Empowering Virtualized Networks with Measurement As a Service (MaaS)

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Context

Network and content providers, enterprises and institutions in the wide sense (schools, administrations) are engaged in a significant reshaping of their IT infrastructure that can take three forms:

- A partial or complete outsourcing of their IT resources. This encompasses scenarios where a subset of the company servers offering legacy services (e.g., authentication, mail, intranet, data) are pushed to the cloud, alleviating the company from the management of hardware resources and focusing on software maintenance. Alternatively, a company might want to benefit from the new possibilities offered by cloud computing like horizontal scaling and virtual CDN for key applications like Web services or data analytics.

- The transformation of their internal data center from a set of physical servers interconnected with switches and routers to private clouds with an integration of computing, data and networking services with platforms like Openstack [1] that enable to manage physical servers, disk resources, create virtual machines and the network interconnecting these VMs.

- The virtualization of their network functions and the substitution of their specialized equipment with commodity hardware piloted by specialized software, to realize different network functions such as routing, forwarding, firewalls and intrusion detection. SDN (Software Defined Network) in general and OpenFlow in particular are the typical examples of such a trend. Network functions then become virtual (i.e. software), referred to as NVF for Network Virtual Function, and can be placed either inside the network or pushed to the cloud as stated before. Network services transform into a matter of chaining these functions together.

These scenarios are characterized by a **tight integration between the networking and software functions that were before physically separated** with physical servers, each hosting one application and physical networking devices (switches and routers complemented with specialized middleboxes like firewalls, NAT or load balancers). **It is largely admitted that such virtualization improves flexibility and lowers deployment and maintenance costs. It increases however the number of**

factors that impact performance and quality of experience as perceived by tenants and end-users. Not only physical equipment becomes generic and off the shelf, but also software starts to play an important role and a complex virtualized layer appears often managed by a different player than the owner of the physical resources. **A commonality then becomes the need to monitor and troubleshoot the performance of such globally virtualized environment both for the service provider and the tenants. This issue constitutes the core of this PhD proposal.** We detail in the next section the challenges of measurements in this new environment, then we cover the specific issues that we want to address.

Challenges

A large body of techniques have been developed for monitoring and troubleshooting legacy IP networks (e.g., [12][13]). However, the development of virtualization comes with unprecedented challenges:

- Specialized hardware is getting replaced by a commodity one over which specialized software runs. Different virtual machines can run on the same physical resource, and mapping of virtual topologies to physical resources can take different forms. Performance perceived by tenants and end users becomes then a complex function of the performance of physical resources, but also of the way the mapping and the chaining of virtual network functions (e.g., a NAT followed by a firewall and coupled with a load balancer) are performed.

- In legacy IP networks, network operators have a global view on the traffic in their network. This gives them the ability to detect and troubleshoot network problems. In virtualized environments, a tenant or an end user has a partial view, the one of its virtual network. This view is unfortunately not enough to troubleshoot performance issues, as it has to be coupled with the view of the owner of the physical resources, who is the only one that knows about the real situation of the underlying infrastructure. For instance, measuring a virtual network does not allow to conclude whether the degradation of a web service is the result of a bandwidth problem, or the saturation of the physical machine hosting it.

- Capturing traffic is extremely difficult in a private and public data centers due to both speed of those networks (10 Gbps or higher) and the diversity of paths that ensures a high bi-sectional bandwidth. It is not an option to mirror all the traffic at one switch. SDN offers rule level statistics, but for obvious scaling issue, a rule is never a single connection between two machines but relates to a path between two hosts or two networks. The reason behind is the limited space offered by SDN switches which is in the order of a few thousands. Some works have investigated the use of sFlow (a packet level capture service that performs sampling) [3] as an alternative to SDN accounting. A more radical approach was proposed in [4] where the authors propose to extend the SDN model with more functionalities in the data path to enable using various sketching techniques that can produce advanced statistics on the fly on traffic. Everflow [5] is proposing a troubleshooting method for data center that mixes passive and active measurement to pinpoint typical data center incidents, e.g., routing loop due to middleboxes, exploration of a variety of path to detect (abnormally) high latency paths, etc.

- The complexity of the path between two machines mixing software or hardware switches and tunneling between them calls for new techniques to troubleshoot performance issues. Especially, it becomes necessary to capture traffic at multiple specific vantage points, to be able to precisely troubleshoot performance problems. The active approach of Everflow [5] might help in this task as it enables marking the application packets to track them along the path from sources to destinations.

PhD objectives

This PhD proposal will focus on the design and deployment of a **MaaS (Measurement as a Service) service for end users and cloud tenants.** The candidate will have to explore ways to measure this new virtualized environment in the most efficient and scalable way. The main idea is to leverage upon the flexibility introduced by virtualization, either via the intelligence of switches, or the virtualization of network functions, to deploy new measurement techniques. These new techniques will be coupled to techniques widely known in legacy IP networks (i.e., traceroutes, delay and bandwidth measurements) to provide the most complete picture on the performance of these new networks and the root causes of any service degradation.

Three use-cases will be particularly considered:

- **Enabling cloud tenants to measure and troubleshoot their own virtual network.** As we focus on a specific tenant, the amount of traffic to be handled is way smaller than when focusing on the complete data center network. We still have to make smart choices concerning the measurement points.

- Empowering end users of services hosted in clouds with techniques and tools allowing them to understand the reality of the service they are getting, and to be able to **decouple performance problems caused by the legacy IP network from those inherent to the cloud service itself**.

- **Enabling the cloud provider to orchestrate the different measurement processes that take place in the different tenant networks sharing the same virtual/physical infrastructure.** Indeed, once MaaS is available for tenants, the cloud provider has to control the amount of resources allocated to those different measurement tasks so as to (i) prevent any overload of the virtual/physical equipment on which measurement is performed, and (ii) allocate resources so as to maximize the efficiency of a measurement task (that can be, for instance, translated as the minimization of the variance of the statistics that is estimated).

Concretely, we will realize the following - see figure 1:

- We will develop an API so as to ease the deployment of MaaS for end users and tenants and let them aware of the ongoing measurement inside the cloud and by the cloud provider.

- Devise orchestration methods to allocate resources efficiently for measurement purposes in a virtualized data center context. The challenge here is to allocate resources in a way to maximize the efficiency of the measurement tasks while not compromising the processing of current operational traffic.

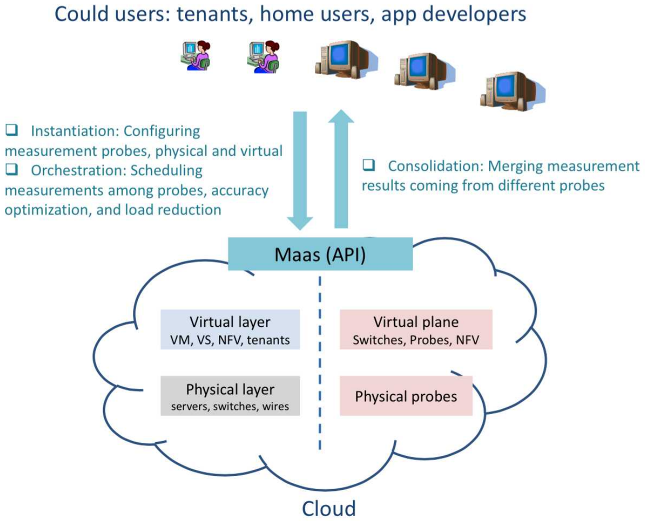

Figure 1: MAAS system overview

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