TO STUDY THE IMPLICATIONS OF SECURE CLOUD COMPUTING THROUGH IT AUDITING

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ABSTRACT

Cloud computing is a collection of net-centric, service oriented concepts, methodologies, best practices and technologies. It promises scaled economic benefits by provisioning computing resources and applications as services to customers while customers base their needs to subscribe related services. The services can be computing infrastructure, storage, development and deployment platform, software services, desktop services, etc.

In this paper the author discuss the evolvement of cloud computing paradigm and present a framework for secure cloud computing through auditing. The approach of the research study is to establish a general framework using checklists by following data flow and its lifecycle. The checklists are made based on the cloud deployment models and cloud services models. The contribution of the paper is to understand the implication of cloud computing and what is meant secure cloud computing via IT auditing rather than propose a new methodology and new technology to secure cloud computing.

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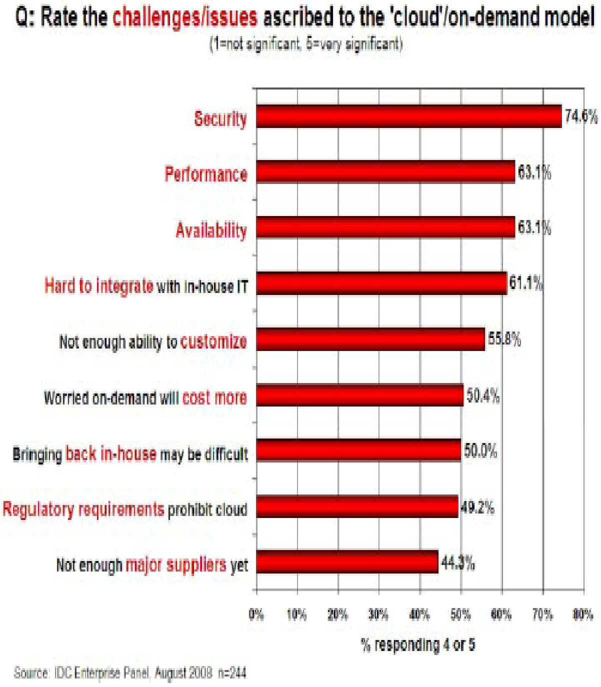
1. INTRODUCTION

Cloud computing is a collection of net-centric, service oriented concepts, methodologies, best practices and technologies. It promises scaled economic benefits by provisioning computing resources and applications as services to customers while customers base their needs to subscribe related services. The services can be computing infrastructure, storage, development and deployment platform, software services, desktop services, etc.

A visionary scenario in the cloud is that a thin client interacts with remote cloud operating system to get virtual desktop with a chosen virtual local operating to access virtual data storage and executes applications from anywhere and at anytime. This idea is not new. It can trace back all the way when IBM Watson claimed the world needed only five machine.

But why is it now? At present, IT is reaching a critical point. Explosion of information is driving 54% growth in storage; large scientific calculation such as weather forecast computation, new medicine, and healthcare informatics is demanding more powerful and faster processing capacity. While in reality, around 85% of computing capacity is idle, average 70% of IT budget is spent on managing IT infrastructure versus adding new capabilities [15]. On the other hand, technologies like virtual computing, parallel computing, services oriented architecture, autonomic computing are advancing in an unusual pace. In addition, as the connectivity cost keeps falling, the world is even more flat. Web-based applications over the internet, depicted by cloud, are becoming standard starting applications. People without extensive period of skill training and manual remembering on underline operating systems and basic hardware maintenance can accomplish their work fairly easily. Consumers purchase computing capacity on-demand and are not generally concerned with the underlying technologies used. Computing resources and data being accessed are typically owned and operated by a third-party provider, not necessarily located in nearby. They can be potentially beyond state even country's physical boundary. Moving traditional applications and their infrastructure to cloud has shifted the in-house control to a third party. It posts many challenges including security and privacy, performance and availability as illustrated by the following widely quoted survey [16] in which security is the number one concern. If the graph includes rate 3, then all the numbers increase by at least 10 points [19]. Clearly using cloud computing does not make the security issue go away. It becomes an even challenging topic. In that sense, it is not quite a usual utility concept we are talking about it.



Source: IDC Enterprise Panel, August 2008 n=244

In this paper, we address the security issue from information assurance and security point of view. That is, we take holistic view of securing cloud computing by using the IT auditing vehicle. IT auditing or in general accounting auditing under cloud computing has added extra role of building strategic plan for the enterprise in addition to the traditional auditing role [17]. We make master checklists as a framework specifically toward cloud computing based on its deployment models and service models. After a section of literature review, we start to make checklists for public cloud, community cloud and private cloud as well as IaaS and SaaS. The last section is devoted to further discussions.

2. LITERATURE REVIEW

Cloud computing is an evolving concept, its technology is emerging. NIST has defined cloud computing in its latest release as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics (on-demand selfservice, broad network access, resource pooling, rapid elasticity and measured Service) , three service models (SaaS, PaaS and IaaS), and four deployment models (Public, Private, Community and Hybrid) [1]. McKinsey and Company released its well quoted “Clearing the Air on Cloud Computing”discussion document in March of 2009 [2] after more than 20 cloud definitions listed byVaquero in [3]. Open cloud published the open cloud taxonomy which represents its view on cloud architecture [4].

The implication of cloud computing on security, privacy and compliance is a working progress. NIST in its “Effectively and Securely Using the Cloud Computing Paradigm” [5] described the security challenges as well as advantages. The major issues include trust, multi-tenancy, encryption and compliance such as FISMA [6], GLBA [7] HIPAA [8], SOX [9], PCI [10], SAS 70 Audits [11].

Cloud security alliance, established by the end of 2008, released its second version of “Security Guidance for Critical Areas of Focus in Cloud Computing” in 2009 in which five governance domains and seven operational domains are identified and discussed [12]. In the domain of compliance and audit, it raises issues regulatory applicability to cloud computing and division of compliance responsibilities between providers and users. It also made 13 recommendations such as legal and contract team involvement, audit rights, compliance scope, impact of regulations on data security, relevant partners and services providers review, contractual understanding, provider infrastructure configuration review, policies and procedures analysis, evidence preparation, auditor qualification and selection, cloud providers SAS 70 Type II status, and ISO/IEC 27001/27002 roadmap and scoping.

The report “above the air” [20] lists top 10 obstacles and opportunities for Cloud Computing. The number 1 obstacle is availability of a service. Most enterprise businesses require 99.99% of uptime while current public cloud providers could not reach this goals. We have heard many downtime incidents from the news. Several outage examples in AWS, AppEngine and Gmail are listed in [20]. Also mentioned in the paper [20] is the confidentiality and auditability of data leads to extra layer of security to data.

Lastly, in terms of architecture and patterns, Open Security Architecture Group provides Cloud Computing Patterns and specific Controls [13]. In this paper, we are focusing on IT Compliance and Audit to assure a secure cloud computing. The goal is to create a framework with master check list so that both internal and external auditors can reference to it when they come to audit this new and dynamic cloud computing territory.

3. DATA LIFE CYCLE

Cloud computing makes the world even flatter. Public cloud providers can have their computing resources locally or globally. The sky is the limit in this case. Cloud users do not need to know in theory where the computing resources location is because they are all virtualized.

We start with cloud data life cycle. Data and information in this paper are exchangeable terms. In general, the data life cycle includes collection, storage, transferring and destruction. The data collection includes both raw data and derived data. Derived data is also called information that is generated from raw data to deliver intelligence, which is usually not see easily from raw data. Data storage includes active data storage and inactive storage. For example, former employee data can be considered as inactive. Its storage procedure could be different from active employee data. Data processing and data storage are not necessarily under the same location in the cloud environment. Therefore data transferring around the net is more a common activity. Data destruction is to destroy data permanently, no backup should be left somewhere either in the user side or the provider side.

We see that cloud data life cycle presents many unique features. Data is crossing different security domain and regulations. Data is constantly moving due to the nature of data storage provided by a third party. Information assurance has a new dimension via contracts among cloud users and cloud providers. They need to establish formal agreement. We can even borrow the term service level agreement (SLA) since we now need to add crossing domain compliance clauses that can be implementable.

The following three sections is a framework of checklists for public cloud, community cloud and private cloud. The core is data protection following the data life cycle.

4. CHECKLIST FOR PUBLIC CLOUD

Public cloud has its root from Google, Amazon, Microsoft, salesforce, and more. Enterprise uses public cloud to focus on its core business and save cost. Government is keen to use public cloud to take the advantage of cost effective by providing public useful information in cloud. It can also explore cloud concept to integrate various computing resources from different departments and agencies into a manageable pool. Therefore making a connected government is a reality. IT auditing in public cloud can have different focus based on different service models. We address two popular service models in this paper, Infrastructure as a Service (IaaS) and Software as a Service (SaaS). We will discuss PaaS late.

4.1 IaaS

Infrastructure as a Service (IaaS) is a popular service model that provides computing resources to cloud users who deploy operating systems and run their applications on top of it or use it as a storage or archive. When it comes to IT auditing, location, geopolitics, data owner and regulatory issues are not going to be virtualized. For the public cloud, our check list focuses on the following issues.

1. Data location Aware

Rationale: Cloud computing makes the world even flatter. Public cloud providers can have their computing resources locally or globally. The sky is the limit in this case. Public cloud users do not need to know theoretically where the infrastructure location is because they are all virtualized. For the IT auditing purpose, public cloud users need to know geometric location of their data storage and their running applications although in general, they do not need to. Public cloud providers o the other hand would like to hide the location information. Knowing the location helps IT auditors understand the applied regulation or study the implication and make proper recommendations and decisions.

What: location aware should include all the history of data location following its life cycle. Pay special attention to those data locate outside legal territory such as in other states or countries.

How: Get these documents from cloud coordinators. Usually it should be in the agreements. Cloud coordinators and IT auditors should talk to cloud providers about location if these documents either not exist or out dated

2. Data ownership aware

Rationale: data owner in public cloud is always a touchy issue between providers and users. We see it happened in the argument among facebook and its users, and a 9th Circuit Court of Appeals ruling stating that providers of hosted e-mail/SMS services may not turn over messages to the company under the Stored Communications Privacy Act without a warrant. Many cloud users are sure to avoid such situations [21]. So far, no universal legal guidance is established. Cloud users could assume they are the owners of their data. This assumption should be written in an agreement. When it comes to move data out of the cloud or destroy data, cloud users should know if they data are destroyed completely and how. No backup should be left alone when the data is supposed to discard. The process should be written in the agreement.

What: Clearly stated in the agreement on data ownership on data life cycle. Also included the data destroy and verification process

How: Discuss with cloud coordinators about the data ownership and data life cycle management. Get written document on data ownership the procedure of data removal.

3. Data protection plan and best practice

Rationale: It is obvious data protection is crucial to cloud users. Detailed data protection plan following data life cycle is important part of agreement among all parties, users, providers and affected stakeholders. In addition to written agreement, actual practice is also important to data protection.

What: Data protection plan should include clear procedure and practice in each phase of data life cycle such as collection, storage, transferring and destruction. The ability of data auditability is an important part of the plan.

How: It auditors needs to understand the classification of essential and non-essential data. With this in mind, they should talk to cloud coordinators and compliance officers to understand what’s been done. In addition, IT auditors should suggest various controls like red tape in place for every phase of data life cycle. These controls can report any incidents happened.

4. Data processing isolation

Rationale: Another possibility of data leakage is during the data processing in a shared cloud environment. Data might be stored in a temporary storage accessed by other applications. To isolate data processing and make sure no other applications can access the data during the processing.

What: Processing isolation should have clear procedure to make sure data processing does not leak data

How: IT auditors should not only read document in written but also look for evidence the procedures are followed.

5. Data Lock-in

Rationale: So far, there is no unified cloud user interface to access cloud. Different cloud providers provide different data access method using different format. This will cause an issue when cloud users want to move their data to another provider or back in house. This phenomenon is called data lock-in.

What: To avoid data lock in, cloud users should know the exit strategy and options

How: It auditors should ask such documents that include exit strategy and options.

6. IaaS IT architecture

Rationale: IaaS architecture varies although we see general reference architecture. Knowing the actual architecture, IT auditors can define their work scope and focus easily. Because of the IaaS is new to many management personnel, the IT SaaS architecture could help them visually get the main IT auditing concerns

What: List all the components inside the architecture, not just a general conceptual one. It should include as much detail as possible.

How: Talk to cloud coordinators and cloud providers to get the IT architecture descriptions.

7. Regulatory Compliance

Rationale: many regulatory issues such as HIPAA [8], GLBA [7], FISMA [6], SOX [9], PCI DSS[10] are new and need to do through investigation when sensitive data are processed and put in cloud. To make compliance in public cloud is a daunting task.

What: Regulatory compliance in terms of public should include privacy, safeguard, security rule, information system Controls, etc.

How: understand the specific needs of compliance for the enterprise by talking to the compliance officers and chief information officers. Collect all the documents and practices.

8. Cloud IT technique

Rationale: IT auditing toward public cloud is challenging because the IT infrastructure basically

offered by a third party to which depending on the agreement auditors may not have direct access. Practical IT auditing techniques need to refine to reflect the change.

What: The techniques should include database, data center, wired and wireless connection, cloud operating system like Azure, virtual technology like VMware, hardware dependencies

How: It auditors should find out the agreement using third party cloud provider, how far it can go and test, talk to cloud coordinators what are procedures of reporting any incidents, inspecting specific areas routinely, what kind of tools can use.

9. Reporting control

Rationale: cloud control structure should be there with or without cloud presence. It is required by SOX. Although SOX is for public trading companies, private companies are recommended to do so too. With cloud presence, the reporting and responsible extend to third parties as cloud providers.

What: Reporting structure should be all the way to CIO, CEO or Board of Directors. It includes incidents and response mechanisms involving cloud providers. Usually it is written in an agreement with cloud providers.

How: Ask IT administrators for such documentation. And check if it is in compliance with regulations and best practices

10. Cloud Disaster recovery plan

Rationale: Cloud disaster recovery plan is crucial for business recovers from any disaster. With cloud in place, the disaster recovery process should include them as well.

What: Cloud disaster recovery plan should include how to get crucial data back and how quickly in the case of disaster either on cloud provider side or on the cloud user side. So the plan should include disaster recovery plan from cloud providers.

How: Ask IT administrators for such documentation, and if it is being frequently tested and updated.

11. Cloud business continuity

Rationale: Business glitch is evitable. Damage minimization is carried out by business continuity. Because of cloud computing, the probability being failure is even higher as services are delivered over internet. Business continuity under cloud should include cloud providers' business continuity plans in addition to own business continuity plan.

What: Cloud business continuity should include those foreseeable glitches from inside and outside.

How: Ask IT administrators for such documentation. Business Continuity plan should be tested frequently.

12. Overall IT projects cost

Rationale: It is desirable to know the actual cost structure using public cloud and how much saving compared to traditional IT model. It may not related to IT auditing directly. Strategically, the but it tied to IT budget and alignment with.

4.2 SaaS

Software as a Service (SaaS) is a popular cloud service model. Applications are accessible various web browsers. It pays for usage. Many checklist items are similar to those from IaaS.

We list some of special toward to SaaS.

13. Data activity surrender

Rationale: Some countries require that data and activity from SaaS providers should be kept within the national boundaries so that government agencies can access them when needed. USA has USA Patriot Act that mandates SaaS providers keeps all the customer data that can be accessed under special occasions such as court order. This is not a pleasant outcome many SaaS users want. Therefore SaaS users should ask if there is a possibility that can avoid such intrusion. One example from [20] is to have cloud location and users are within the same nation.

What: data activity surrender should include what regulation and laws apply, what information is being

surrendered and what option available to avoid such surrender.

How: IT auditors should work with legal and contract team to understand the local law and regulation on data service providers such as phone records, utility bills, library book lending records, etc. T hey should ask documents about what kind of information cloud providers keep and to surrender. This documented policy should be checked on site. It auditors should also ask what option available to avoid surrender.

14. Data format

Rationale: If data format from specific software can be read by many freely available readers like adobe, work, open office and notepad, SaaS users can avoid pay extra software usage. What: Check available data format from the software service.

How: It auditors should test out all availability data format and check if these format can be accessed by general reader applications. They should talk to users to find out reasons that specific format being used or not used.

15. Monitoring for availability and performance

Rationale: From SaaS providers, assuring high level of availability and performance is the key for their business success. For SaaS users, monitoring high availability and performance is an important control.

What: The monitoring control should collect availability and performance data and use the data to work with providers to fine tune SaaS service.

How: Talk to cloud coordinator about such type of controls and data for offline analysis.

5. CHECKLIST FOR COMMUNITY CLOUD

Community cloud is another attractive solution to many large and middle size enterprises that have common business interests within one region. Many corporations are used to regulations within one region or one country. They would like to take the advantages of cloud computing but they do not want to have the complication of cloud crossing their comfortable zones. They want both convenient and control. Hence, community cloud computing is an attractive concept for them. The actual implementation of community cloud varies. It can be built on from scratch. Or it can utilize existing computing resources from the community to form a cloud. The ownership of the cloud is open to discuss. Ideally it should be owned by the community. The technical challenging is enormous and its implication remains to be seen [14].

The IT auditing under community cloud computing is more of under controllable like private cloud. They know where the computing resources located and assigned. It is certainly more work than a pure private cloud as it is owned by a community in which collaboration and competition exist as always. The key to its success is to make sure agreements are clearly written and the whole community needs to obey the rules and regulation. We have made the following list for IT Auditing specially for community cloud computing

16. Community cloud IT architecture

Rationale: Clear cloud community IT architecture will help the community understand its computing resources and its capacity. It can help to build responsible community.

What: The Community Cloud IT architecture should include core infrastructure, resource layer and service layer [14]. Data life cycle, user identifies and trust are important elements. Use case analysis is proper. If the cloud is built upon the contribution of the community, the relation among own computing resources and the community resource should be marked clearly.

How: Talk to cloud administrators to get a sense of its architecture. If possible, get technical documents that describe the community cloud.

17. Community Cloud management

Rationale: Because community cloud is used by a group of industrials of same regions or of same interests, they are collaborative and in the mean time competitive. Clear community cloud management structure will prevent any future arguments. Community cloud can be managed by a third party or by a technical committee made from the community.

What: It should include clear management structure and responsibility. It should include the procedure in case of argument and disagreement.

How: IT auditors from a specific member of the community should have access the latest documents on management.

18. EXIT Strategy

Rationale: When a member wants to leave the community, the community cloud should have procedure of the departure. Without the procedure and agreement, community cloud could not last long.

What: The Exit strategy should include documents on separation. The document should include procedure to follow and a responsible body for the task. The procedure should clear state what to do about the computing resources the member contributed before.

How: IT auditors should ask such document and check if it is feasible and if it needs modification.

6. CHECKLIST FOR PRIVATE CLOUD

So far, a private cloud is a very practical and attractive option to many security sensitive enterprises. The private cloud gives not only the self control but also the benefits of cloud computing, mainly sharing computing resources including processing power and storage capacity among different departments within an enterprise. Traditionally, department computing resources are not shared due to data sensitivity, self control and different business nature of departments. Private cloud could remove or blur these boundaries. It virtualizes all computing resources from different departments into a computing resource pool. Each department is allocated computing resources from the pool by provisioning need on demand. From the department point of view, the computing resource is unlimited. Therefore achieving a task faster or making a task not achievable before due to computing power constrain. In most cases, a private cloud could cut IT cost down, increase flexibility and scalability, make available 24x7 and even do applications that are impossible before the cloud. Private cloud certainly poses a great management challenging as well as auditing challenging.

19. Private cloud IT architecture

Rationale: Different enterprise implements private cloud differently from actual technology realization. Therefore to understand the cloud IT architecture is vital for meaningful IT auditing

What: IT architecture includes technical details about virtualization, provisioning, workflow, data movement, access control, etc.

How: Talk to cloud administrators to get a sense of its architecture. If possible, get technical documents that describe the cloud.

20. Private cloud reporting control

Rationale: Like public cloud, reporting is required not only by the regulation but also vital to the success of the business. Private cloud reporting is more of internal control. Because of sharing computing resources, private cloud has to make sure that sharing does not hamper security and privacy. Any incidents should be logged and reported immediately. The reporting structure should be established and updated often.

What: Reporting structure should includes incidents and response mechanisms and who is in charge. The escalating reporting structure can guarantee any incident and disaster can be handled properly.

How: Ask IT administrators for such documentation. And check if it is updated.

21. Disaster recovery and continuity plan

Rationale: In the private cloud, disaster recovery plan should also follow the procedure like public cloud except that the cloud is managed by the enterprise. The IT team and management should work together to modify the existing disaster plan to fit the cloud scenario.

What: The disaster recovery plan should include how to get crucial data back and how quickly. The plan should include data different location backup.

How: Ask IT administrators for such documentation, and if it is being frequently tested and updated.

7. CONCLUSION

In this paper, we discussed a framework of checklist of IT auditing cloud computing to assure secure cloud computing. It is more toward Cloud than a complete list of IT Auditing. IT auditors should refer general requirements for IT auditing. The checklist also gives a reference point to those want to dive into cloud computing wave and a question set to answer if cloud is good for the business in long run. We would like to discuss on PaaS service model in the future work as we are still looking for a feasible PaaS business model.

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