Elastic NoSQL databases over the Cloud

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Big Data

• ‘Moore's’ Law: Data doubles every 18 months
• 90% of today’s data was created in the last 2 years
  – Facebook: 20TB/day compressed
  – CERN/LHC: 40TB/day (15PB/year)
  – NYSE: 1TB/day
• Many more
  – Web logs, financial transactions, medical records, etc
Data Growth

1 EB ($10^{18}$) = 1000 PB ($10^{15}$)
Last year (2010) US mobile data traffic

0.8 ZB (Zettabyte) = 800 EB
Entire global mass of digital data in 2009 according to IDC

35 ZB ($10^{21}$)
IDC’s forecast for all digital data in 2020
Cloud Computing

• Resource provisioning “as a service”
  – CPUs, Disks, networks, developing platforms, applications, etc
  – Virtualized resources from distant data centers

• Charging model
  – “Pay as you go” model
  – OPEX instead of CAPEX

• Management model
  – Elasticity
  – Easy resource manipulation according to application needs

• Enterprise driven
  – Amazon, Google, IBM, Microsoft, etc
Motivation – the story(1)

- ‘Big-data’ processing era
  - (Web) analytics, science, social, business
  - Store + analyze everything
- Distributed, high-performance processing
  - From P2P to Grid computing
  - And now to the clouds...
- Traditional databases not up to the task
  - NoSQL databases
Motivation – the story (2)

- NoSQL
  - Non-relational
  - Horizontal scalable
  - Distributed
  - Open source
  - And often:
    - schema-free, easily replicated, simple API, eventually consistent (not ACID), big-data-friendly, etc
  - Many, many, implementations...
    - Google’s BigTable, Facebook’s Cassandra, LinkedIn’s Voldemort, MongoDB,
NoSQLs + elasticity

- Column family
  - Hbase, Cassandra, ...
- Document store
  - CouchDB, mongoDB, ...
- Key-Value store
  - Riak, Dynamo, Voldemort, ...
- Many offer **elasticity+sharding**:
  - Expand/contract resources according to demand
  - Pay-as-you-go, robustness, performance
  - Shared-nothing architecture allows that
  - Important! See recent foursquare and netflix outage
- Isn’t that what PaaS offers?
thus...(end of the story)

• PaaS and NoSQLs are (or should be) inherently elastic

• How efficiently do they implement elasticity?
  – NoSQLs over an IaaS platform
    • (EC2, Eucalyptus, OpenStack)
  – No study that registers qualitative + quantitative results

• Related
  – Report NoSQL performance (not elasticity)
  – Cloud platform elasticity (no NoSQL)
  – Domain-specific
Contribution (1)

- VM-based framework for NoSQL cluster monitoring
- For a cluster resize, identify and measure
  - Cost, gains
  - In terms of:
    - Time, effort, increase in throughput, latency, ...?
- Ultimate goal: Provide a generic platform
  - any NoSQL engine
  - User-defined policies
  - Automatic resource provisioning
- Example towards this goal
  - Tiramola
Contribution (2)

• Coding + infrastructure
  – 2K lines open source python code (GFOSS + google code)
  – [http://tiramola.googlecode.com](http://tiramola.googlecode.com)
• Using cloud-based client tools, platform-agnostic
  – EucaTools guarantee execution in numerous cloud platforms
• Cassandra, Hbase and Riak implementation
  – almost Voldemort
• How-to, best practices, glitches, erroneous assumptions, ...
Framework architecture

- **Rebalancing**
  - Get fresh metrics
- **Command Issuing**
  - Balance data
  - NoSQL Cluster resize
  - Hardware resize
- **Monitoring**
  - Collect performance metrics
- **Cluster Coordinator**
  - Manage NoSQL nodes
- **Cloud Management**
  - Adjust resources
  - Add/delete VMs

**Virtual NoSQL Cluster**

**Cloud Provider**

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Architectural considerations

- **Robustness**
  - Daemon process that checkpoints and can be restarted
  - State is provided from the IaaS Cloud and the Monitoring module.
  - Applicable timeouts (not realtime systems!)

- **Modularity**
  - Different interchangeable components
  - APIs that utilize primitives (NoSQL and Policies)

- **Expandability**

- **Speed**

- **Written in Python**
Platform Setup

• 16 physical nodes
  – 2xQuadCore E5520 Intel Xeon® Hyperthreading (@2.27Ghz)
  – 48GB RAM, 2 SAS – RAID 1

• Virtual Machines
  – Similar to an Amazon EC2 large instance
  – 4-core processor, 8GB RAM, 50GB disk space
  – QCOW image: 1.6GB compressed, 4.3GB uncompressed
    • Available for download from googlecode
  – VM root fs instead of EBS (Netflix outage)

• Cluster
  – Eucalyptus 2.0.0 with dedicated Cloud/cluster controller
Experiments overview

• Identify which DB metrics are affected under various loads
  – Consider both server-side and client-side metrics

• Identify costs + gain for a cluster resize
  – Cost of adding/removing nodes
  – Gains of increasing cluster size (how many nodes?)

• Check automated cluster resize
  – Using Hbase
Cluster Resize Time considerations

• VM initialization
  – 3min for addition, negligible for removal (few secs)

• Node configuration
  – Config files and propagation (at most 30 sec cycle)

• Region rebalance
  – Actively participate in the NoSQL cluster
  – Cassandra more efficient, Hbase depends on data, #nodes,...

• Data rebalance
  – Optional
  – Hbase: data / cluster-size dependent (+2h)
  – Cassandra: individual loadbalance signals
Conclusions – best practices (1)

• Choose the right DB for your application/workload (when in doubt, go with the one you’re familiar with)
• HBase is a better all-rounder; Cassandra is handicapped by slow read performance and absence of shared FS.
Conclusions – best practices (2)

• **TIRAMOLA** is robust and in principle can be expanded for any kind of NoSQL DB or application by writing ~100 lines in Python.

• Building PaaS over IaaS is critical for the Cloud – most users won’t have the knowledge, inclination, time or money to do it themselves, but need PaaS tools (in our example, elastic NoSQL databases).
Questions