Evaluating Streaming Strategies for Event Processing across Infrastructure Clouds (joint work)

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Cloud versus Cloud

Custom user environments!
On-demand access!
Elastic computing!
Isolation!
Capital expense -> operational expense!

Too complex: do I need to become a sys admin?

What is the best programming model, what are the tools I need to make effective use of them?

It costs too much! And what if Amazon raises prices?

Performance: especially I/O, especially Big Data!
Cloud Storage Basics

• Ephemeral/Transient Storage
  – Local virtual disk attached to an instance
  – Persists only for the lifetime of an instance
  – Included in the cost of an instance
  – Varying capacity, e.g., 160 GB-48 TB on AWS

• Persistent attached storage
  – Block storage volumes that can be attached to an instance
  – Lifetime independent of a particular instance, can be mounted by many
  – Price based on space and time used
  – E.g., AWS Elastic Block Storage (EBS), Azure drives

• Storage Clouds
  – Data storage as binary objects (BLOBs)
  – Price differs based levels of service, e.g., access time or reliability, space used and time
  – E.g., AWS Simple Storage Service (S3), AWS Glacier, Azure BLOBs, Google Cloud Storage
Streaming Applications

• Repeatedly apply an operation to a stream of data (time events)

• Examples:
  – Virtual Observatories: OOI, Forest project at ANL, IFC
  – Experiment processing: STAR, APS

• Requirements:
  – An “always-on” service
  – Real-time event-based data stream processing capabilities
  – Highly volatile need for data distribution and processing
Data analysis searches in a channel where the Higgs decays into t-anti-t quarks
Collected as successive time events, each event corresponding to the aggregated readings from the ATLAS sensors at a given moment
Size: ~10s of PBs
Streaming Scenarios

VM
Stream Processing Application
VM
Stream Processing Application
VM
Stream Processing Application

Stream & Compute

Cloud Data Center

VM
Stream Processing Application

Copy & Compute

VM
Stream Processing Application
VM
Stream Processing Application
VM
Stream Processing Application

Cloud Data Center
VM Data Node

Stream Source

Persistent Attached Storage
Streaming Scenarios (2)

Stream&Compute (SC)
- Simpler model with fewer moving parts
- Potentially better response time
- Overlap computation and communication (potentially faster)
- Uses ephemeral storage (potentially cheaper)

Copy&Compute (CC)
- Independent of network saturation
- Persistent storage: less liable to data loss
Experimental Configuration

- **Compute rate**: events processed per time unit
- **Data rate**: amount of data acquired per time unit
SC versus CC (FutureGrid)

CC outperforms SC by almost 4 times in both compute rates and data rates!
SC versus CC (Azure)

Why?

Average Compute Rate per VM

Average Data Rate per VM
Data Throughput vs CPU Load

Small

Medium

Large

12/1/13

www.nimbusproject.org
Multi-Core and Stream&Compute

What is the impact of increasing the number of cores in instances on Stream&Compute?

![Graphs showing the impact of increasing cores on Stream&Compute](chart.png)
Scalability for Stream&Compute

**Average Compute Rate per VM**

- Events/sec vs VMs

**Average data Rate per VM**

- MB/sec vs VMs

Legend:
- Stream remote - 1 data source
- Stream local - 1 data source
- Stream local - 2 data source
Scaling Data Sources

Average Compute Rate per VM

Average Data Rate per VM

Number of data sources
Cost

\[
Total_{Cost} = \frac{Total_{Events}}{CompRate_{Total}} \times (N_{VMS_{Data}} + N_{VMS_{Comp}}) \times VM_{Cost} + Storage_{Cost}
\]

- Cost of instance: \(~$0.1\) per hour
- Cost of storage: \(~$0.1\) per 1GB month
- In our case (320M events & 5 GB attached storage)
  - Stream&Compute: $1.33
  - Copy&Compute: $0.48
  - Overall: SC is 2.77 times more expensive
Related Work

• Data management strategies for large unstructured sets of static data – we focus on dynamic time events
  – I/O Performance of Virtualized Cloud Environments, Ghoshal et al., DataCloud-SC ’11
  – A Survey of Large Scale Data Management Approaches in Cloud Environments, S. Sakr et al. IEEE Communications Surveys and Tutorials

• Performance evaluations about data analysis in the clouds focus on the MapReduce processing paradigm - we focus on the stream processing model
  – Evaluating Hadoop for Data-Intensive Scientific Operations. Z. Fadika et al. CLOUD ’12

• Stream processing studies – we focus on multi-site processing
  – GeoStreaming in Cloud, S. J. Kazemitabar et al. 2011
  – Scheduling processing of real-time data streams on heterogeneous multi-GPU systems, U. Verner et al., SYSTOR ’12
Conclusions

• To stream or not to stream?
  – Not to stream!
  – Difference of ~4x in performance and ~3x in cost

• Amplification of virtualization performance trade-offs in the presence of remote traffic

• Hypervisor design
  – Need for controlled allocation of CPU to I/O processing

• Paper: Tudoran et al., “Evaluating Streaming Strategies for Event Processing across Infrastructure Clouds”, submitted to CCGrid