to approve a standard. This system of standards development constitutes one forum for the development of information technology standards.

Z39.50 arose out of the voluntary standards system, and in particular, a system that abides by rules and procedures adopted by ANSI (American National Standards Institute, 1993). The dominant process for voluntary consensus standards in the United States is administered by ANSI. Cerni (1984), Cargill (1989), Sullivan (1983), and the Office of Technology Assessment (1992) provide descriptions of the ANSI process and procedures.

ANSI is an umbrella organization for a wide range of standards developers that abide by ANSI–administered procedures. ANSI does not develop or write standards but rather creates and maintains procedures for developing standards, accredits standards developers that follow those procedures, and provides final approval of standards as American National Standards. ANSI also coordinates national standards activities and represents U.S. national standards interests in several international standards organizations.

ANSI–approved standards are voluntary consensus standards. ANSI has a number of requirements that apply to activities related to the development of consensus. These requirements fall basically under the heading of "due process." Due process means that anyone (e.g., individual, organization, company, and government agency) who has a direct and material interest in the topic for which a standard is under development has a right to participate. ANSI states that there is a minimum set of acceptable due process requirements for the development of consensus that include (American National Standards Institute, 1993):

- *Openness*: There should be no barriers to participation by anyone who is directly and materially affected by the activity in question
- *Balance*: The standards activity should have a balance of interests represented and not be dominated by an single interest category, and consideration for representation should be given the following interest categories: Producer, User, General Interest
- *Appeals*: There must be an appeals process in place to handle complaints, whether they are complaints about the substance of a standard or the procedures by which it was developed
- *Notification*: Announcements of standards activities (whether the development, revision, or withdrawal) must be made to provide opportunities for participation.

ANSI requires its accredited standards developers to submit documentation to show that the developers followed these due process requirements in developing their standards. These methods and procedures evolved over time. In part, these procedures grew out of the need to safeguard the process and to provide protection from legal challenges related to anti–trust activities (Swankin, 1990).

ANSI allows any of the following three methods to determine the existence of consensus on a standards activity:

- *Accredited organization method*: Used most often by associations or societies that have an interest in developing standards but where standards development is not their primary or only purpose or function; this is the only one of the three methods that allows the standards developer to develop its own operating procedures. The National Information Standards Organization (NISO) is an ANSI–accredited standards developing organization.
- *Accredited standards committee method*: These committees consist of directly and materially affected interests and are created for the purpose of developing standards. This method is used most often when a standard (or area of standardization) affects a broad range of interests. It serves as a forum where these interests can be represented. Examples of accredited standards committees include: X3: Accredited Standards Committee for Information Processing Systems; and T1: Accredited Standards Committee for Telecommunications.
- *Accredited canvass method*: This method is used most often by smaller trade associations or societies that have documented certain practices and wish to have them recognized as national standards.

Several ANSI–accredited standards developers are responsible for information technology standards. Table 2–2 lists the names and respective scope of a selection of these standards developers.

2.5.2. De Facto Standards & De Jure Standards

De facto standards emerge primarily in a market–mediated environment. A single firm or a coalition of firms compete to achieve dominance with a product or technology. Market dominance may result in a proprietary product or technology becoming the standard that competitors need to acknowledge and address in developing their own products and technologies. In the information technology arena, examples of *de facto* standards include Microsoft's Windows operating system for computers.

De jure standards result from the actions of an organization that has a legal authority to compel adherence to the standards. The mandatory use of *de jure* standards may be limited to certain jurisdictions. For example, the National Institute for Standards and Technology (NIST) develops and promulgates Federal Information Processing Standards (FIPS); the Federal government mandates the use of FIPS in Federal agencies. *De jure* standards are not necessarily developed independently of other standards processes. For example, NIST can and does adopt voluntary consensus standards as FIPS, and recent Federal policy directs agencies to adopt voluntary standards (Office of Management and Budget, 1993).

Table 2–2
Selected ANSI–Accredited Information Technology Standards Developers

- X3: Accredited Standards Committee for Information Processing Systems. The scope of X3 is standardization in the field of information technology, which encompasses storage, processing, transfer, display, management, organization, and retrieval of information.
- X12: Accredited Standards Committee for Electronic Data Interchange. Creates, develops, and maintains standards for the electronic data interchange (EDI) of business transactions.

- T1: Accredited Standards Committee for Telecommunications. Established in 1984 (upon the divestiture of AT&T) to develop standards related to interfaces for U.S. public telecommunications networks.
- National Information Standards Organization (NISO). Develops standards used in library services, publishing, and other information–related industries. The standards address the communication needs of those industries in areas such as information retrieval, preservation of materials, information transfer, forms and records, identification systems, publication formats, and equipment and supplies.
- Institute of Electrical and Electronics Engineers, Inc (IEEE). A professional organization that has as a fundamental goal the advancement of the theory and practice of electrical and electronics engineering. IEEE has produced standards in the area of local area networks, operating systems (POSIX), and others.
- Electronic Industries Association (EIA). A trade association representing manufacturers. Its standards work focuses on connectors, wiring schemes, residential consumer electronics (e.g., the RS–232 standard connection).

There is little evidence that *de facto* and *de jure* standards offer new approaches to standards development for information technology. Their importance may increase if a voluntary consensus process is unable to produce the standards needed by providers and users of information technology. Companies may try to achieve dominance with specific products and technologies and have these be accepted as *de facto* standards. Or, if government sees that certain national and public interests require agreement on particular standards (a case in point might be requiring openness and interoperability in the emerging National Information Infrastructure), the role of *de jure* standards in certain aspects of information technology may gain prominence.

2.5.3. Standards Developed by Consortia

The development of standards by consortia represent a mechanism by which groups of individuals and organizations acting as a "collection of like–minded interests…participate in the development of what may be a market accepted solution to what is perceived to be a user problem" (Weiss and Cargill, 1992, p. 560). A variety of consortia exist, and at least in the arena of information technology standards, consortia have been particularly active. For example, the World Wide Web Consortium (W3C) emerged in the mid–1990s to address the evolving standards for the Web. It is a membership organization, and only members who pay fees are allowed to participate in the consortium (World Wide Web Consortium, 1998).

Weiss and Cargill suggest a taxonomy of consortia (e.g., implementation consortia, application consortia, and proof–of–technology consortia) that reflects a range from "organizations whose primary role is to facilitate the adoption of existing standards through promotional activities and conformance testing to those that are actively developing new technologies that are intended to form the basis for either *de facto* or voluntary consensus standards" (p. 559). Consortia may have limited memberships (i.e., not be open bodies) and may have special rules on voting (e.g., majority vote rather than consensus) that increase the speed at which standards may be developed (Lehr, 1992).

Consortia provide an important alternative to the voluntary standards process. Weiss and Cargill argue that consortia are a vendor–driven response to the long delays in the formal voluntary consensus standards process. Further, many of the standards that support open systems emerging from the voluntary consensus process reflect the compromises to gain consensus; these standards often contain many options from which vendors must choose when implementing the standard in a technology or product (McCallum, 1994). One of the goals of a consortia is to reach agreement among the vendors on these options to achieve compatibility and interoperability in independently developed implementations of a standard.

Updegrove (1994, p. 1) states that the emergence of many information technology consortia can be attributed to the need to "create a single standard of common need throughout the industry." The following is the taxonomy guiding Updegrove's treatment of consortia (p. 5):

- *Research Consortia*: formed as a result of heightened national procompetitive concerns, and whose interests are often to develop technology in addition to or incidental to developing standards (e.g., SemaTech)
- *Specification Groups*: primarily concerned with developing and maintaining a usable standard and work best when they implement the best technological methods to produce "sensible, robust, practically implemented standards;" such groups may be either vendor– or user–driven (e.g., CAD Framework Initiative, Distributed–Computer Telephony Group)
- *Strategic Consortia*: formed and funded by a limited number of companies for their individual benefit to promote the adoption of certain technologies.

In the case of Z39.50, the Z39.50 Implementors Group (ZIG) might be considered a consortium that acts as a feeder of specifications into NISO's formal standards process.

2.6. Standards Development for Information Technology

Information technology spans a wide variety of products and processes. A broad definition of information technology might be any technological device that assists in processing and handling of information. This definition includes non–electronic as well as electronic devices. A narrower definition restricts the scope to technological devices and associated software that process and handle information represented in electronic or digital form. For example, the National Research Council (1994a, p. 24) defines information technology as "computer and communications hardware, as well as the software and associated services required to exploit that hardware." This still includes a wide range of devices such as fax machines, computers, data communications networks, storage devices, printers, modems, and software. The concept of an "open systems environment" further narrows the range of information technology of interest in this study.

An open systems environment (OSE) is a "a computing environment that supports portable, scalable, and interoperable applications through standard services, interfaces, data formats, and protocols" (National Institute of Standards and Technology, 1994, p. E–1). The characteristics of information technology for an open systems environment include (Office of Management and Budget, March, 1992, pp. 23–24):

- *Portability*: The ability to use, or migrate, systems software, applications software, and data across different computing platforms from multiple vendors
- *Interoperability*: The ability to have applications and computers from different vendors work together on a network
- *Scalability*: The ability to use the same applications and systems software on all classes of computers from desktop workstations to supercomputers
- *Common Programming Interfaces*: The ability to develop applications based on a set of standard programming tools which can be easily transferred across platforms
- *Common User Interfaces*: The ability to create applications with a similar "look and feel" so that users can easily learn new applications after understanding the first.

Technical standards supporting an open systems environment will address these characteristics of information technology. The visions of national and global information infrastructures assume that it will be an "open" environment.

Information technology, in general as well as specific technology supporting an OSE, also has special attributes that can distinguish this technology from other non–information technologies. The following summarizes some important attributes and suggests implications for standards development:

- Information technology is dynamic and given to rapid obsolescence and short product life cycles. While information technology may not be the only technology that changes rapidly, the implication of this attribute is that "after–the–fact" or reactive approaches to standards development may be inappropriate. "Anticipatory standards development," where standards development precedes actual creation, implementation, and marketing of products, may be an important implication for developing information technology standards (see Bonino & Spring, 1991; Cargill, 1989)
- The convergence of telecommunications, computers, computer data networks, and a range of information appliances demands interconnection, interoperability, and interworking of these components to achieve efficient and effective information transfer. Information transfer among interoperable information systems is complex and applicable standards may include those addressing electrical signals, data structures, computer–to–computer communications and network protocols, and document markup. The implication is that many different standards (existing or under development) may need to be considered when developing a new standard to result in successful interaction (see National Institute of Standards and Technology, 1994; National Research Council, 1994b)
- Organizations striving for interoperability of their information technology, both intra–organizational and inter–organizational, must work together to design specifications for the technology in advance of technology deployment. This implies that the models and architecture that can provide the necessary levels of interoperability must be agreed to prior to the writing of technical specifications. Modeling complex interactions and information flows among these systems is non–trivial, and standards development may include, in some cases, a focus on collaborative design (Lynch, 1994a)
- Standards are perceived as strategic tools in the arsenal of companies and organizations competing in international markets, and the forums for developing standards may serve to

coordinate a future market for products, processes, and services. The implication for standards development is that as the economic, political, and technological stakes of the participants increase, the erstwhile technical decisions take on even greater importance when market opportunities are involved (see Betancourt, 1993; Bonino & Spring, 1991; Cargill, 1989).

As noted above, other technologies may share these attributes with information technology. Similarly, information technology standards can serve purposes similar to technical standards for industrial products: simplifying product choices (e.g., 3 1/2 inch diskettes) and interchangeability of parts (e.g., modems and other computer peripherals). These attributes of information technology, however, combined with the need for the technology to support or operate in an open systems environment may have had a sizable impact on the formal voluntary consensus standards development process and the organizations that are responsible for developing information technology standards.

Cerni (1984) acknowledges that information technology and telecommunications standards are of a entirely different order than previous standards. She suggests that prior to information technology, two categories of standards were relevant:

- *Basic Standard*, which establish basic principles for industrial development; includes standards that document units for measurement and reference, precision of test methods, etc.; these are universally applicable
- *Product Standard*, which address performance and output requirements relating to actual product use such as strength, conductivity, and efficiency.

To these categories, she adds a third category that addresses characteristics of information technology standards:

- *Integrated Systems Standard*, which serves the need to match newly developed "high technology" with newly developed frameworks in which individual standards development efforts can be planned and developed within a total system. This approach helps establish a standards direction that is consistent with overall objectives of an industry and allow for multiple development efforts to be integrated into a cohesive structure.

Other writers since Cerni have attempted to identify more precisely categories that are pertinent to information technology standards.

Hack (1987, p. 20), along the lines of Cerni, states that while product standards deal with characteristics of individual products, integrated system standards "are born of: (1) the need for standards in complex systems of interacting equipment and (2) the tendency of computer, telephone, and mass media technologies (formerly perceived as separate) to converge."

Cargill (1989, pp. 32–33) proposes the category of process standards and suggests that such standards have become more common than the traditional product standards. Product standards describe a "product or service being standardized." A process standard "focuses on the transmutation of a customer need into a customer solution, examining a system's inputs and outputs but not concerning itself especially with the products that accomplish the transmutation." For Cargill, process standards are concerned with the ends, not the means. He adds two dimensions by which process standards could be distinguished: implementation or conceptual. While not offering specific definitions, Cargill (1989, p. 30) indicates the difference between the two:

> If the implementation standards are seen as evolutionary, then conceptual standards are revolutionary, seeking to change industry perceptions and direction, to encourage technology conversion or change, or to redefine an industry problem through a different perspective on the approach to a solution (usually technologically based) or a different perspective on the problem itself.

The implication of this statement becomes clearer when one understands that Cargill sees information technology standards, especially "anticipatory" standards (versus reactive standards), as shapers and drivers of information technology markets.

Especially relevant to the research approach used in this study, Cargill (1989, p. 20) suggests that "[f]urthermore, process standards are a function and result of their context: problems or user needs do not exist in isolation; they must come from somewhere. It is this aspect—the context—that become most critical, posing the greatest challenge in consensus standards development." This supports an assumption of this study that the context in which a standard emerges is critical to understanding standards development.

2.6.1. Problems in Information Technology Standards Development

The organizations that produce information technology standards through the formal voluntary consensus standards development process have been criticized for their lack of timely standards development, the cost of their development, and the creation of standards that are difficult to implement. These organizations have also been slow to adopt and use information technology to streamline the standards process—both in the standards writing activities and the dissemination of the actual standards (Cargill, 1989; National Institute of Standards and Technology and The Industrial Technology Institute Center for Electronic Commerce, 1993; National Research Council, 1990).

Special challenges face the developers of information technology standards (Committee for Information, Computers and Communications Policy, 1991):

- The technical complexity of interoperating information systems resulting from the convergence of communications and computing technologies
- The uncertainty of future technology trends
- The need to standardize critical interfaces quickly yet to do it in a way that future development paths are not precluded

- The fact that information technology standards often are addressing processes and procedures (e.g., communications protocols such as Z39.50) rather than products or outputs.

At a time when the individuals and organizations engaged in standards development struggle to address the most effective and efficient ways to produce standards for information technology, there is increasing demand for these standards given the standards requirements of initiatives such as the emerging NII (Kahin & Abbate, 1995; National Research Council, 1994b; National Institute of Standards and Technology, 1994).

To realize seamless and transparent access to information and other benefits of an open information infrastructure, standards will be critical. For example, the Office of Technology Assessment (OTA), a former U.S. Congressional research agency that analyzed and assessed current technological issues and developments, states in a report on electronic commerce that "standards are essential to the open access and seamless interconnection required for electronic commerce" (Office of Technology Assessment, 1994, p. 85). In addition, standards are the building blocks of global competitiveness and can seriously affect international trade. Another OTA report suggests that the formal voluntary consensus standards system in the U.S. is not up to the task of leading the U.S. standards activities (Office of Technology Assessment, 1992). In the cases of international trade and building the NII, standards production rises to the level of policy concerns of the nation. The OTA report also suggests that the government might play a greater role in fostering the cooperative development of standards. In the policy arena of the NII, the U.S. Federal government has called for the formal voluntary consensus standards system to be catalyzed (possibly by increased government involvement) to produce the required standards (Information Infrastructure Task Force, 1993).

The importance of standards for global economic competitiveness (Office of Technology Assessment, 1992), as strategic instruments of organizations (Betancourt, 1993), and in supporting a national information infrastructure (National Institute of Standards and Technology, 1994; Computer Systems Policy Project, 1994; National Research Council, 1994b) argue for effective mechanisms and processes that individuals and organizations can use to identify needed or desirable standards and produce workable standards in an efficient and timely manner.

2.6.2. Standards Developers' Responses to Information Technology

As early as the 1970s, standards organizations responded to user demands for computer systems to communicate and for standards that would ensure that information technology components and applications would interconnect and interoperate. The Open Systems Interconnection (OSI) was a major initiative undertaken at the international level by the International Organization for Standardization (ISO), the International Telecommunications Union (ITU), and the International Electrotechnical Commission (IEC). ISO and IEC are international standards organizations that produce standards according to procedures similar to that of ANSI's formal voluntary consensus standards development process.

Other responses included analysis of existing development processes and attempts to use information technology to improve the speed of standards development.

2.6.2.1. Open Systems Interconnection

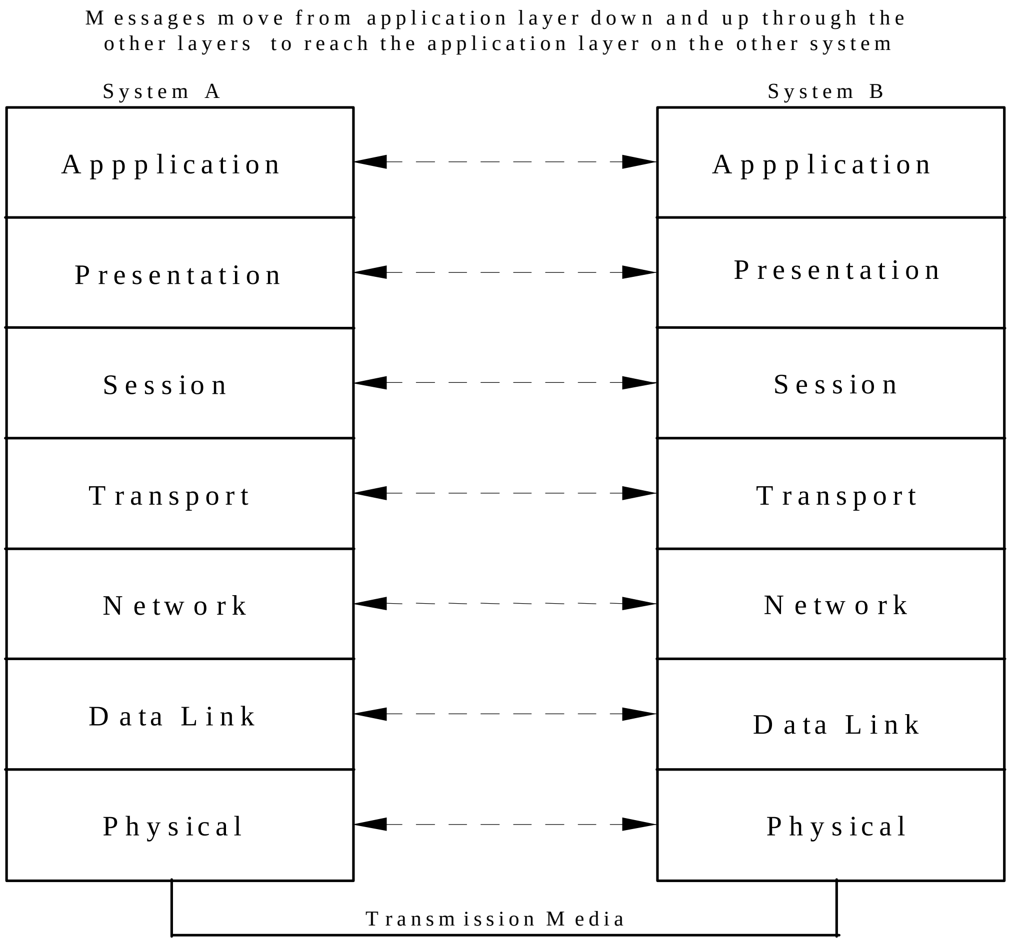
An example of a response to the need for information technology standards was work at the international level beginning in the 1970s on the Open Systems Interconnection (OSI) Basic Reference Model. The OSI model is an International Standard that ISO approved in 1984 (see Piscitello & Chapin, 1993). It provides a framework for developing a set of standards to achieve open systems computer–to–computer communication. To achieve its goal, it separates the communications functions into the familiar seven–layer OSI model (see Figure 2–1). The two stacks of OSI layers sit on separate computers. Each layer represents a set of similar functions, and these functions are carried out by separate standards at each layer. The OSI model serves as a general model for intersystem communication. Its designers intended it as a framework for developing standards to address the functionality of each layer.

The OSI initiative exhibited a new characteristic in standards development. The OSI Basic Reference Model, itself a standard, laid out a framework for modeling and developing standards that would work together to achieve computer–to–computer communication. It provided the impetus to develop these standards prior to their implementation in products. This “anticipatory” (Cargill, 1989) or “preemptive” (Lynch, 1993) stance towards standards development might be considered appropriate in responding to the special attributes of information technology (e.g., the need for many standards to work together for successful interoperability between disparate information systems).

The OSI reference model provided a framework, but the anticipated standards did not develop quickly. When OSI standards finally emerged from the voluntary consensus process, implementations and products were slow to make it to the market, in part, because of the complexity of these standards. Piscitello and Chapin (1993, p. 26) summarize a common reaction to OSI:

> There is a perception (all too often accurate) that the OSI standards process is more apt to converge on a solution that is politically correct than one that is technically so. Within the OSI standards community, there also appears to be a tendency to compromise by embracing multiple solutions to a single problem as well as a tendency to create and tinker with new technology within committees often without implementation and experimentation that is necessary (essential) to determining whether the technology is useful.

Figure 2–1
Open Systems Interconnection Basic Reference Model



OSI has been a target of those who claim that the formal voluntary consensus standards development process does not work for information technology standards development. Problems with OSI standards and OSI's standards development processes opened the entire formal voluntary standards system to severe criticisms about its inability to produce timely, implementable standards. The OSI model is important for this study since Z39.50 was developed as an OSI application layer protocol.

2.6.2.2. Organizational Responses

The organizations responsible for voluntary consensus standards for information technology responded to the pressing need for standards to guide the deployment of the emerging National Information Infrastructure. ANSI initiated the Information Infrastructure Standards Panel to identify standards requirements for the NII and to provide a forum where the primary information technology standards developers could discuss and determine how they would meet these needs (Moen, 1994c).

Some ANSI–accredited U.S. standards developing organizations that focus on information technology attempted to adapt and change in response to demands, pressures, and criticisms. For example, the ANSI Accredited Standards Committee for Information Technology, X3, spent a number of years studying the "standard life cycle" to determine how to plan for and manage development of information technology standards (X3, 1993). The ANSI Accredited Standards Committee for Telecommunications, T1, which develops standards related to interfaces for the U.S. public telecommunication networks, began using electronic technology to accommodate faster distribution of standards documents and communication among members of standards development committees (Reilly, 1994).

The standards organizations undertaking such improvement efforts may not be acting upon a deep understanding of the standards development process, making it unclear whether or not these efforts can or will make a difference. For example, while the use of electronic mail may provide another channel for standards developers to communicate, email may not address the issues raised by Piscitello and Chapin (1993, p. 26) regarding the "tendency to compromise by embracing multiple solutions to a single problem."

Other players, however, are providing alternative paths for developing information technology standards. The success of Internet standards for data networking and networked–computer applications created interest in the standards process that underlies the TCP/IP protocol suite and associated application standards (Crocker, 1994). Industry–based consortia such as the Network Management Forum, the ATM (for Asynchronous Transfer Mode) Forum, and others are working on specifications that particular industries need to develop marketable information technology products. As an alternative to the ANSI voluntary consensus standards development process, consortia provide a way of collectively determining standards solutions in which their members can share; consortia, however, often lack the built–in procedural safeguards of the ANSI process (e.g., due process, openness). Some consortia act as feeders to the formal voluntary consensus standards process while other consortia are bypassing the ANSI process and developing the standards they need now to gain market dominance (Weiss & Cargill, 1992).

Proprietary solutions and *de facto* standards provide yet another alternative to the challenges of information technology. The success story of Microsoft's Windows argues that while the risks are great, the rewards are potentially huge for a company if it can have its way of doing something (i.e., its technology) become the agreed upon way (i.e., the standard) for everyone else to follow (Morris & Ferguson, 1993).

The call for open systems in the 1980s raised expectations of information technology providers and users that a new era of vendor independence, compatible systems, and wide–scale interoperability was on the horizon. The fast–paced changes in information technology, the deployment of electronic networks, the success of proprietary solutions, and the lack of timely and implementable information technology standards emerging from the formal voluntary consensus standards development process, however, raised serious questions about the estimated time of arrival of this new era of open systems (Cargill, 1994). There is general agreement that information technology standards are fundamental to open systems, yet the difficulties in producing these standards have raised questions about the ability of the voluntary consensus standards development process to address this arena of technical standards. Other organizations and groups were heralding new and better ways of making standards.

2.6.3. The Internet Standards Process

In the category of other voluntary standards development mechanisms, the Internet standards process serves as an appropriate example. While sharing characteristics of the formal voluntary standards development process as represented by ANSI (e.g., having open membership and regular meetings), the Internet standards process has specific requirements regarding demonstrable implementations prior to the standard gaining approval (Internet Activities Board and Internet Engineering Steering Group, 1994). The success of the global Internet and its underlying standards has brought increased interest in the Internet standards process as a model for information technology standards development (Lehr, 1994a). The literature does not refer to the Internet process as a consortium, and for the purposes of this discussion, the Internet process is considered an alternative voluntary standards process.

Rutkowski (1994, p. 4) outlines the attributes of the Internet standards and their associated development process which include the following characteristics:

- Premised on individual as opposed to organizational participation
- Constructed for direct open participation by experts and innovators, including the use of the Internet itself for progressing the work
- Output consists of demonstrated working code and demonstrated interoperability
- Emphasis on meeting real user needs employing predominantly “bottom up” development rather than “top down” according to some hypothetical or grand plan
- Standards are approved via a robust expert review process using a peer consensus process.

The Internet standards process has administrative procedures and rules that are maintained and approved by the Internet Society (Internet Activities Board and Internet Engineering Steering Group, 1994). When compared to the traditional voluntary consensus standards development process, the Internet standards process appears much more informal. Lehr (1994a) provides a description of the Internet process and reasons for its attractiveness as an alternative to the traditional process.

2.6.4. Reactive Versus Anticipatory Standards

Several writers have proposed that with information technology standards, we have entered the era of “anticipatory” standards. This is in contrast with how industrial technical standards had been created since the early 20th century.

Organizations and procedures for developing industrial standards responded to the needs and requirements for the rapid industrialization of the late 19th and early 20th centuries. Standardization was a linchpin for the success of industrialization. Technical standards for products and processes served many purposes including safety and quality assurance, reducing product variety (which in turn led to economies of scale in production), providing information to providers and consumers, and uniformity and interchangeability (Hemenway, 1975).

Beniger (1986, p. 293) suggests that "standardization of sizes and processes" was one of the innovations that eased the "crisis of control of production" in the 19th century. Beniger states that "Essential to the assembly line is the standardization and interchangeability of parts...and the basis of the American System of manufacturing by the 1840s." He points to Henry Ford's decision in 1909 "to carry standardization to what may be its modern extreme: he would build *only* Model T's on his line and would use the same chassis for his runabouts, touring, town, and delivery cars" (1986, p. 298; emphasis in original text).

In general terms, the industrial standards codified and documented successful products in an "after–the–fact" manner. The importance of this manner of development will become clear when compared to proposals for "before–the–fact" standards development for information technology standards. Developing standards after–the–fact implies that products or processes already exist in the marketplace, and participants in the standards development process select from the variety of existing products to determine one that would serve as the basis for the standard.

Hemenway (1975, pp. 13–18) provides an example of this type of standards development in a discussion of early American automobile standards. As early as 1900, people involved with the automobile industry recognized that "industrywide standardization could bring substantial benefits....In the decade following 1900 there were sporadic attempts to establish standards for wheels, rims, spark plugs, screw threads, and even for steel specifications" (p. 13). The point is that these particular products already existed, and the industry needed to come to an agreement on specifications for these and other items used in the manufacturing process. Hemenway suggests that in 1910 an economic crisis in the industry accentuated the need for standards, and more importantly, the "establishment of a body of professional automotive engineers, without trade association entanglements" combined to "create a viable standards system" (p. 13). In its first eleven years, the Society of Automobile Engineers (SAE) "created and published 224 different sets of standards" (p. 14) that covered such components as screws and bolts, lock washers, wheels and rims, and spark plugs. To reiterate, these products already existed, but SAE set standards for quality and uniformity based on those products for future products.

Lynch (1993, p. 40) suggests that in the early 1980s, we entered the "age of preemptive standards." Cargill (1989) uses the term "anticipatory" standards; he describes these as "standards that anticipate the actual creation of a product, and which are used to define a market, with all of the attendant implications of that market" (Cargill, n.d., p. 10). Bonino and Spring (1991, p. 101) suggest that the concept of anticipatory standards encompasses a "future oriented and self–creating process of defining standards: writing for the future now."

Anticipatory standards are a response by standards developing organizations to the shortened life cycle of information technology products, the need for compatibility of separately developed information technology components in an open systems environment, and the uncertainty of technology trends. For example, Weiss and Cargill (1992, p. 560) state that the accelerating rate of technological change and the shortening of product life cycles “made it too costly for vendors to engage in the market rivalry necessary to establish *de facto* standards.” They also suggest that the standard development process being used by vendors is an extension of competitive product development and market shaping and/or creation. Bonino and Spring (1991) and Cargill (1989) also assert this phenomenon.

Another characteristic of anticipatory standards development is that it attempts to coordinate activities among stakeholders when the direction and outcome of technology development is uncertain. When there is a major shift from one type of technology to another (e.g., from stand–alone computers to the convergence of computing and communications), there may be a significant increase in technological uncertainty. Cowan (1992, p. 285) suggests that when technologies are relatively new, there is the most uncertainty about “their characteristics, the functions they will perform, and the functions users would like them to perform.” Developing standards for technology when the technology is emerging addresses part of this uncertainty. Cowan sees technology development as comprising episodic periods of disruption (i.e., when the new technology appears) and periods of stabilization that “build coherence into the technological systems” and “an integral part of this stabilizing process is technical standardization” (p. 279).

Anticipatory standards development may take on another characteristic. The group developing the standard (e.g., a standards committee) may come to “resemble a research and development laboratory” (Cowan, 1992, p. 297). Dankbaar and van Tulder (1992, p. 329) assert that anticipatory standards development may be a “process of research and development leading up to a decision” because the market fails to coordinate technology choice. Cowan suggests that as the “standardization process shifts away from choice among artifacts it begins more and more to resemble product development” (p. 279). Cowan (p. 298) describes “before–the–fact standardization” (i.e., anticipatory) as follows:

> The goal of the process is to set a single standard, and thereby create a strong and stable market (or perhaps several markets) for the technology under consideration. There is a further goal, however, namely to create a ‘good’ standard, since the better the standard, the more profitable will be market participation.... If the competing standards are well–defined and thoroughly developed, then the task of the committee is merely to decide which best satisfies the technical requirements. If, however, they are not thoroughly developed, the ‘merely’ deciding becomes a complex task in technological exploration and development.

A threat of before–the–fact standardization, however, is to close off prematurely technological options and development, and “early decisions can lock the process onto sub–optimal technological paths” (p. 299).

Anticipatory standards are problematic. In traditional standards development, a group of stakeholders might examine a number of existing products and then codify a standard based on specifications of the existing products. This might be more properly called “standard setting.” As information technology vendors identify specifications in advance of the product, the process of standards development requires more time. Weiss and Cargill (1992, p. 560) suggest that the complexity of the interoperation of information systems components, the large number and diversity of participants in the standards development process, as well as the traditional formal rules governing standards committees are reasons for the substantial time required for producing anticipatory standards. They suggest also that the debate among the competing interests within the committees "had higher stakes, resulting in increased difficulties in reaching consensus."

2.7. The Literature of Science, Technology, and Society as a Theoretical Basis

As a transition between the literature explored in preceding sections that address standards and standards development, and subsequent sections that use similar sources to discuss modeling of standards development, this section provides a discussion of theoretical and conceptual possibilities from the literature of the study of science, technology, and society (STS). While both reactive and anticipatory standards development encompass social processes, the anticipatory efforts can be viewed as participating in the social construction of solutions to technical problems. In addition, STS offers a possible integrative approach for studying standards development. Particular aspects of STS that provide insights for standards development are the social construction of technology (Pinch & Bijker, 1987), actor network theory (Callon, 1987) and techno–economic networks (Callon, 1991).

The intersection of STS and standards development stems from the interest of STS in understanding how technologies develop. As noted above in the discussion of anticipatory standards, the development of standards may precede technology development, and in some cases, the development of standards parallels the technology development (e.g., the case where a standards development committee acts as in the capacity of research and development).

STS, and, in particular, the social construction of technology, views technology development as an "alternation of variation and selection" and results in a "'multidirectional' model, in contrast with the linear models used explicitly in many innovation studies and implicitly in much history of technology" (Pinch & Bijker, 1987, p. 28). Additionally, STS assumes that to understand the growth and development of technological systems, one cannot look only at the technology but must understand that "politics, technology and all the rest, as going together as an integrated whole" (Law, 1991, p. 9). STS offers a integrative perspective on the social and technological.

STS understands technology as embedded in larger socio–technical systems. A socio–technical system includes "the rules specifying the purposes of the technology, its appropriate applications, the appropriate or legitimate owners, how the results of applying the technology will be distributed and so on" (Burns & Dietz, 1992, p. 209). What is emphasized in STS is the socially organized nature of technology—its production, use, and management. This implies then that "a variety of groups, social networks, and organizations may be involved in the construction, operation and maintenance of sociotechnical systems" (p. 209).

Monterio, Hanseth, and Halting (1994) explore several concepts related to STS to shed light on the development of standards for the emerging information infrastructures. They are particularly interested in how flexibility in a massive socio–technical system such as the information infrastructure can be encouraged so as to allow varied patterns of use. This flexibility within the context of the social construction of technology means that technological artifacts can evolve over time to respond to new uses. Yet an information infrastructure requires a level of stability that is produced through a process of closure, which occurs “with technology when a consensus emerges that a problem arising during the development of technology has been solved” (p. 4). They identify characteristics of information infrastructures that intersect with concerns of standardization:

- Standardization is non–continuous
- Flexibility presupposes standardization
- Relevant groups are dynamically negotiated
- Installed base conditions the reversibility/irreversibility of technology choices.

Monterio, Hanseth, and Halting borrow the concept of irreversibility from Callon (1991). Irreversibility describes the extent to which it is impossible to go back to a point where the path chosen was only one among others and the extent to which the path chosen shapes and determines subsequent choices of paths (Callon uses the term “translation” but the term of “path” seems as apt). In terms of standards development, as in the case of technology choice or development, decisions made at one point in the development of the standard may affect or delimit future choices. With anticipatory standards, this is an important issue because an early decision may lock–in or make irreversible other subsequent decisions. Flexibility in functionality may be a goal, yet that need may have to be balanced by what Monterio, Hanseth, and Halting refer to as standardization for the information infrastructure necessarily being “non–continuous” (p. 11). They suggest that STS “emphasizes the constant, gradual and continuous shaping of a technology” which is qualitatively different with information infrastructures since “standards are a precondition” for the infrastructure’s diffusion and use (p. 11). They conclude that STS does not adequately account for the process of standardization for information infrastructures (p. 19).

Callon’s discussion of actor networks and techno–economic networks (1987, 1991) point to the complexity and heterogeneity involved with technological development. Reacting in part to the linear notions of technology development and innovation and claims that it is “possible to distinguish during the process of innovation phases or activities that are distinctively technical or scientific from others that are guided by an economic or commercial logic,” he suggests that “right from the start, technical, scientific, social, economic, or political considerations have been inextricably bound up into an organic whole” (Callon, 1987, pp. 83–84). The focus of his analysis is “heterogeneous associations,” that complex heterogeneity of technology development that includes animate and inanimate objects, human and non–humans, as actors in networks of mutual shaping.

Callon (1991, p. 133) introduces the concept of a techno–economic network (TEN) which describes “a coordinated set of heterogeneous actors which interact more or less successfully to develop, produce, distribute, and diffuse methods for generating goods and services.” TENs are organized around three distinct poles (p. 133):

- *Scientific pole*, where scientific research is practiced and produces certified knowledge
- *Technical pole*, which conceives of, develops, and/or transforms artifacts
- *Market pole*, which refers to users or consumers who more or less explicitly generate, express or seek to satisfy demands or needs.

For Callon, these three poles are linked in the process of technology development through actors and intermediaries—either of which can be human or non–human. Stabilization and closure of a technology occurs as these actor networks converge and take on characteristics of irreversibility. Convergence addresses the dimension of agreement among actor networks. Irreversibility has the connotation described above. Standardization comes into play for Callon, since standardization "makes a series of links predictable, limits fluctuations, aligns actors and intermediaries, and cuts down the number of translations [paths] and the amount of information put into circulation....It operates by standardising interfaces—that is, by standardising and constraining actors and intermediaries" (1991, p. 151). Callon continues by stating that "irreversibility...is synonymous with normalisation" (i.e., standardization).

Callon's claim that depending on the point in time, networks are more or less convergent and more or less irreversible may be useful in understanding standards development. When there is less convergence and less irreversibility (e.g., at the early stages of developing an anticipatory standard), "the more the actors composing it [a TEN] can be understood in terms of concepts such as strategy, the negotiation and variation of aims, revisable projects, and changing coalitions" (1991, p. 154).

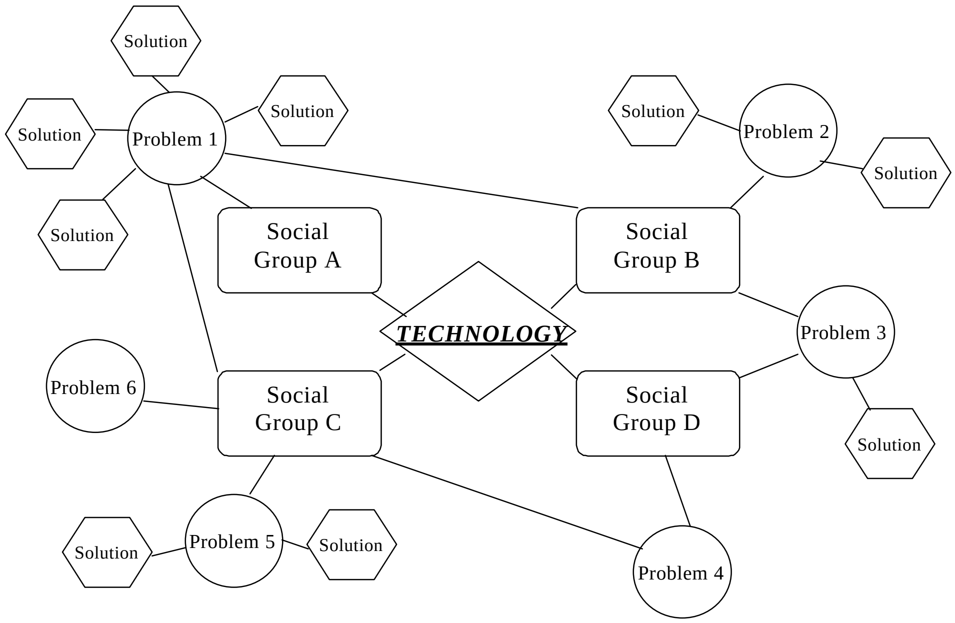
Pinch and Bijker's (1987) model may help to focus this discussion of the STS literature more concretely in terms of standards development. They describe a model developed empirically based on a number of case studies of technology development. Implied in their "multidirectional model" for technology development is an interplay between variation and selection. They illuminate the selection aspect of development by considering the "problems and solutions presented by each artifact at particular moments" (p. 29). Burns and Dietz (1992, pp. 214) suggest that because socio–technical systems are complex phenomenon, developing a "collectively shared model" results from a "process of aggregating individual understanding." Pinch and Bijker state that "in deciding which problems are relevant, social groups concerned with the artifact and the meanings that those groups give to the artifact play a crucial role" (p. 30). A "problem" is defined as such only "when there is a social group for which it constitutes a 'problem'" (p. 30). Social groups may be organized or unorganized groups of individuals, institutions, and organizations, and the requirement for being a social group in Pinch and Bijker's model is that they share the same set of meanings attached to a specific technology.

The first step is to identify the social groups that have a stake in identifying and defining problems related to a possible technology. The next step is to identify the "problems" each group has relative to the technology. Pinch and Bijker claim that this way of "describing the development process brings out clearly all kinds of conflicts" such as "conflicting technical requirements by different social groups...conflicting solutions to the same problem...and moral conflicts" (p. 35). With this approach, it is easy to see that there may be multiple and possibly conflicting solutions to problems with a technology's development. Figure 2–2 is adapted from the Pinch and Bijker model. It includes:

- A technology
- The social groups
- The problems each social group has with the technology
- The various solutions one or more social group has for the problems.

Figure 2–2

Social Groups, Problems & Solutions
(Adapted from Pinch & Bijker, 1987)



For Pinch and Bijker (p. 40), the model highlights the multidirectionality of technology development, and it "brings out the interpretative flexibility of the technological artifacts and the role that different closure mechanisms may play in the stabilization of artifacts." Interpretative flexibility means that there is flexibility in "how people think of or interpret artifacts" and in "how artifacts are *designed*" (p. 40; emphasis in original text). Closure in technology "involves the stabilization of an artifact and the 'disappearance' of problems" (p. 44).

This discussion of selected STS concepts suggests a theoretical perspective from which to view some aspects of standards development. The linkage with STS and standards development is based on the assertion that standards development, particularly the development of anticipatory standards, is integrally connected with development of technology. Kubicek and Seeger (1992, p. 353), in their discussion of data standards, summarize the connection in the following way:

> Data standards are understood as the transformation of models of objects and processes into technical artifacts. The process of model building depends on the interests and perspectives of social actors. The standardization of data standards is a process of negotiation between corporate actors. Dataware as a standardized technical artifact is embedded in organizational and contractual arrangements, which together form a sociotechnical system.

The standardization Kubicek and Seeger discuss "affects the information systems of many organizations and must be conceptualized as a sociotechnical system of a multi–actor and multi–context type" (p. 352).

The commonalties across the STS literature that are relevant to standards development are:

- Acknowledgement of a variety of actors or stakeholders
- Importance of context
- Dynamic interrelationships among a components.

In common with STS, this study's preliminary conceptual model addresses larger contextual and macro–level relationships and the micro–level interactions among individuals and between individuals and the technology. Before introducing that model, however, it is worth examining the models proposed by various writers within the standards literature.

2.8. Standards Development Modeling

While there is little empirical research on standards development, the literature provides examples of models and frameworks for standards and standards development. This section discusses these models.

A model is a representation of reality or a phenomenon (see Wilson, 1984; Checkland, 1981). As a representation, it will likely simplify or otherwise select aspects of the phenomenon to portray in some symbolic form. Models can be representations of phenomenon from specific perspectives, and each perspective might emphasize one or more aspects of the phenomenon. A model will portray entities and their relationships. The utility of a model is not necessarily that it mirrors "reality" but in how congruous or relevant it is to the phenomenon, the level of resolution of the model, and the acknowledgment of the assumptions underlying the model (e.g., the perspective from which it is constructed).

The models discussed in this section do not generally address a holistic perspective of standards development. The aspects of standards and standards development that the models do address offer novel ways of thinking about the phenomenon. They provide, however, an initial foundation for the preliminary conceptual model discussed in Section 2.9.

2.8.1. Models of Standards Development

Modeling the voluntary standards process is a beginning step in understanding the phenomenon. Cargill (1989, p. 45) claims that the traditional approach to standards development is a "simple two–stage model that sees the standards process as a reactive activity that specifies something that already exists, often producing a formalized *de facto* standard that simply confirms what an industry already believes." In response, he proposes a five–stage model for standardization. His model, however, is more of a model of types and functions of standards than a model of a standards development process. Cargill suggests that instead of the two–stage model, a model is needed that acknowledges the concept of anticipatory standards and the fact that providers and users have different interests in and needs for standards. This five–stage model consists of:

- *A Reference Model* that guides and provides a context for the standards that will be needed for the technology
- *Industry Consensus Standards* that describe a set of functions or capabilities; "the implementation of the strategy contained in the reference model" (p. 49)
- *Functional Profiles* that describe a "set of functions extracted from the industry standard and a set of functions required by a larger class of users than is represented in the more precise systems profile" (p. 50)
- *Systems Profiles* that describe "the requirements of groups of similar users, based on a standardized set of needs for that group of users" (p. 49)
- *Application Implementation* that describes "what each particular user wants from the purchased system" (p. 49).

In this model, Cargill attempts to deal with the differing needs of information technology providers and information technology users. He suggests that the provider's interests in standards lay more with the stages dealing with the reference model and industry consensus standards. The user's interests are represented more by the stages of systems profiles and application implementations. For Cargill, the functional profile may be the bridge between the providers and the users.

Cargill's model, as with the frameworks and models proposed by Spring and Bearman (1988) and Rush (1982), is directed more at the types and/or topics of standards to be developed. These models are less concerned with addressing how standards are actually developed.

McCallum (1994) proposes that standardization consists of three interdependent phases, each having complicating factors affecting the pace and success of the standards development efforts:

- *Development*, which includes factors such as determining the appropriate standards development organization; dependency on other standards under development; existing implementations and national standards; and the extent of the particular standard under development
- *Maintenance*, which includes dealing with options that occur in standards; maintaining values and data elements; and enhancing the standard
- *Implementation*, which includes the need to work out specifications and values for options contained in the standard; ensuring interoperability and interworking of separate implementations; and the need to stimulate implementation of the standard.

McCallum does not propose these three phases as an explicit model but is attempting to address the complexity of computer communications standards for interoperability.

The important point to be gained from these models is that they offer the perspective that a standard is not developed in isolation nor is the writing or publication of the standard the end of the standards development process. This understanding informs the preliminary conceptual model that characterizes a range of activities involved with standards development and addresses the varieties of interests in the process.

2.8.2. Life Cycle Models and Best Practices

The Strategic Planning Committee of X3, the ANSI Accredited Standards Committee for information technology, developed a "life cycle" model. A primary purpose of the model was to begin a "rationalized study of standards—technically, managerially, and economically. It is not possible to understand the life cycle of a standard unless the causative forces that impact it—causing both the need for the standard and the standard itself—are understood" (X3, 1989, p. 1). Table 2–3 presents the stages of standards development, implementation, and management outlined in X3's life cycle model. The model appears to be based on the personal experience of those involved in a particular area of standards and with one standards developer (i.e., X3). There is no indication that the model is based on systematic empirical research.

Table 2–3
X3 Standards Life Cycle Model

- Objectives of the market and the standard
- Identification of opportunities
- Commitments of standards developers
- Definitions of objectives and schedule
- Creation of the standard
- Implementation and application standards
- Conformance to the standard
- Maintenance and enhancement of standards
- Reaffirmation and deletion of standards

Reilly (1994, p. 33) depicts a standards life cycle that describes "the steps in developing and evolving standardized products." The six–stage model includes:

- Stage 1: Initial requirements
- Stage 2: Base standard development
- Stage 3A: Profile
- Stage 3B: Product/service/tester development
- Stage 4: Testing
- Stage 5: Deployment (user implementation feedback).

This model advances the notion of feedback, and Reilly acknowledges that although the six stages may appear a linear process, iterations and feedback are part of the process.

Another model that uses a life cycle approach resulted from a 1993 workshop sponsored by NIST and the Industrial Technology Institute (ITI). "Standards Development for Information Technology: Best Practices for the United States" (National Institute of Standards and Technology & Industrial Technology Institute, 1993) attempts to identify best practices that could be used to improve "standards making" for information technology. Workshop members modeled the standards process to identify points to implement best practices. Further, the workshop acknowledged that standards making "must be sensitive to the peculiar nature of the organizations, political, business, and technical factors which constitute the standards making environment" (p. 2). This is an important point in favor of the approach taken by this study: the broader technology and social environment must be accounted for in any conceptual framework of standards production.

The NIST/ITI workshop suggested that at the highest level the standard process consists of two areas, each of which contain a number of subcomponents. Table 2–4 lists these areas and components.

Table 2–4
NIST Best Practices Workshop Model

- Establish the Standards Activity
  - — Business Foundation
    - Establish requirements
    - Make a business Case
  - — Planning
    - Strategic
    - Organizational
  - — Sell the Plan
    - To users
    - To vendors
    - To third Parties
- Develop the Standard
  - — Technical Task of Making Standard
  - — Market Development
  - — Process Management.

It is in the area of the technical work of developing a standard that the workshop participants employed a model of the standards life cycle. Workshop participants indicated that three related domains are important here: “standards *per se*, implementation, and testing” (p. 11). The workshop model identifies a number of stages the standard itself goes through (e.g., working draft, committee draft), but more importantly the model suggests that the development of the standard should not occur in isolation. The development of the standard must be related to product or service implementation and testing activities, some of which (e.g., implementation prototypes, and test requirements) should occur during the development of the standard.

The NIST/ITI workshop advances the understanding that standards development comprises complex components and activities, and their interaction. The workshop concludes (p. 18):

> Improvement [in standards development] requires a knowledge of the process of standards making. We must know what the elements of the process are, their respective time lags, what the feedback loops are, and how various elements affect each other.

Moreover, the workshop participants agreed that improvements to the process can result from changes in the technology used (e.g., deliberations of the committee members), organizational activities of those involved in standards development (e.g., better coordination), and in the individuals involved (e.g., training in group processes for consensus building). By linking changes in the standards development process to an understanding of the interrelated components in that process, the NIST/ITI workshop’s recommendations support this study's concerns that changes to the standards development processes must address the complexity and interrelatedness of the components of standards development.

2.8.3. Models Focusing on Formalized Processes

The literature has examples of models representing activities and events in the more limited aspect of standards development that can be referred to as "standards writing and approval." These models often reflect the formal procedures that standards developers and organizations have established to guide their committees' deliberations and activities. While limited to an aspect of the broader standards development process, these models are helpful in pointing to discrete processes and their interconnection.

Gibson (1995), the chair of the U.S. Technical Advisory Group for Joint Technical Committee 1 (JTC 1 is the primary international standards committee focused on information technology), suggests that the three global standards organizations (i.e., ISO, IEC, ITU) employ a general three–phase process:

- Doing the technical work on the standard
- Building a technical consensus for the work
- Gaining formal approval of the standard.

Gibson details, however, a six–stage process that JTC 1 uses. This process model covers the general steps involved in the standards organization, but does not show relationships of these steps with entities outside its standards development process. Table 2–5 summarizes the JTC 1 six–stage process.

Table 2–5
Six–Stage Process Model for JTC 1 Standards Development

- *Stage 0 — (Preliminary Stage)*: A period of study that may lead to one or more new proposals (NPs)
- *Stage 1 — (Proposal Stage)*: A NP is under consideration by JTC 1; it must be approved before work can begin; members must agree to participate in the work being undertaken
- *Stage 2 — (Preparatory Stage)*: A working draft (WD) is under consideration; WDs record the technical evolution of a standard; when stable and mature, the WD can be registered as a committee draft (CD); ballot period involved
- *Stage 3 — (Committee Stage)*: A CD is under consideration; can evolve until substantial support is reached; may be advanced to a draft international standards (DIS) status
- *Stage 4 — (Approval Stage)*: A DIS is under consideration; ballot period involved
- *Stage 5 — (Publication Stage)*: Follows passage of DIS as an approved international standard (IS)

The attempts at modeling a formalized standards process often reflect the procedures of voluntary standards development in ANSI–accredited organizations. There are other processes, and an important alternative model is offered by Rutkowski (1995). He contrasts the Internet process of "standards making" with the "traditional standards making process" (i.e., the ANSI–accredited process). Rutkowski points out not only the compressed time period in which Internet standards have been developed but also the importance of prototyping. The Internet process is a "single stage" that includes requirements, development, testing, and user implementation feedback all occurring in the process of making the standard. Including a requirement that the specifications in an Internet standard are demonstrably interoperable means that the final approved standard is implementable.

2.8.4. Towards Extended Models

Cargill (1994) proposes a five–stage model in which the formal procedures of standards writing and approval are but components in a more complex process. The new model presents an extended view and understanding that the process of standards development begins earlier than is reflected in most standards developers' flowcharts (see Cargill, 1995).

Cargill's new five–stage model is based on a conceptual separation of three distinct areas of standards development:

- Preconceptualization
- The Formal Standards Process
    - Conceptualization
    - Discussion
    - Writing the standard
- Implementing the standard.

This conceptualization allows Cargill (1994, 1995) to propose a new model for standards development in which different groups, processes, and procedures interact:

- *User Group Requirements (UGR)*: Develops the requirements for the TSG and UPG
- *Technical Specifications Group (TSG)*: Creates a technical specification that is submitted to a SDO
- *Standards Developing Organization (SDO)*: Follows an accredited process and creates nationally accepted standards
- *Testing Organization (TO)*: Creates tests to validate the standards and specifications produced by the TSG and SDO
- *User Procurement Group (UPG)*: Creates user procurement specifications using the UGR and TO documents as the basis for specifications.

A model such as this, combined with the stages identified in the life cycle model, begins to illustrate the complexity of the standards process. In an earlier work, Cargill (1989, p. 8) acknowledges that "the standards process is buffeted by random, nonquantifiable, and at times irrational behaviors and variables"—characteristics that may not be susceptible to modeling, but which need to be acknowledged and identified.

Cargill (1994, p. 13) also proposes an operating metaphor that might capture the essence of this process. He suggests "competitive cooperation," which acknowledges the mutual interdependencies—at the level of actors, groups, and processes—in the development of a standard. Competitive cooperation "requires that groups that might normally compete must first join forces to create the activities over which they will compete." The concept of cooperation is implied by the concept of consensus, but the depth and breadth of the cooperation that occurs in standards development appears an important question.

Moen and McClure (1994b) propose a multi–stage model that reflects the development of the Government Information Locator Service (GILS) Profile (Moen and McClure, 1994a). A profile is an ancillary standards mechanism that provides additional specifications for using one or more standards to improve the likelihood of interoperability. The process to develop a profile can be considered a special instance of standards development. Figure 2–3 depicts the stages and components identified in that profile development process.

The GILS profiling model identifies the following components:

- An existing base standard(s) that appears to be useful in an application. In the case of the GILS Profile, the base standard is ANSI/NISO Z39.50.
- A communication and problem–solving process in which the experts and the representatives of the users attempt to clarify and specify the functional requirements of the system that will implement the standard.
- A communication and negotiating process by which the experts come to agreements on the way the standard will be implemented, which subset of the standard will be chosen for implementation, etc.
- Political, economic, and other environmental factors, including the state of the technology and the standard, that can affect the progress of process.
- A number of people who are experts in the base standard and its implementation or who can be considered stakeholders in the process.
- A number of people who represent a large class of users (i.e., indirect users or acquirers of systems that use the standard) and the functions required by the users.

The multiple stages represented in the model are not necessarily linear, and are likely iterative and may occur in parallel.

- *Problem definition stage* in which the participants in the development process come to an agreement on the nature and scope of the problem to be addressed by the profile.
- *Interpretation stage* occurs when the participants attempt the translation between user requirements (i.e., the functions that the users would like in their system) and the specification of more detailed functional requirements.
- *Modeling stage* is an attempt to fit the interpretation of functional requirements into a comprehensive view or architecture of the system. Assumptions about the use of the system, user behaviors, user information needs, etc., are stated and agreed to by the participants. The outcome of this stage shapes the subsequent choices made for the profile.
- *Problem solving stage* consists of the participants determining how the information systems will actually accomplish the functions that are derived from the interpretation and user modeling stages. This may include some preliminary system design activities.
- *Selection stage* in which the participants, through a negotiation process, decide which subset of the standard will be used to support the application's functions.
- *Consensus stage* occurs when all or a large majority of participants come to an agreement on the entirety of the profile and can sign off on the profile. In actual fact, there are likely

to be many moments of consensus throughout the development process as agreements are reached.

- *Implementation stage* occurs when specifications are used to build actual products either as prototypes for testing or final products.
- *Evaluation stage* refers to all the activities related to evaluating the profile and the specifications it contains, and especially relevant to checking to see if the implementations address the original requirements.

The model of GILS Profile development, as with Cargill's most recent model, expands the conceptualization of standards development to account for a wider range of processes and components than have previous models.

Schmidt and Werle (1992) writing in the context of science, technology and society (STS, see Section 2.7.) propose both a conceptual framework and a theoretical perspective related to their research project that focused on three standards development efforts: X.400 Message Handling Protocols, Telefax, and Videotext. Their conceptual framework addresses compatibility, complementarity, and coordination.

Figure 2–3
GILS Profile Development

<table>
<tr><th colspan="3">Profile Development Process:
Multiple Stages and Numerous Components</th></tr>
<tr><th><u>Stages</u></th><th><u>Components</u></th><th><u>Stages</u></th></tr>
<tr><td>Problem Definition</td><td rowspan="4">Existing Standard
Problem-Solving Process
Negotiating Process
Political, Economic, and Environmental Factors
Technical Experts
Representation of Users</td><td>Selection</td></tr>
<tr><td>Interpretation</td><td>Consensus</td></tr>
<tr><td>Modeling</td><td>Implementation</td></tr>
<tr><td>Problem Solving</td><td>Evaluation</td></tr>
</table>

Compatibility refers to the extent of the required interoperability for "the functioning or for the improved performance and efficiency of a technical configuration" (p. 302). Compatibility, as technical interrelatedness, may comprise three distinct aspects: modularity, multifunctionality, and interconnectivity. Complementarity addresses the interdependence of single objects without necessarily accounting for compatibility. They add, however, that "this interdependence becomes most prevalent where, in addition to simple complementarity, the compatibility of technical components is required" (p. 305). Coordination refers to a situation of interdependence "where it may turn out to be beneficial for all affected actors to coordinate their activities in advance" p. 305). Schmidt and Werle suggest that instead of negotiating all the steps in the development of a technology along the way, "an agreement on general conventions and principles guiding future actions may be the least expensive solution in terms of transactions costs" (p. 305). Standards provide such anticipatory agreements that help actors to coordinate their actions.

Schmidt and Werle's theoretical perspective of the standards process assumes that "technological prerogatives do not stand outside but are an integral part of the social process" (pp. 309–310), a statement that reflects a common assumption in STS. The analytical aspects of the standardization process are structural and procedural, with the output being specific standards. Structural aspects of the process include:

- Institutional Framework (i.e., characteristics of the standards organization)
- Actors/Interests (i.e., stakeholders and their concerns and commitments)
- Technological Foundation (i.e., technical feasibility of the standard)

Procedural aspects concern primarily the decision–making process and activities.

In their model, Schmidt and Werle attempt to identify important aspects of the standardization process, yet they present it as basically linear, where the output (i.e., the standard) is conditioned by the procedural aspects that are in turn conditioned by the structural aspects. The potential dynamic interaction and mutual shaping of these three components are not addressed. However, Schmidt and Werle have usefully dissected the characteristics and attributes of the structural and procedural aspects.

2.8.5. Summary

This section has presented selected models that appear in the literature. Not all of the models were intended to represent the standards development as it is defined for this research (i.e., a multifaceted social process comprising various activities, entities, processes, and forces, and their interactions). Yet each model provided the researcher with insights into aspects of the activities and processes involved with standards and their development. A common characteristic of these models, except for the Schmidt and Werle model, is that none of them appear to result from systematic empirical research. Schmidt and Werle (1992), in their concluding comments, suggest that the "empirical reconstruction of standardization processes is confronted with difficult problems of gathering and interpreting 'data'....Thus, in the final analysis not so much the problems involved in theorizing about standardization but rather the empirical difficulties of grasping the 'real world' of standard–setting processes may turn out to be the main impasses to this on–going research process" (p. 326).

A primary difference between the preliminary conceptual model developed for this study and the models discussed in this section was the focus on the entire phenomenon of standards development. With many of the models, standards development devolves to the procedural activities administered by a standards developer. Cargill's most recent five–stage model and Moen and McClure's model of profile development, however, go beyond the procedural perspective on standards development offered by Gibson and Reilly.

Most of the models focus on a "stage" approach to identifying what occurs in standards development. This is helpful, but potential interaction effects between the stages are not well articulated. Another problem with the stage approach is that each model identifies stages not found in other models. For example, McCallum suggests that standardization includes development, maintenance, and implementation. Others include testing (Reilly), market development (NIST/ITI), and conformance to the standard (X3) as stages in the life cycle of a standard.

This chapter identifies a number of models and frameworks that describe standards development. Generally, these do not accommodate a holistic perspective that acknowledges the complexity of information technology standards development. Returning to the notion of a model offered at the beginning of this section, an objective of the study was to provide a representation of Z39.50 development at varying levels of resolution (thus increasing the power and robustness of the model). The following sections discuss the preliminary conceptual model that guided the study.

2.9. Evidence for the Preliminary Conceptual Model of Standards Development

This section introduces and discusses a systems–theoretic conceptual model for standards development. The model represents standards development as a system, in that standards development:

- Consists of various components (some of which may themselves be systems) that are attempting to work together to achieve certain objectives and goals (i.e. they are purposeful)
- Exists within a larger system or environment of technology production and social use of technology that provides the context (including enabling and constraining forces) for the operation, values, and goals of the entities in the standards systems
- Utilizes resources such as people, scientific knowledge, technical know–how, etc.
- Comprises a series of processes that transform inputs (e.g., technical requirements) into outputs (e.g., standardized specifications)
- Includes informational feedback mechanisms.

The study proposed a preliminary conceptual model that served the following purposes:

- Reflected the researcher's current knowledge and assumptions about Z39.50 development
- Suggested a bounding of the scope of activities, entities, processes, and forces, and the context within which they interact that are a likely focus of this study

- Oriented the study toward a holistic understanding of the phenomenon by viewing the interrelated components of standards development as a whole entity.

A requirement for a preliminary conceptual model was that it supported the exploratory and descriptive intentions of this study. The preliminary conceptual model assisted in organizing data collection and analysis of the study but did not prescribe exactly what to examine or analyze. The preliminary conceptual model was a working model that evolved during the study.

Miles and Huberman (1994) suggest that a conceptual model can serve as a sensitizing framework for the study. The preliminary model identified elements of the phenomenon but did not address the "content" of those elements. As an example, the preliminary conceptual model included the element "stakeholder" but did not suggest specific attributes and characteristics of a Z39.50 stakeholder. The study's data collection and analysis contributed such attributes and characteristics.

While the study resulted in a revised and refined conceptual model based on the data collected and analyzed, it did not "test" the validity of the preliminary model. One goal of this research was to develop, revise, and refine a conceptual model to reflect Z39.50 development. Subsequent research can test the utility and validity of the revised model.

2.9.1. Systems Theory as Conceptual Foundation

There currently exists no substantive theory for standards development (i.e., theory grounded in research on one particular substantive area; see Glaser & Strauss, 1967). The literature identifies components and processes of standards development, and several writers use particular conceptual or theoretic perspectives to address specific aspects (e.g., technology diffusion, negotiation, conflict resolution, game theory, small group behavior, communication, problem–solving, etc.). This study, however, aimed for a holistic description and understanding of the phenomenon. The researcher concluded early in the study that focusing on a specific aspect of standards development could endanger the study from accomplishing its goal.

The imperative for this research was to identify a theoretic or conceptual perspective that would provide the foundation for a holistic description of the standards process. "The final justification for any conceptual scheme, of course, is its ability to organize meaningfully the complex data of empirical reality, and thus throw a bit more light on otherwise confused phenomena" (Buckley, 1967, p. 198).

This study used the perspective of systems theory from which to investigate standards development. It was an appropriate perspective because, as Patton (1990) suggests, systems approaches are useful to emphasize a holistic perspective on complex phenomena. Systems approaches, perhaps more than other alternatives, illustrate that "the complex world of human beings cannot be fully captured and understood by simply adding up carefully measured and analyzed parts" (p. 81). He also notes that a systems approach requires examination of the context in which the phenomenon exists: "A systems perspective is becoming increasingly important in dealing with and understanding real–world complexities, viewing things as whole entities embedded in context and still larger wholes" (Patton, p. 78). Patton suggests that a systems orientation can be very helpful in making sense out of qualitative data.

Checkland (1981) and Churchman (1968) discuss how a systems approach is an appropriate way of investigating what they call "ill–structured" or "soft" problems, problems that often can be characteristic of phenomena "with humans in them" (Churchman, p. 10). Mitroff and Mason (1983) discuss how a systems approach can address the challenges that come when confronting the "messy" problems of complex and dynamic systems. The nature of these problems is not fixed or given, but rather may differ from one interested party to another. Thus, Mitroff and Mason state, "as the world becomes more complex and volatile, problem *defining*, problem *finding*, problem *formulating*, and problem *selecting* become more important than problem solving" (1983, p. 151, emphasis in original text).

Checkland (1981) characterizes a systems approach and systems thinking as ways to provide an "account of the structure of reality and of the processes observed going on within it in terms of whole entities ('systems')..." (p. 100). Checkland suggests that a reductionist approach, favored in the natural sciences, investigates individual elements of a phenomenon with the assumption that by understanding the individual elements the researcher can explain the whole phenomenon. This is in contrast to a systems approach that treats the phenomenon as a "whole" and as having emergent properties (i.e., properties that are not found in the individual elements but emerge as a character of the system taken as a whole).

Taking the phenomenon as a whole does not mean the researcher cannot look at or investigate components of the phenomenon. Churchman (1968), for example, states that "Systems are made up of sets of components that work together for the overall objective of the whole. The systems approach is simply a way of thinking about these total systems and their components" (p. 11). Therefore, a systems approach not only supports one of the study's goals (O2) which is to arrive at a holistic understanding of standards development in the case of Z39.50 but also serves to examine individual components of the system .

In considering a phenomenon in the real world as a system (whether or not it is called a "system" or is claimed to be a "system") several other concepts are necessary. Churchman (1968, pp. 61–62) refers to the "input–output approach" in systems, in which some thing is input into the system and undergoes a transformation process (i.e., where the process represents or performs the functions that define the system) and then some thing is output from the system. Checkland acknowledges that when describing a phenomenon in systems terms, we regard it as "an entity which receives some inputs and produces some outputs; the system itself *transforms* the inputs into the outputs" (1981, p. 169; emphasis in original text).

The use of a systems approach to investigate Z39.50 development did not assume a simple mechanical or linear "input–transformation–output" process nor assume that inputs and outputs were necessarily concrete and tangible. Systems engineering might employ such mechanistic models to design or understand an information system or manufacturing system. Checkland (1981), however, argues against such mechanistic thinking when dealing with what he defines as “human activity systems” or systems in which humans are part of the system and its processes. Inputs and outputs may be “abstract” (Checkland, 1981, p. 315) and take a form that may be subject to dispute or negotiation by the people involved (e.g., technical requirements). This study assumed that in the development of standards, systems–theoretic concepts such as input, transformation, and output may be dynamic and that interaction effects may exist between them.

Another concept important to a systems approach is that of feedback. Miller (1978) examines various types of feedback (e.g., internal, external, positive, negative, etc.) in living systems and Richardson (1991) provides a discussion on the feedback loop in social science and systems theory. For purposes of this study, the researcher viewed feedback as messages or information passing between components in a system, and this information could have an impact on modifying behaviors in the system.

Checkland (1981, p. 173) offers a “formal systems model” which serves as a “formal construct aimed at helping the building of conceptual models that are themselves formal.” He offers the model as a guide to check whether or not conceptual models built to reflect the organized complexity of a phenomenon in the real world are fundamentally deficient. Table 2–6 summarizes Checkland’s formal systems model.

The researcher developed the preliminary conceptual model of standards development proposed below with a consideration to Checkland’s formal systems model as well as contributions by other writers on systems theory.

The preliminary model did not specifically exclude potential activities, entities, processes, and forces, and the contexts that may have been involved with Z39.50 development. Instead, the model directed the researcher to be open to uncovering what should be included in a revised conceptual model based on the data collected about Z39.50 development.

Table 2–6
Checkland’s Formal Systems Model

S is a ‘formal system’ if and only if:

- S has an on–going purpose or mission
- S has a measure of performance signaling progress or regress in pursuing purposes or trying to achieve objectives
- S contains a decision–taking process through which S may take regulatory action in light of its purpose and progress
- S has components which are themselves systems having all the properties of S
- S has components which interact, which show a degree of connectivity such that effects and actions can be transmitted through the system
- S exists in wider systems and/or environments with which it interacts
- S has a boundary separating it from wider systems and/or environments and which is defined to be the area within which the decision–taking process has power to cause action to be taken

- S has resources which are at the disposal of the decision–taking process
- S has some guarantee of continuity, has long–term stability, will recover stability after some degree of disturbance

---

2.9.2. Overview of the Preliminary Conceptual Model

The study began with a preliminary conceptual model of Z39.50 development. The model was not intended to be a concrete representation of the phenomenon itself. Instead, the study accepts Wilson's definition of a "model" (1984, p. 8)

> A model is the explicit interpretation of one's understanding of a situation, or merely of one's ideas about that situation. It can be expressed in mathematics, symbols or words, but it is essentially a description of entities and the relationships between them. It may be prescriptive or illustrative, but above all, it must be useful.

Wilson suggests that since modeling involves interpretation, selection, and simplification, a useful model should strive to be "*relevant* to the situation rather than a model *of* the situation itself" (p. 8; emphasis in original text).

Wilson (1984, p. 9) identifies several general uses for models:

- An aid to clarifying thinking about an area of concern
- An illustration of a concept
- An aid to defining structure and logic
- A prerequisite to design.

As "an aid to clarify thinking about an area of concern" a model provides a "way of making our assumptions explicit" and "is an efficient way of conveying the relationships and of sharpening up the thinking about the area of concern" (p. 9).

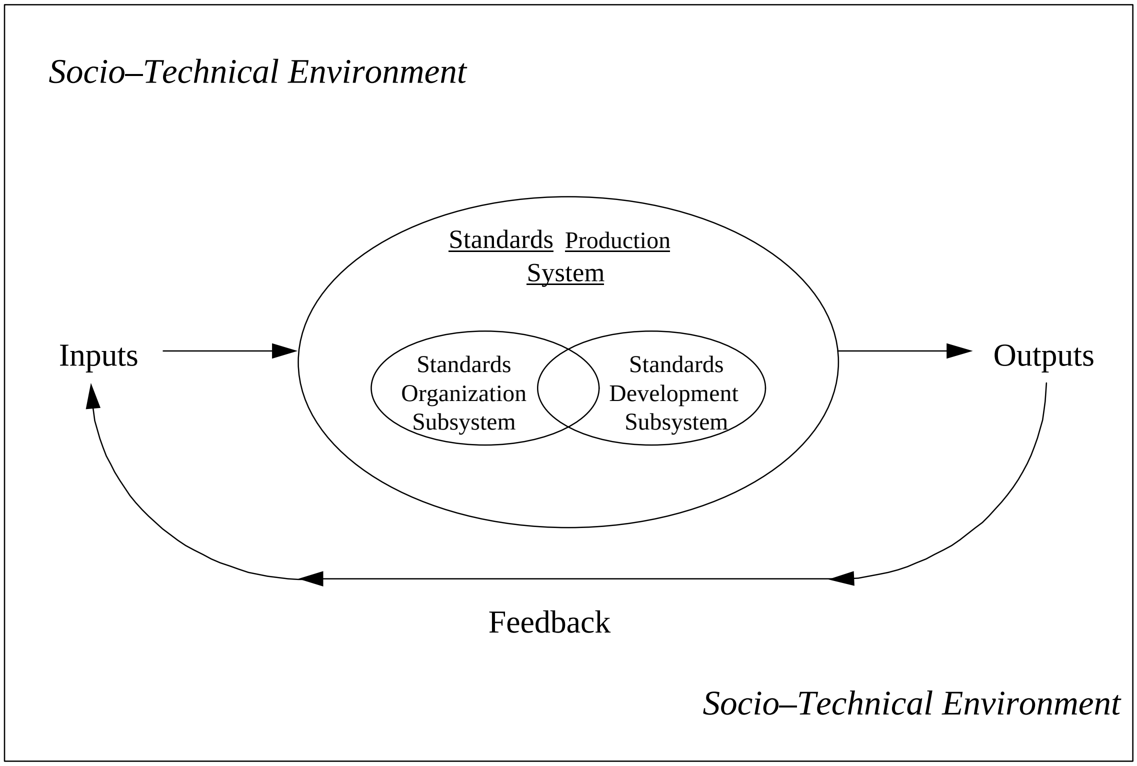
The literature review identified activities, entities, processes, and forces that are represented in the preliminary conceptual model. The constructs in the preliminary conceptual model were not necessarily meant to describe the concrete reality of Z39.50. Instead, this early model reflected a synthesis of the researcher's past experience with and observation of standards development, particularly Z39.50 development, and his current knowledge and assumptions about standards development.

To reduce potential confusion that the preliminary conceptual model provided an exact description of Z39.50 development, the researcher labeled the model as "The Standards Production System." Figures 2–4, 2–5, and 2–6 provide different views of the preliminary conceptual model by focusing on different parts of the model and presenting different levels of detail and granularity of components of the system.

Figure 2–4 presents a high–level view of the conceptual model of the Standards Production System. The model includes the following components:

- *Environment*: The social and technological environment in which the Standards Production System exists. The Standards Production System is one of many systems populating this environment. The environment is outside the system boundary and by definition is not under direct control of the system. The environment may be the source of initial inputs into the Standards Production System and may receive the final output of that system. For purposes of modeling, the environment is called the Socio–Technical Environment. An assumption of the model is that there are informational feedback and information flows between the systems and the environment. (Supporting evidence for this component and its elements may be found, for example, in Cargill, 1989; Farrell & Saloner, 1986; Office of Technology Assessment, 1992; Verman, 1973.)
- *Standards Production System*: This processes and transforms the inputs from the environment and/or other systems and provides outputs to the environment and/or other systems. The system includes some decision–making process by which the system organizes itself and regulates its operation in such a way to pursue its purposes. It is comprised of at least two components/subsystems that are referred to as the Standards Organization Subsystem and the Standards Development Subsystem (see below).
- *Inputs and Outputs*: Inputs move into a system and are transformed by processes within a system. Outputs are the result of those transformation processes. The model shows inputs moving into the system (e.g., technical requirements) and outputs generated (e.g., standardized specifications). As stated earlier, these inputs and outputs may be abstract and subject to negotiation and interpretation by the people or stakeholders in the system. The implication is that while the model reflects an "input—transformation—output" sequence it does not reflect possible interaction effects between, for example, inputs and a transformation process.
- *Information Flows*: A system requires information to regulate and control its operation. The model represents one of these information flows as feedback from output to input (e.g., information contained in the standardized specifications may feedback into technical requirements and reshape those as new inputs into the system). There may also be information flows within processes in components of the system and information flows between the environment and the system.

Figure 2–4
The Standards Production System



At its most parsimonious, the conceptual model has only these four components. To achieve one of the study's objectives (O2) of this study, namely, *revise and refine the preliminary conceptual model of information technology standards development to reflect the development of Z39.50*, the researcher needed to answer the research question (RQ2): *What are the components of the systems–theoretic conceptual model that represents Z39.50 development?* The research also addressed other questions related to the model such as the following:

- What elements exist in the Environment that affect and are affected by the System?
- What is the purpose(s) (i.e., stated and actual) of the System?
- How does the System regulate and control its operation (i.e., what is the decision–making process)?
- What are the various inputs and outputs of the System?
- What are the information flows within the System and between the System and the Environment?

These types of questions directed the researcher to identify activities, entities, processes, and forces involved in Z39.50 development and then cast those in terms of the conceptual model. Evidence provided by the collected data helped to characterize more fully the components of the model.

The researcher assumed that data collection and analysis during the research would provide the basis for the revised and refined conceptual model. At the outset, however, the researcher tentatively identified some of the elements based on the literature and the researcher's experience in standards development.

2.9.3 The Socio–Technical Environment

The Standards Production System and its components exist within a broad social and technological context. The standards production system is only one of many systems populating this environment. The environment is outside the system boundary and by definition is not under direct control of the system. One of the challenges for the research was to identify more clearly the boundaries of the Standards Production System. Callon (1987, p. 100) notes that a system concept implies making a distinction between the system itself and its environment. He is concerned, however, in cases where there are complex interactions between components of a system and the environment, it is not always easy to "define the limits of a system and explain concretely the influence of the environment."

The Socio–Technical Environment may be a source of inputs such as "technical requirements for standards." For example, one or more stakeholders might identify the need for disparate computer systems to communicate for the purposes of information retrieval. Such a need could be stated as a technical requirement that a standard should address. Outputs from the Standards Production System might include "standardized specifications" (i.e., the "technical requirements for standards" transformed into "standardized specifications"). There may be feedback between the Socio–Technical Environment and the Standards Production System. The Environment may receive information (i.e., feedback) from the Standards Production System (e.g., information on market opportunities and direction) or provide information to the System (e.g., information on market needs). In addition, stakeholders exist in the environment and may influence the Standards Production System.

While implied in much of the writing about standards and standards development, this context or environment is seldom dealt with directly or comprehensively. The preliminary conceptual framework, based on a systems–theoretic perspective, directed the researcher to identify the characteristics and components of the environment in which standards production occurs. Since the environment for the Standards Production System has both social and technological, the preliminary conceptual model refers to this as the Socio–Technical Environment.

The literature does not identify specific entities and processes as characteristics and components of the Socio–Technical Environment. It does address, however, entities and processes that may be appropriately placed outside the Standards Production System and its subsystems.

Markets and economic units (e.g., corporations, vendors, consumers, manufacturers) play an important part in discussions of the standards process (see for example, Gabel, 1987). Cargill (1989, p. 42) states that a "corporation will accept and use standards only if it believes that it cannot control the market directly and that standards can." There are a number of implications from this statement. An organization may not have been involved in the development of the standard but, rather, it receives the output of the standards process (e.g., an organization may "accept and use" but not necessarily help develop the standard). Since an interaction between the market and standards development is implied by Cargill, the market may be considered an entity in the environment.

The level of technology, the state–of–the–art, and the associated understanding or level of knowledge that exist in the Socio–Technical Environment can enable or constrain technical solutions that may be offered in standards development. For example, Farrell & Saloner (1986) and others discuss the influence of the installed base of technology on compatibility standards and technological choice. One can see in a definition of standardization prescribed by ISO (quoted in Verman [1973, p. 20]) that the existing knowledge may be an input and influence in standards development: "It [standardization] is based on the consolidated results of science, technique and experience." David (1987) mentions standards and their role in technology development and diffusion.

Politics, both domestic and international, are part of the Socio–Technical Environment. Political choices and agendas are identified as involved with standards development. Frenkel (1990) and the Office of Technology Assessment (1992) discuss standards and international political realities and international trade and competitiveness.

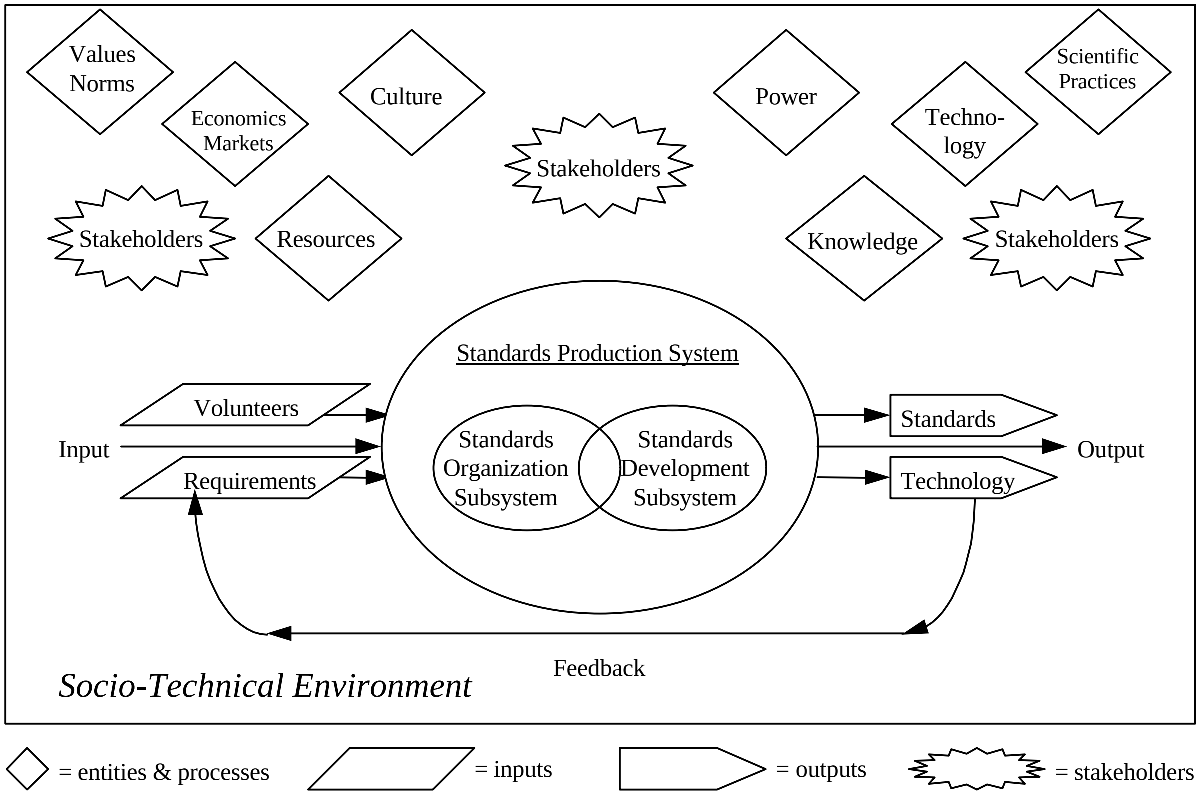
One can also see a domestic political initiative having widespread influence on standards development. In September 1993, the Clinton Administration outlined its vision of the emerging National Information Infrastructure (Information Infrastructure Task Force, 1993). The Federal Information Infrastructure Task Force's *Agenda for Action*, while acknowledging the need for information technology standards to create an open and interoperable NII, suggests that the "Government can catalyze this industry–driven process by participating more actively in private–sector standards–writing bodies..." (p. 9). The ANSI–sponsored Information Infrastructure Standards Panel (IISP) can be viewed as a response from a component of the Standards Production System to its environment (i.e., the IISP is a response to worries that the government might make an attempt to set standard for the NII). Thus, the government may be an entity in the Socio–Technical Environment affecting standards development.

The participants in the standards process, especially the traditional voluntary consensus process, come to the process from the Socio–Technical Environment. These participants are representatives of vendors, manufacturers, and users of existing products or potential standards–based technologies and products. As volunteers working on standards committees, they along with the requirements they bring may be in fact primary inputs into the system from the Socio–Technical Environment

The foregoing indicates that there are interactions between entities and processes existing outside the boundaries of Standards Production System. Measuring exact levels of interaction, influence, and impacts of the Socio–Technical Environment and standards was not, however, a goal of this research. The research, however, intended to identify and describe the entities and processes in the Socio–Technical Environment *vis a vis* Z39.50 development.

Figure 2–5 provides another view of the model and identifies a preliminary set of entities that may be found in the Socio–Technical Environment.

Figure 2–5
The Socio–Technical Environment



The environment provides inputs and may receive outputs of the Standards Production System, and it contains entities and processes that may constrain and/or enable the Standards Production System, including:

- Stakeholders, which may be considered a special kind of entity (Meek, 1990)
- Technology, especially in the form of installed base or emerging technologies (Farrell & Saloner, 1986)
- Level of knowledge, particularly scientific knowledge (Verman, 1973)
- Power (Weiss & Sirbu, 1990; Hemenway, 1975)
- Politics (Office of Technology Assessment, 1992; Frenkel, 1990)
- Economics/Marketplace (Farrell & Saloner, 1986; 1987; Reddy, 1987).

This is a dynamic and complex environment with likely interactions between the components in the environment and between the environment and the components of the Standards Production System.

2.9.4. Stakeholders

The voluntary standards development process exists because people participate in it. The ANSI–accredited process is open to anyone directly or materially interested in the subject of the standard. In ANSI terms, anyone with a “direct and material interest” can participate in the development of the standard. Moen and McClure (1994b) in a discussion of the role of users in the standards development process suggest that "direct and material interest" is not an unproblematic term. In part, this study examined the "interests" that were represented or not represented in the development of Z39.50. For the purposes of this study, however, it was necessary to identify who was involved, their roles and levels of participation, and their understanding of the process (and their understanding of what it meant to participate in the process). This section reviews what the literature presents about participants in the process and provides a tentative identification of what this study refers to as "stakeholders."

Stakeholders are the interested parties involved in all levels and aspects of the Standards Production System, but they are particularly focused on the outcome of the system. Stakeholders may be specific individuals, organizations, business and commercial companies, government agencies, etc. Specific stakeholders may play different roles at different time during standards development. These entities may have conflicting value systems, different perspectives on the problem the standard is attempting to address, and may wish to achieve differing objectives. An assumption of this study was that the activities and behaviors of stakeholders may be key factors in understanding standards development.

Meek (1990) suggests that there are two primary interest groups that contribute to the standards development process: suppliers and vendors, and purchasers and users. These groups are affected at the technical level. He includes two additional groups: the general public and the standards organizations. The standards organizations, although not directly interested in the technical content of the standards, "they do have a vested interest in maintaining their existence and influence, and are likely to have a tendency to guard the rules and procedures which they have built up in the past..." (p. 31).

Cargill (1989) perceives that although providers and users having an interest in standards development, they do not have the same goals, particularly in the world of information technology. He concludes that in standards development, "users rarely participate on standards committees and are virtually absent from the accredited SDOs" (p. 47). Reasons for the lack of participation, according to Cargill, include the prohibitive cost of participation and the users' general focus on short–term solutions and implementation. Providers, on the other hand, have more "global concerns." This distinction between users and providers is a basic premise for the Cargill's framework for standardization.

The issue of users and providers is interesting in that there is an assumption that there is a clear distinction between these two monolithic groups. Moen and McClure (1994b) point out that there may be various categories of users; there may well be various categories of providers. All have their own interests and stakes in the standards development process and its outcomes.

2.9.5. Participants

The working groups that actually write the standard are entities in the Standards Production System. The working groups consist of volunteers representing the stakeholders or other interested groups—users, providers, government agencies, academics, etc. Cargill notes (1989, p. 99) that it is in these working groups where the technical details are debated and resolved, consensus is reached, and the standard is actually created:

> A working group's deliberations should be relatively simple, since everyone is like–minded and working for the common good. Unfortunately, as I have pointed out before, the term "common good" not only is unclear at best, it is virtually meaningless in this context. When a working group begins its creative function, there is no guarantee as to what will emerge from the standards process—the common good is a complete unknown. It is the process of consensus—the interaction among members, the compromises and confrontations, and the ability to reframe questions so that they admit of a common answer—which leads the successful standards working group to its goal. (p. 100)

Working group members may not be of like–mind and may be motivated by agendas that pursue private rather than common good.

What can be said about the participants in the process? Cargill (1989, pp. 40–41) suggests that participants have their own reasons for participating—reasons that may be negative, positive, or neutral. For example, some individual might participate in an attempt to "slow or neutralize a standard so that a competing technology or process will prevail." Cargill posits another assumption—that everyone participating has an opinion about the subject under discussion, but in some cases those opinions might constitute a hidden agenda. This implies that participants may use various strategies in the standards development process, strategies whose goals may be known only to the individual.

Individuals may participate in the process as individuals, but more likely they will participate as representatives of an organization—especially given the cost of participation, organizational support is essential. In one of the few empirical studies of the standards development process, Spring, et al. (1995) found only 25% of their respondents participate for the benefit of their employers, although all participants were nominally representing their employers' or organizations' interest. Instead, "personal prestige, curiosity, and the desire to positively influence future events account for sixty–six percent of the stated motivation for participation" (p. 13).

The respondents in Spring, et al., (1995, p. 12) survey disclosed what they saw as their personal contribution to the standards development process. Following are the statements from which the respondents chose as best reflecting their personal contribution, a designated label of the dominant characteristics (assigned by Spring, et al.), and the percentage choosing a statement.

- Attention to technical detail (Perfectionists)—32%
- Ability to initiate proposals to get things moving (Doers)—18%
- Ability to focus on objectives (Leaders)—6%
- Ability to forge consensus (Diplomats)—13%
- Ability to listen attentively and monitor activities (Observers)—14%
- Ability to head–off bad ideas (Obstructionists)—11%.

Whether a participant's contribution is always focused in one of these areas or whether a participant takes on various roles throughout the process is not addressed in Spring's findings, but his findings are important since they identify and document the complexity of motivation and purposes of individual participants.

Cargill (1989, p. 25) suggests a number of categories of participants (whether provider or user):

- *Observer*: observes and reports back to an organization
- *Participant*: takes an active role in the process, shares knowledge, and supports or opposes particular developments
- *Contributor*: advocates and/or sponsors a solution or technology.

No matter which category (Cargill's or Spring, et al.'s) characterizes participants' involvement, they have access to a wide range of information that may be valuable to their sponsoring organization.

An important benefit of participation in standards development may be the amount and type of information that can be gathered. Cargill (1989, p. 85) identified several categories of information:

- *Competitive*: knowing the positions of other organizations
- *Technical*: knowing what the industry seems to believe is the correct technical way to proceed
- *Marketing*: knowing what the committee believes will occur in the future.

Another important issue raised in the literature is the basis on which participants have power, authority, dominance, etc., in the standards process. Hemenway (1975, p. 98) suggests, for example, that larger organizations relative to small firms have a disproportional share of power in the standards development process. This is due in part to the diversity of concerns of the smaller firms and the difficulty in coordinating their concerns. Weiss & Sirbu (1990), in an empirical investigation on technology choice in standards committees, report that size of a firm could be a significant factor in decisions that standards committees reached regarding that firm's proposals and technologies.

Brock (1975, p. 91) points out that individual users do not exercise a strong voice in standards development because they are small relative to the overall market and their own self–interests are often hard to organize or coordinate to make their common needs understood. Brock identifies an important role for the Federal government in standards development (e.g. COBOL and ASCII); the government is a single large user with immense purchasing power and can thus have a countervailing influence to typically diverging and competitive interests of manufacturers.

This discussion on characteristics of participants in standards development points out that there are various types of participants and many motivations and purposes for their involvement in standards development. Further, the participants are not always just individuals with a technical competence but usually are representatives of various organizations or interests.

2.9.6. Subsystems

ANSI–accredited standards developers such as NISO, IEEE, and EIA (see Table 2–2) have a number of functions, only one of which is to develop standards. Organizations such as ANSI Committees X3 and T1 focus primarily on the development of standards. Generally, however, two components of standards developers can be distinguished:

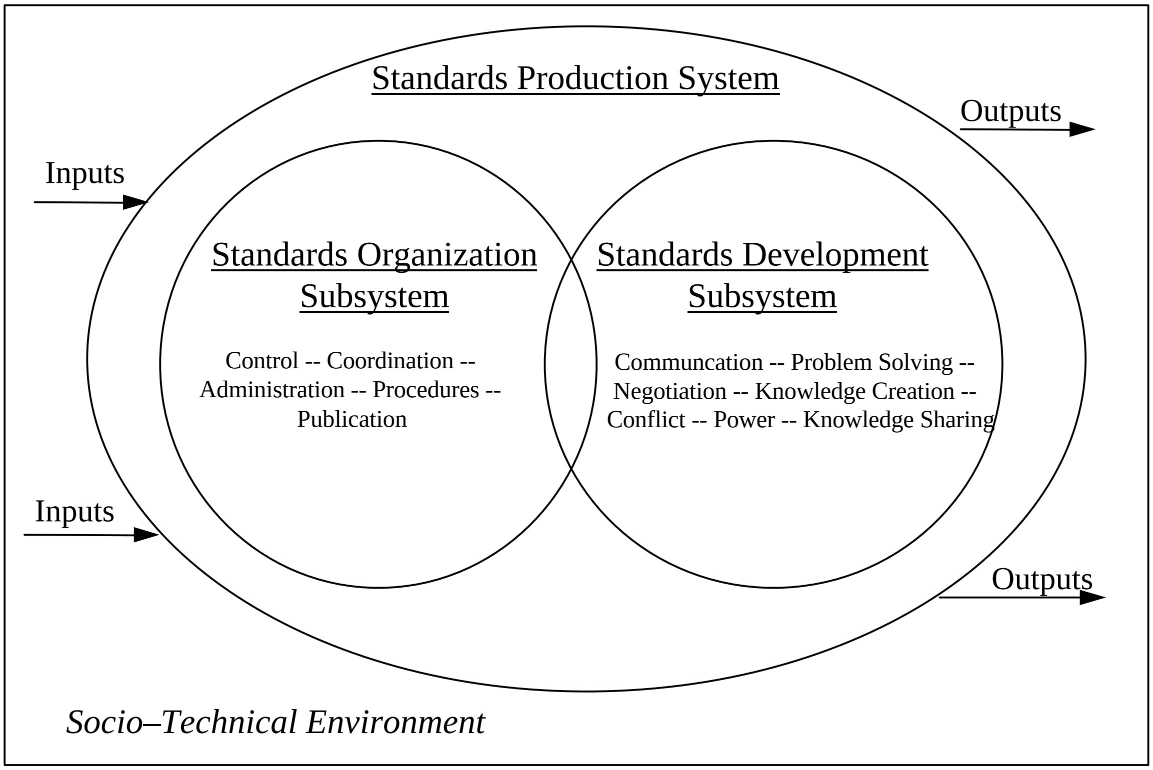
- An administrative component that oversees the rules, procedures, and logistical matters related to standards development
- Committees and working groups of individuals who actually write the standards.

The preliminary conceptual model distinguishes these as the Standards Organization Subsystem and the Standards Development Subsystem, since a system is defined, in part, by the functions and processes it comprises. The literature provides evidence for the functions, processes, and roles of these two subsystems.

For modeling purposes, the Standards Production System can be divided into at least two subsystems: the Standards Organization Subsystem and the Standards Development Subsystem. Figure 2–6 presents a more detailed look at the preliminary conceptual model of the Standards Production System with a focus on these two subsystems. The researcher separated these two components at the beginning of the study based on perceived separate processes, functions, or purposes served by these components of the Standards Production System.

The Standards Organization Subsystem addresses the administrative functions involved in standards development (for supporting evidence from the literature, see for example, Cargill, 1989; Greenstein, 1992; American National Standards Institute, 1993). The Standards Organization Subsystem includes, for example, the formal administrative processes and procedures that govern the way standards can be developed and approved, coordination functions related to standards activities, and revenue generation from the sale of standards and other products.

Figure 2–6
Standards Organization Subsystem & Standards Development Subsystem



The Standards Development Subsystem is a locus of activities, entities, and processes where the actual discussion about and writing of the standard occurs. Its function generally relates to what may be thought of as the "making" of the standard. Based on the literature the researcher tentatively includes the following as part in the Standards Development Subsystem (see for example, Weiss, 1993; Spring, et al., 1995):

- Communication
- Problem Solving
- Conflict
- Negotiation

As depicted in the model, there may be an interaction between these two subsystems, and it may be possible to represent some of that interaction as information feedback between the Standards Organization Subsystem and the Standards Development Subsystem.

2.9.6.1. The Standards Organization Subsystem

This subsystem addresses the administrative functions involved in standards production. The Standards Organization Subsystem includes, for example, the formal administrative processes and procedures that govern the way standards can be developed and approved, coordination functions related to standards activities, and revenue generation from the sale of standards and other products.

Cargill (1989, p. 96–98), when describing the administrative functions, includes: planning, controlling, organizing, coordinating, and commanding. ANSI–accredited standards developers also receive revenue from the sale of standards they have developed, and thus have a vested interest in the number of standards its technical committees develop. In its review of the U.S. voluntary standards system, the Office of Technology Assessment (1992) notes that these organizations often rely upon the sale of their standards to support the organization's activities. Percentage of the organization's income derived from the sale of standards ranged from 28% to 80% (Office of Technology Assessment, 1992, p. 51).

Section 2.5. described administrative procedures that ANSI and other standards developers have established to govern standards development. In contrast to the traditional ANSI standards process, for example, consortia can restrict membership and set up processes and procedures that do not acknowledge the hallmarks of the ANSI procedures—due process, balance of interests, and consensus. It may be precisely because of the control over these procedures that consortia appear successful in their timely development of standards. This point is important since the conceptual framework of the Standards Production System suggests that the Standards Organization Subsystem, with its rules and procedures, interacts in important ways with the Standards Development Subsystem (e.g., how the working group or committee actually carries out its work).

Lehr (1994a) noted that while the decision–making process within the Internet process is less bureaucratically constrained than in other standards developers, it is also less open since it lacks formal voting rules. He also points to a relatively homogenous community in which informal decision making has worked well. Weiss (1993) in an examination of political theory and standards development discusses how voting rules may affect the outcome of a standards process. The point here is to emphasize the potential impacts of and interconnection between the administrative procedures and rules of a standards organization and how standards are developed under those rules and procedures.

Standards organizations constitute an important component in the standards development process. This brief discussion shows that organizations and organizational structure, functions, and roles need to be accounted for in understanding the standards development process. Standards organizations may have impacts beyond that of standards development. For Greenstein (1992, p. 544) standards organizations provide a forum for solving coordination problems among vendors (when coordination for compatible or interoperable products has not been reached in the market). Since standards organizations contribute particular functions and processes to standards production, the preliminary conceptual model identified a component of the Standards Production System as the Standards Organization Subsystem as an appropriate way to examine these processes and functions.

2.9.6.2. The Standards Development Subsystem

The preliminary conceptual model also identifies the Standards Development Subsystem. This system comprises the activities, entities, and processes where the actual discussion about and writing of the standard occurs. Its function relates to what may be thought of generally as the "making" of the standard.

ANSI identifies three paths for developing a standard: the Accredited Organization method, the Accredited Standards Committee method, and the canvass method (American National Standards Institute, 1993). Common to all of these methods is the concept of consensus. "Consensus" is an important concept relating to the process of developing standards. Consensus reflects the level of agreement needed in the development of the standard for it to qualify as an ANSI–approved standard. Verman (1973, p. 12–13) saw the principle of consensus as the foundation upon which rests the effectiveness of voluntary standards. The goal of consensus is to achieve the largest possible agreement among all the interests concerned with the standard. The resulting consensus then constitutes the authority for the standard's use.

Verman (1973, pp. 128–129) identifies a set of underlying principles for the preparation of national standards. These principles provide the guidelines for the actual procedures used by standards developers. The main objectives of the principles are to "ensure the standards being sound from technological as well as economical points of view and secondly, to secure its acceptance on the widest possible scale" (p. 141). According to Verman (1973, pp. 132–133), the procedures reflect the following steps in the standards development process:

- Emergence and receipt of proposal
- Preliminary scrutiny of proposals
- Approval of projects
- Allotment of work
- Appointment of joint responsibility committees
- Preparation of draft standards
- Wide circulation of drafts
- Compilation of comments
- Finalization of drafts
- Approval of standards
- Publication and publicity.

Verman recognizes that these steps result in a lengthy and complex process. Yet, if the principles underlying the process are accepted and valid, then "there is little one can do to abbreviate or simplify the practice that has been evolved over several decades in several countries" (p. 141).

When one looks for descriptions of the voluntary standards development process, one often finds simply the listing of the formal procedural steps recognized by Verman. While this may be a context in which standards development occurs (serving to constrain and enable certain activities), Cargill (n.d.) and Weiss (1993) suggest that the *rules of the process* are not the same as the *process* and that the standards development process transcends these formal procedures. Cargill (1989, p. 71), for example, identifies "preconceptualization" as an important step in standards development; according to Cargill, preconceptualization occurs prior to the formal process being initiated.

Weiss (1993, pp. 36–37) describes unique characteristics of the process not accounted for by the formal procedures, including:

- An extension of the competitive product development process
- Negotiations on the details of the technical attributes occurs as a result of the diverging goals
- The standards process is educational
- Committee participants may exhibit strategic behavior.

Thus, if standards developers try to speed up their development processes by changing their formal procedures (e.g., changing the voting rules), they might only be introducing another set of tradeoffs (Weiss, 1993, p. 41).

The voluntary standards development system in the United States may be governed by rules and procedures to ensure the appropriateness of the standard and its widespread acceptance, however, the formal rules and procedures are only one level at which to understand standards development. A number of writers indicate that there is much more going on in the development of standards than is acknowledged in the formal procedures. Such a perspective supports this research's preliminary conceptual model of the Standards Production System. The model identifies and accommodates the formal procedures (e.g., as part of the Standards Organization Subsystem) and also reflects in the Standards Development Subsystem a separate set of activities, entities, and process, and their interaction at work in standards development.

2.10. Summary

The literature on standards and standards development provides an important foundation for the conceptualization of this study. This review has examined the literature to provide context for the study, and it has been used to identify components and aspects of standards and the standards development process that are salient to this research.

The preceding sections have reviewed contributions from the literature on the complex phenomenon of standards development. This discussion pointed to evidence in the literature for the basic components of the study's preliminary conceptual model. Through this discussion, the researcher has identified components involved in standards processes including the entities and forces in the environment, the standards organizations, the standards development processes, and the stakeholders and participants. The primary components of the Standards Production System were painted broadly at the outset of the study since the model served as an organizational framework to initiate the study.

Identifying and describing processes in the Standards Production System and its subsystems may help account for activities that are not constrained within the "boundary" of a single system or subsystem. For example, "recognizing a problem" or "identifying technical requirements" may be activities that occur in the Socio–Technical Environment, the Standards Organization System, or the Standards Development System. These activities may be distinguished as separate and distinct processes according to where in the Standards Production System they occur.

A detailed identification and description of the processes involved in Z39.50 development is essential in building a holistic understanding of how Z39.50 developed. A systems–theoretic perspective on standards development assumes the existence of processes. The study identified and described the processes involved in Z39.50 development. The analysis of those processes were incorporated into the revised and refined conceptual model discussed in Chapter 5.

Standards development, as presented in this discussion, is a complex phenomenon. To develop a holistic understanding required a research method that accommodated examination of the multifaceted character of standards development. The preliminary conceptual model laid a foundation for representing the richness and complexity of the components and aspects discussed in this section. Chapter 3 describes the research strategy that addresses this complexity by exploring and describing the development of Z39.50.