CLOUD COMPUTING:

A business and economical perspective

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Abstract— **We present a Systematic Literature Review (SLR) on Cloud Computing that selected 51 papers from first tier journals and conferences in the period 2008-2012. The selective approach captures the economical perspective on Cloud Computing highlighting especially the business issues, cost/pricing models, and legal issues raised by the adoption of this new technological approach. Finally, it also spots emerging issues as a general lack of framework for security and service level management that respond to the peculiar profile of Cloud Computing.**

Cloud Computing, Literature Review, Cloud Deployment Model, Cloud Delivery Model, IT management

I. INTRODUCTION

Undoubtedly, Cloud Computing (CC) is a fashionable topic from 2007 onwards. The issue we deal with is about the kind of comprehension we have about CC. In more precise terms we state it as "What cloud computing really is and what level of maturity has reached". To answer it, we have conducted a Systematic Literature Review (SLR). In the following sections we illustrate its method.

A. The method of Systematic Literature Review (SLR)

SLR is an "explicitly formulated, reproducible and up-to-date summary" [1]. As opposed to narrative reviews, it is based on a specified structured method. Our SLR includes the following steps:

- Formulation of the research question
- Selection of sources and inclusion of primary studies
- Quality assessment and data extraction
- Summary of study result
- Results interpretation.

B. Formulation of the research

The overall research question is, as we said earlier, "What cloud computing really is and what level of maturity has reached". Once the question is stated, the second point is how to classify articles. This point is discussed by various authors [2] [3]. We have classified research by a two levels grid (Table 1). Each of these research domains is illustrated by a dedicated section in section 2.

TABLE 1 - CLASSIFICATION OF CLOUD COMPUTING ISSUES

Primary Domains	Secondary Domain	Content
Service Level Management	Performance, Security	Performance studies to refine workflow setting and security.
Business Issues	Cost, Legal Issues	The economic value and privacy issues.
Other		Papers that cover multiple domains

C. Source Selection

A SLR may be complete or selective. We follow the latter approach. We are aware that in this case some relevant ideas may be missed, but analyzing thousands of papers would be frankly infeasible. Our selective SLR has been based on web search engines:

- IEEE Computer Society
- Google Scholar
- ACM Digital Library

We have selected English-written sources given the small number of relevant documents in other languages. Books were not considered, because they often deal many different concepts that may cover too many areas. In short, 51 articles were selected trough three steps:

- An initial set of pertinent studies is extracted from the titles retrieved by search engines by reading title, abstract and introduction.
- Eliminate short papers, non-English papers, non-international
- Select the final set of papers based on to their adherence to research questions.

Within each of the research perspectives we have mentioned in Table 1, a source may fall in various categories, that we list in Table 2.

TABLE 2 - CATEGORIES OF SOURCES

Category	Description
Case study	An investigation on a single individual, group, incident, community or enterprise
Theory	Guidelines on or introduction to a particular subject; theoretical considerations on the

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	research issue
Survey	An investigation on a given topic based on the analysis of a given sample
Simulation	A study that introduces simulation methods and related results
Position paper	Presents an opinion about an issue
Literature Review	Profiles the literature related to a given topic

II. FINDINGS

We here discuss the positions emerging from the SLR, segmented by domain [2] [4] [5].

A. Service Level Management

Cloud computing is the last technological trend that has changed the concept of IT infrastructure. The physical servers are split into virtual machines whose resources are flexible and scalable according to the requests made by users. In this way the same machine can be shared by multiple users and data can be fragmented in different locations. These characteristics raise important doubts about the security of these systems and the ability of properly governing the services provided.

1) Security

The architectural concept of cloud computing involves benefits as centralization of security, data redundancy and process segmentation. However it introduces also new security issues [6] [7] [8].

Authentication and identity management: a critical factor is to provide a robust federated identity management architecture and strategy [9] [10]. The use of different identity tokens and identity negotiation protocols may generate challenges. While an user interacts with a web service, the same service may need to ensure that identity is protected from other services. Therefore, in multi-tenant cloud environments, providers should isolate customer identity and authentication information by integrating related components to other security components [11]. Cloud providers offer different options to fortify traditional authentication based on ID and password using one-time password systems or digital certificates. Higher levels of protection can be obtained by Open Authorization (OAuth), that allows users to easily login without revealing the information of user account and password, or by ID management systems based on open ID frameworks as the Security Assertion Markup Language (SAML) and WS-Federation [12] [13].

Privacy and data protection: Cloud customers fear greatly that data and applications are stored outside their datacenters. Cloud Providers should therefore assure a high security and, at the same time, a complete transparency in operations. Another important issue is tracking data changes, that could be used for the history-based access control; however the balance between data provenance and privacy becomes complex in clouds, where physical perimeters are abandoned [11] [14]. To solve this issue, providers offer solutions based on classic cryptography and hybrid encryption technique. Moreover, by combining the technique of proxy re-encryption with KP-ABE, it is possible to solve the issue of user revocation, by delegating burdensome tasks to cloud servers [15]. A common vision proposes a Trusted Third Party (TTP) to ensure authentication, integrity and confidentiality of data and communications [16] [17].

Trust management and policy integration: The combined use of multiple service providers increases performance and flexibility but raises security issues because of different security and privacy mechanisms. Therefore, mechanisms that handle dynamic collaboration properly and that effectively monitor during interoperations security breaches, are needed. A framework should be established with a set of indicators to measure security levels and manage evolving requirements [11]. Cloud computing also attracted Governments, because it offers substantial opportunities for information sharing, applications processing and cost saving. However cloud computing involves tangible risks, as unauthorized accesses, and intangible risks, as the reliability of the access. Governments should create a policy structure to avoid unforeseen risks and to provide effective risk management that identifies common tangible risks and intangible risks [18].

2) Performance

The real potential of cloud computing is the subject of several studies that consider performance measurement and performance improvement by workflow scheduling and load balancing. Let us summarize the main topics of this area.

Computational power: the power promised by cloud is attracting the community of scientific computing, who saw an alternative where resources are no longer in a private data center but leased as needed. Scientific applications as astronomical calculations or human genome sequencing require huge computing power and, thus, are good tests. Several experiments have shown that cloud systems can provide excellent computing performance but have also highlighted scheduling delays and wide area communications issues [19] [20]. Moreover cloud computing is still immature, because, in solving linear systems, cost grows exponentially with the problem size, and this is in contrast with scalable high-performance computing systems (HPC). This challenge opens new scenarios for cloud providers; for, they could use, in future, different cost models and better interconnections or nodes with greater physical memory to overcome the bottleneck caused by slow networks [21] [22] [23].

Performance Provisioning: Although cloud has been created to prevent provisioning operations, simulating alternative provisioning scenarios is highly recommended. For, a proactive approach allows to test performances in a free cost environment and to identify bottlenecks before deployment [24]. However, these simulations reflect forecasts and not actual requests. Therefore, some researchers have developed systems to test the cloud by the load profile extracted from the execution history, with a plausible scenario [25].

Load balancing: In real time whatever load beyond the limits considered in the simulations may block the system;

therefore, resources should be allocated dynamically. This option could be extended beyond the resources available in a private cloud or in a traditional data center by directing extra load requests to resources of a public cloud [26]. The importance of an efficient load balancer has prompted many researchers to study improvements that allow shorter activation time and better use of pre-allocated resources [27]. Moreover, to increase the flexibility of cloud systems, new paradigms have been developed, such as MapReduce and Hadoop, that allow applications to work with thousands of nodes and petabytes of data [23]. These solutions involve, however, to redesign agile data centers, where applications are loosely coupled with underlying infrastructure and easily communicate and share virtual resources [28].

Service level agreement: the benefits offered by resource scalability and pay-as-you-go approach contrast with the low standardization and continuous change of systems. Therefore, a clear Service Level Agreements (SLA) is critical. The lack of a precise set of metrics complicates management, especially when services are across many providers. Other factors, as trust in the cloud providers, become important to companies that are clouding critical data. Web Service Level Agreement (WSLA) framework offers a mechanism for SLA monitoring and SLA enforcement in a Service Oriented Architecture (SOA) proposing itself as an optimal approach as seen in cloud computing environment [29].

B. Business Issues

Cloud computing offers benefits to all actors involved in the service but has raised new business models and legal issues about data confidentiality and privacy; other less obvious topics as cultural imperialism or issues of accountability are important ethical problems in cloud computing [30] [31] [32]. Therefore, many researchers have investigated cost and benefits of cloud computing and legal issues that may undermine it [4] [33].

1) Cost

The ability of quickly scaling resource usage is a popular benefit of cloud computing. For, it avoids both the cost of over-provisioning and the risks of under-provisioning during a peak [34]. Therefore, cloud providers have introduced pricing models where users "pay as they go". These new business models together with the concept of multi-tenancy generate benefits for end users and providers. The commonest pricing models are [35]:

- **Tiered pricing**: several levels of hardware specifications are provided at a cost per unit time;
- **Per-unit pricing**: resources provided are flexible and scalable on the basis of the requests and the user pays for their exact usage;
- **Subscription-based pricing**: typical of SaaS, involves a contract that specifies the resources available and the number of users.

Some researchers have developed frameworks to compare the cost of cloud computing to conventional in-house approaches; they identify business domains, objectives, demand behavior and technical requirements as the key elements through which the analyst can compute the cost of the solutions [36] [37] [38] [39]. If a complete migration is impossible or inconvenient, companies can buy resources in a public cloud to augment their capacity. This scenario has pushed the University of Melbourne to a series of experiments. The results show that the cost of performance increases where the cluster is under-utilized; also, cloud computing may have different complexities that should be assessed and managed before its adoption [40]. The first item to assess is the cost to create a datacenter and to provide resources for both internal and commercial services. To simplify this task, researchers have developed a framework to calculate the Total Cost of Ownership (TCO), that takes into account the number of physical server and storage space, on the basis of the maximum number of VMs that can be deployed and simultaneously executed on a physical server [41]. With the same purpose of low cost, other researchers propose to run data centers at hotter temperatures to reduce cooling cost and to build micro data centers near end users to reduce bandwidth cost. This strategy, however, implies additional initial cost and maintenance operations outside corporate walls [42]. To eliminate the need of micro data centers, an economic model for self-tuned cloud caching has been proposed. This requires minimal capital expenditure and also ensures an high QoS to multiple users [43]. A second step is pricing. To get higher profit, an autonomic pricing may be used; it self-adjusts pricing parameters on the amount of resources reserved to each user and their actual utilization. For reservation ensures users to access future resources and improves planning and management of operations [44].

2) Legal issues

Cloud computing raises several legal issues both for customers and providers [45]. The physical location is critical because there are no international agreement on data protection and privacy [46]. Governments might play a strategic role to promote cloud computing as they supported Internet in the years '80-'90 [47]. Although many critical factors are common with web services, some legal issues have a particular prominence and are ruled differently in different countries.

USA: U.S. have legal and regulatory rules, especially on privacy rights, that hardly can be enforced in massive cloud computing [48].

- **HIPAA Restrictions on Health Data**: it imposes significant restrictions on the disclosure of protected health information.
- **Gramm-Leach-Bliley Act**: it restricts financial institutions from disclosing consumers personal data to third parties, verifying that service provider is capable of maintaining an appropriate data management and of ensuring such security level by contract.
- **State Breach Notification Laws**: it requires that data owners notify individuals whose computerized personal information has been subject to unauthorized access. In a cloud computing control is

complex because the data owner has not a complete control on the security of company data.

Europe: data protection authorities have recently covered cloud computing to ensure compliance with EU data protection requirements [49].

- **Data Controllers and Service Providers**: Data Controller determines purposes and methods of treatment of personal data and is responsible for compliance with data protection law. Service providers have to ensure measures to protect personal data against accidental or unlawful destruction or loss or unauthorized access and alteration.
- **International Data Transfers**: transferring personal data outside European Economic Area is prohibited, unless the receiving country provides an adequate protection. This rule is tight and recognizes data transferring to few countries, causing significant limitations to cloud computing. Currently, U.S. do not satisfy EU specifications and a data transfer to them may be authorized only if the data recipient has implemented a legal mechanism to enforce an adequate protection (e.g. U.S. Safe .Harbor Program).
- **Legal Bases for Processing Data in a Cloud**: Under EU data protection law the data upload in a cloud computing environment is considered as processing. Furthermore the organizations should have a legal basis to process personal data or obtain permission through an explicit agreement of specific items in the contract.

UK: UK shares with EU several measures [50].

- **The Data Protection Act** 1998 contains eight principles for protection and restriction on personal data treatment. The first principle states that personal data should be processed fairly and lawfully. In accordance with its principle the cloud provider obtains permission to treat these data by inserting a specific consent in contracts. The seventh principle states that "appropriate technical and organizational measures must be taken to prevent unauthorized or unlawful processing or accidental loss or destruction of personal data". However, in cloud computing access to data can be accessed from any device thus violating such restrictions. Anyway, data fragmentation used by cloud computing system indirectly provides some level of security by preventing to know the location of files.
- **The Copyright and Rights in Databases Regulations** 1997 established a stand-alone intellectual property right where a database has originality in the selection or arrangement of its contents and there has been a substantial investment in obtaining, verifying or presenting that content". Afterwards, a court has clarified the meaning of "substantial investment" by specifying that it applies to the creation of the database itself and not to the collection of information content.

III. CONCLUSION

Our SLR has illustrated the current academic research landscape on Cloud Computing (CC) and has highlighted relevant trends. In our review, we found different definitions that still show a conceptual uncertainty. All articles, even underline important benefits provided by the CC adoption, have also addressed several issues. These issues are developed, in most cases, from the provider's perspective, while research should still cover the quality of the service from the end-user's viewpoint [51]. Some authors have considered benefits and challenges of cloud computing from a broad perspective, thus showing economic benefits for providers and end users. On the other hand, CC might imply key ethical and legal issues that may delay or even prevent a mass adoption. The review shows that the CC involves not only the corporate world but can provide computational power to the masses. For this reason we can describe CC as an IT "commodization" that provides technological services in the same manner of standard utilities such as electricity, water and telephony. Finally, as highlighted by our review, despite of the high potentiality, cloud computing has also server issues resulting from the lack of precise definition and the lack of standards that are slowing the massive spread of this technology still not completely mature.

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