COSBench: Cloud Object Storage Benchmark

Qing Zheng
Reliable, Scalable, Intelligent Systems Group
School of Software, Shanghai Jiao Tong University
http://reins.se.sjtu.edu.cn

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qzheng2010@hotmail.com

Data Centers are Evolving!

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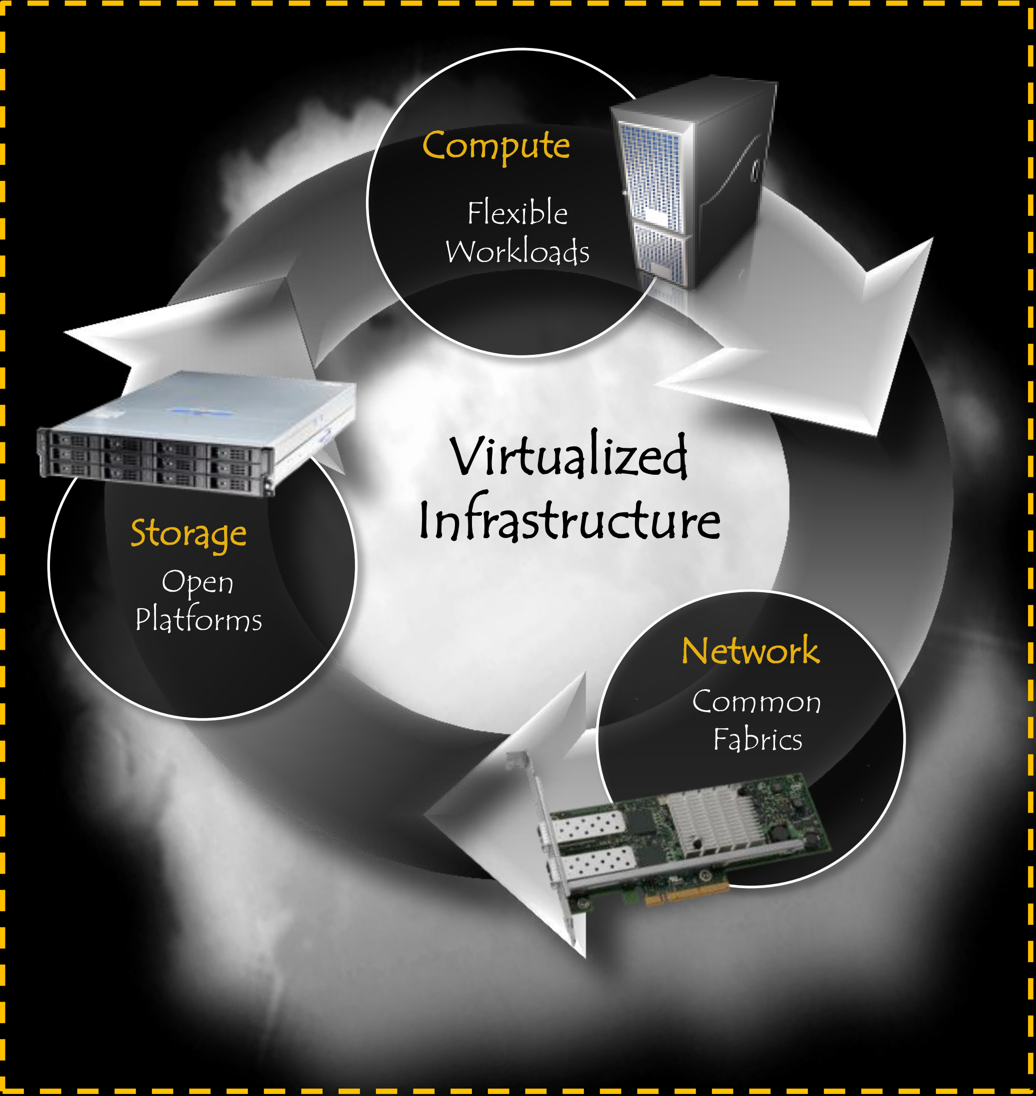

- Data centers are built upon 3 fundamental pillars:
  - Compute
  - Network
  - Storage
- To achieve high efficiency in performance & utilization
  - A balanced data center is essential!

Storage Capacity Growth

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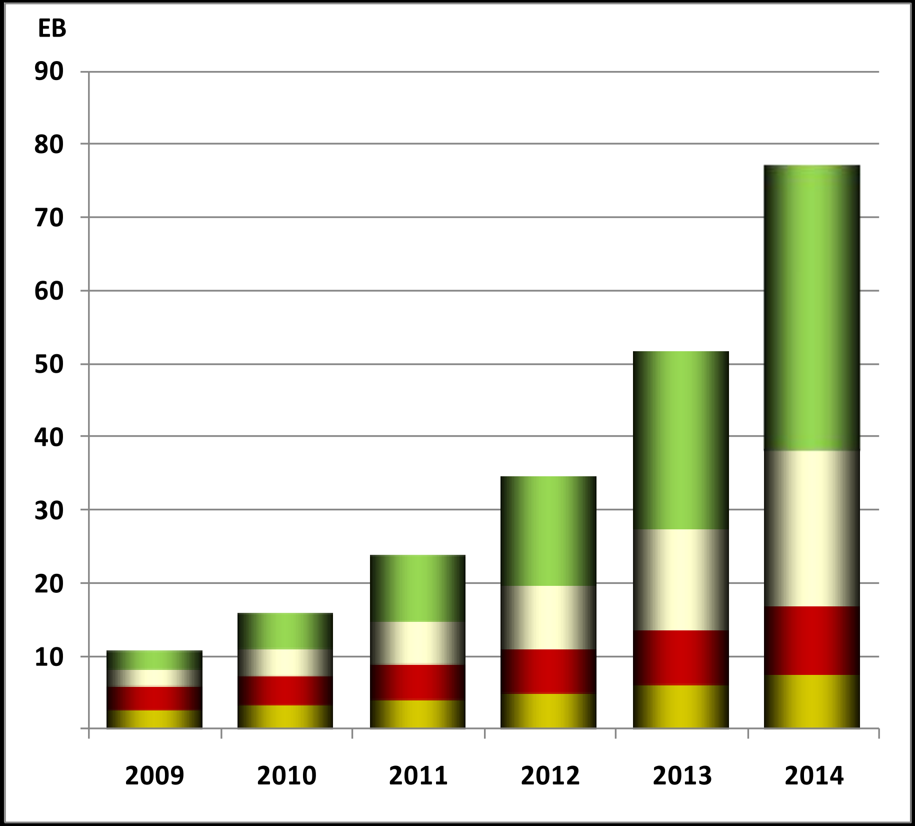
Structured data (23.6% ↑)
- Traditional enterprise database

Replicated data (24.2% ↑)
- Backups
- Data warehouses

Unstructured data (54.8% ↑)
- Archives

Content Depots (75.6% ↑)
- Web
- Email
- Document sharing
- Social network content (pictures/videos)



2012 deployment estimation

~ 7.6 million drives

~ 500,000 storage systems

Solutions dictated by Usage Models

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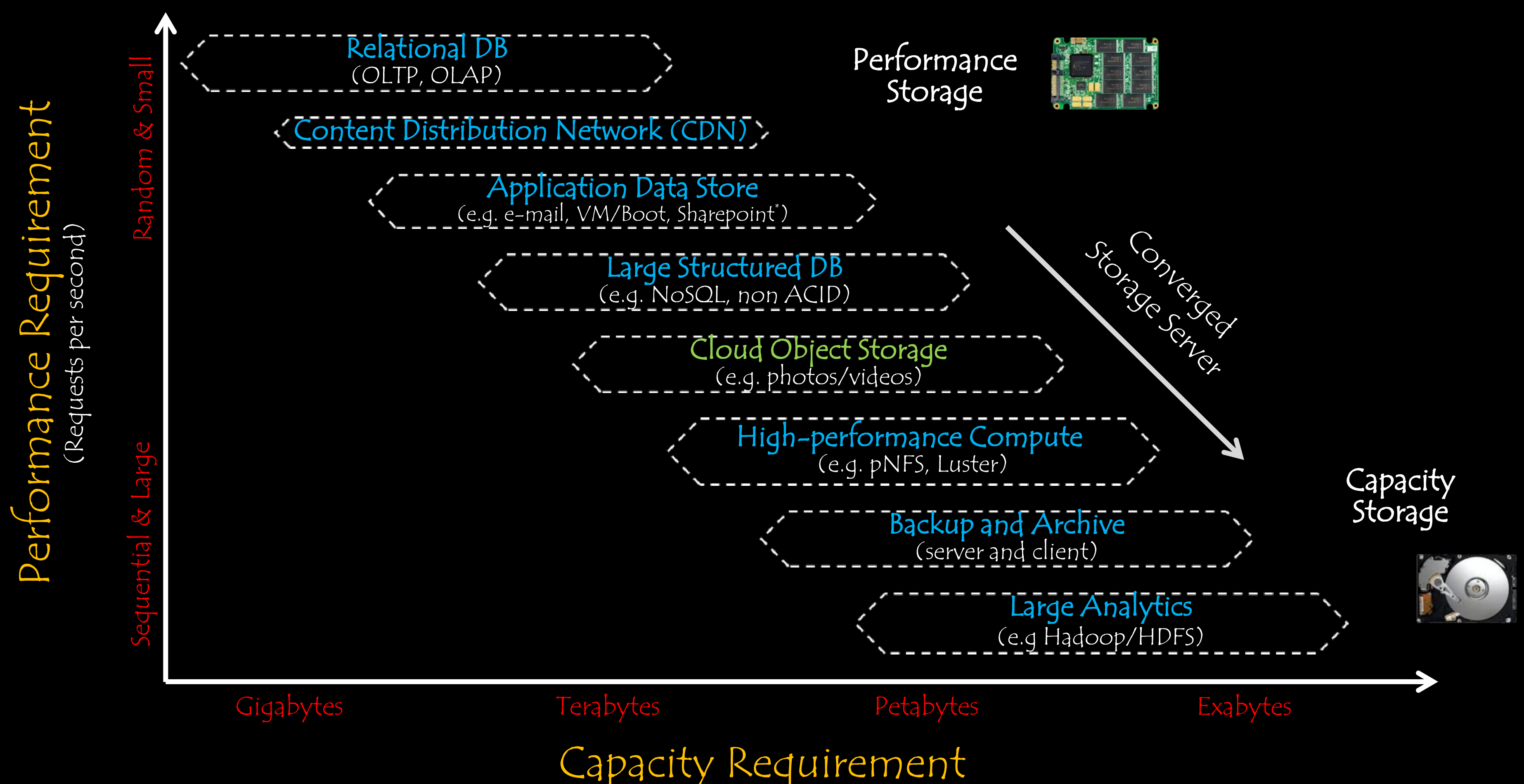

Different storage usage models create different ecosystems!

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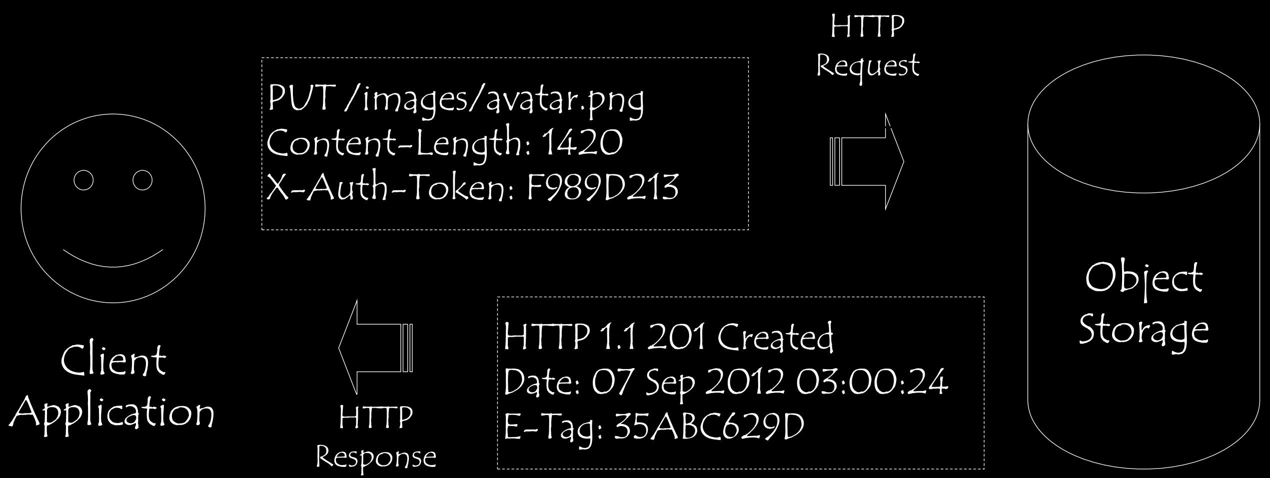
- Storage Interface



HEAD / GET / PUT / POST / DELETE / COPY

Object Storage in Getting Accepted

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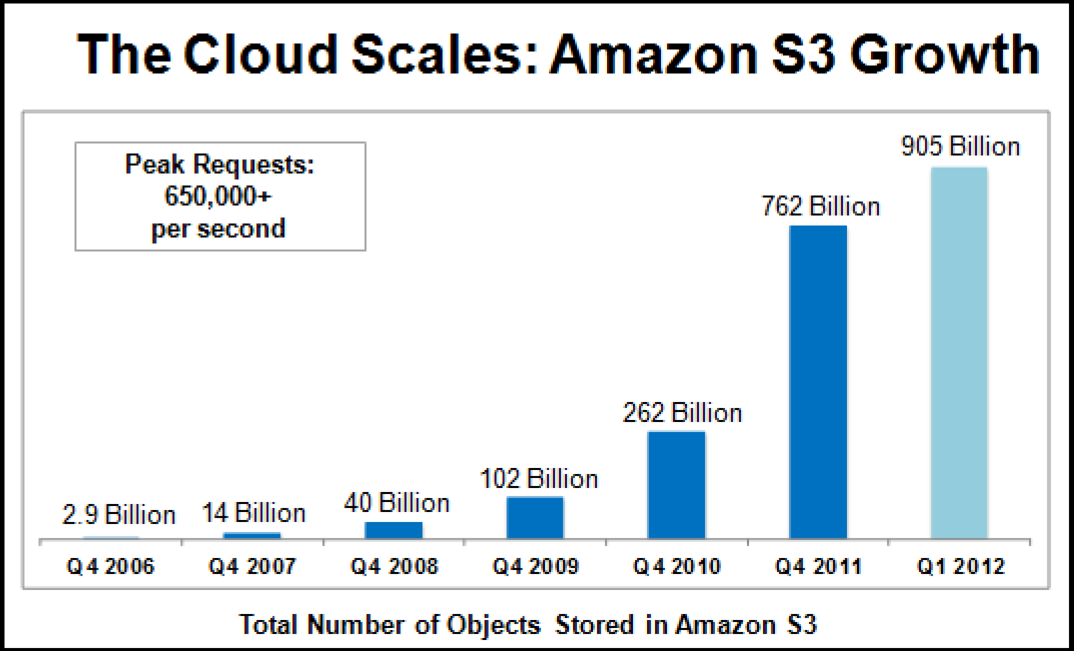

Object storage have been increasingly recognized as a right destination for data outsourcing

Challenges …

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- The proliferation of existing offerings
  - Amazon S3, Rackspace Cloud Files, Google Cloud Storage, HP Cloud Object Storage, Windows Azure, EMC ATMOS, Openstack Swift, Ceph, …
  - coupled with a lack of workload modeling object storage apps
  - makes it difficult for one to choose the right infrastructure!

- Tuning systems to their optimal performance is also nontrivial
  - resulted from the complexity in the designs of various available solutions

We need a benchmark tool
dedicated for object storage system!

We present COSBench

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- People can use this tool to evaluate & compare different
  - hardware and software stacks
  - and obtain a better understanding of these offerings

Throughput / Latency / Scalability / Flexibility

- People can also use this tool to characterize their systems
  - and get insights to guide system designs, tuning, & optimization

Architecture Decisions / Algorithms / Hardware Impacts / Innovation

COSBench Key Component

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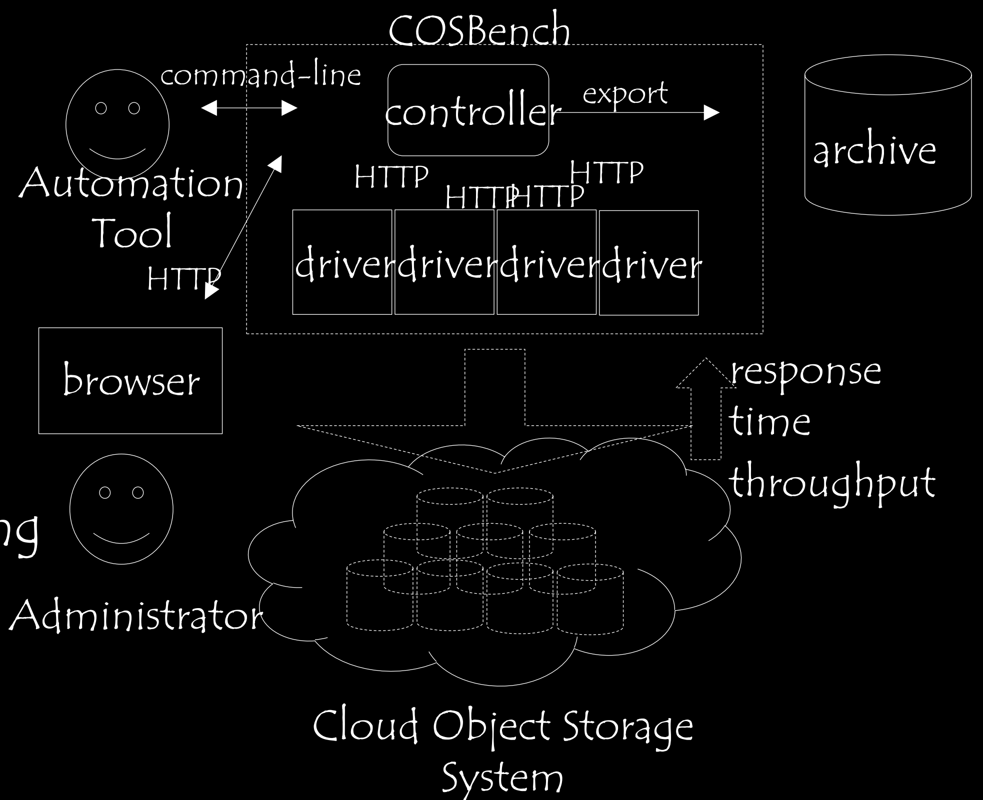
- Config.xml:
  - define workload with flexibility.
- Controller:
  - Control all drivers
  - Collect and aggregate stats.
- Driver:
  - generate workload according to config parameters.
  - can run tests without a supervising controller.
- Web Console:
  - System facade
  - Browse real-time stats
  - HTTP based Communication (RESTful style)



Web Console

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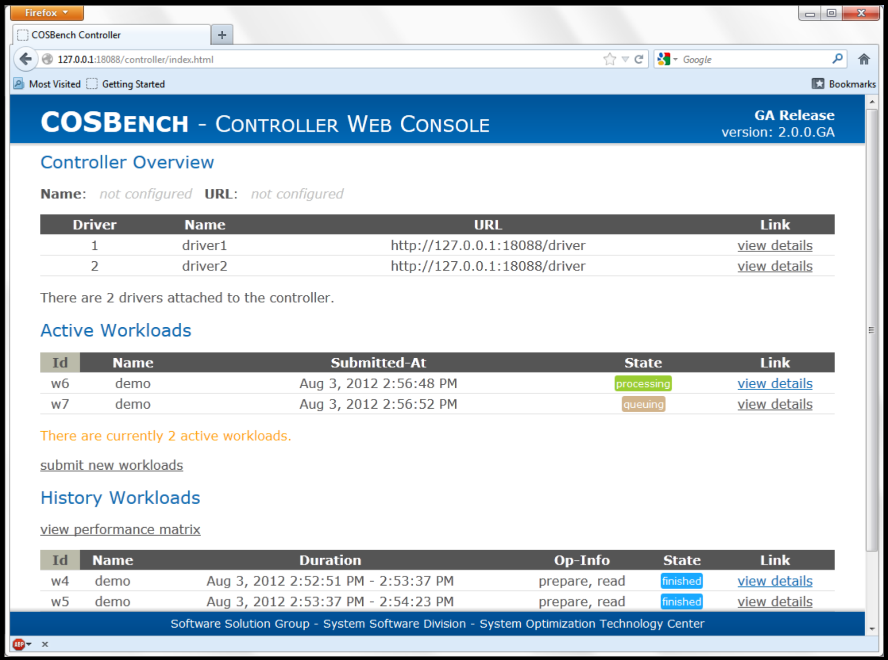

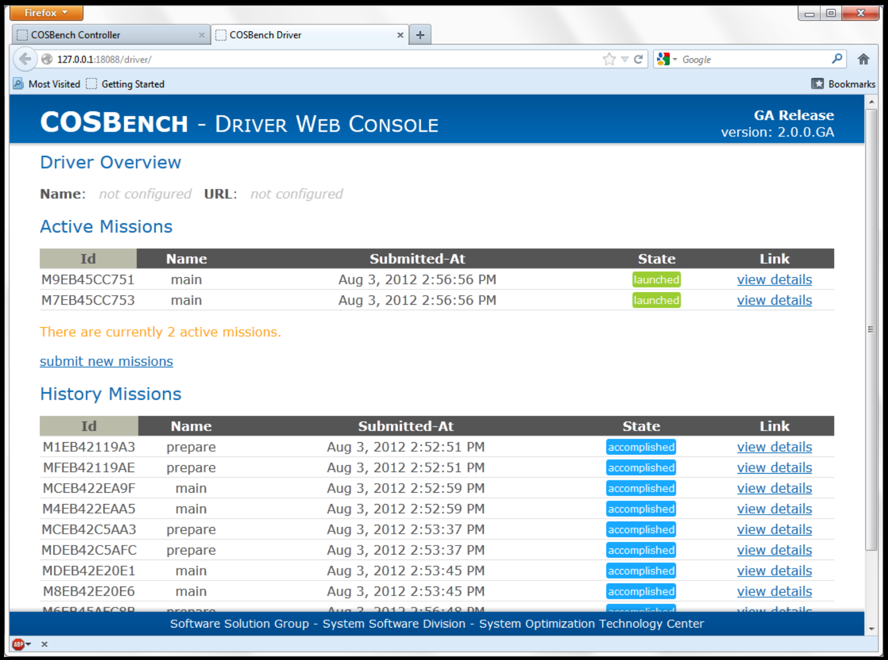

Controller

Driver

DEMO

Workload Configuration

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```
- <workflow>
  - <workstage name="init">
      <work type="init" workers="8" config="containers=r(1,32)" />
    </workstage>
  - <workstage name="prepare">
      <work type="prepare" workers="8" config="containers=r(1,32);objects=r(1,50);sizes=c(64)KB" />
    </workstage>
  - <workstage name="main">
    - <work name="main" workers="8" rampup="100" runtime="300">
        <operation type="read" ratio="80" config="containers=u(1,32);objects=u(1,50)" />
        <operation type="write" ratio="20" config="containers=u(1,32);objects=u(51,100);sizes=c(64)KB" />
      </work>
    </workstage>
  - <workstage name="cleanup">
      <work type="cleanup" workers="8" config="containers=r(1,32);objects=r(1,50)" />
    </workstage>
  - <workstage name="dispose">
      <work type="dispose" workers="8" config="containers=r(1,32)" />
    </workstage>
  </workflow>
</workload>
```

Flexible Load Control

Path/Size Distribution

Read/Write Patterns

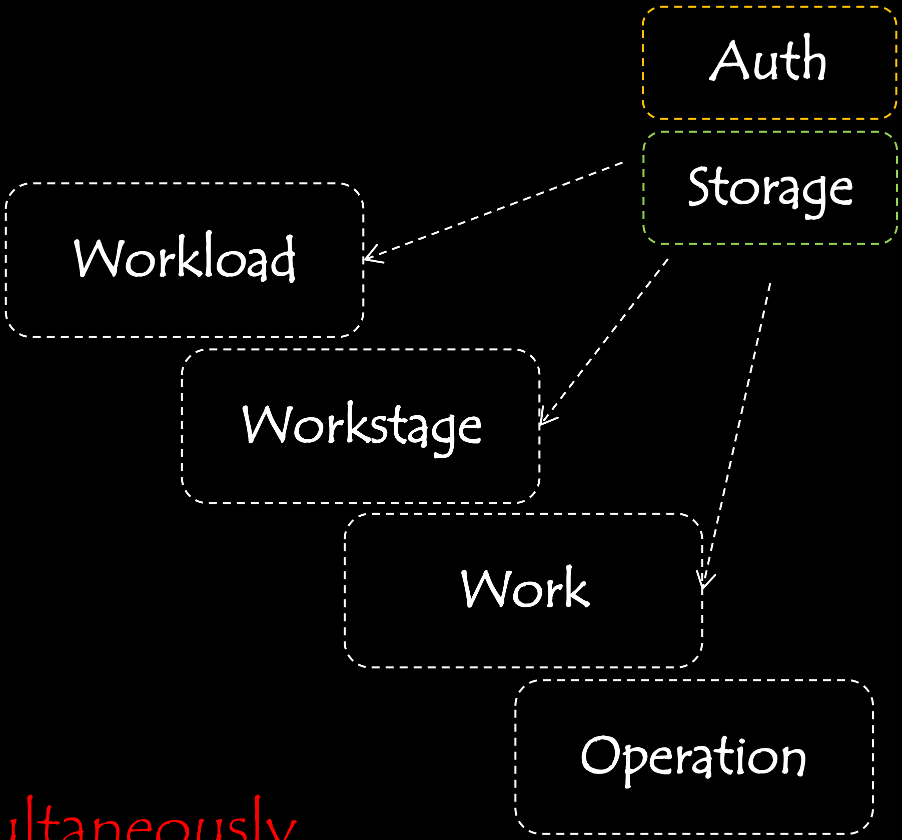
Extensible Parameters

Workflow Model

Flexible configuration which gives birth to diverse usage patterns

Configurable workload

- Mixed operations (GET/PUT…)
- Mixed object sizes
- Multiple stages
- Auth/storage association
- Load control
- Extensible parameters



Stress multiple systems simultaneously

Extensible API

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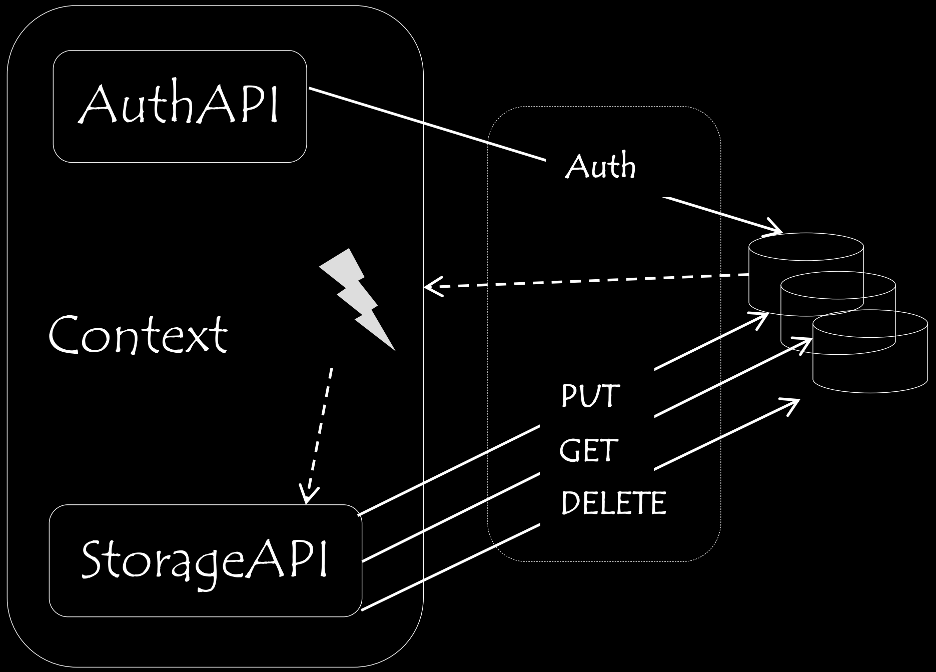
- Separate auth and storage API, so
  - One auth → multiple storages
  - One storage → multiple auths



Extensible API which support various storage systems

Modular Design

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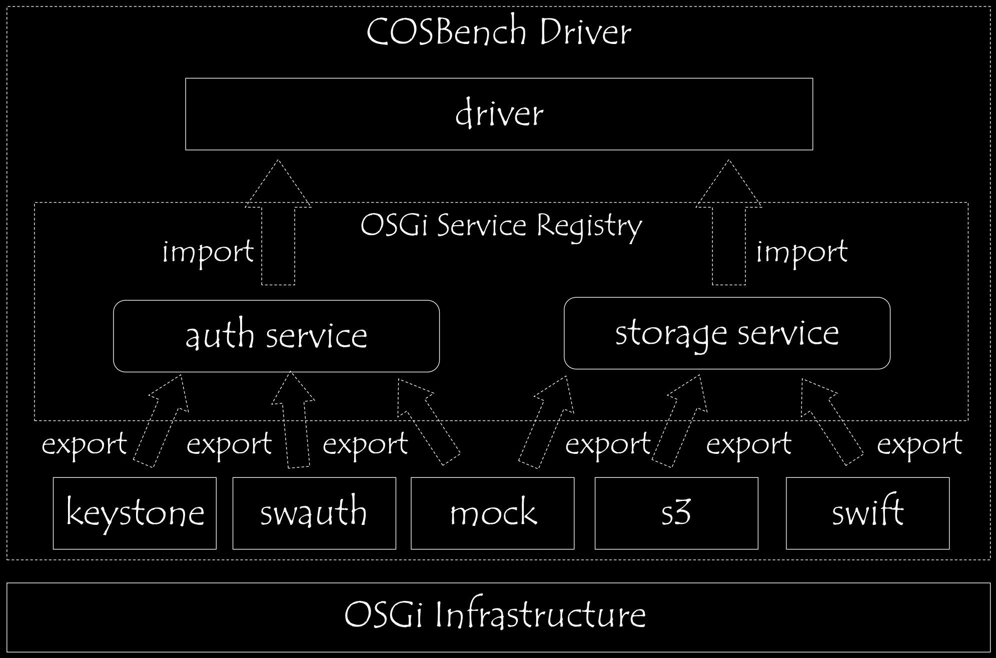

New adaptors can be separately developed, individually configured, and dynamically plugged into the env. without the knowledge of the core system

Performance Metrics

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- Throughput (Operations/s): the operations completed in one second
- Response Time (in ms): the duration between operation initiation and completion.
- Bandwidth (KB/s): the total data in KiB transferred in one second
- Success Ratio (%): the ratio of successful operations

Swift

- Object Storage for Openstack

Main Features

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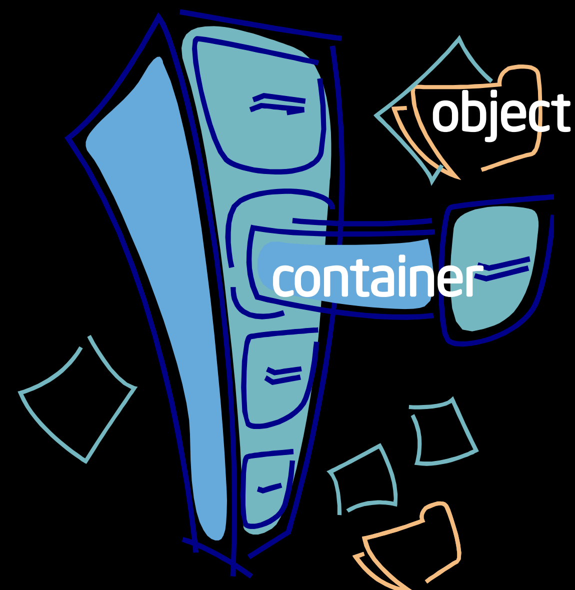
- As an object storage system, Swift:

1. allows users to create containers and to stores data objects in these containers
   - *objects are identified by their paths and have metadata associated with them*
2. can be accessed via "RESTFul" interface
   - *including "GET"/"PUT"/"DELETE"*
3. can be well built upon commodity storage devices and is highly scalable
   - *achieving cost effectiveness*
4. is redundant and is eventually consistent
   - *suitable for long-term storage*



As you see, container cannot be nested

Services on Proxy/Storage Node

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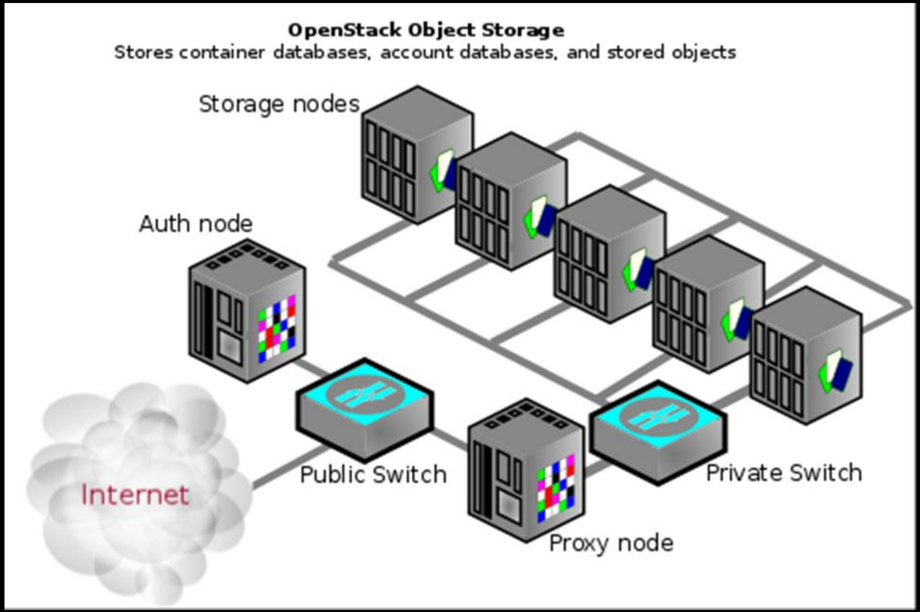
- Proxy Node
  - proxy-server
    - cluster gateway
  - swauth-server
    - authentication & authorization



- Storage Node
  - account/container/object - server
    - listing containers
    - listing objects
    - saving/retrieving/removing objects
  - account/container/object - replicator
    - pushing local replicas to other storage nodes should replicas of those nodes are missing
  - account/container/object - auditor
    - quarantining local corrupted data entities
  - container/object -updater
    - updating metadata asynchronously

Load Balance

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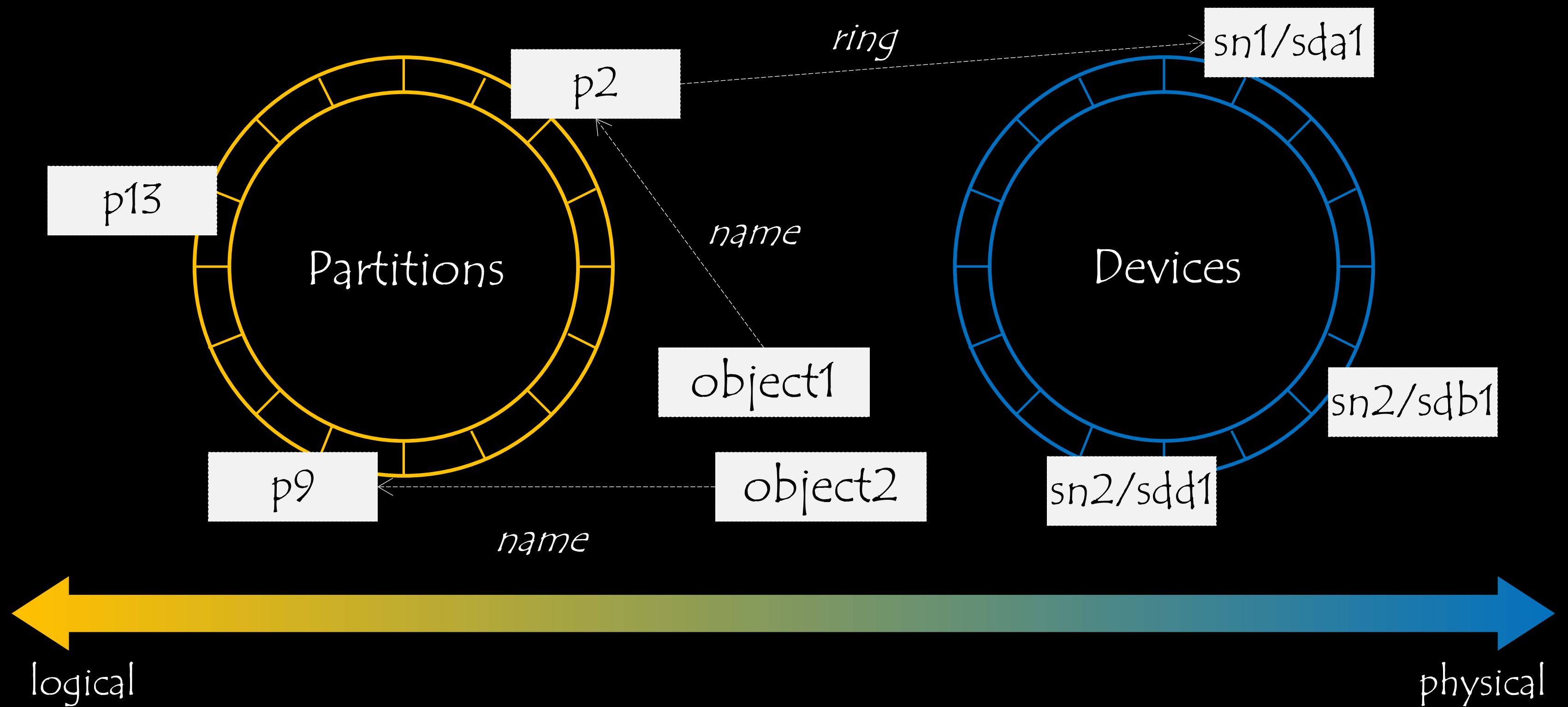
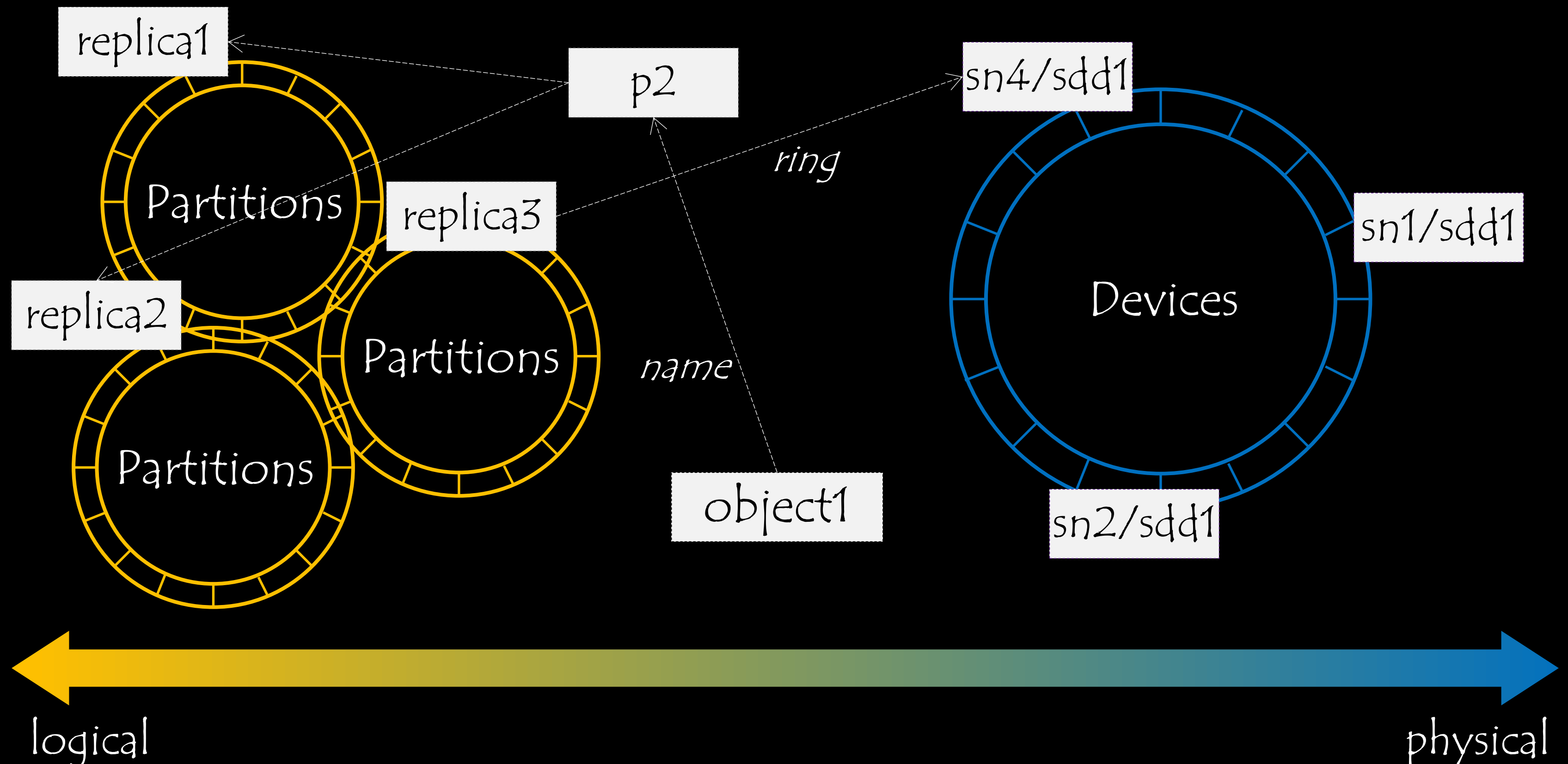
- A ring maintains its mapping using
  - physical perspective: devices
  - logical perspective: partitions



Load Balance

REINS

- A ring maintains its mapping using
  - physical perspective: devices
  - logical perspective: partitions -> replicas



How ring is initialized?

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- In ring, each device is associated with metadata
  - describing device's weight, # replica wanted and # replica assigned
- A ring is built as
  - replicas from each partitions are in turn assigned to
  - the device currently enjoying the highest value of
    - "# replica wanted - # replica assigned"
  - Note that best attempts will be made to assign replicas from a sample partition to different zones or at least different nodes if possible

System Configuration

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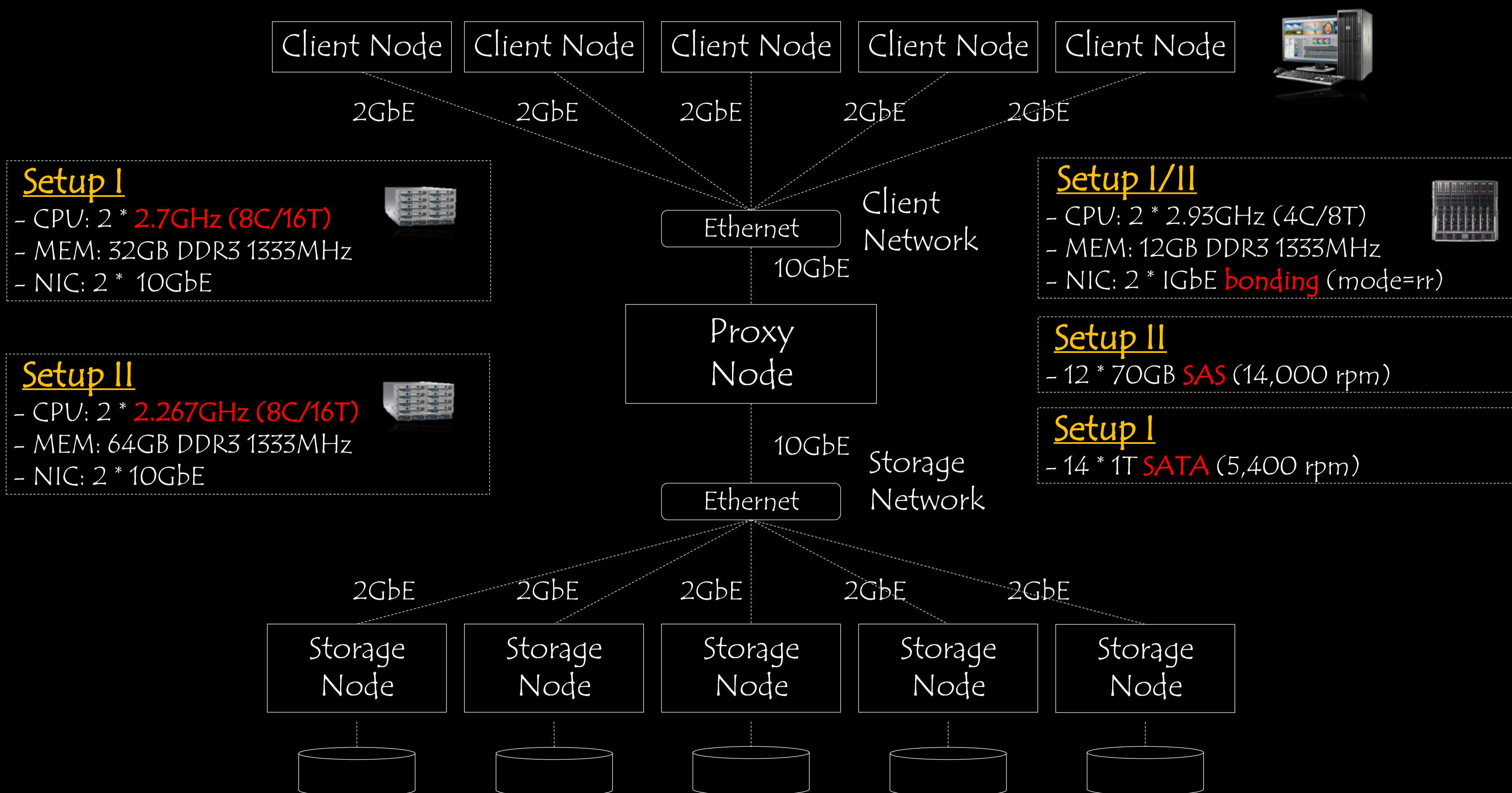
Setup-I had higher CPU power, Setup-II had faster disks



A: 128KB-Read

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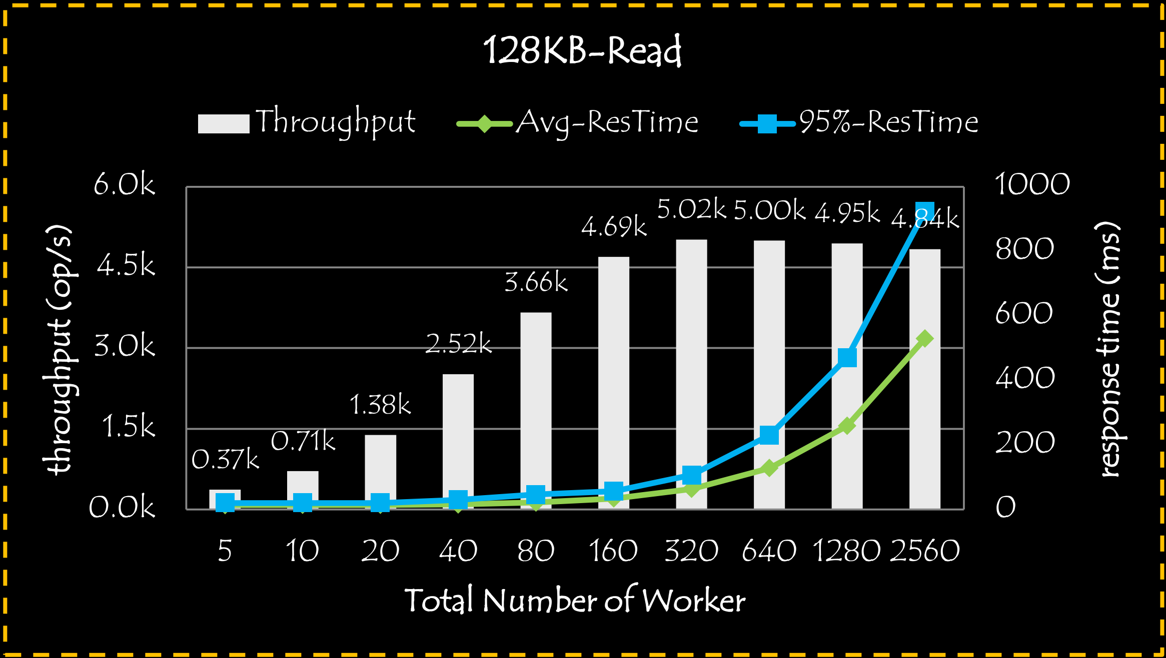
- SLA: 200ms + 128KB/1MBps = **325ms**



Workers	95%-ResTime	Throughput
	ms	op/s
5	20.00	369.49
10	20.00	711.24
20	20.00	1383.30
40	30.00	2517.94
80	46.67	3662.71
160	56.67	4693.97
320	106.67	5019.85
640	230.00	4998.13
1280	470.00	4947.15
2560	923.33	4840.19

The **bottleneck** was identified to be the **proxy's CPU**

-- The CPU utilization at that node was **93**%!

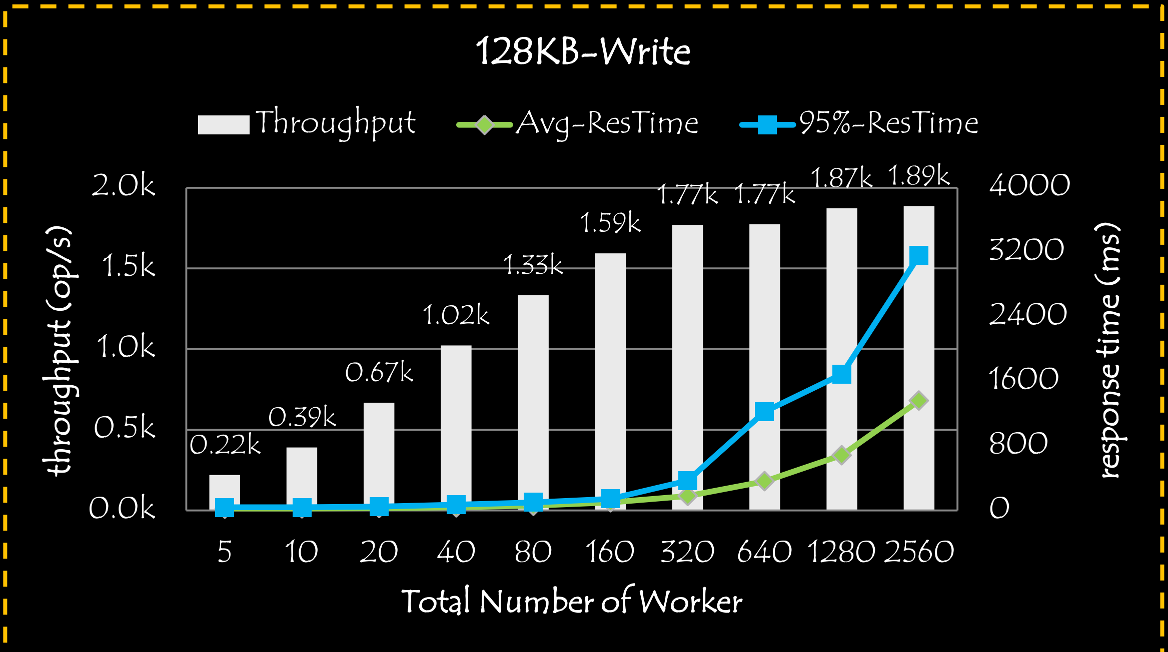
-- The peak throughput for setup-I was **5576** op/s (640 workers)

↑ CPU could ↑ throughput

B: 128KB-Write

REINS

- SLA: 200ms + 128KB/1MBps = 325ms



Workers	95%-ResTime	Throughput
	ms	op/s
5	40.00	219.73
10	40.00	391.14
20	50.00	668.19
40	70.00	1022.07
80	100.00	1333.34
160	143.33	1594.12
320	370.00	1769.55
640	1223.33	1773.12
1280	1690.00	1871.58
2560	3160.00	1886.81

The **Disks** at storage nodes had significant impact on overall throughput

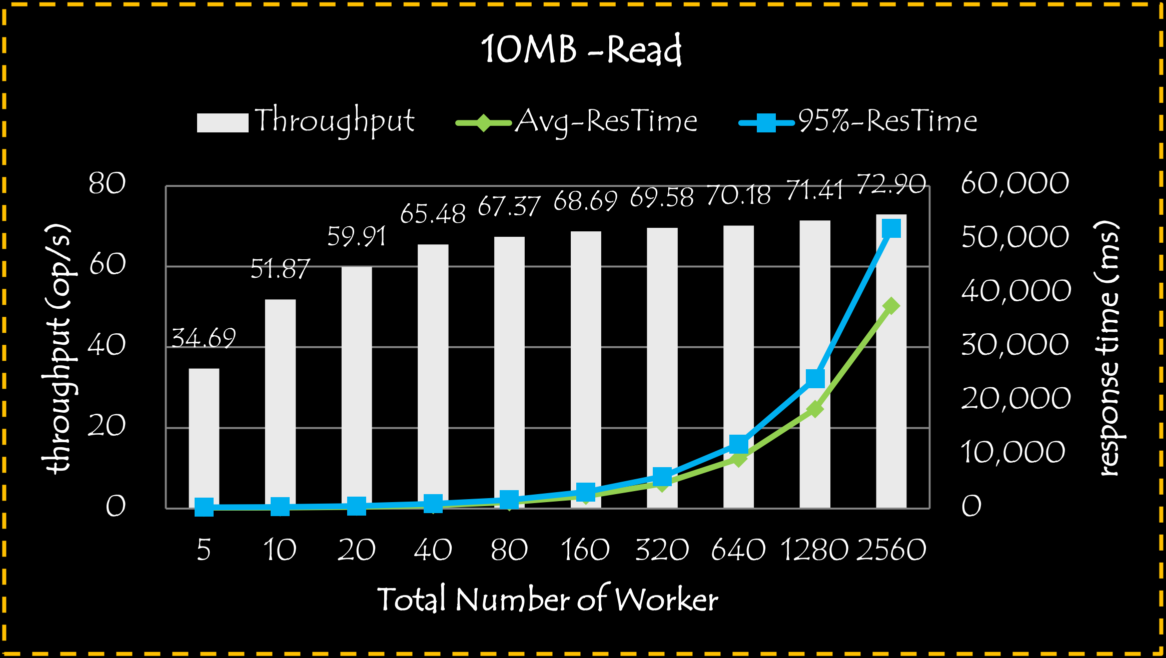
-- The peak throughput for setup-I was only **155** op/s (20 clients)

-- HDD → SSD in setup-I would ↑ throughput to **1621** op/s (320 clients)

storage disks ←→ throughput

C: 10MB-Read

- SLA: 200ms + 10MB/1MBps = **1200ms**



Workers	95%-ResTime	Throughput
	ms	op/s
5	270.00	34.69
10	320.00	51.87
20	480.00	59.91
40	900.00	65.48
80	1636.67	67.37
160	3093.33	68.69
320	5950.00	69.58
640	11906.67	70.18
1280	24090.00	71.41
2560	52090.00	72.90

The **bottleneck** was identified to be the **clients' NICs**

-- in setup-II, adding 5 more clients ↑ throughput to 103 op/s (80 clients)

-- in setup-I, using vClient + SRIOV could achieve similar improvements

D: 10MB-Write

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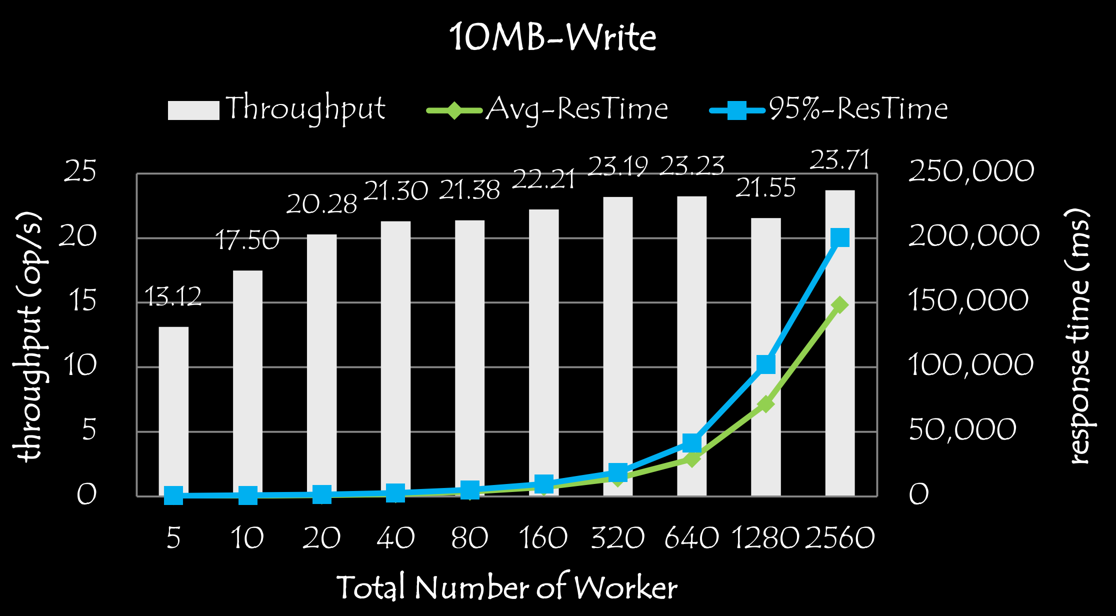
- SLA: 200ms + 10MB/1MBps = <u>1200ms</u>



Workers	95%-ResTime ms	Throughput op/s
5	536.67	13.12
10	**936.67**	**17.50**
20	1596.67	20.28
40	2786.67	21.30
80	5133.33	21.38
160	9800.00	22.21
320	18623.33	23.19
640	41576.67	23.23
1280	102090.00	21.55
2560	200306.67	23.71

The **bottleneck** might be the **storage nodes' NICs**

-- in setup-I, the peak throughput was 15.74 op/s (10 clients)

-- in both setups, the write performance was 1/3 of the read performance

Thank you!