WED3O03

MADOCA II Data Logging System Using NoSQL Database for SPring-8

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NoSQL

OR: How I Learned to Stop Worrying and Love Cassandra

Outline

- SPring-8 logging database
- Why NoSQL, why Cassandra
- Implementation
- Production Run

SPring-8 Logging database

- Relational database system (RDBMS) has been used since 1997
- Grows from 871 signals to 27,626 signals (end of 2014)
- 7,000 signal inserts per seconds
- 4TB raw data at end of 2014
- SACLA (X-ray FEL) is also using it

SPring-8 Logging database

- What made the system live long?
  - Uniform data store
  - Simple access

SPring-8 Logging database

- What made the system live long?
  - Uniform data store
    - Every data
    - Every time
    - in one database
  - Simple access

SPring-8 Logging database

- What made the system live long?
  - Uniform data store
  - Simple access
    - Just Key + time range access

```
get (“sr_mag_ps_b/current_adc”,
        “2014/10/10 19:24:12”,
        “2014/10/10 22:00:00”)
```

RDBMS to NoSQL

- For the next generation SPring-8-II
- We changed logging database for SPring-8 from RDBMS to a NoSQL database; Cassandra
- Why NoSQL, Why Cassandra ?

RDBMS is great

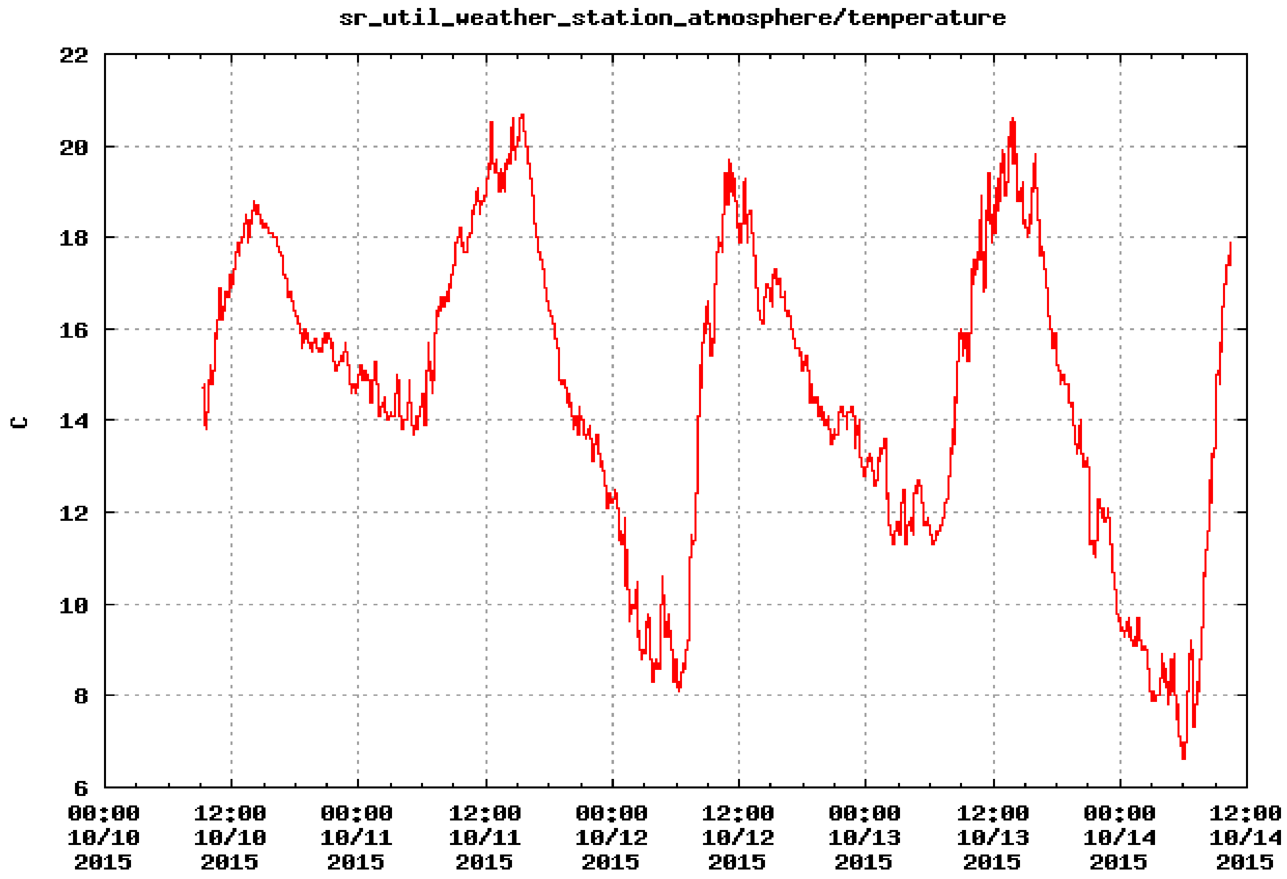
- We are currently using RDBMS for
  - Configuration management
  - Parameter management
  - Alarm record
  - Etc
- But,

RDBMS limitation in logging

- Performance
- Scalability
- Availability
- Flexibility

Logging in Accelerator Control

- Time series data



Logging in Accelerator Control

- Time series data
- Write many and rare read

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- Is RDBMS is suitable for this task?

Logging in Accelerator Control

- Time series data
- Write many and rare read
- Is RDBMS is suitable for this task?
- Looking for new database
  - Keeping advantage of the old system
  - Make up for its shortcomings

NoSQL (Not only SQL)

- Simplicity of design, simpler "horizontal" scaling to clusters of machines, which is a problem for relational databases, and finer control over availability. (Wikipedia)

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NoSQL variations

  - Key-value
  - Graph
  - Document
- No solutions for time-series data in above NoSQL
- Wide-column

Wide-column database

- One type of NoSQL (Not only database)

Row Key

sig1:20130504

sig2:20130504

sig3:20130504

Column key

Column value

Wide-column database

- Columns are added when data added.

Row Key	Column
sig1:20130504	t0 value0
sig2:20130504	
sig3:20130504	

Column key

Column value

Wide-column database

- **Columns are added when data added**

Row Key	Column	
sig1:20130504	t0	t1
	value0	value1
sig2:20130504	T'0	
	Value'0	
sig3:20130504	T''0	
	Value''0	

Column key

Column value

Wide-column database

- Row is added at any time

Row Key	Column			
sig1:20130504	t0	t1	t2	Column key
	value0	value1	value2	Column value
sig2:20130504	T'0	T'1		
	Value'0	Value'1		
sig3:20130504	T''0			
	Value''0			
sig4:20130510				

Wide-column database

- And it grows

Row Key	Column				
sig1:20130504	t0	t1	t2	t3	**Column key**
	value0	value1	value2	value3	**Column value**
sig2:20130504	T'0	T'1	T'2		
	Value'0	Value'1	Value'2		
sig3:20130504	T"0				
	Value"0				
sig4:20130510	T"0				
	Value'"0				

Wide-column database

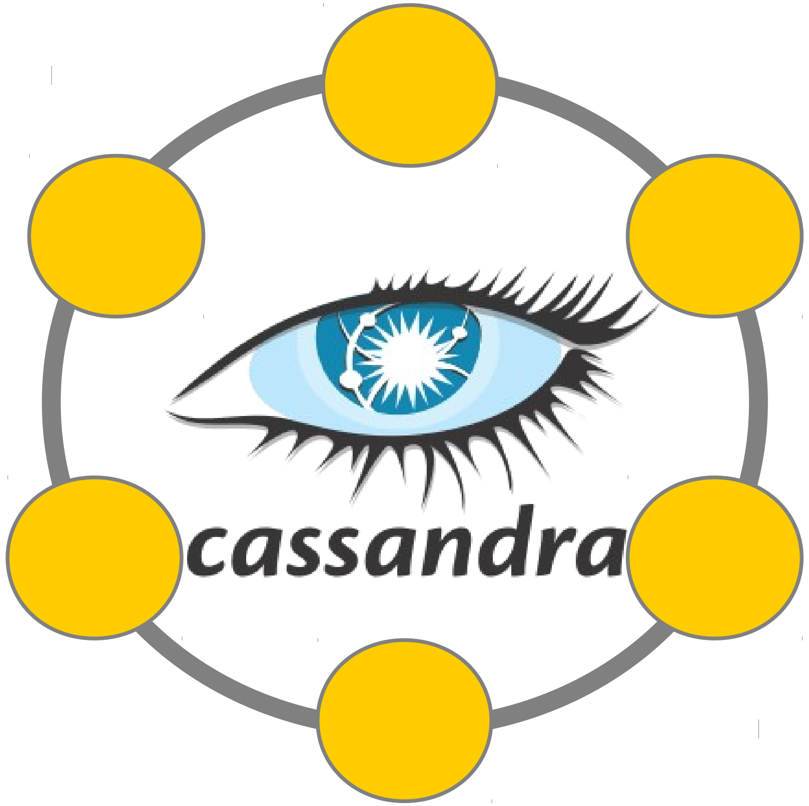
- Suitable for time-series data logging
  - Each data has its own time-stamp
    - cyclic data + event driven data in same place
  - Access
    - Key+ column range
      - same as current access method

Which Wide-column DB?

- Major wide-column database
  - Apache Cassandra
  - Apache Hbase
  - Hypertable

Apache Cassandra

- We select by its availability
- Every node has the same role
  - No master node
    - No single point of failure (SPOF)
    - HBase and Hypertable have masternode: SPOF



Apache Cassandra

- Our criteria
  - Reliability
  - Scalability
  - Flexibility
- Consistency is covered by the other DB

Reliability

- **Most essential**

Reliability

- Most essential
- Cassandra
  - No master node, no single point of failure
  - Data redundancy
    - 3 data replicas

Scalability

- Just add nodes when you need more power
  - No cluster reboot is needed
- Apple is operating 100,000 node cluster for iTunes

Flexibility

- Insert at any time

Flexibility

- Insert at any time
  - Signal by signal

Flexibility

- Insert at any time
- Data type

Flexibility

- Insert at any time
- Data type
  - Store data using object serialization
    - Not using cassandra's data type
    - blob type column only

Flexibility

- Insert at any time
- Data type
  - Store data using object serialization:MessagePack
    - Very fast
    - Low overhead 8 Byte float -> 9 Byte string
    - Self described
      - NO Interface Definition Language like Protocol Buffer

Consistency

- Cassandra does not guarantee consistency
- In our cluster, it takes about 1 second after insert to obtain consistent value.
  - No real-time access

Redis

- Covers Cassandra's inconsistency

Redis

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- Stores newest data only

Redis

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- In-memory key-value database

Redis

- Covers Cassandra's inconsistency
- Stores newest data only
- In-memory key-value database
  - Very fast by key access
  - Newest value+ meta data only
  - Data packed by MessagePack

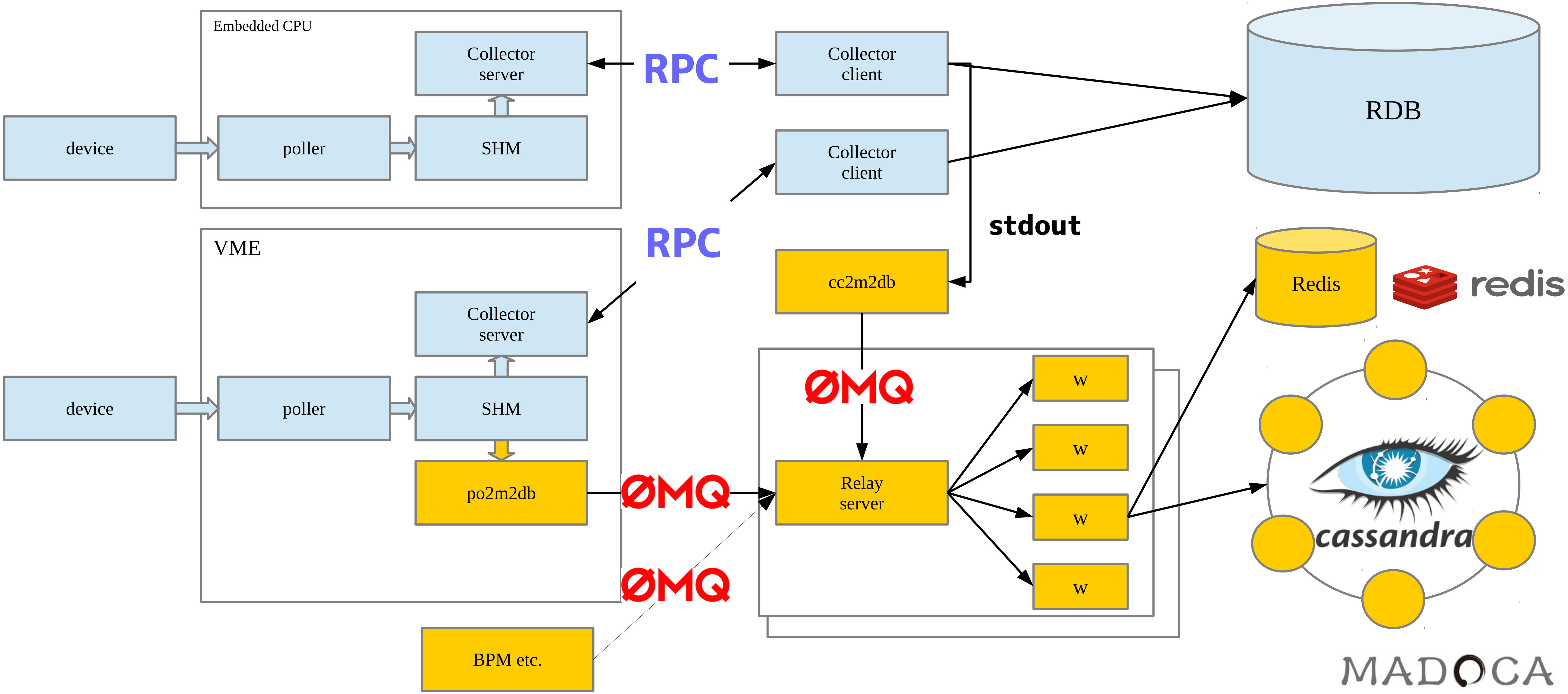
Redis

- Covers Cassandra's inconsistency
- Stores newest data only
- In-memory key-value database
- Two redis servers are running in parallel for redundancy

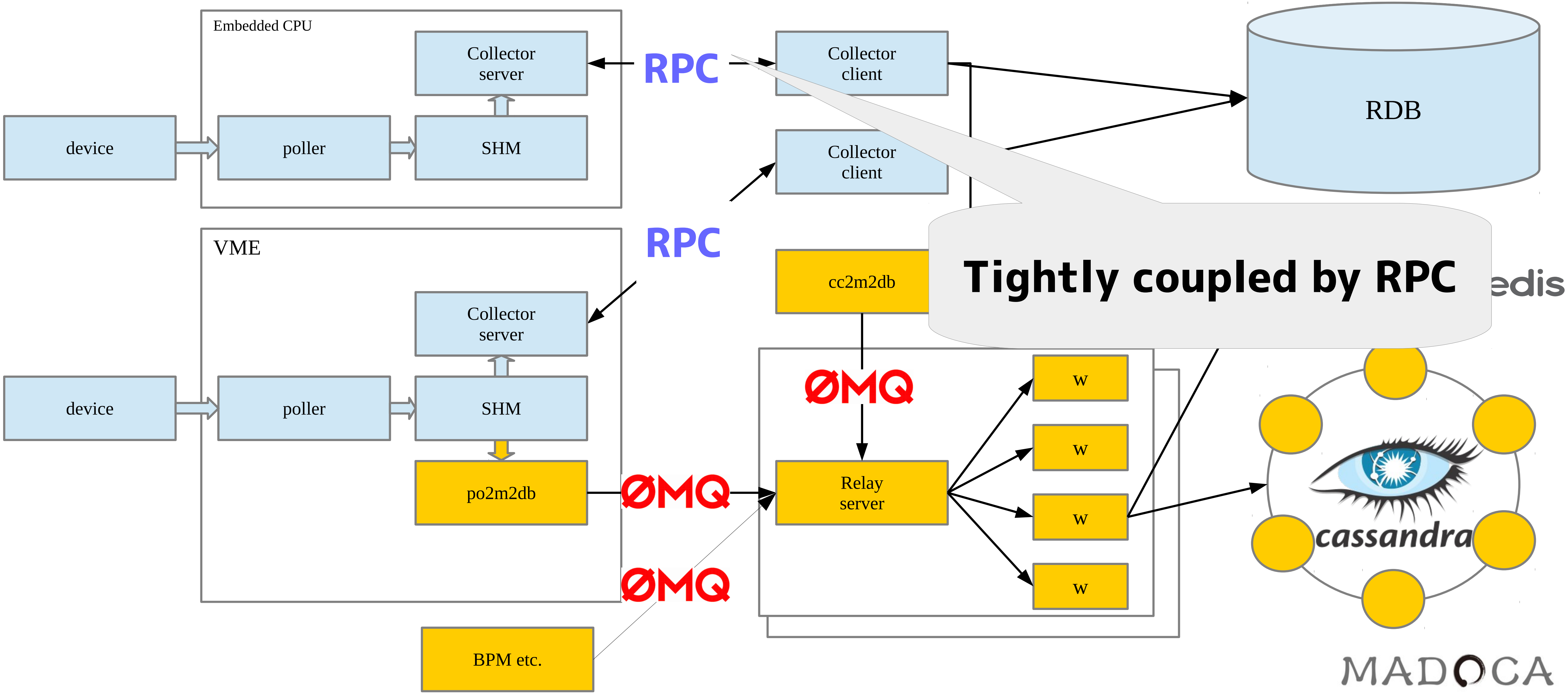
Implementation

- Data acquisition system
- Cassandra structure
- Performance

Entire system

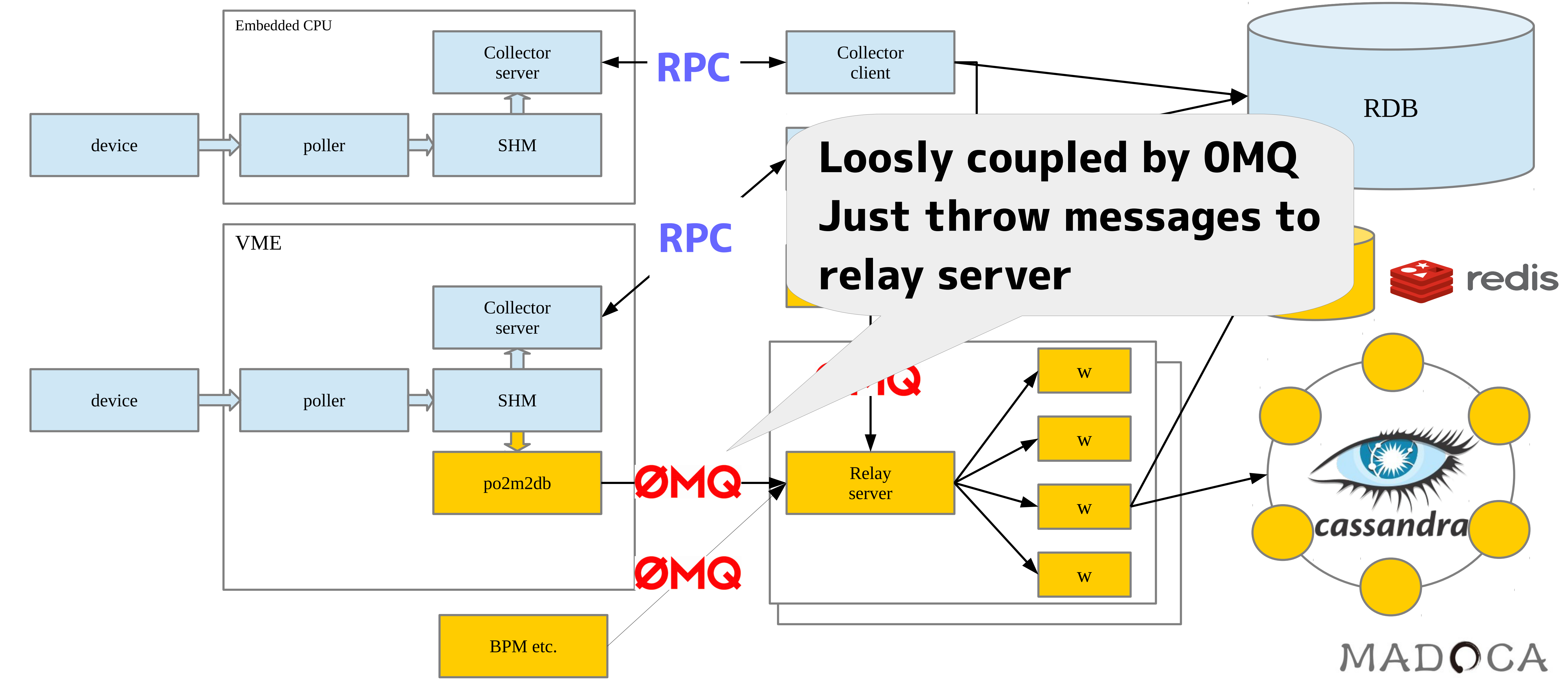


Entire system



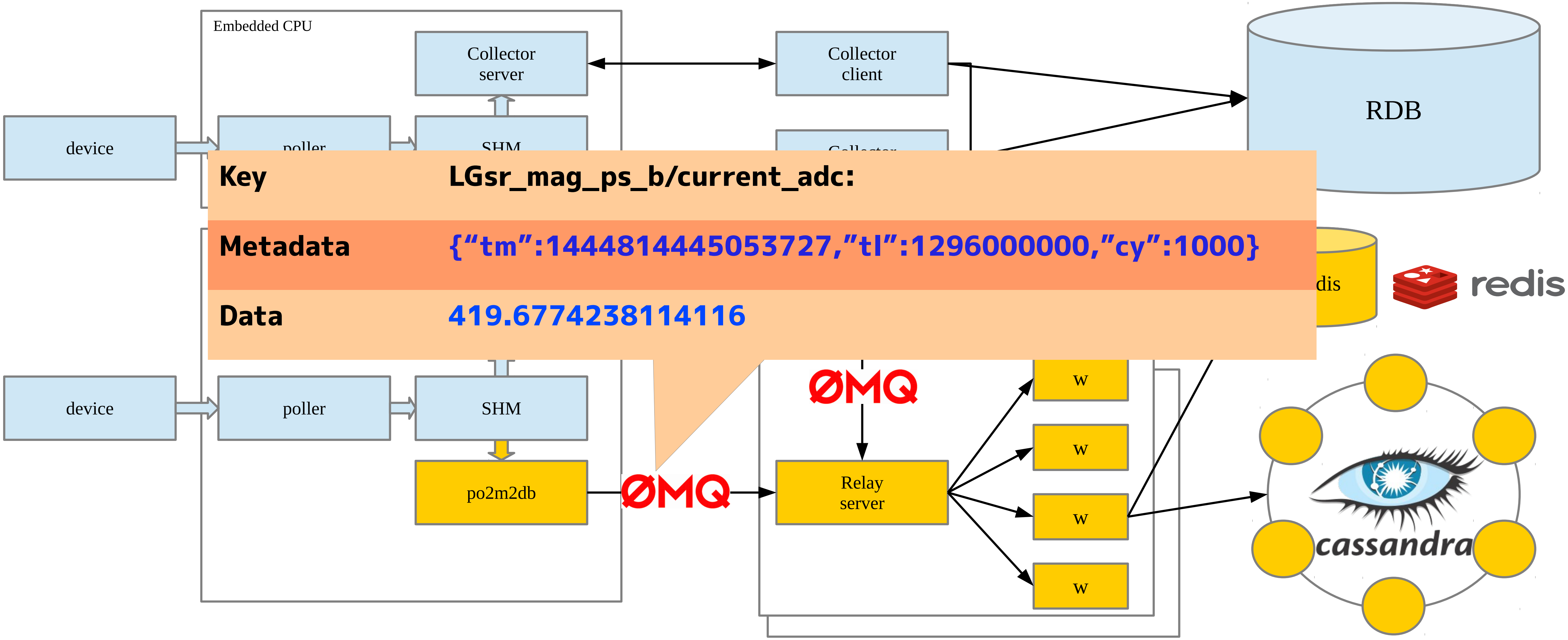
Tightly coupled by RPC

Entire system



Loosly coupled by 0MQ
Just throw messages to relay server

Message creation



Key	**LGsr_mag_ps_b/current_adc:**
Metadata	**{"tm":1444814445053727,"tl":1296000000,"cy":1000}**
Data	**419.6774238114116**

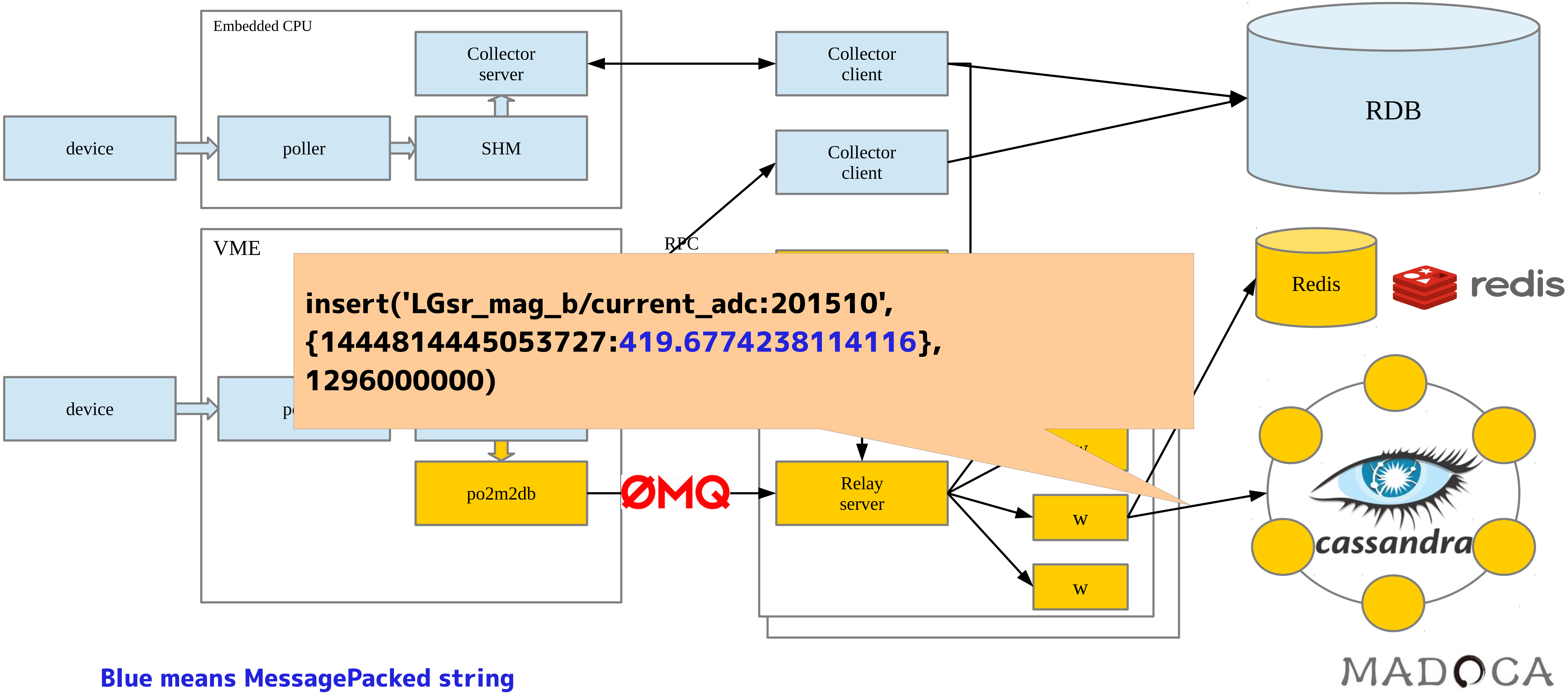
Message structure

- 3 part message

Key	LGsr_mag_ps_b/current_adc:
Metadata	{“tm”:1444814445053727,”tl”:1296000000,”cy”:1000}
Data	419.6774238114116

- Key: raw string
- Metadata and data are packed by MessagePack

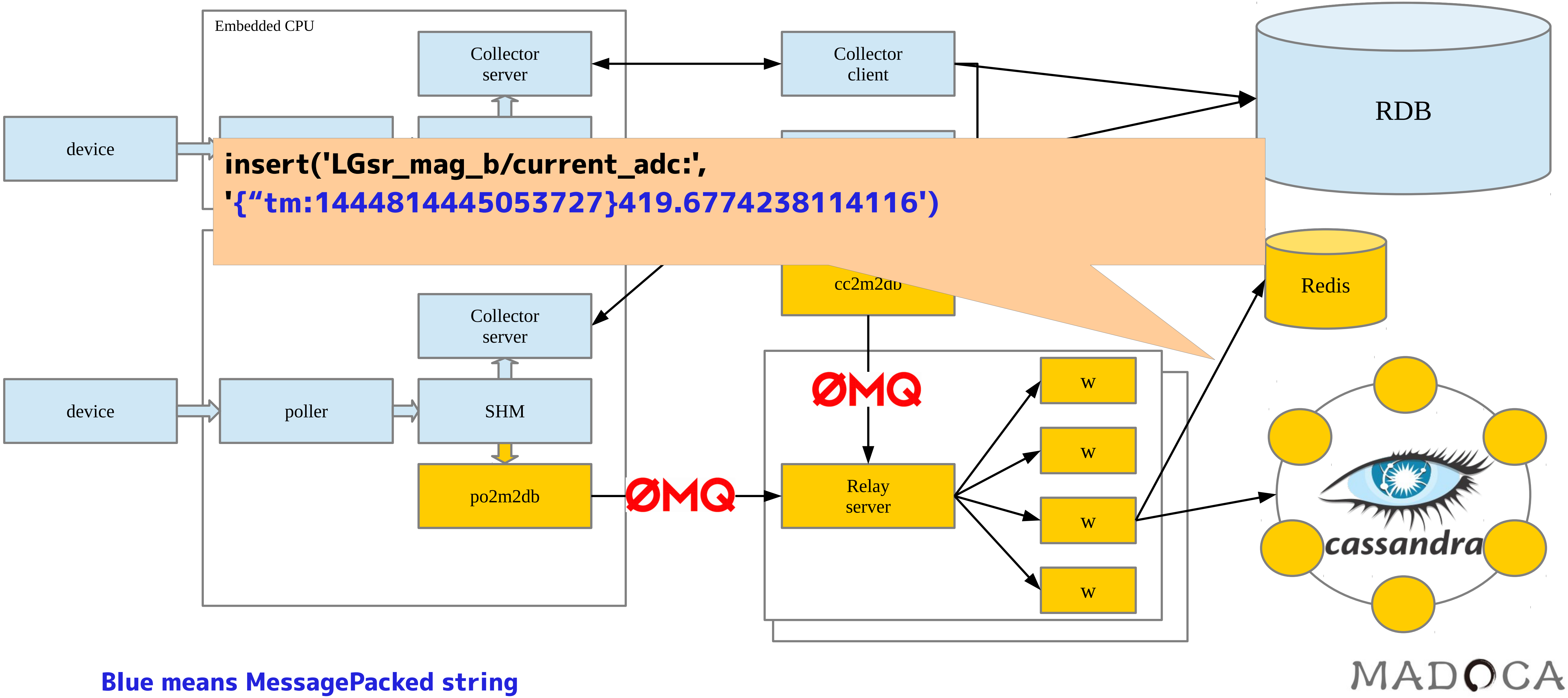
Convert to Cassandra command



insert('LGsr_mag_b/current_adc:201510',
{1444814445053727:419.6774238114116},
1296000000)

Blue means MessagePacked string

Convert to Redis Command

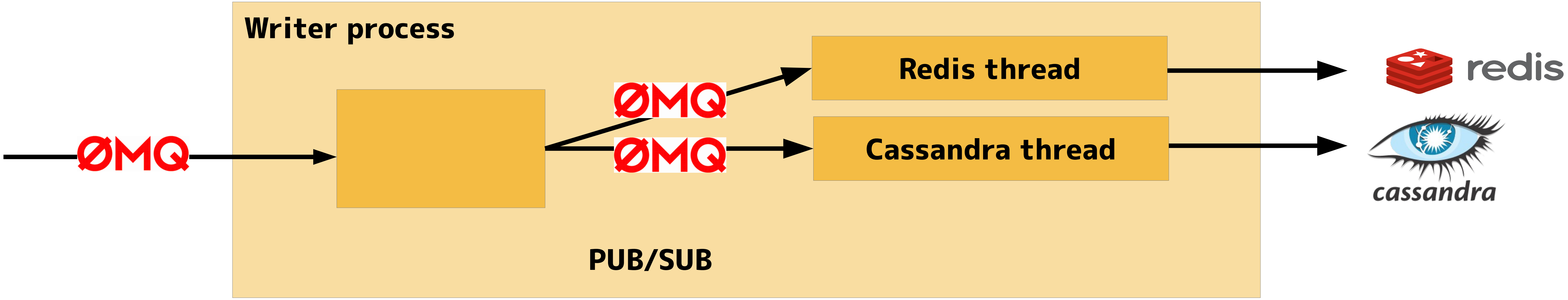


insert('LGsr_mag_b/current_adc:', '{“tm:1444814445053727}419.6774238114116')

Blue means MessagePacked string

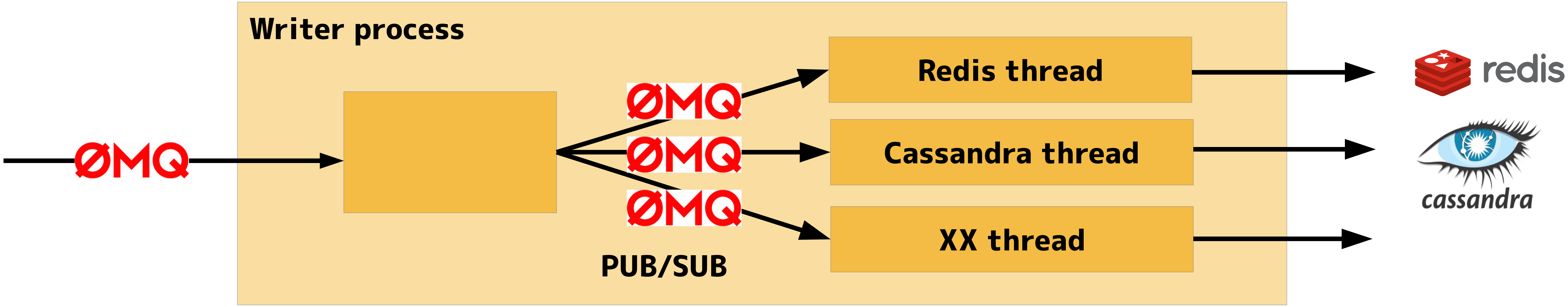
Writer

- Converts messages to insert commands
- Plug-in structure using 0MQ's in-process pub/sub



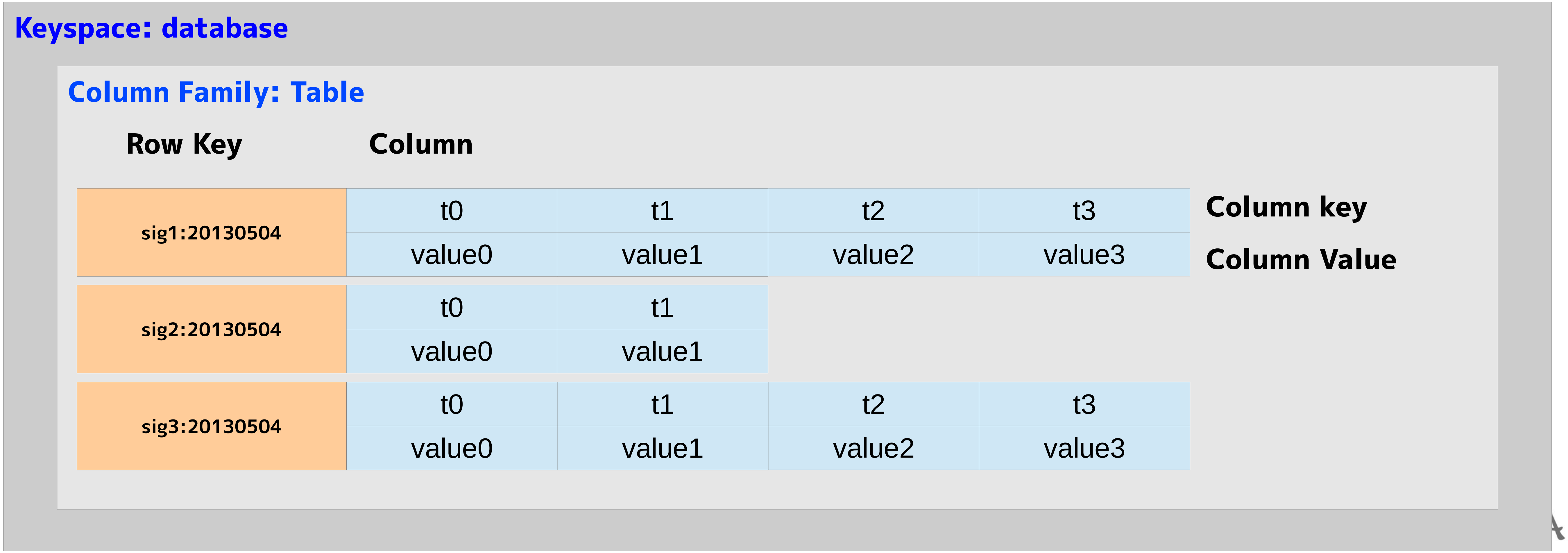
Writer

- Converts messages to insert commands
- Plug-in structure using 0MQ's in-process pub/sub
  - Other DB engine or anything may be added in the future



Structure of Cassandra

- key : one key / one signal one day
- LGsr_mag_ps_b/current_adc:20151003

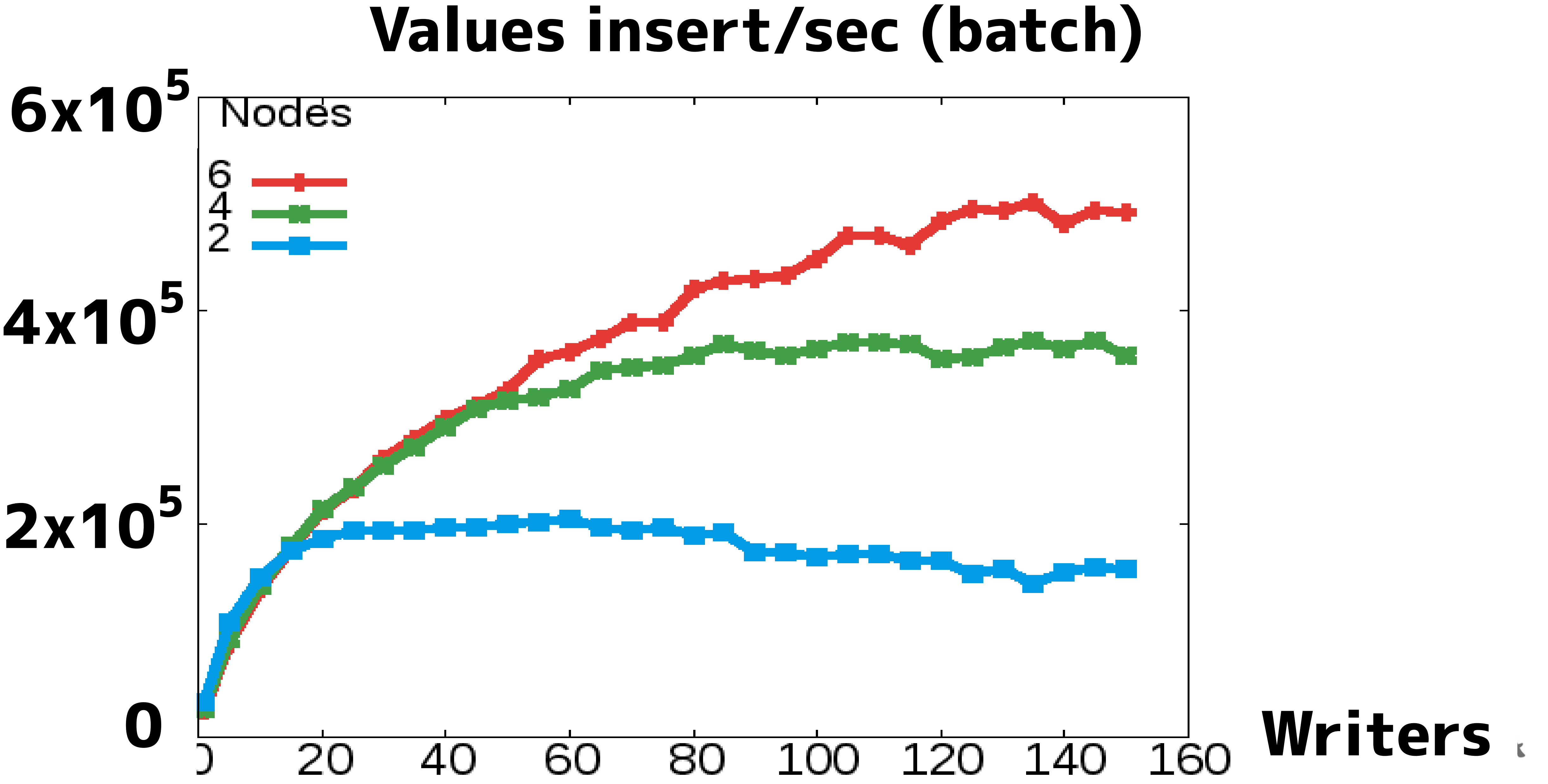


Keyspace: database

Column Family: Table

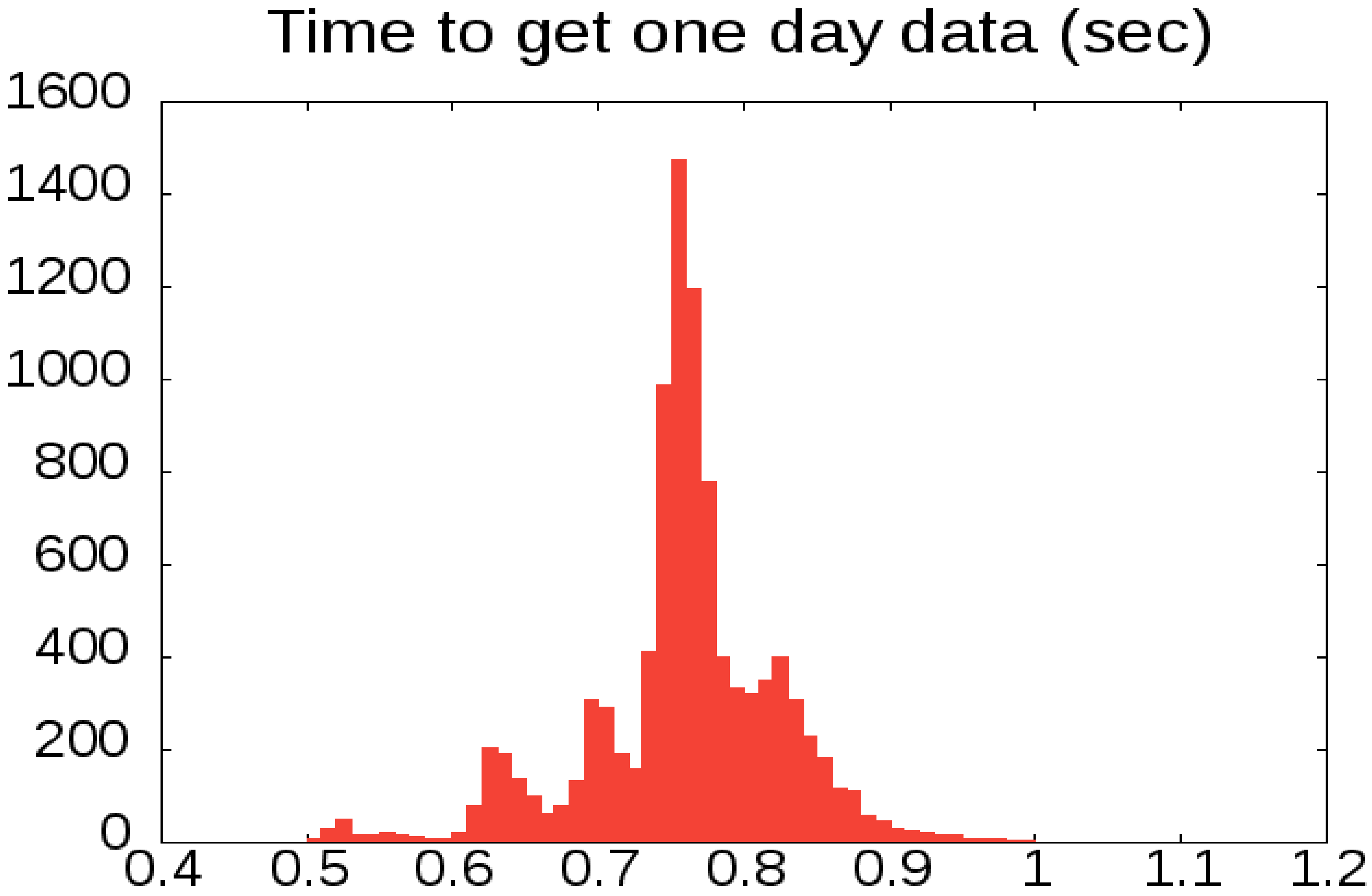
Row Key	Column				
sig1:20130504	t0	t1	t2	t3	Column key
	value0	value1	value2	value3	Column Value
sig2:20130504	t0	t1			
	value0	value1			
sig3:20130504	t0	t1	t2	t3	
	value0	value1	value2	value3	

Performance; write to Cassandra



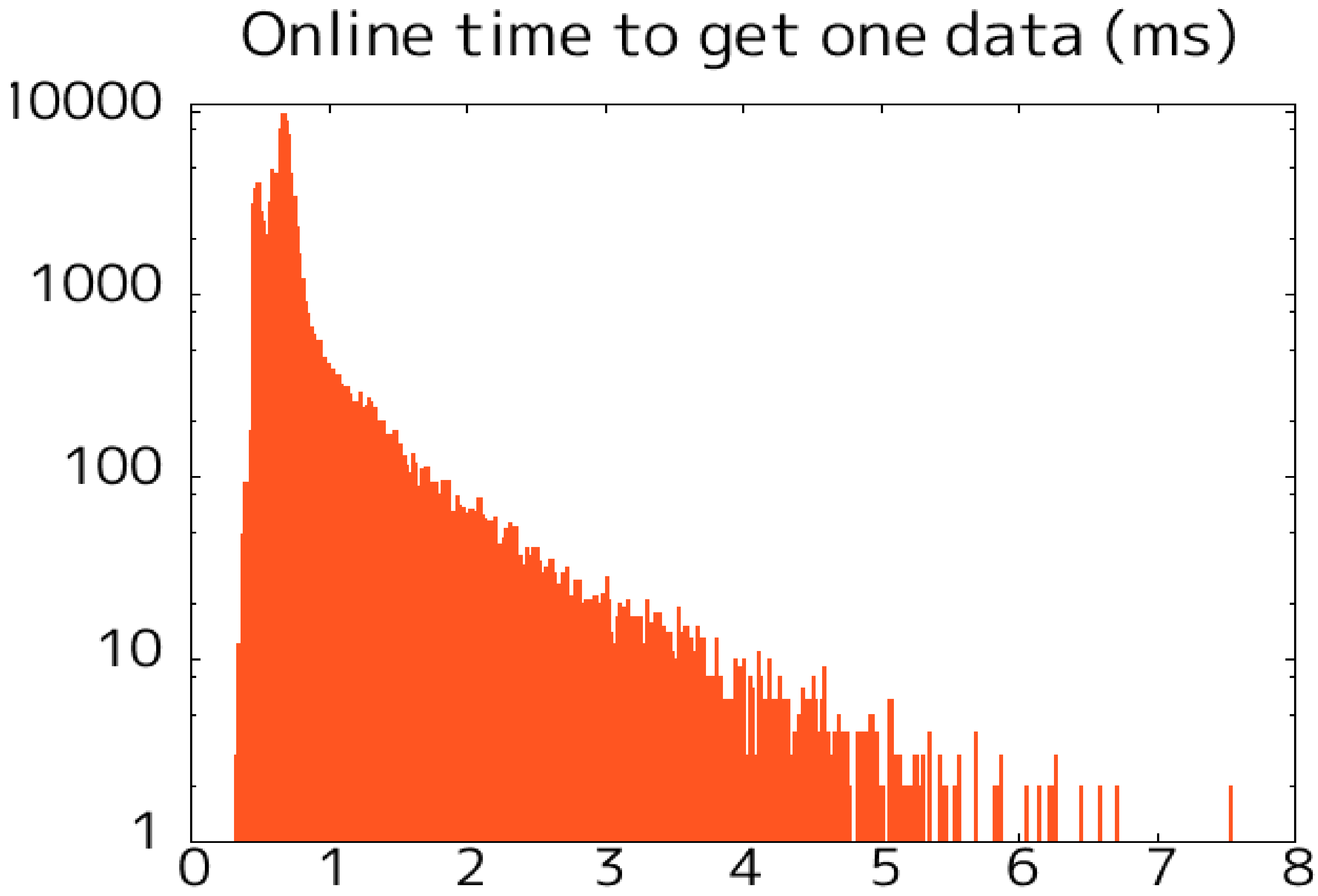
Read from Cassandra

- One day data = 60s*60min*24hour
- Done during normal writing operation



Mean	0.76sec
Sigma	0.06sec
95%	0.86sec

Read from Redis



Mean	0.77ms
Sigma	0.47ms
95%	1.4ms

One year Test

- Test performed about one year
- No major trouble
  - Test
    - Forced to shutdown a node and recovery
- Some modification are needed for the production run

For production run

- Data migration from RDBMS
- Structure modification
- Monitoring tools
- Client libraries
- Node added

Data migration from RDBMS

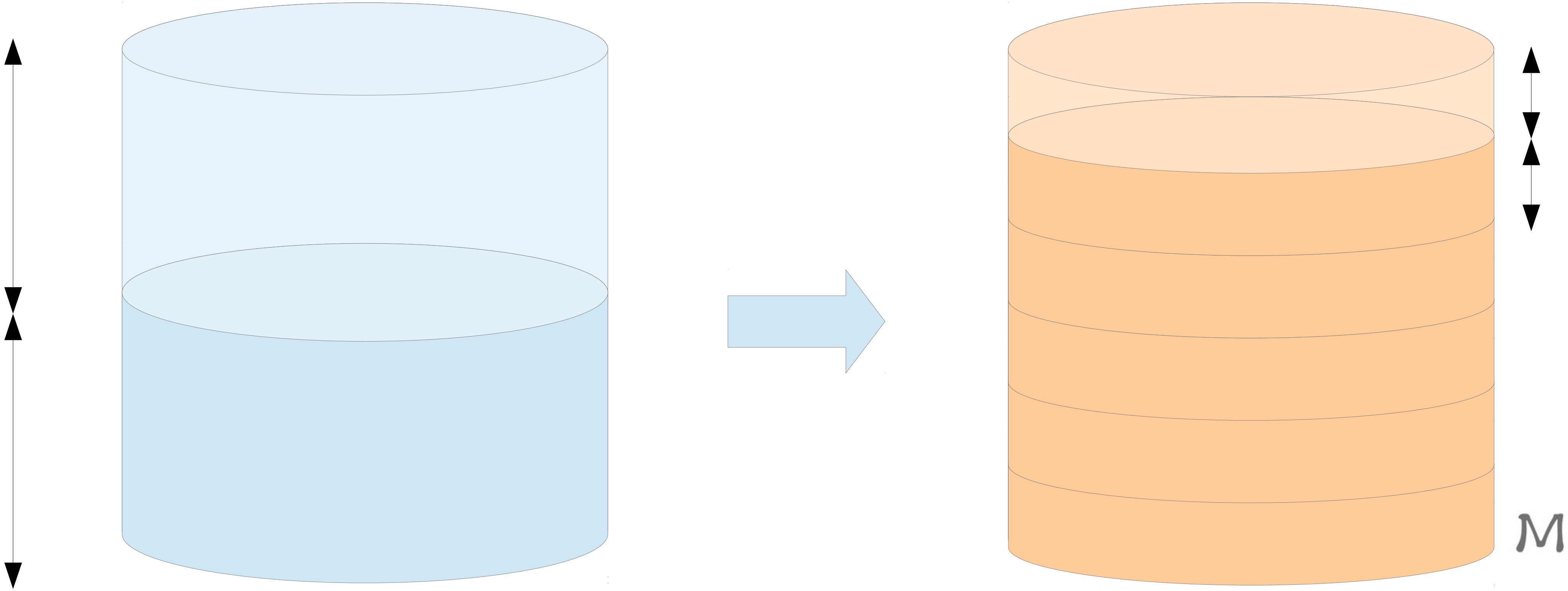
- Data since 1997
  - 4TB in RDBMS (logical file size, become larger in RAID disks)
  - 0.75TB/node 9TB in total in 12 nodes (3 replicas)

Structure changed

- One large column family was divided into small column families of each month
  - Cassandra's compaction operation
    - Batch operation
    - Columns that marked as “delete” are deleted at this time.

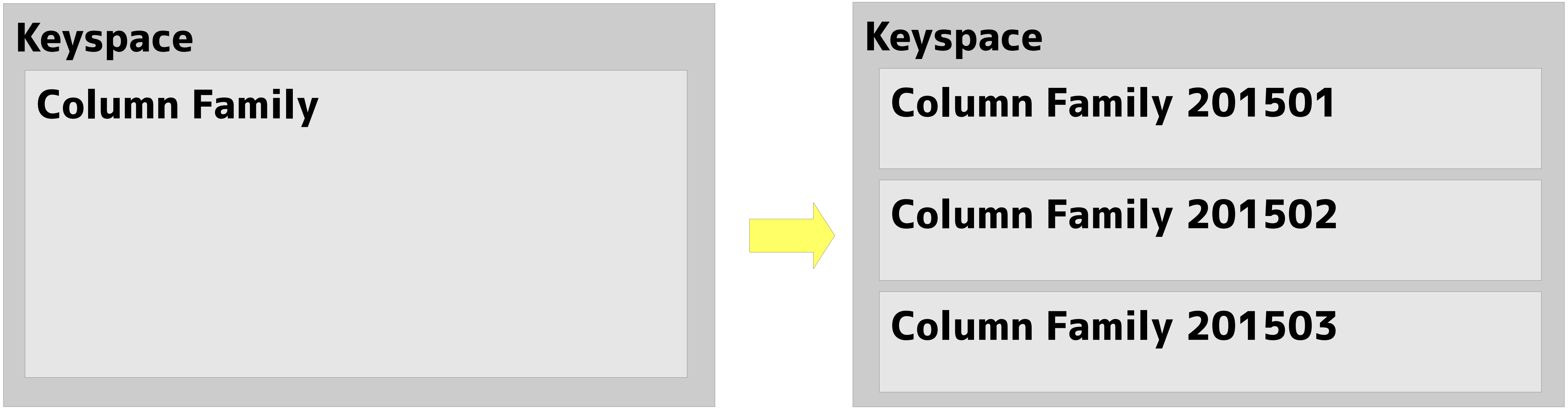
Temporary disk space for compaction

- One column family needs same size temporary disk space at compaction.
- One big column family cannot be larger than ½ disk space.



Structure changed

- One big column family was divided into small column families of one month



Keyspace

Column Family

Keyspace

Column Family 201501

Column Family 201502

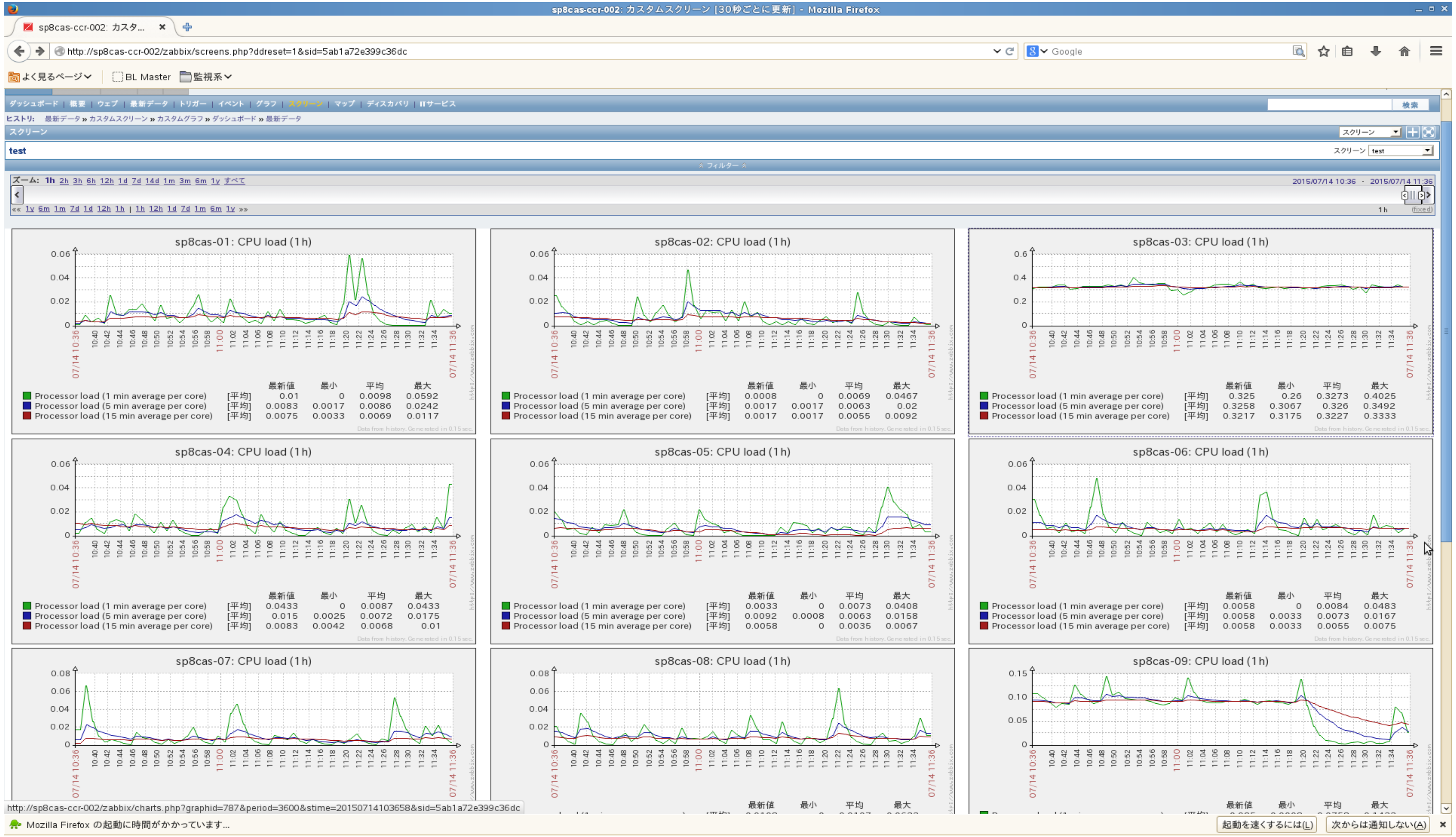
Column Family 201503

- Backup becomes easy by copying separate files

Monitoring tool

- Server system monitoring by Zabbix.
  - Not only SNMP but also JXM
    - Cassandra is written by JAVA
    - JAVA VM monitoring
- DAQ system monitoring tool
  - For experts
  - For operators

Zabbix screen



http://sp8cas-ccr-002/zabbix/screens.php?ddreset=1&sid=5ab1a72e399c36dc

ヒストリ: 最新データ » カスタムスクリーン » カスタムグラフ » ダッシュボード » 最新データ

スクリーン

test

スクリーン test

sp8cas-01: CPU load (1h)

		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.01	0	0.0098	0.0592
🟦 Processor load (5 min average per core)	[平均]	0.0083	0.0017	0.0086	0.0242
🟥 Processor load (15 min average per core)	[平均]	0.0075	0.0033	0.0069	0.0117

sp8cas-02: CPU load (1h)

		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.0008	0	0.0069	0.0467
🟦 Processor load (5 min average per core)	[平均]	0.0017	0.0017	0.0063	0.02
🟥 Processor load (15 min average per core)	[平均]	0.0017	0.0017	0.0055	0.0092

sp8cas-03: CPU load (1h)

		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.325	0.26	0.3273	0.4025
🟦 Processor load (5 min average per core)	[平均]	0.3258	0.3067	0.326	0.3492
🟥 Processor load (15 min average per core)	[平均]	0.3217	0.3175	0.3227	0.3333

sp8cas-04: CPU load (1h)

		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.0433	0	0.0087	0.0433
🟦 Processor load (5 min average per core)	[平均]	0.015	0.0025	0.0072	0.0175
🟥 Processor load (15 min average per core)	[平均]	0.0083	0.0042	0.0068	0.01

sp8cas-05: CPU load (1h)

		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.0033	0	0.0073	0.0408
🟦 Processor load (5 min average per core)	[平均]	0.0092	0.0008	0.0063	0.0158
🟥 Processor load (15 min average per core)	[平均]	0.0058	0	0.0035	0.0067

sp8cas-06: CPU load (1h)

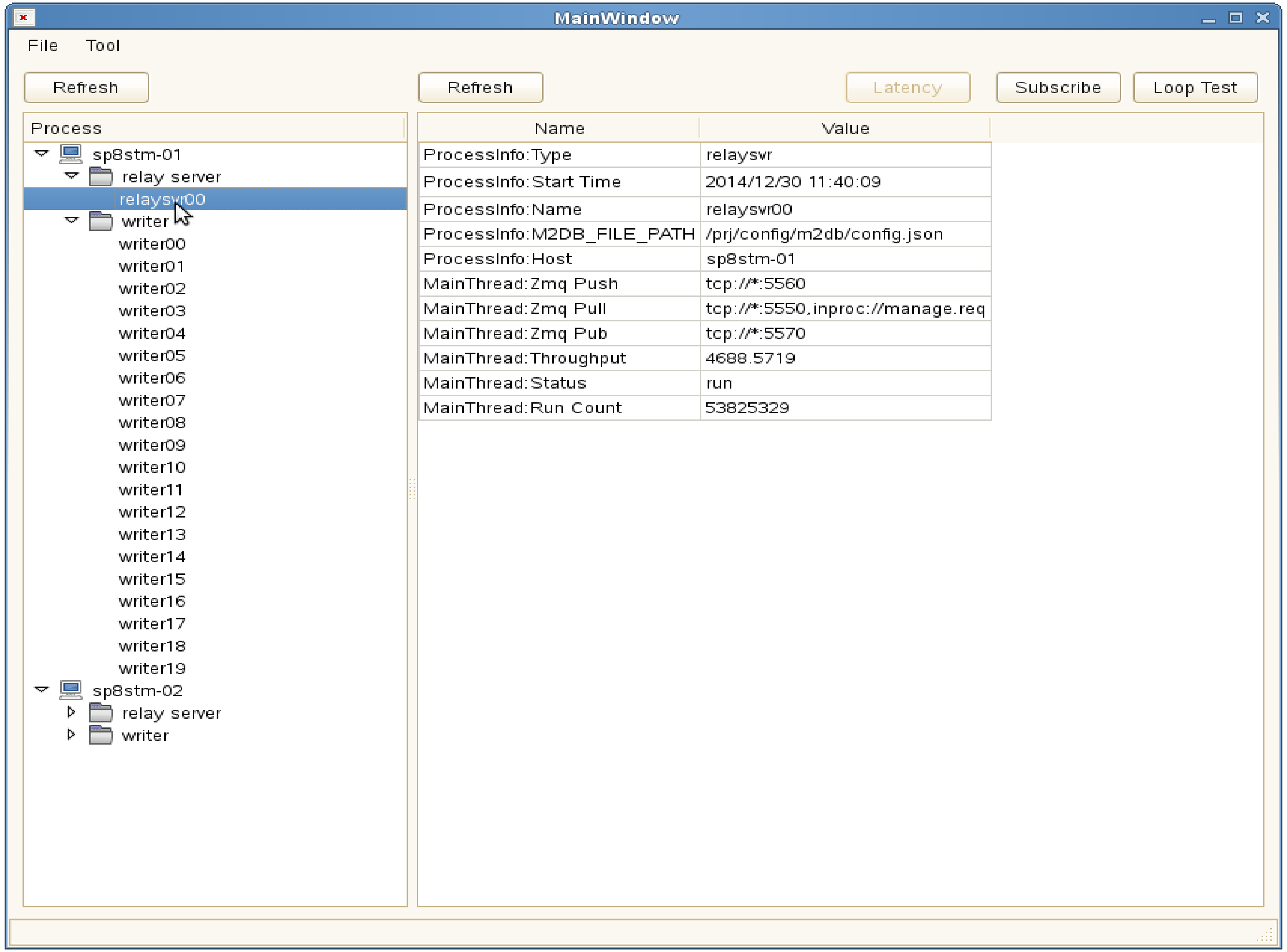
		最新値	最小	平均	最大
🟩 Processor load (1 min average per core)	[平均]	0.0058	0	0.0084	0.0483
🟦 Processor load (5 min average per core)	[平均]	0.0058	0.0033	0.0073	0.0167
🟥 Processor load (15 min average per core)	[平均]	0.0058	0.0033	0.0055	0.0075

http://sp8cas-ccr-002/zabbix/charts.php?graphid=787&period=3600&stime=20150714103658&sid=5ab1a72e399c36dc

Mozilla Firefox の起動に時間がかかっています...

起動を速くするには(L) 次からは通知しない(A)

DAQ system monitoring for experts

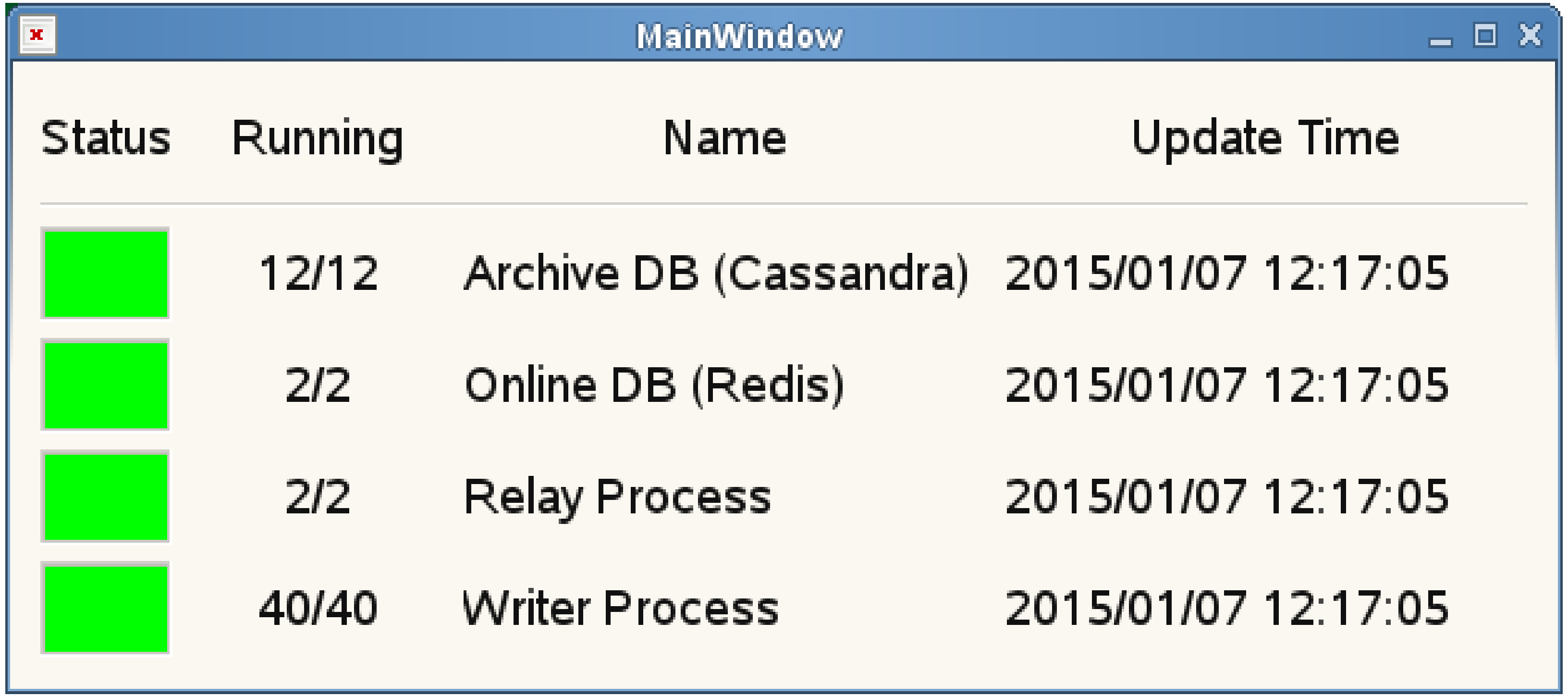


Process

- sp8stm-01
  - relay server
    - relaysvr00
  - writer
    - writer00
    - writer01
    - writer02
    - writer03
    - writer04
    - writer05
    - writer06
    - writer07
    - writer08
    - writer09
    - writer10
    - writer11
    - writer12
    - writer13
    - writer14
    - writer15
    - writer16
    - writer17
    - writer18
    - writer19
- sp8stm-02
  - relay server
  - writer

Name	Value
ProcessInfo:Type	relaysvr
ProcessInfo:Start Time	2014/12/30 11:40:09
ProcessInfo:Name	relaysvr00
ProcessInfo:M2DB_FILE_PATH	/prj/config/m2db/config.json
ProcessInfo:Host	sp8stm-01
MainThread:Zmq Push	tcp://*:5560
MainThread:Zmq Pull	tcp://*:5550,inproc://manage.req
MainThread:Zmq Pub	tcp://*:5570
MainThread:Throughput	4688.5719
MainThread:Status	run
MainThread:Run Count	53825329

DAQ System monitoring for shift operators



Status	Running	Name	Update Time
🟩	12/12	Archive DB (Cassandra)	2015/01/07 12:17:05
🟩	2/2	Online DB (Redis)	2015/01/07 12:17:05
🟩	2/2	Relay Process	2015/01/07 12:17:05
🟩	40/40	Writer Process	2015/01/07 12:17:05

Client libraries

- Mainly C and C++
  - For applications written in C
  - Same interfaces, no modification to source code of application
    - Just re-link
- Python modules
  - for Web applications
- We used
  - ZeroMQ, Messagepack, Cassandra CQL/Thrift , Redis

Cassandra Cluster

Number of nodes	12
Server	Dell PowerEdge R420
CPU	Intel Xeon E5-2420 2.2GHz
Memory	16GB
System disk	600GB 15k rpm
Data disks	3TB 7200 rpm x3
Cassandra	2.0.10
JavaVM	JRE1.7.0-67-b01

Summary

- We implemented new data acquisition and store system with new technologies
- Apache Cassandra provides high-performance, reliable, scalable and flexible data store that was impossible by RDBMS
- We build supporting infrastructures for healthy operations
- The system is stably running more than one year including test run