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A novel framework for software defined based secure storage systems

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ABSTRACT

The Software Defined Systems (SDSys) paradigm has been introduced recently as a solution to reduce the overhead in the control and management operations of complex computing systems and to maintain a high level of security and protection. The main concept behind this technology is around isolating the data plane from the control plane. Building a Software Defined System in a real life environment is considered an expensive solution and may have a lot of risks. Thus, there is a need to simulate such systems before the real-life implementation and deployment. In this paper we present a novel experimental framework as a virtualized testbed environment for software defined based secure storage systems. Its also covers some related issues for large scale data storage and sharing such as deduplication. This work builds on the Mininet simulator, where its core components, the host, switch and the controller, are customized to build the proposed experimental simulation framework. The developed emulator, will not only support the development and testing of SD-based secure storage solutions, it will also serve as an experimentation tool for researchers and for benchmarking purposes. The developed simulator/emulator could also be used as an educational tool to train students and novice researchers.

1. Introduction

Virtualization has been widely adopted across different sectors following the rapidly increasing adoption of Cloud Computing technology and services due to its advantages over traditional computing provision. One of the most critical issues faced by the system administrators, in Cloud Computing, is the construction and management of systems in a manner that eliminates or hides their complexity from the end users, at the same time, maintains flexibility, dependability, and security of the systems. To achieve these goals, a recent trend is to move towards software to address most of the control and management challenges.

Software Defined Systems (SDSys) is a recent paradigm, proposed to address these challenges by hiding their complexities from the end users. This is achieved by isolating the data plane from the control plane. SDSys technology has grown very

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rapidly to encompass a number of disciplines such as Networking (SDN), Data Centers (SDD), Storage (SDStore). For instance, to address issues in today's complex and heterogeneous networks, Software Defined Network (SDN) was proposed recently and quickly gained popularity in both Academia and the industry [1]. Similarly, several Software Defined Security (SDSec) systems and Software Defined Storage (SDStore) systems appeared to handle the special challenges associated with storage and security. This is different from older concepts such as software deployed systems, where the functionality of the service is deployed on the computer hardware. In the new systems, the APIs and software are used to control and manage the resources and devices enabling the control layer to control all the underling resources regardless of their vendor variations by physically isolating them from the hardware resources in the data layer. The concept of abstraction here is similar to the idea of Object Oriented design, where the implementation is separated from the interface. The reason behind this separation is to simplify the modification process, since any change in the implementation will not affect the interface and vice versa [2].

SDN is meant to simplify the network management by separating the control plane from the data plane, where the data plane used the forwarding tables that were prepared by control plane in the controller to forward the messages, flow-packets [3]. However, in large data storage like data centers that store a huge amount of data and exploit virtualization to expand the system; the data forwarding, processing and management processes occur at the same place, infrastructure assets, which increases the burden on the underling devices and subsequently reduces the system performance. Software Defined Storage (SDStore) was proposed to facilitate and simplify such complexity , and at the same time, maintain an acceptable level of QoS [4]. SDStore takes the responsibility of managing huge data in storage systems by isolating the data control layer from the data storage layer. The control layer refers to the software component that manages and controls the storage resources, whereas the data layer refers to the underling infrastructure of the storage assets [5].

SDSys, as a technology, is still not widely adopted due to some issues causing some concerns among IT enterprise managers, which hinders its spread. One of the major issues is the network security. In addition, it may be inappropriate to follow traditional security mechanisms with the new technology paradigms like SDN and SDStore. For that, the Software Defined Security (SDSec), which is an example of Network Function Virtualization (NFV) has emerged as a new proposal. Similar to SDN, SDSec works and provides a new way to design, deploy and manage the security by separating the forwarding and processing plane from security control plane [6]. Such separation provides a scalable distributed security solution, which virtualizes the security functions but remains manageable as a single logical system [7]. SDSec was proposed as a solution to help secure virtualized environment infrastructures, including virtual network, virtual storage and even virtual servers from different threats whether they are traditional such as intrusion detection and denial of service attacks or specific to virtualized environments such as insider threats [8,9].

Researchers from both academia and the industry are already experimenting and deploying aspects of SDN, SDStore and SDSec systems. However, transferring their ideas into real workable systems is not a simple task. Building such systems without testing and evaluation prototypes in simulation environments is an inefficient approach that is considered costly and risky. Hence, there is an imminent need to have experimental framework capable of mimicking/simulating the workings of such systems in order to evaluate their performance and validate their correctness. Such frameworks already exists for SDN, but not for SDSec or SDStore. The Mininet [10] simulator is considered the most commonly used framework by the SDN researchers due to its simplicity and usability. Hence, we extended the features and functionalities of the Mininet simulator to build our SDStorage [11], SDSecurity [12] SDDC [13] experimental frameworks.

In this work, we endeavor to extend the features and functionalities of the Mininet simulator and integrate our SDStorage and SDSecurity frameworks into one novel framework. The proposed framework can also help in motivating researchers to build an integrated systems that handle the challenges of SDN, SDStore and SDSec, all at the same time [1,6,14]. It will also serve as an experimentation tool for researchers and for benchmarking purposes. The developed simulator could also be used as an educational tool to train students and novice researchers.

The rest of this paper is structured as follows. In Sections 2 and 3, we explain the ideas of SDStore and SDSec, respectively, in details (covering the architecture as well as the benefits and characteristics) while discussing some real SDStore and SDSec systems. After that, a brief introduction about Mininet is given in Section 4. The proposed experimental framework is explained in Section 5 while the results and discussions are presented in Section 6. Finally, we conclude this paper and present our future plans in Section 7.

2. Software Defined Storage (SDStore)

This section provides the necessary background and related work in Software Designed Storage. This sections covers briefly challenges in traditional storage systems, and the motivation for developing Software Defined Storage systems. An illustration for a typical SDStore architecture is also provided with the description of its characteristics. Then exiting SDStore solutions are presented, analyzed and compared.

2.1. Challenges in traditional storage solutions

Building a SDStore solution requires taking into consideration the challenges facing traditional storage solutions. Some of these challenges are discussed in details in [5], which are summarized below:

- Allocation, migration and reliability of data.