A first look at public-cloud inter-datacenter network performance

Valerio Persico, Alessio Botta, Antonio Montieri, Antonio Pescapè
University of Napoli “Federico II” (Italy) and NM2 srl (Italy)

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Cloud networks

- Companies more and more leverage cloud solutions to supply services across the Internet
- Top players have made huge investments in networks of datacenters to cope with this increasing demands
- These expensive investments are justified by cloud-traffic trends
- Without high-performance networks, there would be no such thing as cloud computing*

*Mogul2012
Cloud-traffic growth

- Since 2008, most of the Internet traffic has originated or terminated in a datacenter
- Datacenter traffic is expected to continue to dominate Internet traffic
- More than three-quarters of datacenter traffic will be **cloud traffic** by 2018

*Cisco Global Cloud index*
Cloud inter-datacenter networks

• Traffic between datacenters is growing faster than both traffic to end users and traffic within the datacenter

<table>
<thead>
<tr>
<th>Traffic Type</th>
<th>Expected Growth (CAGR 2014–2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-datacenter traffic</td>
<td>24%</td>
</tr>
<tr>
<td>Inter-datacenter traffic</td>
<td>31%</td>
</tr>
<tr>
<td>Cloud-to-user traffic</td>
<td>25%</td>
</tr>
</tbody>
</table>

*Cisco Global Cloud index

• The performance of wide-area networks interconnecting geographically distributed cloud nodes is gaining more and more interest
  – Data shuttling among clouds
  – Data replication across datacenters
  – Novel solutions leveraging the inter-datacenter WANs to support high performance applications in spreading multimedia contents world-wide
Issues for cloud customers

The cloud-to-user interface provides high-level abstraction

**PROS**
- No need for hardware maintenance
- Real-time resource provisioning
- Ubiquitous access to resources
- Resource automatic scaling
- No upfront investments

**CONS**
- Cloud providers rarely expose detailed information about performance
- Poor network provisioning impacts user experience
- Customers have to cope with limited awareness about cloud networking environment
  - Application performance unpredictability
  - Application performance variability

Contribution

- Experimental evaluation of the performance of the inter-datacenter network for the two leading public-cloud providers

- Our work depicts a clear picture of the performance of the inter-datacenter networks
  - (mainly) in terms of **throughput** and **latency**
  - considering the impact of several **configuration factors** under customer control
  - providing **insights into the infrastructure** leveraged by cloud providers
  - analyzing phenomena generated by **traffic management strategies**
Resource setup

• Two global providers dominating the cloud market
  – Amazon + Azure = 40% market share

• Four regions hosting datacenters for both providers
  – Ireland (EU)
  – North Virginia (US)
  – Sao Paulo (SA)
  – Singapore (AP)

We assess the performance of the paths interconnecting these geographically distributed datacenters
The inter-datacenter WAN is assumed to be the bottleneck of the communication due to technological and physical considerations.

*Nuttcp* to inject *synthetic traffic* into the network for measuring the raw TCP and UDP throughput and latency.
Dataset

Measurements performed acting as general customers

Experimentation subjected to provider fees

General information
• Data gathered from Mar. to Nov. 2015
• 300-hour-long traffic generation results
• Repeated 5-minute-long measurement experiments

Details about leveraged resources
• 4 cloud regions
• 12 combinations of the 4 regions
• General purpose eXtra-Large Virtual Machines (VMs)

Dataset freely available at:

http://traffic.comics.unina.it/cloud
Overall view of the performance

Azure infrastructure performs better than Amazon’s in terms of (TCP) throughput

- **Average:**
  - +52%
  - 77.8 Mbps vs. 118.2 Mbps

- **Max:**
  - +65%
  - 284.5 Mbps vs. 171.6 Mbps

- **Min:**
  - 1 Mbps for Amazon
  - 13 Mbps for Azure
Region breakdown

A significant difference of performance can be observed across different regions

- Up to about 80% variation
- Very low variability within a fixed region pair
  - some Azure region pairs show a larger standard deviation
- Same region-pair ranking for the two providers
  - only one exception: i.e., US↔AP vs EU↔AP pair for Azure

UDP Throughput / path capacity

- UDP throughput is significantly higher than TCP
- In some cases UDP inter-datacenter throughput durably reaches the performance figure of attainable within the datacenter
- UDP throughput appears mainly limited by the bottlenecks imposed by providers at source

Lower TCP performance (shown in previous analyses) may depend upon the different number of users
Traffic-management policies

Providers enforce traffic-management policies along the path

- Throughput is not stable over time
  - performance variation within each of the 5-minute-long experiments

- Characterization of the high-to-low throughput transition
  - always happens around 100 seconds
  - in the 80% of the cases 10 GB have been transferred

Performance vs. Cost

Higher costs for the customers do not imply Higher network performance

The size of the VM may have no effect on inter-datacenter network performance

- Smaller VMs reported the same performance in terms of throughput
- VM advertised to have Moderate and High network performance expose the same performance in terms of throughput

Higher networking cost for the customer is related to worse network performance

- Worst performance typically related to AP and SA regions
- Data transfer from AP and SA is subjected to higher costs with respect to EU and US regions
  - Up to 8× for Amazon,
  - and up to 3.2× for Azure
Network latency

Latency is very stable over time

• **CoV values**
  – smaller than 0.1 in all but two of around 70 experiments for Amazon

• **Latency values**
  – are symmetric
  – are smaller than those reported in previous works

Markedly higher latency for Azure for EU↔AP
CloudSurf
a platform to monitor public-cloud networks

– Non-cooperative approaches
  - adoption of the point of view of the general customer
  - no need for access to information restricted to the provider

– Comprehensiveness
  - different providers
  - different use scenarios

– Predictability of experimental costs
  - computation cost
  - network-usage cost

– Results sharing
  - community results repository

– Ease of use
  - on demand measurements
  - no specific monitoring skills needed

– Public availability
  http://traffic.comics.unina.it/cloudsurf

Conclusion

• Cloud inter-datacenter networks are gaining more and more interest

• In this work we have provided an experimental assessment of these network for Amazon and Azure

• Main findings
  – Azure inter-datacenter network performs better than Amazon (+52%, on average) probably because of the smaller number of customers
  – Counterintuitively, higher costs do not imply better network performance
  – Network latency is comparable for the two providers, with the remarkable exception of the path interconnecting AP to EU
  – Traffic engineering policies enforced have been identified and characterized
Questions?

valerio.persico@unina.it
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Performance (a)symmetry

Performance between regions is (typically) symmetric

Some notable exceptions found
• Severe performance degradations lasting for several hours
• Throughput dropping down to values smaller than 5 Mbps for only one direction of the communication

Impact of placement inside a region

- The AZ* does not clearly impact the achievable throughput.
- In a limited number of cases severe performance degradations involving only one AZ
  - throughput dropped down to values smaller than 5 Mbps
  - lasting for several hours

*Availability zone (AZ): isolated locations made available inside a region by Amazon