Cloud Computing Standardization

Insights from past standardization

Ken Krechmer

Abstract: Cloud computing is the delivery of computing as a service rather than as products. It promises to dramatically simplify the development and deployment of new and very large economic, social and environmental applications. The future success of these applications will be greatly impacted by the standardization processes used to define the building blocks and interfaces in these systems. The standardization of very large, multi-national cloud computing systems is just beginning. The history of standardization and other large system standards offers valuable lessons on how cloud computing standardization might proceed to maximize vendor participation and user acceptance. This paper proposes a technical approach to assist cloud computing standard development organizations accomplish these difficult tasks.

1.0 Introduction

Cloud computing is a service, like a utility, that allows software, platforms and infrastructure to be available as needed to mobile and stationary users over the Internet.[1] Cloud computing is desirable for distributed applications such as: financial exchange, international trade, social networks, epidemic monitoring, health care informatics, emergency services, smart power grids, and environmental monitoring and management. These vital new services suggest significant commercial cloud computing opportunities.

Commercial motivation will stimulate investment in cloud computing systems, which is very desirable, but also makes standardization more difficult. Commercial organizations will work to maximize profit by asserting their intellectual property rights (IPR) or market advantage, to control cloud computing markets. Achieving higher profit is a legitimate goal of commercial organizations. Because standardization is vital to establish multi-national markets for cloud computing services,[2] cloud computing standardization should be managed to support both innovation and competition, maximize participation in the standardization process and minimize incompatibility of competing cloud services. This paper proposes a technical approach to assist cloud computing standard development organizations (SDOs) accomplish these difficult tasks.

First, the complex interaction between standardization and innovation needs some clarification.[3] Standardization of similarity (e.g., similar clothing sizes, lumber grades, time zones or battery voltage) reduces variation and therefore reduces potential innovation. However, the standardization of compatibility increases variation and innovation.[4] As example: compatibility standards and specifications include: WiFi, the cellular air interface, the Universal Serial Bus (USB 2.0), and Windows™ Applications Program Interfaces (APIs). In each case, large new markets (wireless LAN, smart phones, memory cards, PC software) have emerged from the creation of these compatibility standards/specifications.

Compatibility standardization defines interfaces and protocols which increase innovation and invention, but also increase the costs of interface design. Similarity standardization defines specific properties of a product or service which forestall innovation, but decrease the costs of production, operation and maintenance.[5] While similarity and compatibility standardization have completely different effects, similarity and compatibility are functionally tightly intertwined. In all cases, when the similarity of each of two interrelated entities (e.g., a cell phone and base station) is standardized, a compatible relationship between the two standardized entities is also defined (e.g., the same protocols connect both).[6]

Compatibility standards (e.g., APIs, interfaces, protocols) are crucial for multi-vendor cloud computing systems, but there are different standardization approaches. Standardization history helps to explain the different approaches.

2.0 The beginnings of standardization

The increasing application of technology after 1600 AD differentiates Western culture from other cultures in the same period.[7] The Indian, Ottoman, or Chinese cultures which began with a similar, or perhaps greater, grasp of technology were left behind by the growth and success of technology in the West. One little explored aspect that differentiates the West from other cultures is the emergence of technical standardization.[8]

In England, the Royal Society began meeting in 1660. King Charles III granted the Royal Society a charter in 1663. As a result of the efforts of the Royal Society, the scientific (fact-based) description and publication of what had previously been craft emerged.[9] The Royal Society's publications on measurement instruments defined the then-current measurement technology.[10] The structure of the Royal Society established a powerful concept – that a balance between public interests (the King's charter) and private interests (of the members) could codify technology for everyone.[11]

With measurement instruments, rigorous measurement standards became practical. A similar organization to the Royal Society was established in France in 1666. By 1799 (after the French revolution), the then named "l'Institut national des sciences et des arts" established the technical basis of the metric system, a fact-based standard measurement system.[12]

With measurements standards defined, similarity specifications could be created. Thomas Jefferson reported (1785) to the United States Congress on H. Blanc's work in France on interchangeable parts for the rapid repair of muskets after a battle.[13] By 1819, interchangeable parts were made using fixed metal gauges (early similarity specifications) which verify if the musket parts are interchangeable.[14] As measurement technology advanced,[15] the difficult to use gauges were replaced by written measurements to define similarity. Because of the close connection between similarity and compatibility, it is always possible, but often undesirable, to achieve extensibility (compatibility) by defining similarity. In cloud computing, the standardization of similar software, platforms or infrastructure is one approach to creating extensible systems. Defining similarity has the unfortunate aspect of picking specific implementations and rejecting others. Even if an implementation is selected without IPR, it is one version. Different cloud computing user requirements will need different versions.

Once similarity is defined, compatibility standardization develops. As similar parts are made accurately enough to be interchangeable, related parts become compatible, i.e., they fit together. In England in 1841, J. Whitworth proposed to the Institution of Civil Engineers the standardization of screw threads on nuts and bolts.[16] Mechanical compatibility establishes fixed interfaces: the relationship between a bolt and a nut, a train's wheels and the track, a pipe and its coupling, or an AC plug and socket. In the 19th century, the public value of defined interfaces was not understood[17] and large scale systems that needed to be compatible were operated by one organization (i.e., a railroad or a utility). Currently each cloud computing vendor offers incompatible services which protect and limit each vendor's market, much like a 19th century utility. In the 21st century, cloud computing should be a ubiquitous utility, not a private utility company.

Software standardization emerged in 1959 with the programming language COBOL (COmmon Business-Oriented Language), which creates software similarity.[18] Writing programs in the same language decreases the costs of development, operation and maintenance. With COBOL, the software market emerged; then compatibility between different programs developed (e.g., COBOL applications and mainframe operating systems).

An early consortium, the European Computer Manufacturers Association (ECMA), was formed in 1961.[19] Consortia are SDOs operated for commercial (private) interests,[20] often, by establishing an acceptable way for all members to exchange IPR. Two consortia which address cloud computing standardization are the Distributed Management Task Force (DMTF) and the Storage Networking Industry Association (SNIA). International cloud computing standardization is also being addressed by public SDOs including: the ITU (e.g., Focus Group on Cloud Computing), ISO/IEC Joint Technical Committee 1 (SC 38, Distributed application platforms and services), and the IEEE Cloud Computing Initiative.[21]

In 1961 ISO/IEC JTC-1 established an important precedent by inviting ECMA to become a liaison member of a new committee, TC-97 (Computers and information processing), to work on software standardization.[22] Today ISO/IEC JTC-1 continues its interaction with consortia by recognizing the work of DMTF and SNIA as "PAS submitters." PAS (Publicly Available Specifications) submissions allow these consortia to submit draft specifications directly to ISO/IEC JTC-1 for review and approval. This allows the different SDOs to support one specification/standard for one function.

The next step is to support different standards/specifications from different SDOs for one function. It is already common for programmable systems to support multiple compressions algorithms or multiple browsers. While counter-intuitive, when systems are programmable, standardizing multiple different ways to provide similar functions (multi-mode) offers some advantages. These advantages are developed in sections three and four. The technical approach to multi-mode standardization is described in sections five and six.

3.0 Public and private reasons

When an SDO operates without collusion (private interests are not joined), a compatibility standard should emerge that establishes a balance between private gain and public desires (low cost and backward/forward compatibility). However, intellectual property issues appear to unbalance more and more compatibility standards.[23] Inventor's IPR are granted to help them profit from their inventions by precluding competition from similar (i.e., copied) products. IPR are now applied to both sides of a compatible interface, created not by invention, but agreement. IPR on compatibility represents an unintended expansion of IPR which adds costs to an interface required in a standard. To better support the public interests, cloud computing SDOs should find ways to balance the increasing creation, assertion and cost of intellectual property in compatibility standards.

Establishing and maintaining a balance between private gain (e.g., market control and profit) and the public's need for economical compatible operation may be the most difficult task of modern standardization committees. The philosophy underlying standardization helps to understand why new approaches to balance public and private reasons are needed in cloud computing SDOs.

The philosophical basis for balanced standardization emerges from public reason, which was first enunciated by T. Hobbs (1651) as the sovereign's view.[24] Recently, the philosopher J. B. Rawls expanded public reason to include common sense, the clear results of science (e.g., technical merits), and public political values (e.g., representation, consensus and due process).[25] Public reason is distinguished from private reason which includes private gain (both economic and egotistic), and personal moral or religious values.

Both private and public reasons exist in the cloud computing standardization process.[26] Some standardization policies (e.g., PAS submissions) help to balance these interests. However, concerns have been raised over the expansion of consortia standardization.[27] Such concerns are unnecessary, so long as market competition exists. Representational governments are dominated by politicians who receive the most votes from citizens. In a similar manner, markets are dominated by the most widely used products. Continuing the analogy, citizens are represented by a government only if they can choose among multiple politicians (voting); users are represented by markets only if they can choose among multiple vendor's products (competition). When there are free markets (i.e., no restraint of trade), consortia usually support public reason, as each consortium becomes a proxy for its vendors and the vendors are a proxy for the users. Cloud computing standardization by different SDOs, representing diverse standardization approaches, is much more likely to support and expand all markets. But the politics of standardization can get in the way, as not every member of a cloud computing SDO has the same view, or definition, of the public reason.

4.0 The politics of standardization

The standardization of cloud computing is accomplished in a committee which attempts to balance its memberships' public and private reasons. The members of an SDO may represent users, academia, implementers or government organizations. Like any group of people, these members form political alliances within the standardization committee to further their own interests, which are often altruistic, and the interests of the organizations (often commercial) they represent. Looking at the dimensions of standardization: who, where and when helps explain the politics of standardization.[28]

4.1 Who is supporting the standardization?

The participants in any standardization committee come from different organizations. Their affiliation is less important to the standardization process than their motivation (Table 1).

Standardization participants	Motivation
Creators	Define the most desirable technology
Implementers	Organizational goals (e.g., profit)
Users	User requirements
Government	Public reason

Table 1. Motivation of standardization participants.

Creators and implementers, usually the majority of a standardization committee, attempt to support public reason by defining technology best suited to the known user requirements, most of the time. But that does not assure a consensus (required in most SDOs) when some participants place their private reasons ahead of public reasons.

Where markets are controlled by dominant suppliers, where IPR costs become excessive, or where fixed compatibility creates market control (e.g., railroad track gauge, early cell phone systems, Microsoft APIs), standardization can exacerbate anti-competitive behavior. This can occur legally, as example, when multiple patent holders pool their intellectual property and require an expensive license to implement a standard. The high cost of the IPR associated with MPEG/H.32x audio/video compression technology is an indication that public reasons are not well balanced. In this case, the Chinese government promoted an alternative standard.[29] When SDOs do create a balance of interests, no government intervention need occur. Governmental anti-trust and anti-competitive review is all that is necessary.[30]

4.2 Where will the standardization apply?

Standardization may occur within an organization, industry group (e.g., consortia or trade association), country, region or world-wide. As "where" becomes geographically larger, the market size and the need for standardization becomes greater. As example, a single facility could implement a proprietary local area network, but world-wide networking such as the Internet or cloud computing requires world-wide compatibility standards.

4.3 When does the standardization occur?
It is not uncommon, when a large new market is beginning, for precursor products to emerge in advance of the standardization process, as shown in Fig. 1. Amazon Web Services,[31] GoogleAppEngine[32] and Microsoft Azure[33] are examples of three precursor and incompatible cloud computing services.

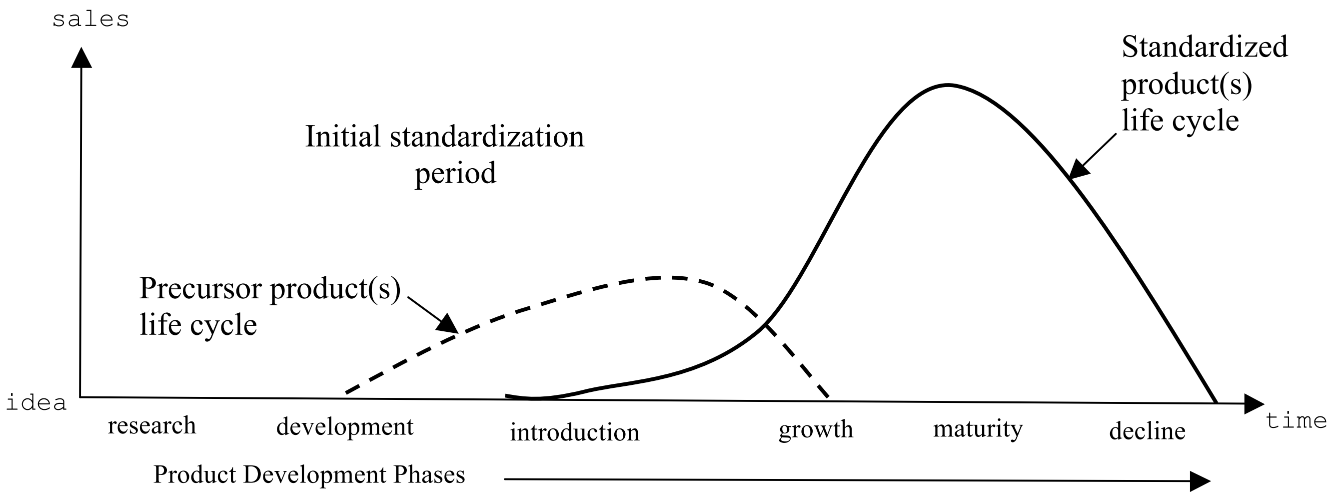

Figure 1. Products phases relative to standardization, when precursor products are not compatible with the standard.

When and how standardization occurs can make a significant difference in the growth of cloud computing markets. Fig. 1 identifies how precursor products sales are negatively impacted by incompatible standardized products. One example of a precursor product is IBM's proprietary Synchronous Network Architecture (SNA) which was the dominant network architecture for many years before the Internet established a public network architecture. The users of the precursor product in Fig. 1 will bear the costs to migrate their cloud computing services to the standardized version, once it becomes commercially available.

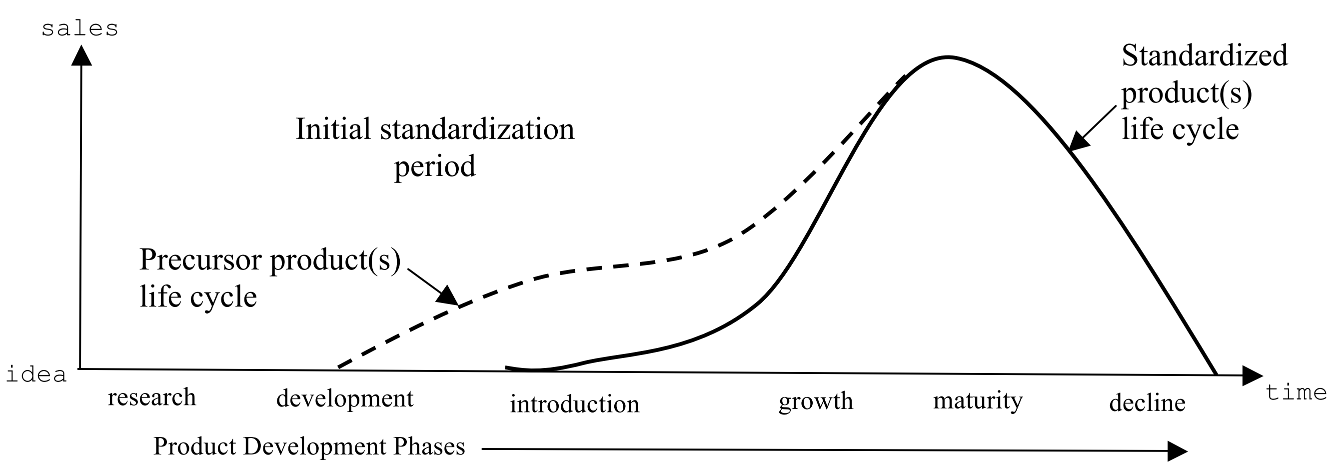

Figure 2. Products phases relative to standardization, when precursor products are compatible with the standard.

Fig. 2 identifies that the user investments and operations are less disrupted when standardization supports backward compatibility. Because of backward compatibility, the standardized product eventually subsumes the sales of the precursor product. Supporting multiple cloud computing services (i.e., common syntax and conversions between different semantics) would allow Amazon Web Services, GoogleAppEngine and Microsoft Azure to interwork (to some extent) with a future standard.

If one of these precursor services can gain a substantial market share, it may become a "de facto standard." Then the de facto vendor will enjoy a sizeable market without competition – an advantageous position from a commercial vendor's viewpoint. This possibility of a closed market for their de facto cloud computing service is an unfortunate incentive to the vendor to avoid or delay standardization.[34]

An indication of the implementers' strong desire to control a standard is a "standards war." As example, consider the video disk format war (a compatibility war): Blu-Ray or HD-DVD.[35] This standards war occurred when competing implementers with different technical solutions to the interface between the disk and the disk player refused to agree on one technical solution to be included in a fixed compatibility standard.[36] Such wars represent a standardization breakdown, as standardization should be a balanced process with a focus on public reason. Standards wars occur because the economic stakes are very high. The more users who are compatible with one format, the more desirable (and profitable) that format becomes.

Economists call this powerful effect of compatibility *network externalities*.[37] Network externalities often create dominant suppliers (e.g., IBM SNA, Cisco routing protocols, Microsoft APIs) in systems where compatibility is required. In such systems, users have little choice and public reason may be subverted.

5.0 The standardization challenge for cloud computing

The cloud computing SDOs' challenge is getting each competing implementer to agree to negotiate their proprietary interfaces and services (compatibility specifications) as a part of a meta standard that only negotiates (without data transfer or control functions) which APIs, protocols, formats, converters, gateways, and specifications to utilize. When the meta standard defines a single logical tree structure where the only changes allowed (in one revision level) are additions, backward compatibility is always maintained. Such meta standards are termed *adaptability standards*. Krechmer[38] defines the minimum syntax and identifies existing adaptability standards.

Considerable cloud computing standardization activity is underway. A reference architecture and use cases for cloud computing have been created,[39] and work on compatibility standards is underway (e.g., IEEE draft P2302). But cloud computing today has few standardized APIs, and different proprietary services support incompatible protocols and formats. The technical problems of achieving and maintaining compatibility between different precursor products and systems in the cloud computing environment are considerable.[40] At the semantics level, "mash-ups"[41] are proposed to define converters to connect different cloud computing services.[42] Adaptability standards could negotiate which converters to apply.

When an adaptability standard defines how to negotiate all capabilities, a desirable feature for implementers emerges. Each adaptable end sends to the other a menu of all available capabilities. The class of capabilities that are proprietary are identified and each proprietary option (if supported) is also identified by a representation of a trademarked name. The trademarked name must be received at each end to invoke any proprietary option. If an unlicensed implementer sends someone else's trademarked name, it is a case of illegal use of trademark, not a complex intellectual property litigation.

Adaptability standards could negotiate all cloud computing capabilities, including open source implementations (e.g. OpenNebula, OpenStack). Even open source implementations manifest private reasons. Any private APIs (e.g., Amazon's Elastic Compute Cloud APIs), even when supported by others (e.g., Eucalyptus), should also be optional and negotiable. When intellectual property is identified after a compatibility standard is in use, the meta adaptability standard can be revised (and the new revision downloaded from the Internet) to change the negotiation of the patented technology to optional. As all implementations must maintain previous revisions, backward compatibility is maintained. When the technology in a compatibility standard is fixed, royalty charges can be what the market will bear rather than what is fair. For these reasons, all private algorithms, functions, protocols or interfaces should only be supported as negotiable options. Only when the public reason is clear, e.g., the cost is small relative to the performance gain, should private property, no matter how controlled, be required in a cloud computing standard used by the public.

Bluetooth (short range wireless for headsets and other applications) is an example of the public benefit created (zero royalties) and commercial success possible, when private control is supported in a standard. The 16,000 Bluetooth consortium members have agreed to zero royalties between them on the basic interface standard and together shipped billions of Bluetooth products.[43] The Bluetooth interface supports a member controlled code (rather than a trademark exchange) identifying the proprietary features offered.

If a proprietary cloud computing service becomes successful, other commercial implementers, hoping to capitalize on its success, may reverse engineer key interfaces to compete with the original implementer. The trademark exchange proposed via adaptability standards offers a means for innovative cloud computing implementers to control their proprietary options similar to how a patent gives control of similar products to the inventor. When the value of trademark negotiation is understood by proprietary cloud computing implementers, they will have a reason to participate in cloud computing standardization.

The Internet increased innovation by establishing two layers of protocol standards (TCP and IP) which define compatibility within the network. The TCP/IP protocols operate over almost any communications service and provide communications support to almost any application. In this way TCP/IP supports multi-mode communications and applications. But any changes to the fixed TCP/IP compatibility layers are very difficult to accomplish. As example, the IP version 4 to IP version 6 conversion has gone on for over 10 years and is a long way from accomplished.[44] The success of the Internet is based upon multi-mode operation. Cloud computing' success has a similar requirement, hopefully without the limitations of fixed compatibility standards.

6.0 Standardizing adaptability

Programmable cloud computing systems, developed by different implementers and standardized in different SDOs, can support overlapping or multiple standards and options for compatibility, to maximize competition and diversity, so long as the SDOs define an independent, automatic, bidirectional negotiation (adaptability) to achieve compatibility. Including all the ways (if proprietary, only as options) to interface and/or operate in the cloud, in the same standardization committee, or in multiple standardization committees, avoids choosing standards winners and losers. Each implementer of a proprietary capability will need to market directly to their customers, as they currently do. If users find the proprietary capabilities desirable, they will use them. When alternative features, functions and standards from different vendors are available, competition occurs and royalties will be established by market forces, not forced by SDO selections.

There are also political examples to support multiple standards for the same function (another form of multi-mode operation): China did not participate in the development of 2G cellular standards, therefore Chinese companies had little intellectual property relating to the next generation 3G cellular standards. To address this economic problem, China chose to standardize an additional 3G compatibility standard (TD-SCDMA) and support the use of this technology in China.[45] Then cross licensing of the TD-SCDMA technology with technology from other companies allows the Chinese companies to minimize royalty payments.

The disadvantage is that each multi-standard cell phone system has one more cellular technology (and associated development costs). When cell phones were not programmable, requiring another standard would have been near impossible. And a trade war with China could have resulted. Now, with programmable cell phones, an additional standard seems a less disruptive way to resolve such a problem. While multi-standard 3G cellular is not adaptive, multi-standard 3G does show how multi-mode operation can mitigate IPR issues.

Computers (e.g., in cell phones, tablets or PCs) are programmable and can easily support multi-mode operation. One example is the operation of Chrome, Mozilla and Microsoft Internet Explorer browsers in a single computer. In PCs, the user manually selects which browser to use. Multi-mode systems may be adaptable (both ends negotiate, e.g., G3 facsimile), flexible (one end changes in response to the other end, e.g., XML), or fixed (e.g., IPv4). The current state of the standardization art is to use XML as a meta standard to select common modes. In programmable systems this is better than fixed standardization, but XML makes requests for defined functions, and does not negotiate between independent functional lists (menus). For this reason XML selection processes do not mitigate standards wars or high royalties. XML processes might be enhanced to support negotiation and trademark exchange, but that is beyond the scope of this paper.

The users' choices decrease and costs increase when competition is diminished. Implementers, with intellectual property or market power, are often unwilling to give up the profits made possible by controlling which function is requested. The implementers would rather, for realistic commercial reasons, have a standards war or a standoff where no standard is agreed. Such actions are not in the public interest. Where there are different implementations of the same capability, rather than SDOs choosing one, an adaptability standard is able to negotiate any selection from many implementations.

7.0 Meeting the challenge

Adaptability standards will accelerate the markets for cloud computing. Without adaptability mechanisms to negotiate common revision levels, individual cloud computing system vendors might change APIs, protocols and formats at will, and other independent vendors would be unable to maintain compatibility.

Formats and protocols require rigorous specification for compatibility, including revision levels and options. Since many formats and protocols are independent standards, new revisions of these standards would propagate across independent cloud computing systems at different times. Adaptable interfaces allow negotiations to occur to select the highest revision of an API, protocol or format that is available on each side of an interface. Without trademark-protected adaptable negotiation, there is little incentive for successful implementers to join a cloud computing standardization effort. These are cogent reasons why cloud computing SDOs should develop adaptability standards.

All the cloud computing standardization stakeholders need to understand this new technical approach to multi-mode system standardization and how it can change intellectual property issues. Exchanging trademarks across an interface provides a reason for all implementers to participate in the standardization process. Innovative implementers gain better control of their technology and market position. This makes standardization avoidance and standards wars unnecessary. Without conflict and confusion, the cloud computing markets will grow more rapidly, benefiting all implementers and users.

Adaptability standards offer cloud computing SDOs a new means to achieve a balance between public and private reasons, attract proprietary implementers to standardization, increase competition, and avoid standardization winners and losers. When cloud computing SDOs standardize adaptability and let market forces chose compatibility, everyone wins.

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