The Role of Standards in Vacuum Electronics

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Introduction

The spectrum of physical characteristics that are critical in vacuum electronics design makes it a particularly challenging product category to model. However, a well integrated set of information exchange standards for vacuum electronics would provide an opportunity to reduce the cost of doing business and improve the quality of products sold. Use of existing standards and establishment of the necessary industry standards for microwave–tube design data will have significant impact on the future costs and effectiveness of maintaining and extending power–tube design systems such as Microwave and Millimeter–Wave Advanced Computational Environments (MMACE).

Cooperative development efforts such as MMACE also face broader issues of standardization. The most prominent of these are how best to exploit existing standards and what strategy to adopt when confronted with missing or conflicting standards. The MMACE approach can best be understood in terms of layered standards. At the base are common standards pertinent to a very wide variety of application areas (such as C, Portable Operating System Interface for Computer Environments (POSIX), X Windows, etc.), often sanctioned by a recognized body such as the American National Standards Institute (ANSI) or the International Standards Organization (ISO). Next come application–specific standards, such as various parts of the Standard for the Exchange of Product Model Data (STEP). Finally, there are standards and conventions formulated and used by a single company or consortium. These narrowly focused standards should be built on the underlying layers previously mentioned. The adoption of strong local standards can, moreover, provide "firewall" protection for applications even when the underlying base standards change, conflict, or simply aren't there.

The Problem

The software applications used by the vacuum electronics industry have historically been developed as stand–alone solutions to problems and do not share a common model for representing electromagnetic, thermal, and mechanical properties. Applications written by different individuals usually have little in common. Styles and techniques for user interfaces, data entry, data structures, data output and data visualization vary from application to application. Exchanging information between these applications is a difficult and laborious task, often requiring manual reentry of data. This has resulted in design systems which are expensive (in both human and dollar terms) to use, maintain, and extend.

This software management philosophy results in a difficult and laborious exchange of information between applications. Errors are often introduced when data are manually reentered and the product development cycles are stretched–out as manual tasks are repeated with each design iteration. While modern software engineering could be used to eliminate some of the inefficiencies, this problem lingers on since no single contract or project can afford the cost of a rewrite of the existing software. Instead, patches are added as needed to keep the old code alive. Software information exchange standards are a vehicle for improving the efficiency of product development, but a change in management tactics will be required before any solution will have an effect.

Industry Standards and the Standards Process

Experience indicates that the development of industry standards can cut the cost and improve the reliability of a product. In the U.S., the 110 Volt electrical outlet is a good example of how a uniform standard can impact commerce. Consider how the complexity of day–to–day living would be increased if appliances required a special plug and used separate voltages and frequencies. While the standardized voltage and frequency may force some appliances to operate at less than the optimal efficiency, the overall cost of ownership has been reduced by the existence of a uniform standard.

Standards are used on a daily basis to facilitate commerce. Transactions between or within organizations commonly are specified in terms of standard measures for physical properties such as weight, volume, pressure, and current. For more complicated exchanges, such as when a mechanical design is contracted out for manufacture, the use of industry standards for paper–based drawings can be used to specify contract obligations. These standards save time and eliminate errors by allowing the transaction partners to conduct business using prearranged agreements.

The formal process of standardizing product information definitions is slow and does not always lead to a definitive conclusion. For example, even after decades of work, standards for representing mechanical design on paper have not resolved all the differences in design representation. Notations vary between ANSI, ISO, and Military standards. As product development has migrated to computer–based tools, a number of organizations have taken on the task of creating software information exchange standards. Many of these projects follow the traditional national or international standards process, but a number of the popular standards have evolved as *de facto* standards. Clones of popular software will often enter the marketplace using the leader's file format with the eventual outcome of the file format becoming a *de facto* standard. Alternatively, standards have been developed by collaboration over the Internet. This usually involves researchers simply exchanging software and documentation until a suitable "standard" has been defined.

Problems arise when international, national, and *de facto* standards exist for the same subject area. The cost of compliance with all possible standards may be prohibitive. If the information models of the standards conflict, it can be impossible to comply with the conflicting standards for all situations. Over time, the differences between standards should be resolved. Groups will either come to consensus on a common standard, or the marketplace will pick a winner. As a member of the industrial community, the vacuum electronics industry can potentially affect which standards ultimately are adopted. Active participation in this process can help ensure that the special interests of the vacuum electronics community are served by the broader industry standards.

How Successful Standards are Created

Actions taken by U.S. companies indicate that the official process of creating standards does not always work well for software. Discontent over the results of official efforts by ANSI, ISO, or the International Electrotechnical Commission (IEC) has resulted in a number of consortia being formed for the sole purpose of creating viable software standards. Organizations, such as the CAD Framework Initiative (CFI), the Internet Society, and the Object Management Group (OMG) have been formed by industry and are basing the new methods of standardization on the process that led to the creation of *de facto* standards such as Transmission Control Protocol/Internet Protocol (TCP/IP), telnet, ftp, and X Windows.

Simply submitting a written definition of a complex software standard and conducting a peer review of the definition does not appear to be a successful method for gaining industry acceptance. The cost of developing and validating software that complies with the written definition can be prohibitive, and the lack of a reference implementation makes understanding the standard difficult. In addition, the economic incentives for being the first vendor to be compliant are weak.

The alternative model for creating a standard starts with a research group collaborating on the development of a reference implementation of the standard. A release package containing source code that implements the standard, examples of proper use of the source code, and a comprehensive set of documentation is then freely distributed for peer review. An iterative process of refinement follows. Comments and bug reports to the developers are used to fix and improve the reference implementation. This distribute–test–fix process is repeated until a relatively bug–free version is released. The utility of the software then determines whether it will be successful.

The Challenge to the Vacuum Electronics Industry

The difficult design and manufacturing requirements of the vacuum electronics industry require a wide spectrum of interacting design parameters to be available in a single standard. This conflicts with the general trend of the standards community to create application protocols with narrow domains. In addition, the design and production of vacuum electronics is a difficult engineering task, and the small market size for vacuum electronics software limits the interest of the commercial software vendors. The challenge to the vacuum electronics industry is to create a standard that will attract commercial interest in spite of these obstacles.

The Role of NIST in Developing Standards

NIST's charter includes assisting U.S. industry in the development of useful standards. The technical staff is experienced and actively involved in the standards development process for a wide range of scientific and engineering disciplines. Generally, only the largest corporations can afford to devote resources to the full time task of monitoring and participating in the standards process. Small companies can use the pool of experts at NIST as a resource on standards in lieu of setting up an in–house staff. NIST participates directly on many standards committees and supplies support services such as testing, validation, and calibration.

How to Standardize When Standards Don't Exist

The MMACE project is using existing standards when available. Extensions are being developed to bridge gaps between existing standards for the vacuum electronics industry. This must be done with care so that forthcoming official standards can be integrated into the MMACE framework. Creating a framework as an application programming interface (API) between the information exchange standard and the application will limit the impact of integrating new standards into MMACE. The purpose of the framework is to isolate applications from each other while allowing them to share common information.