LunarBase

-- A real time database engine for managing both structured and unstructured data

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Content

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Big data era

Internet, Internet of Things

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Real-time mode

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Structural, semi-structural search engin

Application

Big data era

Big data market grows from billons to thousands of billions, as Gartnar surveyed world-wild. Several important facts worth paying attention to:

1. 80% of data is unstructured or semi-structured

2. data coming from everywhere, e-commerce, communities, mobile, IOT.

3. Data business covers all the corners of the world: goverments, financial, telecom, retail, logistic......

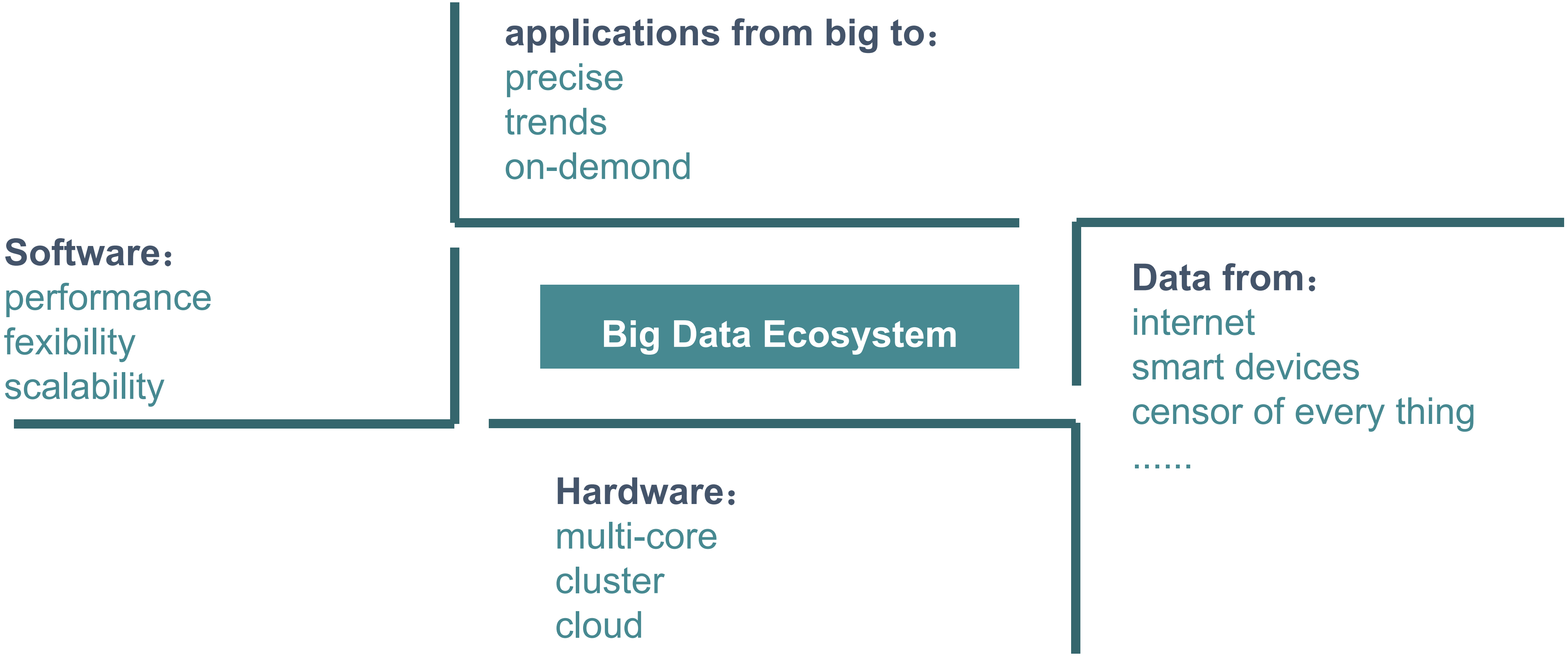
4. Storage and Analysis requiroments grow much more fast than the growth of data itself. Predefined shema, as what RDBMS does, just meets a little portion of this thrend.

5. In big data ecosystem, performance, scalability and flexibility are the three key-indexes for all the supporting technologies, including hardwares, softwares, architectures.

6. Big data is just the beginning, digging out trends, precise info, on demond responding are the purpose.

Application

Big data era



applications from big to：
precise
trends
on-demond

Software：
performance
fexibility
scalability

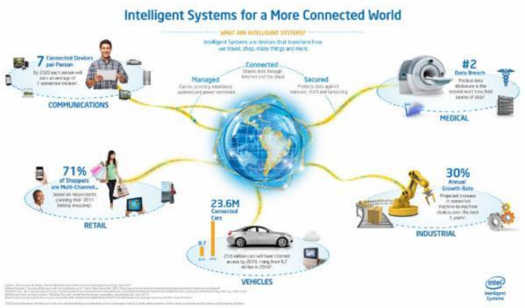
Big Data Ecosystem

Data from：
internet
smart devices
censor of every thing
……

Hardware：
multi-core
cluster
cloud

Application

Internet, Internet of Things


Intelligent Systems for a More Connected World
WHAT ARE INTELLIGENT SYSTEMS?
Intelligent Systems are devices that transform how we travel, shop, make things and more.
7 Connected Devices per Person
COMMUNICATIONS
Managed
Connected
Secured
#2 Data Breach
MEDICAL
71% of Shoppers are Multi-Channel...
RETAIL
23.6M Connected Cars
8.7
VEHICLES
30% Annual Growth Rate
INDUSTRIAL
intel
Intelligent Systems

Traditional data comes from home and office, infront of computers.

But from now on, every thing commits data for analysis, diagnosis, communication. Data may from:

Mobile phone
Auto cars
Nano robots inside your body
Refrigerator
Bed
Tooth brush
Meeting room projector
Coffee cup
....

Even within a small office, tons of data is generated every moment

Overview

What LunarBase do for your business

LunarBase as a database engine, it is able to:

manage structured data with fundamental DB functionalities;

be a fulltext **search engine**, supporting unstructured data;

embed to your application as a general purpose database;

be a standalone database server with network plugin;

time serial data analysis;

online Transaction

e-Commerce

CRM

Fnancial

Telecom

Retail

Smart Device

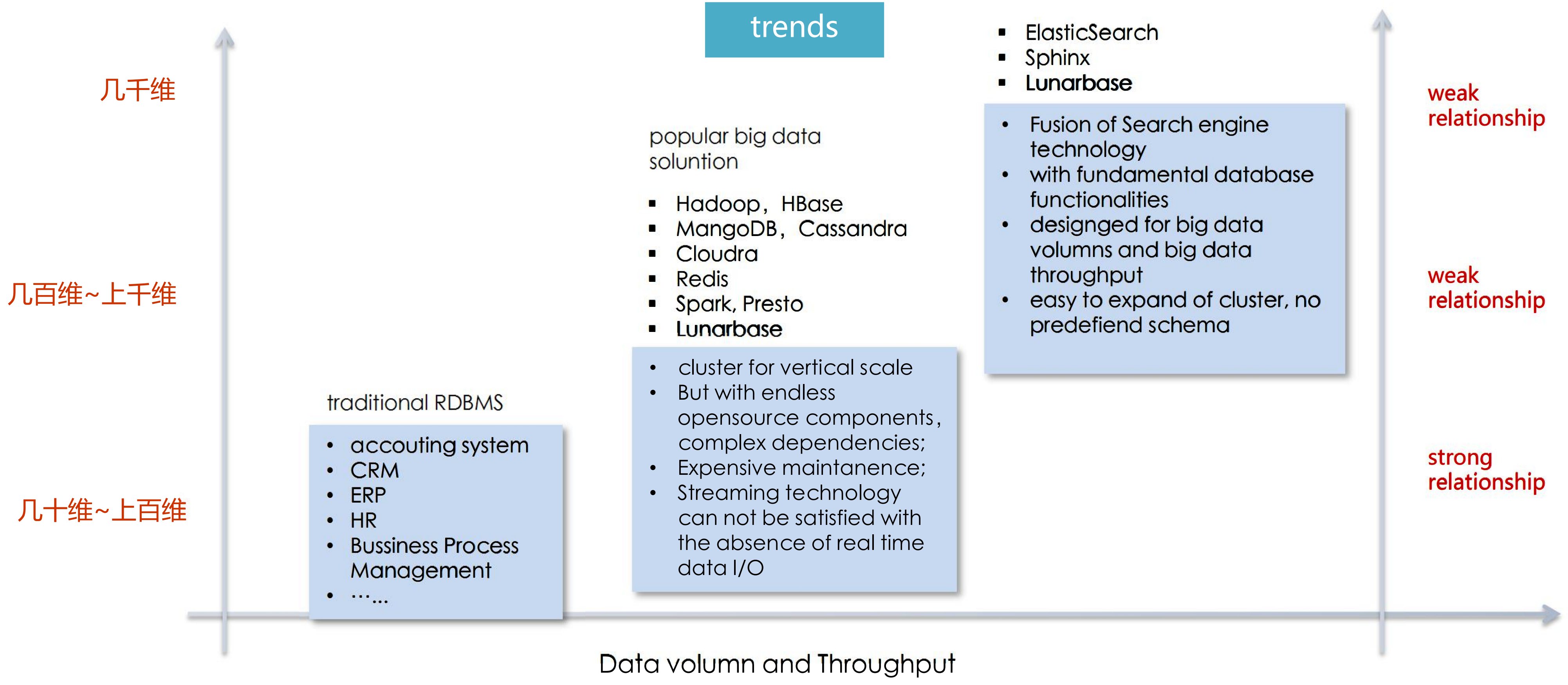
Social Media and network

CMS

…………

Overview

data volumn and deminsion grows simutaniously, while the relationship



trends

几千维

几百维~上千维

几十维~上百维

traditional RDBMS

- accouting system
- CRM
- ERP
- HR
- Bussiness Process Management
- ……

popular big data soluntion

- Hadoop，HBase
- MangoDB，Cassandra
- Cloudra
- Redis
- Spark, Presto
- **Lunarbase**

- cluster for vertical scale
- But with endless opensource components，complex dependencies;
- Expensive maintanence;
- Streaming technology can not be satisfied with the absence of real time data I/O

- ElasticSearch
- Sphinx
- **Lunarbase**

- Fusion of Search engine technology
- with fundamental database functionalities
- designged for big data volumns and big data throughput
- easy to expand of cluster, no predefiend schema

weak relationship

weak relationship

strong relationship

Data volumn and Throughput

Application

Use cases as general DB

LunarBase is a database for genral purpose, use cases include but not limited to:

1. Content management for internet and intranet

2. Business for goverments, financial, telecom, retail, logistic.........

3. e-Commerce transaction like shopping, travaling, hotel reservation......

4. Financial big data analysis including up-selling, fraud detection, e-billing......

5. Industry and consumer smart device data collection, storage, transmittion

6. Social activity data management

....

Application

Real Time mode

LunarBase supports real time analysis by LunarMax module, when its real time mode turned on. Close database, set rt_mode = on, and open database again, LunarMax is running.

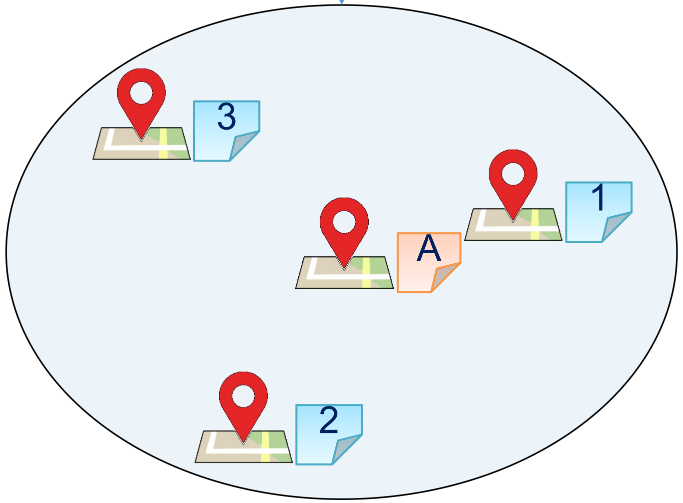
After a database is created, user opens the configuration file and find the location where to turn on the real time mode under the "real time mode" section:

```
rt_mode = on
rt_analysable = string:name, int:payment, int:age, string:product

# order of how index building.
rt_order = 7

# for float data: 0 for integer, 1 for 0.1, 2 for 0.01, 3 for 0.001, and so on.
rt_precision = 3

# threads for real time computation.
# Concerning performance, rt_threads+ internal_cache_concurrent_level
# will never exceeds the threads that OS can provide.
# One property with one thread gives the best performance.

rt_threads = 4
```

Application

range search

Map is a typical application scenario of range search



Without LunarBase, the deployment enviroment and dependency stack are extreamly complex.

query

select shops where distance < 1000

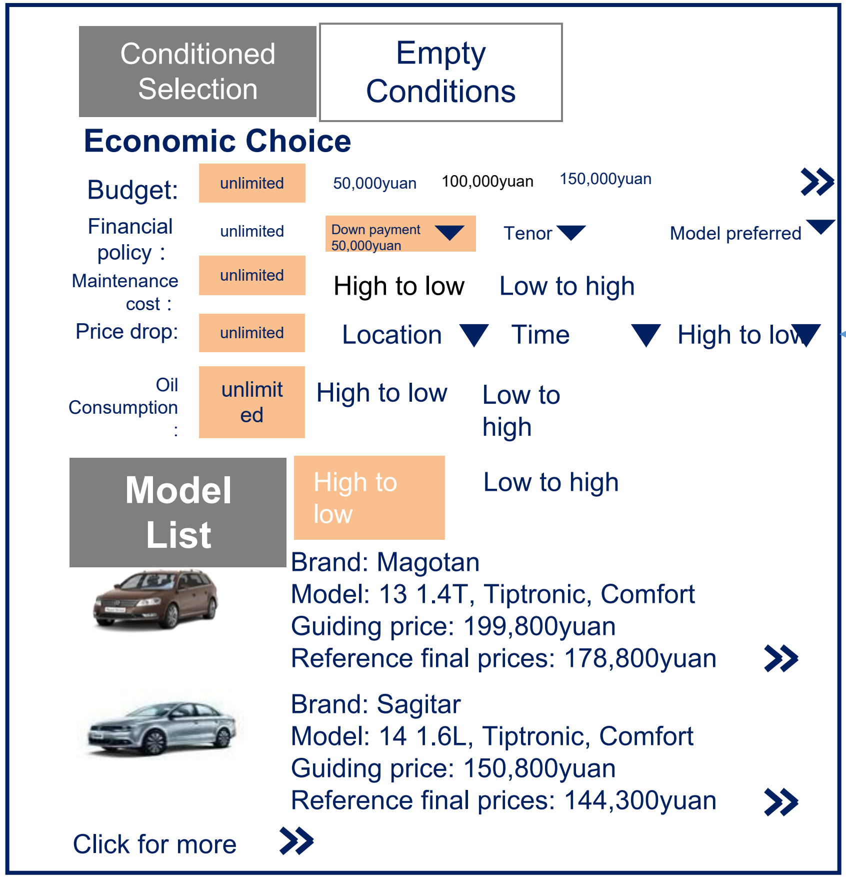
Streaming computation for quick range search and sort

Shop 1: distance = 100
Shop 2: distance = 120
Shop 3: distance = 120
......

For this kind of information retrieval and analysis, in addtion to the underlying basic data structure(stored in tables, regardless of sql or no-sql database systems), we need to build extra indexes for geo-spatial search, need to cache hot areas, to manage swapping, consistency, update notifications, cache missing and all the related tough tasks.

Application

Structural, semi-strucural search engin



Conditioned Selection | Empty Conditions

Economic Choice

Budget: unlimited 50,000yuan 100,000yuan 150,000yuan

Financial policy : unlimited Down payment 50,000yuan Tenor Model preferred

Maintenance cost : unlimited High to low Low to high

Price drop: unlimited Location Time High to low

Oil Consumption : unlimited High to low Low to high

Model List High to low Low to high

Brand: Magotan
Model: 13 1.4T, Tiptronic, Comfort
Guiding price: 199,800yuan
Reference final prices: 178,800yuan

Brand: Sagitar
Model: 14 1.6L, Tiptronic, Comfort
Guiding price: 150,800yuan
Reference final prices: 144,300yuan

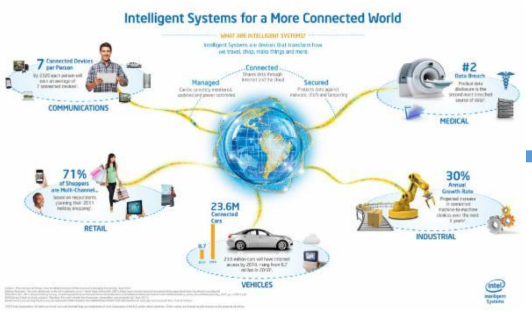
Click for more

query with **hundreds** of properties

```
select cars from table1, table2, ..., table n
            where
            size >100,
            and price <50000,
            and color = write,
            and performance >100,
            and maintainenceCost = low,
            and city = Los Anglos,
            and ( brand = BMW or Audi or Benz or Ford or Porsche )
            ............
            hundreds of properties
```

Application

Internet, Internet of Things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Intelligent Systems are devices that transform how we travel, shop, make things and more.
7 Connected Devices per Person
By 2020 each person will own an average of 7 connected devices
COMMUNICATIONS
Managed
Can be remotely monitored, updated and power controlled
Connected
Shares data through internet and the cloud
Secured
Protects data against malware, theft and tampering
#2 Data Breach
Medical data disclosure is the second most breached source of data
MEDICAL
71% of Shoppers are Multi-Channel...
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INDUSTRIAL
intel Intelligent Systems

RDBMS works
for old days

Simple tasks became **tough** in exponentially growing data volumn

Not Only SQL

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Overview

What is LunarBase

Power Comsumption VS Data Compression

Data Security

JSON document model

Point and Range(geo-spatial) Query

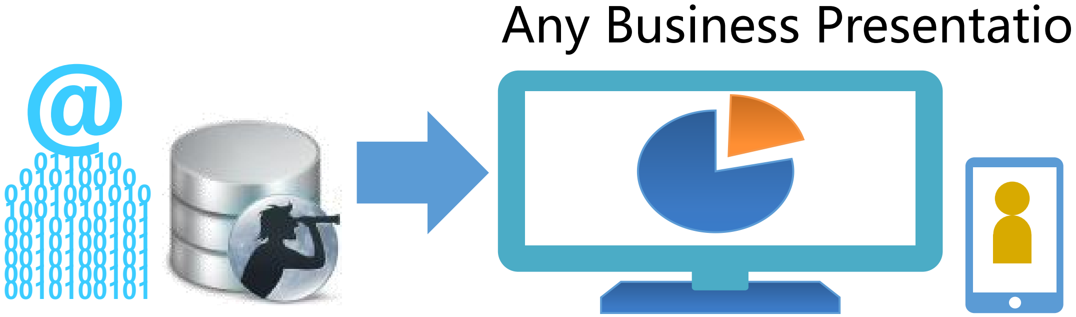
Concurrent Architecture for multi-core

All in One for lower TCO

RoadMap of LunarBase future

Overview

What is LunarBase?



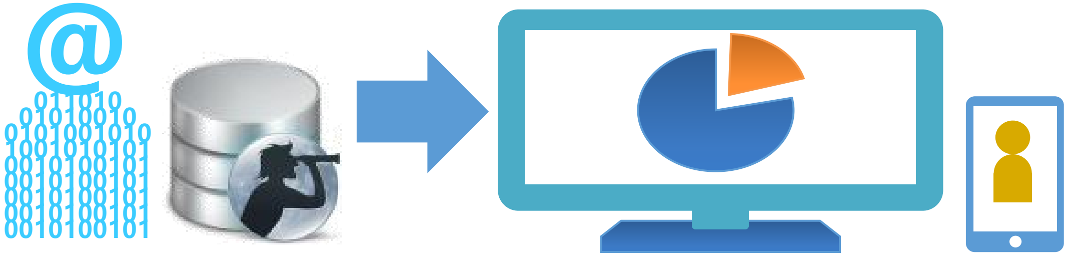
LunarBase engine targets a real time analysis and free-style database engine, managing 2 billions records in one table, where each record has a size limitation up to 32k bytes. Therefore 64 TB data can be stored and queried via one table of LunarBase.

- *The following features makes LunarBase different, and efficient for your application:*
- *Non-pause GC;*
- *Active defragmentation;*
- *Big memory;*
- *Vertical scalability;*
- *Materialized view;*
- *Multi-dimensional Real time LunarMax;*

Overview

What is LunarBase?

Any Business Presentation



- ➢with a persistent DB storage
- ➢with LunarMax, an engine managing an in-memory file system for real-time computation;
- ➢Free scalable, document-oriented without predefined schema, as all NoSQL database designed for;
- ➢LunarBase has extremely fast retrieval speed, within 20-ms response time for a normal X86 server;
- ➢for multiple purpose. One DB for both data storage and search, and even full text engine with simple word parsing plugins;

Overview

CPU power consume VS data compression

VS

Data compression is a trade off of cumputation resource and storage occupation. Compression rate of the data depends on the goal of the system design. For example, we need to compress the size of an index, then we compress a 4 bytes interger to a variant length one. Values less then 32K may be stored in two bytes. But the cost is the deserialization time, which takes three times of cpu clocks than deserializing a fixed 4 bytes integer. Meanwhile this a highly frequent internal invocation.

A well known trend is that it is going to be cheaper and cheaper for each GB storage, while the electric charge is going to be expensive. For running a data center, the pwer comsumption is one of the top priorities, since records can be qieried billions a day, really no need to compress integer. 1 billion integers only use 4G disk space~~

But other necessary compression is implemented by lunarbase.

Overview

Single node supports

single DB stores 2 billion records, each has a size limitation of 32K bytes. Hence the total size of one table is 64TB ;

One server runs one db Instance, managing tables of records. The number of tables depends on the hardware capability ;

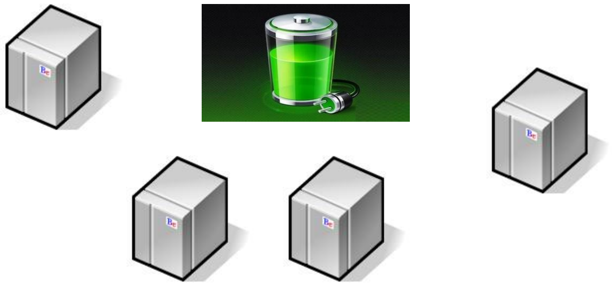
Concurrency support depends on the core of CPU. There is a one-one mapping from internal threads and CPU cores ;

Memory Consumption: LunarBase has an internal MMU, will not produce memory fragments after a long time running. This is an very important feature for any server-end middle ware;

Query speed: on a 4-core X86 server, mechanical HDD, 8G mem, LunarBase responses a query in 10 ms. If the big cache is opened and all hot data stores in it, the query speed of hot data are extremely fast.

Overview

Power Consumption of a Cluster



Power consumption is one of the biggest cost in running a data center. LunarBase optimized its key computation modules that are invoked frequently within the engin. These modules includes: hard disk IO, memory alloc/dealloc, FS Block management, Linear Hash storage, geo-hash computation.

The CPU workload is well managed. On the memory side, once LunarBase boots up, with correctly configured memory size, say 16GB, it is running with this constant resource, never grows. This means it does not compete resource with other services running on the same server.

LunarMMU produces no memory fragments no matter how long it is running, which means its alloc/free operation is still in constant time, will never slow down the operation system.

Overview

MMU

- physical Memory
- Memory Buckets
- Slab-like allocation
- LRU Strategy
- Memory Locker
- Concurrency Management

For any server-end middle ware, stability is the most important thing. A well designed memory management system can significantly reduce the memory fragments, fasten the alloc/free speed. You really do not want your application alloc a block of memory every time from a busy OS, since it will leads to a failure allocation, proved to be fatal for any application. LunarMMU is designed for such purpose:

1) constant time of alloc and free
2) has an upper bound of memory consumption
3) produce no memory fragments, even after billions of alloc/free

LunarMMU is not a memory system for general purpose. It is for LunarBase and cache only. There is a price payed for the above three advantages. The memory occupation will be little more bigger than that is really needed.

But as the plummet of hard disk price, so is the memory price. This trade off is much worthy.

Overview

IO for Linux X86 platform

Memory Mapped File is the most fast mechanism for read and write. Data from user space to the kernal space and then hard disk persistent takes just one copy.

MMAP system call exposed by linux kernal, and it is the only solution for a quick IO procedure. LunarBase kernal invocates MAP for IO, provided in libLunar_Linux_X86_64.so

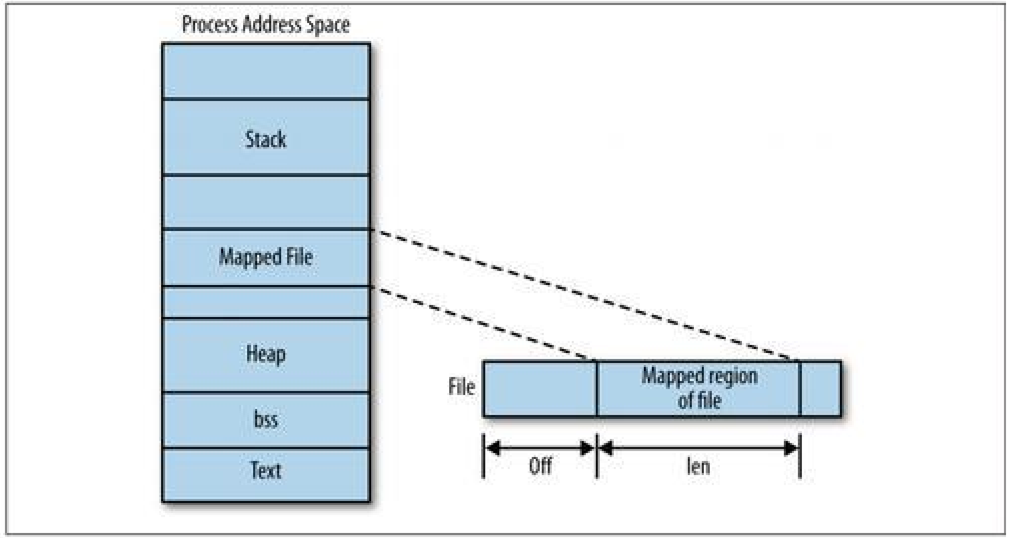


Figure 4-1. Mapping a file into a process's address space

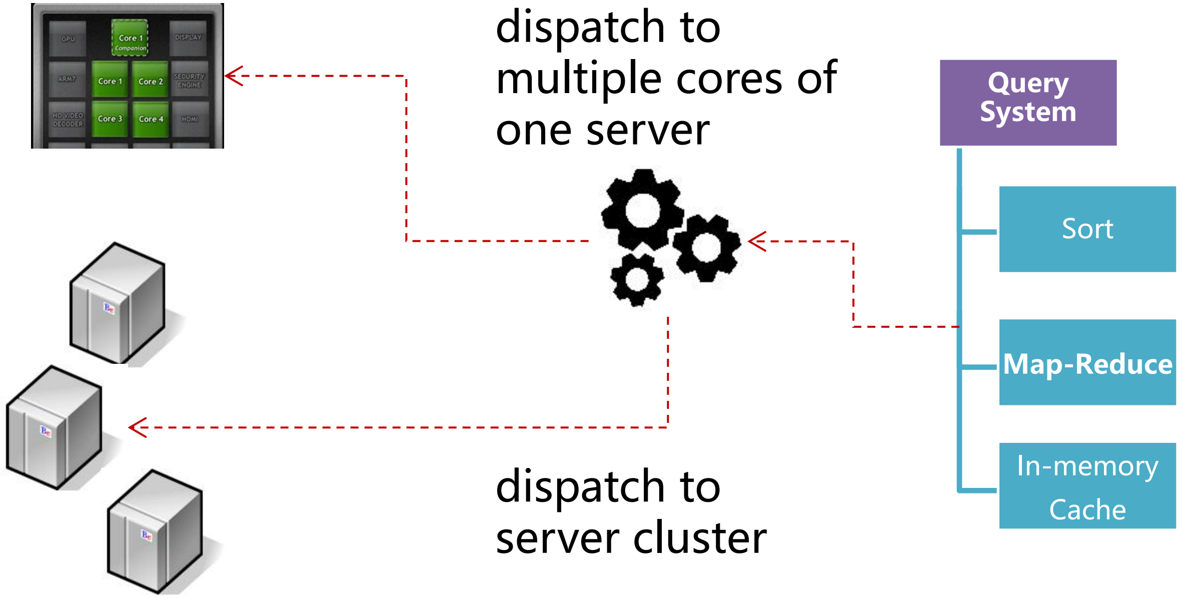
this picture is from internet for illustration purpose. Any violation of copyright please let me know.

Overview

Multi-Core performance

LunarBase writes in one thread and reads with multiple threads. Multi-threaded write does no good to the performance for that eventually we flush data into the hard driver, there is a queue waiting; With the big memory solution LunarMMU, the multi-threaded reading is possible, since hot-data are all in memory waiting. Cold data will be swapped out by LRU strategy.

LunarBase engin is an nosql database engin written in java, but its basic IO，file system（Lunar virtual FS), Memory management unit(MMU) are implemented in C++. Performance is the only reason for our C++ implementation.



dispatch to multiple cores of one server

Query System

Sort

Map-Reduce

In-memory Cache

dispatch to server cluster

Overview

Data Security

➢Log system is first of all we implemented, every command user commits is recorded before excute real database operation:

```
succeed@    insert: {name=jack, age=30, payment=500, date=20150728};
succeed@    insert: {name=michal, age=25, payment=800, date=20150728};
succeed@    insert: {name=jackson, age=45, degree=master, address=somewhere, payment=2000};
……
```

WAL: Write a Log first when a write committed.

If any error (system crash, electricity failure…) occurs during writting, LunarBase will check Log first, all the failed commands will be excuted again to make sure the data is succesfully stored;

Log system is also the fundamental component for Data migration and backup. LunarBase exposes several API to support these functionalities. User need only to tell LunarBase where the log directory is.

Overview

JSON input

✓

name, age, payment, date and all these alike are **Properties,** programmers need no further work to tell Lunarbase which one is the key explicitly. Any Property with its value is a key, and searchable with equal performance.

Json document is the primative unit for data manipulation. Quite like other NoSQL solutions, but not exactly the same.

DB Insert:

➢records in simple JSON formart:

```
{name=jack, age=30, payment=500, date=20150728};
{name=michal, age=25, payment=800, date=20150728};
{name=frank, age=25, payment=1200, date=20150729};
{name=jackson, age=45, degree=master, address=somewhere, payment=2000};
……
```

Billians of records in one DB

Scalability

- Schema Free, all properties is added on demand. As what the example illustrates, name ,age, payment, date appears when new records inserted. In the future, the comming data may includes new properties like address, school, LunarBase recognizes these, and store them automatically:

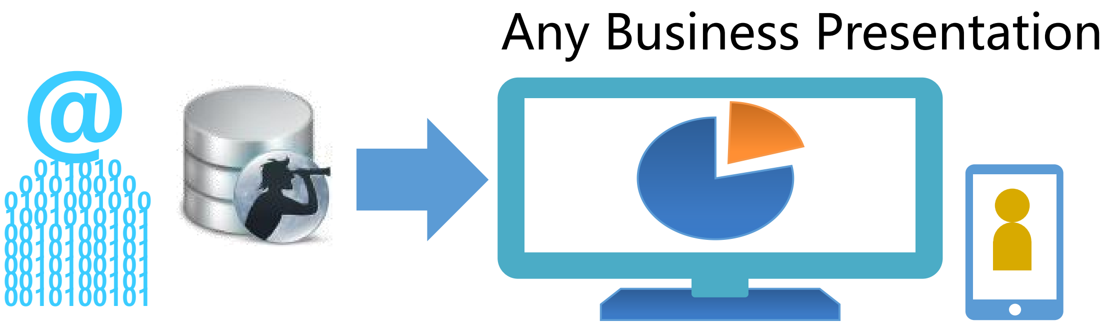
property@ name, age, payment, date, degree, favorate......

Properties of a Data Application is the very first thing need to be clear when start to design and program in old days. But now, the data types variants much more frequently than before, no one has the capability to know the future category a bunch of data belongs to.

This is what the industry calls ***Scalability*** *and* ***Flexibility,*** *an advantage of NoSQL database.*

Overview

Point and Range Query



We query **any property** with any value, if exists. Never need to specify which one is the key. Simple and Happy programming

DB Query:

- **select records where age=25**, LunarBase returns:

  docID = 1, Value = {name=michal, **age=25**, payment=800, date=20150728};
  docID = 2, Value = {name=frank, **age=25**, payment=1200, date=20150729};
  ......
  Millions of records matching the query in DB

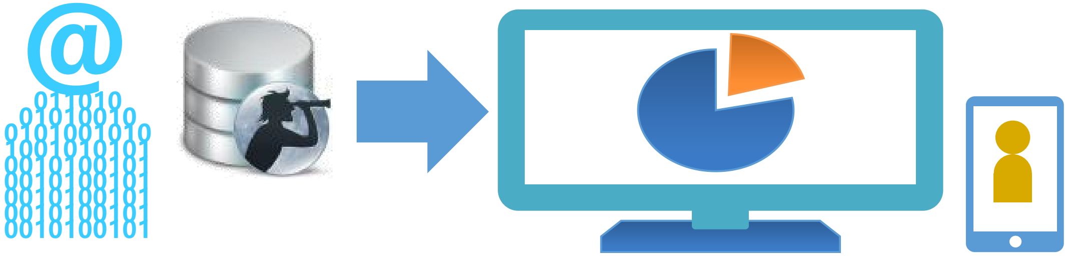
- with Geo-Spatial index, LunarBase supports range search as: **select records where payment >500 and payment < 2500:**

  docID = 1, Value = {name=michal, age=25, **payment**=800, date=20150728};
  docID = 2, Value = {name=frank, age=25, **payment**=1200, date=20150729};
  docID = 3, Value = {name=jackson, age=45, degree=master, address=somewhere, **payment**=2000};

Overview

Point and Range Query

Any Business Presentation



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  ……
  Millions of records matching the query in DB

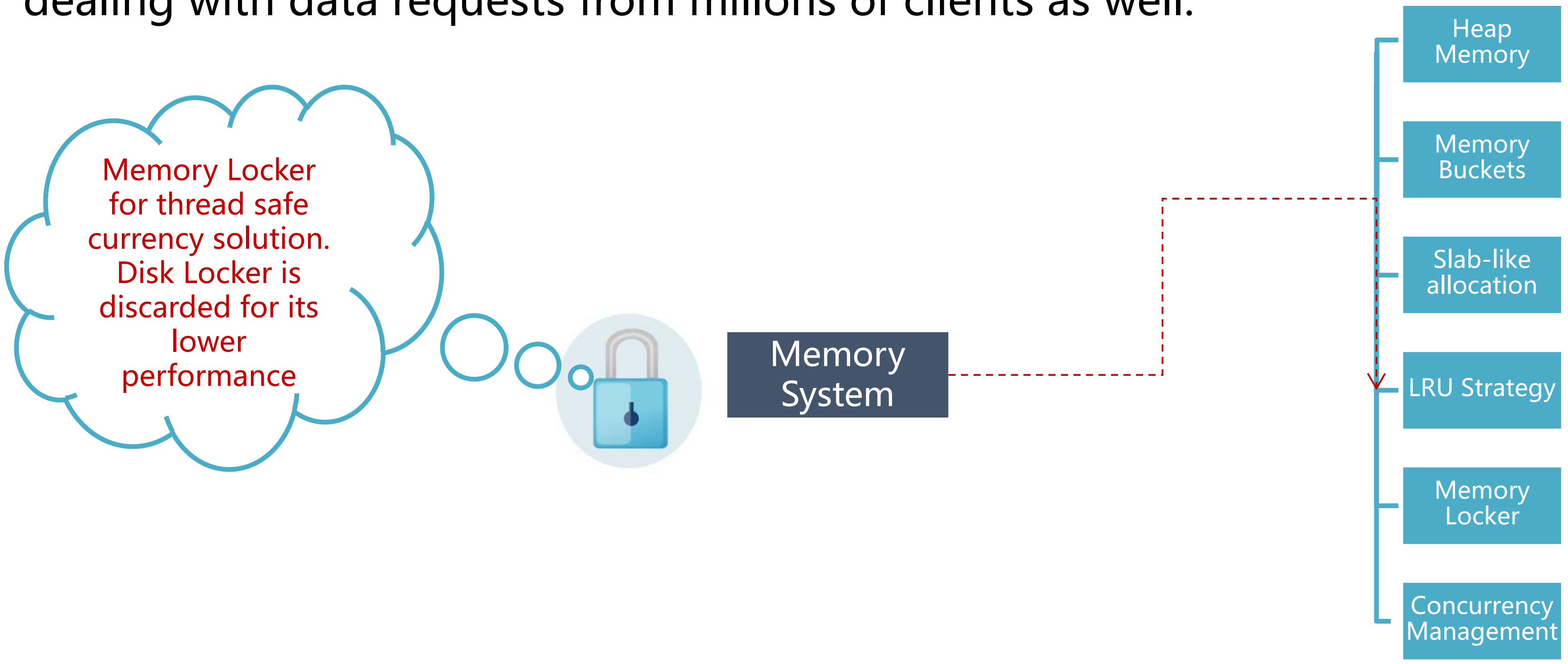
The query language is quite simple. Under the package of (LunarBaseTutorial)LCG.DBAPI, you will find a bunch of implementation of how to query. In practice, you need to implement your handler(this what we used special term for internal Event-Driven framework) to deal with query results like above. you my order them by the date, payment, or age. Check out how to do it under the package LCG.DB.EventHandler

Overview

Concurrent Architecture for multi-core

LunarBase = persistent storage system + big memory management sytem for cache:

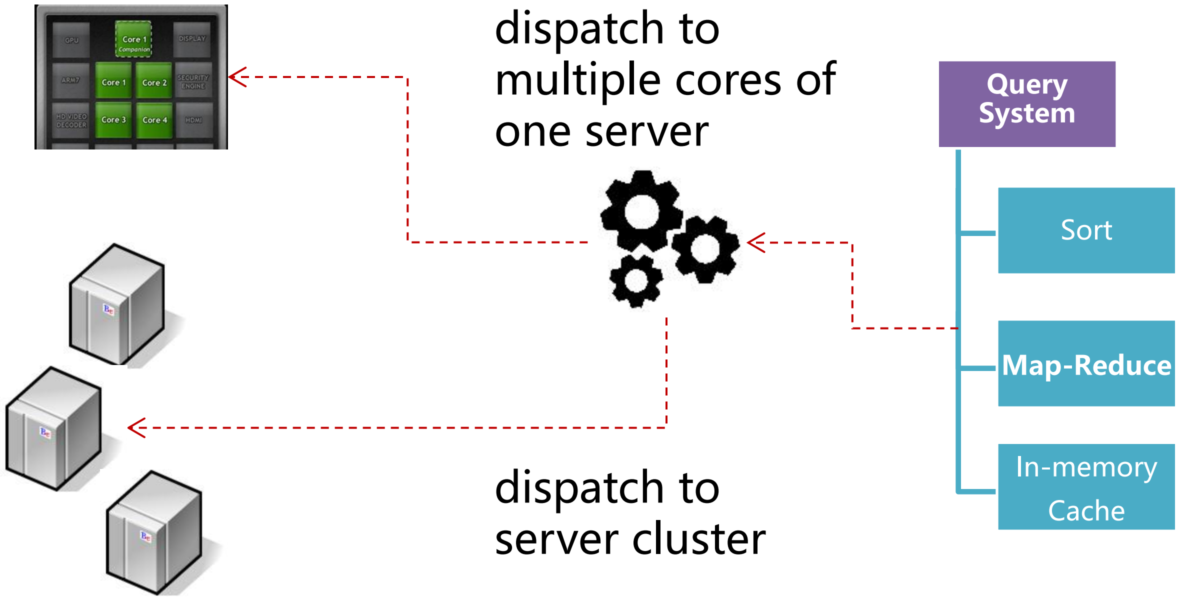
big memory system allocate memory for db usage, and implements concurrent model dealing with data requests from millons of clients as well.



Overview

Concurrent Architecture for multi-core

Map-Reduce is implemeted inside LunarBase. Tasks are automatically dispatched to multi-core or several server by task-center.



dispatch to multiple cores of one server

Query System

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In-memory Cache

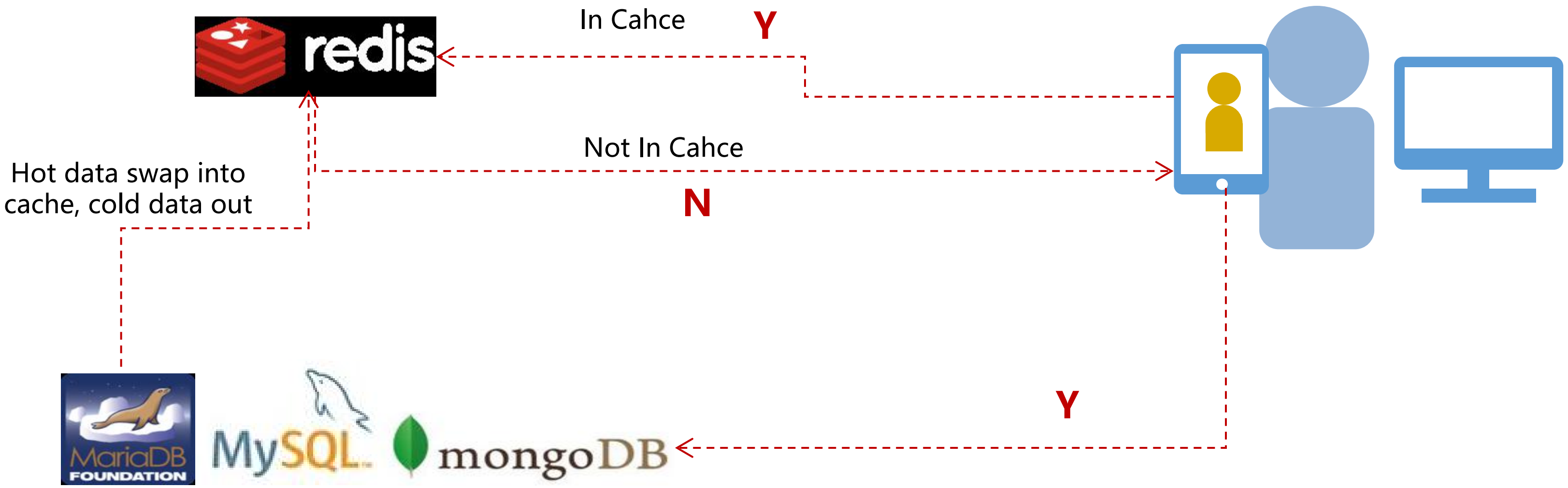
dispatch to server cluster

Overview

All in One

For high performance, deploy cache systems for a persistent DB storage is a common solution for various on-line applications. The following combinations are quite familiar:

1. k-v cache like memcached or redis + storage like mongo (or RMDBS like mysql, mariadb).
2. cluster of memory db + duplicated backup. One fails, another image take place. Discard the persistent solution.

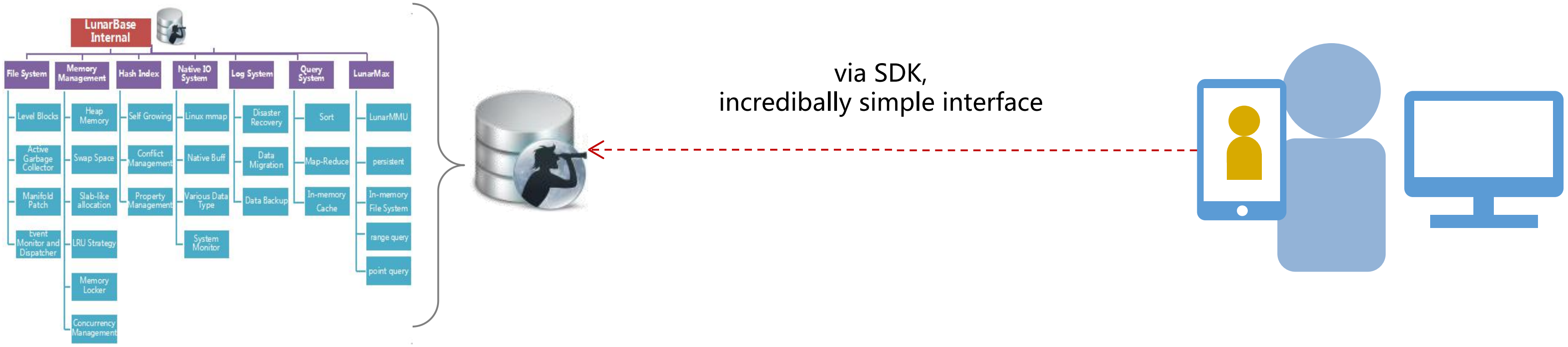


Overview

All in One

LunarBase = LunarMax + persistent storage system + big memory management sytem for cache:

1. Automatically manage hot and cold data, greatly simplify application development .
2. Deployment and maintainent became incredibally terse.
3. Solve data consistency between underlying tables and cache.
4. Therefor the cost decreases.



LunarBase Internal

File System
- Level Blocks
- Active Garbage Collector
- Manifold Patch
- Event Monitor and Dispatcher

Memory Management
- Heap Memory
- Swap Space
- Slab-like allocation
- LRU Strategy
- Memory Locker
- Concurrency Management

Hash Index
- Self Growing
- Conflict Management
- Property Management

Native IO System
- Linux mmap
- Native Buff
- Various Data Type
- System Monitor

Log System
- Disaster Recovery
- Data Migration
- Data Backup

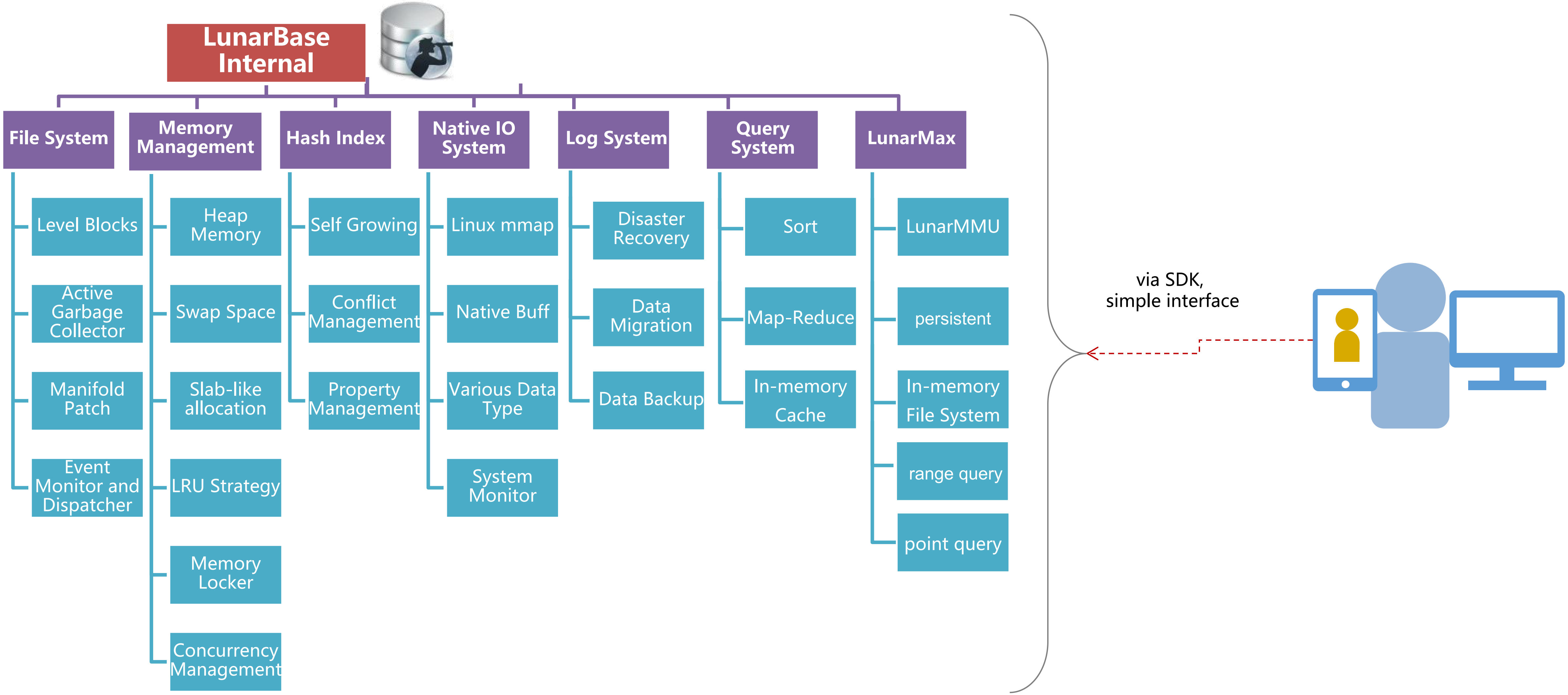
Query System
- Sort
- Map-Reduce
- In-memory Cache

LunarMax
- LunarMMU
- persistent
- In-memory File System
- range query
- point query

via SDK,
incredibally simple interface

Overview

All in One



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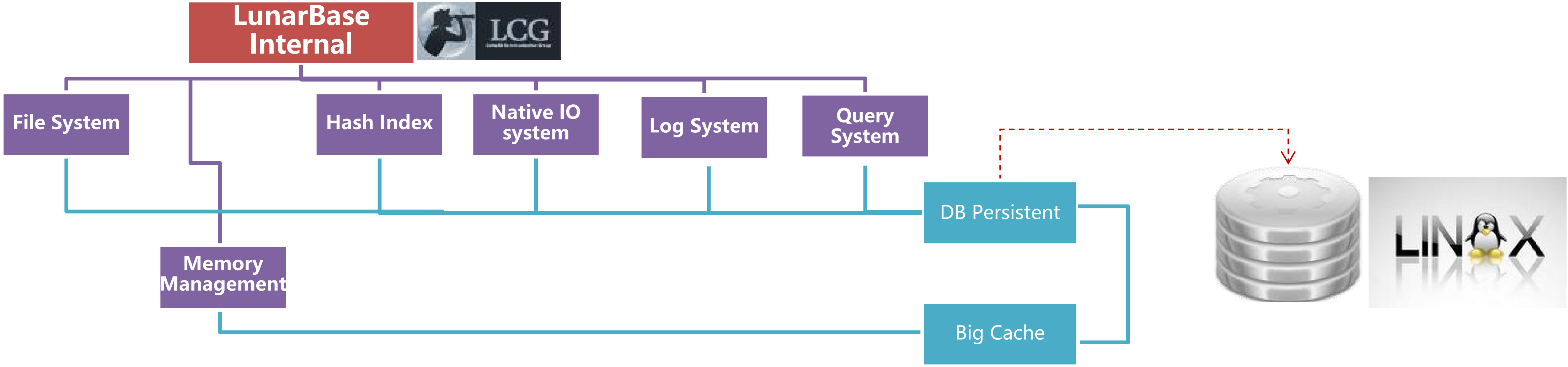
via SDK,
simple interface

Overview

All in one

LunarBase simplifies deployment



Overview

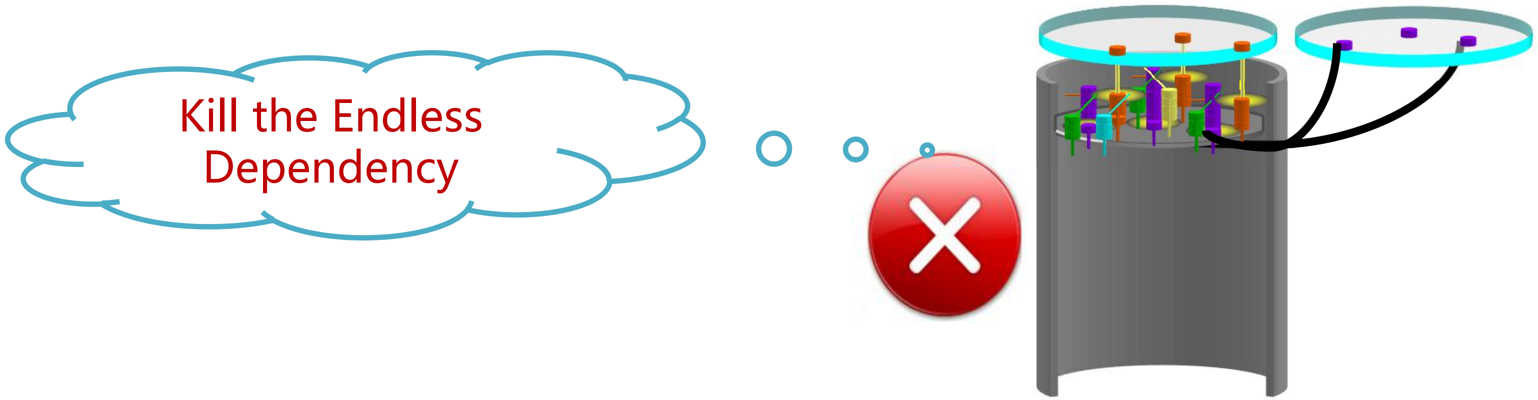
Little Dependency for Lower TCO

LunarBase has the duty to reduce the complexity of database server enviroment, therefor to reduce the TCO (Total Cost of Ownership) for any company. The dependency list is short:

1. OS: Linux on X86 hardware

2. JVM: IBM or Oracle

3. Network Communication Framwork (server version only): Netty



Kill the Endless Dependency

Overview

All in one

Embeded version is published as: jar packages, together with native C/C++ libararies and a bunch of command tools.

Server version is published as a DB server, equipted with a client driver for interacting with the LunarBase server. At present, java is the only language supportted . Other languages, php, scala, erlang, etc. are in developing.

Overview

Road Map

LunarBase is going to be :

1.0.0 Beta:

geo-spatial search, range search, Auto-Sharding, data migration, disaster recovery

2.0.0 Alpha:

LunarBase Server: running as an independent server, programmers operate LunarBase via a client driver (java driver), simple SQL language support, Interpreter for complex math formular in analysis

3.0.0 Alpha:

LunarBase cluster, nodes management, automatic backup, migration, load balance, disaster recovery among nodes, HA monitor, Cloud Platform based on LunarBase

4.0.0 Alpha:

Cluster management and Monitor system, UI to lower the management cost

5.0.0 Alpha:

Support real time big data processing, this functionality may appear before version 5, Cloud Platform Commercialize

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Architecture

Blueprint

Log System

Hash Storage

Slab-like Memory Management System

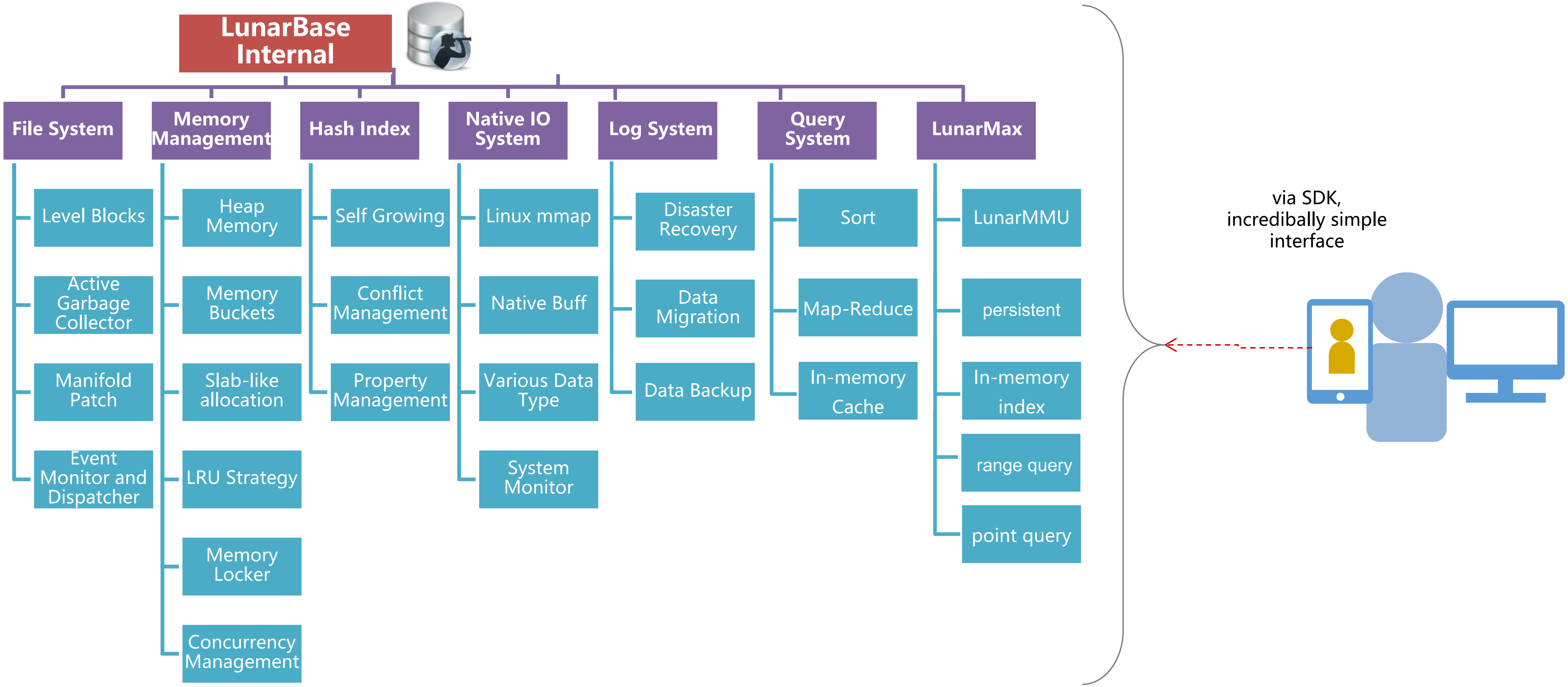
LunarMax for Real time analysis

Lunar File System

Active Block Garbo for SSD

Architecture

Blueprint



- **LunarBase Internal**
  - **File System**
    - Level Blocks
    - Active Garbage Collector
    - Manifold Patch
    - Event Monitor and Dispatcher
  - **Memory Management**
    - Heap Memory
    - Memory Buckets
    - Slab-like allocation
    - LRU Strategy
    - Memory Locker
    - Concurrency Management
  - **Hash Index**
    - Self Growing
    - Conflict Management
    - Property Management
  - **Native IO System**
    - Linux mmap
    - Native Buff
    - Various Data Type
    - System Monitor
  - **Log System**
    - Disaster Recovery
    - Data Migration
    - Data Backup
  - **Query System**
    - Sort
    - Map-Reduce
    - In-memory Cache
  - **LunarMax**
    - LunarMMU
    - persistent
    - In-memory index
    - range query
    - point query

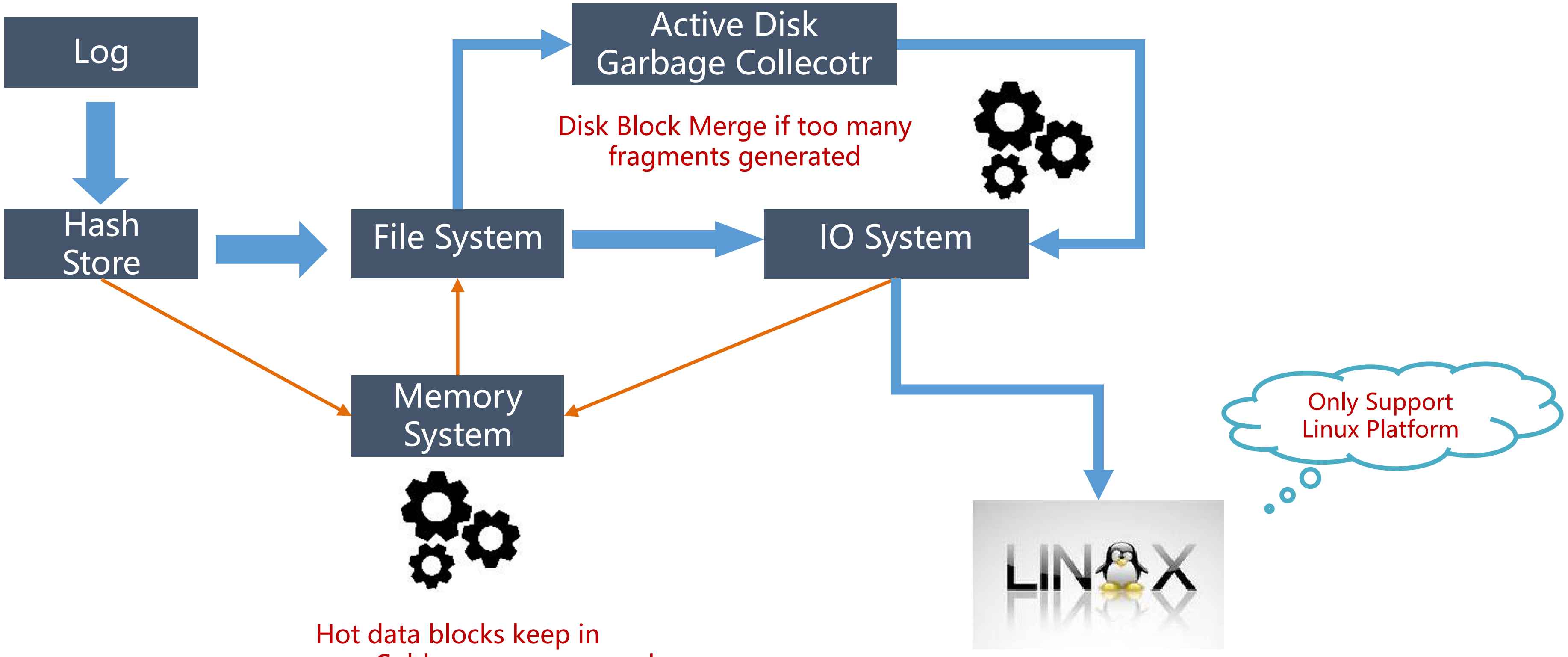
via SDK,
incredibly simple
interface

Architecture

Blueprint

- records in simple JSON formart:

{name=jack, age=30, payment=500, date=20150728};
{name=michal, age=25, payment=800, date=20150728};
{name=jackson, age=45, degree=master, address=somewhere, payment=2000};
……



Disk Block Merge if too many fragments generated

Only Support Linux Platform

Hot data blocks keep in memory, Cold ones are swapped out. LRU strategy is applied

Architecture

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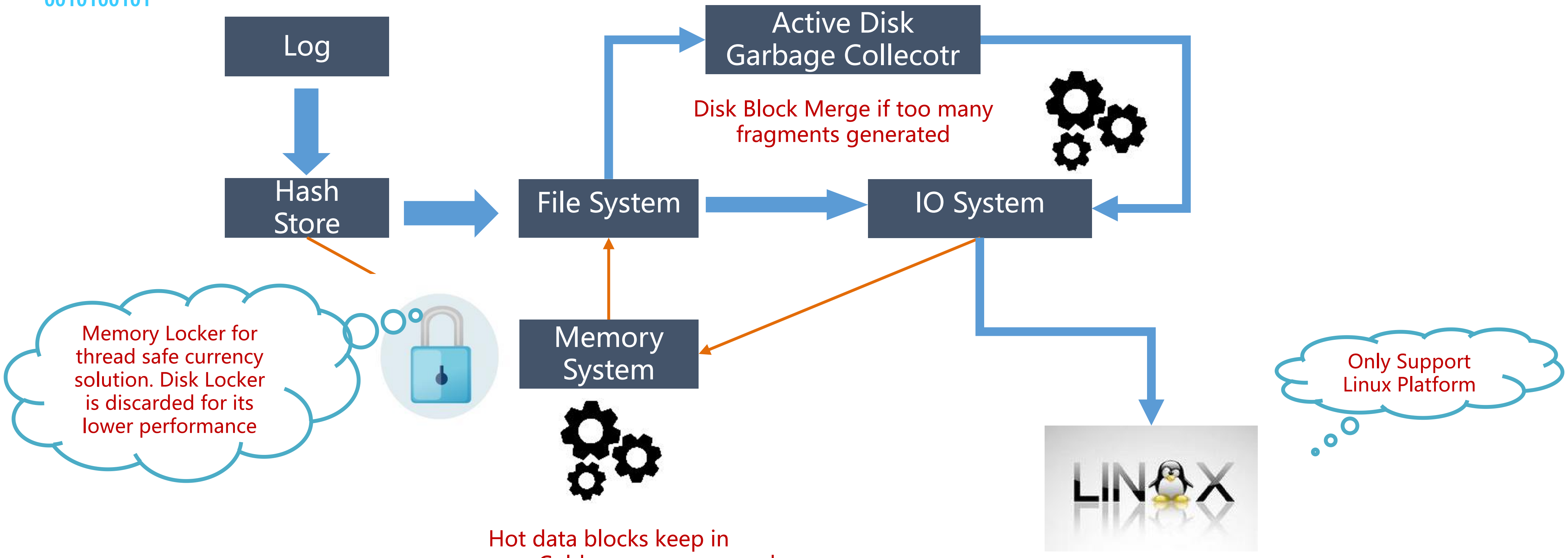


Log

Hash Store

File System

IO System

Active Disk Garbage Collecotr

Memory System

Disk Block Merge if too many fragments generated

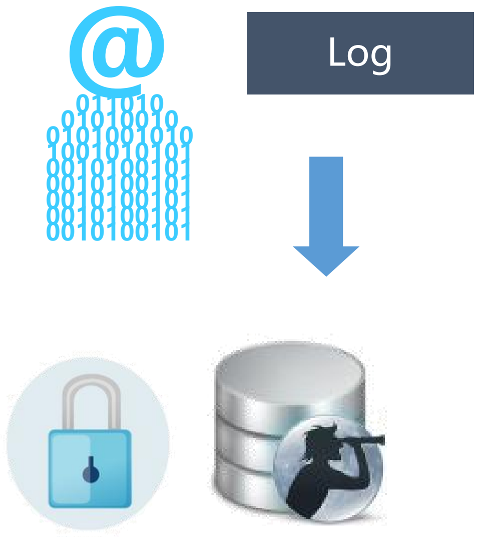
Memory Locker for thread safe currency solution. Disk Locker is discarded for its lower performance

Only Support Linux Platform

Hot data blocks keep in memory, Cold ones are swapped out. LRU strategy is applied

Architecture

Log system



➢Log system is first of all we implemented, every command user commits is recorded before excute real database operation:

succeed@ **insert**: {name=jack, age=30, payment=500, date=20150728};
succeed@ **insert:** {name=michal, age=25, payment=800, date=20150728};
succeed@ **insert:** {name=jackson, age=45, degree=master, address=somewhere, payment=2000};
……

it is the key component for:
disaster recovery,
data migration,
data duplication,
consistent check
…………..

Architecture

Lunar Virtual File System

The virtual file system defines levels of blocks, which is configurable to db administrators:
Level 0: block size 64 bytes
Level 1: blcok size 512 bytes
Level 2: block size 4096 bytes = 4K
Level 3: block size 32K
Level 4: block size 256K
Level 5: block size 2048K = 2M
Level 6: block size 16M

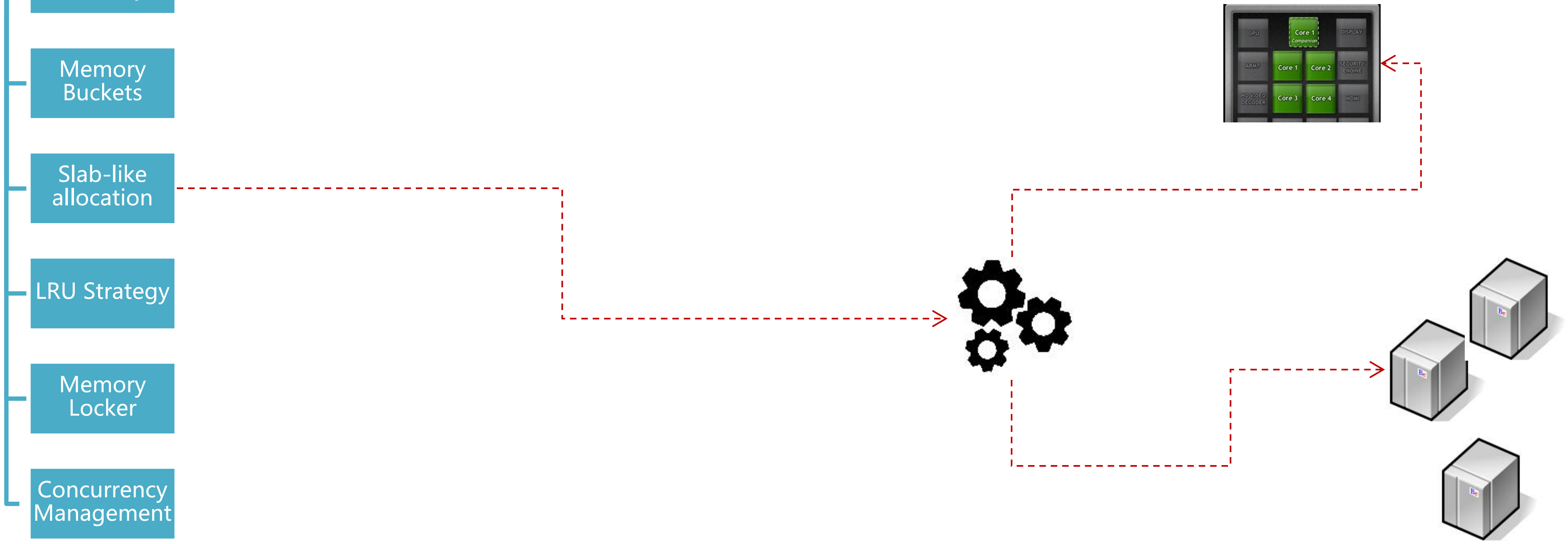
Total 7 levels are supported. Objects acquire disk spaces from Lunar VFS, and Lunar VFS decides how many blocks is needed and how much of each size. As an example, we assume a requirement of 5K space, Lunar VFS follows a certain rule and allocates:
1 4K block + 2 512-bytes blocks.

Of course, they are chained if they belong to one object

LunarMax

Manage your billions of small objects

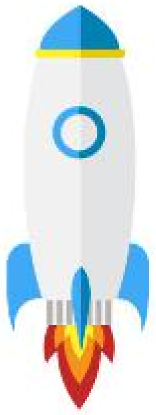
Java claims it can do this for programmers, then we have GC. But in most of cases, in mission critical tasks, GC stops the world. In 64-bit time, a cheap server has several billions of memory, but jvm can only provide you small portion of it. That's a bit waste.



- physical Memory
- Memory Buckets
- Slab-like allocation
- LRU Strategy
- Memory Locker
- Concurrency Management

LunarMax

In-process off heap storage



Control off-heap memory via java interfaces in LunarMMU.jar

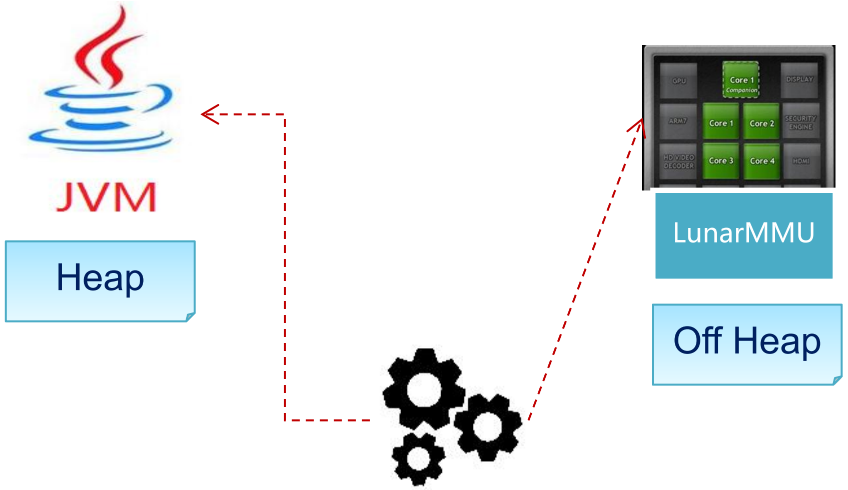
10~100X hot data on a single server, fully digging the potential of one machine.

cost effective scaling - 1000X faster than disk.

LunarMax supports 2 types of memory:

1. small objects with short lift cycle.

2. Big memory disk that stores data for a long time running.



目录

Performance

vs. Lucene for fulltext search

vs. Mysql for range query and k-v query

vs. Hadoop+HBase for throughput and k-v query

vs. Lucene

Benchmark

Hardware:

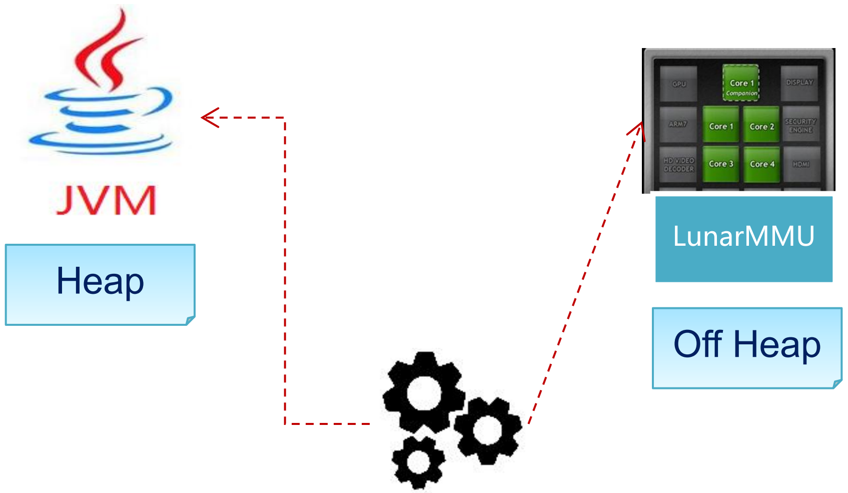
CPU: ntel(R) Core(TM) i5-6200U@2.30GHZ 2.40GHZ
Mem：4096MB
OS：ubuntu16.04
JDK：1.8.0_101
Lucene version：6.2.0
LunarBase version：0.8.2
disk：SSD

Dataset:

documents: 2M, 10M, 20M

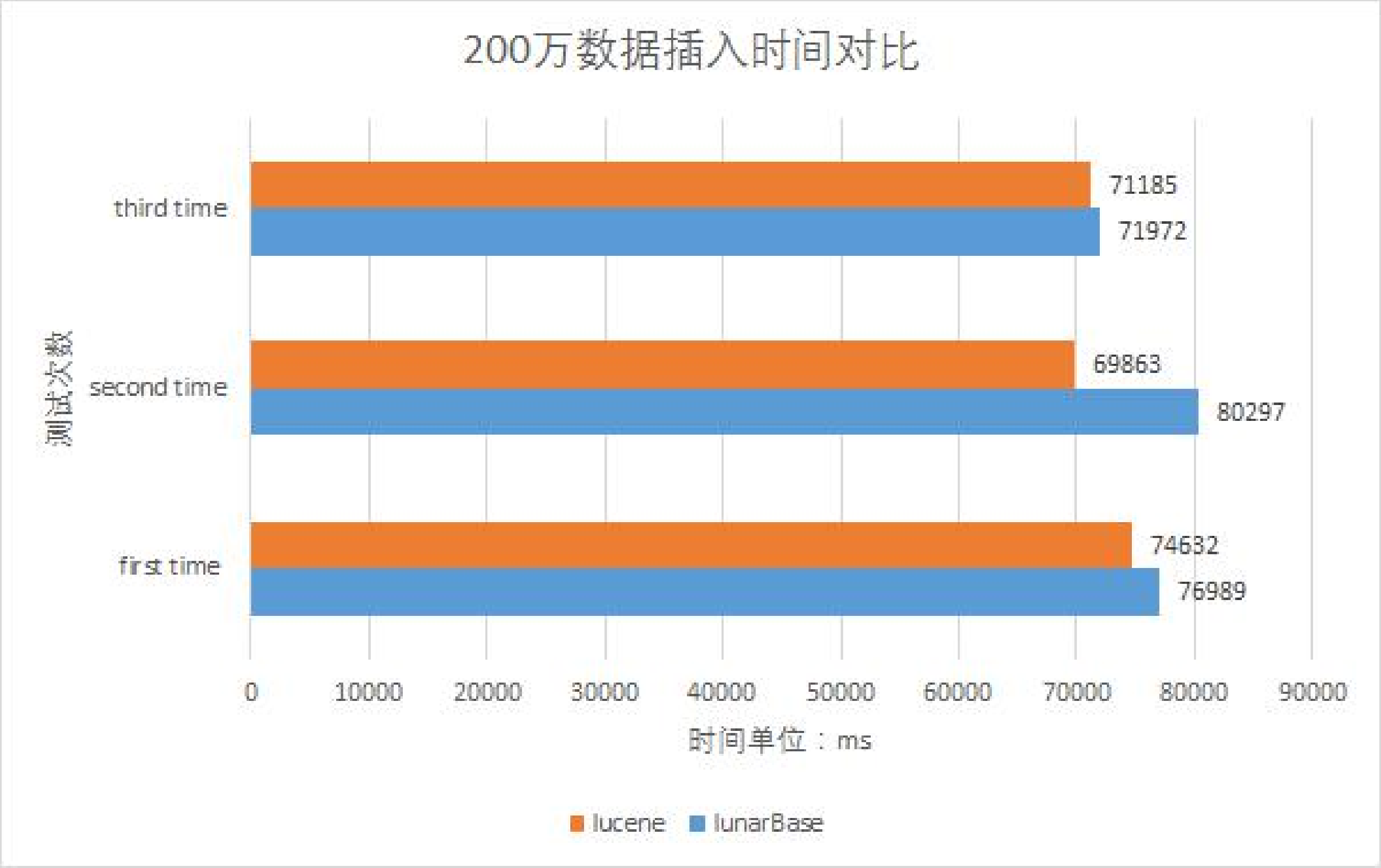
each with: ~1000 words

content includs: blog articals, letters, papers, reports that crawled from internet.



vs. Lucene

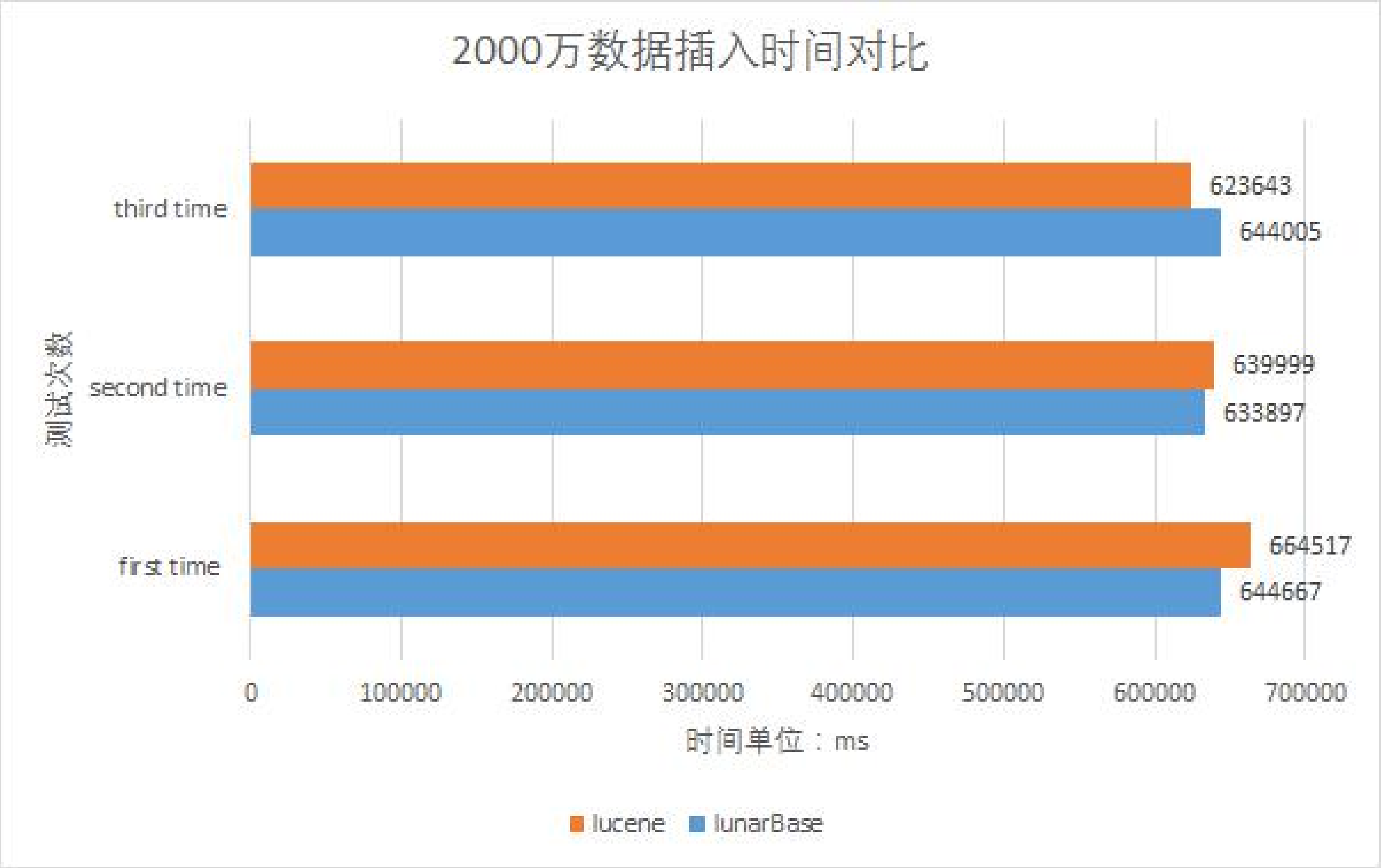
Insert



insert 2M records costs around 71 seconds. LunarBase and lucene has almost equal time to finish the job

vs. Lucene

Insert



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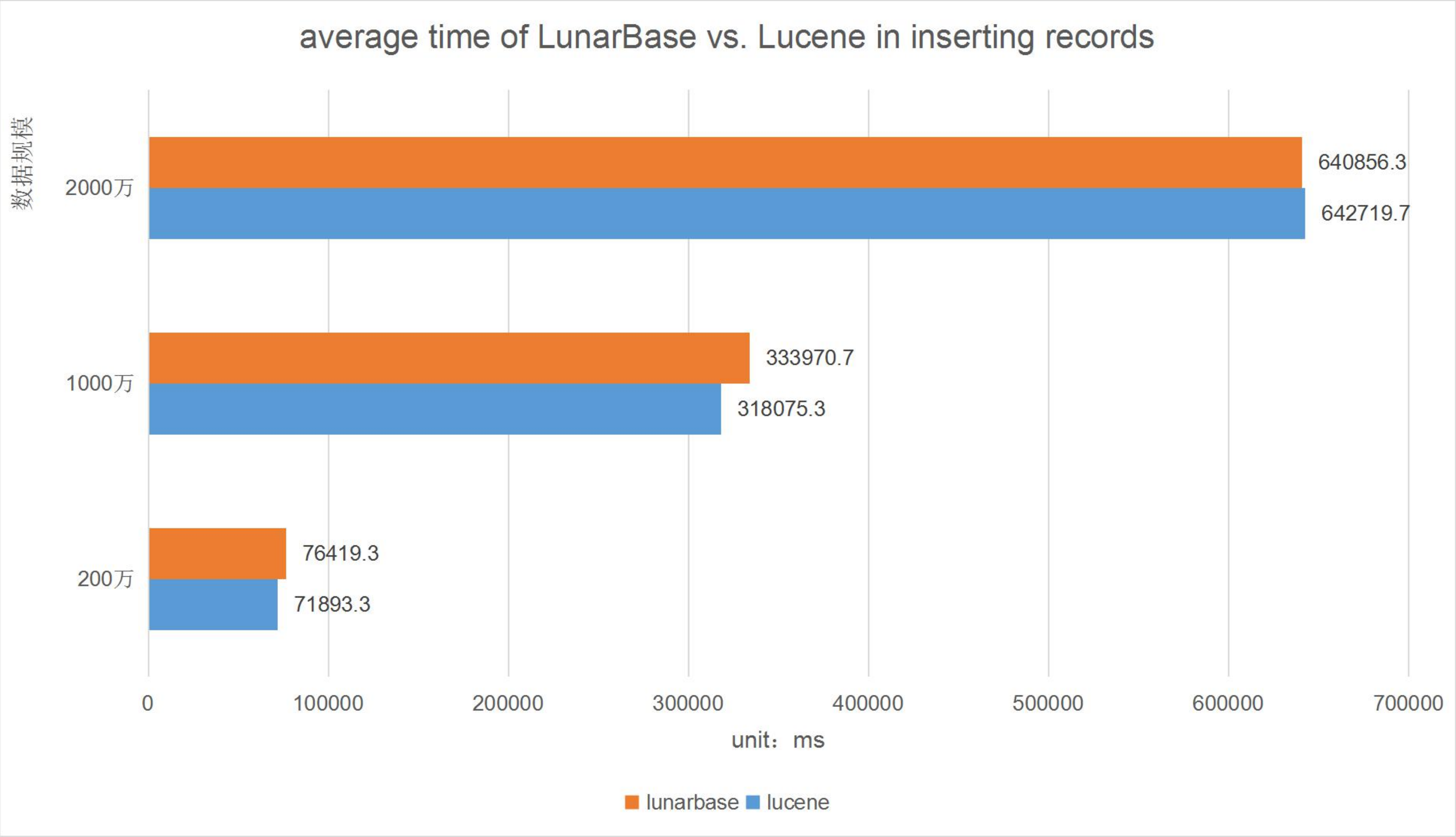
vs. Lucene

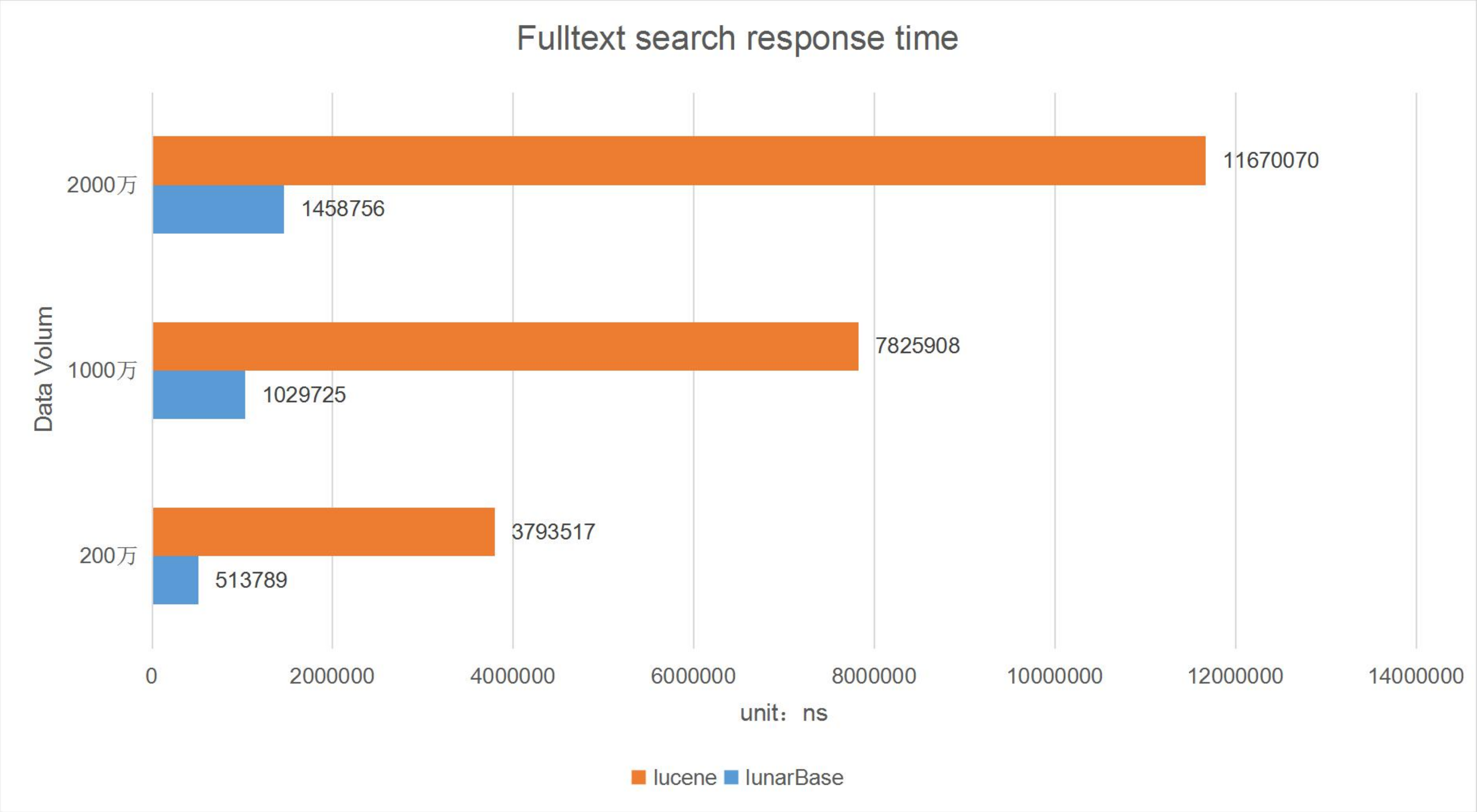
Insert



average time of insert., the two have close performance.

vs. Lucene

fulltext search



for 20M records, lucene costs 11.6ms to get results, while Lunarbase just takes 1.5ms;

for 10M records, lucene costs 7.8ms to get results, while Lunarbase just takes 1.0ms;

for 2M records, lucene costs 3.8ms to get results, while Lunarbase just takes 0.5ms;

Thank You

LCG

Lunarion Consultant Group, Co., LTD.