Flash Controller Solutions in Programmable Technology

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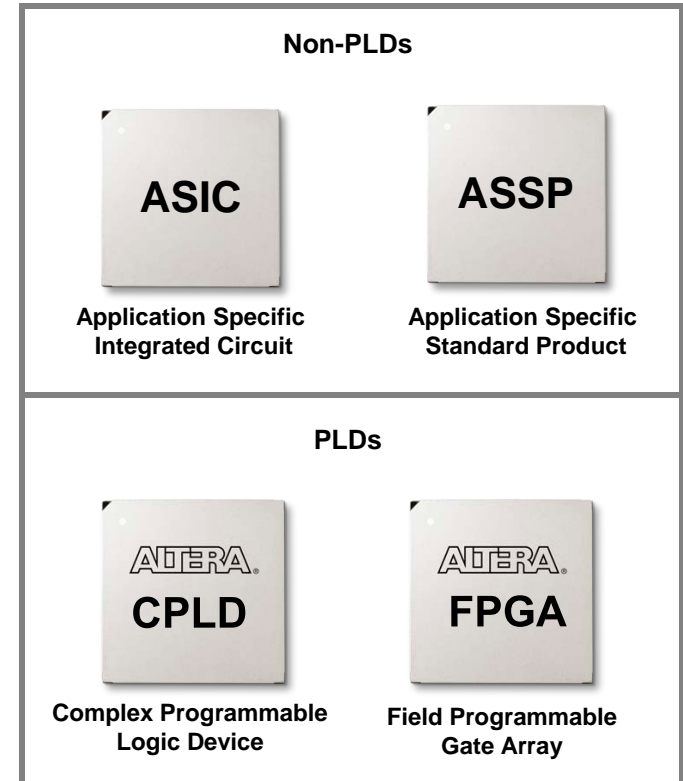
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Overview

- What is a PLD?
- Programmable Technology for Flash Controllers
- Example Applications
- Notable Emerging Memory Types

What Is a PLD?

- A programmable logic device (PLD) is a type of semiconductor

- Most semiconductors can be programmed only once to perform a specific function

- PLDs are reprogrammable—functions can be changed or enhanced during development or after manufacturing

Non-PLDs

ASIC
Application Specific Integrated Circuit

ASSP
Application Specific Standard Product

PLDs

ALTERA
CPLD
Complex Programmable Logic Device

ALTERA
FPGA
Field Programmable Gate Array

Flexibility Makes PLDs Lower Risk and Faster to Design Than Other Types of Semiconductors

PLD Tipping Point vs. ASICs
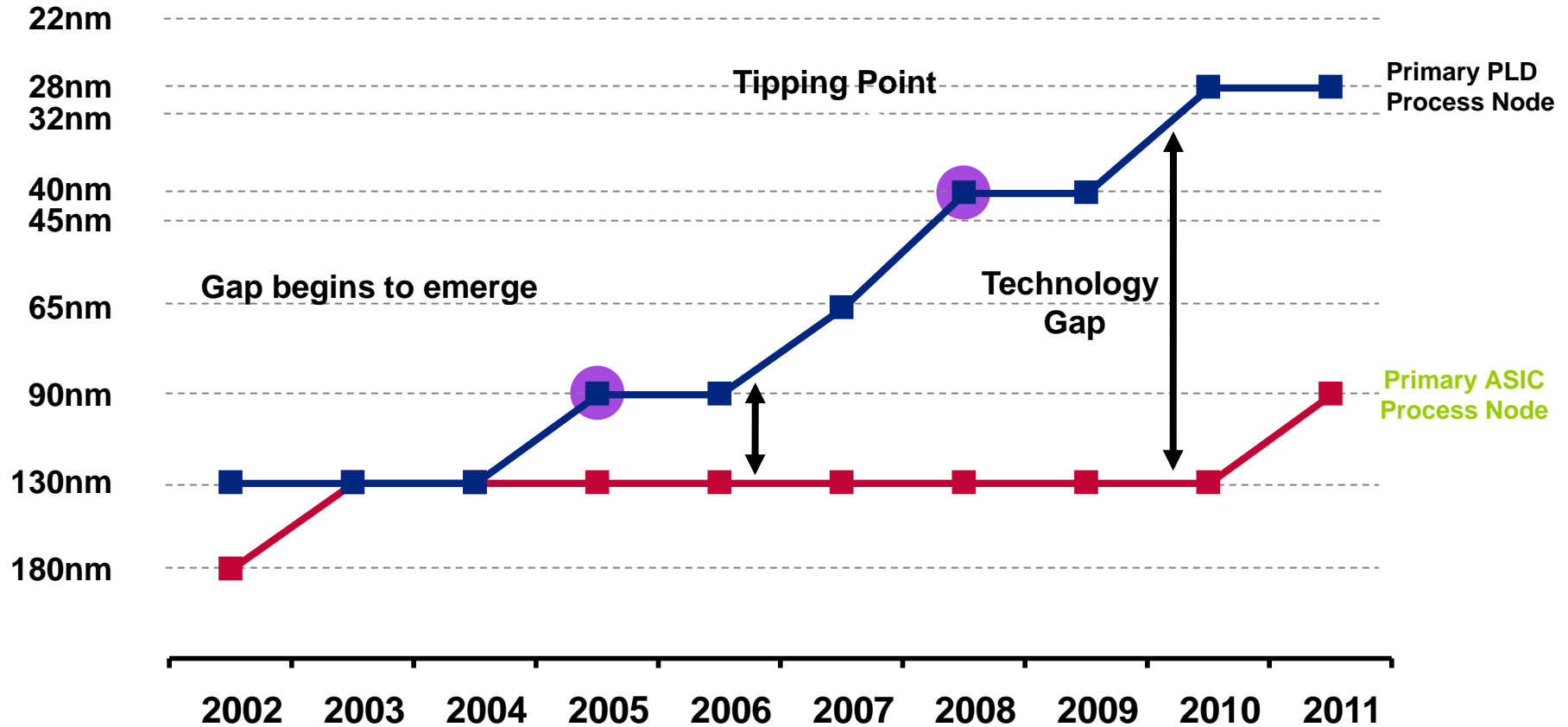
PLDs Outstripping Traditional ASICs in Technology and Total Cost of Ownership

Source: Altera; data applies to new design starts.
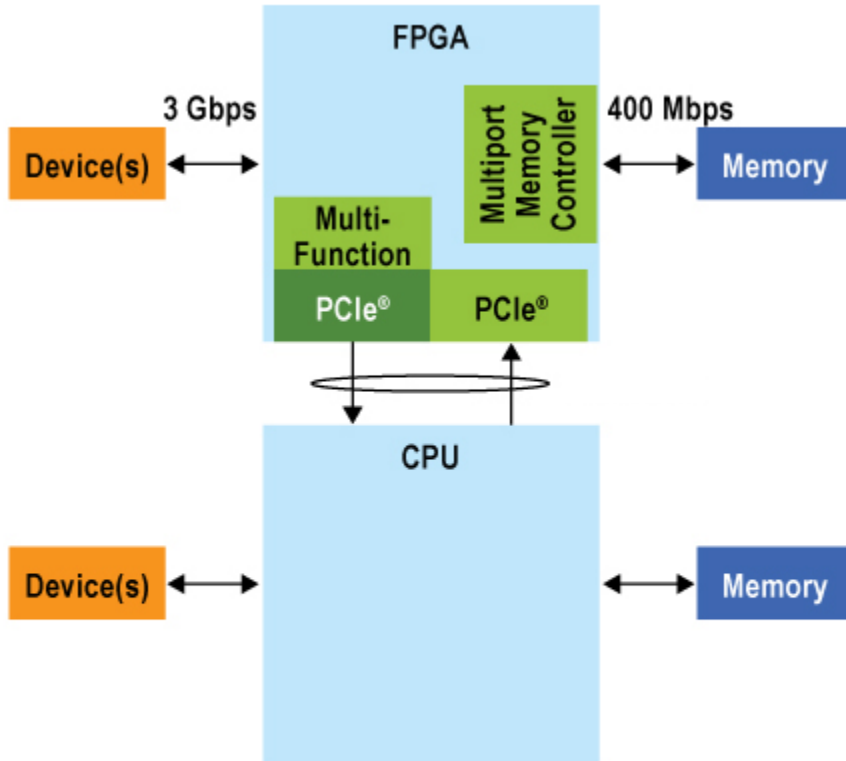
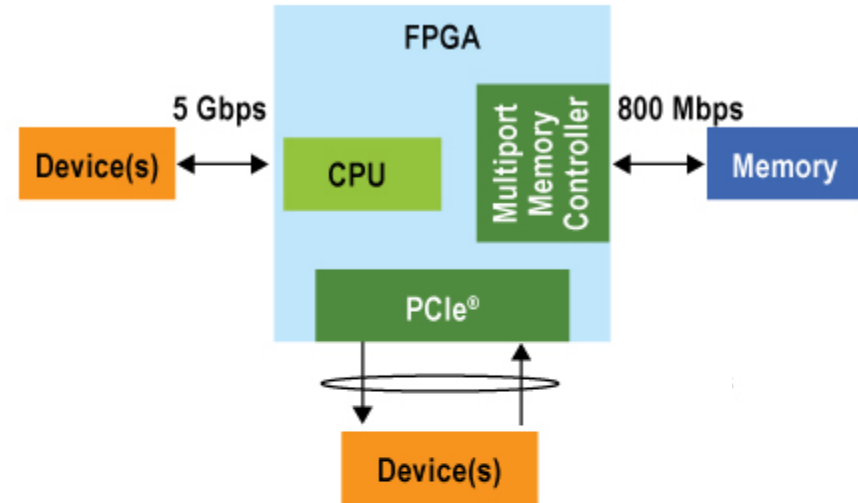# Enabling Technology- Programmable Logic Devices

- Design Logic support

  - Increasing densities to support system on chip (SOC) programmability

- Increased Computational Performance

- Reduced Power

    - Intelligent power management

    - Hardened IP blocks

- High Speed Serial Interface Support

    - Embedded Transceivers

Cost Reduction by Integration
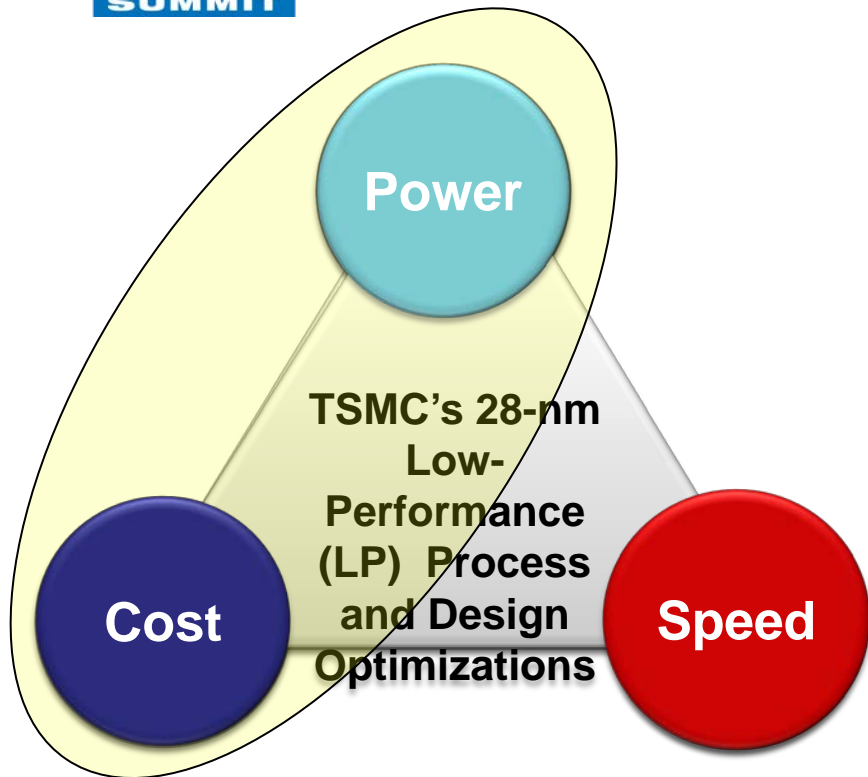
Before

After

FPGA

3 Gbps

Device(s) ↔

Multiport Memory Controller

400 Mbps

↔ Memory

Multi-Function

PCIe®   PCIe®

CPU

Device(s) ↔

↔ Memory

FPGA

5 Gbps

Device(s) ↔

CPU

Multiport Memory Controller

800 Mbps

↔ Memory

PCIe®

Device(s)

Soft IP

Hard IP

Balancing a FPGA Family by Process Technology

Power

Cost

Speed

TSMC's 28-nm Low-Performance (LP) Process and Design Optimizations

Power

Cost

Speed

TSMC's 28-nm High-Performance (HP) Process and Design Optimizations

- The optimal choice for addressing today's power- and cost-constrained applications
- Lowest absolute power
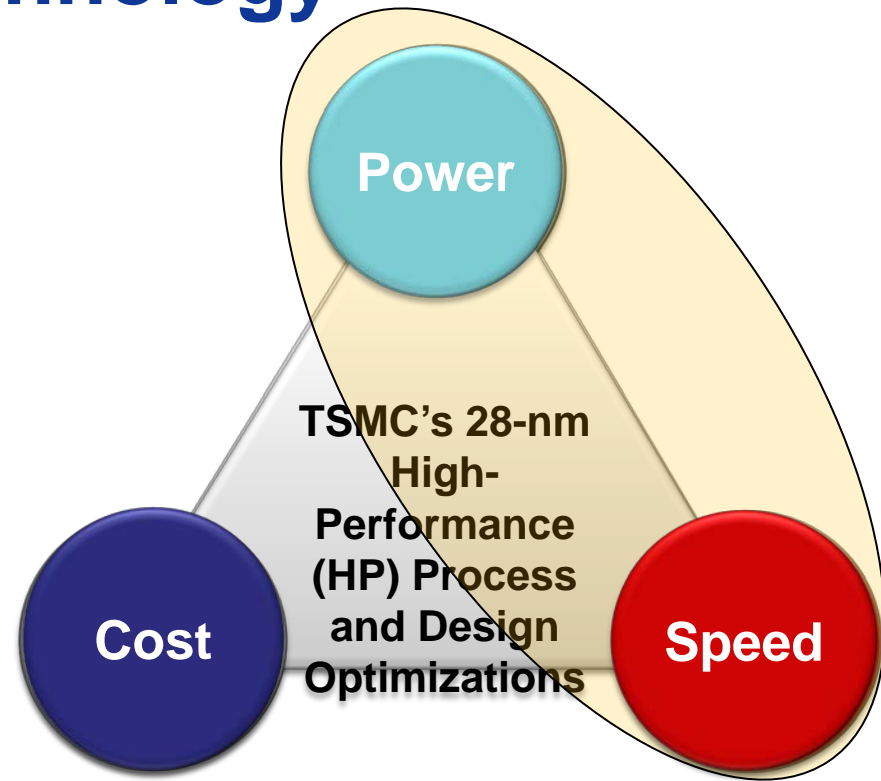
- Highest bandwidth
- 28G transceivers at 200 mW
- Lowest power in high-performance systems

A Complete Solutions Portfolio

MAX Series

Cyclone Series

Arria Series

Stratix Series

HardCopy Series

Lowest Cost, Lowest Power CPLDs

Lowest Cost, Lowest Power FPGA

Cost- and Power-Optimized FPGA

Highest Bandwidth FPGA

Lowest Risk, Lowest Total Cost ASICs

Nios II

ARM

MIPS Technology

Embedded Soft Processors

Intellectual Property (IP)

QUARTUS II

Design Software

Development Kits

PLD's Have Evolved!

The Lab

The Data Center

Prototyping
1-250 units

Production
10ku-1Mu

Data Center Applications- Servers

Application		Usage Examples
Flash SSD	**Flash Controller**	PCIe to ONFI bridging, Flash Control
Acceleration	**Accelerator Card**	Algorithm acceleration for vertical markets
Bridge Plus		Interface bridging with IP function, e.g. compression and encryption, Dedupe
I/O Virtualization (10GbE and PCIe)		ASIC alternative; low cost with flexibility
Co-ASIC	**Mainframe**	Features enhancement
Management (BMC, KVM)	**Blade Server**	IP Flexibility supported with low power

Data Center Applications- Storage

Application	Usage Examples
Flash Cache/SSD **Memory BackUp/Restore**	ONFI bridging and RAID adaptor NV DIMM backup, RAID for Flash
RAID Bridging	PCIe Gen 3 x8 best of class signal integrity
Bridge Plus	Interface bridging with IP function
ASIC Replacement **Tape**	Lower cost development with flexibility

Flash Controller Applications

Flash Controller Requirements

- Uncertainty Favors PLDs for Flash Control Solutions
- Flash Challenges Continue
  - Data loss, slow writes, wear leveling, write amplification, RAID
- Many Performance Options
  - Write back cache, queuing, interleaving, striping, over provisioning
- Many Flash Cache Opportunities
  - Server, blade and appliance

Flash Controller Design Challenges

- **Emerging memory types**
  - ONFI 3.0, Toggle Mode 2.0
  - PCM, MRAM
  - DDR4
- **Controller Performance Options**
  - Write back cache, queuing, interleaving, striping
- **ECC levels**
  - BCH encryption
- **Data transfer interface support**
  - PCI Express, SAS/SATA, FC, IB

Flash Controller Support

IP	Sources	IO	Speed	Logic Density	Comments
ONFI 3.0	SLS, Cadence	40 pins/ch	400 MTps	5KLE/ch	NAND flash control, wear leveling, garbage collection
Toggle Mode 2.0	SLS, Cadence	40 pins/ch	400 MTps	5KLE	Same
DDR3	Altera	72 bit	1066 MHz	10KLE	Flash control modes available for NVDIMM
PCM	Micron			5KLE	PCM- Pending production $
MRAM	Everspin			5KLE	MRAM- Persistent memory controller (Altera based)
PCIe	Altera	G3x8	64Gbps	HIP	Flash Cache

PCI Express Support
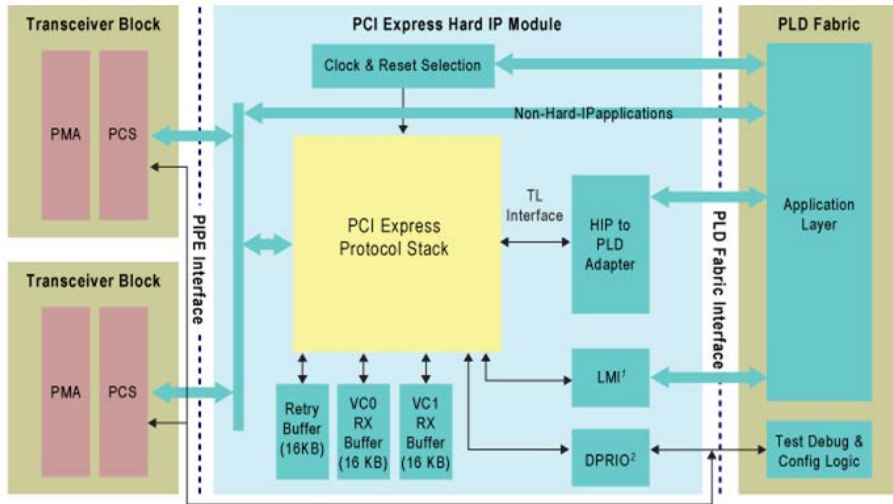
| PCIe Mode	Thruput (GT/s per lane)	Production
Gen 2	2.5	Now
Gen 3	5.0	Now
Gen 4	8.0	2016

Note:

1. LMI: Local Management Interface
2. DPRIO: Dynamic Partial Reconfigurable Input/Output

Hardened IP (HIP) Advantages

- Resource savings of 8K to 30K logic elements (LEs) per hard IP instance, depending on the initial core configuration mode
- Embedded memory buffers included in the hard IP
- Pre-verified, protocol-compliant complex IP
- Shorter design and compile times with timing closed block
- Substantial power savings relative to a soft IP core with equivalent functionality

SAS/SATA IP
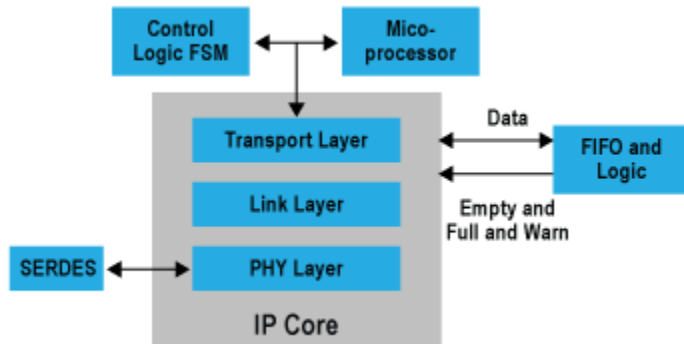
- Flash Controllers can manage SAS/SATA SSD interfaces
- 12Gbps SAS support required for enterprise drives
- FPGA transceivers need to support electrical performance and OOB signaling
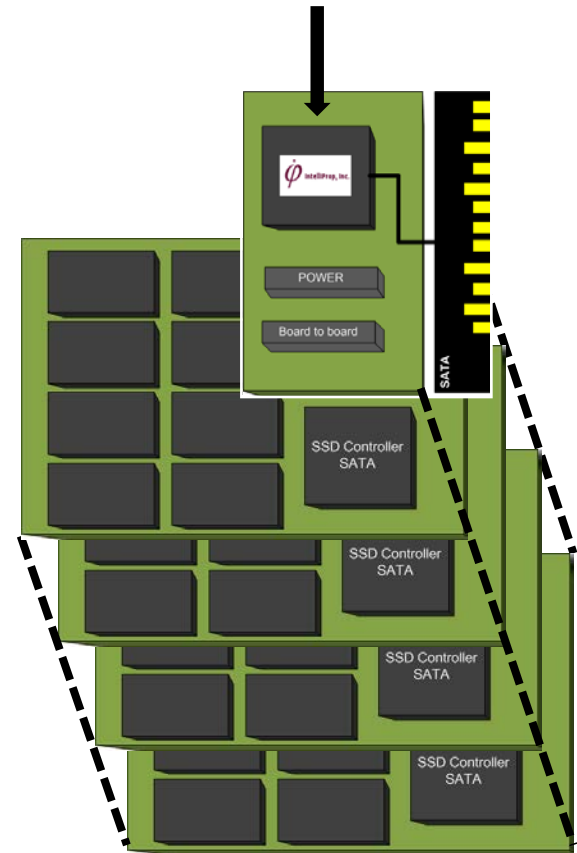
Flash Controller Example

HYDRA

Intelliprop Hydra **can provide 4X the capacity and up to 4X the performance of a single drive**

Single SATA
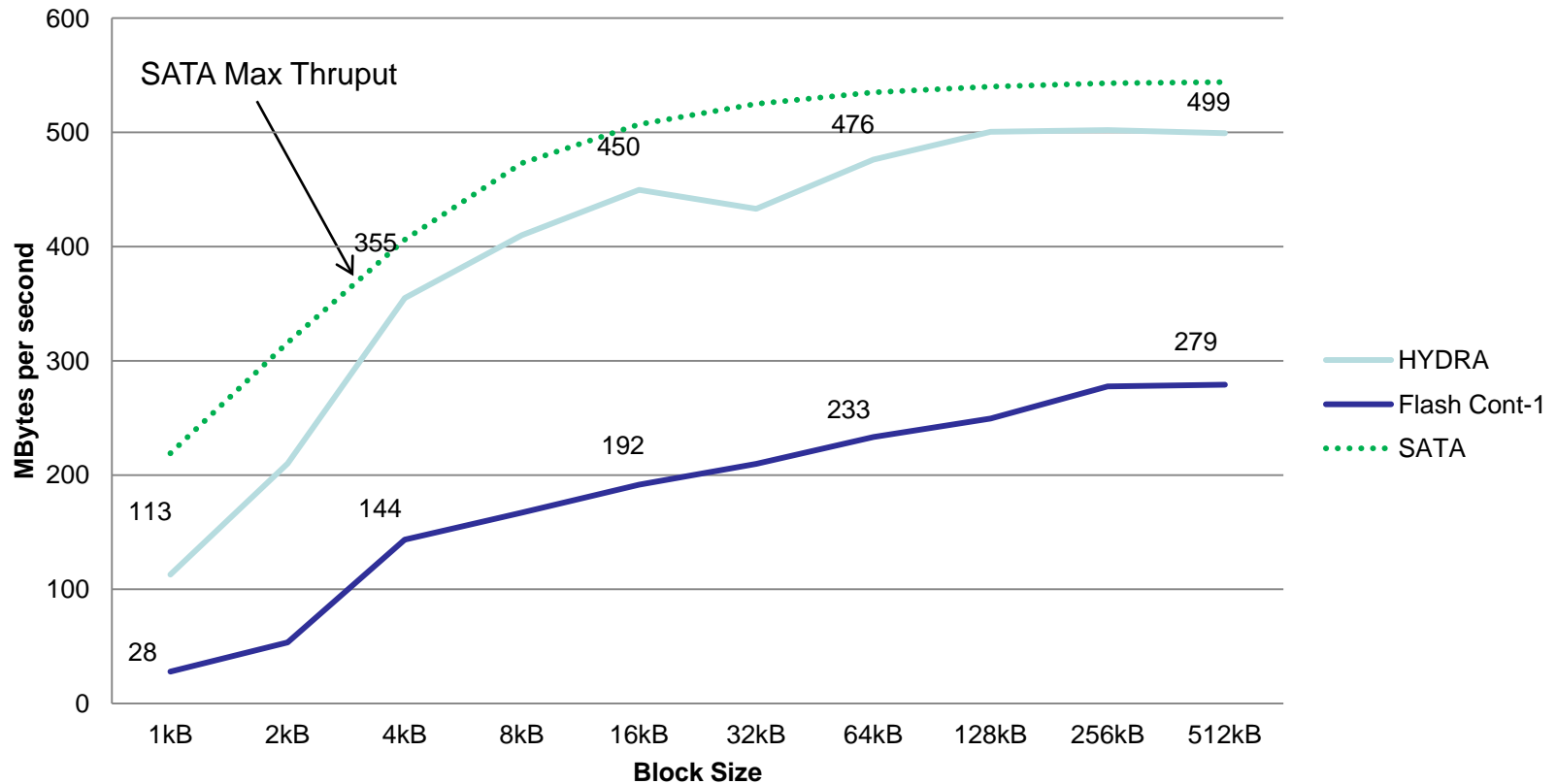
Applications

- SSD manufacturers with a need to build larger drives (1TB, 2TB, 4TB)
- Applications requiring stable read/write bandwidth
- Enterprise systems requiring high IOPS and bandwidth
- Host systems writing large amounts of "raw" data
- Systems where economical controllers can be used while still achieving performance of "enterprise" class controllers

2 or 4 Stacked drive cards

MBps
70% Random Read / 30% Rand Write

Chart showing MBytes per second vs Block Size for HYDRA, Flash Cont-1, and SATA.

SATA Max Thruput

HYDRA values: 113, 355, 450, 476, 499

Flash Cont-1 values: 28, 144, 192, 233, 279

SATA value: 355

Test Conditions

- Non-compressible data
- Testing done using IOMETER 2010
- Testing with HYDRA in 4 port configuration using 32-bit DRAM
- 4kB page size flash
- Host PC: Intel Core i7-3770K Ivy Bridge 3.5GHz

FPGA RAID Controller for Flash Arrays

- 10+TB plus of Flash Storage
- FPGA Applications
    - Flash Control
    - RAID
    - Data Transfer
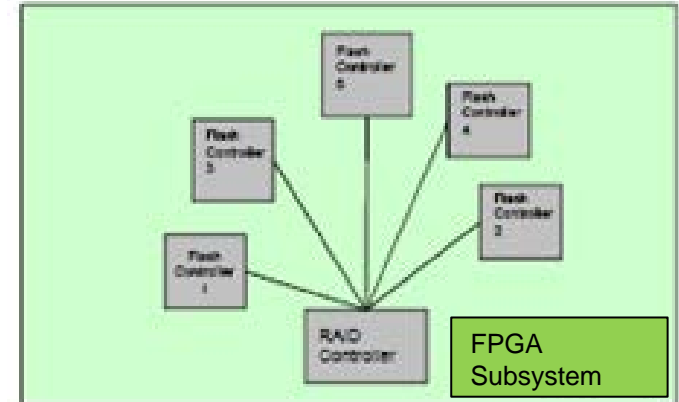
PLD Violin Product Portfolio

V3000: Performance Apps

- **Any SAN/PCIe**
- **High Reliability**
- **Low entry cost**
- **5TB-20TB per 3U**
- **100K – 200K IOPS**

Stackable

V6000: Primary Flash Storage

- **HA in box**
- **High bandwidth**
- **Integrated SAN**
- **6-32TB per 3U**
- **200K-1M IOPS**

Integrated

Technologies

vSHARE — Block Storage with full performance and flexible LUN management

vCLUSTER — Array management software with Web, CLI, Email and XML & Clustering
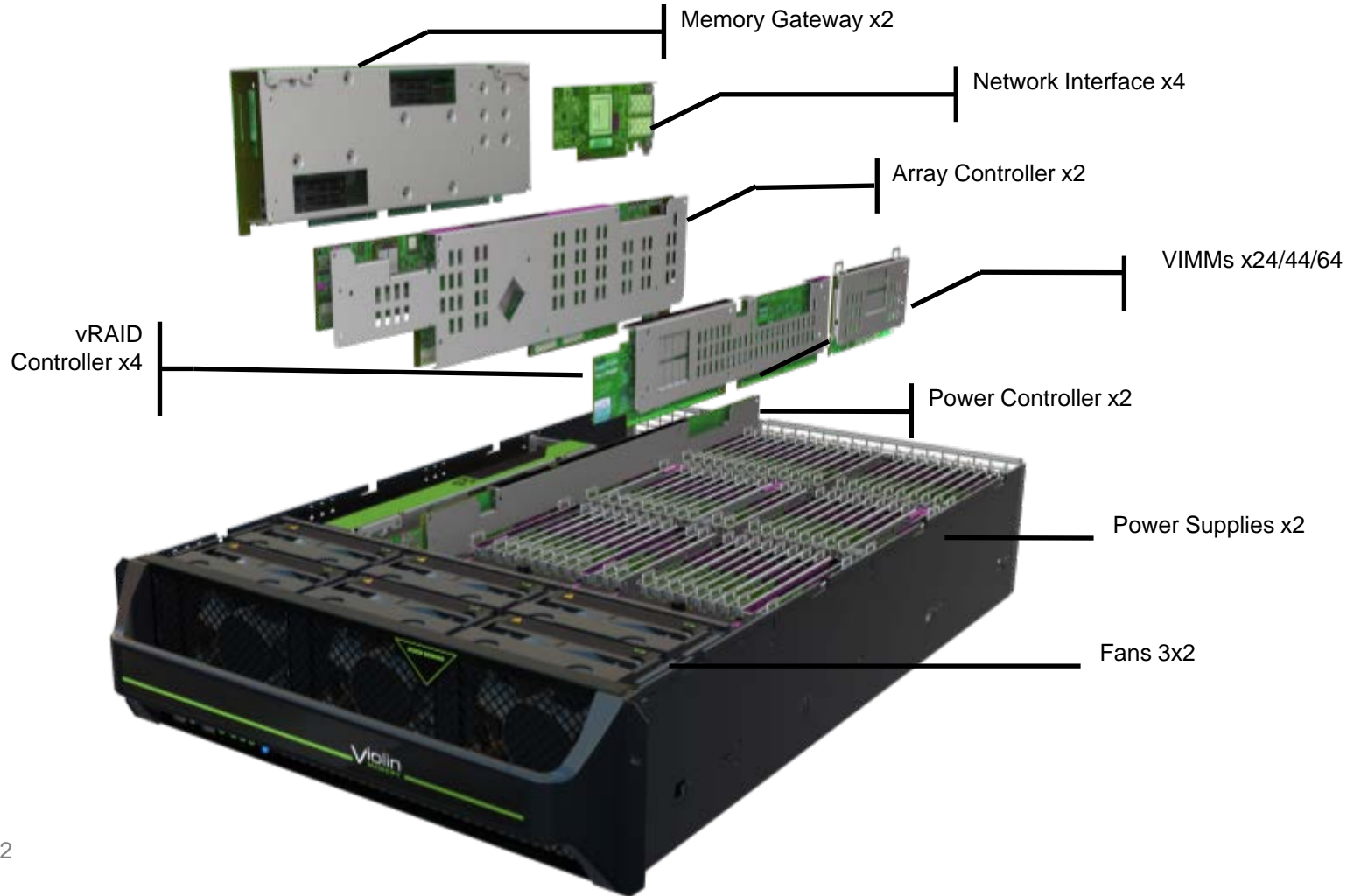
vRAID — Hardware Flash RAID with 4+1 efficiency

Violin Intelligent Memory Modules (VIMMs) with distributed grooming

High Availability

No Single-Point-of-Failure and Hot Swap Everything

Memory Gateway x2

Network Interface x4

Array Controller x2

VIMMs x24/44/64

vRAID Controller x4

Power Controller x2

Power Supplies x2

Fans 3x2

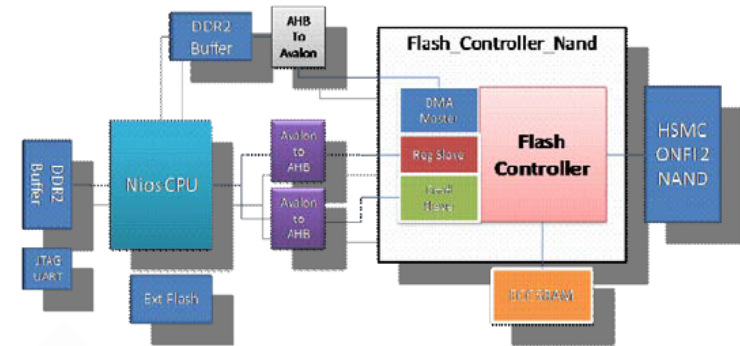# Flash Cache
PCIe or Appliance

- # Benefits

  - High performance for cache
    - Better bandwidth vs SSD
      - PCIe up to 5X
  - Lower power than DRAM
  - Less space than disk based
  - Hardcopy (structured ASIC) path

- # Solution

  - Altera
    - ONFI 2.0 & Toggle Mode cards
    - ONFI 3.0 daughtercard (3Q12)
    - ONFI 3.0 App Note (3Q12)
  - Partner
    - Denali/Cadence IP
    - SLS for single channel controller

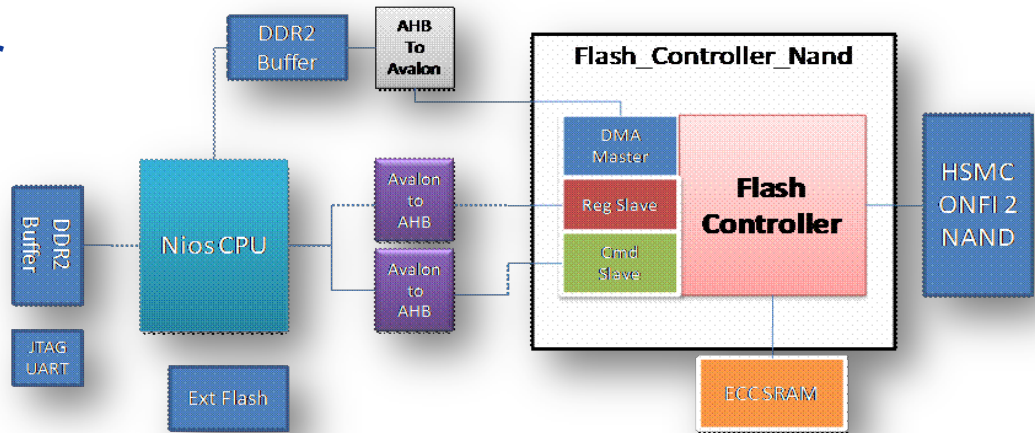**Denali Flash Controller**

**Nallatech
PCIe Gen 3x8
Card**

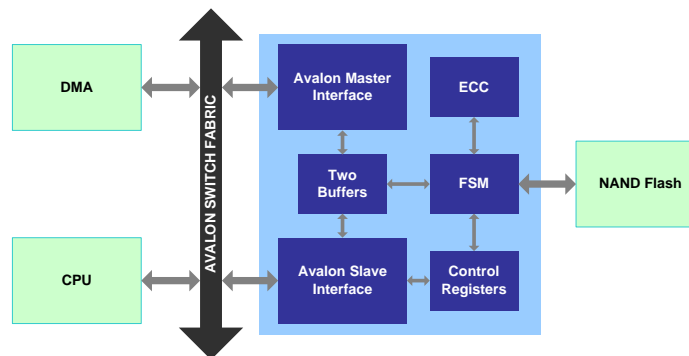**Micron ONFI Daughtercard**

Flash Cache Controllers

Denali Multi Channel Controller

- Single to multi Flash channel capability
- Basic NAND development platform
- Provides High Speed ONFI & Toggle NAND PHY
- ECC of 8 and 15 bits of error correction

Third Party Single Channel Controllers

Data Integrity- The Green Approach

Battery Backed Data Recovery

Add-on modules that protect against data loss in the event of a server or power failure by providing emergency power to the cache memory. When power is restored, the data not yet written to the hard drives can be retrieved from cache memory.
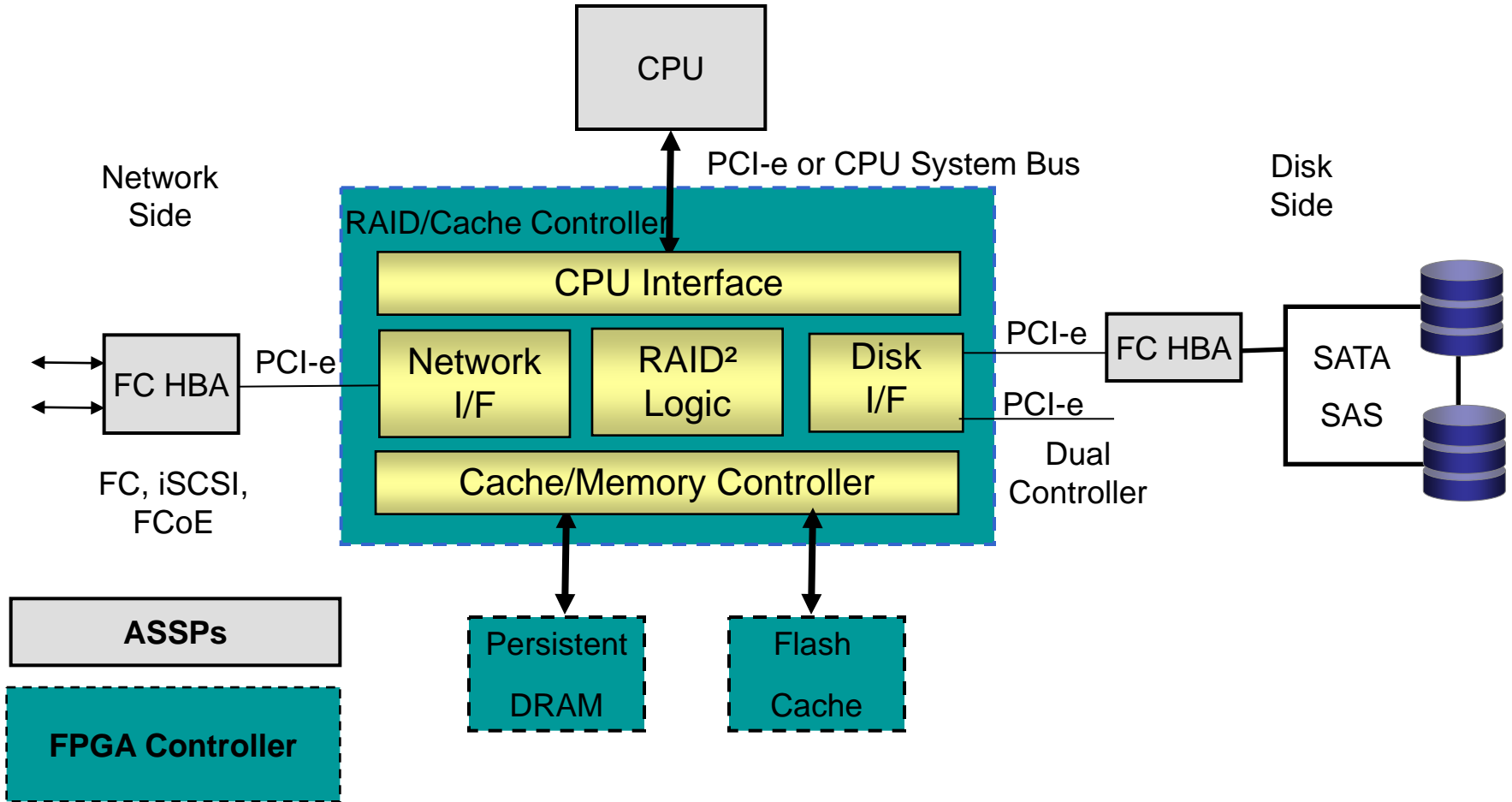
Super Capacitor Based Alternative

Benefit	Battery Power Source	Super Cap Power Source
Less Cost		☑
Lower Power		☑
Smaller Footprint		☑
Field service required	☑	
Permanent backup		☑

NVDIMM Controller Architecture

Hybrid RAID System
- Persistent DRAM and Flash Caches

Hybrid RAID System
- PCIe Switch Centric

CPU

Persistent DRAM

PCI-e or CPU System Bus

Network Side

FC HBA — PCI-e

FC, iSCSI, FCoE

PCIe Switch

PCI-e — FC HBA

Disk Side

SATA SAS

PCI-e

Dual Controller

PCI-e

PCI-e

ASSPs

FPGA Controller

Flash Cache

Dedupe/ Encrypt
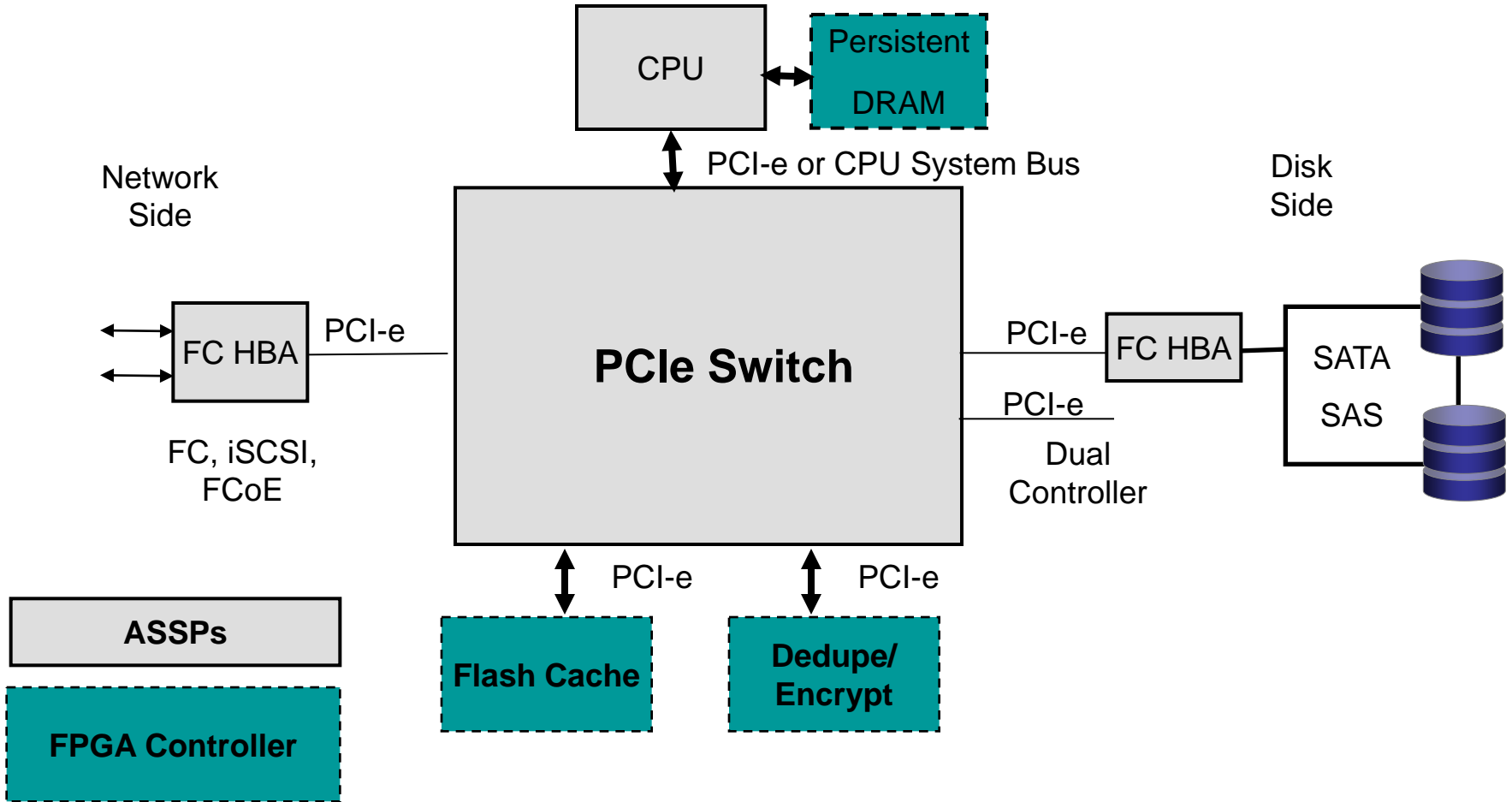
Flashing Forward

- Programmable Logic Devices (PLDs) are a well suited technology for emerging flash memory controller requirements.
  - Multiple memory types
  - BCH enhancements
  - Emerging technologies (MRAM)
  - High Speed Interface Requirements (PCIe, SAS)

Visit the Altera Exhibit Booth to Learn More!