The Native NDB Engine for Memcached

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Program Agenda

- MySQL Cluster Today
- A little bit about memcached
- Design Decisions
- Configuration
- Performance
- Links
- Demo
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MySQL Cluster Today
The Basics

API Nodes

Node Group 1

Node Group 2

NDB Data Nodes
The Basics – Data Storage

- High Read and Write Performance
  - Automatic data partitioning, multi-master, parallel execution
- High Availability
- Fast Failover
  - sub-second fault detection and reconfiguration
- Scalable
  - Using commodity hardware

NDB Data Nodes

Node Group 1

Node Group 2
The Basics – Data Access

API Nodes

- High throughput
  - tens-to-hundreds of thousands of transactions per second
- Low latency
  - sub-millisecond response
- Multiple Access Methods
  - SQL and NoSQL
Recent History

• Cluster 6.3 (2008)
  – multi-master replication, key-distribution awareness

• Cluster 7.0 (2009)
  – Multi-threaded NDB nodes
  – Ability to add nodes online to a running cluster

• Cluster 7.1 (2010)
  – ClusterJ
  – MySQL Cluster Manager
  – ndbinfo (and then MEM support for Cluster)
  – Windows support

• Plus
  – Extensive improvements to BLOB performance, locking behavior, node restart times, etc. in monthly releases
ClusterJ Example

```java
Employee findEmployee(long id) {
    Employee employee = session.find(Employee.class, id);
    return employee;
}
```

- Runs faster than JDBC
- Almost as fast as the C++ NDB API
- 3 lines of code
MySQL Cluster 7.2 Beta

• Push-Down Joins
  – Many “SPJ” (Select/Project/Join) operations can be executed at the data nodes rather than the MySQL server
  – Long-term effort (presented at this conference last year)
  – 50x improvement for some queries
• MySQL privilege tables can be stored in cluster
• Memcache API
About memcache

• It’s a cache!
• It’s not your data store!
• If it fails, you get a cache miss!
Two levels of hashing

httpd

PHP/Perl

Memcache

hash key to pick server

friends:12389
memcache Key

memcached

hash key to find data

memcached
Cache hit

httpd

PHP/Perl

Memcache

friends:12389

memcached

hash key to pick server

hash key to find data

VALUE friends:12389 0 31\r\n101, 11009, 11150, 55881, 77798 \r\n
Cache miss (1): fetch from DB

httpd
PHP/Perl
Memcache
mysql

default
memcached
hash key
hash key to find data

MySQL Slave
SELECT friend_id
FROM user_friends
WHERE user_id = ?

hash key to pick server
NOT FOUND
Cache miss (2): manage cache

httpd

PHP/Perl

Memcache

memcached

| set friends:12389 31 |
| 101, 11009, 11150, 55881, 77798 |
Data change (1): Write to DB

INSERT INTO user_friends
(user_id, friend_id)
VALUES (12389, 999101);
Data change (2): manage cache

- httpd
- PHP/Perl
- mysql
- MySQL Master
- memcached

DELETE friends:12389 \r \n
Expected Latency & Throughput

httpd

PHP/Perl

memcache

memcached

10,000s of operations/sec.
~ 200 µs round trip

mysql

MySQL Slave

1,000s of operations/sec.
~ 2 ms round trip
Cost per $n$ active users

- **httpd**
- **PHP/Perl**
- **memcache**
- **mysql**

$1

$10
A little bit more history

- Memcached 1.2 (2007)
  - The 2000-line Facebook patch
    - UDP support
    - Vector I/O and other “details”
      - adding up to 25% improved CPU efficiency
  - Multithreaded (for a small number of libevent threads)
  - Compare-And-Set operation (CAS)

- Memcached 1.4 (2009):
  - Binary Protocol
  - SASL Authentication

- Memcached 1.6 (upcoming)
  - Storage Engines
  - Logging modules
  - Windows platform support
Design Decisions
Goals

• Access NDB data from memcache clients

  – Memcached perspective:
    • NDB is a reliable, write-scalable, replicated data store

  – MySQL Cluster perspective:
    • memcache is an easy-to-use high performance API
Goals

• Support existing schemas and all MySQL data types

• Cache NDB data inside memcached
  – with automatic cache management
  – and flexibility to fine-tune (or disable) the cache policies

• Support the whole memcache protocol

• Achieve superior performance
  – *latency* as expected from memcached
  – *throughput* as expected from memcached
## Which codebase?

<table>
<thead>
<tr>
<th></th>
<th>memcached.org</th>
<th>libmemcached</th>
<th>build our own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Text Protocol</strong></td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td><strong>Binary Protocol</strong></td>
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<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>TCP</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td><strong>UDP</strong></td>
<td>✔️</td>
<td></td>
<td></td>
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<tr>
<td><strong>Authentication</strong></td>
<td>✔️</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>
Server Architecture

- Memcached separate from ndbd
  - Definitely!
  - “m:n” ratio of memcache servers to data nodes

- Memcached inside ndbd
  - Maybe!
  - we know how to do it
    - “embedded” API-to-TC channel
    - lower latency
      - network round trip + tens of microseconds
  - Not as flexible
Decisions

- Use memcached 1.6 tree
- Isolate the NDB-specific code into an *ndb_engine*
  - which currently exists outside the memcached source tree
  - and runs in an unmodified memcached server
- Build a standalone server binary
- Possibly also build an *ndbmttd-embedded* server
- Share code with InnoDB Memcache team
  - on basic configuration and user-visible concepts
  - and on changes that would allow a memcache server module to be loaded into either ndbmttd or mysqld
Other decisions

- Memcache INCR & DECR
  - Fully supported
  - Atomic operations
  - Performed at the data node

- Memcache CAS (version id check)
  - Fully Supported
    - either at local cache or at database
  - CAS check is pushed down to the data node
  - Ideally an update that comes from a non-memcache API node should invalidate the CAS
    - *we still need to decide the best design for this*
Limitations

• The size of stored values is limited to the NDB row size
  – currently just less than 8 KB
  – vs. 1 MB typical limit for memcached
  – due to the lack of BLOB support in the async NDB API
Configuring It
What’s Configurable

- Does it use local cache?
- Does it use NDB?
- What columns hold the keys?
- What columns hold the data?
- Are memcache commands like DELETE and FLUSH allowed to delete records from the database?
- You decide all of this ...
- on a “per-key-prefix” basis.
A Key Prefix

user:1248

the prefix

the database key
Fundamentals

- memcached command line specifies a connectstring for a primary cluster
- primary = “where the config is stored”
- The NDB Engine reads the configuration tables from the ndbmemcache database on the primary cluster
- You, the administrator, manage the config via SQL
- An NDB Memcache server can operate on data in the primary cluster or in other clusters
- Different NDB Memcache servers can fetch different configurations
Standard Tables in *ndbmemcache*

- **meta**
  - stores configuration schema version (for upgrade compatibility); consider it to be read-only
- **ndb_clusters**
- **containers**
  - where data is stored
- **cache_policies**
  - how it can be accessed
- **key_prefixes**
- **memcache_server_roles**
- **last_memcached_signon**
- **demo_table**
ndb_clusters

- **cluster_id**
  - int, referenced by key_prefixes
- **ndb_connectstring**
  - varchar(128) – how to reach this cluster
- **microsec_rtt**
  - default 250; used for internal performance tuning
containers

- **name**
- **schema_name**
- **table_name** (the existing table where your data lives)
- **key_columns** (comma-separated)
- **value_columns** (comma-separated)
- **flags** (either a constant number, or a column name)
- **increment_column** (optional, for INCR/DECR)
- **cas_column** (optional)
- **expire_time_column** (optional)
cache_policies

- **policy_name**
- **get_policy**
  - enum (cache_only, ndb_only, caching, disabled)
- **set_policy**
  - enum (cache_only, ndb_only, caching, disabled)
- **delete_policy**
  - enum (cache_only, ndb_only, caching, disabled)
- **flush_from_db**
  - enum(false, true)
A key-prefix mapping

Memcache key prefix → Cluster → Container → Cache Policy
A memcache server role
key_prefixes

- server_role_id
- key_prefix
- cluster_id
- policy
- container
demo_table

- Not really part of the configuration ...

- mkey
  - varchar(250) NOT NULL PRIMARY KEY

- math_value
  - bigint unsigned

- cas_value
  - bigint unsigned

- string_value
  - varchar(7500)
Performance
Measured Latency

memcachetest -t 2 -M 7000 -c 25000

<table>
<thead>
<tr>
<th></th>
<th>ICMP ping</th>
<th>Memcached Default Engine</th>
<th>NDB 1-Node Cluster</th>
<th>NDB 2-Node Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read avg.</td>
<td>98</td>
<td>184</td>
<td>351</td>
<td>374</td>
</tr>
<tr>
<td>Write 95th</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write avg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write min.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

μsec
Links

• This Presentation

• Memcached 1.6 development tree
  – git clone git://github.com/memcached/memcached
  – cd memcached
  – git checkout -t origin/engine-pu

• MySQL Cluster 7.2 with Memcached Engine
  – bzr clone lp:~mysql/mysql-server/mysql-cluster-7.2-labs-memcached
  – or look for it at labs.mysql.com

• Mailing List
  – cluster@lists.mysql.com
Demo

• What we’ll see:
  – Memcache Server Window
    • start memcached “sandbox”
      – default role (NDB-only)
      – mc-only role (plain memcached)
      – ndb-caching role (NDB with local cache)
  – Client Window
    • run memcapable
  – MyQSL Window
    • examine data and configuration