

# Auditing Deployed Software Licenses on Cloud using a Secure Loopback Protocol



Srabanti Chakraborty, Rajesh Bose, Sandip Roy, Debabrata Sarddar

**Abstract:** *The rapidly growing cloud-centric focuses among organizations and enterprises have thrown into sharp relief the pressing need to progressively upgrade security within a cloud infrastructure. While a significant portion of threat perception emanates from malicious software that can infiltrate a cloud computing infrastructure, the risk of unlicensed software deployments in infrastructure-as-a-service model can expose an affected cloud service provider to a host of legal and statutory issues. The task of managing software licenses and conducting license validation checks can be an intense activity. The onus of tracking and managing licenses of software that have been deployed on an infrastructure-as-a-service cloud model is on both cloud service provider as well as its customers. However, the business of effectively managing software licenses is contingent upon the ease and use of an effective license auditing management tool to which auditors can connect through a secure conduit. In this paper, we propose a model that would allow cloud service providers to securely track software deployments and tally corresponding usage of appropriate licenses within an infrastructure-as-a-service model. Using the proposed model a cloud service provider can match all software licenses that have been deployed by a customer within the IaaS cloud space allotted. Further, a license auditor can securely connect to cloud service provider's console and generate reports on license usage and software deployments from any modern browser. At the core of our model, lies a secure loopback connection framework that prevents access to any other web site once a secure connection to the primary console for monitoring and tracking software deployments has been established.*

**Keywords:** *Billboard Manager, Cloud Computing, Loopback, Software License.*

## I. INTRODUCTION

Cloud computing is a modern information technology paradigm that is associated with responsive and elastic on-demand services. Its roots are embedded in the early days of networking and timesharing that were considered to be a

novel approach in harnessing computing resources efficiently and as cheaply as possible.

The origins of cloud computing can be traced as far back as the Cold War period even as the then two super powers strived to gain an advantage politically, militarily, economically, and technologically. Among the first stellar examples, though not categorized later as among the more successful ones, Tymshare is often considered to be a specimen of the first cloud computing service model ever to have been in production use as far back as in 1972 [1], [2]. Tymshare worked on the principle of enabling users connected from remote computers geographically apart, to access a set of computer applications. It did not succeed in sustaining its momentum as the designers failed to incorporate features that could allow it to connect computers to computers, and not just computers to users. It's eventual and often unheard of demise paved the way for ARPANET that later on morphed into the present day Internet that millions of users have grown to rely on at any given time [1].

## II. GENESIS OF CLOUD COMPUTING

The concept of cloud computing received an important official sanction when in September, 2009 the first US Chief Information Officer announced the use of a cloud computing strategy for the US Government [3].

In doing so, the National Institute of Standards and Technology (or *NIST*) was given the mandate of shifting to cloud computing technologies. However, the more important focus areas that were to govern all cloud computing technologies from that point forward were formulating the definitions of cloud computing itself and describing the underlying concepts thereof, and clearly defining the security and privacy aspects explained in technical terms [3]. In comparison to similar service-oriented approach such as Service-Oriented Architecture, cloud computing offers extensive scalability. This is the fundamental theme behind developing better system optimization, reduction in costs, improved reliability, and robust functionality.

Cloud computing differs from traditional approach of IT ownership in that that it does not need to build into it any extra overhead to cater to peak load demands. In other words, subscribers to a cloud computing service can scale up or down depending on their individual requirements without having to factor in any extra costs for a more sophisticated infrastructure that would only be utilized if and when a peak load is reached.

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### III. CLOUD COMPUTING MODELS AND SERVICES

Cloud computing has several key attributes that have made it the paramount choice of consumers worldwide. These attributes are: on-demand self-service for consumers and service providers' alike, rapidly deployable services on demand, pooling of resources without affecting services that are consumed by clients, and delivery of a multitude of networks supporting both thick and thin client machines.

NIST categorizes cloud deployment itself in four distinct ways. These are: public cloud, private cloud, community cloud, and the hybrid cloud. These are distinct from the manner in which cloud resources are made actually available as services to consumers. The three basic levels of cloud services that have been described by NIST, and from which all other cloud services branch off are Infrastructure-as-a-Service, Platform-as-a-Service, and Software-as-a-Service. While Software-as-a-Service (SaaS) and Platform-as-a-Service (PaaS) are service models where cloud service providers enable consumers to use software, and software programming tools, respectively, it is the Infrastructure-as-a-Service (IaaS) model that allows consumers to install and manage their own software without any intervention from service providers [4] – [6].

In IaaS, the liability of a cloud service provider is limited to the extent of providing hardware resources, data storage and retrieval facilities, virtual network infrastructure, and virtual operating systems. In this particular type of service model, while consumers are free to install their own software and application tools, issues involving software licensing often take root [7].

Research has shown that mid- and large-scale organizations prefer to manage their need for cloud resources in order to streamline with their business operations. In such cases, IaaS [8] has been observed to be the preferred choice over SaaS or even the PaaS service models.

### IV. SOFTWARE LICENSING ON CLOUD

Use To generate more revenues and be self-sustaining in the long-run, cloud service providers are obliged to attract new customers. In doing so, the focus of their marketing attention has shifted towards those customers who operate their own Data Centres, or on-premise deployments.

One of the significant obstacles for consumers exploring cloud options from on-premise deployments is the deployment and use of software licenses that had been purchased keeping in mind on-premise deployment [8]. This is especially important in the light of the fact that compliance is a key focus area in terms of cloud computing security and service level agreement issues are concerned [9].

Cloud service providers need to be cautious and aware of software license deployments that take place in IaaS deployments. With a number of software licensing management approaches available, the more common and tested options are node-locking, floating license, and named user [10].

With independent software vendors (ISVs) reserving the right to investigate an organization's usage of their respective software, it behoves organizations to be alert at

all times to track and monitor use of all commercial software by their end-users. This can pose a challenge in cloud computing environments for cloud computing service providers (CSPs) as well as their enterprise customers given the intrinsic elastic nature of cloud computing itself [11], [12]. Researchers have also observed the popularity of two forms of software licensing avenues in cloud computing context.

The first of which is the Bring Your Own License (BYOL), and the other being License Charges Included (LCI) [13]. Yet another licensing model that is offered by many software manufacturers is *Client Access License (CAL)* [14]. Given that the platform in a cloud computing environment is often dynamic in nature, a valid user must be allowed to use a software license irrespective of the underlying virtual machine that forms the cloud computing environment in use [15].

The chief overriding factor among all that are to be considered while discussing license management and compliance in cloud computing is virtualization. Virtual machines produced from virtualizing resources based on physical machines, are at the core of any cloud computing environment. Elasticity, scaling, and compliance concerns are products of harnessing advantages that virtual machines allow [16], [17].

### V. LITERATURE REVIEW

Improper software license management can be expensive for organizations. The popularity of cloud computing, though attractive for corporates and individuals alike, is not without software licensing pitfalls. It is not unknown for independent software vendors (ISVs) to seek and legally obtain huge penalties from organizations that fail to record and keep track of software licenses that are in use at any given point of time [12].

In a prototype designed and proposed in one study [12], persisted data approach has been fused with *Management-based License Discovery*. The prototype was designed to offer an overview of software licenses used and the associated license types deployed and consumed at any given point of time.

The dashboard overview is equipped to deliver a detailed view of all virtual machine instances running, at the click of a button by an administrator. In another study conducted by researchers, it has been suggested to bank on a web service that would monitor license management and a job scheduler [10]. Independent Software Vendors (ISVs) are also known to rely on licensing mechanisms to prevent unauthorized use of their respective software [11]. ISVs may choose to rely on, a dongle-based solution, a biometric approach, or central license servers to manage license deployments. However, the authors [11] have shown that the first of the two approaches can be only of limited use. In cases where licenses have to be deployed at remote locations, which in the case of cloud computing is often mandatory and/or obligatory, dongle-based or biometric-based solutions can prove to be restrictive and not entirely workable propositions.

On the other hand, license servers offer the flexibility of being deployed anywhere with considerably more ease and effectiveness than the former two approaches within cloud computing environments. In the paper, researchers propose unlimited pay-per-use licenses keeping in mind the intrinsic trust factor in relation to ISVs and customers consuming cloud services. Significantly, the most important exercise in connection with software license management is creation and maintenance of software inventory. In their paper [12], the authors describe their method as *software discovery*.

The conventional practice and process of inventorying software begins with software programs that act as agents to detect signature patterns of software installed. In addition to the data collected by such agent tools, it is possible to reap information on hardware itself.

The authors argue that this method is suitable to make a determination whether a software program installation detected could be a part or component of a larger installation. However, they also point out the disadvantages of adopting such a method. The chief drawback of such a method, the authors point out, is that the agent tools can produce incomplete or erroneous data.

The software inventory reconciliation itself, in such cases, involve certain amount of human involvement that can not only be time-consuming but can also tie down significant amount of IT skilled manpower that could have otherwise been gainfully employed elsewhere.

To address the problem, the authors offer a virtual machine based approach that is anchored by a proposed design offered by the authors that they call *Management-Based License Discovery*. Describing a set of seven different software licensing models, the authors discuss the implications of calculating licensing costs on per virtual machine basis [13].

Based on available literature on research conducted concerning license management, the authors explain that in most cases maintaining a centralized software repository is an effective and accurate approach to keep track of software licenses. Although, emphasis of research into software license inventory in cloud has been in evidence, it has been also equally important to secure the licensing information gathered and collated in a repository for software license inventory.

Discussing the threats from malicious sources and attackers to cloud-based license management models, the authors present a model to counteract this problem using a combination of encryption, application binding, memory protection, delegation protocol and local binding [15].

What is significant to note from their research is that their proposed design settles on secure encryption session to obtain licensing data even on public networks. As has been documented by researchers in [16], many cloud service providers (CSPs) are providing the option of Bring Your Own Licenses (BYOLs).

Progressively, as this form of software licensing becomes widely available and accepted by most cloud computing consumers, the question of managing software licenses itself becomes one of paramount importance.

## VI. PROPOSED WORK

The model that we propose in this paper is a secure web-based software license agent monitoring and management framework targeted at cloud computing environments where software licenses are deployed on virtual machines in IaaS or PaaS modes.

The core design harnesses the features of the *Billboard Manager* model as the primary license collation and tracking system deployed in a cloud environment [17], [18].

Our proposed design uses the *Billboard Manager* to look up all underlying virtual machines set up by a cloud service provider for offering IaaS and PaaS services [19].

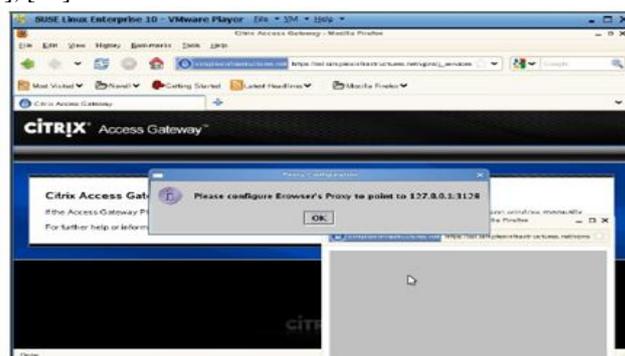
In the course of initialization and periodic monitoring, our model shall examine and gather data related to hardware specifications. All software instances running on individual virtual machines.

A central repository shall contain interlinked and indexed set of tables containing information on latest hardware specifications and software license deployed on respective virtual machines shall be kept updated by our Billboard Manager based model.

We call our model SSL-augmented Software License Management System (SASLMS). At the user end, the operating system of the PC is SUSE Linux Enterprise Desktop 10.3 running a Mozilla Firefox version 3.5.2.

The primary components to this model are composed of three inter-linked sections each interwoven in terms of its functionalities with the other two.

The first section of our proposed model is the software license detection tool itself that scans individual virtual machines. This helps the core Billboard Manager Engine to inventories and update indexed tables listing the hardware specifications and licenses that are deployed in each virtual machine. The second component of our model is the *Billboard Manager* engine itself that is a multi-factor gateway providing SSL services. The following picture demonstrates the display on computer screen after a user attempts at logging in using proper username and password [17], [18].



**Fig. 1. Screenshot to display on the computer after a user attempts at logging in using proper username and password.**

The Billboard Manager also maintains a database consisting of tables that keep track of user accounts, biometric data, virtual machine information, software license data and history. As well as it



also extends a Hypertext Transfer Protocol Secure (HTTPS) link for users to connect.

The secure link is the third component of our proposed design. Designed keeping in mind the requirements of a software auditor who would need to guard against malicious attacks [16].

The Billboard Manager allows users to establish a secure and dedicated link between it and users logging to our SSL-augmented Software License Management System (SASLMS) [20].

Once a SSL connection is established, the Billboard Manager shall automatically configure user's browser proxy to point at localhost with the IP address set at 127.0.0.1:3128.

Once this mode is enabled, users shall only be able to access the software license management web portal, and no other site. Legitimate and authorized users would then be allowed to initiate software license auditing and view reports obtained [14], [15].

This loopback method has been tested to be secure. Experiments have shown that once engaged by the Billboard Manager, a user has only access to the secure portal to which link is established through it.

## VII. CONCLUSION

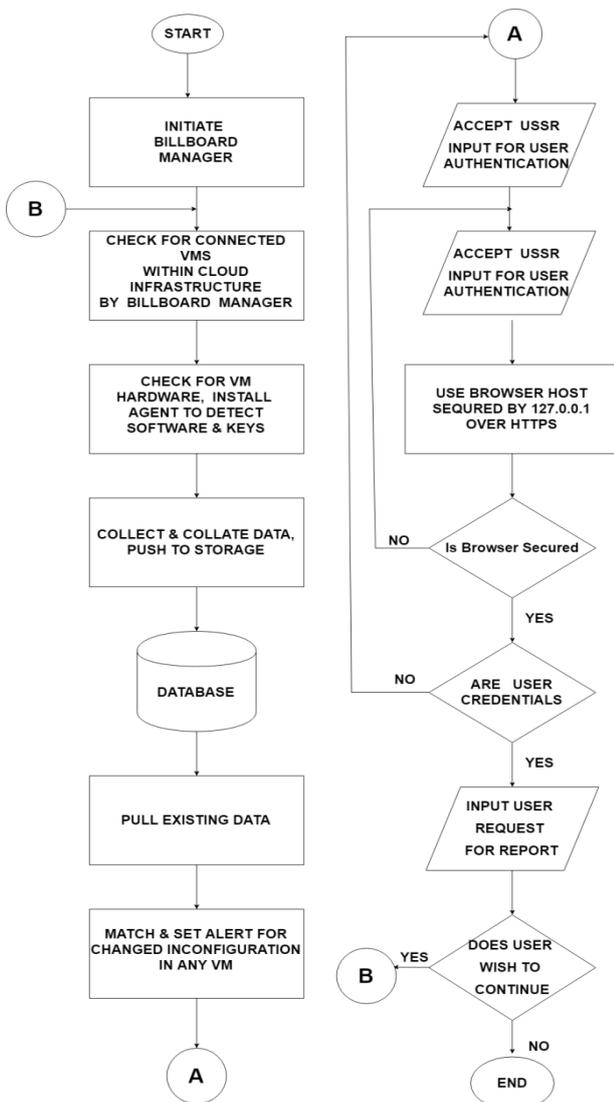
Our proposed SSL-augmented Software License Management System (SASLMS) has the potential to help cloud service providers and their respective consumers take stock of the licenses that are deployed and in use in cloud computing environments. Where legal issues and license compliances are of paramount concern in cloud computing operations, our proposed model can provide a secure and agile form of approach to meet such stringent requirements. Our proposed model not only enables users and auditors to investigate the software license usage at any given point of time, but also allows this activity to be done through a secure channel. The aspect of security can never be over-emphasized in cloud computing environments, and hence, our proposed design holds forth a unique advantage for cloud service providers. While the software license management tool can be based on several established frameworks, future work based on this paper may possibly consider using Java and its associated frameworks to achieve better results. As it stands, the contribution of JavaScript in securing web portals and enabling secure user authentication mechanisms has been researched and documented.

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## REFERENCES

1. N. Gregoy. (2018, May). The Untold Origins of Cloud Computing. *IEEE-CNSV Consultants' Network of Silicon Valley*. Available: <https://californiaconsultants.org/event/the-untold-origins-of-cloud-computing/>
2. D. C. Brock. (2017, August). Someone Else's Computer: The Prehistory of Cloud Computing. *IEEE SPECTRUM Silicon Revolution*. Available: <https://spectrum.ieee.org/tech-history/silicon-revolution/someone-elses-computer-the-prehistory-of-cloud-computing>
3. E. Simmon, and R. Bohn, "An Overview of the NIST Cloud Computing Program and Reference Architecture," *In proc. 19<sup>th</sup> ISPE, Int. Conf. on Concurrent Engineering, 2012*, pp. 1119 – 1129.
4. J. Ellman, N. Lee, and N. Jin, "Cloud computing deployment: a cost-modelling case-study," *Wireless Netw.*, 2018, pp. 1 – 8.
5. S. Roy, R. Bose, and D. Sarddar, "Fuzzy based dynamic load balancing scheme for efficient edge server selection in Cloud-oriented content delivery network using Voronoi diagram," *IEEE Int. Adv. Comp. Conf.* 2015, pp. 1 – 6.
6. S. Roy, R. Bose, and D. Sarddar, "A novel replica placement strategy using binary item – to – item collaborative filtering for efficient voronoi – based cloud – oriented content delivery network," *Int. Conf. on Adv. in Comp. Engg. and App.*, 2015, pp. 1 – 6.
7. R. Buyya, S. N. Srirama, G. Casale, R. Calheiros, Y. Simmhan, B. Varghese, E. Gelenbe, B. Javadi, L. M. Vaquero, M. A. S. Netto, L. M. Vaquero, M. A. S. Netto, A. N. Toosi, M. A. Rodriguez, I. M. Liovente, S. D. C. D. Vimercati, P. Samarati, D. Milojicic, C. Verela, R. Bahsoon, M. D. D. Assuncao, O. Rana, W. Zhou, H. Jin, W. Gentsch, A. Y. Zomaya, H. Shen, "A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade," *ACM Computing Surveys*, vol. 51, no. 5, 2019, pp. 1 – 38.
8. G. Satzger, L. Patricio, M. Zaki, N. Kuhl, and P. Hottum, "Exploring Service Science," *In proc. 9<sup>th</sup> Int. Conf. IESS, 2018*, pp. 1 – 413.



**Fig. 2.**Flowchart of the proposed SSL-augmented Software License Management System (SASLMS).

9. N. Gonzalez, C. Miers, F. Redigolo, M. Simplicio, T. Carvalho, M. Naslund, and M. Pourzandi, "A Quantitative Analysis of Current Security Concerns and Solutions for Cloud Computing," *Journal of Y. Raekow, C. Simmendinger, P. Grabowski, and D. Jenz, "License Management in Grid and Cloud Computing," 2010 Int. Conf. on P2P, Parallel, Grid, Cloud and Internet Computing*, 2010.
10. M. Dalheimer, and P. J. Pfreundt, "GenLM: License Management for Grid and Cloud Computing Environments," *IEEE Computer Society*, 2009, pp. 132–139.
11. A. Ghose, H. Zhu, Q. Yu, A. Delis, Q. Z. Sheng, O. Perrin, J. Wang, Y. Wang, "Service-Oriented Computing," *Int. Workshops ASC DISA, SeMapS, WESOA paper*, 2012.
12. M. K. M. Murty, M. N. Ameen, H. A. Sanjay, and Y. A. Yasser, "Software Licensing Models and Benefits in Cloud Environment: A Survey," In: M.A. Kumar M. A., R. S., Kumar T. (eds.) Proc. of International Conference on Advances in Computing. Advances in Intelligent Systems and Computing, vol. 174, 2013, pp. 645–650.
13. S. K. Shrivastava, P. Kumar and A.N. Pandey, "Impact of Software Licenses in Cloud Computing based E-Governance Initiatives," *In proc. 4<sup>th</sup> Int. Conf. CSNT*, 2014.
14. S. Kiyomoto, A. Rein, Y. Nakano, C. Rudolph, and Y. Miyake, "LMM: A common component for software license management on cloud," *In proc. IEEE Int. Conf. on Security and Cryptography*, 2013.
15. M. McRoberts, "Software Licensing in the Cloud Age," *International Journal of Soft Computing and Software Engineering*, vol. 3, no. 3, 2013, pp. 395 – 402.
16. R. Bose, S. Roy, and D. Sarddar, "User Satisfied Online IaaS Cloud Billing Architecture with the Help of Billboard Manager," *International Journal of Grid Distribution Computing*, vol.8, no. 2, 2015, pp. 61–76.
17. R. Bose, S. Roy, and D. Sarddar, "A Billboard Manager Based Model That Offers Dual Features Supporting Cloud Operating System And Managing Cloud Data Storage," *International Journal of Hybrid Information Technology*, vol. 8, no. 6, 2015, pp. 229 – 236.
18. S. Roy, and D. Sarddar, "The Role of Cloud of Things in Smart Cities," *International Journal of Computer Science and Information Security*, vol. 14, no. 11, 2016, pp. 683 – 698.
19. H. Aissaoui - Mehrez, P. Urien, and G. Pujolle, "Framework implementation based on grid of smart cards to authenticate users and virtual machines," *In Proc. 11<sup>th</sup> Int. Conf. IEEE Security and Cryptography*, 2014, pp. 1–6.

*Cloud Computing: Advances, Systems and Applications 1*, 2012, pp. 1 - 18.



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