# Flash Controller Solutions in Programmable Technology
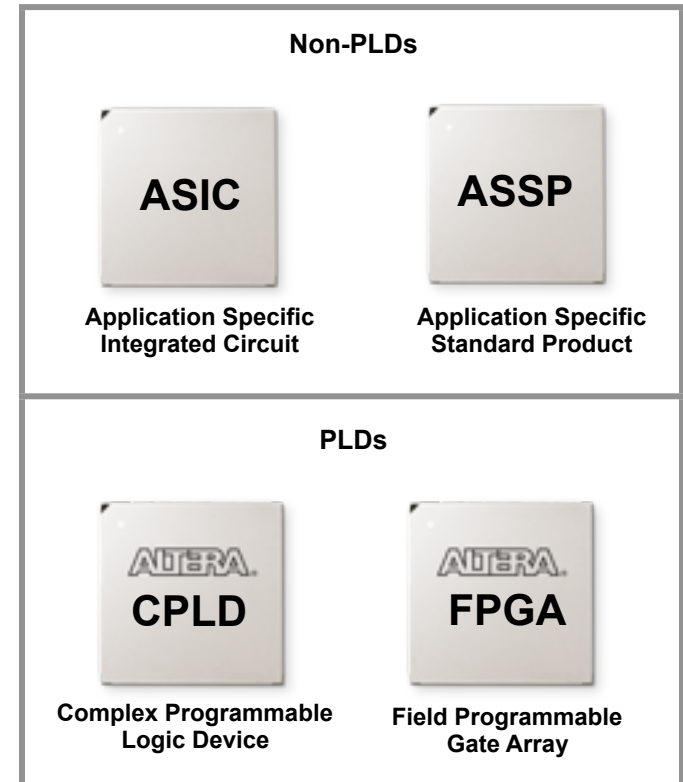
## David McIntyre

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Computer and Storage Business Unit

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Thursday, August 25, 11

# 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

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# PLD's Have Evolved!

The Lab

The Data Center
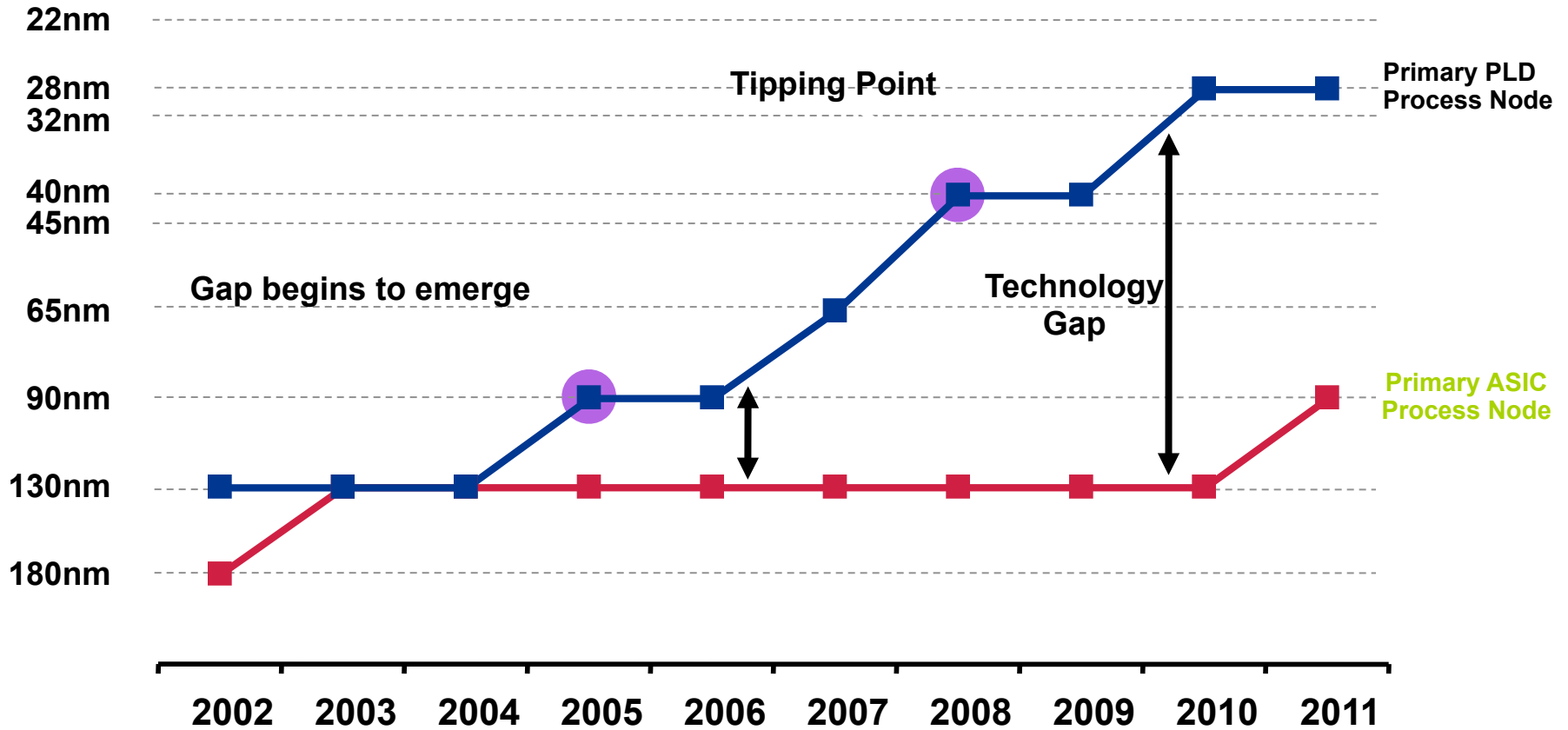
Prototyping
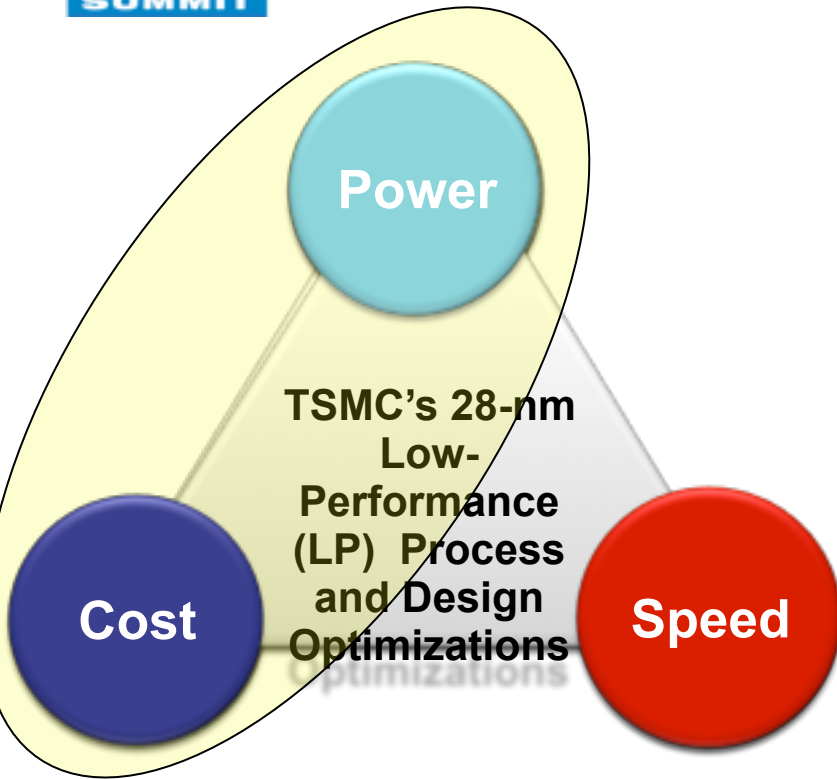1-250 units

Production
10ku-1Mu

# PLD Tipping Point vs. ASICs

**PLDs Outstripping Traditional ASICs in Technology and Total Cost of Ownership**

Source: Altera; data applies to new design starts.

# Balancing a FPGA Family by Process Technology

**Power**

**Cost**

**Speed**

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

- The optimal choice for addressing today's power- and cost-constrained applications
- Lowest absolute power

**Power**

**Cost**

**Speed**

TSMC's 28-nm High-Performance (HP) Process and Design Optimizations
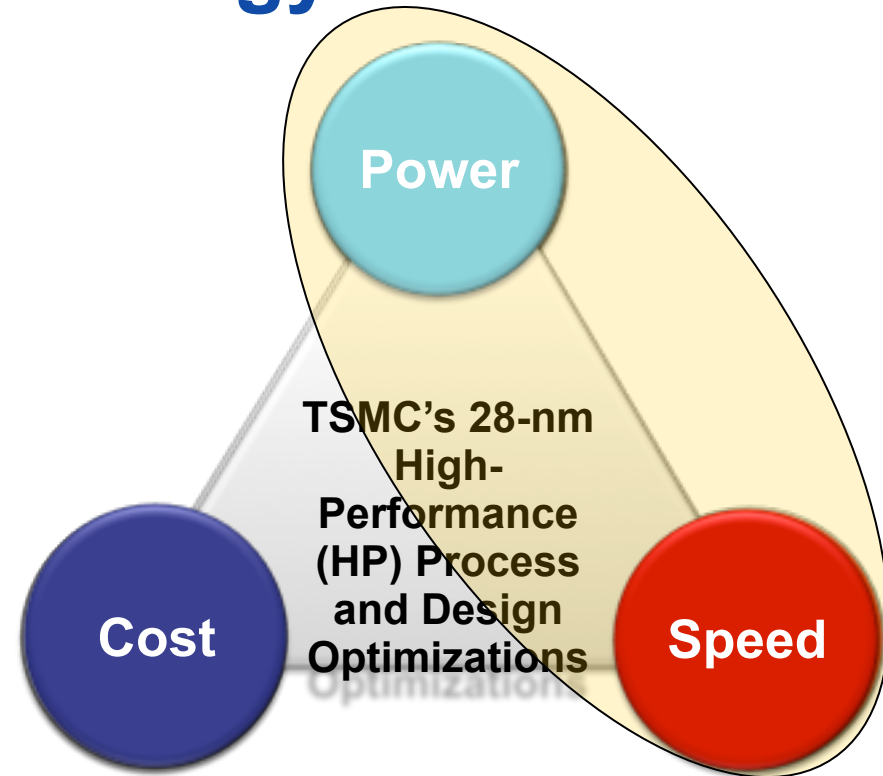
- Highest bandwidth
- 28G transceivers at 200 mW
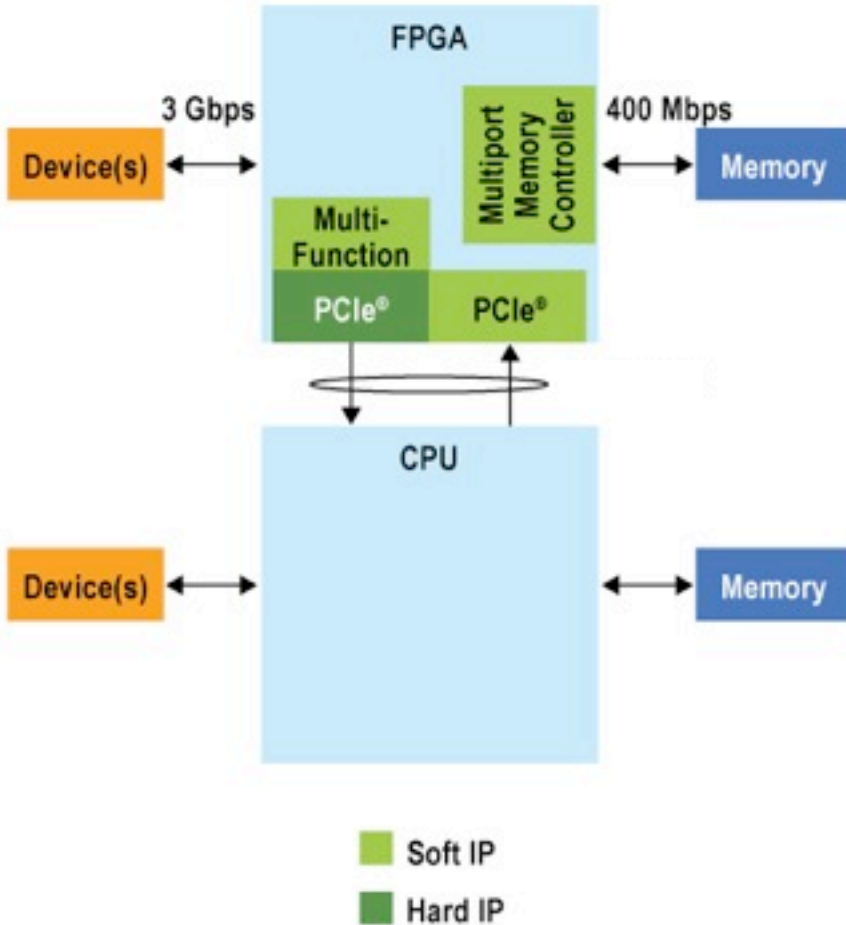- Lowest power in high-performance systems

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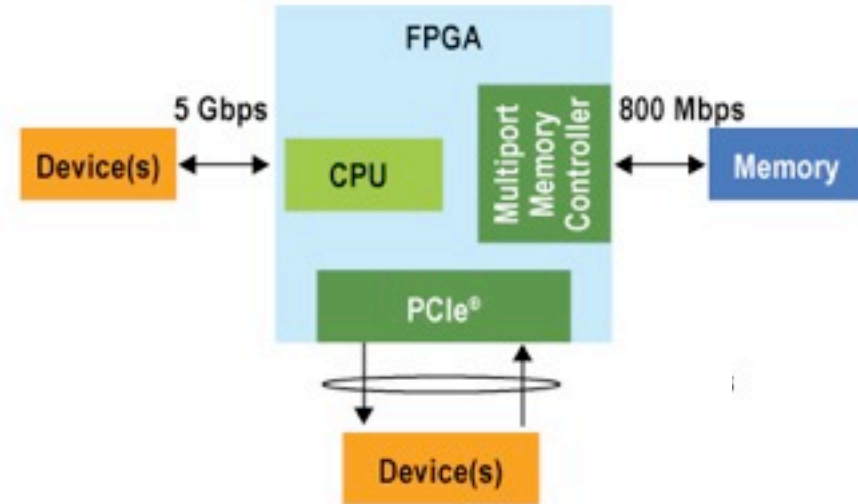# Enabling Technology-Programmable Logic Devices

- Design Logic support

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

- Increased Computational Performance

- Power Consumption

  - Intelligent power management

  - Hardened IP blocks

- High Speed Serial Interface Support

  - Embedded Transceivers

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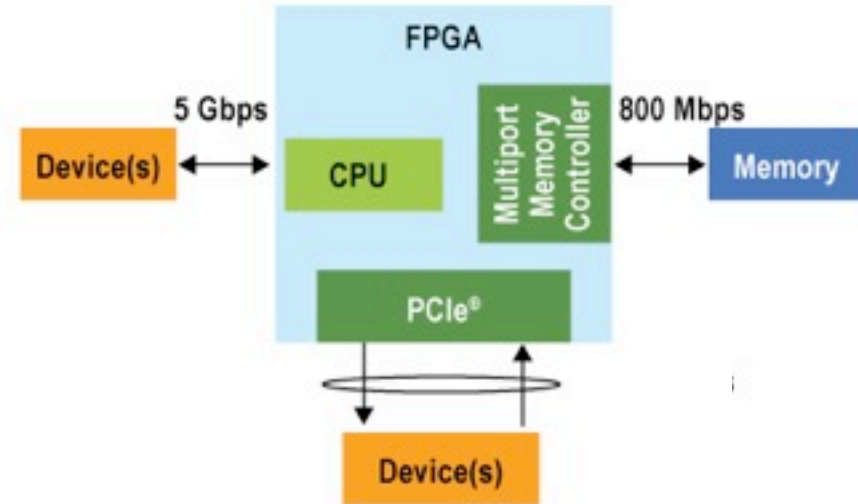
# System Cost Reduction via Integration

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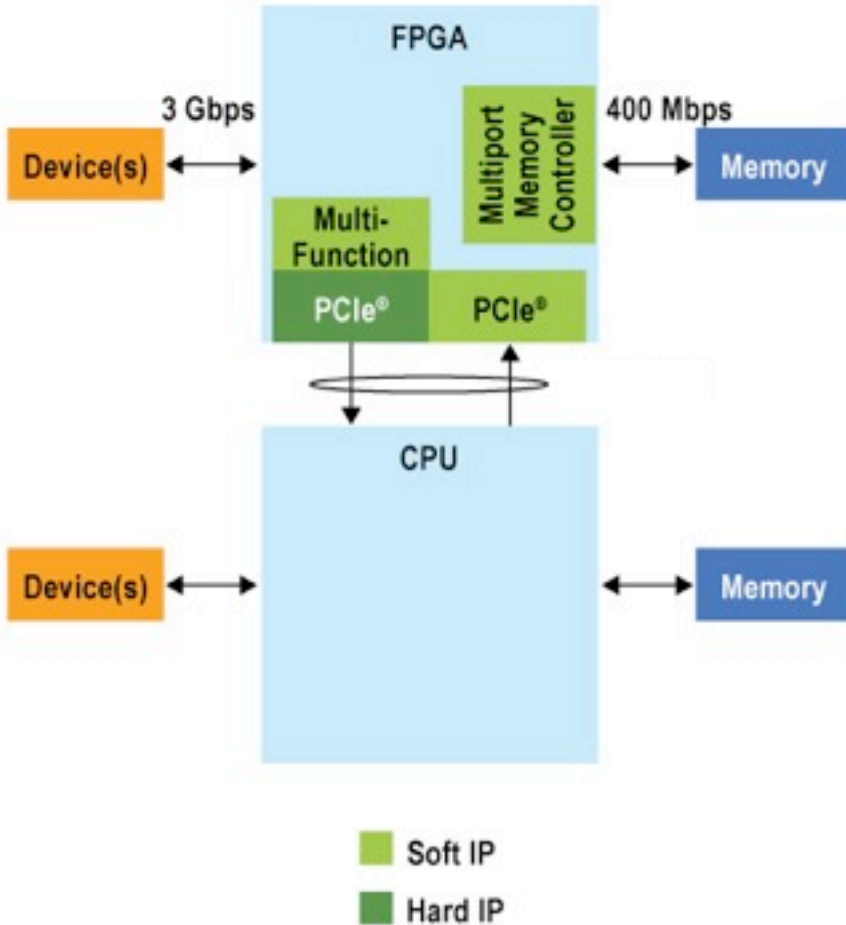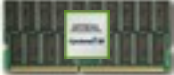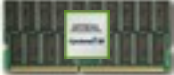
# Compute Target Applications

| 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 |

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# Storage Target Applications

| Application | Usage Examples |
|---|---|
| Flash Cache/SSD <br> **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 <br> **Tape** | Lower cost development with flexibility |

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# Storage Target Applications

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# Flash Controller Design Challenges

- Emerging memory types
  - ONFI 3.0, Toggle Mode 2.0
  - PCM (Phase Change Memory)
  - DDR3, DDR4
- ECC levels
  - BCH encryption
- Data transfer interface support
  - PCI Express, SAS/SATA, FC, IB

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# 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.
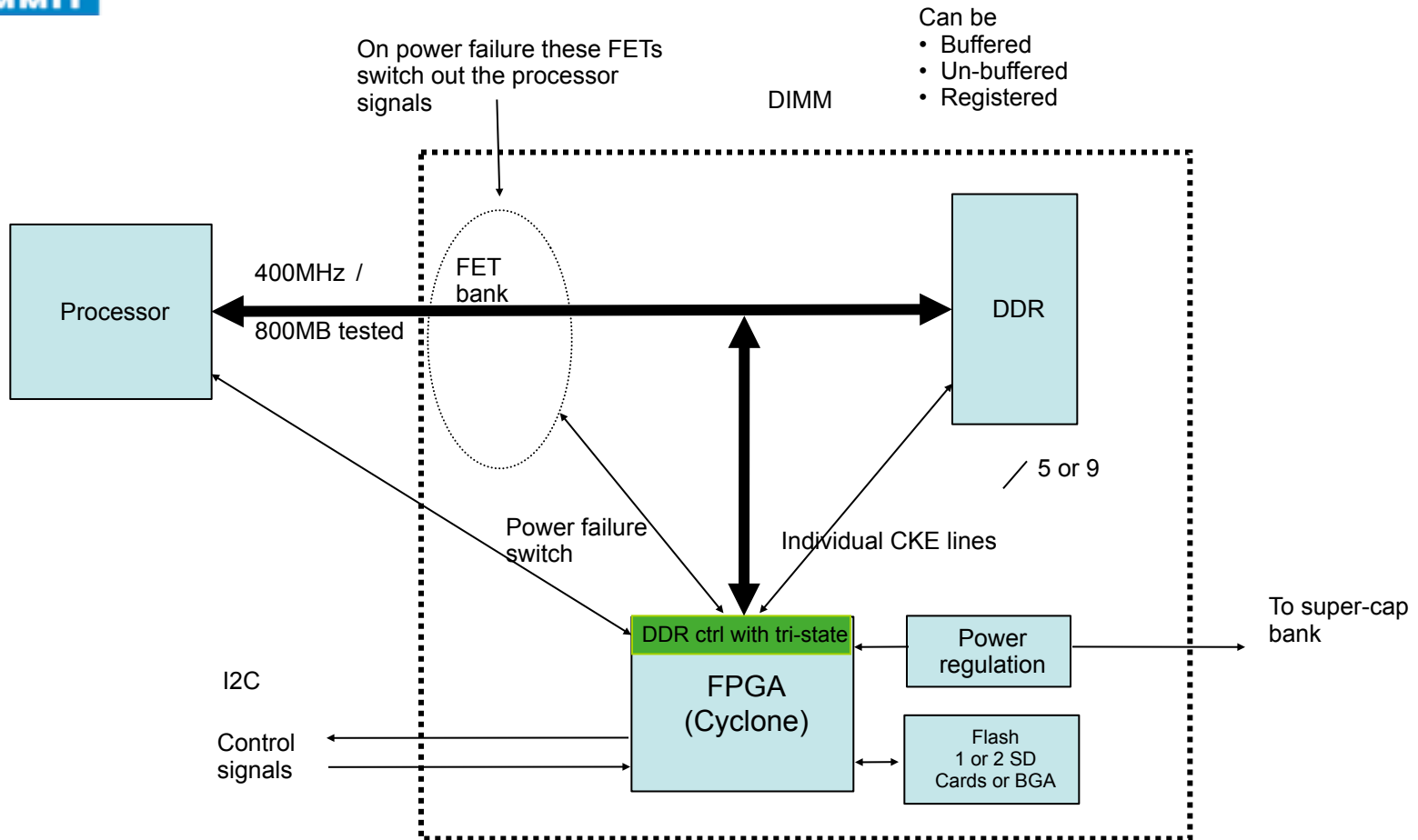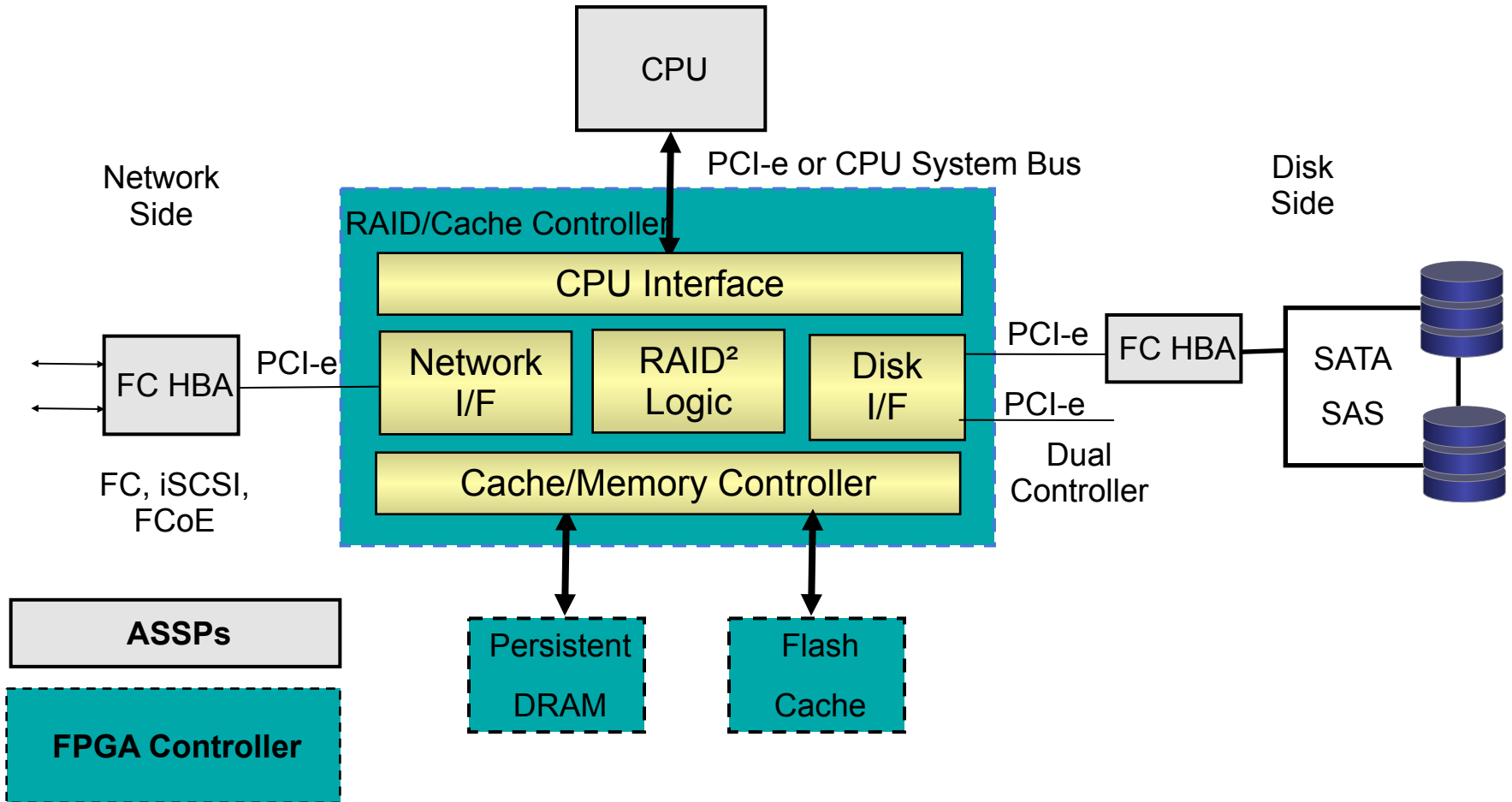
**Super Capacitor Based Alternative**

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

# NVDIMM Controller Architecture



On power failure these FETs switch out the processor signals

DIMM

Can be
• Buffered
• Un-buffered
• Registered

Processor

400MHz /
800MB tested

FET bank

DDR

5 or 9

Power failure switch

Individual CKE lines

I2C

DDR ctrl with tri-state

FPGA (Cyclone)

Power regulation

To super-cap bank

Control signals

Flash 1 or 2 SD Cards or BGA

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# Hybrid RAID System
## - Persistent DRAM and Flash Caches



CPU

PCI-e or CPU System Bus

Network Side

Disk Side

**RAID/Cache Controller**

CPU Interface

FC HBA — PCI-e — Network I/F | RAID² Logic | Disk I/F — PCI-e — FC HBA — SATA SAS

PCI-e

Dual Controller

FC, iSCSI, FCoE

Cache/Memory Controller

**ASSPs**

**FPGA Controller**

Persistent DRAM

Flash Cache

# Hybrid RAID System
## - PCIe Switch Centric

CPU

Persistent DRAM

PCI-e or CPU System Bus

Network Side

**PCIe Switch**

Disk Side

FC HBA — PCI-e

FC, iSCSI, FCoE

PCI-e — FC HBA — SATA SAS

Dual Controller

ASSPs

FPGA Controller

PCI-e

PCI-e

**Flash Cache**

**Dedupe/ Encrypt**
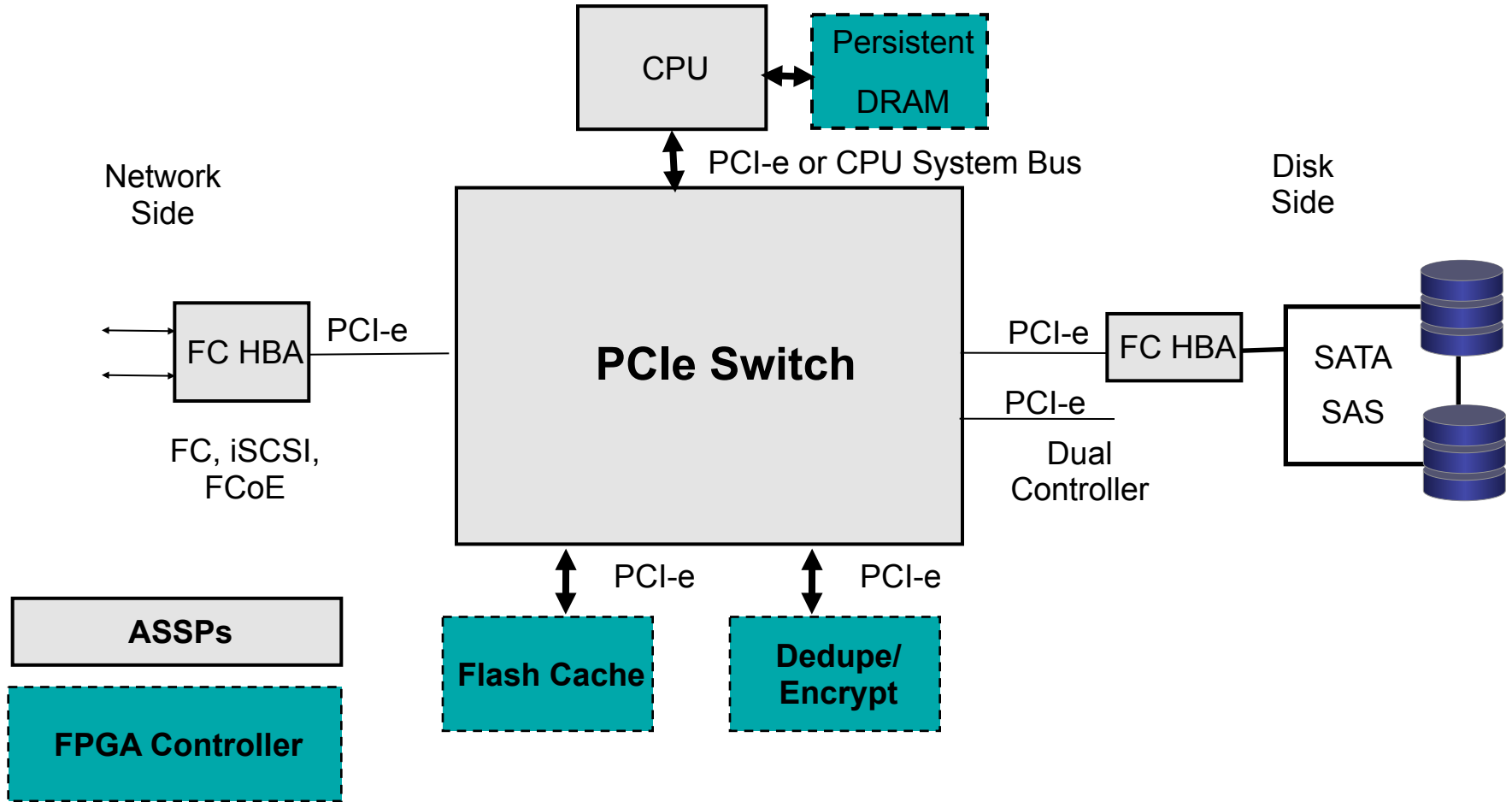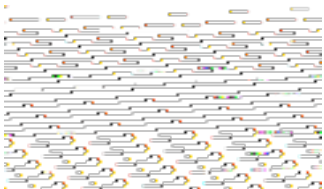
# FPGA RAID Controller for Flash Cache

- 10 TB of Flash Storage
- FPGA Applications
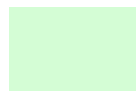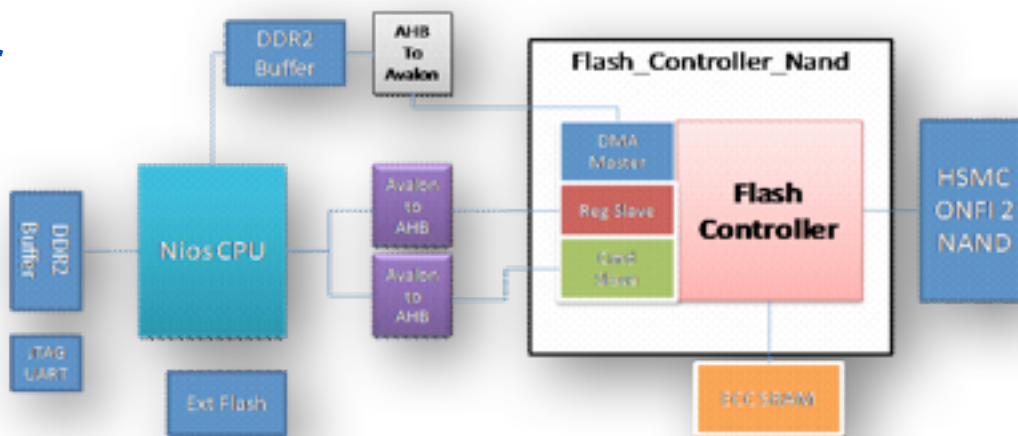  - Flash Control
  - RAID
  - Data Transfer
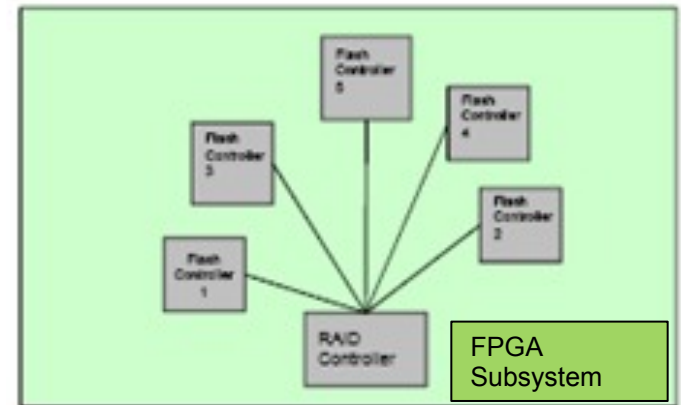
# Flash Cache Controllers

**Denali Multi Channel Controller**
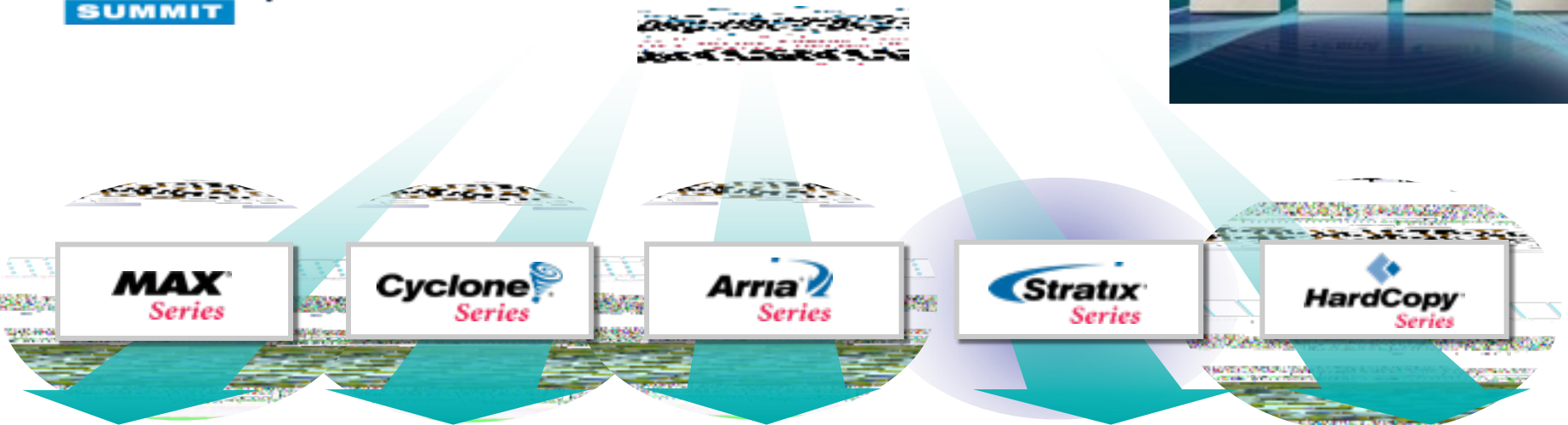
•Single to multi Flash channel capability

• 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**

# A Complete Solutions Portfolio

**MAX Series** — *Lowest Cost, Lowest Power CPLDs*

**Cyclone Series** — *Lowest Cost, Lowest Power FPGA*

**Arria Series** — *Cost- and Power-Optimized FPGA*

**Stratix Series** — *Highest Bandwidth FPGA*

**HardCopy Series** — *Lowest Risk, Lowest Total Cost ASICs*

Nios II
ARM
**MIPS Technology**

*Embedded Soft Processors*

*Intellectual Property (IP)*

*Design Software*

*Development Kits*

18

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# **Flashing Forward**

- 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