STORAGE DEVELOPER CONFERENCE

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Challenges & Opportunities with Hyper-Scale Boot Drives

Hyper-Scale Boot Drives

Karthik Shivaram, Storage Engineer, Facebook Inc.

Agenda

- Introduction
- Hyper-Scale Boot Options
- SSD Boot Drive: Challenges
- SSD Boot Drive: Solution

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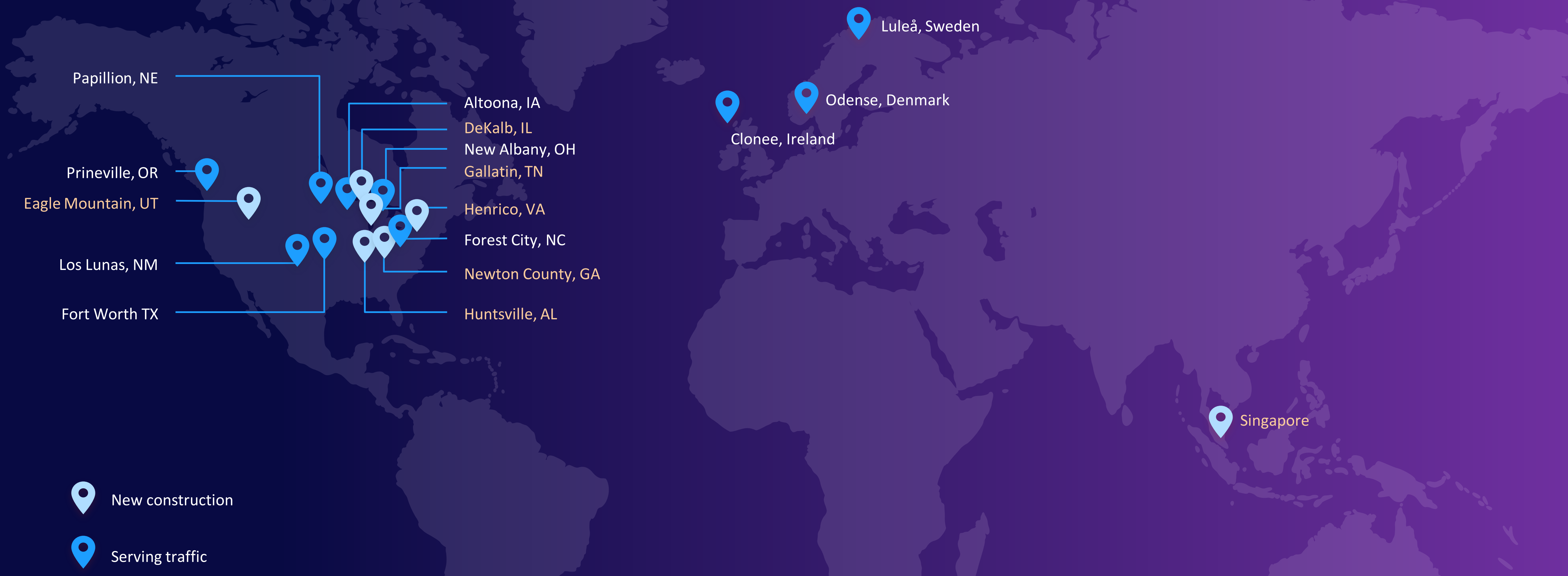
Facebook Infrastructure’s goal is to build the most innovative and highly efficient Data Centers on earth

Facebook Data Center Locations



Boot Drives are deployed all over the world!

Background

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- Data Center Server’s typically contain two forms SSDs:
    - Data Drives
        - Use Case: Generally used as a data-store e.g., Database, Cache
        - Capacity: 2 to 8TB
        - Power: 8.5W to 20W
        - Form-Factor: E1.S, M.2 (22x110), U.2
        - Power Loss Protection: Required
    - Boot Drives
        - Use Case: Host OS, Logs, Scratchpad
        - Capacity: <512GB
        - Power: <5W
        - Form-Factors: M.2 (22x80)
        - Power Loss Protection: Not Supported

Hyper-Scaler’s deploy boot drives, but the requirements for these boot drives are not public or understood in the industry

Where do Hyper-Scalers use Boot Drives?

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Network Switches

Compute Servers

Storage Nodes

- JBOD
- JBOF

Hyper-Scale Boot Drive Options

Boot Options

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HDD
Boot Drive

Client SSD
Boot Drive

Network
Boot

HDD Boot Drive

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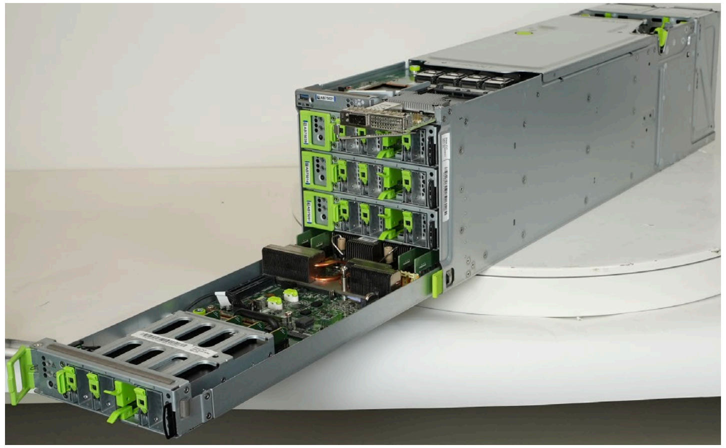
- Contains mechanical components
  - Reduces reliability which increases operational complexity
- Poor random performance
- High active power (>5W)
- Significantly larger in capacity than what’s needed
- No side-band access (I2C)
- Physically occupies more space which doesn’t fit in high density designs



HDD as a Boot Drive is undesirable in high density server designs

Network Boot

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- Consumes critical network bandwidth
- Reduces reliability of the system and rack
  - Blast radius on a single failure can be very high
- Increases boot time
- Increases I/O latency
- Disaster recovery can be very challenging

- **Network Boot is complex and challenging to implement @Scale**
- **Introduces many risks into Data Center Infrastructure Reliability**

Client SSD Boot Drive

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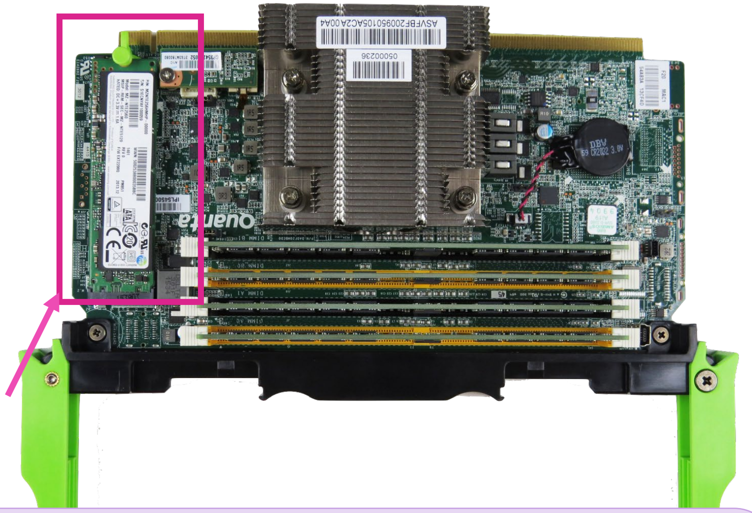
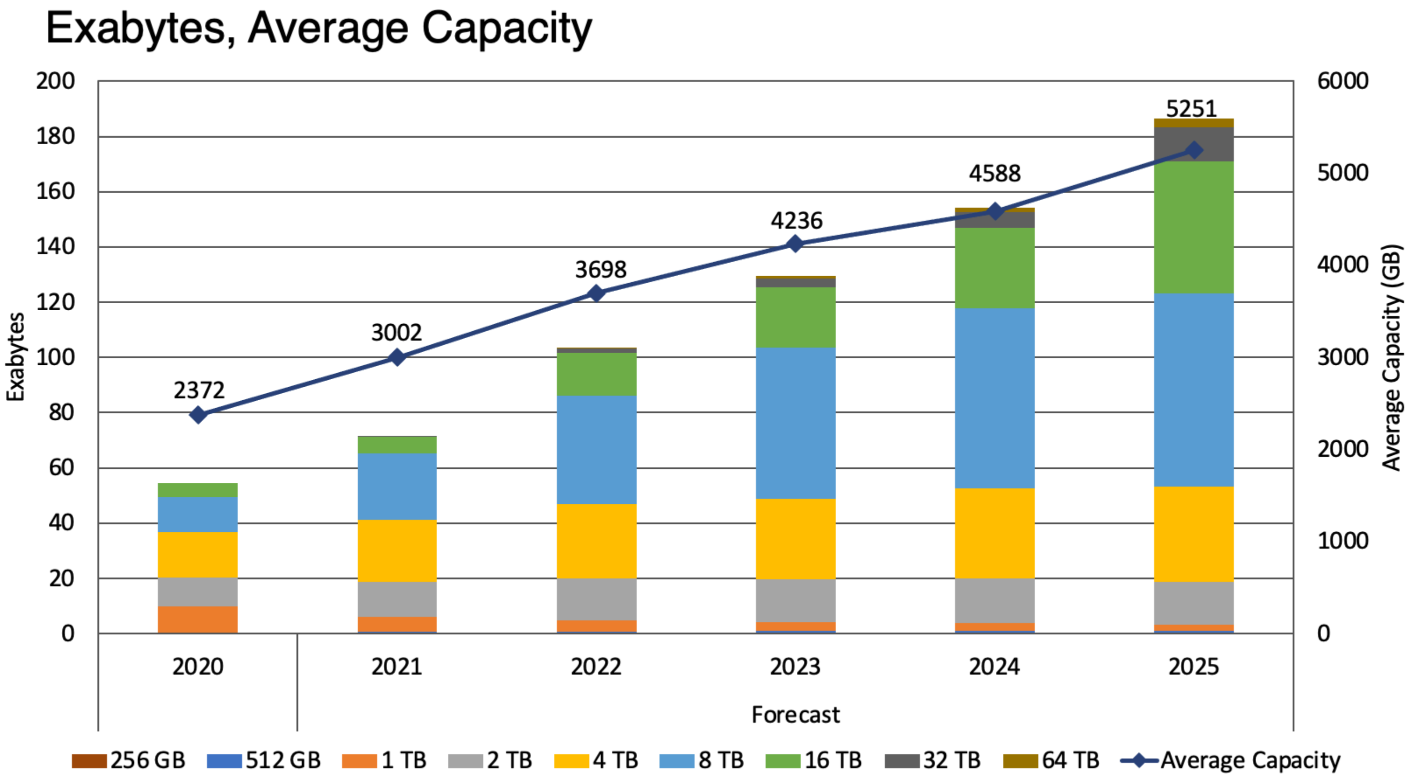
- High random performance
- Capable of supporting Hyper-Scaler needs:
  - Consumes lower power
  - Supports security features such as Secure Boot
  - Increased reliability as there are no moving parts
  - Reduces blast radius due to being local to the system
- Physically small (M.2: 2280/ 2230)
- Widely available


M.2 2280

- **Client SSDs are more aligned to be used as a Boot Drive in a Hyper-Scaler environment, compared to other options**
- **But it comes with some challenges …**

SSD Boot Drive: Challenges

Capacity Trends



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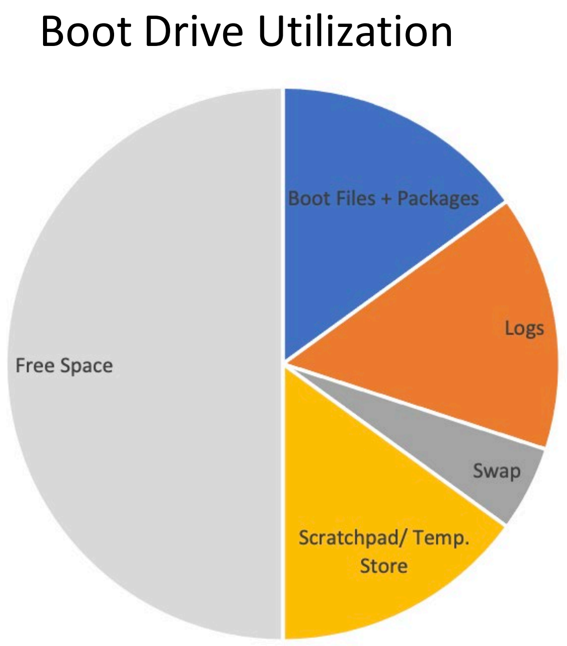
Source: TRENDFOCUS

- Data Drive capacity keeps increasing
- Boot Drive capacity needs 512GB or smaller
- Increasing capacity = Increasing expense

Boot Drive Utilization

- Typical Disk Utilization Remains low (<50%)
- Mostly of capacity used by user-space applications.
  - OS + Swap doesn't occupy a lot of footpr



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Hyper-Scaler desire is to have support for low-capacity Boot Drives

Differences in Client and Hyper-Scale Usage

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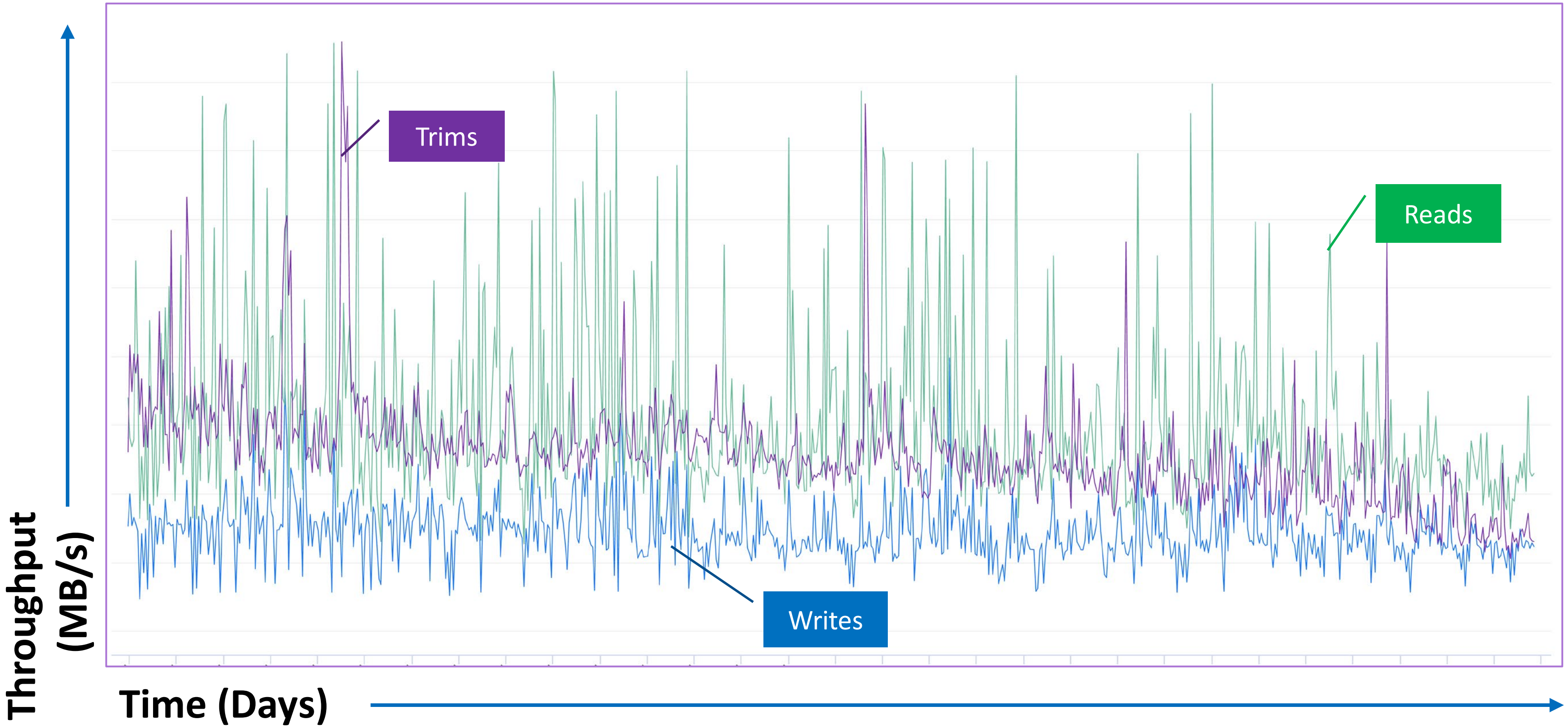
- Client SSDs are designed typically around a laptop usage model
- Client vs Hyper-Scale feature comparison:

Metric	Client	Hyper-Scale
Idle Time	Plenty	Almost none
Power Saving Features	Required	Not Required
On-board PLP	Not Required	Not Required
Performance	Fresh out-of-box	Sustained
Monitoring	Not important	Very important
Endurance	Low	Very high

Client and Hyper-Scale SSDs have different requirements

An example Hyper-Scale Boot I/O Profile



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- **Boot Drives experiences constant traffic with no idle time**
- **TRIM rate on Boot Drive is very high**
  - **Latency stalls due to TRIM are not desirable**

Boot Drive I/O Traffic Breakdown

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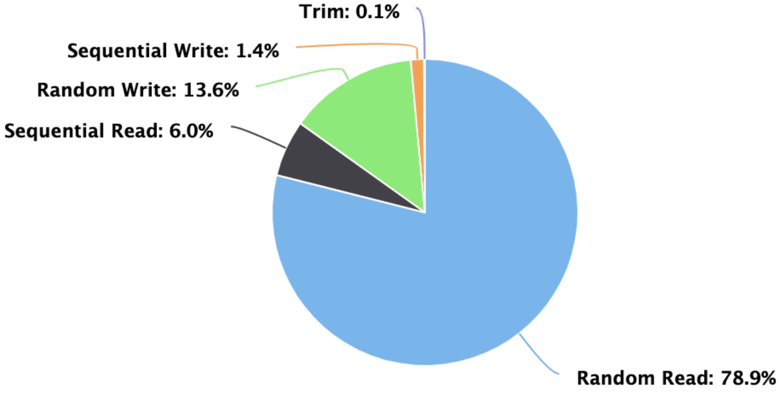
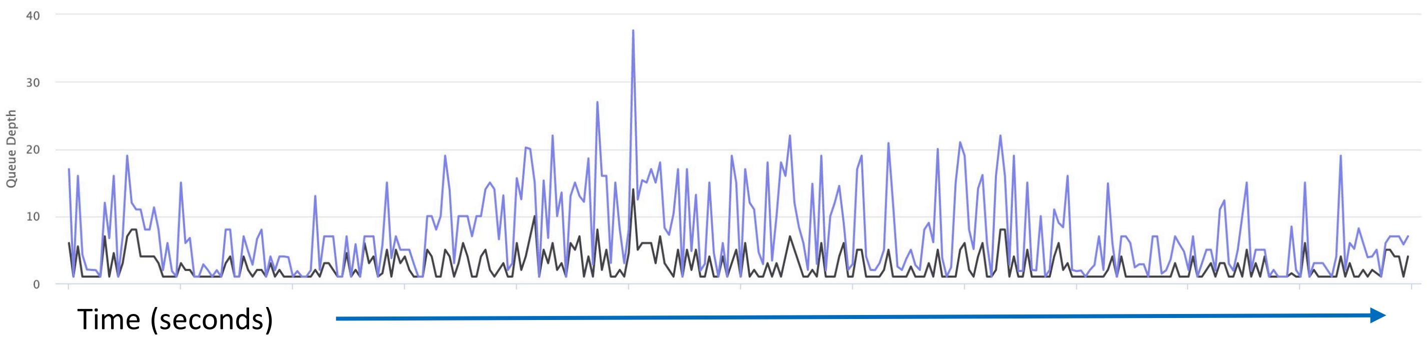
- Majority of the traffic is random in nature
  - Increases Background Activity
  - Increases Write Amplification

Device Level



- Majority of the traffic is low queue-depth:
  - Services are sensitive to drive latency
  - Latency stalls lead to poor user experience

Queue Depth Timeline



- Majority of traffic is random in nature
- Workloads have low queue depth
- User experience is sensitive to latency

Managing variable performant devices @Scale

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- Performance methodology for Boot Drives is not clear
  - No minimum bar (or performance target) defined
- No open benchmarks for Boot Drives
  - Leads to huge drive-to-drive performance variation

Hyper-Scalers must deal with huge variation in drive performance due to lack of industry standards

Hyper-Scale Endurance & Monitoring Requirements

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- Monitoring at scale is important
  - Boot Drives are deployed all over the world
- Monitoring helps predict & detect failing drives
- Boot SSDs need higher Endurance to prevent early wear out
  - Reliability is extremely important as repair at-scale is extremely challenging

Hyper-Scaler Boot SSD require higher endurance and enhanced monitoring

Summary of Challenges with Boot SSDs

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- Capacity of SSDs are increasing
  - Boot Drive capacity needs remains constant
- Client SSDs are designed with a focus on Client use-cases
- Hyper-Scalers require higher endurance and enhanced monitoring compared to Client SSDs
- Hyper-Scalers have confidential Boot SSD specifications which doesn’t encourage industry collaboration

SSD Boot Drive: Solution

How do we solve these challenges?

Path to solving the problem…

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Facebook & Google are collaborating and combining requirements to create a OCP Hyper-Scale Boot SSD Specification.

Benefits of an Open Boot Drive Specification

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- Facebook & Google have merged their SSD boot drive requirements into a single document enabling the following benefits:
  - Allows the market to understand what features Hyper-Scalers need to manage an SSD at-scale.
  - Allows the market to understand and use the SSD’s that Hyper-Scalers are using.
  - Reduces SSD market fragmentation.
  - Enables open-source tools like NVMe-CLI to manage & monitor SSDs at-scale.
  - Allows 3rd parties to create test-suites which simplifies the drive qualification process.

Opening requirements helps increase industry collaboration and reduces SSD market fragmentation

Key Focus Sections of the Specifications

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- Specifies requirements needed to build & manage a Hyper-Scale Boot SSD
- This includes requirements around:
  - NVM Express
  - PCI Express
  - SMART Logs
  - Reliability
  - Thermal
  - Power
  - Performance
  - Security
  - Side-Band/SMBus
  - Monitoring & Tooling

Everything needed to build a Hyper-Scale Boot SSD!

Conclusion: Roadmap to a brighter future

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Today

Future

Lack of Industry Standards for Hyper-Scale Boot Drives

- SSD Boot Drives are customized but there is no Industry Standard to capture all the requirements.

OCP Hyper-Scale Boot Drive Specification

- Benefits system makers and SSD providers.
- Enables additional collaboration between Hyper-Scaler's and industry.

Thank you!

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