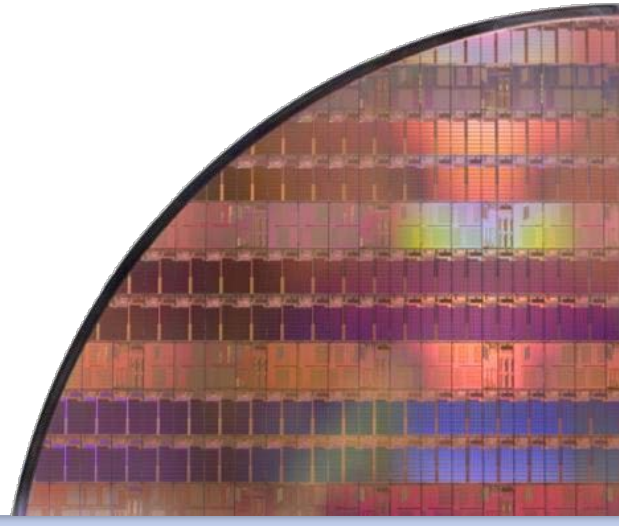
Optimize your system designs using Flash memory

Howard Cheng
Sr. Segment Applications Manager
Embedded Solutions Group, Micron



Agenda

- Non-Volatile Market & Trends
- Flash Cell Architectures
- Flash Memory Choices
- System Considerations
- Summary

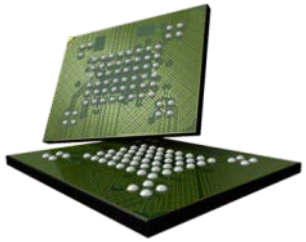
2012 Semiconductor Market Forecast

Worldwide Semiconductor Market

$313B

DRAM **$32.1B**

- PC **$12.4B**
- Specialty **$19.7B**



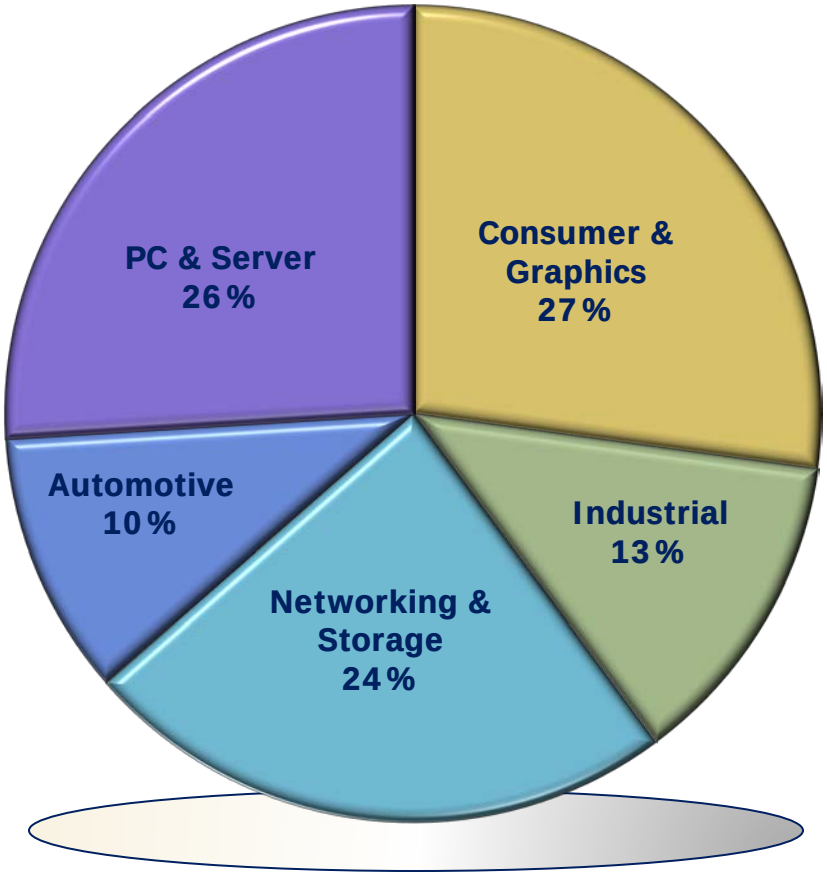
Flash **$32.4B**

- NOR **$3.9B**
- NAND **$28.5B**

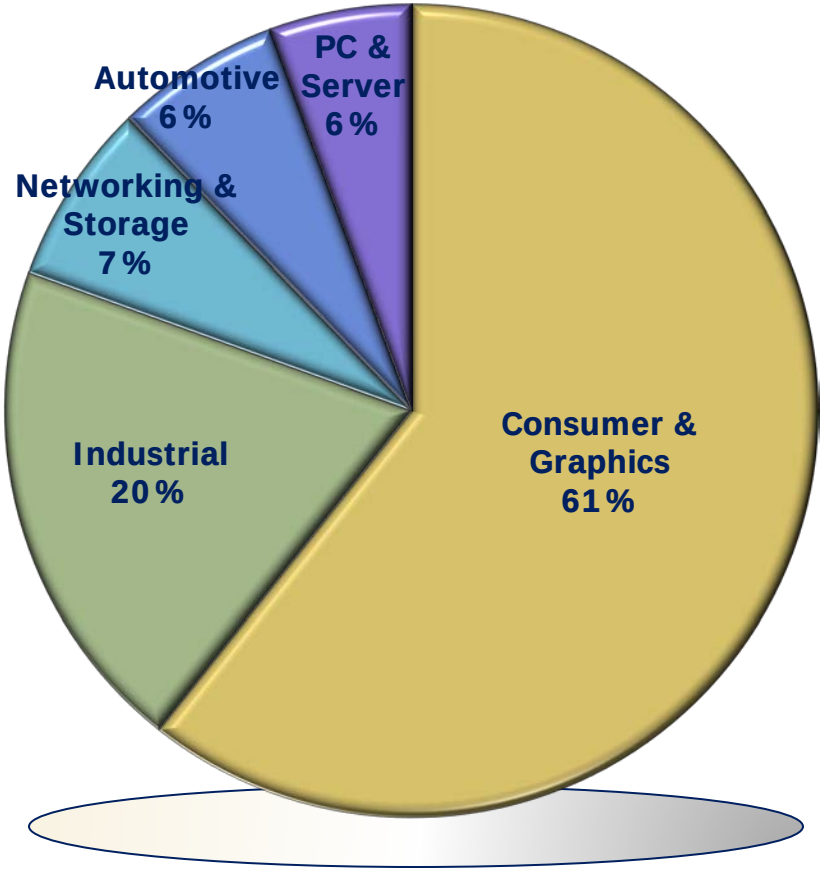
Source: Gartner 3Q11

The Embedded Markets

NOR: %Revenue – 2011 $2.2B

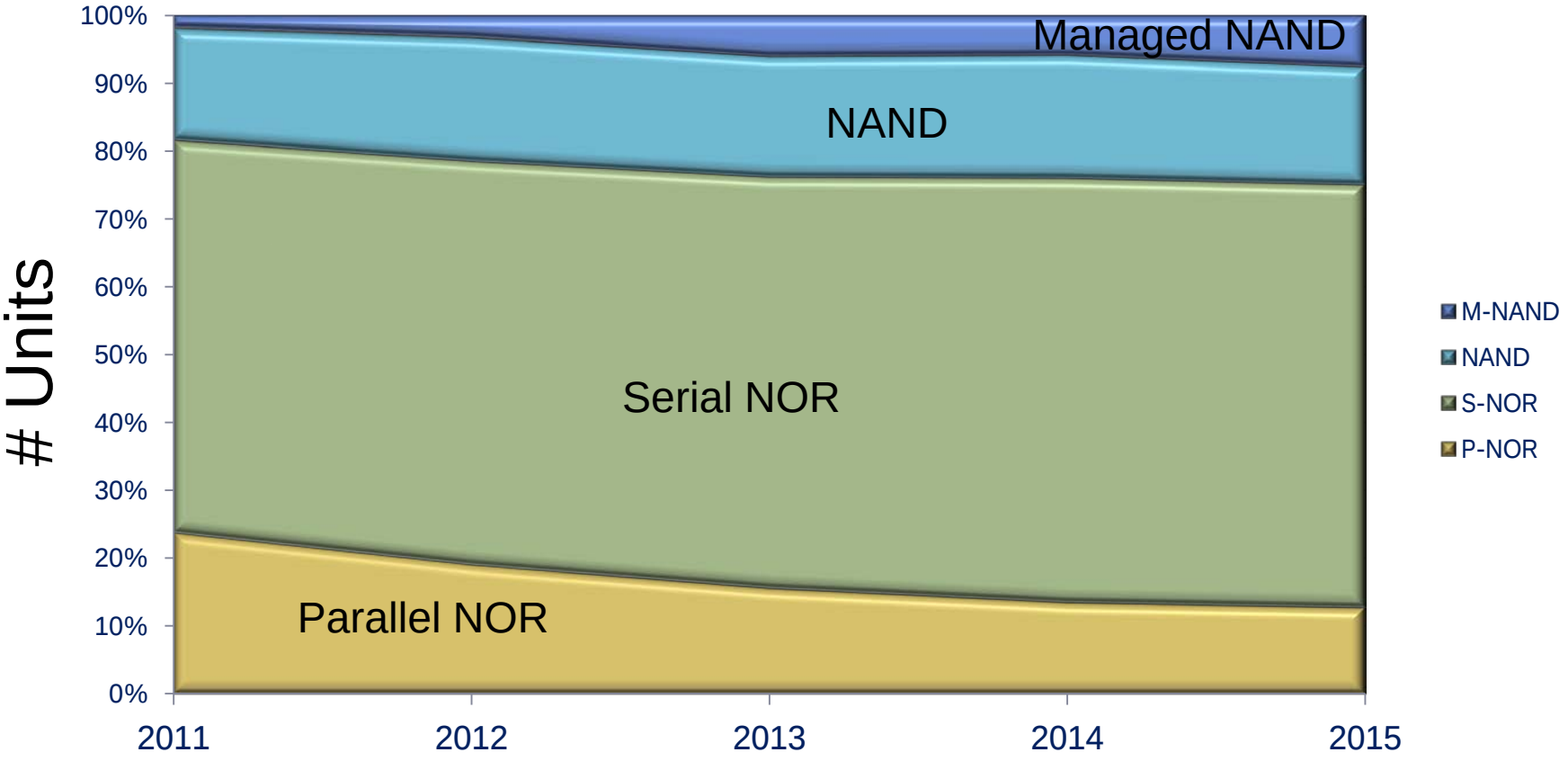


NAND: %Revenue – 2011 $1.7B



Source: Gartner/iSuppli/Micron 2011

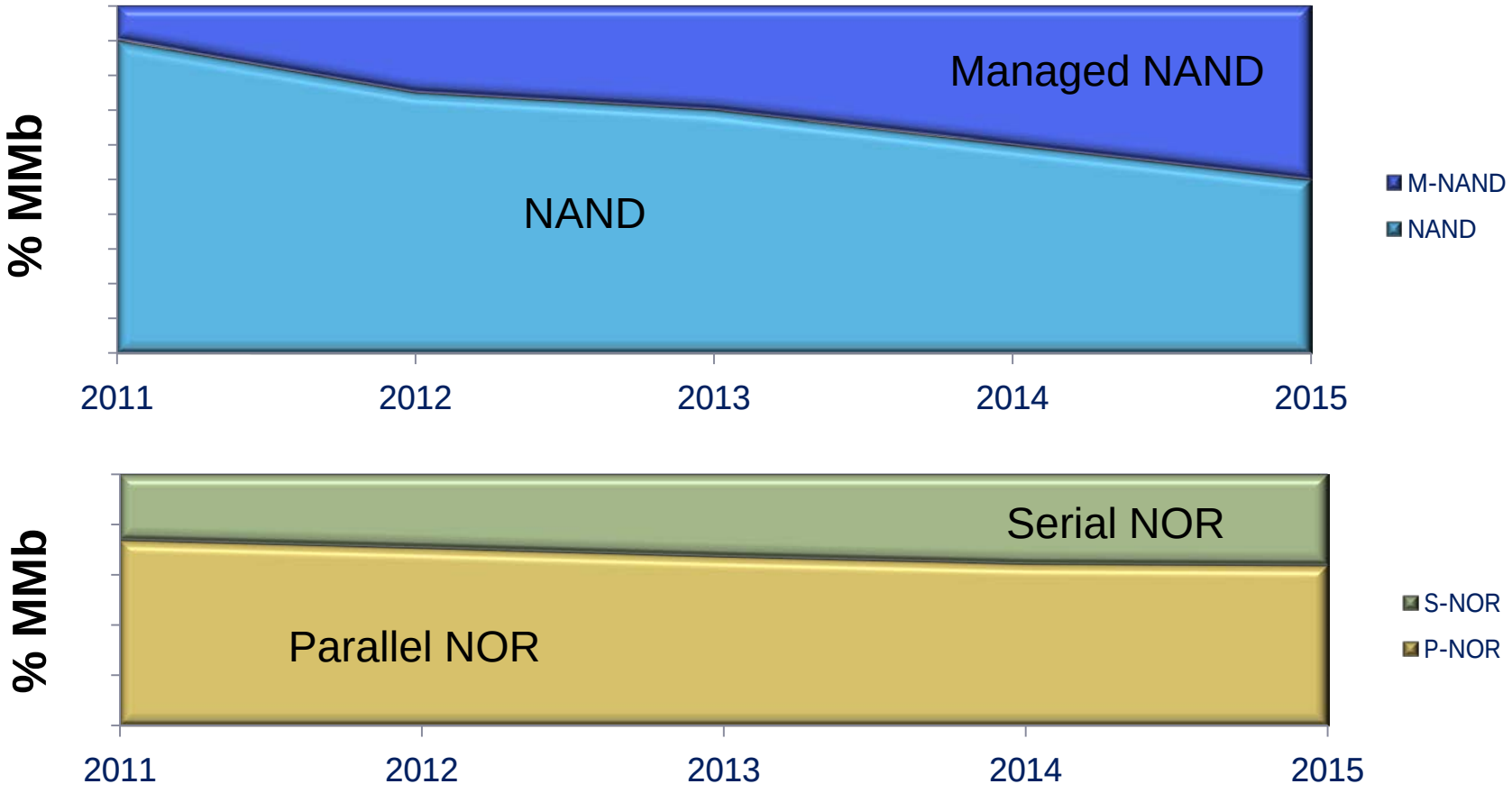
Embedded Flash Technology Trend



- NAND growing in units with managed NAND coming on strong for ease of design
- NOR uses still versatile, but parallel losing popularity due to board simplicity

Source: iSuppli, Mkt research, does not include large data applications (ie PMP, MP3, SSD, Media Cards, etc)

Embedded Flash Technology Trend



- Code + Data bit growth increasing the need for NAND and cost/bit
- Serial NOR gaining momentum on parallel due ease of design

Source: iSuppli, Mkt research, does not include large data applications (ie PMP, MP3, SSD, Media Cards, etc)

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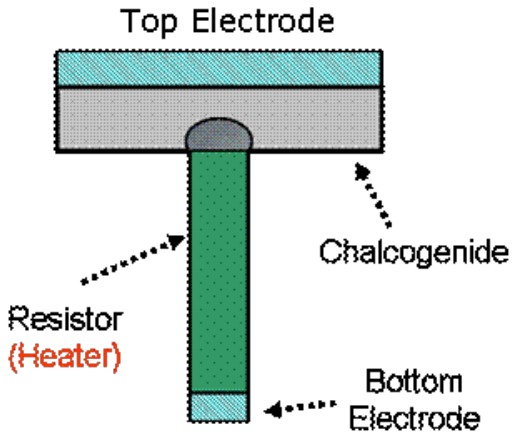
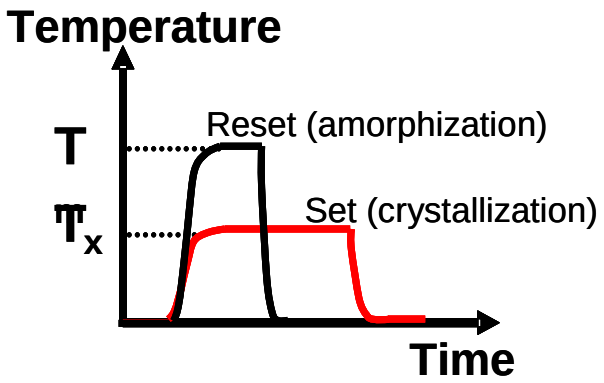
Cell architectures

Floating Gate Technologies

PCM Technology





PCM product attributes

- Available in NOR-type options
- Industry driving toward LPDDRx
- Fast programming for NVM
- Fast read capability

Evolved Options

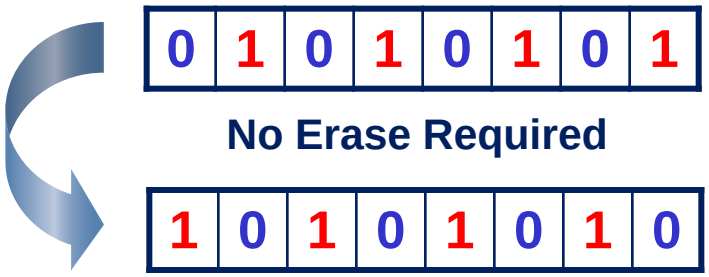
- NOR replacement NOW
- NAND replacement <5 yrs
- RAM replacement <5 yrs

Disruptive Options

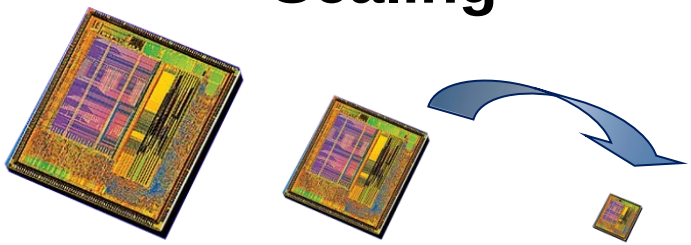
- Integrated memories NAND/RAM
- System Cache Options
  - HDD/SDD Integration
  - PCIe

PCM benefits

Bit Alterability



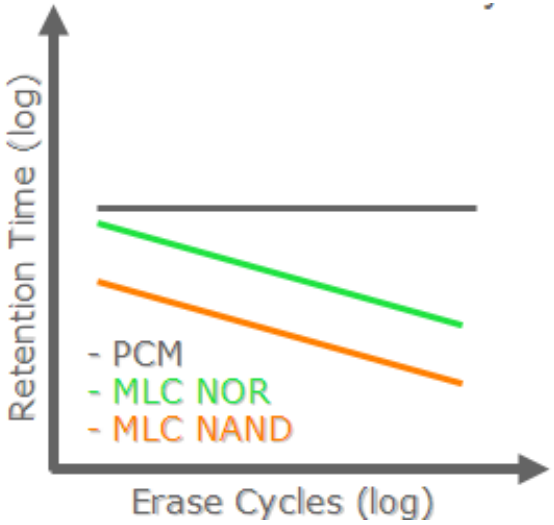
Scaling



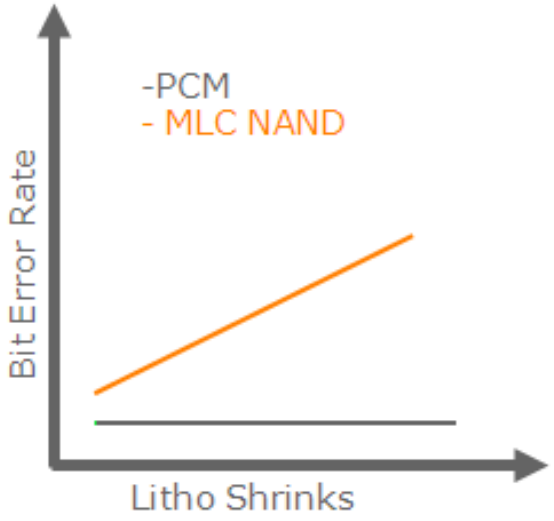
90 & 45nm Today

5nm Future

Endurance



Bit Errors



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Solutions for different requirements

NOR vs. NAND

Serial NOR	Parallel NOR	SLC NAND	Managed NAND	MLC NAND
• Longer lifecycles • Ease of use • Diverse products • Lower Floor cost • Code, Code+Data		• Shorter lifecycles • Focus on cost/GB • Expanding markets • Mostly Data Focused		

Customer Requirements Dictate the Solution

NOR product attributes

- Simple command sets
- Cost effective at low densities
- Stable architectures
- Value added features (XiP, security, quality, small data, etc)

Serial

- Low pin counts
- Easy PCB routing
- Smallest footprint
- Synchronous operations
- Cheapest low density

Parallel

- Basic add/data interface
- Asynchronous random access
- Synchronous burst operations
- Higher throughput
- Best XiP architecture

NAND product attributes

- Low pin counts
- Cheapest cost/bit at high densities
- Frequent conversions/migrations required
- Fast programming

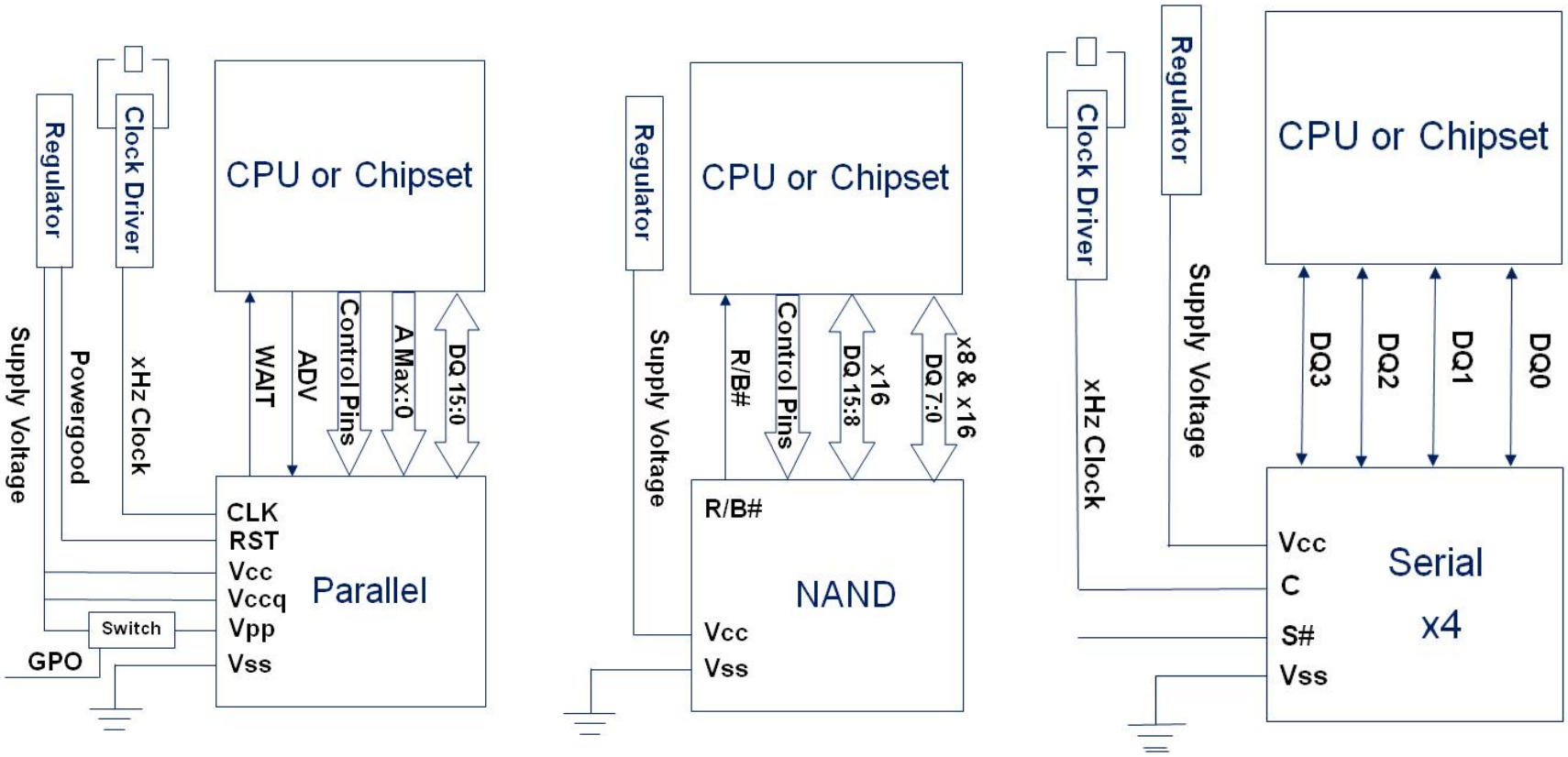
Discrete

- Some controllers support boot
- Some standards (ONFI)
- Common packages
- Needs SW for error management
- Demand paging – saves bits

Managed

- Error management onboard
- Some controllers support boot
- Higher density reach
- Easier conversions/migrations
- Standards (MMC, USB, uSD…)

Flash Architectures – Component Level

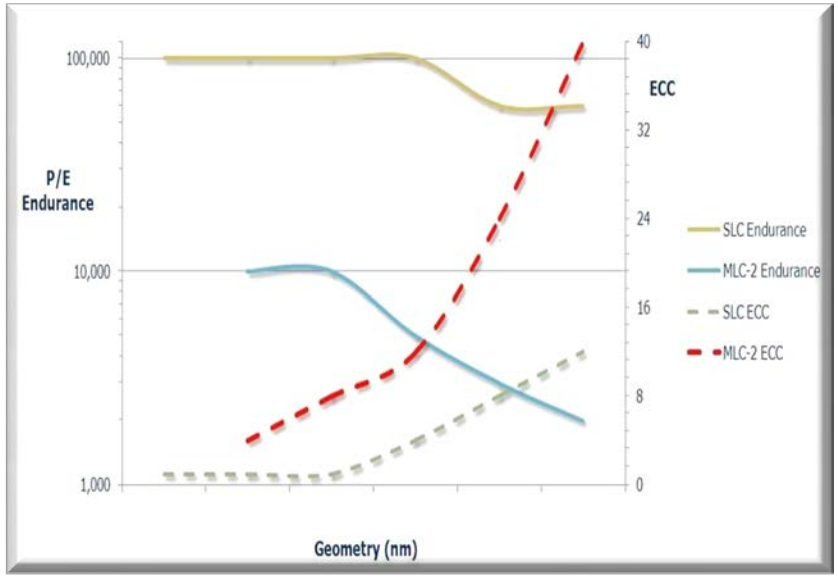


- All architectures have their advantages
- Trend in the industry moving toward the lower pin count architectures

NAND technology challenges

How to manage the ECC requirements?

- NAND controllers with high ECC capability
- ECC NAND managed solutions
  - on-die ECC, ClearNAND
- Fully managed solutions
  - eMMC, eUSB, others



How to manage lower Endurance?

- Understand the application and usage model
  - How does the file system work?
  - How often are you programming?
  - How big is the data file/s?
  - What is the PLC of your system?

Determines PE Cycles and Density Required

Intersecting your project and the memory technology is key to success!

NAND system solutions for Industry

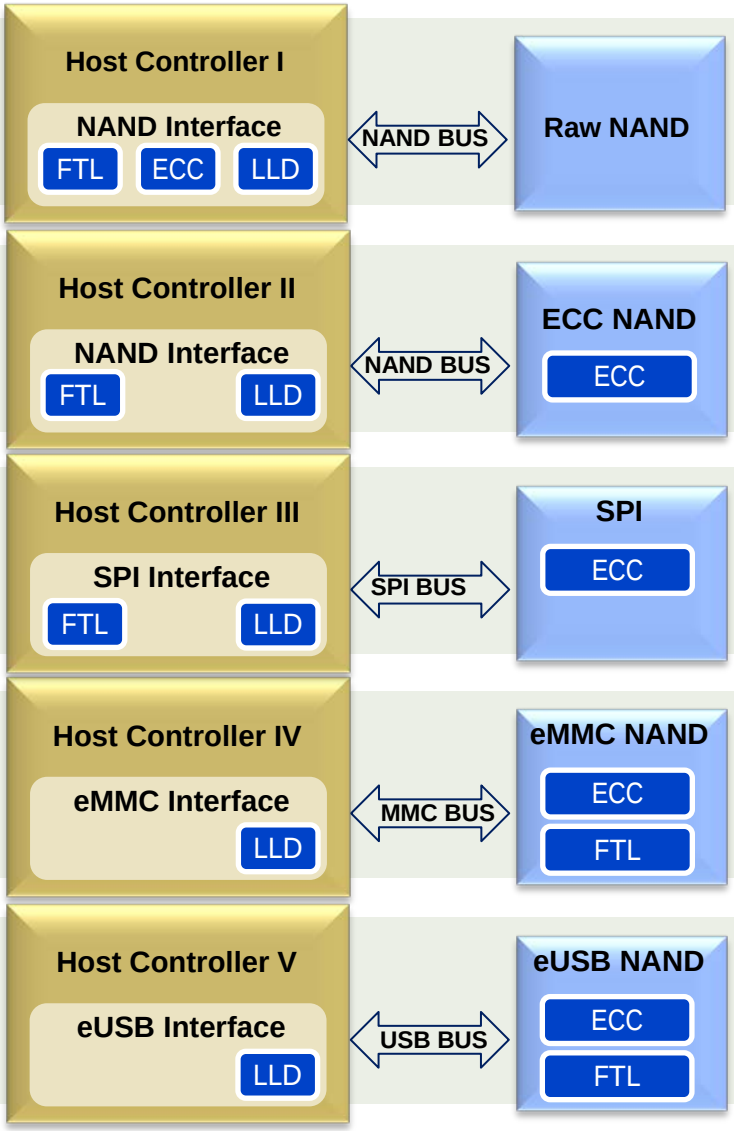
Raw NAND for application “expert” with NAND data management and ready to support ECC needs.

ECC NAND for application that do not want to change the ECC with the NAND litho shrink.

Serial NAND for application requiring high density with Serial protocol.

eMMC interface for application that want to offload by any NAND data management with a standard interface.

eUSB interface for application that want to offload by any NAND data management with a standard interface.



Level of Management by NAND solutions

	Raw NAND	ECC NAND (On-Die ECC, ClearNAND)	Fully Managed (eMMC, eUSB)
Complexity of Customer Development (NAND Management by Host)	High	Med	Low
New Product Qualification (Complexity & Effort)	High	Med	Low
Relative Cost	Low	Med	High

Trade offs between Complexity, Qualification Effort & Cost

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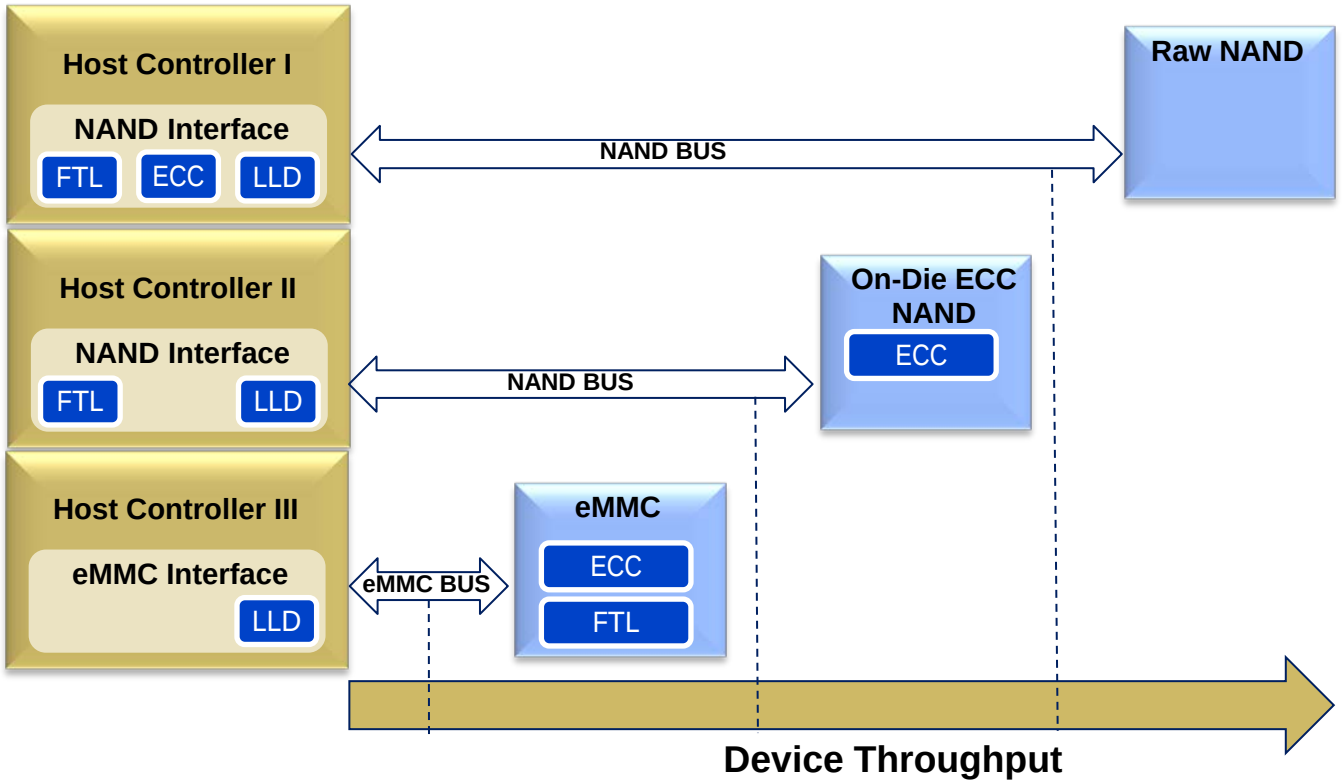
Performance considerations for system solutions

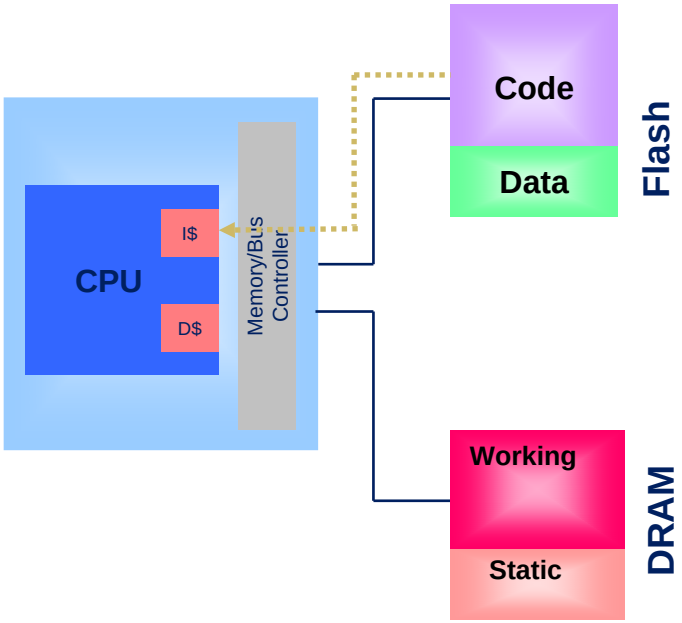


- Raw NAND, ECC NAND and eMMC require different management software
- The correct performance evaluation is at system

LLD = Low Level Driver | ECC = Error Correction Code | FTL = NAND Scheduling Logical Mapping, Bad Block Management, Wear Leveling

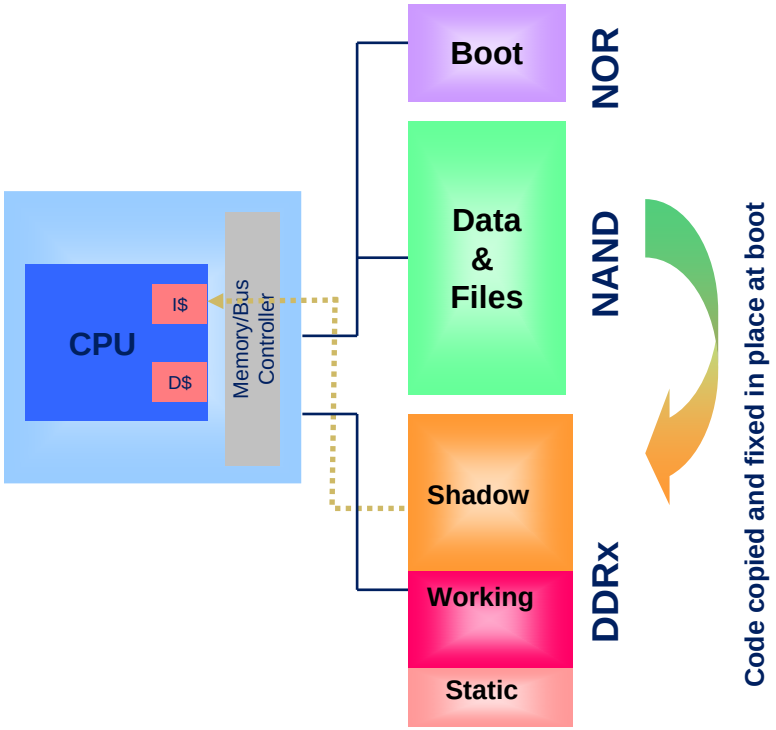
Memory subsystem designs/architecture

Execute in Place (XIP) Architecture



- Simple architecture
- Possible to reduce DRAM density
- Lower stand-by power

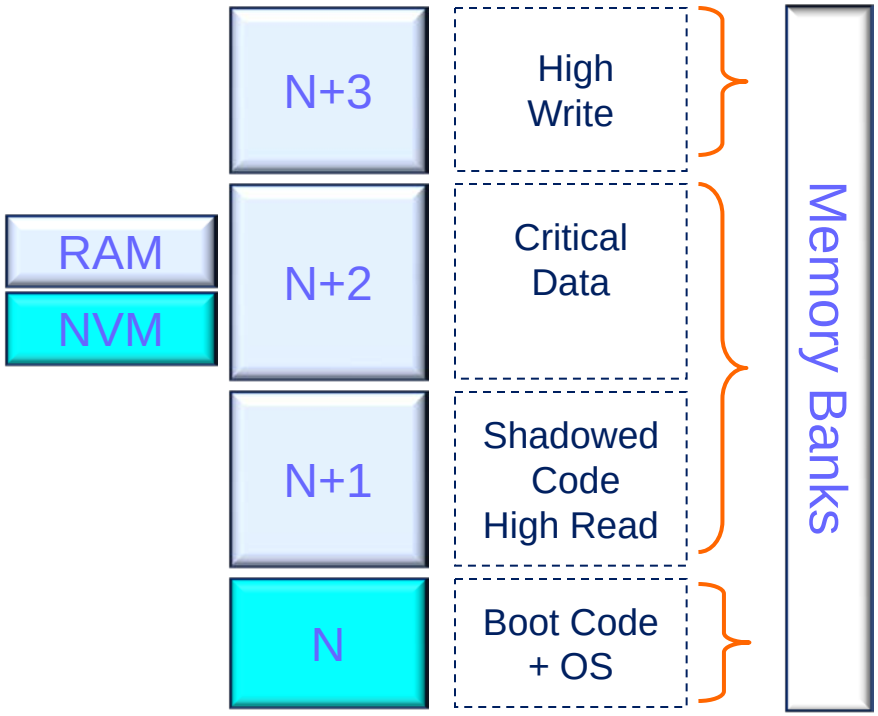
"Store and Download" (SnD) Architecture



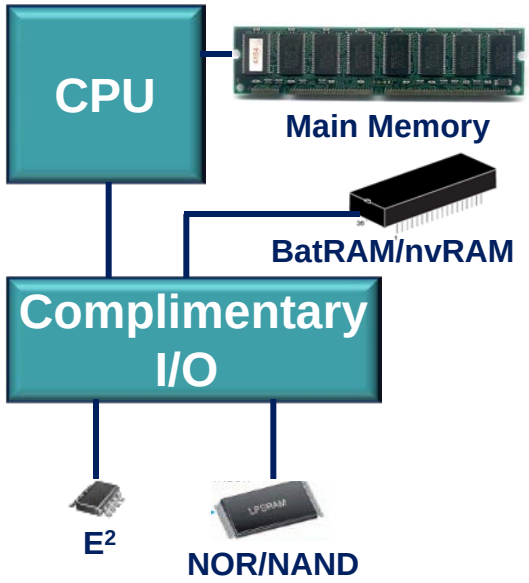
- Complex but higher performance
- More DRAM required
- Higher stand-by power

System cost reductions and simplification

Software Architecture



System Architecture



Understand Your Usage Model

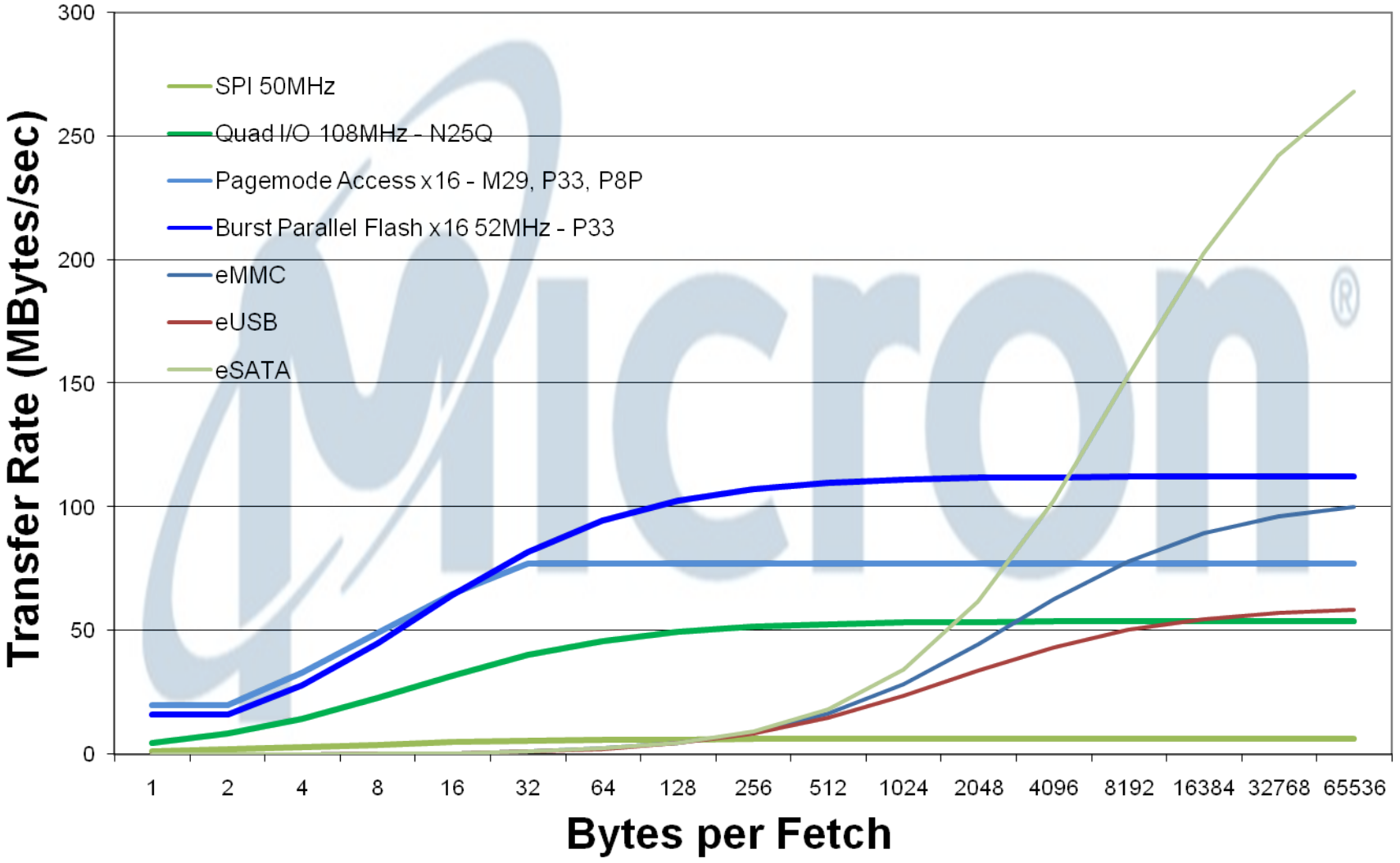
- **xRAM Usage models**
- **How many CE#/Banks do you use**
- **Why might you split memory into separate chips**
- **Other system SW requirements (file system, data logging, etc)**

System BOM

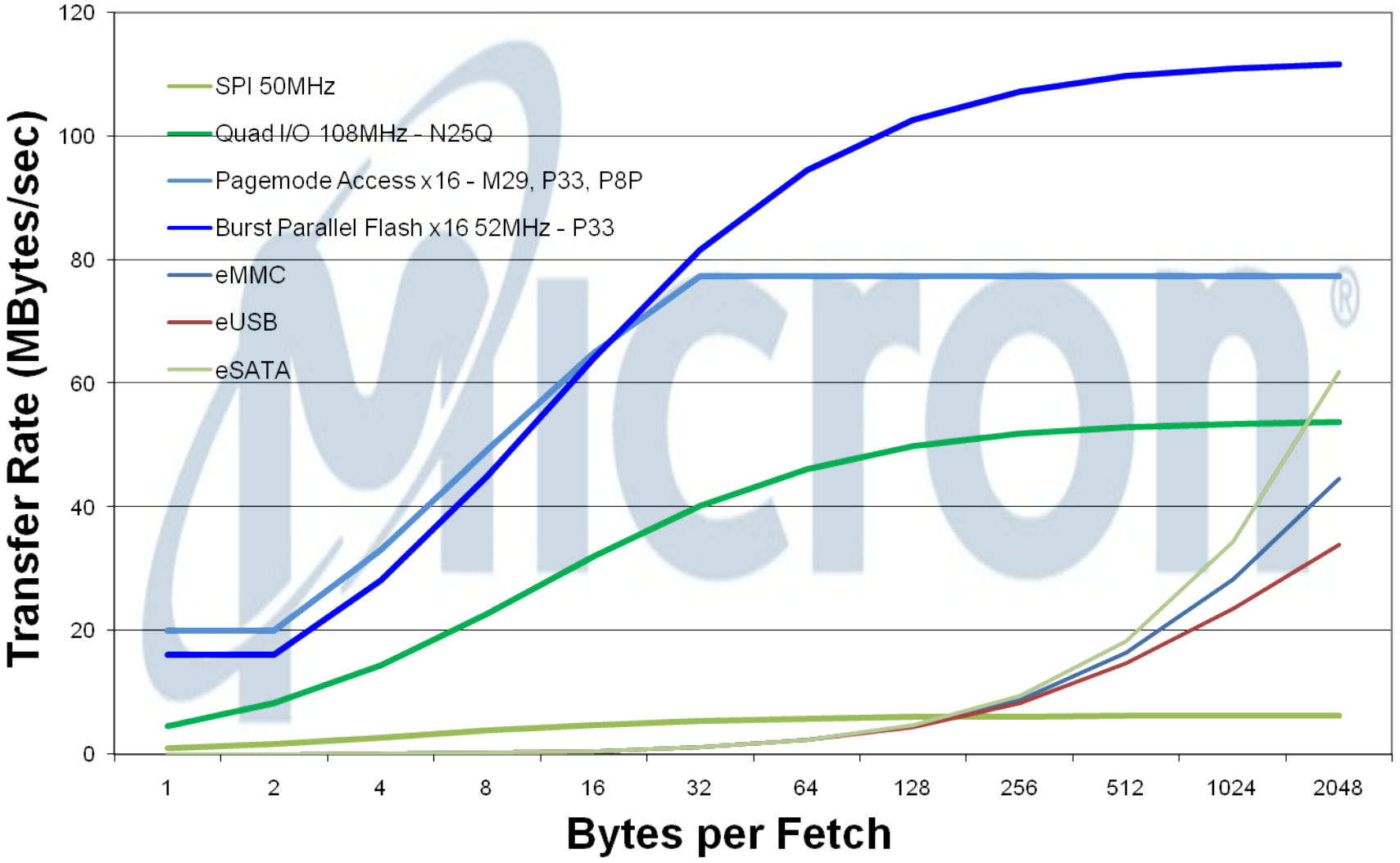
- **Can you eliminate or partially eliminate any unnecessary memory?**
- **Performance vs. Cost ratio**

Larger Data Fetches

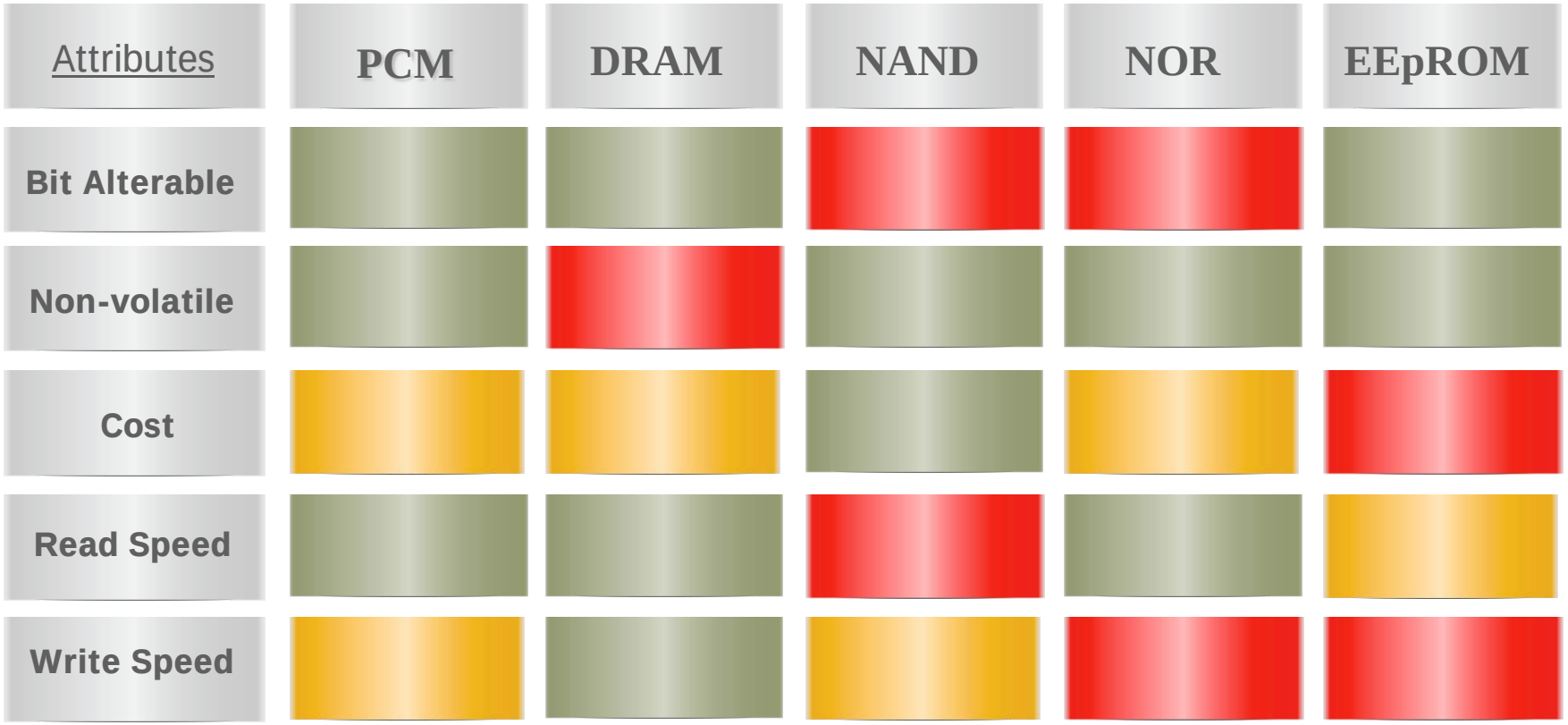
Random Read Access Performance vs. Data Size



Performance Comparison – Small Data



Memory technology comparison



- All memory technologies have their advantages
- Look for ways to differentiate and stay cost effective

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What's next?

Customers

1. Understand memory usage
2. Understand true cost
3. Work with a trustworthy supplier

Suppliers

1. Provides technology leadership & product longevity
2. Architecture transparency
3. Systems expertise & silicon/solution standards

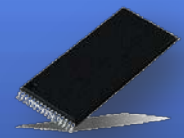
Broadest Portfolio

- Industry's broadest portfolio
- Computing, server/networking, embedded, mobile, consumer

Micron's Product Portfolio

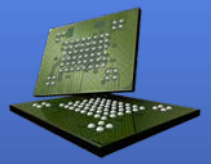
NOR

- Parallel and Serial NOR product portfolios, densities 512Kb-2Gb+
- Technology leadership on 65nm and 45nm.
- Automotive and industrial qualified solutions



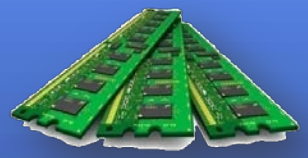
NAND

- Discrete and managed solutions, densities 128Mb-64GB
- Technology leadership on 20nm
- Automotive and industrial qualified e·MMC™ solutions
- Legacy support for low density NAND



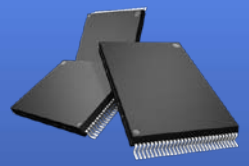
DRAM

- Legacy SDRAM through cost/performance leading DDR3 offerings
- Discrete and module DRAM solutions
- High speed RLDDRx Options
- Automotive and industrial qualified solutions



Phase Change Memory

- First commercially available PCM products
- P5Q: Serial NOR compatible, densities 32-128Mb
- Award winning technology
- New families on 45nm




Flash Memory
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