Research infrastructures for a Cloud-driven future Internet

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Abstract. *The availability of vast commoditized processing and storage technologies together with the success of the Internet has enabled the realization of a computing mode known as Cloud Computing, also touted as the Fifth Utility. Although it is still an evolving paradigm, there is little disagreement in recognizing that the Cloud is here to stay. Consequently, the inter-networking requirements of the Cloud should be regarded as a major driving force shaping the future Internet, i.e., the set of protocols governing the global-scale interaction of computing processes.*

In a recent talk [1], Internet evangelist Vint Cerf has noted that "the Cloud represents a new layer in the Internet architecture and, like the many layers that have been invented before; it is an open opportunity to add functionality to an increasingly global network." Indeed, it can be argued that the emergence of the Cloud is another example of the history repeating itself. We can draw an analogue between Cloud Computing and the time when simple terminals devices (i.e., thin clients) accessed mainframes running applications and hosting users´ data. Also noteworthy, there are three Cloud initiatives that have an analogue in the Internet's past, including (i) the rising importance of academia, (ii) the increasing interest in interoperability among cloud vendors, and (iii) the carrier (infrastructure owner) interest in new service opportunities.

While the transformations of the Cloud in the service area are more-or-less more obvious, the implications of the core networking technologies are less predictable. It has been reported that Cloud computing has contributed to a flatter Internet topology [2] as a consequence of content providers deploying their own wide-area networks, closer to users and bypassing Tier-1 ISPs on many paths. In addition to peering, other profound impacts may include mobile offload for large data volumes from 3G/4G networks or further developments of application content infrastructures [3].

When distributing the Cloud data center footprint closer to the users, network providers are in a good position to leverage their infrastructure and knowledge (e.g., topology, usage patterns) while embracing the Cloud business model. A noteworthy technology enabler to become smart pipes is current industry trend towards open programmable network platforms (e.g., OpenFlow, Cisco IOS, Juniper Junos), aka network operating systems providing true network support for challenging applications, enabling rapid introduction of network innovations, and custom networks for different segments.

While the architecture for Inter-Cloud standards is still very much in its early stages [4] and the market implications are unclear, we may however expect that a global market of cloud resources (e.g., computational, storage, networks) will eventually

emerge. We may speculate that the geo-distribution of data centers may drive the development of a cloud-oriented connectivity market beyond traditional multi-homing.

Driven by the same forces that are leading to an architectural transformation of the data centers, we should expect innovative inter-networking solutions, re-examining cost/control trade-offs and revisiting the incentives for a broader adoption of mature protocols (e.g., VPNs, IPv6, IP Multicast, Secure BGP, DNS Security Extensions), novel routing mechanism (e.g., LISP, energy-aware protocols, or even XML routing) and radical information-centric inter-networking architectures (e.g., CCN, PSIRP).

Future Internet projects need to move from technical reports to running code and large scale prototypes that illuminate the benefits of beyond-IP proposals while devising an incentive-proven migration path is devised. This pragmatic step in future Internet research becomes clear in initiatives like GENI or the EU PPP and the EU new flagship large-scale integrating project called SAIL. As a key step, experimental research infrastructures should be fed by the requirements and opportunities of the Inter-Cloud, exposing the research community to enterprise-level requirements, yielding realistic traces of cloud workloads and all in all foster networking research around cloud computing developments by federating heterogeneous datacenters. By embracing open source developments (e.g., Eucalyptus) and vendor-independent open APIs (e.g., OpenFlow), existing infrastructures can be leveraged setting the path of the next generation of network devices. Remarkable approaches towards those Cloud-driven research infrastructures include OpenCirrus [5] and the GENICloud project, which among other goals aim at providing a federation interface for compute clusters running Eucalyptus open-source software infrastructure.

References

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Biography

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