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A standardization initiative for Cloud computing

September 2009

ISO/IEC JTC 1 SWG-Planning

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1. Scope

With the significant advances in Information and Communications Technology (ICT) over the last half century, and computing is being transformed to a model consisting of services that are commoditized and delivered in a manner. In such a model, users access services based on their requirements without regard to where the services are hosted or how they are delivered. Several computing paradigms have promised to deliver this computing vision, of which the latest one is known as Cloud computing. The term “Cloud" denotes the infrastructure as a “Cloud” from which businesses and users are able to access applications from anywhere in the world on demand. Thus, the computing world is rapidly transforming towards developing software for millions to consume as a service, rather than to run on their individual computers. This concept is known as Cloud computing, and it represents a paradigm shift that will redefine the relationship between buyers and sellers of IT-related products and services.

This document intends to provide an overall review on the specified topics of Cloud computing in terms of exploring standardization opportunities. The SWG-Planning will make the report based on this review result.

This document deals with:

- reviewing current concept, characteristics, definitions, type and components of the Cloud computing;
- comparison between Could computing and related technologies;
- reviewing business perspectives of Could computing, and the threats of Cloud computing;
- analysing standardization activities of Cloud computing in standardization organizations; and,
- proposing prospective standardization areas and topics toward ISO/IEC JTC 1, and recommendations to JTC1

2. References

This document refers to the following standards, specifications, articles and papers:

[1]“*Above the Clouds: A Berkeley View of Cloud Computing*”, UC Berkeley TR 2009, Feb. 2009

[2]Cloud computing Interoperability Forum Web Site, http://www.cloudforum.org/

[3]Distributed Management Task Force Web site, http://www.dmtf.org/

[4]Eric Newcommer and Greg Lomow, “*Understanding SOA with Web Services*”, Addison-Wesley, 2005

[5]James Staten, “*Is Cloud Computing Ready For The Enterprise?*”, Forrester Research, March 7, 2008

[6]Mircea Goiaclose, “*Cloud computing, grid computing, utility computing – list of top providers*”

[7]*OASIS Reference Model for Service Oriented Architecture 1.0* (2006), OASIS Standard, 12 October 2006, http://www.oasis-open.org/specs/index.php#soa-rmv1.0

[8]OASIS Web Site, http://www.oasis-open.org/home/index.php

[9]OMG Web Site, http://www.omg.org/

[10] Open Cloud Consortium Web site, http://www.opencloudconsortium.org/

[11] Open Grid Forum Web Site, http://www.ogf.org/

[12] W3C Web Site, http://www.w3.org/

[13] WIKIPEDIA, *"Cloud computing,"* http://en.wikipedia.org/wiki/Cloud_computing

[14] WIKIPEDIA, *"Grid computing,"* http://en.wikipedia.org/wiki/Grid_computing

[15] WIKIPEDIA, *"Utility computing,"* http://en.wikipedia.org/wiki/Utility_computing

[16] Luis M. Vaquero et al., A Break in the Clouds: Toward a Cloud Definition, ACM SIGCOMM Computer Communication Review, Volume 39, Issue 1, January 2009

[17] Cloud Security Alliance Web site, http://www.cloudsecurityalliance.org/

[18] Subhajyoti Bandyopadhyay, etc., "*Cloud Computing: The Business Perspective*," Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1413545, June 3, 2009

[19] Cloud Standards Wiki, http://cloud-standards.org/

[20] European Telecommunications Standards Institute (ETSI) Web site, http://www.etsi.org/

[21] WIKIPEDIA, *"SOA,"* http://en.wikipedia.org/wiki/Service-oriented_architecture

3. Terms and definitions

3.1. Terms defined elsewhere

This document uses the following terms defined elsewhere:

IaaS: the delivery of computer infrastructure (typically a platform virtualization environment) as a service.

PaaS: the delivery of a computing platform and solution stack as a service

SaaS: A model of software deployment whereby a provider licenses an application to customers for use as a service on demand. SaaS software vendors may host the application on their own web servers or download the application to the consumer device, disabling it after use or after the on-demand contract expires.

3.2. Terms defined in this report

This document defines the following terms:

Could Computing: Cloud computing provides IT infrastructure and environment to develop/host/run services and applications, on demand, with pay-as-you-go pricing, as a service. It also provides resource and services to store data and run application, in any devices, anytime, anywhere, as a service.

4. Abbreviations, acronyms and conventions

This document uses the following abbreviations and acronyms:

API	Information and Communication Technology
BPEL	Business Process Execution Language
CAGR	Compound Annual Growth Rate
CCIF	Cloud Computing Interoperability Forum
CMIS	Content Management Interoperability Services
CSA	Cloud Security Alliance
DITA	Darwin Information Typing Architecture
DMTF	Distributed Management Task Force
ebXML	Electronic Business XML
ETSI	European Telecommunications Standards Institute
IaaS	Infrastructure as a Service
ICT	Information and Communication Technology
KMIP	Key Management Interoperability Protocol
MDA	Model Driven Architecture
NaaS	Network as a Service
OASIS	Organization for the Advancement of Structured Information Standards
OCC	Open Cloud Consortium
OCCI	Open Cloud computing Interface
ODF	Open Document Format
OGF	Open Grid Forum
OMG	Object Management Group
ORMS	Open Reputation Management Systems
OVF	Open Virtualization Format standards
PaaS	Platform as a Service
QoS	Quality of Service
RDF	Resource Description Format
SaaS	Software as a Service
SAML	Security Assertion Markup Language
SC	Sub Committee
SCA	Service Component Architecture
SDD	Solution Deployment Descriptor (SDD)
SDO	Service Data Objects
SDO	Standards Development Organization
SLA	Service Level Agreement
SOA-RM	SOA Reference Model

SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SPML	Service Provisioning Markup Language
UDDI	Universal Description, Discovery, and Integration
UDT	UDP-based Data Transfer
UML	Unified Modeling Language
VM	Virtual Machine
VMAN	Virtualization Management Initiative
W3C	World Wide Web Consortium
WSDL	Web Services Description Language
XACML	eXtensible Access Control Markup Language
XML	eXtensible Markup Language

5. Introduction to Cloud computing

5.1. General concept and characteristics of Cloud computing

The concept of Cloud Computing is drawing a great attention from the Information and Communication Technology (ICT) community, thanks to the appearance of a set of services with common characteristics, provided by important industry players. However, some of the existing technologies that the Cloud Computing concept draws on (such as virtualization, utility computing or distributed computing) are not new [16].

The term Cloud is used as a metaphor for the Internet, based on how the Internet is depicted in computer network diagrams and is an abstraction for the complex infrastructure it conceals [13].

The followings are the key characteristics of Cloud computing [13].

- Agility improves with users who are able to rapidly and inexpensively re-provision technological infrastructure resources. The cost of overall computing is unchanged, however, and the providers will merely absorb up-front costs and spread costs over a longer period.
- Cost is claimed to be greatly reduced and capital expenditure is converted to operational expenditure. This ostensibly lowers barriers to entry, as infrastructure is typically provided by a third-party and does not need to be purchased for one-time or infrequent intensive computing tasks. Pricing on a utility computing basis is fine-grained with usage-based options and fewer IT skills are required for implementation (in-house). Some would argue that given the low cost of computing resources, the IT burden merely shifts the cost from in-house to outsourced providers. Furthermore, any cost reduction benefit must be weighed against a corresponding loss of control, access and security risks.
- Device **and location independence** enable users to access systems using a web browser regardless of their location or what device they are using (e.g., PC, mobile). As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere.
- Multi-tenancy enables sharing of resources and costs across a large pool of users thus

allowing for:

– **Centralization** of infrastructure in locations with lower costs (such as real estate, electricity, etc.)

– **Increase of Peak-load capacity** (users need not engineer for highest possible load-levels)

– **Utilization and efficiency** improvements for systems that are often only 10–20% utilized.

- Reliability improves through the use of multiple redundant sites, which makes Cloud computing suitable for business continuity and disaster recovery. Nonetheless, many major Cloud computing services have suffered outages, and IT and business managers can at times do little when they are affected.
- Scalability via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis near real-time, does not impose users to engineer for peak loads. Performance is monitored and consistent and loosely-coupled architectures are constructed using web services as the system interface.
- Security typically improves due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data and verification of users' identity. Security is often as good as or better than traditional systems, in part because providers are able to devote resources to solving security issues that many customers cannot afford. Providers typically log accesses, but accessing the audit logs themselves can be difficult or impossible. Ownership, control and access to data controlled by "Cloud" providers may be made more difficult, just as it is sometimes difficult to gain access to "live" support with current utilities. Under the Cloud paradigm, management of sensitive data and other security-related functions (e.g., user's enrollment and verification of users' identity) could be placed in the hands of Cloud providers and third parties.
- Sustainability comes about through improved resource utilization, more efficient systems, and carbon neutrality. Nonetheless, computers and associated infrastructure are major consumers of energy. A given (server-based) computing task will use X amount of energy whether it is on-, or off-site.

5.2. Definition of Cloud computing

There are many definitions of Cloud Computing, but they all seem to focus on just certain aspects of the technology. So, more than 20 definitions of Cloud computing have been developed allowing for the extraction of a consensus definition as well as a minimum definition containing the essential characteristics [16]. The followings are the remarkable definitions and descriptions of Cloud Computing.

- A pool of abstracted, highly scalable, and managed compute infrastructure capable of hosting end-customer applications and billed by consumption [5].
- A style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet. Users need not have knowledge of, expertise in, or control over the technology infrastructure in the "Cloud" that supports them [13].
- Cloud computing is an emerging approach to shared infrastructure in which large pools of systems are linked together to provide IT services (Press release on "Blue Cloud", IBM).
- A paradigm in which information is permanently stored in servers on the Internet and

cached temporarily on clients that include desktops, entertainment centers, table computers, notebooks, wall computers, handhelds, etc (ORGs for Scalable, Robust, Privacy-Friendly Client Cloud computing", IEEE Internet Computing).

In conclusion, for the business perspective, Cloud computing is providing IT infrastructure and environment to develop/host/run services and applications, on demand, with pay-as-you-go pricing, as a service. And, from the users point of view, Cloud computing is providing resource and services to store data and run application, in any devices, anytime, anywhere, as a service.

Nowadays, the usage of Cloud computing is extended for many domain-specific areas including network services, mobile services, media service and etc.. So, it is expected that there will be lots of variations for future Cloud service and related standardisation issues as well.

5.3. The Type of Cloud computing

Distinctions among 'public', 'private' and 'hybrid' Clouds are as follows:

- In a public Cloud, the services are delivered to the client via the Internet from a third party service provider.
- In a private Cloud, these services are managed and provided within the organization. There are less restriction on network bandwidth, fewer security exposures and other legal requirements compared to the public Cloud.
- In a hybrid Cloud, there is a combination of services provided from public and private Clouds.

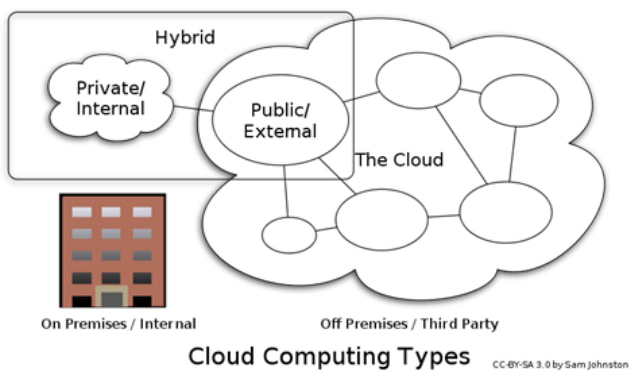

Figure 1. Types of Cloud computing

5.4. Components of Cloud computing

Figure 2 depicts the basic entity of Cloud computing. **Cloud Service** includes products, services and solutions that are delivered and consumed in real-time over the Internet. For example, Web Services which may be accessed by other Cloud computing components, software, e.g., Software plus services, or end users directly. Also, Cloud service leverages the Cloud in software architecture, often eliminating the need to install and run the application on the customer's own computer. **Cloud Platform** is the delivery of a computing platform, and/or solution stack as a service, facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers. And, **Cloud Infrastructure** is the delivery of computer infrastructure, typically a platform virtualization environment

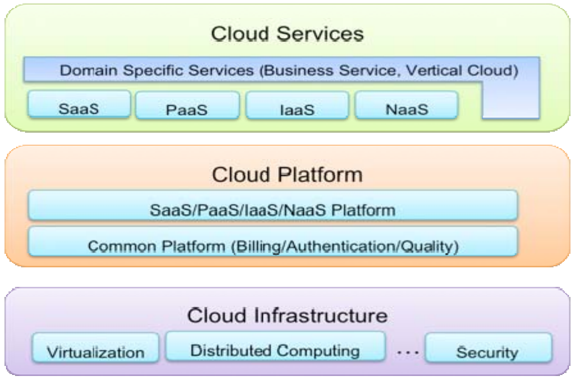

Figure 2. Conceptual Diagram of Cloud Computing

In Figure 2, domain-specific services are located in the Cloud services layer. These are Clouds specializing in certain industries, such as the healthcare field, financial institutions, IPTV field, media field, and etc, as a kind of intra-industry "mutual aid organization." Examples for how such a Cloud might form include present-day third-party vendors, or an industry-leading large company possibly opening up its internal resources to allow third-party access.

5.5. Related technologies

Cloud computing is often confused with grid computing (a form of distributed computing whereby a "super and virtual computer" is composed of a cluster of networked, loosely-coupled computers, acting in concert to perform very large tasks), or utility computing (the packaging of computing resources, such as computation and storage, as a metered service similar to a traditional public utility such as electricity). Indeed many Cloud computing deployments are today powered by grids, have autonomic characteristics and are billed like utilities, but Cloud computing can be seen as a natural next step from the grid-utility model. Some successful Cloud architectures have little or no centralized infrastructure or billing systems whatsoever including Peer to peer networks[6].

5.6. Grid computing

Grid computing is a collection of servers that are clustered together to attack a single problem. For a period of time, the entire resources of the grid are available to a user to tackle a particularly difficult compute problem. The engineering of such a grid requires complex inter-cluster networking, and usually the tuning of a grid is not for the faint of heart.

Grid computing[14] is the application of several computers to a single problem at the same time — usually to a scientific or technical problem that requires a great number of computer processing cycles or access to large amounts of data.

It is a form of distributed computing whereby a "super and virtual computer" is composed of a cluster of networked loosely coupled computers acting in concert to perform very large tasks. This technology has been applied to computationally intensive scientific, mathematical, and academic problems through volunteer computing, and it is used in commercial enterprises for such diverse applications as drug discovery, economic forecasting, seismic analysis, and back-office data processing in support of e-commerce and Web Services.

What distinguishes grid computing from conventional cluster computing systems is that grids tend to be more loosely coupled, heterogeneous, and geographically dispersed. Also, while a computing grid may be dedicated to a specialized application, it is often constructed with the aid of general-purpose grid software libraries and middleware.

The term "grid computing" is often used to describe a particular form of distributed computing, where the supporting nodes are geographically distributed or cross administrative domains. To provide utility computing services, a company can "bundle" the resources of members of the public for sale, who might be paid with a portion of the revenue from clients.

5.7. Utility Computing

Utility computing[15] is the packaging of computing resources, such as computation and storage, as a metered service similar to a traditional public utility (such as electricity, water, natural gas, or telephone network). This system has the advantage of a low or no initial cost to acquire hardware; instead, computational resources are essentially rented. Customers with very large computations or a sudden peak in demand can also avoid the delays that would result from physically acquiring and assembling a large number of computers.

Conventional Internet hosting services have the capability to quickly arrange for the rental of individual servers, for example to provision a bank of web servers to accommodate a sudden surge in traffic to a web site.

"Utility computing" has usually envisioned some form of virtualization so that the amount of storage or computing power available is considerably larger than that of a single time-sharing computer. Multiple servers are used on the "back end" to make this possible. These might be a dedicated computer cluster specifically built for the purpose of being rented out, or even an under-utilized supercomputer. The technique of running a single calculation on multiple computers is known as distributed computing.

5.8. Web Services

A Web Services is defined by the W3C[12] as "a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards." Web services are frequently just Internet Application Programming Interfaces (API) that can be accessed over a network, such as the Internet, and executed on a remote system hosting the requested services.

Web services provide a standard means of interoperating between different software applications, running on a variety of platforms and/or frameworks. Web services are characterized by their great interoperability and extensibility, as well as their machine-processable descriptions thanks to the use of XML. They can be combined in a loosely coupled way in order to achieve complex operations. Programs providing simple services can interact with each other in order to deliver sophisticated added-value services.

Web Services enable business entities and applications to intercommunicate openly with each other over a network. Web Services have program language independent properties, uses the message-driven communication, and is easily bound to different transport protocols.

5.9. SOA

SOA is an architectural and design discipline conceived to achieve the goals of increased interoperability (information exchange, reusability, and composability), increased federation (uniting resources and applications while maintaining their individual autonomy and self-governance), and increased business and technology domain alignment.

The definition of SOA as in [7] reads as follow: “a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations."

Another definition [4] of SOA is a style of software design that guides all aspects of creating and using business services. SOA is also a way to define and provision an IT infrastructure to allow different applications to exchange data and participate in business processes, regardless of the operating systems or programming language underlying those applications.

SOA realizes its business and IT benefits through utilizing an analysis and design methodology when creating services that ensures they are consistent with the architectural vision and roadmap, and adhere to principles of service-orientation [21].

6. Business perspectives of Cloud computing

The IT industry's expansion towards Cloud computing will accelerate, a new report has claimed. According to the IDC, the bad economy will drive more users to the Cloud model's low costs this year, with IT suppliers set to follow suit. The IDC says that while IT Cloud services offerings such as Software-as-a-Service, Cloud server capacity and Cloud storage will slow in growth this year, this will be by a smaller amount than traditional IT alternatives.

6.1. Market estimation

In a May 2008 report, Merrill Lynch estimated that 12% of the worldwide software market would start using Cloud technology in the next 5 years and that the annual revenue for Cloud computing will increase to $95 billion in the same period.

In a March 2009, Gartner predicts that by 2012, 80% of Fortune 1000 enterprises will be paying for some Cloud computing services, and 30% will be paying for Cloud computing infrastructure services. Gartner also estimates the current market for Cloud services is $46.4 billion. By 2013, the market will reach $150.1 billion. The compound annual growth rate (CAGR) varies widely between different types of services. The overall CAGR is 26.5%.

Table 1 depicts the sizing of the market for Cloud services in 2008 and a forecast through 2013 at a worldwide level.

Table 1. Cloud Services, Worldwide, 2008-2013 (Billions of Dollars)

	2008	2009	2010	2011	2012	2013	CAGR (%)
Business Process Services							
Cloud-Based Advertising	28	33	38.9	47.4	59.2	76.9	22.1
E-Commerce	1.3	1.8	2.5	4	7.2	12	56
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**CAGR (%)**
Human Resources	7.5	8.9	11.3	14.1	16.2	18	19
Payment Processing	0.3	0.5	0.75	1	1.9	2.6	54
Others	1.8	2.4	3.5	4.9	7	9.8	40.3
Business Process Services Total	**38.9**	**46.6**	**57.0**	**71.4**	**91.5**	**119.3**	**25.1**
Applications Total	**5.04**	**6.52**	**9.6**	**11.4**	**14.6**	**20.2**	**32**
Application Infrastructure							
Platform Infrastructure	0.05	0.07	0.09	0.13	0.2	0.4	51.6
Integration Services	1.47	1.54	1.62	1.7	1.78	1.86	5
Application Infrastructure Total	**1.52**	**1.61**	**1.71**	**1.83**	**1.98**	**2.26**	**8.3**
System Infrastructure							
Compute Services	0.66	1.17	2.00	3.40	4.90	6.80	59.5
Storage Services	0.009	0.025	0.084	0.241	0.525	0.750	52.8
Backup Services	0.30	0.37	0.45	0.55	0.67	0.82	22.3
System Infrastructure Total	**0.96**	**1.56**	**2.53**	**4.19**	**6.10**	**8.37**	**53.8**
Infrastructure Total	**2.6**	**3.4**	**5.0**	**6.0**	**8.1**	**10.6**	**33.5**
Cloud Services Total	**46.4**	**56.3**	**70.8**	**88.8**	**114.2**	**150.1**	**26.5**
Note: Technically, the cloud services market is a composite or "meta" market; that is, it is an aggregate of other categories that have the true characteristics of markets.							

Source: Gartner (March 2009)

6.2. Threats of Cloud computing and related Issues

While the Cloud computing has lots of benefits, there are several issues to be resolved. In particular, the security issue is one of biggest considerations for future deployment of Cloud computing-based service model. Figure 3 shows some results of questionnaire about Cloud computing by IDC.

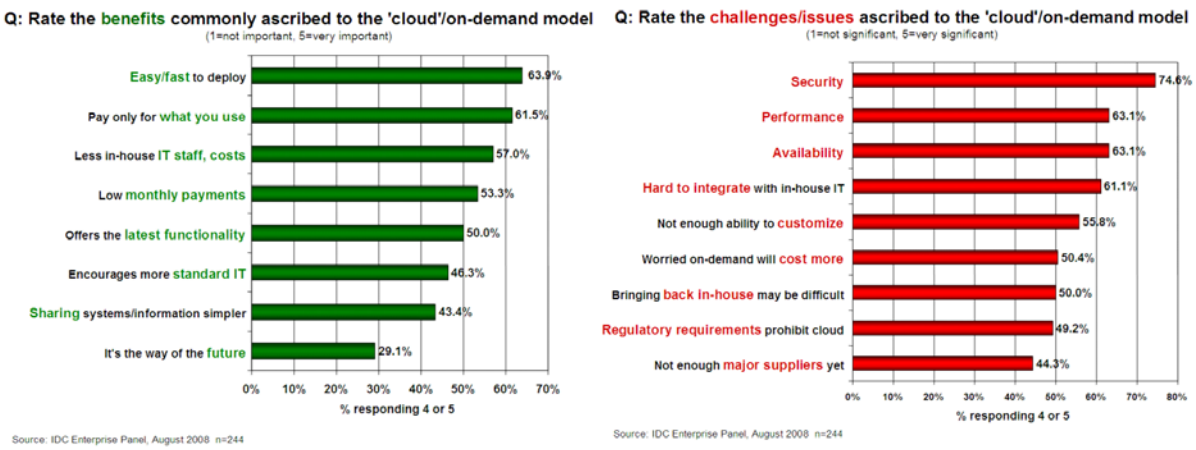

Figure 3. Issues on Cloud computing (IDC Enterprise Panel, August 2008)

Because Cloud computing does not allow users to physically possess the storage of their data (the exception being the possibility that data can be backed up to a user-owned storage device, such as a USB flash drive or hard disk) it does leave responsibility of data storage and control in the hands of the provider.

Cloud computing has been criticized for limiting the freedom of users and making them dependent on the Cloud computing provider, and some critics have alleged that is only possible to use applications or services that the provider is willing to offer.

Corporations or end-users wishing to avoid not being able to access their data (or even losing it) are typically advised to research vendors' policies on data security before using their services. One technology analyst and consulting firm, Gartner, lists several security issues that one should discuss with Cloud-computing vendors [13]:

- **Privileged user access**: Who has specialized access to data and about the hiring and management of such administrators?
- **Regulatory compliance**: Is the vendor willing to undergo external audits and/or security certifications?
- **Data location**: Does the provider allow for any control over the location of data?
- **Data segregation**: Is encryption available at all stages, and were these encryption schemes designed and tested by experienced professionals?
- **Recovery**: What happens to data in the case of a disaster, and does the vendor offer complete restoration, and, if so, how long does that process take?
- **Investigative Support**: Does the vendor have the ability to investigate any inappropriate or illegal activity?
- **Long-term viability**: What happens to data if the company goes out of business, and is data returned and in what format?
- **Data availability**: Can the vendor can move your data onto a different environment should the existing environment become compromised or unavailable?

Table 2 summarizes the top twelve obstacles and opportunities to the growth of Cloud Computing which is extended list of obstacles from Berkeley's report [1].

Table 2. Top Twelve Obstacles to and Opportunities for Adoption and Growth of Cloud Computing

No.	Obstacle	Opportunity
1	Availability of Service	Use Multiple Cloud Providers to provide Business Continuity; Use Elasticity to Defend Against DDOS attacks
2	Data Lock-In	Standardize APIs; Make compatible software available to enable Surge Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, and Firewalls; Accommodate National Laws via Geographical Data Storage
4	Data Transfer Bottlenecks	FedExing Disks; Data Backup/Archival; Lower WAN Router Costs; Higher Bandwidth LAN Switches
5	Performance Unpredictability	Improved Virtual Machine Support; Flash Memory; Gang Scheduling VMs for HPC apps
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large-Scale Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on Machine Learning; Snapshots to encourage Cloud Computing Conservationism
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses; Bulk use sales
11	Latency and Political boundary†	Management of the physical location of data
12	Verification of users' identity†	Use of alternative means of user verification such as biometric identifiers and tokens with biometric identifiers; Use of authentication providers to provide verification of users' identity

†) Items being newly added from Berkeley's list [1].

7. Relevant standardization activities

Specific Cloud computing standards are being developed by a variety of new and also by well established consortia.

7.1. Open Grid Forum (OGF)

OGF is an open community committed to driving the rapid evolution and adoption of applied distributed computing, and the purpose of this group is the creation of a practical solution to interface with Cloud infrastructures exposed as a service (IaaS). Applied Distributed Computing is critical to developing new, innovative and scalable applications and infrastructures that are essential to productivity in the enterprise and within the science community. OGF accomplishes its work through open forums that build the community, explore trends, share best practices and consolidate these best practices into standards [11].

The OGF is developing on an Open Cloud computing Interface (OCCI), which is an API for managing Cloud computing infrastructure. The purpose of this group is the creation of a practical solution to interface with Cloud infrastructures exposed as a service (IaaS). They are focus on a solution which covers the provisioning, monitoring and definition of Cloud Infrastructure services. The group should create this API in an agile way as we can have advantages over other groups if we deliver fast. Overlapping work and efforts will be contributed and synchronized with other groups.

7.2. Cloud computing Interoperability Forum (CCIF)

The Cloud Computing Interoperability Forum (CCIF) [2] was formed in order to enable a global Cloud computing ecosystem whereby organizations are able to seamlessly work together for the purposes for wider industry adoption of Cloud computing technology and related services. A key focus will be placed on the creation of a common agreed upon framework / ontology that enables the ability of two or more Cloud platforms to exchange information in an unified manor.

Unified Cloud Interfaces and API's are being developed by the CCIF. Unified Cloud Computing is an attempt to create an open and standardized Cloud interface for the unification of various Cloud API's. A singular programmatic point of contact that can encompass the entire infrastructure stack as well as emerging Cloud centric technologies all through a unified interface. One of the key drivers of the unified Cloud interface is to create an API about other API's. In this vision for a unified Cloud interface the use of the resource description framework (RDF) is an ideal method to describe a semantic Cloud data model (taxonomy & ontology). The benefit to an RDF-based ontology languages is that they act as general method for the conceptual description or modeling of information that is implemented by web resources. These web resources could just as easily be "Cloud resources" or API's. This approach may also allow us to easily take an RDF -based Cloud data model and use it within other ontology languages or web services making it both platform and vendor agnostic. Using this approach we're not so much defining how, but instead describing what.

7.3. Distributed Management Task Force (DMTF)

DMTF[3] is also working on *virtualization standards* in the Virtualization Management Initiative (VMAN). In a press release the Open Virtualization Format standards (OVF) has been announced in March 2009. "As part of the DMTF Virtualization Management Initiative (VMAN), OVF simplifies interoperability, security and virtual machine lifecycle management by describing an open, secure, portable, efficient and extensible format for the packaging and distribution of one or more virtual appliances and applications. This enables software developers to ship pre-configured, ready-to-deploy solutions, allowing end-users to distribute applications into their environments with minimal effort. The standard can also serve as a building block for Cloud computing." (from the DMTF Press release).

DMTF in April, 2009, also announced "that it has formed a group dedicated to addressing the need for *open management standards for Cloud computing*. The "Open Cloud Standards Incubator" will work to develop a set of informational specifications for Cloud resource management".

7.4. Open Cloud Consortium (OCC)

The Open Cloud Consortium (OCC)[10] is a non-profit organization established and led by the University of Illinois at Chicago that is researching the creation of inter-Cloud interfaces in the aim of developing compatibility standards. The goal of such standards is to allow for smooth transitions from one Cloud service to another. The OCC is continuing development with an eye to extensibility for the next generation of Clouds, such as carrying out experiments with wide-area network Clouds using not the widely employed TCP protocol for communications, but rather the new UDP-based Data Transfer (UDT) protocol better suited to high-speed bulk data transfer.

The Open Cloud Consortium according to its web site "Supports the development of standards for Cloud computing and frameworks for interoperating between Clouds;

- develops benchmarks for Cloud computing;
- supports reference implementations for Cloud computing, preferably open source reference implementations;
- manages a Testbed for Cloud computing called the Open Cloud Testbed;
- sponsors workshops and other events related to Cloud computing.

However, the OCC to date is still a very academic consortium under the University of Illinois' leadership, and the only major IT company participating is Cisco Systems. Without the participation of a Cloud company that has already launched its services, there remains considerable concern that the OCC might not be able to produce a practical and implementable standard.

7.5. Cloud Security Alliance (CSA)

The Cloud Security Alliance[17] is a non-profit organization formed to promote the use of best practices for providing security assurance within Cloud computing, and provide education on the uses of Cloud computing to help secure all other forms of computing.

The Cloud Security Alliance's objectives are to:

- Promote a common level of understanding between the consumers and providers of Cloud computing regarding the necessary security requirements and attestation of assurance.
- Promote independent research into best practices for Cloud computing security.
- Launch awareness campaigns and educational programs on the appropriate uses of Cloud computing and Cloud security solutions.
- Create consensus lists of issues and guidance for Cloud security assurance.

7.6. ETSI

ETSI[20] Technical Committee (TC) GRID is updating its terms of reference to include the emerging commercial trend towards Cloud computing which places particular emphasis on ubiquitous network access to scalable computing and storage resources. Since TC GRID has particular interest in interoperable solutions in situations which involve contributions from both the IT and Telecom industries, the emphasis is on the Infrastructure as a Service (IaaS) delivery model.

7.7. OASIS

OASIS[8] drives the development, convergence and adoption of open standards for the global information society. The source of many of the foundational standards in use today, OASIS sees Cloud Computing as a natural extension of SOA and network management models. The OASIS technical agenda is set by members, many of whom are deeply committed to building Cloud models, profiles, and extensions on existing standards, including:

- Security, access and identity policy standards -- e.g., OASIS SAML, XACML, SPML, WS-SecurityPolicy, WS-Trust, WS-Federation, KMIP, and ORMS.
- Content, format control and data import/export standards -- e.g., OASIS ODF, DITA, CMIS, and SDD.

- Registry, repository and directory standards -- e.g., OASIS ebXML and UDDI.
- SOA methods and models, network management, service quality and interoperability -- e.g., OASIS SCA, SDO, SOA-RM, and BPEL.

7.8. Object Management Group (OMG)

OMG[9] is now spearheading a multi-party effort to establish a uniform vocabulary for Cloud Computing, as well as to synchronize standards development. Recently OMG announced the collaboration at its Cloud Standards Summit on July 13. Participants include the Distributed Management Task Force, the Open Grid Forum, the Storage Networking Industry Association, the Open Cloud Consortium and the Cloud Security Alliance.

OMG's objective with the standards group is to establish a set of terms so that users know that vocabulary across organizations and providers is consistent. It is also coordinating specification activity to make sure we don't tread on each other’s toes. That work will focus on the deployment and configuration of services, interoperability and security.

OMG's technical contribution is likely to be in modeling Cloud deployment, especially service-level agreements. Separately, its Governance, Risk Management and Compliance Roundtable will be active in providing resources, such as best practices and documentation, for cloud service provisioning.

The followings are the emergent categories for Cloud Computing standards in OMG:

- Meta-Element Association: For defining "Distributed and non-deterministic computing" from the Cloud and SOA perspective.
- Governance: There is Services Governance domain and a Cloud Governance Domain. The key is how to integrate these two point of view for governing "Distributed and non-deterministic computing“.
- SLAs: For Services/Clouds.
- SOA, Events, and Agents: Defining communication among and within clouds between services enabled in these clouds.

7.9. Other Standard Organization

- Web services and SOA standards are the cornerstone of Cloud computing. As Irving Wladawsky-Berger, Chairman Emeritus, IBM Academy of Technology has stated, “SOA is to Cloud computing as HTML is to the internet.” Most of these standards are developed by the IETF, W3C, OASIS, WS-I and JTC 1/SC6.The World Wide Web Consortium (W3C) is an international consortium where Member organizations, a full-time staff, and the public work together to develop Web standards. W3C's mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web [12]. W3C developed Web Services standard, which is the core technology of Cloud computing.
- Utility computing standards are developed by the Open Grid Forum, the W3C, OASIS and the Distributed Management Task Force. A software recoverability evaluation standard is also under development in JTC 1/SC7.
- IT Service Management standards are developed by the OGC, itSMF and ISO/IEC JTC1 SC 7.

Table 3. The mission and key members of major Consortia for Cloud computing standardization

SDOs	Mission For Cloud computing	Key members
Open GRID Forum (OGF)	Creation of a practical solution to interface with Cloud infrastructures exposed as a service (IaaS).	Microsoft, Sun Microsystems, Oracle, Fujitsu, Hitachi, IBM, Intel, HP, AT&T, eBay, etc
Cloud computing Interoperability Forum (CCIF)	Enable a global Cloud computing ecosystem whereby organizations are able to seamlessly work together for the purposes for wider industry adoption of Cloud computing technology and related services	Cisco, Intel, Thomson Reuters, Orange, Sun, IBM, RSA, etc
Distributed Management Task Force (DMTF)	Standardizing interactions between Cloud environments by developing Cloud resource management protocols, packaging formats and security mechanisms to facilitate interoperability	Board Member : IBM, Microsoft, Novell, Oracle, Sun Microsystems, VMware, EMC, etc http://www.dmtf.org/about/list
Open Cloud Consortium (OCC)	Improve performance of storage and compute Clouds spread across geographically disparate data centers and promote open frameworks that let Clouds operated by different entities work seamlessly together	Cisco, MIT Lincoln Labs, Yahoo, various colleges including the University of Illinois at Chicago
Cloud Security Alliance (CSA)	Promote use the best security practices for computing performed over the Cloud, while providing education on the uses of Cloud computing	eBay, ING, Qualys, PGP, zScaler, etc

8. JTC 1 perspective standardization areas and issues

Regarding the work scope of existing SC in JTC 1, there are some relationships with their work on several Cloud computing issues (See Appendix. I)

Currently, there are many initiatives to make the standards related to Cloud computing as already shown in clause 8. However, since some of those activities are very beginning stage and some of them are only focused on narrow work scope which is not global perspective, those activities are being done by only small number of interest group not NB-level so far.

Hence, in terms of JTC 1 perspective, basically it is required to identify new work items and to develop the standards for Cloud computing with more global viewpoint under the NB-level. In particular, it is required to consider the standards for adoption of Cloud computing in various public sectors such as e-Government. It is also needed to consider the collaboration and liaisons with other relevant SDOs.

In order to identify new work items for Cloud computing in JTC 1, the following issues should be investigated as the first priority:

1 **General & Fundamentals:** There are lots of Cloud computing technologies and solutions even if some of them do not tend to real Cloud computing philosophy. These include: what are the general and common requirements for future Cloud computing environment? How to deploy the Cloud service with relevant scenarios; and so on.

2 **Data/Service Lock-in** : Software stacks have improved interoperability among

platforms, but the APIs for Cloud Computing itself are still essentially proprietary, or at least have not been the subject of active standardization

3 **Quality of Service (QoS)**: QoS will be an oft-employed term in Cloud computing. Given that enterprises as well as private consumers demand a guaranteed quality of service, high levels of reliability and continued availability from their computing infrastructure, what level of service should users demand and expect from Cloud computing vendors? How do we set service level agreements (SLAs) for Cloud computing applications? Equally importantly, what are the parameters that determine the quality of one vendor with respect to another? It is worth bearing in mind that corporate users might reluctantly accept IT downtimes when it takes place within the organization, but the expectations can be radically higher when the computing service is outsourced to an external provider, so the service providers will have to play a role in educating their customers in developing rational expectations about downtimes.

4 **Security**: With a lot of responsibilities transferring to the Cloud computing vendor, the organization will need to discuss several issues with the Cloud-computing vendor, including privileged user access (the personnel in the vendor organizations who will have specialized access to data, and the hiring and management of such administrators), regulatory compliance (enforced through external audits), end user control over data location, data segregation (to make sure that encryption is available at all stages and that these encryption schemes were designed and tested by experienced professionals), data recovery and disaster management (including “intelligent” Clouds that can automatically relocate computing resources), investigative support for inappropriate or illegal activity, and long-term organizational viability.

5 **Data Confidentiality and Auditability**: Current Cloud offerings are essentially public (rather than private) networks, exposing the system to more attacks. There are also requirements for auditability and confidentiality for data in Cloud. Although, there are no fundamental obstacles to making a Cloud-computing environment as secure as the vast majority of in-house, that many of the obstacles can be overcome immediately with well understood technologies such as encrypted storage, Virtual Local Area Networks, and network middleboxes (e.g. firewalls, packet filters).

6 **Data ownership**: Data ownership is an interesting issue. Will the concept itself become outdated, just like data ownership “within a department” has become an outdated concepts in an enterprise after the introduction of centralized database management systems? However, data authentication will become very important: business processes and technologies will need to be developed to ensure end users that when they access data on the Cloud, its integrity has not been compromised.

7 **Data privacy**: If confidential data is to be maintained on the Cloud, users need to be aware as to how it might be shared. Can a court subpoena a consumer’s financial data that is maintained by a financial aggregator? Can the government do so under any circumstance? What will be the liabilities of the provider if data security is breached? If a consumer (or for that matter, a business) closes her account with the provider, till what time would her data be still maintained on the provider’s servers, and at what point of time will the provider guarantee that the data has been completely purged from its servers? Privacy and security would be some of the main reasons why many enterprises might opt for what are being called “private Clouds”, whereby users within the organization share resources of a computing infrastructure that is maintained and is under the control of the organization.

8 **SoftwareLicensing:** Current software licenses commonly restrict the computers

on which the software can run. Users pay for the software and then pay an annual maintenance fee. In the Cloud computing, it is required new licensing mechanism for the Cloud service and applications.

9 **Legal issues**: If consumers and organizations are to depend on Cloud computing providers for all their computing needs, a host of new legal issues will have to be tackled. Contracts will need to specify the required standards for vendor availability. Standards need to be developed so that consumers and organizations are not overly dependent on their current set of vendors. Providers will need to specify how they define concurrent use and therefore licensing. The old models of licensing based on CPUs or instances or named users simply do not work in the on-demand, elastic world of Cloud computing and virtualization. Rigid software licensing models need to be changed just as the static network and application network infrastructure will get modified. The models need to evolve into something more fluid and flexible, and applicable to the new world of on-demand computing. One piece of good news for software providers will be that piracy will cease to be much of an issue, since it will be relatively simple to ensure that only paying customers can access the service.

10 **Inter-Cloud Interoperability**: The Inter-Cloud is an interconnected global "Cloud of Clouds" and an extension of the Internet "network of networks" on which is based. For the Inter-Cloud, ensuring interoperability among Clouds is essential to the proliferation and adoption of Cloud computing among developers and enterprise, and new protocols and formats for Cloud computing for inter-Cloud shall be considered.

11 **Device Independence**: The number of different kinds of device such as phones, smart phones, personal digital assistants, interactive television systems, voice response systems, kiosks that can be accessed in the Cloud computing, and in a viewpoint of standardization, methods by which the characteristics of the device are made available for use in the processing associated with device independence and methods to assist authors in creating sites and applications that can support device independence in ways that allow it to be widely employed is required.

The followings are some candidates for work items on the Cloud computing under the above contexts:

Table 4. Candidate work items for standardization on the Cloud computing

Issues	Candidate work items
1 General & Fundamentals	• General requirements for Cloud computing • Reference model and Taxonomies for Cloud computing • Deployment model and Service scenarios for Cloud computing
2 Data/Service Lock-in	• Common API among the Clouds • Data exchange formats for Cloud service • Resource description & specification
3 Quality of Service	• Service Level Architecture (SLA) • Parameter of Service Quality for Cloud computing
4 Security	• Framework for Trust & Secure Cloud computing

	• Secure Cloud service mechanism and protocols
5 Data Confidentiality and Auditability	• Secure Data format for Cloud computing
6 Data ownership	• Data authentication
7 Data privacy	(TBD)
8 Software Licensing	(TBD)
9 Legal	• Legal recommendation for distributed Cloud service
10 Inter-Cloud Interoperability	• Protocol for inter-Cloud service • Data format for inter-Cloud service • Universal Format for Cloud VM(Virtual Machine)
11 Device Independence	(TBD)

9. Recommendations to JTC 1

According to investigation work on Cloud Computing, it is needed to initiate a dialogue with relevant consortia as identified in this document with a view to establishing the state of the work on Cloud Computing in the various consortia.

In conclusion, SWG-Planning recommends that JTC 1 establish a Study Group on Cloud Computing to understand the current state of standardization and to explore a possible role for JTC 1.

Appendix I. The mapping table between SCs and issues of Cloud computing

SC No.	The title of SCs	Relationship to Cloud Computing
SC 02	Coded character sets	(TBD)
SC 06	Telecommunications and information exchange between systems	• Inter-Cloud communication & protocol issues • Cloud Service architecture issues
SC 07	Software and systems engineering	• Software architecture for Cloud computing (Platform, Middleware) issue • Development environments (platform, language, etc.) issue for Cloud service
SC 17	Cards and personal identification	(TBD)
SC 22	Programming languages, their environments and system software interfaces	• Development environments (platform, language, etc.) issue for Cloud service
SC 23	Digitally Recorded Media for Information Interchange and Storage	(TBD)
SC 24	Computer graphics, image processing and environmental data representation	(TBD)
SC 25	Interconnection of information technology equipment	• Common information and data storage device issue
SC 27	IT Security techniques	• Cloud security issue (Privacy, Security, Authentication, etc.)
SC 28	Office equipment	(TBD)
SC 29	Coding of audio, picture, multimedia and hypermedia information	• Media-level Cloud service issue (e.g., Media Cloud)
SC 31	Automatic identification and data capture techniques	(TBD)
SC 32	Data management and interchange	• Common Cloud data format and Cloud service interchange issue
SC 34	Document description and processing languages	(TBD)
SC 35	User interfaces	(TBD)
SC 36	Information technology for learning, education and training	(TBD)
SC 37	Biometrics	Verification of users’ identity – user verification by biometric identifiers – personal recognition issues (e.g., architectures, protocols, remote user identification/verification).