Transforming Storage Controllers with Low-cost, Low-power Compute

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Agenda

Quick overview of computational storage
Computational storage drives and interfaces
Programmable computational storage drives
On-drive Linux
Low-cost, low-power compute

Arm is a founding member of SNIA Computational Storage Technical Working Group (TWG)
Compute waits for data
Takes time to move data across fabric
*Processing stalled until data is available*

Adds latency
Multiple layers of interface and protocols
Data copied many times
Bottlenecks often exist

Consumes bandwidth/power
Moving data is expensive
Data copies increase system DRAM
Computational Storage Drive (CSD)

Compute happens on the data
Data moved from flash to in-drive DRAM and processed

Lowest possible latency
No additional protocols – just flash to DRAM

Minimum bandwidth/power
Data remains on the drive – only results delivered

Data centric processing
Workloads specific to the computation deployed to the drive

Security
Unencrypted data does not leave the drive

Simplified model with computational storage

1. Request operation
2. Compute
3. Return result
Methods to control and manage a CSD
SNIA TWG developing standards enabling interoperability
SNIA TWG defining NVMe CSD control (advertising, use...)

Programmable CSD
Programmed to provide computational storage services

Fixed Purpose CSD
Performs a fixed function

Key interfaces to CSDs
PCIe and NVMe: Local server offload
NVMe-oF: Offload over fabric e.g. NVMe/TCP
Ethernet to on-drive Linux - the drive is ‘just a server’
Programmable CSDs

Computational Storage workloads
- Workloads are developed, deployed to the drive and services advertised
- Workloads are initiated and results returned or stored
- Workloads are updated/enhanced and re-deployed

On-drive Linux is the simplest development and deployment
- Huge number of applications and protocols already available
- Wide range of development tools and vast open-source developer community
- Easy to deploy through existing infrastructure and operations teams

Other development systems have applications
- Bare-metal for hard real-time, FPGA development systems, ...
On-drive Linux: Two Main Approaches

1. ‘Just another networked server’: To the infrastructure, the CSD is a server
   - Runs any standard Linux distribution, standard protocols and standard applications
   - Workloads/containers downloaded using standard Linux systems e.g. Docker, Kubernetes…
   - Standard applications, such as databases or ML, can run directly on the data in DRAM

2. NVMe/PCle or NVMe/TCP: Enables standard drive or CSD
   - Standard NVMe-of TCPIP operates as normal – drive processes NVMe storage commands
   - New NVMe CS commands received over NVMe intercepted to instigate CS functions
   - Linux workloads/containers developed, deployed and actioned

Linaro founded in 2010

www.linaro.org

www.worksonarm.com
Options to Add On-drive Linux

Three main options to run on-drive Linux
1. Add a separate applications processor SoC in-drive
2. Integrate into a single SoC for lower cost/latency
3. Single compute cluster for lowest cost/latency

Linux storage and DRAM requirements
e.g. Debian 9 ‘buster’ states system requirements...

Table 3.2. Recommended Minimum System Requirements

<table>
<thead>
<tr>
<th>Install Type</th>
<th>RAM (minimum)</th>
<th>RAM (recommended)</th>
<th>Hard Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>No desktop</td>
<td>128 megabytes</td>
<td>512 megabytes</td>
<td>2 gigabytes</td>
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</table>

Smaller Linux distributions are available
A typical 16TB SSD already has ~16GB DRAM
Linux requires an applications processor
Memory Management Unit (MMU) to virtualise memory
Arm Cortex-A series have 21 processors available and a strong roadmap
From a single processor to many clusters of compute
Meeting every possible performance point at the lowest possible power

Some eSSD controllers already use Cortex-A series processors
Other controllers, using real-time Cortex-R series, can easily add them

Arm Neon enables high-performance ML as standard
Neon Single Instruction Multiple Data (SIMD) greatly accelerates ML functions
ML processors, FPGAs, ISPs or dedicated hardware easily integrated
Computational storage is happening today

CSDs are available now from multiple manufacturers

SNIA CSD standards to deploy/manage workloads over NVMe/PCIe or NVMe/TCP

Linux delivers the fastest route for workload development, deployment and management

The drive as ‘just another networked server’ fully leverages Linux ecosystem

An Enterprise SSD connected via ethernet and running Linux *is* a low-cost, low-power server
To Learn More…

I’ll be here all week

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Thank you