Operating System Standards: Perspective

Summary

The Austin Group merged the major operating system standards into one identical specification, superceding the old versions of IEEE POSIX.1, POSIX.2 and The Open Group’s Single Unix Specification.

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Technology Basics

Standards for operating systems began with the emergence of Unix, after decades of vendor-proprietary systems. With Unix, the “open systems” movement began in the mid-1980s. The term “open systems” implied much more than Unix variants, evolving to encompass a broad range of computer technologies, standards and specifications. The industry moved to deliver enabling technologies to promote open systems. The objective of the open systems effort was to help users purchase and vendors provide systems that met portability and interoperability needs.

As IT departments incorporate heterogeneous hardware, open system standards provide the means to be able to sustain diverse applications. Standard operating systems provide portability so that organizations can use applications on more than one platform with little or no change. As the industry adopts standards, we all benefit from source-level compatibility of applications between operating systems. Standardized systems are desirable because they allow users to:

- Adapt and modify their systems and technologies as business requirements change.
- Protect their IT investments in a quickly evolving business world.
- Deploy systems and software from a variety of technology suppliers.

Operating System Standards History

The industry was compelled to come up with a set of operating system standards because 15 years ago, there were many flavors of Unix from different computer manufacturers and lots of cross-pollination between these versions. In 1984, the Bison Group (a predecessor of The X/Open Company Ltd.), representing Bull, International Computers Limited (ICL), Siemens, Olivetti and Nixdorf, formed to develop a standard specification for their systems and to stop the proliferation of divergent versions — these became known as X/Open Portability Guides (XPG) and were closely aligned with the Unix system. Independently of the Bison Group activities, in 1985 the Institute of Electrical and Electronics Engineers (IEEE) Portable Operating System Interface (POSIX) group was also created to form a comprehensive set of standards for operating systems.

Around that time, other major groups defining guidelines and standards for open systems and influencing new technology development were X/Open, Unix International, X Consortium and the Open Software Foundation (OSF). In the late 1980s, X/Open (a predecessor of The Open Group) chose the Unix system as the platform for the basis of its open system standards efforts. In 1992, X/Open published the X/Open Portability Guides, XPG4. Groups like the IEEE, which established the POSIX standards; X/Open, with its Common Open System Environment (COSE) Common Desktop Environment (CDE) specification and Motif user interface, which it stewards on behalf of the industry; and The Open Group’s Unix 95, Unix 98 and the Single Unix Specification, helped to shape the face of Unix and standards for operating systems. Today, IEEE’s POSIX and The Open Group’s Single Unix Specification are the main operating system standard specifications.

Terminology Basics

De Jure vs. De Facto Standards

There are two types of standards: de jure and de facto. They can be described in the following way:

- A formal standard, also called de jure, is a format, language or protocol that has been certified and approved by a recognized standard-setting organization, such as IEEE. In the computing world,
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formal standards exist for communications protocols, data formats, operating systems and programming languages.

- A de facto standard is one that has evolved because it is widely accepted and recognized by those in the industry as being a standard and not because it has been certified by a standard-setting organization.

Is the Software Conformant or Compliant?

Is software “compliant” or “conformant” with standards? These two terms can be misleading. The term “compliant” is often evasive and can mean anything from complete consistency with a standard to “kind of resembling” a standard. The term that is important is “conformance.” Software that is “standards conformant” ensures that the system strictly adheres to a standard’s functionality.

How Operating System Standards Are Produced

A structured chain of organizations develops standards. These include formal standards organizations at the international, regional and national levels, as well as informal organizations, such as user groups. Often standards projects initiated at the grass-roots industry consortia level are introduced to formal national or regional organizations to become accredited and are then presented at the international level to be accredited globally.

Who Makes the Standards?

There are many standards bodies in effect. Formal standards, like the ISO/IEC C language standard, are set by accredited standards organizations, such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). On the other hand, de facto standards are typically developed by major vendors or consortiums that have no formal accreditation but that are well received by the buying public. A technology becomes a de facto standard in the industry by popular vote — as is the case with Microsoft Windows.

IEEE, ISO and The Open Group are the leading computer standards and specifications groups. Within these and other similar groups, there are hundreds of subcommittees of formal standards-producing organizations working on computer technology standards. These subcommittees are working on or have approved over 1,500 computer industry standards. These formal processes include participation of vendors, end-user organizations, academic institutions and government agencies. The Open Group has focused on certification programs to gain interoperability. The Open Group prefers to work with standards bodies to enhance market acceptance of products by ensuring that specifications are adopted and used in vendors’ products.

Vendors are generally responsible for much of the standards research and development. Standards organizations also highly regard input from user organizations and academia, and they encourage users to be involved in developing standards. But user organizations, except for those information technology-relevant Fortune 500 companies, are generally not well represented. This is because smaller companies find it too costly to dedicate time and people to these projects. Vendor organizations, however, are extremely well represented in standards-setting activities because they have an economic interest in influencing the outcome of standards.

Vendors’ Roles

After a standard is established, vendors choose whether to support it in their own products. Operating system vendors almost always support the IEEE POSIX standards and The Open Group initiatives. Application vendors, in general, are slow in supporting standards or in making their software available on
all the standards-based operating systems. While some application developers strongly support standards and a variety of operating systems, most prefer to limit the platforms on which they offer their software for the following reasons:

- They do not always know what standards are in existence, and they do not fully understand them.
- Investigating standards takes time away from a developer’s main job, and many would rather develop a marketable product extension than spend the time tracing standards.

**Technology Analysis**

**The Austin Group’s Convergence of POSIX and Single Unix Specification**

In 2002, the Austin Common Revision Standards Group (www.opengroup.org/austin) introduced a common revision of the traditional Unix standards, which combined the POSIX.1 and POSIX.2 standards, and the core of the Single Unix Specification Version 3 (or Base Specifications). The Austin Group is a joint working group of different communities (including representatives of the Linux and Berkeley Software Distribution [BSD] communities) and several different standards bodies: the IEEE Portable Applications Standards Committee, members of The Open Group and members of ISO/IEC Joint Technical Committee 1. Before the existence of this group, these standards bodies worked on their similar operating system standard projects independently of each other. Now, however, working together has resulted in a single standard.

Sharing the copyright of the revision, the groups replaced the following established standards:


The specifications were completed in June 2001. They were approved by The Open Group in September 2001 as the Base Specifications Issue 6. They were approved by the IEEE in December 2001 as IEEE Std 1003.1-2001. ISO/IEC finally announced their approval of the merger of these specifications as an international standard (designated as ISO/IEC 9945:2002) in November 2002. While the naming designation for the merged standard is different in all three organizations, the specifications are functionally identical. The standard has been made freely available on the Web, which is intended to encourage widespread adoption. The HTML version of the specification can be viewed at www.unix-systems.org/version3/online.html.

**Other Operating System Standard Initiatives**

**The Free Standards Group**

The Free Standards Group (www.freestandards.org) released the Linux Standard Base (LSB) in June 2001. It was developed to create and promote a set of standards that will foster compatibility between Linux distributions and Linux-based applications in order to help programmers build applications that work similarly on all versions of Linux. Its group of volunteers created the LSB specification, a base set of APIs, libraries and interoperability standards. The group has garnered support from the leading Linux distributors and application providers as well as from hardware manufacturers, such as IBM and Hewlett-Packard. In January 2003, LSB 1.3 was introduced. It supports newer CPU architectures, internationalization, pluggable authentication modules and additional APIs. LSB 1.3 also includes test suites, development environments, sample implementations and developer documentation.
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The Embedded Linux Consortium

In February 2003, the Embedded Linux Consortium (ELC) (www.embedded-linux.org) introduced its first standards specification in the attempt to encourage development of software for embedded devices, such as automobile control panels, cell phones, set top boxes and PDAs. The standard, called the ELC Platform Specification (ELCPS), will make embedded Linux applications more portable, allowing developers to write an application on one Linux distribution and then move it to another distribution, as long as both are compliant with ELCPS. Ongoing work for the ELC is to determine specific Linux APIs that members are most interested in using in devices, determining a test policy and establishing testing tools. The organization expects that ELCPS-compliant products should start appearing before year-end 2003.

Business Use

Operating system standards and, most notably, Unix standards have created a much wider variety of applications software than was ever available for most proprietary operating systems. In addition, standardization has helped to protect businesses’ application software investments. This is because applications that can run on one version of Unix are easily ported to another; thus, independent software vendors (ISVs) offer their software on multiple operating system versions.

Benefits and Risks

Benefits

• Software vendors substantially enlarge their market potential by supporting standard operating systems.

• The lack of source-level portability has been a hidden cost in developing software. A single standard reference for developers allows easier porting to more platforms and faster deployment, contributing to keeping software development costs down.

• Standards make it easier for vendors to maintain multiple versions of their applications. With easy porting, less support staff is needed for each operating system, and less documentation is required.

• Operating system standards have provided freedom of choice in selection of systems from competing suppliers. It also allows developers to choose the best OS for the job at hand without having to rewrite their entire code base or change their programming model.

Risks

• At the international level, the standards process can take up to six years from inception to completion, although the latest Austin Group initiative took only about three years.

• While the formal standards process dictates that a consensus review by all appropriate parties is necessary, such thoroughness tends to elongate the process.

• The lengthy standards process is also a problem because technology changes rapidly. By the time a standard receives the stamp of approval by an accredited organization, the resultant technology may have already become outmoded. However, in the case of the Austin Group’s specification, the interfaces are relatively stable already. This refresh is intended to be stable for another five years.

• In a perfect world, operating system standards should make software designed with one operating system run automatically on another operating system. While standards do resolve major compatibility problems, they cannot always guarantee perfect compatibility, such as where the operating system interfaces with different hardware.
Standards


The Austin Common Standards Revision Group (CSRG) is a joint technical working group formed to develop, combine and maintain a common revision of the IEEE POSIX.1 and POSIX.2 specifications and the Single Unix Specification. The scope of the project involved the three “base volumes” of the Single Unix Specification, version 2, which duplicated much of the functionality contained in the IEEE POSIX.1 and POSIX.2 standards. This project merged the standards’ functionality and eliminated obsolete features. The resultant new specification — ISO/IEC 9945.2002 — revises 9945-1, ISO/IEC 9945-2, IEEE Std 1003.1, IEEE Std 1003.2 and parts of The Open Group Single Unix Specification. It is technically identical to the current Open Group Base Specifications Issue 6 and IEEE Std 1003.1-2001. The ISO/IEC 9945 specifications carry both the IEEE POSIX and The Open Group’s Technical Standard designation, as well as an ISO/IEC designation.

ISO/IEC 9945 (parts 1 to 4): 2002 defines a standard operating system interface and environment. It includes a shell and utility programs that support applications portability at the source code level. ISO/IEC 9945 is organized similarly to the old Single Unix Specification and consists of the following parts:

- **Part 1: Base Definitions** (includes general terms, concepts and interfaces common to all volumes of the standard, including utility conventions and C language header definitions)
- **Part 2: System Interfaces** (includes definitions for system service functions and subroutines; C language-specific system services; and portability, error handling and error-recovery function issues)
- **Part 3: Shell and Utilities** (defines a standard source code-level interface to the shell services and common utility programs for application programs)
- **Part 4: Rationale** (includes rationale that did not fit into other areas of the document, such as historical information and reasons for inclusion and elimination by the standard developers)

The following areas were not dealt with in the scope of ISO/IEC 9945 (parts 1 to 4): 2002:

- Graphics interfaces
- Database management system interfaces
- Record I/O considerations
- Object or binary code portability
- System configuration and resource availability

**POSIX Standards**

POSIX is a set of operating system standards supported by system suppliers, heavily influenced by the Unix operating system. Developed by the Portable Applications Standards Committee (PASC) of the IEEE Computer Society, POSIX promotes portability of application code.

POSIX 1003.1 (POSIX.1) was historically the base POSIX standard, first published in 1988, with amendments published every few years. In 1999, the organization decided to make the first major revision to POSIX.1 in 10 years. This revision was carried out by the Austin Group and included a merger with the POSIX 1003.2 standards (POSIX.2) (the shell and utilities), which until now had been a separate standard, as well as the base volumes of the Single Unix Specification. At the same time, the PASC determined it would stop amending the base standard after completing IEEE Stds 1003.1a, 1003.1d,
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1003.1g, 1003.1j, 1003.1q and 1003.2b. All of these projects were moved into IEEE Std 1003.1-2001. Other POSIX projects in progress were then converted to stand-alone documents other than those included in IEEE Std 1003.1-2001, including test specs and language interfaces. As of this writing, current POSIX standards available through the IEEE include:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>ISO/IEC 16509:1999</td>
<td>Year 2000 Terminology</td>
</tr>
<tr>
<td>IEEE 2003.2-1996</td>
<td>Test Methods for Measuring Conformance to POSIX Shell and Utilities</td>
</tr>
</tbody>
</table>

Source: IEEE

The Single Unix Specification

The new ISO/IEC 9945:2002 specification is technically identical to the core of The Open Group’s Single Unix Specification, Version 3’s Base Specifications, Issue 6 and the POSIX standard IEEE Std 1003.1-2001; they are the same document. Key changes included dropping legacy and obsolete features, incorporating new POSIX real-time options, eliminating X/Open Transport Interface (XTI) and making STREAMS optional. In addition to the Base Specifications included in the merged documents, the Single Unix Specification, Version 3 includes an additional specification — the X/Open Curses, Issue 4, Version 2 specification.
In February 2003, the Open Group announced general availability of test coverage for the Single Unix Specification Version 3. The certification program for the Single Unix Specification Version 3 builds on the established source API test tools. The test suites use The Open Group’s Test Environment Toolkit and the VSXgen generic test frameworks, which provide a standard software layer into which test cases can be modularly integrated. The Open Group encourages developers to use these test tools in-house as part of the quality-assurance cycle through regular regression tests.

**Linux Standard Base**

LSB v.1.3 consists of the Linux Standard Base (LSB) specification and software that checks whether a version of Linux, or software that runs on Linux, complies with the standard. LSB specifies the binary environment in which an LSB-compliant or certified application executes. LSB defines the application interfaces at a binary level to ensure that applications run on each LSB-compliant or certified platform of the same processor type. There is a Generic LSB specification (gLSB), and for each processor there is an architecture-specific specification (archLSB) that describes the details specific to the different processor architectures.

The LSB includes development tools, such as test suites and reference-conforming applications.

The LSB specification governs those parts of a Linux operating system that deal with application compatibility, such as which libraries of reusable software components should be available, what basic commands Linux should execute or where to find specific programs in the file system. Thus, the LSB specification is concerned with the standardization of the following Linux elements:

- The most widely used shared libraries
- Draws on IEEE POSIX 1003.1-1990 and the Single Unix Specification Version 2 for many interfaces; differences are documented where they exist
- System commands
- File system hierarchy
- System initialization process and scripts
- Basic software installation
- Sockets
- Object file format

The Free Standards Group also has other active projects:

- The Linux Standard Base — interface standards for portability of applications across open source platforms.
- The Open Internationalization Initiative (OpenI18N) — a standard that provides a foundation for language globalization.
- The Linux Assigned Names and Numbers Authority (LANANA).
- OpenPrinting — a scalable and standardized printing architecture.

**Embedded Linux Consortium (ELC) Platform Specification (ELCPS)**

Linux is becoming important in the embedded software market. The ELCPS enables interoperability between different Linux distributions by standardizing the API layer of embedded applications. The
ELCPS is a source level API profile. A profile is a set of one or more specifications, or subsets of a standard to define a certain application environment; ELCPS draws on other standards, such as the LSB 1.2, IEEE POSIX 1003.1-2001 and the Single Unix Specification Version 3. The ELC Core Platform Working Group is a standardization panel composed of independent vendor representatives, chartered by the ELC. ELC is composed of representatives from technology firms to advance Linux in the embedded market.

Technology Leaders

Major Standard-Setting Bodies

American National Standards Institute (ANSI)

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ANSI promotes and coordinates the establishment of standards for a broad range of industries, including the IT industry. It is a private, nonprofit membership organization composed of more than 1,000 national and international companies; 30 government agencies; and over 270 consumer, educational, professional and technical organizations. ANSI is the U.S.’s representative to the world’s two largest standards organizations — the ISO and the IEC.

ANSI itself does not perform tests or technical evaluations of products or services. Instead, it accredits other organizations to conduct testing and evaluations. There are approximately 13,300 ANSI-approved standards in the areas of dimension rates, performance and safety requirements, test methods and terminology. In the software arena, ANSI has certified a variety of programming languages and system software interfaces, quality assurance, software engineering and software life-cycle standards.

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The Open Group’s membership includes information technology vendors and end-user organizations. It concentrates on lowering time, cost and risks associated with integrating new technology across the enterprise. The Open Group provides a forum where members can share knowledge, integrate open initiatives, and certify approved products and processes. The Open Group was formed as the result of the merging of two research and standards groups — the OSF and X/Open Company Ltd. The member organizations that contribute technology are involved in the process of accepting and adopting industry standards and directives. The Open Group has a family of test suites and certification facilities for ensuring that standards-based products conform to industry-standard APIs and interoperability specifications. The organization is involved in working with customers to address current and emerging requirements, establish policies and share best practices. It also works with suppliers, consortia and standards bodies to develop consensus and facilitate interoperability and to evolve and integrate specifications and open source technologies.

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The IEEE is the largest technical professional society and a major standards facility. It produces standards for many industries. It has over 900 standards with 700 in development, 50 of which are for software and systems engineering. The IEEE is composed of more than 377,000 individual members in 150 countries. The IEEE Computer Society is the largest of the 36 technical societies of the IEEE, with about 100,000 members. POSIX standards are under the IEEE control. The POSIX series of standards has evolved to specify environment variables, library routines, operating system primitives and shell commands.

ISO, IEC and JTC 1

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ISO and IEC are organizations that focus on international standards. Organizations that are members of ISO or IEC participate in the development of international standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and nongovernmental, in liaison with ISO and IEC, also take part in the work. The JTC 1 (Joint ISO/IEC Technical Committee) (www.jtc1.org) works to develop, maintain, promote and facilitate information technology standards required by global markets. Established in 1987, JTC 1 is made up of 24 participating countries, with an additional 42 countries which participate as observers in the committee’s technical work. JTC 1 collaborates with ISO/IEC technical committees and other management-level groups as well as industry and consortia. To date, the committee has published over 600 standards.

Insight

Operating system standards take years to develop, and operating system vendors take years to bring their systems to full conformance. But The Austin Group’s recent revision to POSIX and the Single Unix Specification was done quickly as far as standards go — in about three years. This revision combines the forces of standards groups that had previously been working independently of each other. Because vendors will no longer have to conform to two divergent sets of standards, the Austin Group’s efforts mean that vendors will more quickly and easily ramp up to the newest Unix standards.