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Monitoring Virtual Nodes using mashups

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ABSTRACT

The use of virtualization technologies is one of major trends in computer networks. Up to now, most of monitoring tasks on Virtual Nodes, made up of several system virtualization environments and network virtualization environments, require manual intervention via non-standardized interfaces. Although monitoring based on proprietary command lines and graphical user interfaces may be enough for homogeneous Virtual Nodes, it is certainly not suitable for monitoring, in an integrated way, Virtual Nodes in which, the aforementioned environments use heterogeneous virtualization technologies, both in networks and systems. In this paper, we demonstrate that the mashup technology can be used to carry out the integrated monitoring of heterogeneous Virtual Nodes. In this sense, we present a mashup-based architecture targeted to monitor such type of Virtual Nodes, we introduce a reference implementation of the mashup-based architecture, and we develop on it, three monitoring mashups. The quantitative assessment of these mashups corroborates that they generate low traffic and have short response time. Furthermore, their qualitative assessment reveals that it is feasible to provide flexible and extensible mashups for monitoring Virtual Nodes.

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1. Introduction

Although the research on network virtualization is quite active today [1], little research was found concerning the integrated monitoring of physical and virtual resources that form part of Virtual Nodes. In order to monitor virtual resources of systems and networks, virtualization vendors are primarily providing proprietary and incompatible Command Line Interfaces (CLIs) and Graphical User Interfaces (GUIs). This lack of compatibility and standardization inevitably hinders the work of Virtual Infrastructure Administrators (including both network and system Administrator competences), who are many times forced to employ multiple monitoring tools, which may lead to serious consequences (*e.g.*, erroneous actions and increase of operating costs) for the organizations.

Even though monitoring based on proprietary and non-standardized CLIs and GUIs may be enough to homogeneous Virtual Nodes, it is certainly not suitable for monitoring, in an integrated way, Virtual Nodes formed by different Virtual Management Interfaces (VMIs), System Virtualization Environments (SVEs) [2], and Network Virtualization Environments (NVEs) [3]. For instance, Virtual Infrastructure Administrators are forced to employ multiple tools to monitor a Virtual Node made up of: (i) one or more virtual machines running on Xen, VMware, and VirtualBox (*e.g.*, Citrix XenCenter and VMware vCenter Operations Management Suite); and (ii) several virtual network elements, such as Open vSwitch (*e.g.*, sFlowTrend) and Vyatta Router (*e.g.*, NetFlow Analyzer). This

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multiplicity of tools leads to an overload on the monitoring tasks to be conducted by Virtual Infrastructure Administrators in the Virtual Nodes [4].

In our previous work [5], we analyzed the feasibility of using the mashup technology to manage traditional computer networks. It was observed that mashups are able to integrate information from multiple network resources, such as devices and services. We concluded that mashups enable network Administrators to accomplish very specific tasks (*e.g.*, botnet detection) [6] and to create customized management applications (*e.g.*, displaying the traffic of the border gateway protocol between two autonomous systems) [7]. Notwithstanding all the benefits of using mashups in network management, we have not observed their employment for monitoring the aforementioned Virtual Nodes yet.

In this paper, we extend our previous work in order to provide a mashup-based mechanism able to monitor heterogeneous Virtual Nodes. We argue that the composition model of mashups allows to deal with the heterogeneity, complexity, and stiffness of any VMI, SVE, and NVE. This model enables any Virtual Infrastructure Administrator to adapt, customize, and combine existing monitoring tools in order to improve system and network monitoring tasks on virtualized environments. In addition, the employment of mashups also supports the integrated monitoring of both system and network virtual elements, abstracting all technical details related to the interaction with these elements.

The key contributions of our research are:

- Demonstrate that it is feasible the use of the mashup technology for monitoring, in an integrated way, heterogeneous Virtual Nodes made up of several SVEs, NVEs, and their corresponding VMIs.
- Present a reference implementation of a mashup-based architecture for integrated monitoring of Virtual Nodes in which, the above mentioned environments use heterogeneous virtualization technologies, both in networks and systems.
- Demonstrate that, in realistic scenarios, monitoring mashups – built by using the implemented architecture – are flexible, extensible, do not consume bandwidth intensively, and have short response times.

The remainder of this paper is organized as follows. In Section 2, we present the mashup technology background. In Section 3, we review the related work about the virtual network monitoring. In Section 4, we introduce a mashup-based architecture for integrated monitoring of Virtual Nodes. In Section 5, we present the reference implementation of such an architecture. In Section 6, we describe and discuss the case study raised to evaluate our proposal. In Section 7, we provide some conclusions and implications for future work.

2. Mashups background

Mashups are Web applications created by combining different resources available on the Web [8]. They have been considered a fundamental piece of the Web 2.0, allowing end-users, who are not expert programmers, to create their own customized applications. Furthermore, mashups also encourage reusing pre-existing applications and cooperation among end-users.

Two important things contributed to dissemination of mashup technology usage. First, the number of available services and online APIs has increased, and second, new usability-oriented technologies (*e.g.*, AJAX and Macromedia Flash) allowed the creation of more dynamic applications and sophisticated GUIs [9,10]. Online APIs and usability-oriented technologies are the fundamental basis for supporting mashups creation.

The mashup technology is mainly characterized by a simple composition model, which enables customized applications to be easily and rapidly developed and executed by end-users [11,12]. The use of the mashup technology enables, for example, the integration of information from multiple sources at various levels (*i.e.*, data, presentation, and logic). The process of developing new mashups is conducted by mashup systems, which are also responsible for storing and executing these mashups. Mashup systems employ high-level abstractions in order to hide technical details for end-users. Another important characteristic of mashup systems is to support the reuse and extending of existing compositions for generating more sophisticated applications.

Nowadays, mashups are being used in many and distinct domains [13], ranging from simple weather reports [14] to project [15] and network management [5]. In the network management domain, for example, we have observed in a previous work [5] that network Administrators rely on several incompatible tools to manage their networks. Considering that such tools usually expose their results through Web interfaces, these results can be included as part of more complex management mashups. For example, graphs of the Multi Router Traffic Grapher (MRTG) could be displayed within a Google Maps Web page in order to create a monitoring tool able to display the current network status taking into account the geographical location of network elements. Mashups also enable network Administrators to address punctual needs, such as the exhibition of the border gateway protocol traffic exchanged between two autonomous systems [7], that otherwise would be very costly to resolve.

Despite all the benefits of using mashups in network management, their employment for monitoring virtual environments has not been observed yet. Thus, in this paper, we focus on analyzing the feasibility of using mashups to integrate disparate management information sources in virtualized environments of systems and networks. We highlight that our goal is not to observe how easy the employment of mashups for management is, because the easy-of-use is an intrinsic characteristic [11,12,16] of mashups. In order to define a mashup-based solution for monitoring Virtual Nodes, we review, in the next section, some of most important virtual network monitoring solutions found in the literature.

3. Virtual network monitoring

Although issues such as the heterogeneity, complexity, and stiffness of nodes monitoring on virtual environments

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