# 東京キャビネット 京都キャビネット
# Tokyo Cabinet Kyoto Cabinet

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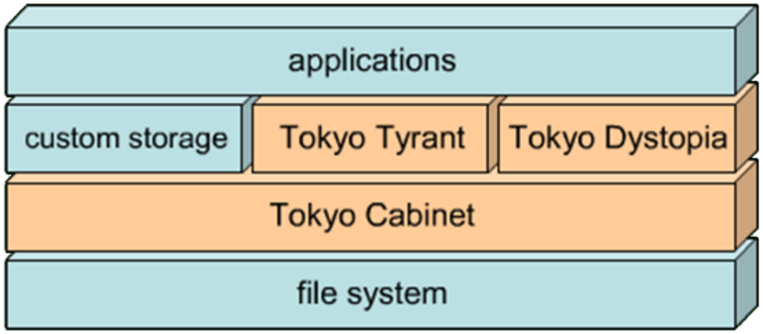
# Tokyo Cabinet

# Tokyo Family

- Tokyo Cabinet
  - Core DB library
- Tokyo Tyrant
  - Network accessible
- Tokyo Dystopia
  - Full Text Indexing/ Search
- Tokyo Promenade
  - CMS



# Tokyo Cabinet

- Modern implementation of DBM
  - e.g., NDBM, GDBM, TDBM, CDB, Berkeley DB, QDBM
- Library for managing key/value-type store
- High performance, efficient use of space
- C99 and POSIX compatible
- 64-bit architecture support
- Database size limit is 8EB
- LGPL

# The High Points

- Multiple data storage options
  - Hash tables, B+-tree tables, fixed-length arrays
- Offers breadth of functionality
- Interfaces for several languages
  - Ruby, Java, Lua, and Perl

# History

mixi ミクシィ mixi, Inc.
お問い合わせ
TOP
会社情報
広報情報
IR情報
採用情報
より健全なSNSを目指して
mixiがユーザーの皆さまにとって居心地のよいサービスであり続けるために
詳細はこちら
広報情報 Press Information
プレスリリースなどメディア向けの情報を掲載しています
IR情報 IR Information
IRニュース・スケジュール・資料など各種IR情報を掲載しています
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過去の一覧 RSS
PRESS ソーシャルアプリケーション「mixiアプリ」提供開始 ―本日より先行リリースとしてPC版の提供を開始―
IR ソーシャルアプリケーション「mixiアプリ」提供開始
2009年08月20日 PRESS 女の子のためのコミュニティ「SWEET BLACK」にて、杏さん主演のケータイドラマ配信決定！ ―SWEET BLACK作品集発売記念ユーザーイベントも開催―
2009年08月13日 IR 2010年3月期 第１四半期報告書
2009年08月10日 PRESS Yahoo!ツールバーやgooスティックでmixiの情報をチェックしよう！
mixi ソーシャル・ネットワーキング サービス「mixi」
Find Job! Webな人の転職サイト「Find Job !」
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技術情報をお伝えするエンジニアブログ


# History

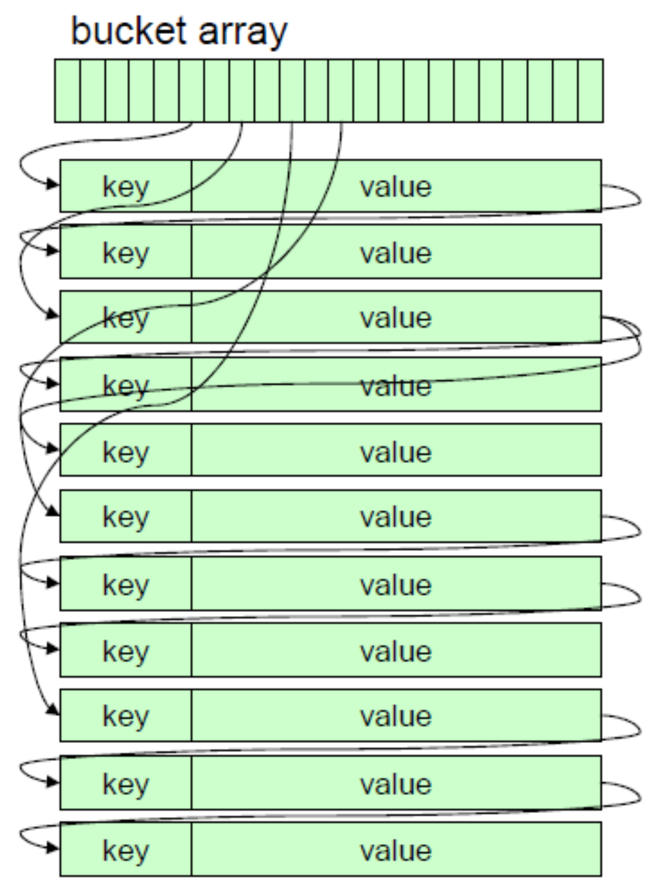
- 2001: Development of Estraier using GDBM
- 2003: Development of QDBM, applied to Estraier
- 2004: Development of Hyper Estraier
- 2006: Joins Mixi.jp, production run of Hyper Estraier
- 2007: Tokyo Cabinet development
- 2008: Tokyo Tyrant and Tokyo Distopia development
- 2010: Leaves Mixi.jp, founds FAL Labs
  - Releases Kyoto Cabinet

# Features

- High concurrency
  - Multi-thread safe
  - read/write locking by records
- High scalability
  - Hash and B+-tree structures = O(1) and O(log *n*)
- Transactions
  - Write ahead logging and shadow paging
  - ACID properties (atomicity and durability)
- Various APIs
  - On-memory list/hash/tree
  - File hash/B+ tree/array/table

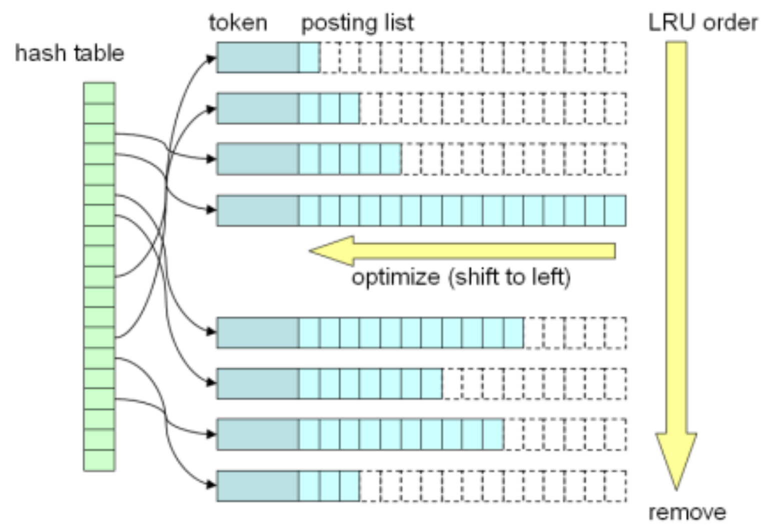
# Data Storage Options – Hash Table

- Standard hash semantics
- Permits insert/lookup/delete and traversal of keys
- Unordered
- Fast operations
- O(1) for retrieval, store and deletion
- Collision managed by separate chaining



# Hash Table - Optimizations

- Chains are built from binary search trees
- Bucket array is mmap'ed
- Three modes for store:
  - Insert
  - Replace
  - Concatenate
- How to deal with fragmentation
  - Padding
  - Free block pool



# Hash Table – Typical Use Cases

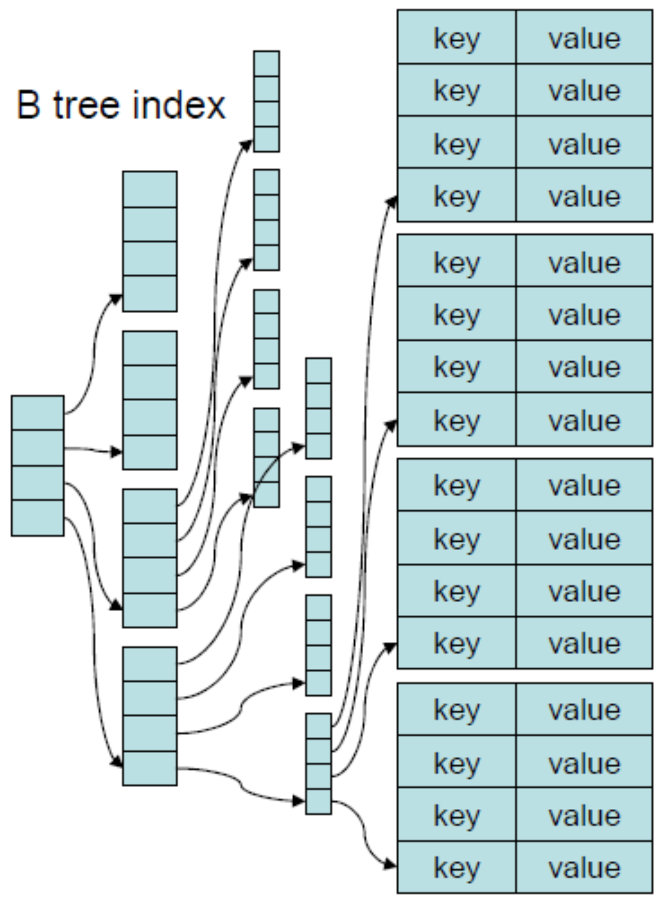
- Job/message queue
- Sub-index of relational database
- Dictionary of words
- Inverted index for full-text search
- Temporary storage for map-reduce
- Archive of many small files

# Hash Table – Tuning

- *bnum* - Specifies the number of elements to use in the bucket array.
- *rcnum* - Specifies the maximum number of records to be cached.

# Data Storage Options – B+ Tree

- Keys can be duplicated
- Records stored in order
- Same operations of HT, plus range queries
- Inserts are fast, but lookup is slower than HT
- More space-efficient than HT

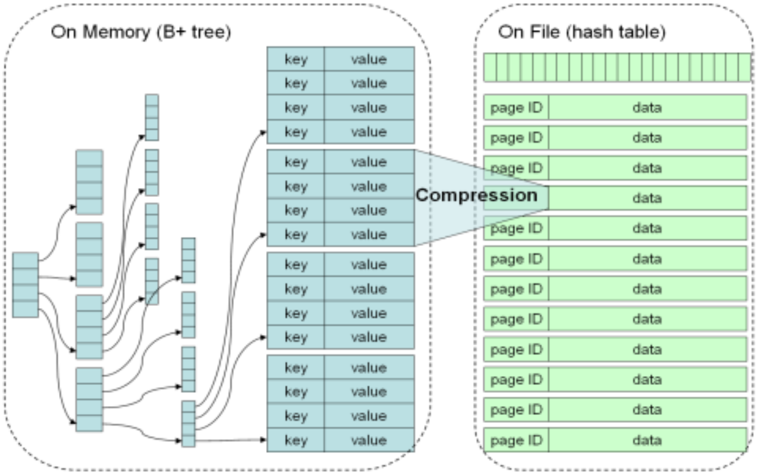


# B+ Tree Example

```
require "rubygems"
require "tokyocabinet"

include TokyoCabinet

bdb = BDB::new  # B-Tree database; keys may have multiple values
bdb.open("casket.bdb", BDB::OWRITER | BDB::OCREAT)

# store records in the database, allowing duplicates
bdb.putdup("key1", "value1")
bdb.putdup("key1", "value2")
bdb.put("key2", "value3")
bdb.put("key3", "value4")

# retrieve all values
p bdb.getlist("key1")
# => ["value1", "value2"]

# range query, find all matching keys
p bdb.range("key1", true, "key3", true)
```

# B+ Tree - Optimizations

- Records are stored and arranged in nodes
- Sparse index for accessing nodes in memory
- Each leaf node is stored on disk as a hash table record
- Nodes can be compressed using ZLIB or BZIP2
  - Size can be reduced to about 25%



# B+ Tree – Typical Use Cases

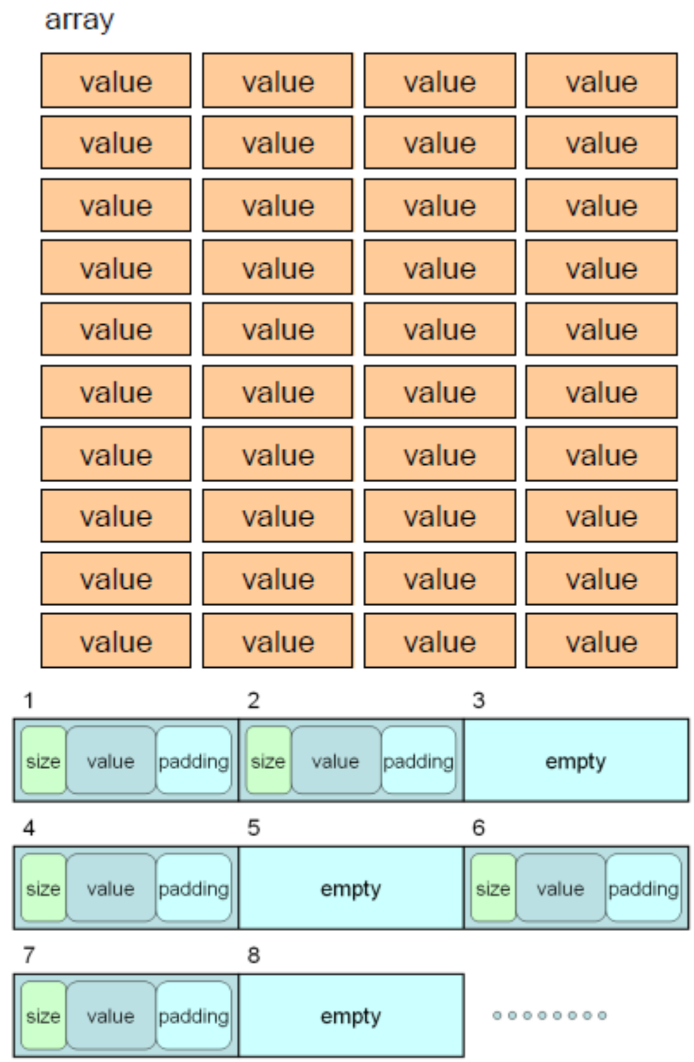
- Session management for a web service
- User account database
- Document database
- Access counter
- Cache of CMS
- Graph/text mining

# B+ Tree – Tuning

- *bnum* - Specifies the number of elements to use in the bucket array.
- *cmpfunc* - Specifies the comparison function used to order B+Tree Databases.
- *lmemb (nmemb)* - Specifies the number of members in each leaf (non-leaf) page.
- *lcnum (ncnum)* - Specifies the maximum number of leaf (non-leaf) nodes to be cached.

# Data Storage Options – Fixed-Length Array

- Keyed by unique integers
- Fixed record size – limited length for each value
- Fastest insert/lookup
- Uses mmap() to reduce file I/O overhead
  - Multiple processes share same memory space

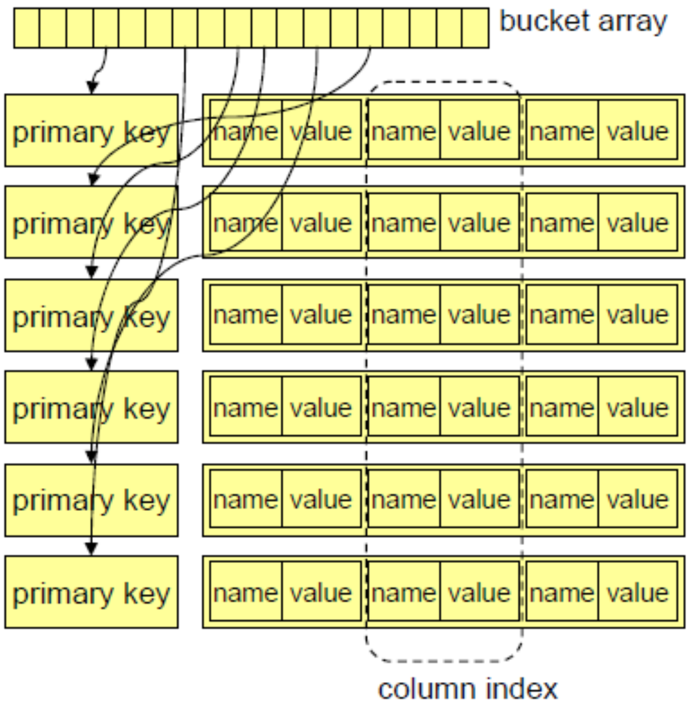


# Fixed-Length Database – Tuning

- *width* - Specifies the width of values (255 by default).
  - Anything beyond specified length will be silently discarded.
- *limsiz* - Specifies the limit on database file size in bytes (268435456 by default).
  - Setting *width* = 1024 and *limsiz* = 1024 * 4, will produce a database that holds only 4 keys.

# Data Storage Options – Table Database

- Built out of other table types
- Free form-schema, resembles document-oriented DB
- Permits sophisticated querying
- Arbitrary indexes on columns
- Slower, but easy to use



# Table DB Example

```
require "rubygems"
require "rufus/tokyo/cabinet/table"

t = Rufus::Tokyo::Table.new('table.tdb', :create, :write)

# populate table with arbitrary data (no schema!)
t['pk0'] = { 'name' => 'alfred', 'age' => '22', 'sex' => 'male' }
t['pk1'] = { 'name' => 'bob', 'age' => '18' }
t['pk2'] = { 'name' => 'charly', 'age' => '45', 'nickname' =>
    'charlie' }
t['pk3'] = { 'name' => 'doug', 'age' => '77' }
t['pk4'] = { 'name' => 'ephrem', 'age' => '32' }

# query table for age >= 32
p t.query { |q|
  q.add_condition 'age', :numge, '32'
  q.order_by 'age'
}

# => [ {"name"=>"ephrem", :pk=>"pk4", "age"=>"32"},
#      {"name"=>"charly", :pk=>"pk2", "nickname"=>"charlie",
    "age"=>"45"},
#      {"name"=>"doug", :pk=>"pk3", "age"=>"77"} ]
```

# ACID Properties: Atomicity

- Transactions
- Isolation levels:
  - Serializable
  - Read uncommitted
- Locking granularity
  - Per record

    Hash database

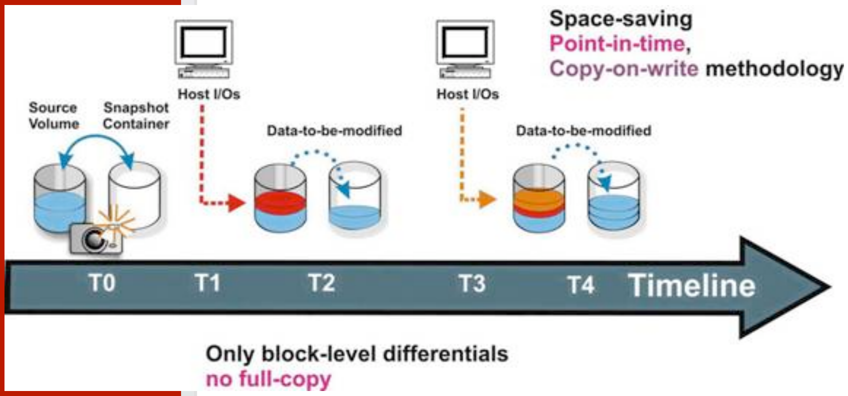
    Fixed-length database
  - Per file

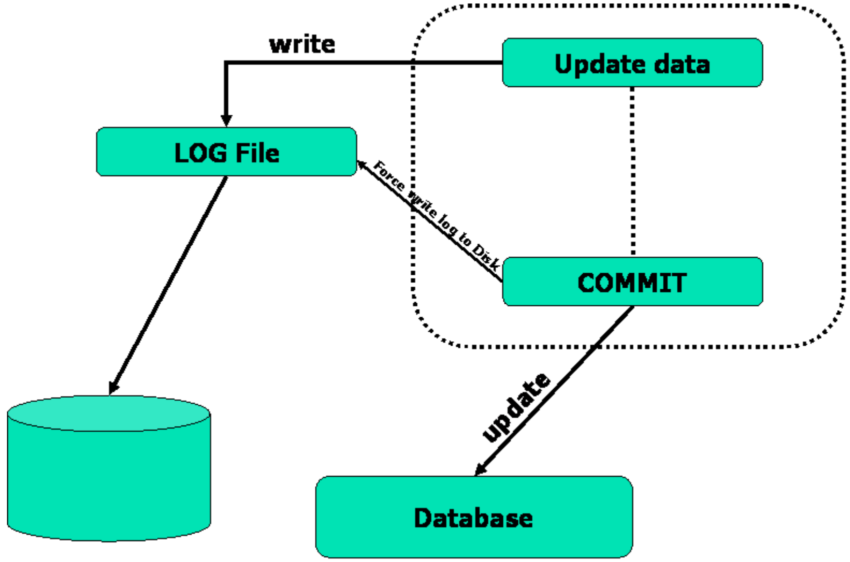
    others

# ACID Properties: Durability

Shadow paging (COW)

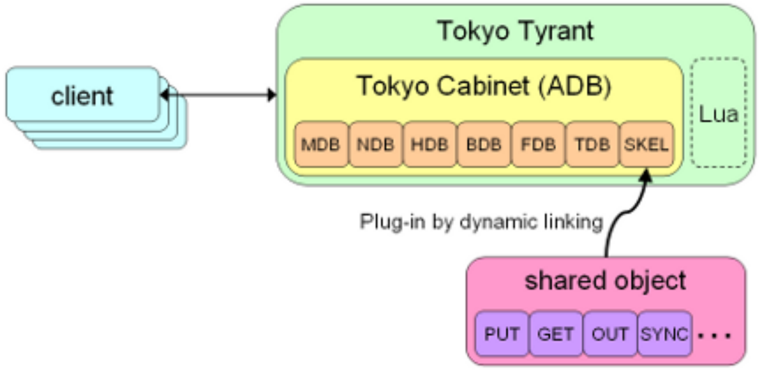
Write-ahead logging



# Tokyo Tyrant

- Network interface for Tokyo Cabinet DB
- Turns TC into a database server
- Client/server model
- Multiple applications can access one database



# TT Features

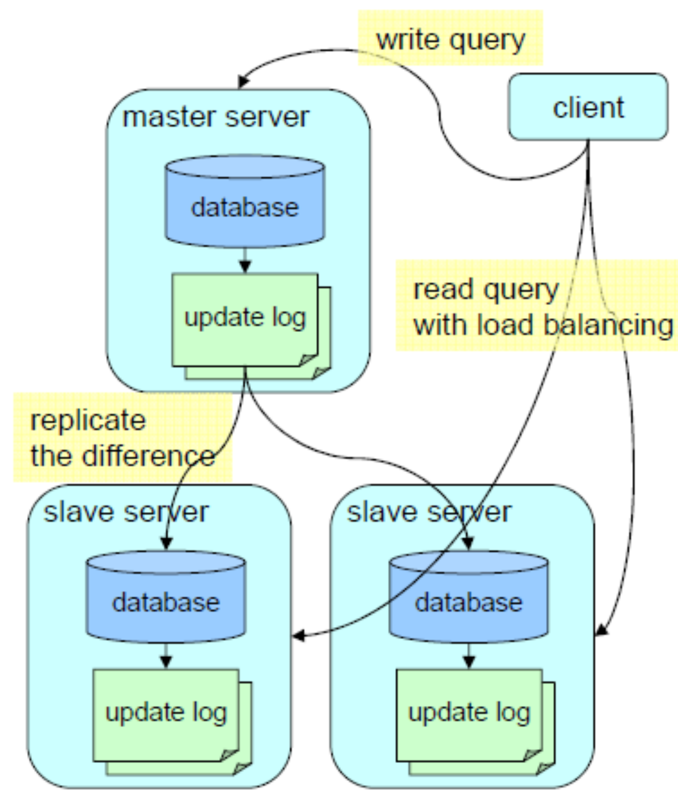
- High concurrency via thread pool
- Speaks three different protocols: binary, memcached, and HTTP
- Uses abstract API to converse with internal storage
- Embedded Lua scripts

# Replication I

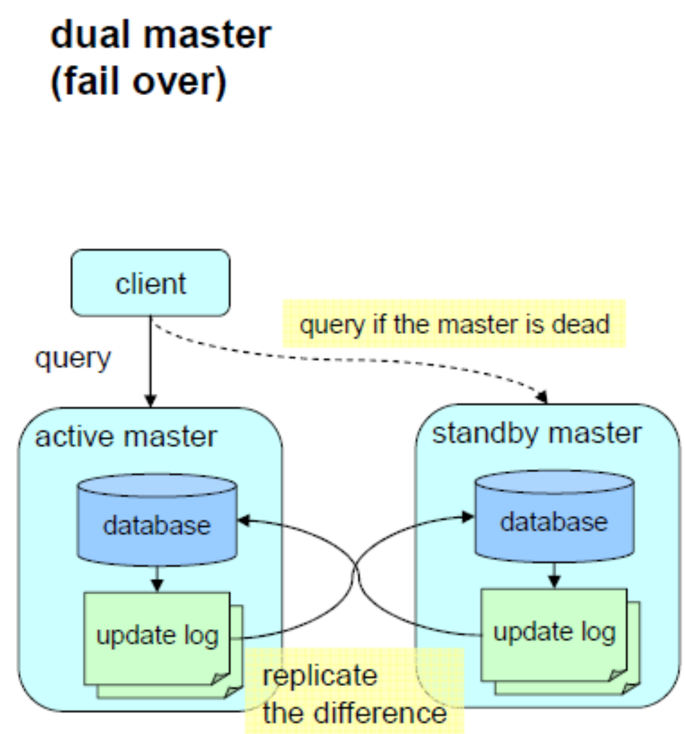
Master-slave(s) topology

- All participants must record the update log
- Each server must have a unique ID

**master and slaves (load balancing)**



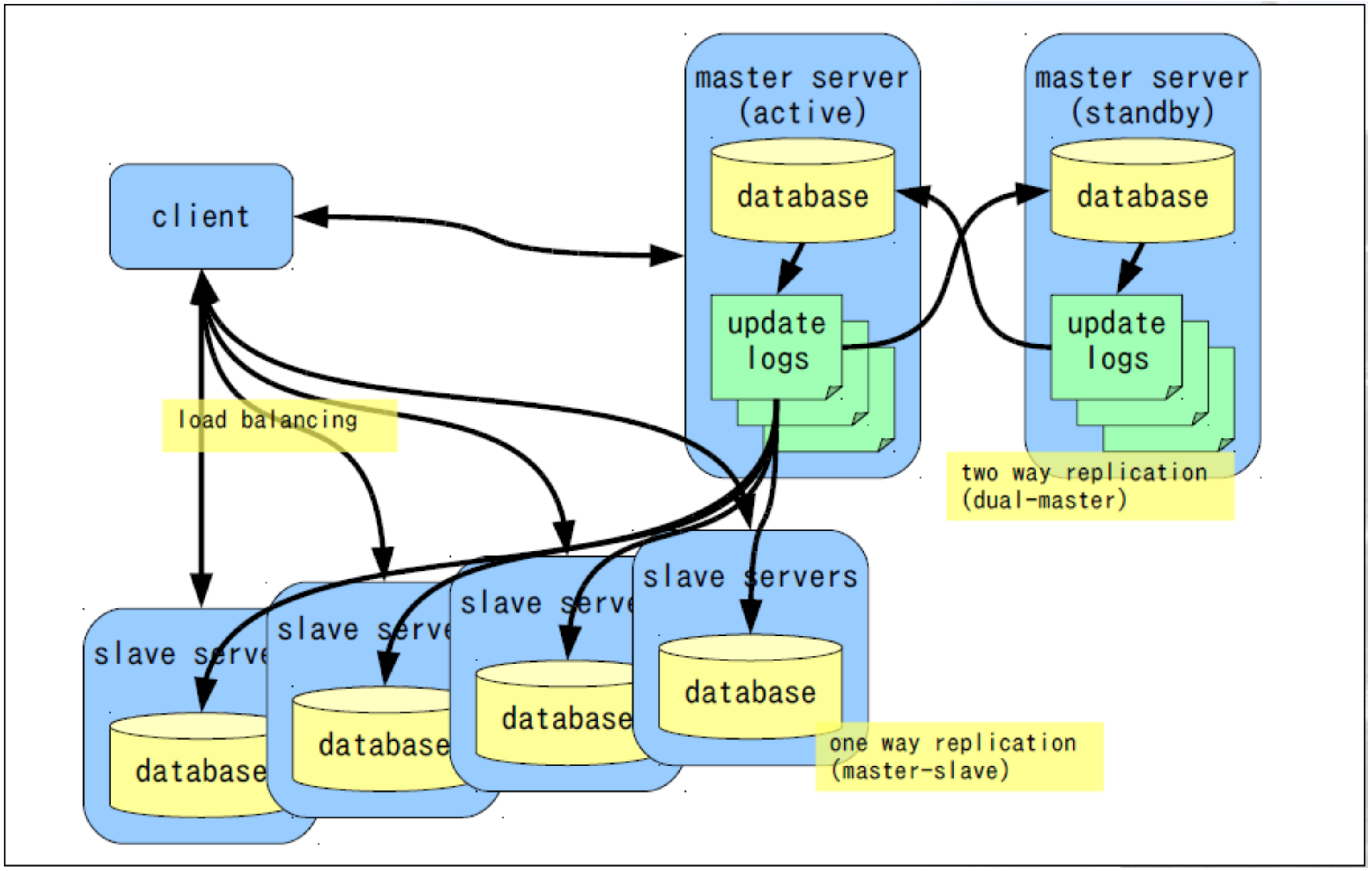
# Replication II



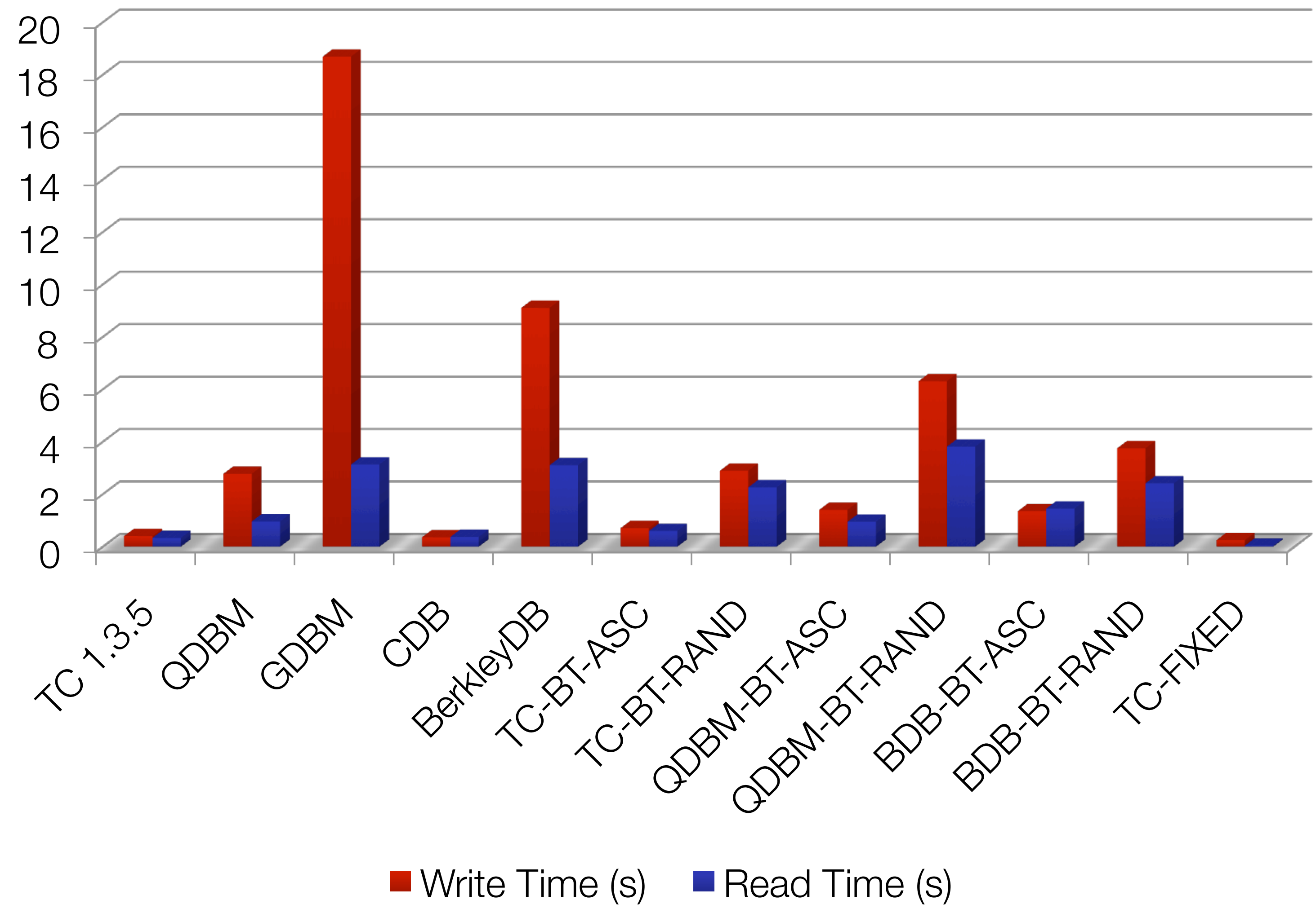

Dual master

- Reciprocal replication
- May cause inconsistencies

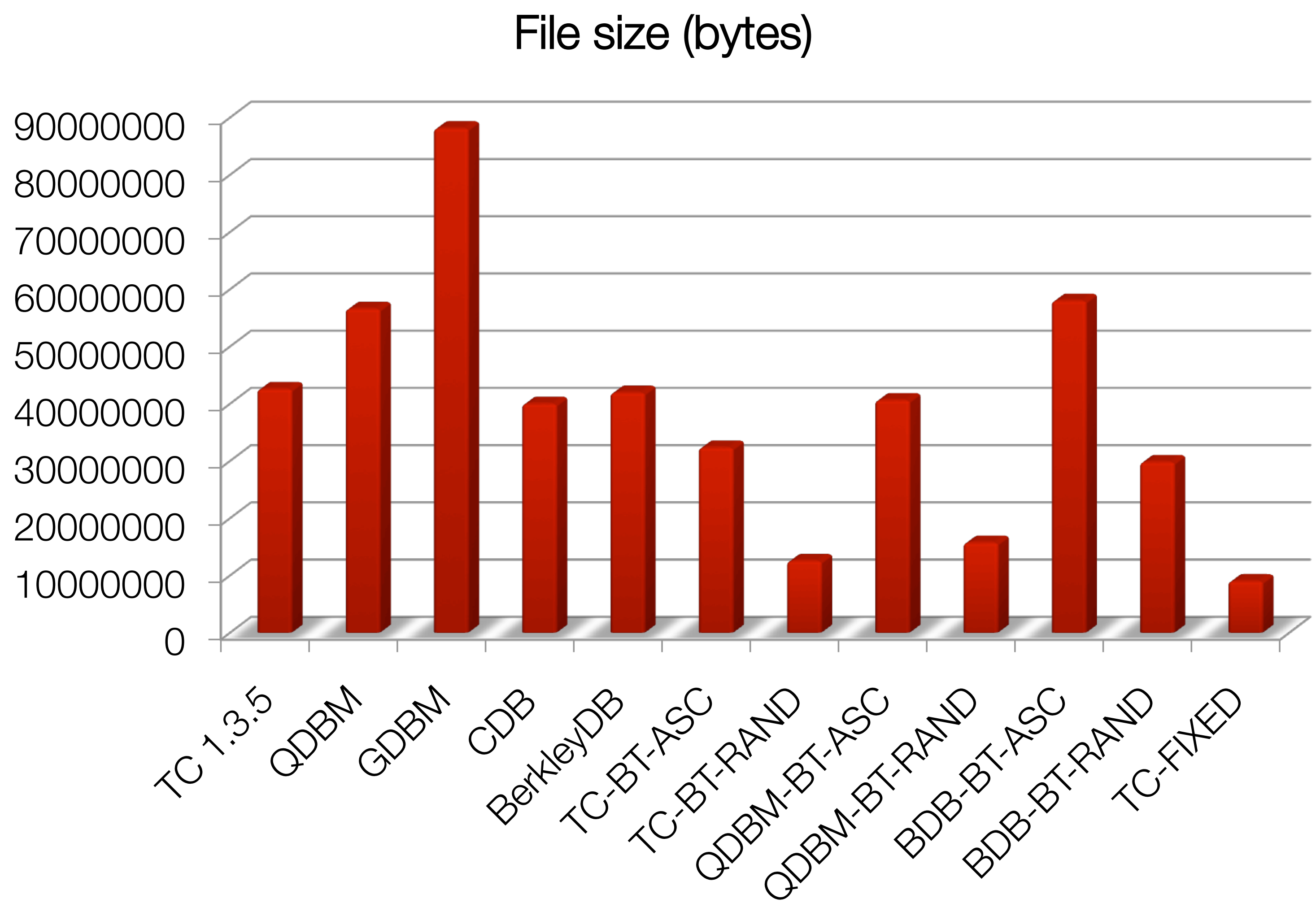
# Replication II



# Tokyo vs. DBM Family (time)



# Tokyo vs. DBM Family (file size)



# Tokyo vs. NoSQL (qualitative)

| Evaluation Criteria | Tokyo Cabinet + Tokyo Tyrant | Berkeley DB + MemcacheDB | Voldemort + BDB JE | Redis | MongoDB |
|---|---|---|---|---|---|
| Insertion (small data set) | 👆👆👆👆 | 👆👆 | 👆👆 | 👆👆👆👆 | 👆👆👆👆 |
| Insertion (large data set) | 👆 | 👆 | 👆 | 👆 | 👆👆👆 |
| Random Read (small data set) | 👆👆👆👆 | 👆👆 | 👆👆 | 👆👆👆👆 | 👆👆👆👆 |
| Random Read (large data set) | 👆👆 | 👆👆 | 👆 | 👆👆👆 | 👆👆👆 |
| Speed Consistence | 👆 | 👆👆👆 | 👆👆 | 👆👆👆👆 | 👆👆👆👆 |
| Storage Efficiency | 👆👆👆👆 | 👆👆 | 👆 | 👆👆 | 👆👆👆 |
| Horizontal Scalability | 👆👆👆👆 | 👆👆👆 | 👆👆 | 👆👆👆 | 👆👆👆👆 |
| Manageability | 👆👆👆👆 | 👆👆👆👆 | 👆👆 | 👆👆 | 👆👆👆👆 |
| Stability | 👆👆👆👆 | 👆👆👆👆 | 👆👆 | 👆👆👆 | 👆👆👆👆 |
| Feature Set | 👆 | 👆 | 👆 | 👆 | 👆👆 |
| Project Activeness and Community Support | 👆👆 | 👆 | 👆 | 👆👆 | 👆👆👆👆 |

PerfectMarket

http://perfectmarket.com/blog/not_only_nosql_review_solution_evaluation_guide_chart

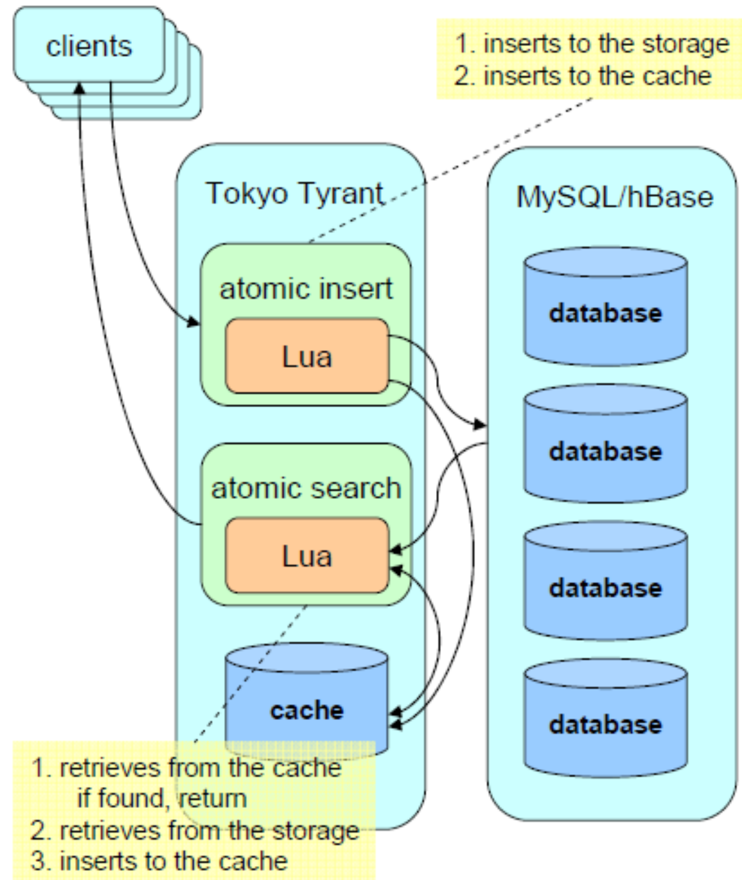
# Tokyo vs. NoSQL (Small data)

- "2.8 million records (6GB) were loaded, and then a half million records were retrieved from the database"
- http://bcbio.wordpress.com/2009/05/10/evaluating-key-value-and-document-stores-for-short-read-data/

| Database | Load time | Retrieval time | File size |
|---|---|---|---|
| Tokyo Cabinet/ Tyrant | 12 minutes | 3 1/2 minutes | 24MB |
| CouchDB | 22 hours | 14 1/2 minutes | 236MB |
| MongoDB | 3 minutes | 4 minutes | 192-960MB |

# Case Study: Storage cache at mixi.jp

- Work as proxy
  - Mediate insert/search
- Lua extension
  - Atomic access per record
  - Uses LuaSocket to access storage
- Proper DB scheme
  - On-memory hash: suitable for generic cache
  - File hash table: suitable for large records, e.g., images
  - File fixed array: suitable for small, fixed-length records, e.g., timestamps



# Case Study: Ravelry

- Online knit and crochet community
  - Organizational tool
  - Yarn/pattern database
  - Social site: forums, groups, friend-related features
- Ruby on Rails
- 70,000 DAU (2009)
- 3.6 million pageviews per day (2009)
- Uses Tokyo Cabinet/ Tyrant to cache larger objects
  - Tons of rendering Markdown into HTML
  - Too large to store in memcached

# Case Study: Ravelry

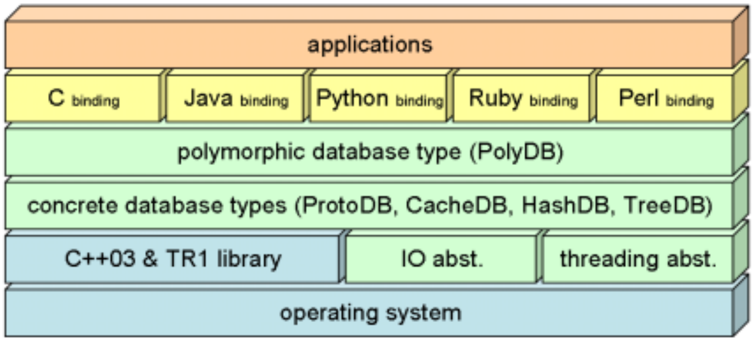
Casey Forbes, Ravelry's only developer, on TC/TT:

- *"I think it is a very nice solution for storing large chunks of HTML, etc.— MySQL is not a very good solution for this (waste of Innodb buffer pools, lots of growth in database files, less than ideal performance when dealing with large tables of blobs) and memcached can become full very fast depending on how much memory you have to devote to caches."*
- *"We've stored up to 25 GB but we are currently storing 10 GB of data. Performance is so close to memcached (even though it hits the disk) that speed is really a non-issue."*

# Kyoto Cabinet

# Kyoto Cabinet

- Very similar to Tokyo Cabinet
- Dropped support for fixed-length and table databases
- Support for external compression
  - LZO and LZMA
- Support for atomic-increment and CAS
- Supports Win32
- License: GPLv3 (TC: LGPL)



# Kyoto Cabinet vs. Tokyo Cabinet

- Better performance and concurrency
  - Parallelism in a multithreaded environment
  - Decreased efficiency per thread due to grained locking
  - User-land locking by CAS
- Space efficiency
  - 16B footprint/record (vs. TC’s 22B)
- Robustness
  - Auto-transaction
  - Auto-recovery
- New database types
  - Four new on-memory databases
  - Two new file-based databases

# Storage Options - Volatile

| Name | Data structure | Complexity | Ordering | Locking | Usage |
|---|---|---|---|---|---|
| Proto HashDB | Hash table | O(1) | None | File (rwlock) | None (testing) |
| Proto TreeDB | Red black tree | O(log *n*) | Lexical | File (rwlock) | Ordered records |
| StashDB | Hash table | O(1) | None | Record (rwlock) | |
| CacheDB | Hash table | O(1) | None | Record (mutex) | General caching |
| GrassDB | B+ tree | O(log *n*) | Custom | Page (rwlock) | |

# Choosing the Right Tool

- No persistence required? On-memory DB
- If order is important, use cache tree DB (GrassDB)
- Time efficiency: CacheDB > StashDB > ProtoHashDB > ProtoTreeDB > GrassDB
- Space efficiency: GrassDB > StashDB > CacheDB > ProtoHashDB > ProtoTreeDB

# Auto Snapshot

- Similar to the one in Redis
- Periodically saves on-memory records into files
- Thanks to COW, each snapshot operation is performed atomically

- Performance comparison for 1M records

| Format | Size | Time |
|---|---|---|
| Raw | 22.888MB | 0.322s |
| LZO | 10.215MB | 0.411s |
| ZLIB | 6.367MB | 2.010s |
| LZMA | 2.787MB | 17.619s |

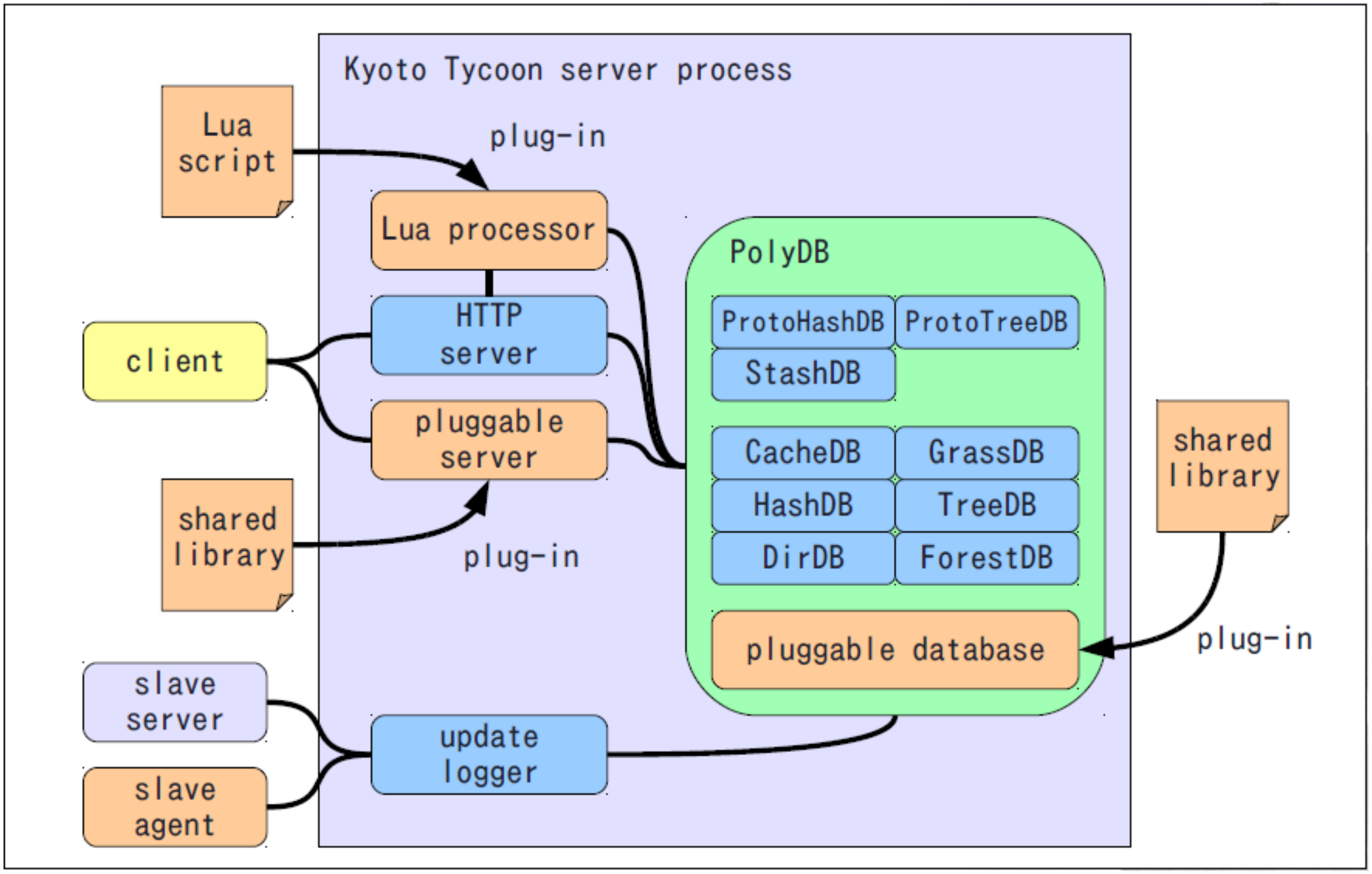
# Storage Options - File

| Name | Data structure | Complexity | Ordering | Locking | Usage |
| --- | --- | --- | --- | --- | --- |
| HashDB | Hash table | O(1) | None | Record (rwlock) | Small, but numerous metadata |
| TreeDB | B+ tree | O(log *n*) | Custom | Page (rwlock) | Small, but numerous meta data, ordered |
| DirDB | Undefined | Undefined | None | Record (rwlock) | Large but few data |
| ForestDB | B+ tree | O(log *n*) | Custom | Page (rwlock) | Large and many data, ordered |

# Kyoto Tycoon

- Persistent cache server
- High concurrency
  - 1M queries / 25 sec = 40,000 QPS or more
- Supports auto-expiration mechanism
- Discarded replication mechanism
- Like TT and memcached, no data sharding
- Usage: large web services
  - Access counters
  - Time stamp trackers
  - User account managers
  - Session data

# Kyoto Tycoon



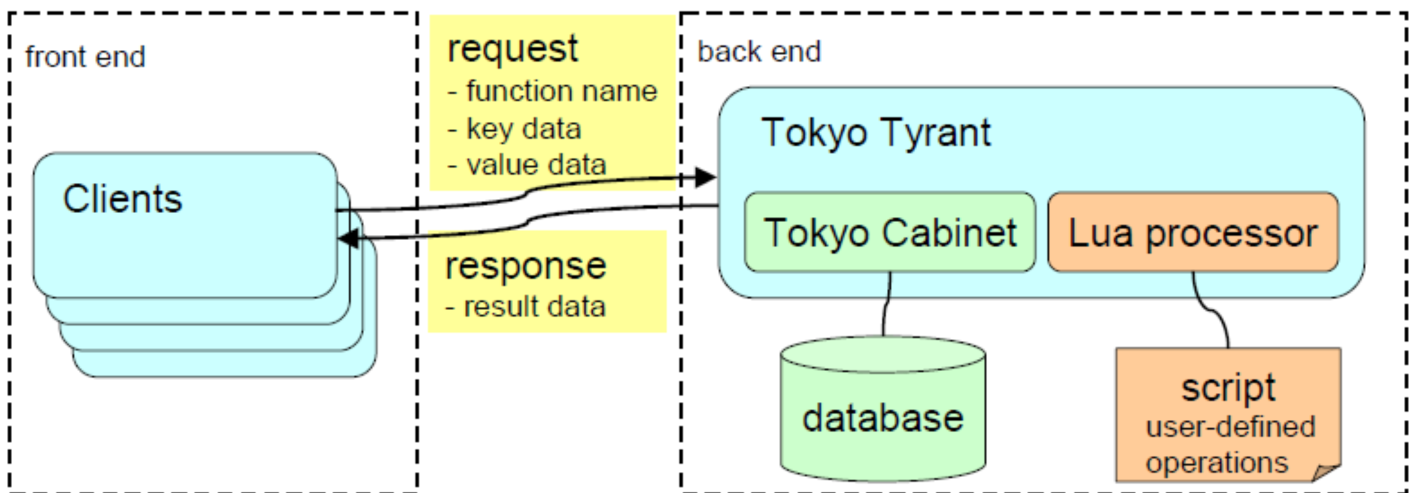
# Auto Expiration

- Expiration time given to each record
- Records removed timer expiration
- "GC cursor" eliminates expired regions gradually

# BACKUP SLIDES

# Primitive Map-Reduce with Tokyo Tyrant

- Lua Extension
- Defines DB operations as Lua functions
- Client sends function name, plus key/value
- Server returns function result



# Primitive Map-Reduce w/ Tokyo Tyrant

```
function wordcount()
      function mapper(key, value, mapemit)
         for word in string.gmatch(string.lower(value), "%w+")do
            mapemit(word, 1)
         end
         return true
      end

      local res = ""
      function reducer(key, values)
         res = res .. key .. "\t" .. #values .. "\n"
         return true
      end

      if not _mapreduce(mapper, reducer) then
         res = nil
      end
      return res

end
```

Emit: {word: 1}

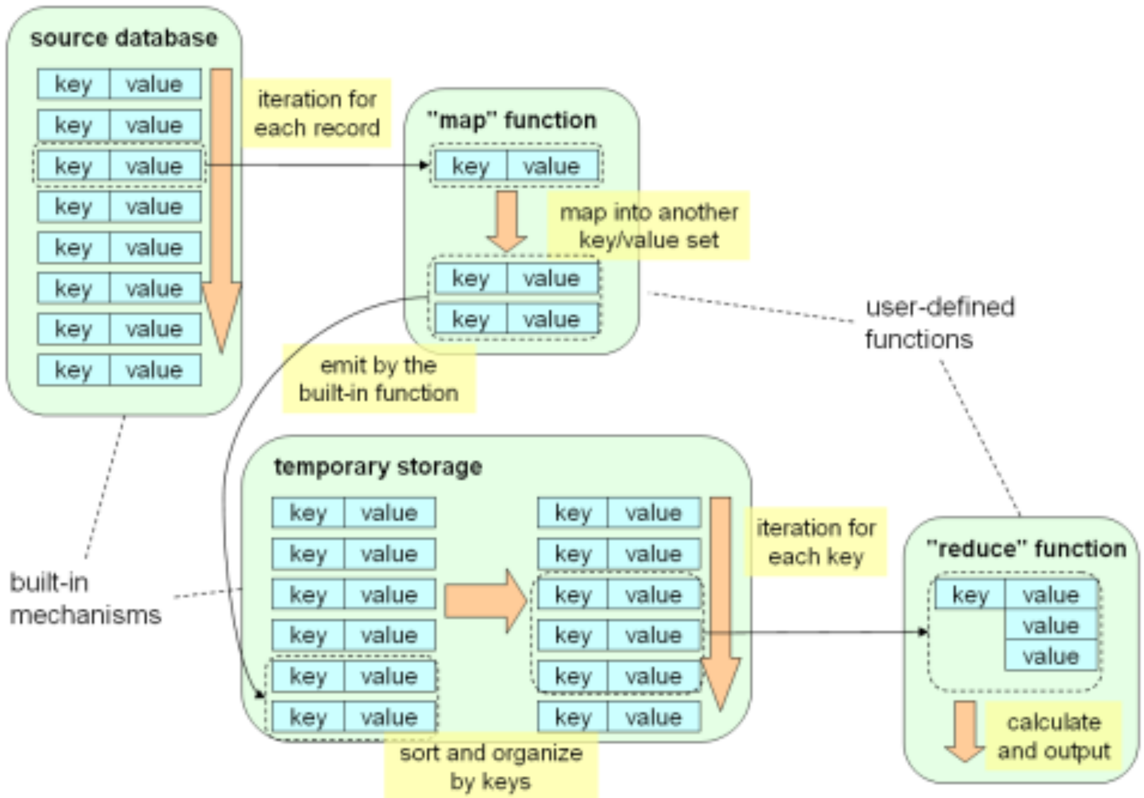
# Primitive Map-Reduce w/ Tokyo Tyrant

```
function wordcount()
      function mapper(key, value, mapemit)
         for word in string.gmatch(string.lower(value), "%w+“)do
            mapemit(word, 1)
         end
         return true
      end

      local res = ""
      function reducer(key, values)
         res = res .. key .. "\t" .. #values .. "\n"
         return true
      end

      if not _mapreduce(mapper, reducer) then
         res = nil
      end
      return res
end
```

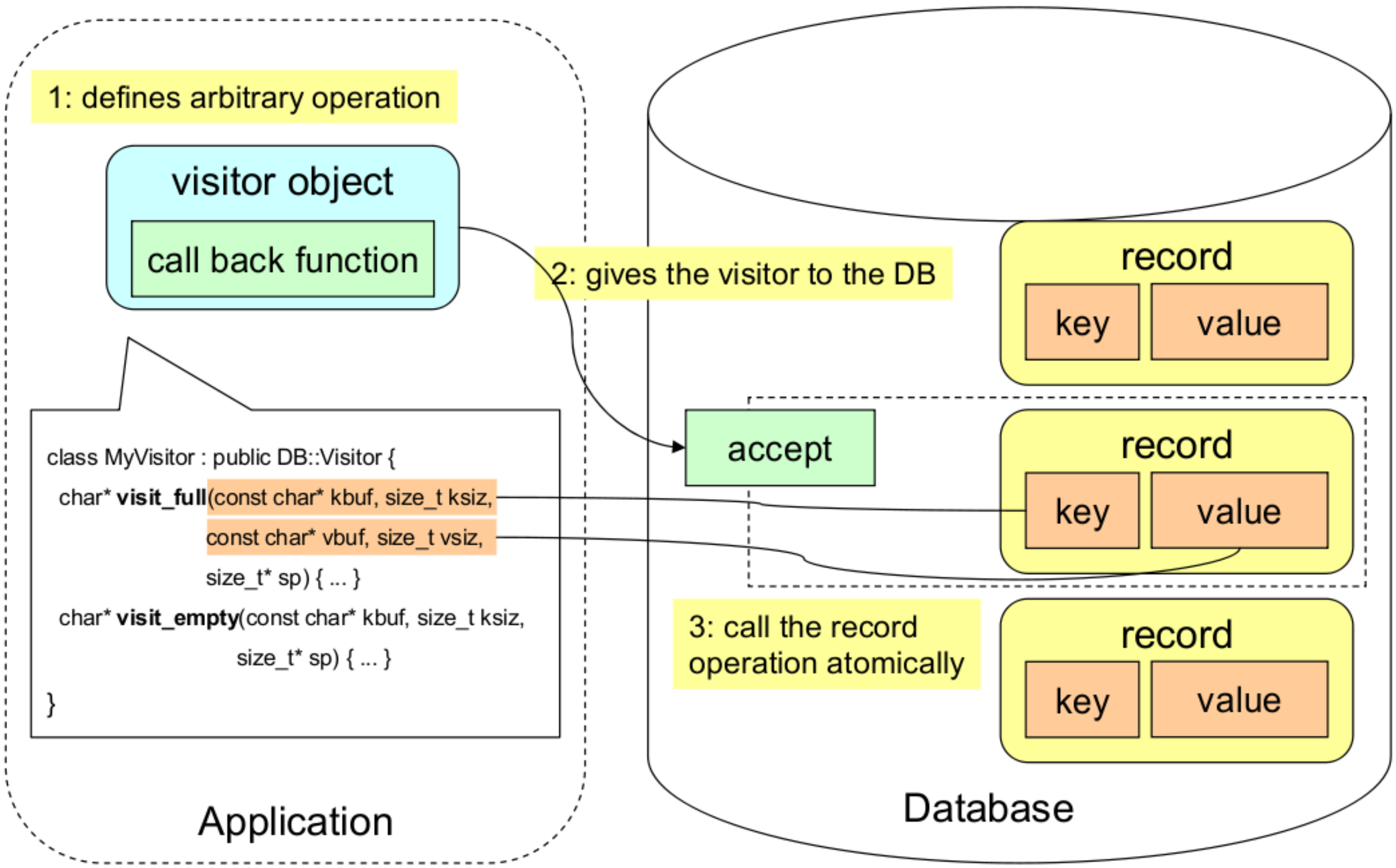
Emit: {word: 1}

sizeof(values)

# Map-Reduce with Tokyo Tyrant (III)



# Kyoto Cabinet - Visitor Pattern



# Tyrant/Tycoon Internals