ICT Standards Management in the Twenty-First Century

Architectural Challenges and Management Opportunities

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Introduction

This article explores opportunities to manage standards and standardization with a particular focus on the information and communication technologies (ICT) sector. It looks at the historical "management" of standards primarily in the United States highlighting government and industrial approaches and the forces that have shaped the management process. It then turns to the current pressures and forces facing the management of ICT standards and standardization and makes some suggestions for activities that might enhance the management of standards.

An Historical Perspective: Focus on the United States

It is somewhat misleading to believe that we manage standards and the standardization process. Broadly, standards serve to improve commerce. Nations try to cope with the myriad forces which impact commerce and standards organizations and government agencies work to produce standards and manage standardization are one part of that endeavor. The United States, often held up as a prime example of business and industry led standardization, highlights some of the relationships between government and industry in this process. Over the last fifty years, developments in the ICT arena provide a prime example of how outside forces impact standards and standardization in a period of rapid change. Both reviews can inform a view of how the management process for standards and standardization might be improved.

Standards for communication (languages) and commerce (money) have been with us for more than two millennia. Few would argue that these developments were "managed". In the last millennia, there have been at least two broad periods of standardization. (Some might argue for three or four periods, but this analysis begins with just two.) The first period of managed standardization can be observed to begin with government control of weights and measures and monetary standards written into the constitutions of governments. Which nation was first is not as important as the centuries long tradition of governmental control of instruments deemed essential to commerce. A second period of managed standards begins with the industrial revolution. Scientific and technical standards were called for and to a large degree they became the purview of professional societies and industry. In some countries, governments played a facilitating role. In others, the government was inactive, as was largely the case in the United States. A few examples set the stage.

In order to schedule trains, railroads needed standard time. In Great Britain, standard time for the railroads was adopted in 1847. In the United States, the industry adopted standard time in 1870 (two time zones) and 1883 (four zones). This process was managed by the railroad industry out of a need. The U.S. government did not adopt standard time until 1912. Similarly, the infamous QWERTY keyboard standard arose from the dominance of the early Remington typewriter (No. 2) introduced in 1878 based on the patented design of the 1867 Sholes and Glidden typewriter. The arrangement was intended to prevent jams of hammers striking during the upstroke. The QWERTY keyboard, the IBM PC, the Microsoft Word document format are all examples of the many standards that arose based on various factors that led to market dominance. It would be hard to imagine that they were managed although it might be argued that "fast-tracking" of publicly available specifications is one management response to this situation.

Over the twentieth century, standards were increasingly set by professional societies such as the American Society of Civil Engineers (ACSE) and the American Society of Mechanical Engineers. Indeed, in part due to the prevalence of boiler explosions, the American Society of Mechanical Engineers established standards for boiler construction. ACSE provides standards for the construction of bridges and other civil structures. The development of standards for fire equipment and safety is often linked to the Baltimore fire. The fact is that fires in Chicago, San Francisco and other cities faced similar challenges. In Baltimore, the problem was highlighted by the number of cities that tried to provide help, but were unable to comment their equipment because of incompatible connections. The National Fire Protection Association adopted a national standard for fire hydrant and hose connections. While the standardization of fire hydrants and hose couplings grew, it was not an immediate accomplishment, and even today some cities have equipment that is non-standard. A 2004 study by NIST found:

> *Most of the major cities in the U.S. do not have standard fire hydrants and fire-hose couplings. In fact, only 18 out of the 48 most populated cities have both small hose and pumper connections on fire hydrants that comply with the NFPA standard. (Seck and Evans, 2004, p.11)*

While professional societies provide guidance and assistance, few would suggest a coordinated management plan existed for the adoption of their standards.

In large part, standards were developed when industry saw the need. At the same time, the players did introduce management structures when and where they deemed them appropriate. Perhaps the most significant innovation related to management of the process arose from the efforts of the Pennsylvania Railroad to influence the composition of steel rails for the railroad. At that time the Pennsylvania Railroad was the largest corporation in the US and Charles Dudley, as the head of its chemistry department, was responsible for the quality of the steel, paint, wood, and other products purchased and used. In 1878, Dudley published a report on the durability of different types of steel rails. Dudley was shocked at the reaction of the steel companies. In short, they did not want consumers telling them how to make steel. In search of a solution, Dudley suggested a meeting of consumers and producers to come to consensus about how to produce rails that could be efficiently produced by the producers and that would meet the durability needs of the consumers. The voluntary consensus process was born and Dudley went on to become one of the major forces in the founding of the American Society of Testing and Materials serving as president from 1902-1908. Like so many aspects of the standardization process, the vaunted voluntary consensus process and the mandate of involving consumers and producers was born as part of a solution to a very specific problem. It suggested a particular management process that proved useful when standards crossed industry groups. Interestingly, the British Standards Institution began in 1901 as the Engineering Standards committee and early on was also concerned with standards for steel used for railways.

The role of government in the management of standards, at least in the US, is also born out of a particular need. The articles of confederation and the Constitution gave the federal government of the United States the sole and exclusive right of fixing the standards of weights and measures. Similar to other modern governments, these standards that had a significant impact on commerce were defined as within the scope of the government. Presidents Washington, Jefferson, Adams and Madison all emphasized the importance of having the federal government act on standards, but Congress demurred and ignored the matter, leaving it to the states (Cochrane, 1974, pp 21-23.) What responsibility existed for standards in the government moved from the Department of Treasury to the Department of Navy (maps) and then back to Treasury. With the rise of the industrial revolution and the need for new standards of measurement for electricity, light, chemicals, etc., there was a ground swell of support for a national organization.

> *And under pressure to produce or to satisfy their own demands for quantitative results, it was the scientists who sought better standards of measurement, better tools, precision instruments, and materials.... Science, better than industry, was aware that only Federal legislation could establish the necessary criteria, criteria that would possess national as well as international validity.*
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> *Other nations, more advanced in commerce and industry, had long since recognized the need for such legislation and had established national standards laboratories....The meeting of these forces at the end of the 19th century—the growing needs of science and technology, coinciding with a new sense of national the impulse that created the National Bureau of Standards. (Cochrane, 1974, pp 15.)*

1901 a bill to form the U.S. National Bureau of Standards was enacted into law and in 1903 the Bureau was transferred from Treasury to the Department of Commerce and Labor. The focus on standards and metrics for the burgeoning engineering and science branches can be clearly seen. The divisions addressed: heat and thermometry,

light and optical instruments, resistance and EMF, magnetism and current, inductance and capacity, measuring instruments, and photometry.

In the early 1900s, several important events occurred related to the development and management of standards. What would become the British Standards Institution was founded as the Engineering Standards Committee in London in 1901. In 1906, the International Electromechanical Commission was formed. Also in 1906, the International Radiotelegraph Union was created as a companion to the International Telegraph Union which had been formed in 1865. These organizations would ultimately become the International Telecommunications Union (in 1932), a special agency of the United Nations since 1947. In the U.S. an important event related to the management of standards occurred in 1916 when four organizations that were developing standards (AIEE, now IEEE, ASME, ASCE and AIME, now ASTM) became concerned about the public acceptance of the standards they were developing. They established an impartial body to coordinate standards development, and reduce user confusion about who was developing the standards. The American Engineering Standards Committee (AESC) was founded in 1919 and over time played a role in the establishment of the International Standards Association which would evolve into the International Organization for Standardization. The AESC grew and reorganized as the American Standards Association in 1928 and then the American National Standards Institute in 1969. This suggests that at very least the professional societies developing standards were concerned with establishing a membership organization that could play a role in clarifying the legitimate standards developers for the public. Over the twentieth century, most of the U.S. standards developers, professional society and industry based, followed the practice of using ANSI as a mechanism to provide oversight of their processes. It is worth noting that the US movement to provide standards oversight played a role in the formation of the International Federation of the National Standardizing Associations which would evolve into International Organization for Standardization.

History suggests that, at least in the U.S., there was a general lack of interest in "managing" standards. Standards did emerge from invention, professional concern, industrial need, and other forces. At the same time, through the 18th and 19th century, there was little effort to manage the process strategically, tactically, or in any other fashion. Consensus based on participation of all the involved parties – consumers and producers – grew out of the need to invent a particular solution that would satisfy two industrial giants of the day, steelmakers and railroads. The idea of a voluntary consensus process developed by Dudley was a major strategy for the American Society of Testing and Materials and has become a dominant theme in many standards developing organizations. Stakeholder management has become an area of study for those interested in balanced standards (De Vries, H., Verhuekl, H. & Willemse, H., 2003) The need to provide assurance to the public about their efforts led to the creation of an oversight body that could provide certification of practice. Finally, the need for broad cross industry development of metrics for the sciences was seen as something most appropriate for the central government. This might be seen as an extreme case of a need for or cross industry standardization – i.e. electricity, optical and magnetic measures would impact many scientific and industrial enterprises.

More Recent Trends and Forces: Focus on Computers and Networking

Looking at more recent events, there have been numerous changes in the standards landscape. Some impact a broad array of standards. For example, the growth of free trading blocks has led to an increased use of standards as barriers to trade which has impacted agricultural and ICT products (Yue, C. 2006). The emergence of the European Union has spurred the use of standards to structure trade within the Union (Buttle, 1997). The growth of the Chinese economy has spurred Chinese efforts in the standards arena which have had impacts on intellectual property and trade (Ernst, 2011).

Other forces have a more narrow impact. Specifically, the demand for new Information and Communication Technology (ICT) standards has been extraordinary. ICT standards tend have a very short life span. They are often lengthy and complex. The organizations developing them are more transient and diverse than those in other sectors. Indeed rather than a half dozen SDOs, there are several hundred groups advocating or developing standards. ICT standards tend, more than standards in other areas to be coupled to intellectual property. Finally, the products being developed based on these standards have a significant and direct impact on many aspects of personal and social life including a significant impact on the privacy and security of information about humans. Below, we examine some of the more interesting developments in the ICT area.

Over the twentieth century, only a few groups were responsible for setting standards in each area of standardization. In the area of information and communications technologies (ICT) there were less than a dozen major players. Today, hundreds of consortia, working groups and organizations supply standards in the ICT arena. Most are aware of the major developers of these standards – ISO, ITU, ECMA, INCITS, ATIS, IETF and W3C. The

standards for other of the ubiquitous technologies have emerged in a less controlled fashion from other well-known organizations, e.g. Bluetooth SIG, USB Implementers Forum. The number of standards developers in the ICT arena has exploded and includes, to name just a few, the ZigBee Alliance, 3MF Consortium(3D Printing), Mobile Payment Forum (MPF), Car Connectivity Consortium, SD Card Association Security Industry Association (SIA), Smart TV Alliance, Clinical Data Interchange Standards Consortium (CDISC), EIS Alliance(energy management and smart grid), Genomic Standards Consortium, HDMI Forum, HomePlug Powerline Alliance, Open Automotive Alliance, Open Geospatial Consortium (OGC), Personal Connected Health Alliance. Most of these organizations are engaged outside the historical coordinating structures. Unlike more traditional SDO's, the various fora, consortia, and working groups come and go more quickly. They operate in new ways that are not subject to the traditional approaches recommended for the development of voluntary consensus standards (Baron, J., and Pohlmann, T., 2013; Baron, J., Ménière, Y., and Pohlmann, T., 2014). The growth of consortia and other groups signals a decentralization of standardization without control. Does this need to be managed? What leverage do we have, and what are the key concerns for management?

Almost a century after the founding of ANSI, on August 19, 2012, the IEEE, the W3C, the IETF, the Internet Architecture Board, and the Internet Society joined to form Open Stand and invited others to join them in establishing a new set of principles to guide standardization. There are many similarities between Open Stand and ANSI. So why a new organization? Is it a commitment to make standards available free of charge? Is it a concern about patent and intellectual property issues that have become especially troublesome in the ICT arena? Is it a shift in power from the center (ANSI) to the SDOs (W3C, IETF, etc.)? Does OpenStand represent the beginning of a new oversight structure for standardization both within the United States and internationally?

The standards developed by the Internet Engineering Task Force (IETF) are different from standards developed by other SDOs. (Oksala, S., Rutkowski, A., Spring, M.B., and O'Donnell, J., 1996**)** IETF standards tend to emerge from the bottom up rather than the top down. Further, one result of the requirement that IETF candidate standards be working prototypes is that multiple standards sometimes compete for adoption. Does the IETF signal a growth of "wisdom of the crowd" standardization? Will it be standardization by competition? Security, extensibility, and comprehensive application were not the primary goals of the IETF standardization effort. The weak security built into the Internet we know today is often explained as an oversight. Security was not a primary goal when the original protocols were developed. This is particularly interesting given the ARPANet goal of better communication system for the military! Over time, the Internet standards that emerged from the "competitive" standardization approach of the IETF focused on quickly providing capability. The goal was focused standards that maximized capability and sic, minimized complexity. Egyedi has focused much of her research on the implications of competing standards (Egyedi, T.M. 2010; Egyedi, T.M. 2012;).

The impact of Tim Berners-Lee on the direction of standardization undertaken by the W3C has been dramatic. While businesses play the important role in the W3C, as they do in any consortium, the technical staff of the W3C provides a damper on rampant commercial interests and focuses the standardization effort on what they consider the best technical approach. A careful reading of the W3C procedures makes clear that there are multiple checks and balances on standardization efforts that are closely tied to the central technical staff of the W3C.

> *Members express interest in the form of Member Submissions, and the Team monitors work inside and outside of W3C for signs of interest.… When there is enough interest in a topic …, the Director announces the development of a proposal for a new Activity or Working Group charter, depending on the breadth of the topic of interest.…. When there is support within W3C for investing resources in the topic of interest, the Director approves the new Activity and groups get down to work. (W3C, 2005)*

Do the efforts of the W3C signal a return to standards dominated by technical experts? Does the W3C model offer a mechanism for institutionalizing professional guidance of standards development?

The academic community has begun to examine the processes for standards setting. The issues examined, to cite just a few, include the roles of end users (Jakobs, 2002), the productivity of consortia processes (Egyedi, 2012), and the overall organizational structuring of standardization (Brunsson, 2012). More needs to be done in this area, but carefully structured research does exist in a number of areas.

What Might We Worry About Managing

Studies by the Office of Technology Assessment (OTA, 1990; OTA, 1992), suggested various roles that might be appropriate for the government in the standards process. In the ICT world, standards may focus on architecture, design, interconnection/interoperability, or implementation/derivation for specific situations. Some of us suggested two decades ago that architectural or design standards would be undersupplied in an environment driven by a business return on investment (Spring, M.B., and Weiss, M.B., 1995). This seems to be true, especially for the standards efforts of the ad hoc organizations developing ICT standards. They tend to be guided by very narrow goals directed at maximizing capability. While few want to see more government control of standardization, there is less aversion to government support of the cost of standardization. It might be the case that government could support industry development of architecture standards that would help to guide particular product efforts. Is there a role for government in helping to support the development of roadmaps where such are possible but don't exist? Is there a role for government in adopting important standards efforts that are orphaned by small consortium efforts? Is there a value in supporting open standards(Egyedi, T. M., & Enserink, B., 2013).

With the emergence of the Chinese market and the corresponding growth in standards development by the Chinese, there appears to be growth in trade controlling standards. Will standardization focus increasingly on market control and national interests? Will standards become a new mechanism for controlling trade in a post tariff world of free trade? There is a new role that standards have played in a post tariff world. Is this an appropriate role for standards? Some believe that we are beginning to work are way out of this problem by explicitly addressing the issue in the negotiation of free trade agreements. There is some belief that the TransPacific Partnership may simplify standards issues related to trade rather than complicate them. Do nations need to step in to manage the use of national standards as barriers to trade (Okun-Kozlowicki, J., 2016)?

The rapid and competitive standardization in the ICT field is occurring with very little centralized control. It would appear that many standards are focused on capabilities with a relative disregard for security or interoperability. While the standards are rich in capability, it is not clear that the players have a game plan when it comes to extensibility, security and privacy. Some organizations, such as the IEEE and NIST continue to think about roadmaps and architectures in their areas (NIST, 2011; IEEE, 2014). Others are more focused on developing capabilities for their specialized technologies with less regard for frameworks. Should the government play a role in assuring that a security framework is an a priori consideration in standardization for Bluetooth, ZigBee, USB, etc.? This is not to suggest that NIST, DHS or DOD should develop the standards, but rather that government might play a role. The government could act as convener or help to provide a structure for less formal organizations to work toward in areas like security and privacy. Further, the national government organizations might commit to financing the development of the reference models that business cannot justify based on a simple return on investment. Is there a way to maintain the entrepreneurial spirit that leads to rapid development while insuring that the structure put in place accounts at very least for security and privacy? It would be a shame if we look back in a couple decades to find that we enabled the Internet of Things without the forethought to secure the environment and protect the privacy of all who wish to embrace what it promises. It may be the appropriate time to look at the dilemma in the same way Charles Dudley did in the 1880's.

Conclusion

Standards and standardization are one of the mechanisms by which industries, nations, or groups of nations encourage commerce. Historically, standardization has not been managed so much as it has responded to "incidents" and "accidents". Industrial agreements, cross industry relationships and government control have been incorporated into best practices to enhance the process. The growth of the structures and management practices have emerged from particular sets of needs that occurred at particular times. This discussion suggests that the current systems for managing standards may be adequate for many areas of standardization but in areas where there are many players new to standardization or where standards are appearing very rapidly, roadmaps or architectural oversight may be lacking. In these situations, industries or professional societies may not be able to afford the cost of providing structures and government support for the efforts might be warranted. This could include support for research on various approaches, and provision of guidance and architectures for action. In the ICT arena, which is expanding very rapidly, a first step might include a government study of who is currently involved in the standardization process with a focus on the under-documented consortia and working groups currently setting standards. A second step might include an analysis

of how well the current efforts are doing in moving toward a secure cyberinfrastructure with appropriate provisions for privacy.

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