Fermilab

Comparison of the Frontier Distributed Database Caching System with NoSQL Databases

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Outline

- Common characteristics of NoSQL databases
- The Slashdot Effect
- Frontier Distributed Database Caching system characteristics
- CMS Frontier/Squid deployment examples
- Comparison of Frontier to NoSQL in general
- Comparisons to MongoDB, CouchDB, Hadoop HBase, and Cassandra
- Conclusions

The Slashdot Effect

- Slashdot Effect (or, slashdotting): when a too-small server is overwhelmed by the same request from too many clients
  - Named for slashdot.org, a very popular “News for Nerds” website that often hyperlinks to less-popular sites
- For web servers, usual solution is to use a Content Delivery Network (CDN) that either replicates or caches the objects around the world
- Some database applications have similar need

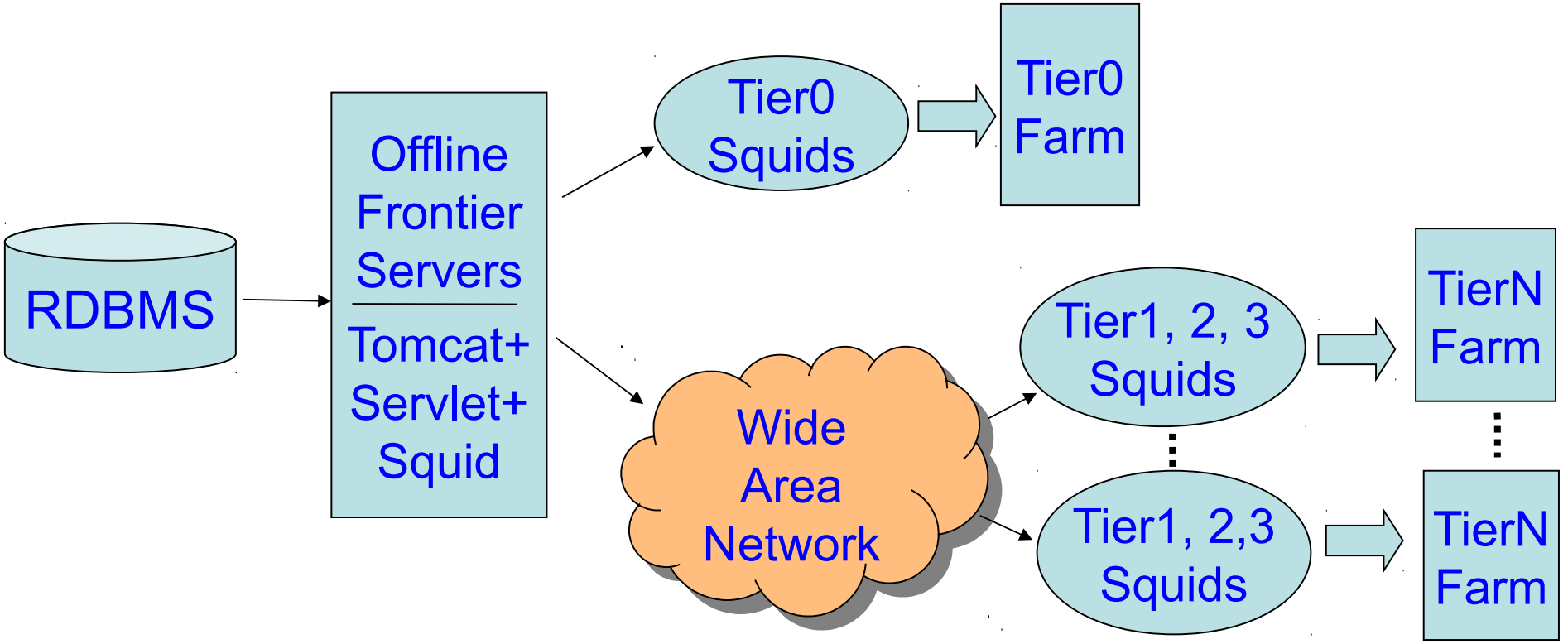
NoSQL common characteristics

- "NoSQL" denotes a large variety of Database Management Systems (DBMS)
- Primary unifying characteristic: not a Relational Database Management System (RDBMS)
  - Generally nested key/value instead of row/column
    - Run-time flexibility, doesn't need pre-defined schemas
  - Most don't support the RDBMS standard Structured Query Language SQL
- Most popular NoSQL DBs support being distributed and fault-tolerant – highly scalable on commodity HW
- Most give up atomicity of updates (ACID) and instead have eventual consistency (BASE)

Frontier characteristics

- The Frontier Distributed Database Caching System is designed for the Slashdot Effect – many readers of same data, few writers
  - Distributes RDBMS SQL queries (not “NoSQL”)
  - RESTful, so cacheable with standard web proxy caches (we use Squid)
  - Web caches on client premises make ideal CDN
    - Most network traffic on LAN, scalable as needed
    - Practically maintenance-free
  - Simultaneous same requests collapsed to one
  - Simultaneous different requests queued at server

CMS Offline Frontier/Squid Conditions deployment



- Only custom software is Frontier servlet in Tomcat and frontier_client in application on worker node farms
- Planning to replicate RDBMS & Frontier servers for availability

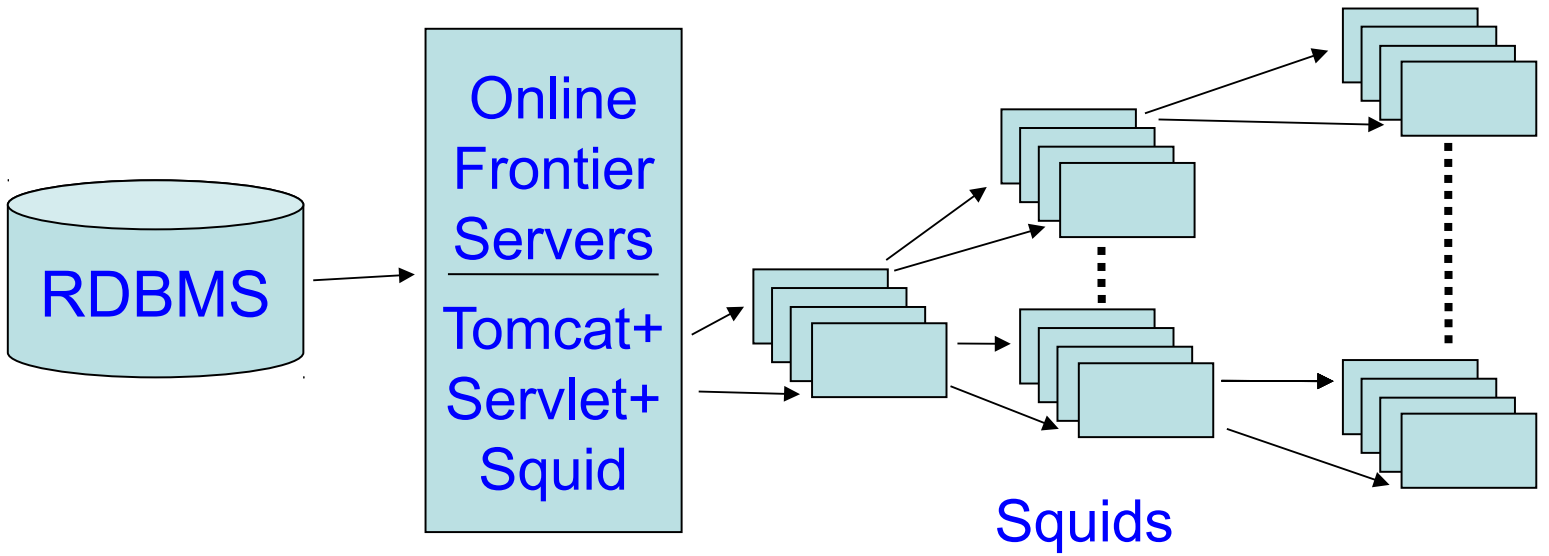
CMS Offline Frontier/Squid Conditions stats

- For Tier 0, 1, & 2 (not counting Tier 3):
  - Average 250 job starts per minute worldwide
  - Average 500,000 total Frontier requests per minute, aggregate average total 500MB/s
    - Bursts at sites are much higher than average
- The 3 central server Squids at CERN only get 4,000 average requests per minute, 0.5MB/s
  - Factor of 125 improvement on requests and 1000 on bandwidth (not counting Tier 3)
- Vast majority of jobs read very quickly because results already cached & valid in local Squids

Squid & Frontier limits

- Frontier tomcat server
  - 3-year old 8-core machine (Xeon L5420 @ 2.5Ghz):
    - Without compression, easily saturates 1Gbit network out
    - With gzip compression, drops to 25MB/s out (but saves much bandwidth later in the caches)
    - Adds 1/3rd overhead before gzip to avoid binary data
- Squid
  - 2-year old machine (Xeon E5430 @ 2.66Ghz):
    - Saturates 2Gbit network with one single-thread Squid
  - modern machine (AMD Opteron 6140):
    - Up to 7Gbps on 10Gbit network with a single-thread Squid
    - Can get full throughput with two Squids on same port

CMS Online Frontier/Squid Conditions deployment



- Squid placement is very flexible for more bandwidth
  - Hierarchy of Squids on every worker node
  - Blasts data to all 1400 nodes in parallel

Frontier vs. NoSQL in general

	Frontier	NoSQL in general
DB structure	Row/column	Nested key/value
Consistency	Eventual	Eventual
Write model	Central writing	Distributed writing
Read model	Many readers same data	Read many different data
Data model	Central data, cache on demand	Distributed data, copies
Distributed elements	General purpose	Special purpose

MongoDB

- “Mongo” for “humongous” - for big, cheap data
- Stores binary JSON (JavaScript Object Notation) data
- Any field can be memory-indexed for performance
  - Common in RDBMS, not common in NoSQL
- Flexible queries
  - By fields, ranges, and regular expressions
  - Similar to RDBMS, not common in NoSQL
- Only one write server per data item
  - Copies are read-only, can take over as master if master goes down

MongoDB cont'd

- Scales by sharding, splitting writing of different data to different servers
  - Not great at Slashdot effect
- Used by CMS for Data Aggregation Service (DAS)
  - Needed the dynamic structure, liked other features
  - Not a big installation though, only one server
- Supports MapReduce for distributing query processing to where the data is
  - An ATLAS evaluation showed this didn't work well but it is supposed to be better now in version 2.0

CouchDB

- Stores JSON
- RESTful interface
  - Can use http proxy caches where needed
  - Also easy to insert authentication proxy
- Automated, low-maintenance replication
- All copies get all data, all can read and write
- Uses MultiVersion Concurrency Control (MVCC)
  - Feature of RDBMS – transactions, ACID
  - Readers get consistent view
  - Writing doesn't block reading
  - Write conflicts automatically detected and aborted

CouchDB cont'd

- Supports MapReduce
- Used by CMS for some data and workflow management queues, job state machine
  - CouchDB data replicated between CERN and Fermilab, 3 replicas at CERN and 4 at Fermilab

Hadoop HBase

- HBase is built on Hadoop Distributed FileSystem
  - HDFS automatically distributes files and replicates them across a cluster
  - Very reliable and automated for large amount of data
- Modeled after Google's BigTable
  - Billions of rows with millions of columns
  - Good for search engine-like applications
- Very good at MapReduce
- Good for big installations, not small

HBase cont'd

- Tunable replication level
- Also has SQL interface via Hive add-on
- Used by ATLAS distributed data manager for log analysis and accounting on a 12-node cluster
  - 8 to 20 times faster than Oracle for accounting summary, depending on replication level
- HBase recognized by the WLCG Database Technical Evolution Group as having greatest potential impact of all the NoSQL technologies
- CERN IT is setting up a cluster

Cassandra

- Like HBase, modeled after Google BigTable
- All nodes are masters, decentralized control for geographically distributed fault tolerance
  - Dynamic re-configuration with no downtime
- Keys and values can be any arbitrary data
- Has static “column families” used like indexes in RDBMS
- Tunable consistency from always consistent to eventual consistency
- Tunable replication level

Cassandra cont'd

- Originally written by Facebook, but they abandoned it in favor of HBase
- Used in production by ATLAS PanDA monitoring system
  - Hosted on 3 high-power nodes at BNL, 12 hyperthreaded cores each, 1TB of RAID0 SSDs each

Conclusions

- NoSQL databases have a wide variety of characteristics, including scalability
- Frontier+Squid easily & efficiently add scalability to Relational databases when there are many readers of the same data
  - Also enables clients to be geographically distant
- CouchDB with REST can have same scalability
- Hadoop HBase has most potential for big apps
- There are good applications in HEP for many different Database Management Systems