

TOSHIBA

DRIVING TRANSFORMATION

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First things first . . .

an announcement

Next week our name changes to....

KIOXIA Corporation

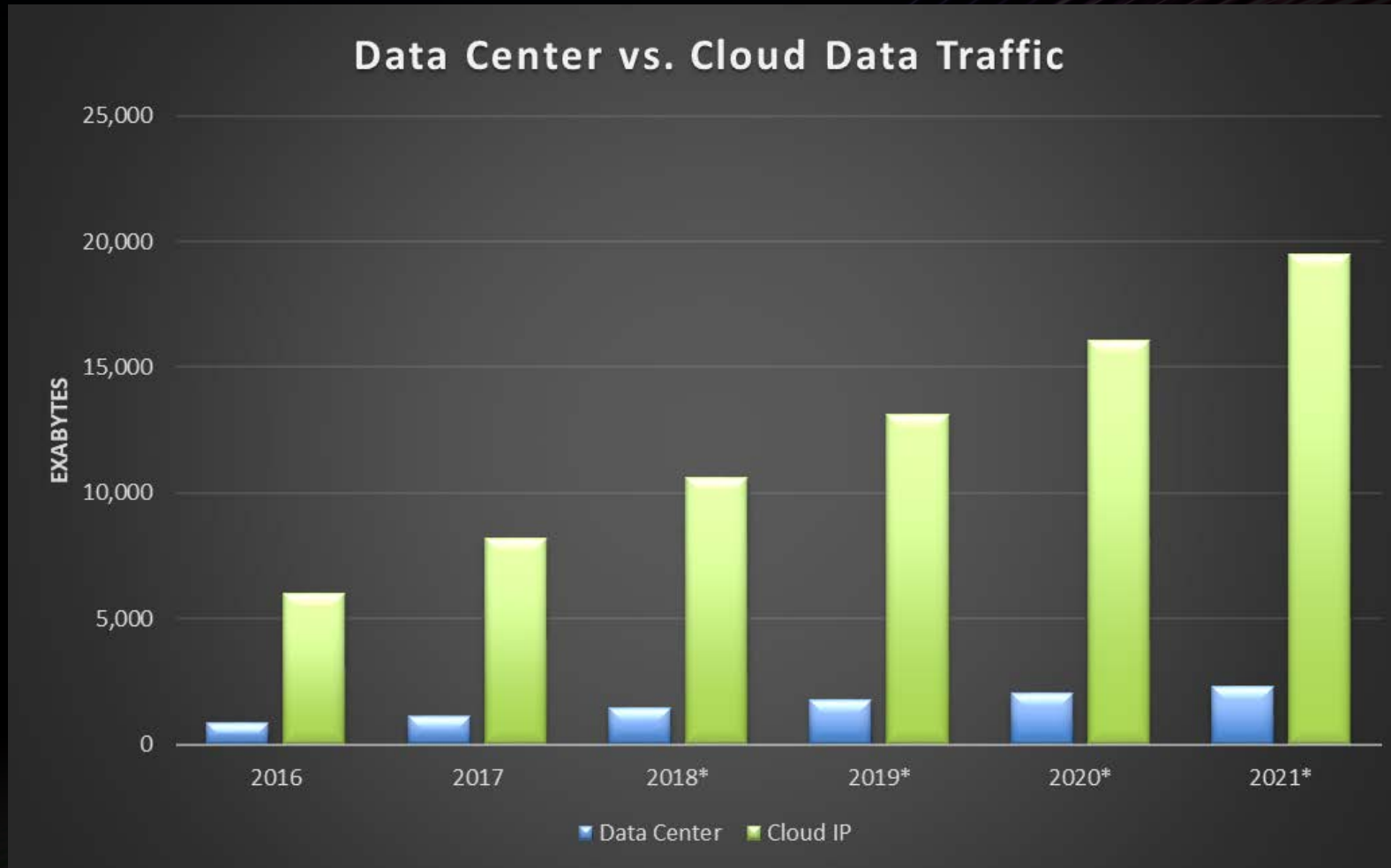
KIOKU + AXIA

KIOXIA is a combination of the Japanese word *kioku* meaning “memory” and the Greek word *axia* meaning “value.” Kioku, which underpins our mission and vision, goes beyond the notion of memory as mere data to broadly encompass experiences, emotions and ideas.

And now,
for something completely different...

our storage world continues changing
and the change is accelerating...

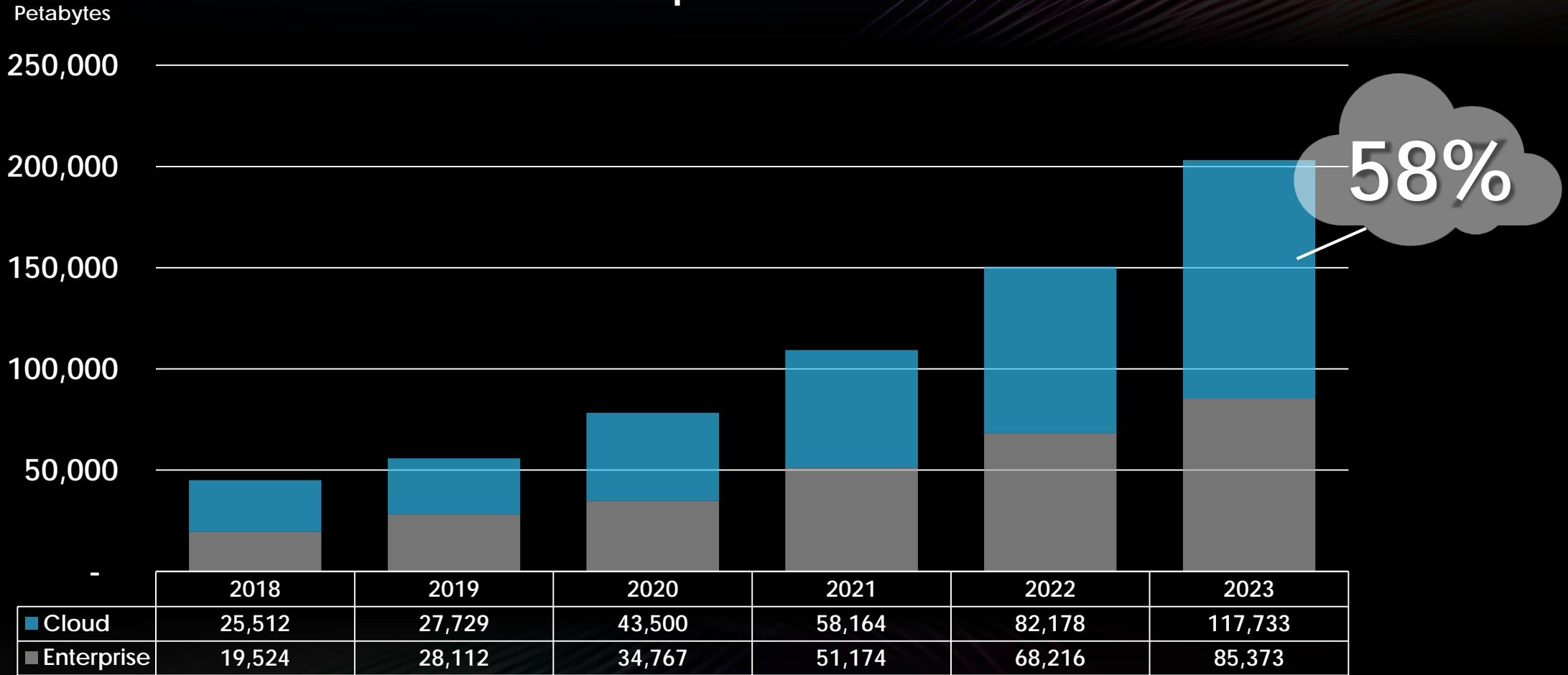
Cloud Storage is Inescapable (nearly)



Source: <https://www.statista.com/study/26788/data-storage-statista-dossier/>

...and the
majority of Exabytes sold
will shift to
Cloud vendors

Flash Shipments



Source: Forward Insights Aug 2019

Cloud will consume majority of new flash storage.

The majority of Cloud bytes
will go to the
Hyperscale
providers

Hyperscalers

(we've noticed)

use storage differently...

**Hyperscale cloud
is application-driven
(software-defined)**

Storage devices
are
NOT
(software-driven)

So,
the Hyperscale cloud providers
began defining their own
flash storage devices

These devices are
host-controlled, application-driven
and
highly integrated into the stack

The host and application
control many of the
flash-unique processes

Garbage
Collection

Data
Placement

Wear
Leveling

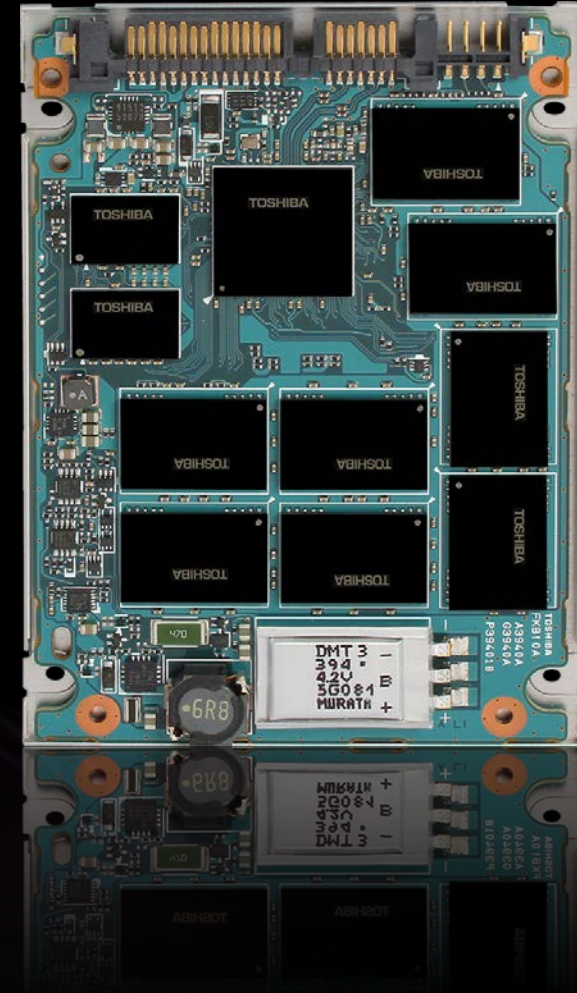
As developers
you know this.

Storage,
as a device,
has evolved at its own pace

For so long it was just “rotating rust”



The big new
“innovation”
was enabling
FLASH
for storage



Solid-state storage is
digital,
yet it is still delivered
like a drive

Solid-state storage must be
enabled for
Software Control

Hyperscale cloud
is already
doing it.

Storage vendors need to pay attention.

Today's
innovations in
storage
are driven by cloud
applications



Yet today's
storage devices
define their own
mode of access...

Cloud operators require
their applications to
define
how data is stored...

and these storage-related factors
impact
Hyperscale service quality

Performance
Parallelism

(orchestration)

Predictable Latency
Data Placement

This is where Hyperscale is innovating with storage

Performance
Parallelism

(orchestration)

Predictable Latency
Data Placement

Solid-state devices are digital.
A software-enabled device can
control these features

Performance
Parallelism

(orchestration)

Predictable Latency
Data Placement

AND MORE...

As developers,
You know a
new paradigm
is coming to solid-state storage.

In the new paradigm
the application is king.

Solid-state storage
must embrace this.

**Cloud-based applications
are the new normal.**

**This will drive further innovation
demands for solid-state storage.**

Future versions of software-enabled solid-state storage may support:

- Workload-driven aggregation and disaggregation of a storage pool
- Multi-mode capability/functionality
- Latency control by software
- Host control over garbage collection and wear leveling

The Cloud is eating into Enterprise.
Hyperscale cloud is software-driven.
Their applications are king [for storage].

This new paradigm is at our heels.

You've talked about these concepts before...

We're exploring how to make
flash
more valuable
in a software-defined world.

Two examples:

1. Software can be drive-aware
2. Software can be “media-aware”

Toshiba Memory's KumoScale™

Software that deploys SSDs at cloud-scale
...enables NVMe™ Flash as a Service

NVMe is a trademark of NVM Express, Inc.

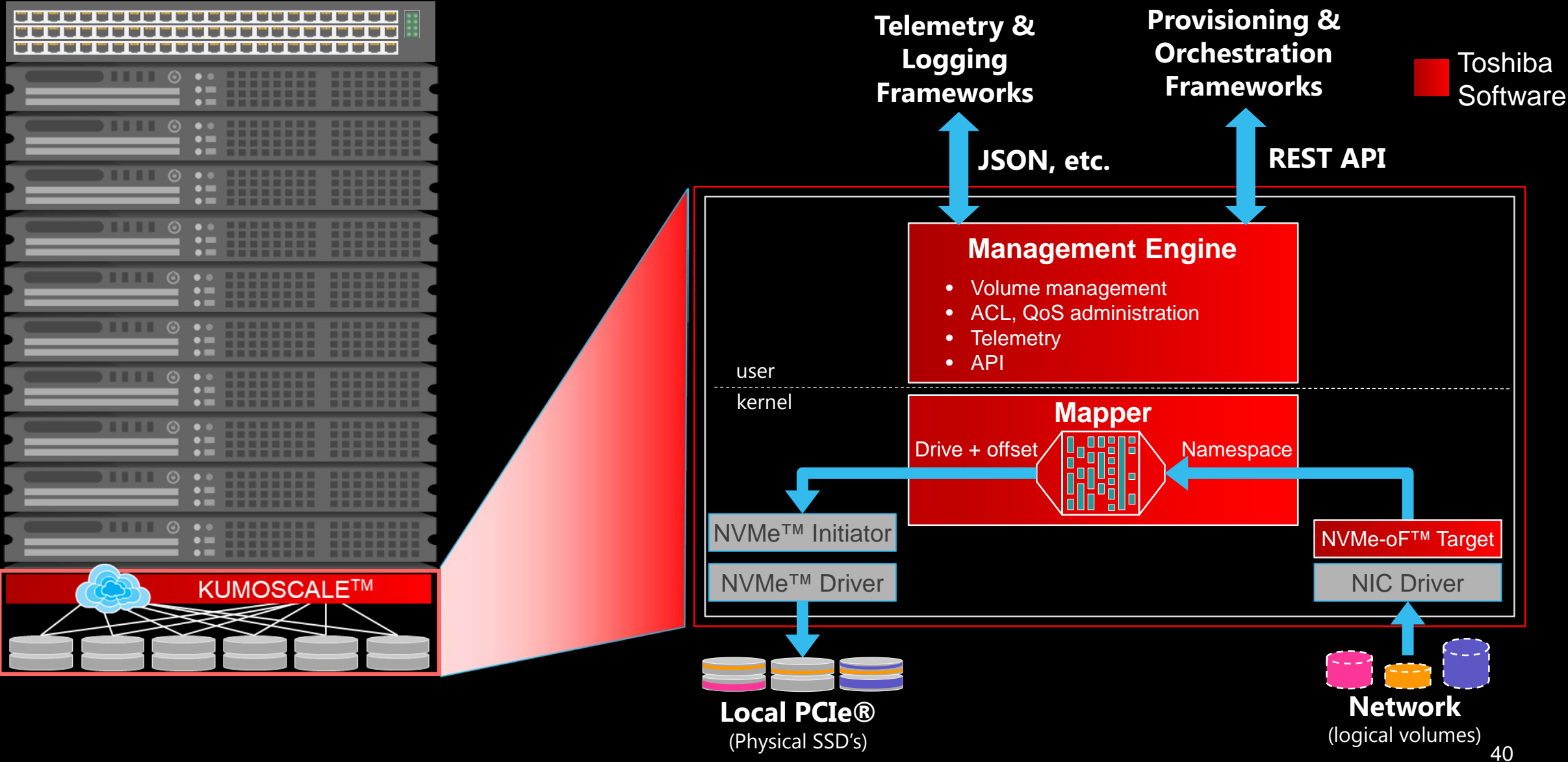
What is KumoScale?

- **A Software product**
 - Implements a fast, *networked block storage service*
 - Disaggregation based on NVMe™ -over-Fabrics standard
 - *Focused on speed, very low cost*
- **Target:**
 - Mid to large-scale (50k-500k nodes) on-prem data center
 - Bare metal or containerized
- **Architected for Private Clouds (not enterprise)**
 - Integrates with (not replaces) management infrastructure
 - Tight integration with Kubernetes®/CSI
 - Zero touch deployment at scale

"kumo"		
雲	<も	Cloud
蜘蛛	<も	Spider

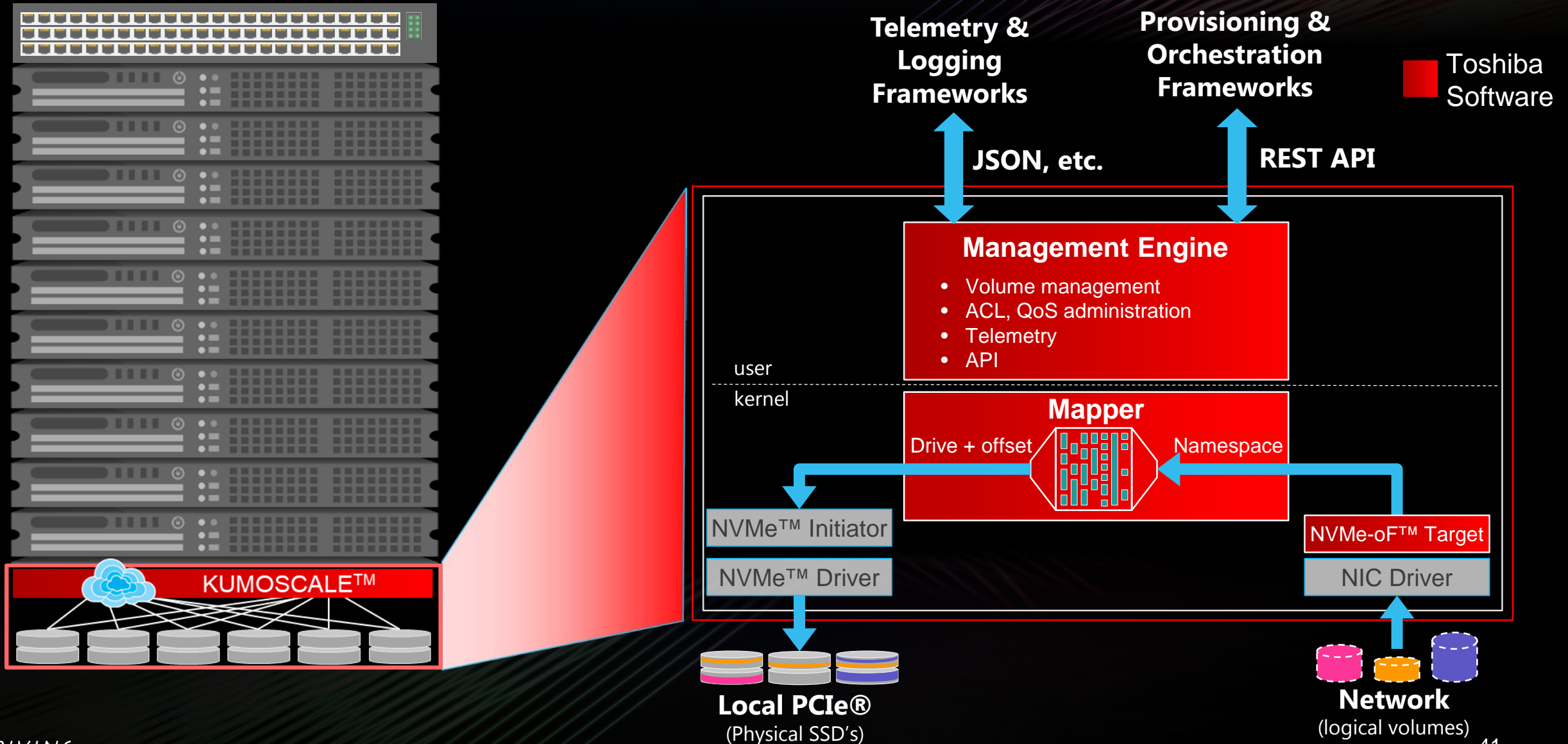
Software enabling
NVMe™ Flash as a Service

Storage Node Architecture

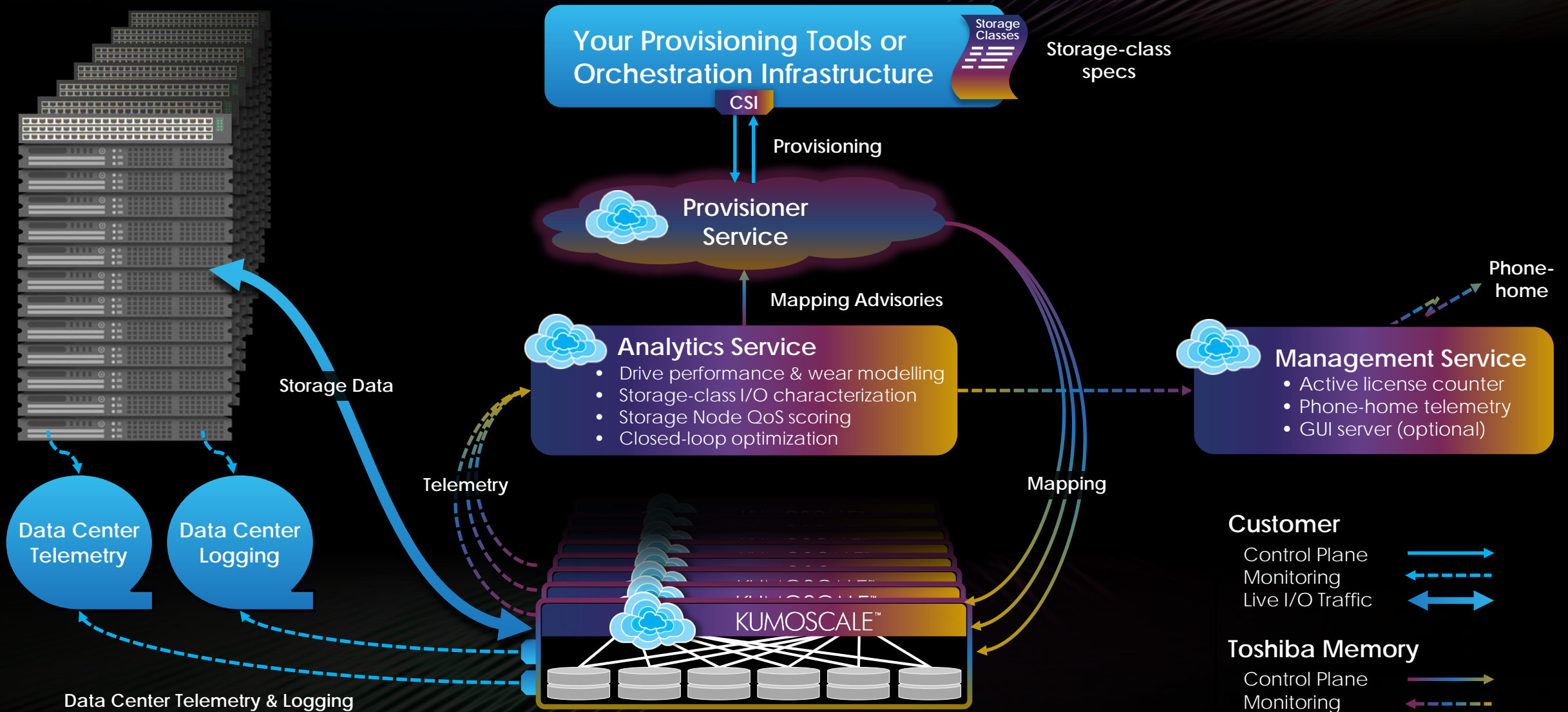


NVMe and NVMe-oF are trademarks of NVM Express, Inc. PCIe is a registered trademark of PCI-SIG.

Storage Node Architecture



KumoScale™: Storage Software Enabling NVMe™ Flash as a Service



TRocksDB

Modified RocksDB
to be more “media-aware”
for better TCO

RocksDB

- A popular data storage engine
- Used by a wide range of database applications:

ArangoDB

Cassandra®

Ceph™

MariaDB®

MyRocks

Python®

Rockset

Cassandra is a registered trademark of The Apache Software Foundation. Ceph is a trademark of Red Hat, Inc. or its subsidiaries in the United States and other countries.
Python is a registered trademark of the Python Software Foundation. MariaDB is a registered trademark of MariaDB in the European Union and other regions.

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RocksDB

- Good for HDD and small database values
- Not “flash media-aware”
 - Compaction layer heavily rewritten
 - Generates write-amp of 20x to 30x
 - This degrades flash memory endurance

TRocksDB

But...
there is a better way

TRocksDB

Toshiba Memory America
re-architected RocksDB
to be more
flash media-aware

TRocksDB

...all done in software;
no changes to the SSD necessary.

TRocksDB

We want to show you
what software can do if it's media-aware.

How does TRocksDB work?

RocksDB

Keys & Values are paired together

Compaction layers updated regularly by rewriting keys & values together

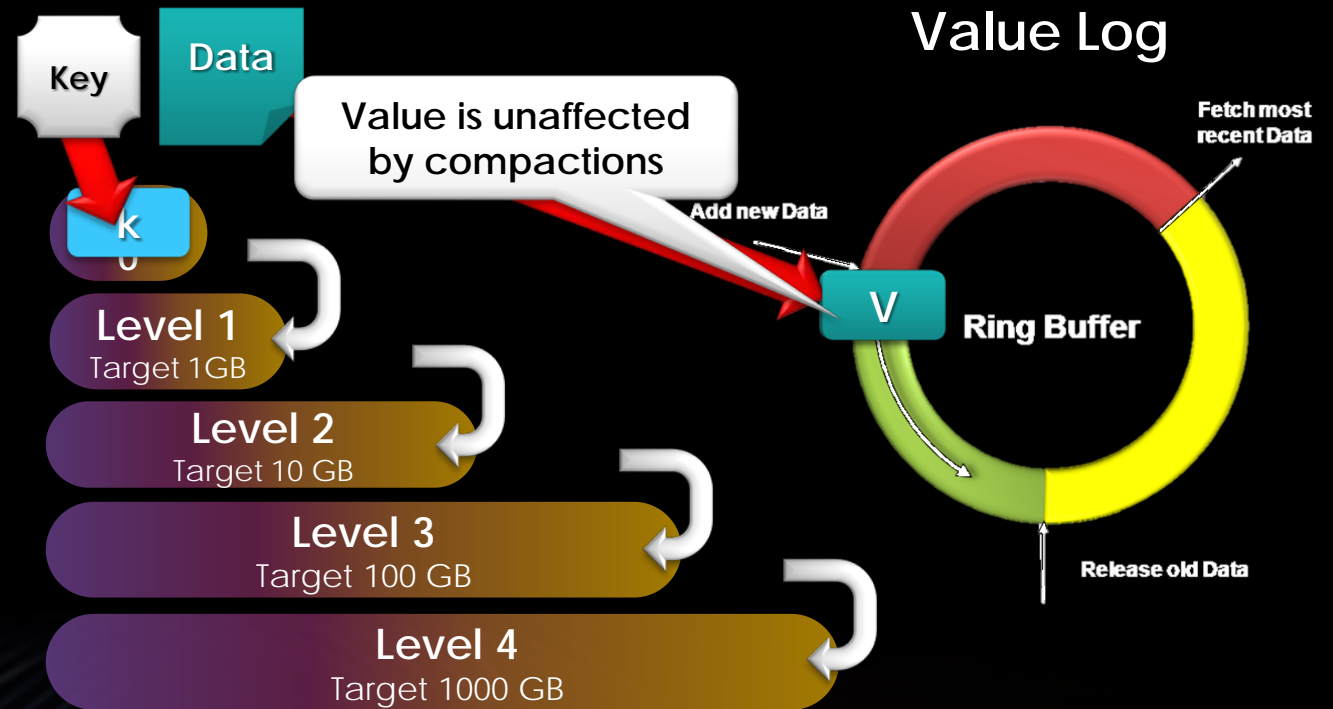
WRITE AMP

TRocksDB

Keys & Values are split

Keys go into compaction layers

Values are stored separately in a ring buffer



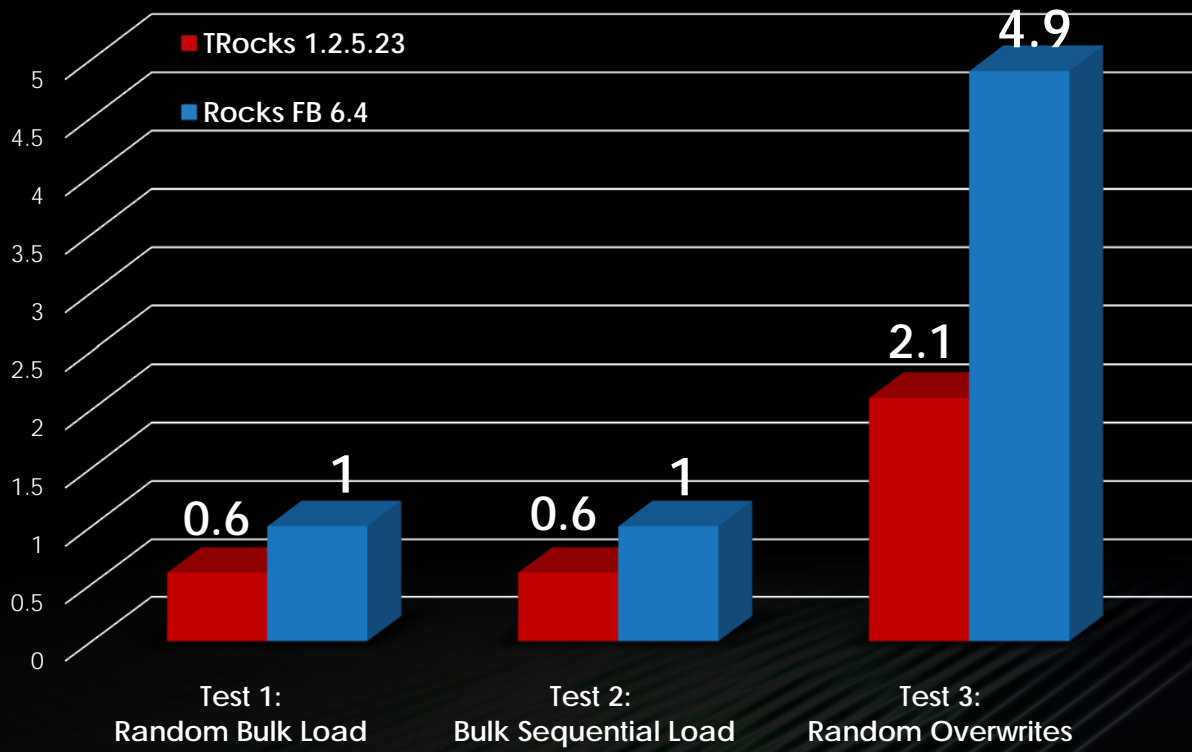
By being cognizant of
media characteristics,
a developer can enhance
storage value.

The greatest value:
improved endurance
at no performance cost.

Greater SSD Endurance: Better TCO

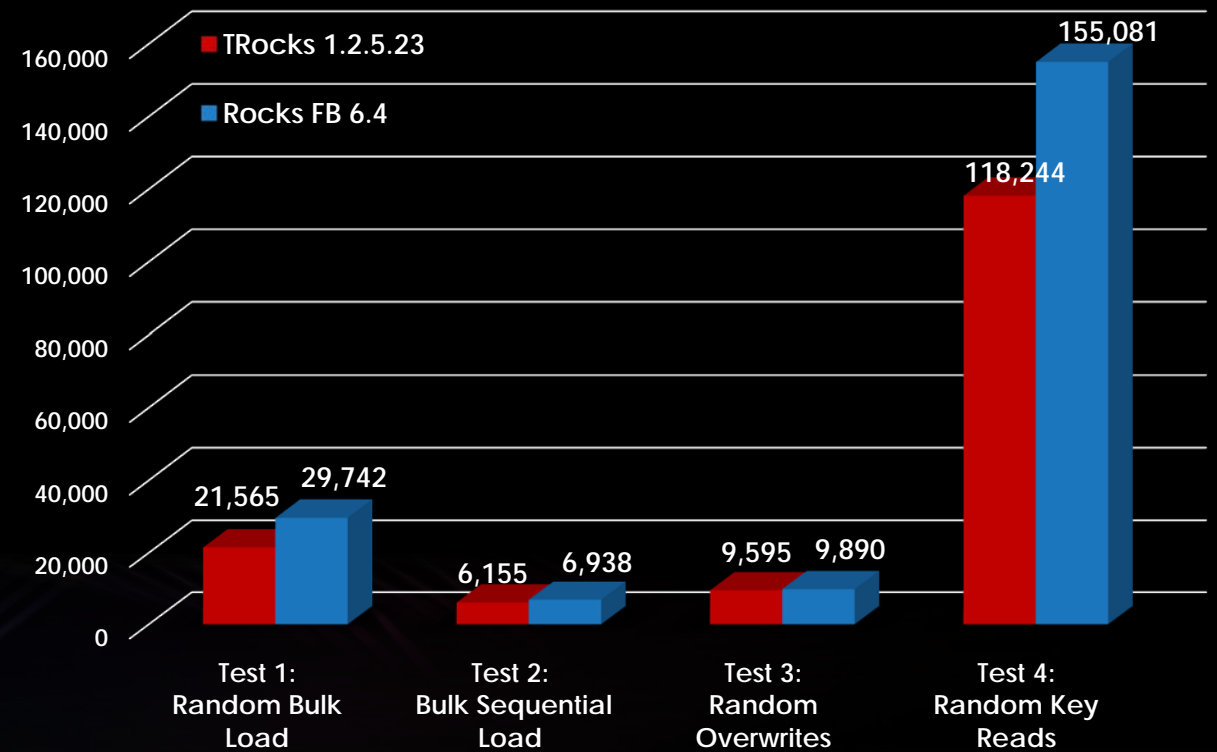
Improved Write Amplification

Write Amplification
(lower is better)



Same or Better Performance

Performance Comparison
(lower is better)



Toshiba Memory wants to show
examples of how software can enhance
solid-state storage...

So, we developed TRocks as
Open Source software
available today:

<https://github.com/ToshibaMemoryAmerica>

Join the project;
improve and contribute
to the code:

<https://github.com/ToshibaMemoryAmerica>

To conclude,
a new paradigm shift in storage
is coming...

Continued innovations in software
are necessary and...

...Solid-state storage
has a big role to play...

...but,
it needs to be software-enabled
to take advantage
of its
digital nature.

I shared two modest examples
of Toshiba Memory's
efforts in this direction

We are investing
in these and other methods
on a larger scale
in both media and
software.

There's more to discuss in future.



Thank You

DRIVING
TRANSFORMATION

TOSHIBA

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