

Western Digital®

Open Composability

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Flash Memory Summit

Forward-Looking Statements

Safe Harbor | Disclaimers

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Key risks and uncertainties include volatility in global economic conditions, business conditions and growth in the storage ecosystem, impact of competitive products and pricing, market acceptance and cost of commodity materials and specialized product components, actions by competitors, unexpected advances in competing technologies, difficulties or delays in manufacturing, and other risks and uncertainties listed in the company's filings with the Securities and Exchange Commission (the "SEC") and available on the SEC's website at www.sec.gov, including our most recently filed periodic report, to which your attention is directed. We do not undertake any obligation to publicly update or revise any forward-looking statement, whether as a result of new information, future developments or otherwise, except as required by law.

Composable Infrastructure

A Quick, Industry Primer

- *The What:*

- An emerging category of datacenter infrastructure that seeks to disaggregate compute, storage, and networking fabric resources into shared resource pools that can be available for on-demand allocation (i.e., “composable”).¹

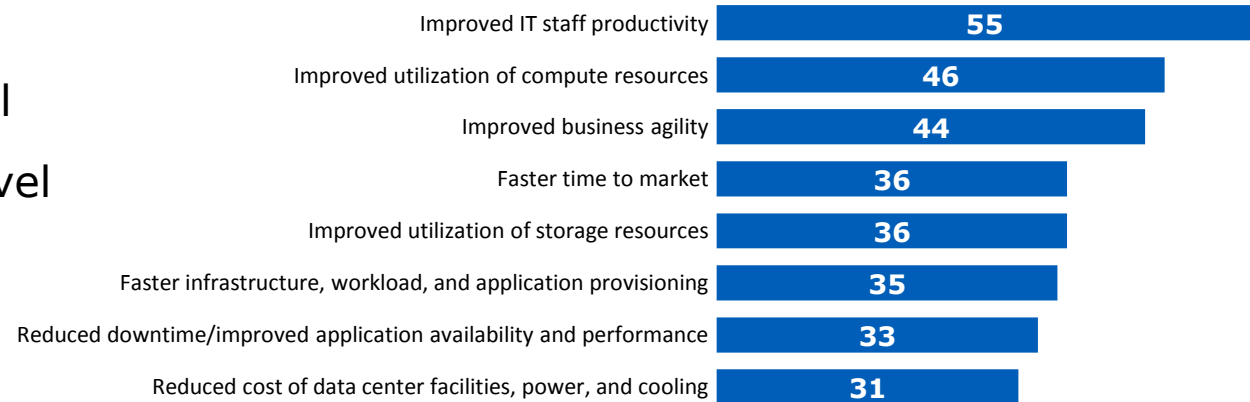
- *The How:*

- Composability occurs at the software level
- Disaggregation occurs at the hardware level

- *The Why:*

- Productivity, agility, time-to-market
- Improved utilization and faster provisioning
- Higher availability and performance

Top Desired Benefits of Composable Infrastructure ²

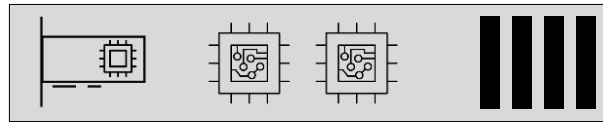


² “Infrastructure Usage and Overprovisioning Trends Survey,” IDC, November 2016.
N = 301
Base = app respondents
Note: data is weighted by employee size

¹ “Quantifying Datacenter Inefficiency: Making the Case for Composable Infrastructure,” IDC, March 2017.

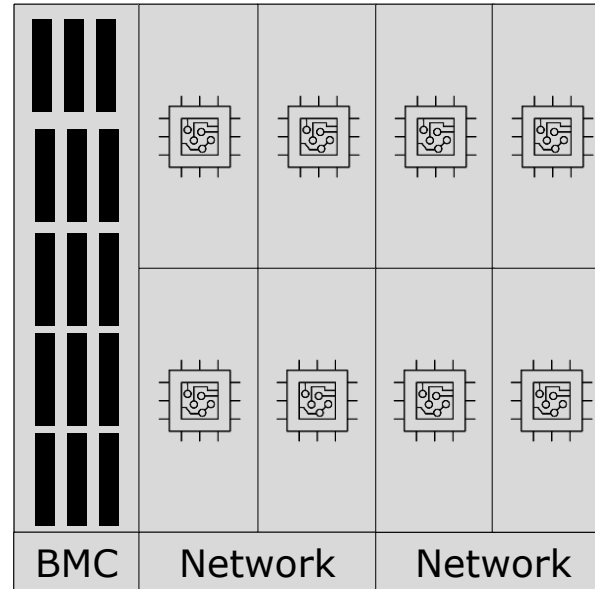
Levels of Composability

Hyper-converged



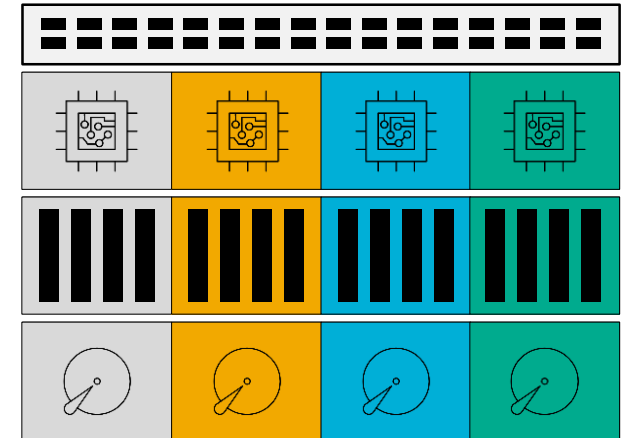
Server

Brand Composable



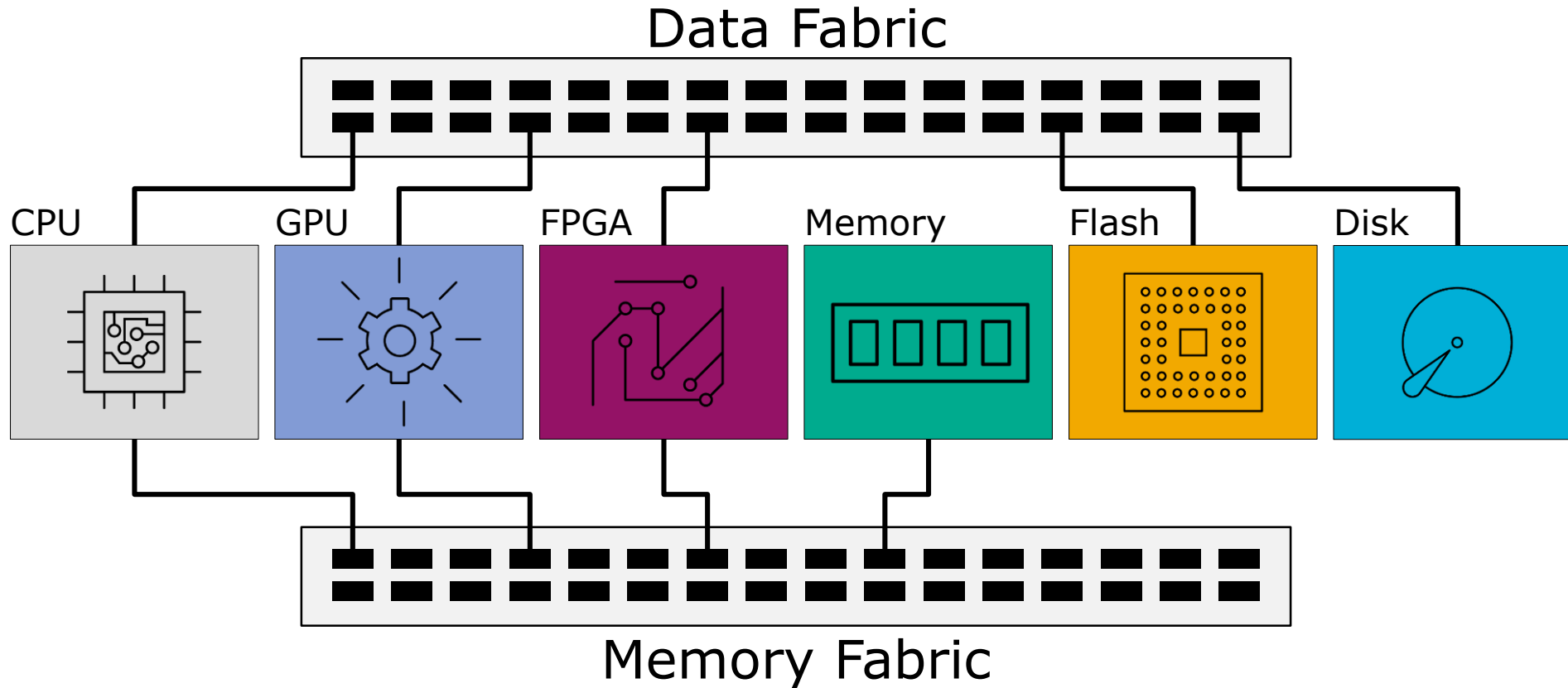
Chassis

Open Composable



Network

Composable Element Vision

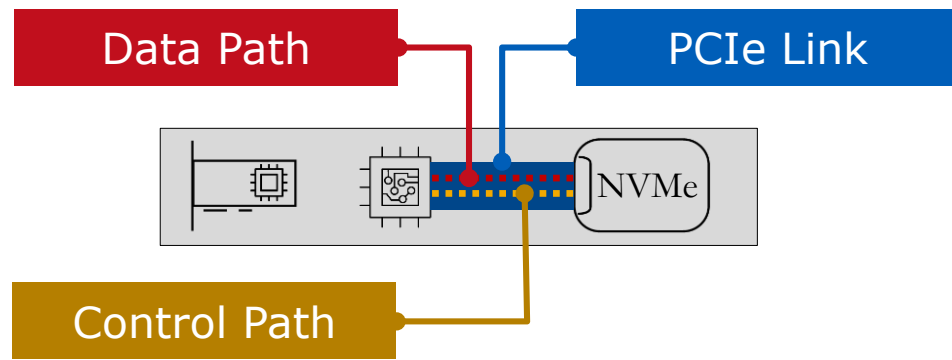


- No physical systems – Only virtual systems
- Each element provides a service that is offered over the network
- No established hierarchy – CPU doesn't 'own' the GPU or the Memory
- All elements are peers on the network & they communicate each other

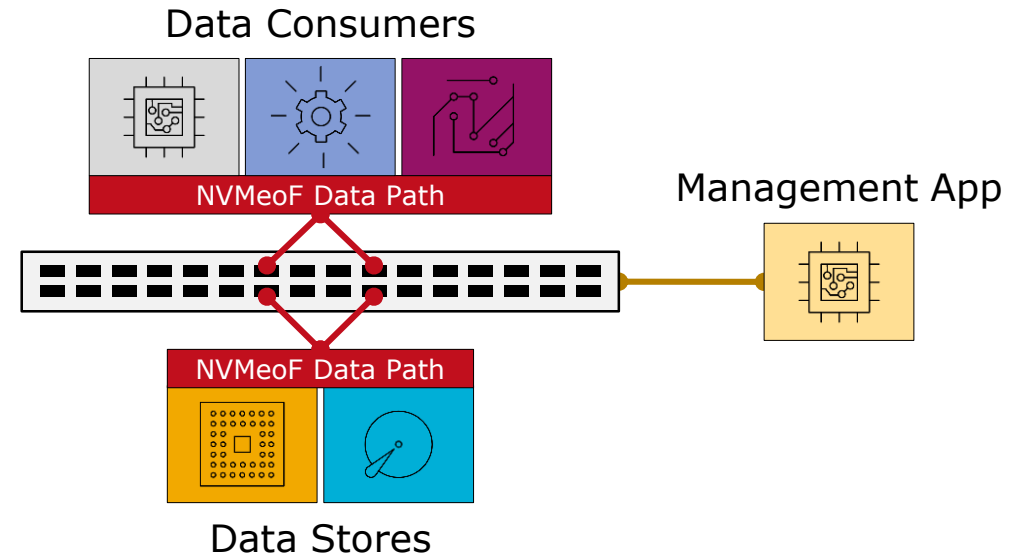
Moving the Control Path to the Fabric

NVMf protocol for data path & a separate protocol for management

Merged Data & Control Path



Separate Data & Control Path



Challenges for NVMf Management

- NVMe™ was designed in-server use
- Single host owned the data & control path
- NVMe protocol does not separate control & data
- No notion of multitenancy
- NVMf requires RDMA even for management
- NVMf can't manage other composable elements

Data Path Actions

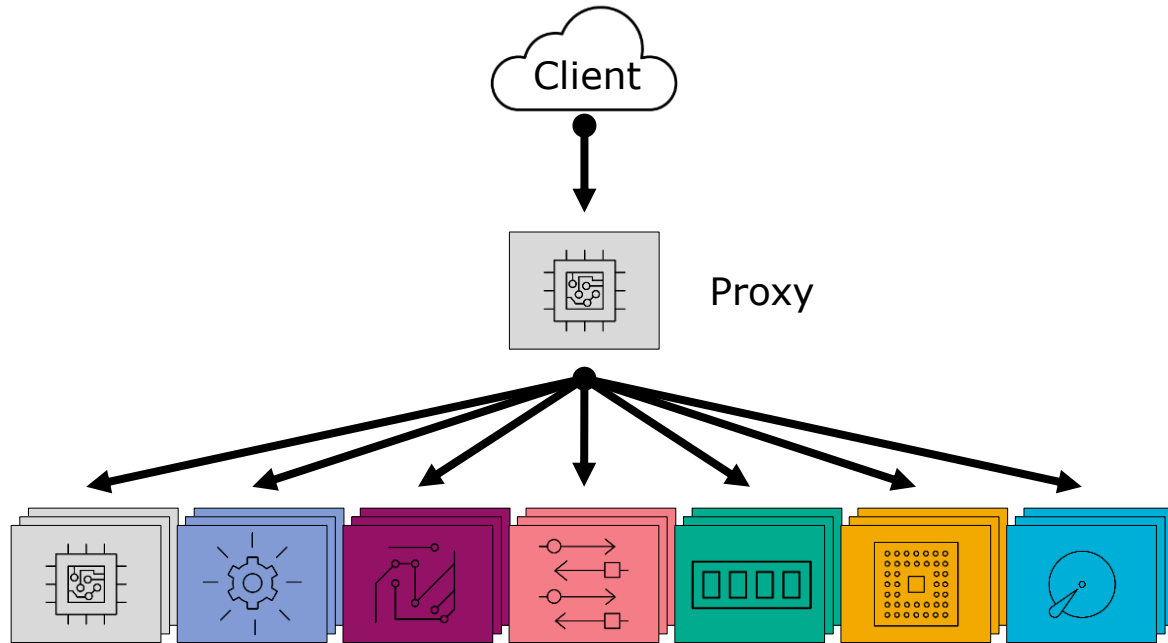
- Create/Delete Queues
- Get Features
- Read/Write/Flush
- Write Uncorrectable
- Compare, Write zeros
- Dataset Mgmt. (Trim)
- Limited Read Retry
- Reservations
- Format/Sanitize NS

Management Actions

- Update Firmware
- Create/Modify/Delete NS
- Set Features
- Self Test
- Set Volatile Write Cache
- Get Log Page
- Health Information
- Enclosure Monitoring
- Sensors: Temp/Fan/Slot

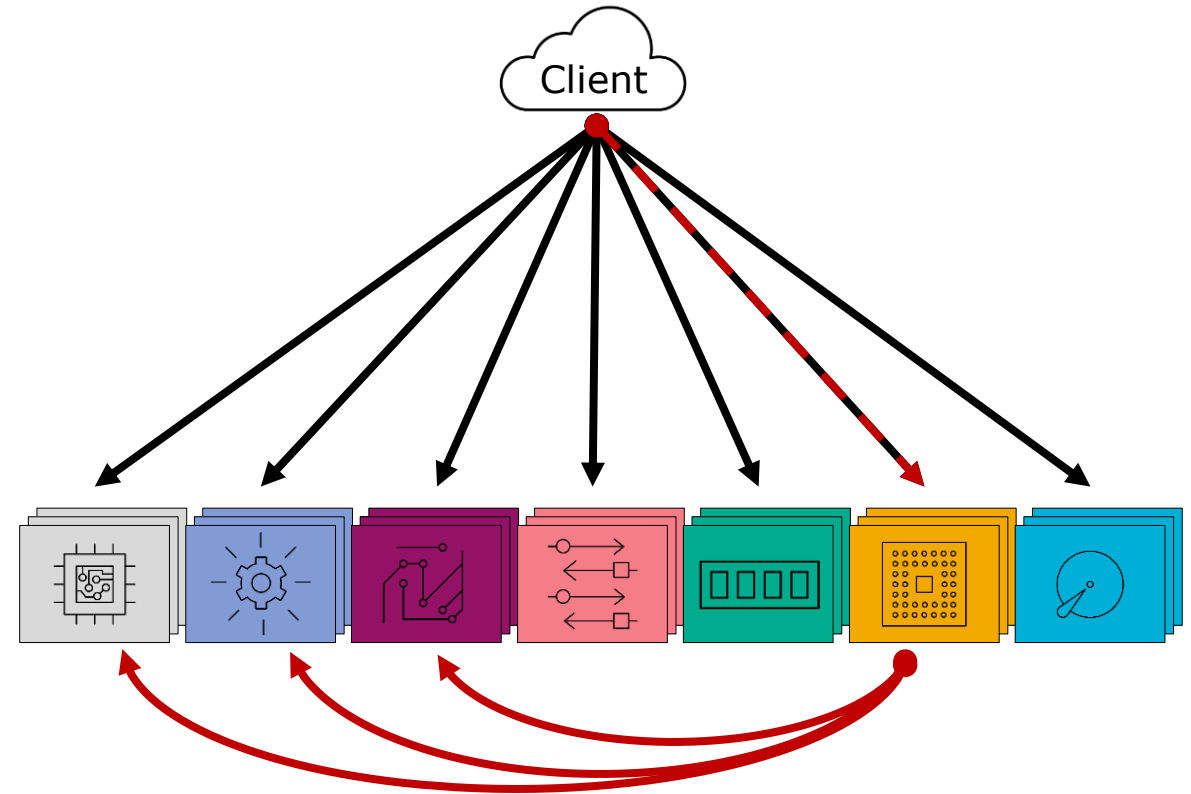
Resource vs Service Oriented Architectures

Service Oriented Architecture



- Classic hierarchy model
- No communication between elements
- Elements have no knowledge of peer services

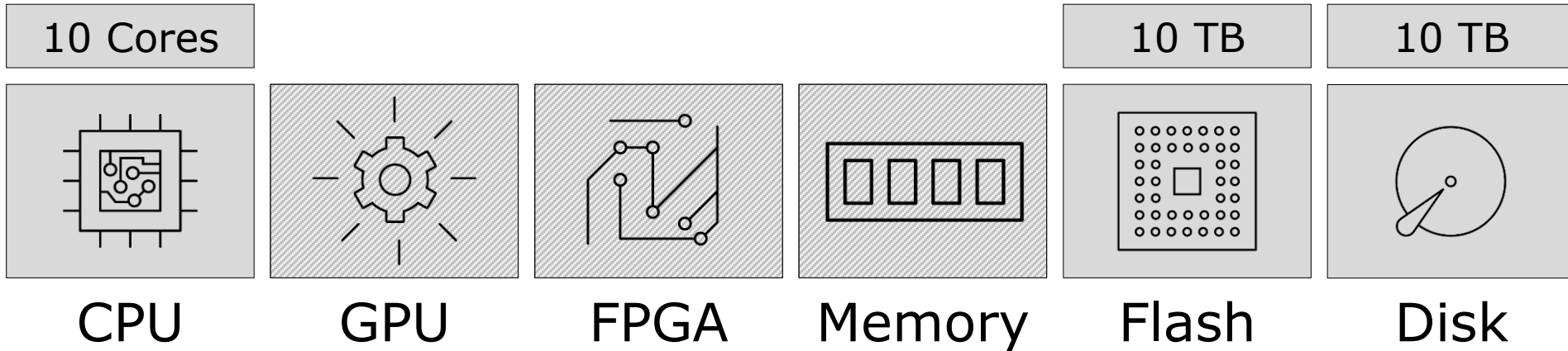
Resource Oriented Architecture



- True disaggregated model
- Elements resolve requirements together
- Physical elements can represent other elements in a virtual system

Self-Organizing Elements

Free	0 Cores	2 TB	6 TB
C	4 Cores	2 TB	
B	4 Cores	4 TB	2 TB
A	2 Cores	2 TB	2 TB



Western Digital's Open Composability Vision

Essential Pillars

1. Open

- API & form factor
- Interoperability of multi-vendor solutions

2. Scalable

- Ability to compose solutions at the width of the network
- Enable self-organizing systems of composable elements that communicate horizontally

3. Disaggregated

- Pools of resources available for any use case that is defined at run time
- Independent scaling of compute & storage elements to maximize efficiency & agility

4. Extensible

- Entire ecosystem of composable elements managed & orchestrated using a common API framework
- Prepared for yet-to-come composable elements – e.g., memory, accelerators



Kingfish™ Toward Open Composability

Proposed new composability API

Key Features

- Resource Oriented Architecture
- Disaggregated element model
- Element-to-Element communication to enable self-organizing virtual systems

Standardization Path

- Not currently committed to any standards body
- Could be extensions to existing standard or new standard
- Develop proposed specification with consortium peers & standardize at a later date

Call to Action

- Visit our booth to see demo of disaggregated storage
- Visit wdc.com/nvmf to learn more and register to receive updates
- Join Western Digital to help define what is needed for Open Composability

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