Flash Challenges for Embedded Computing

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Modular Technologies

Overview

- Embedded Computer Systems
  - Diverse ecosystems
  - Unique requirements & challenges
- Impacts of flash product dynamics
  - Retention
- Responses

What are Embedded Systems?

- Embedded systems are highly pervasive
- 2009: 10B embedded processors (EETimes)
  2009: 300M PCs (Gartner)
- "Fixed function system"
  - Telecom: routers
  - Cars: ignition & engine control, ABS
  - Industrial control systems
  - Medical equipment
  - ...
- Commonality: Flash Storage
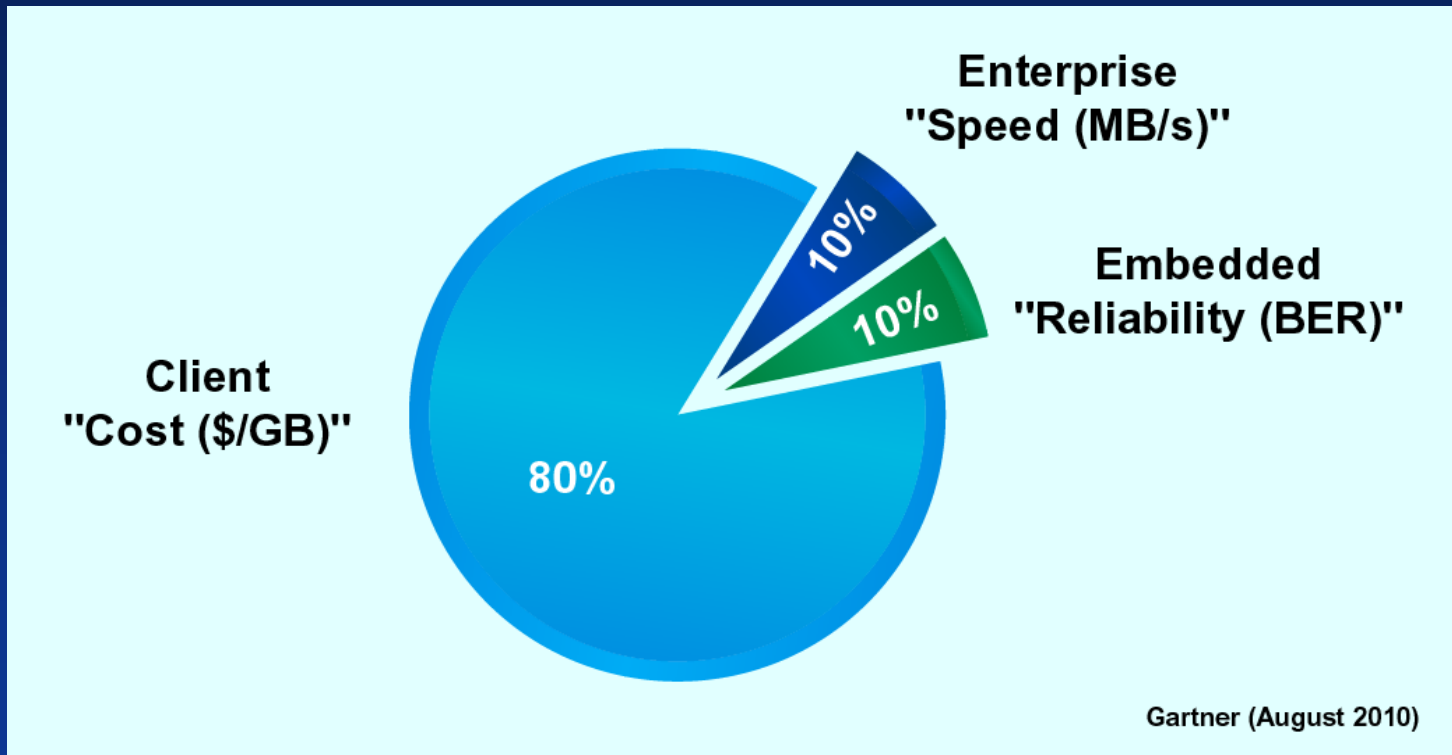 - Code & data

(Wikipedia – Creative Commons)

Embedded Systems Ecosystem: Diversity

- Platforms (EETimes 2012)
  - 16 real-time operating systems, #1 in-house (13%)
  - 18 processors (>2% market share)
  - Host chipsets
  - File systems
- Applications
  - Usage
  - Command (kernel)
  - Environment (temperature & voltage)
- Challenge: Bringing products into unknown conditions
- Flash specific requirements:
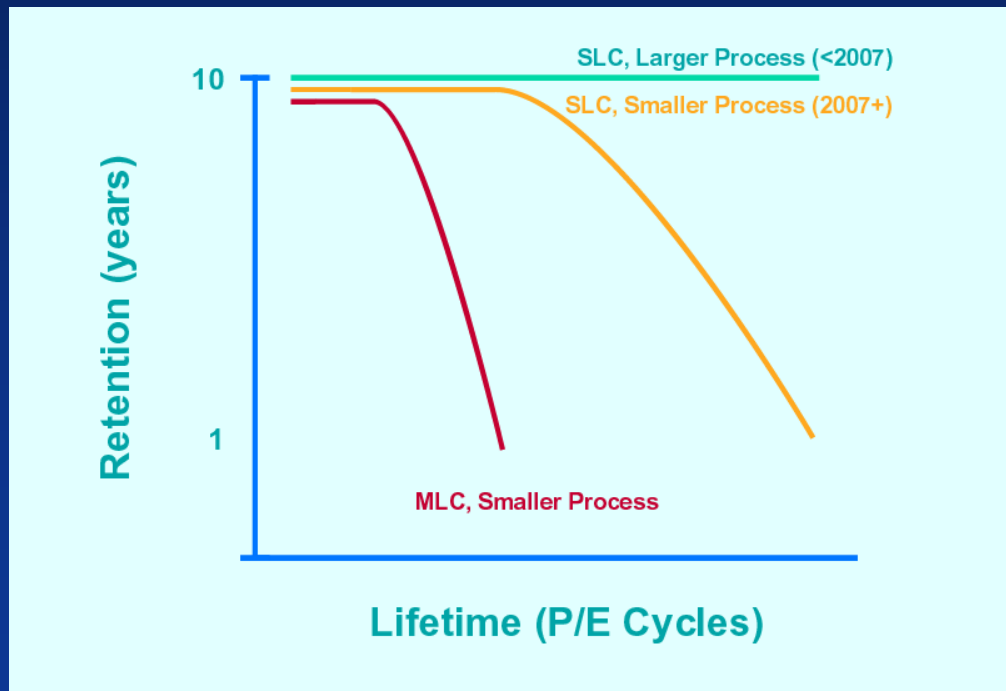 - Reliability over life (long)

Client Segment Impacts

- 2010 – NAND $18.7B (iSupply)

Enterprise "Speed (MB/s)" 10%

Embedded "Reliability (BER)" 10%

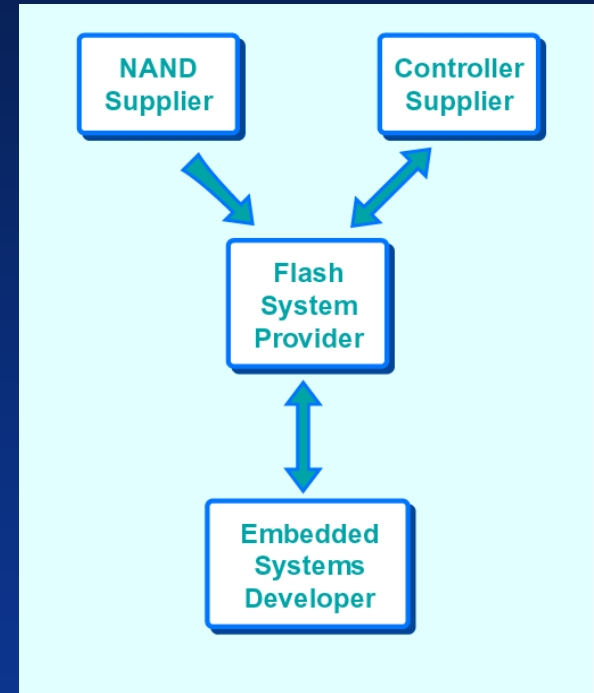Client "Cost ($/GB)" 80%

Gartner (August 2010)

Challenges of NAND Dynamics

- Smaller process, more bits per cells
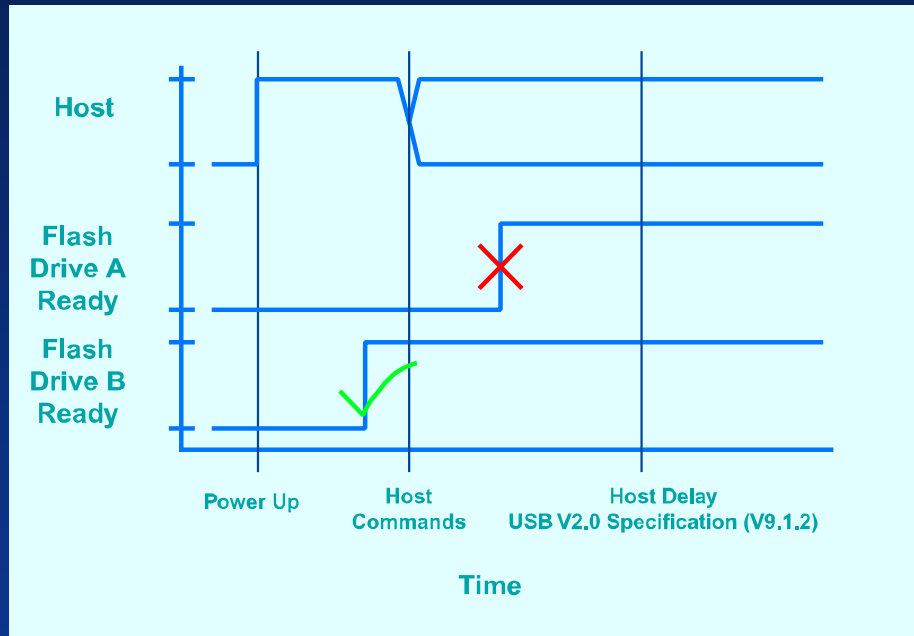 - Endurance & ECC
  - Retention

Responses to NAND Challenges in Embedded Ecosystem

- Adaptive products
  - Multiple flash memory devices
  - Multiple flash memory controllers
  - Custom firmware
- Testing & Characterization
  - PC emulators of embedded platforms
  - Customer systems
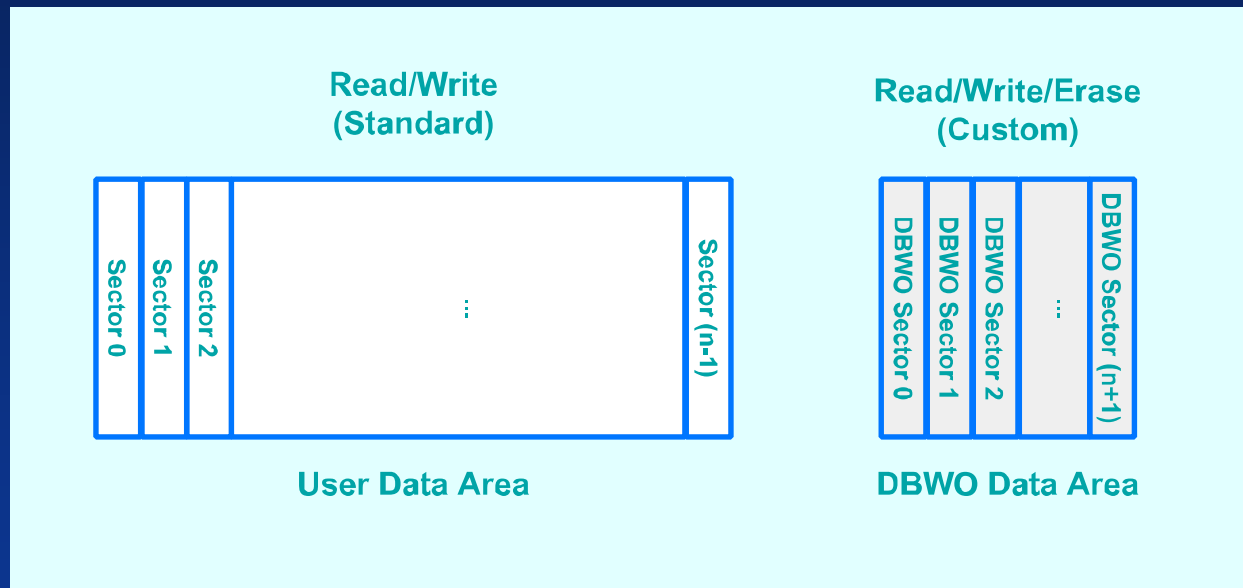- "Co-design"
  - Supply chain feedback

- Multiple Controllers

- Ex: Insufficient power up time allowance by host system. One flash product tolerated, one didn't

Case Study – Custom Firmware

- Deterministic Burst Write Operations (DBWO)
  - Write to pre-erased blocks

Read/Write (Standard)

Sector 0 | Sector 1 | Sector 2 | ... | Sector (n-1)

User Data Area

Read/Write/Erase (Custom)

DBWO Sector 0 | DBWO Sector 1 | DBWO Sector 2 | ... | DBWO Sector (n+1)

DBWO Data Area

- Ex: Time to write measurable and repeatable
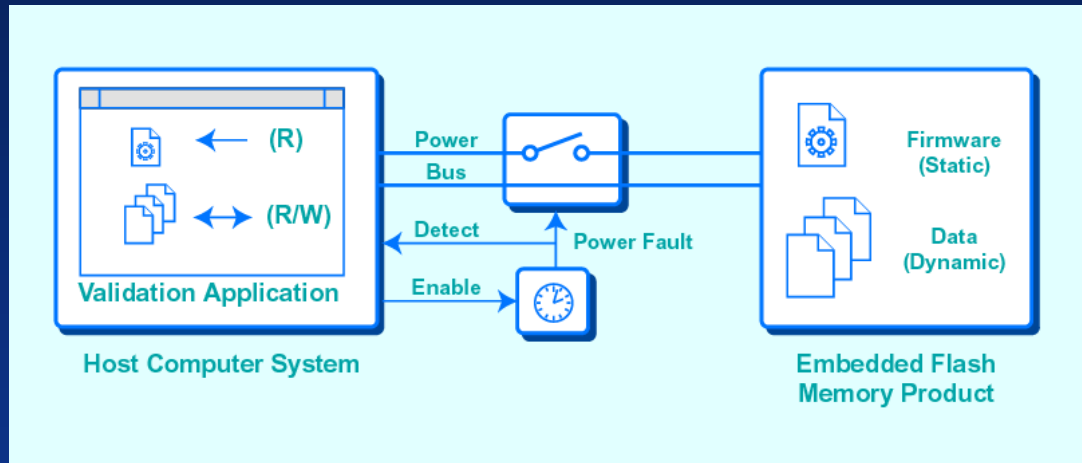
Case Study – Emulator (PC)

- PC Systems for Command Validation
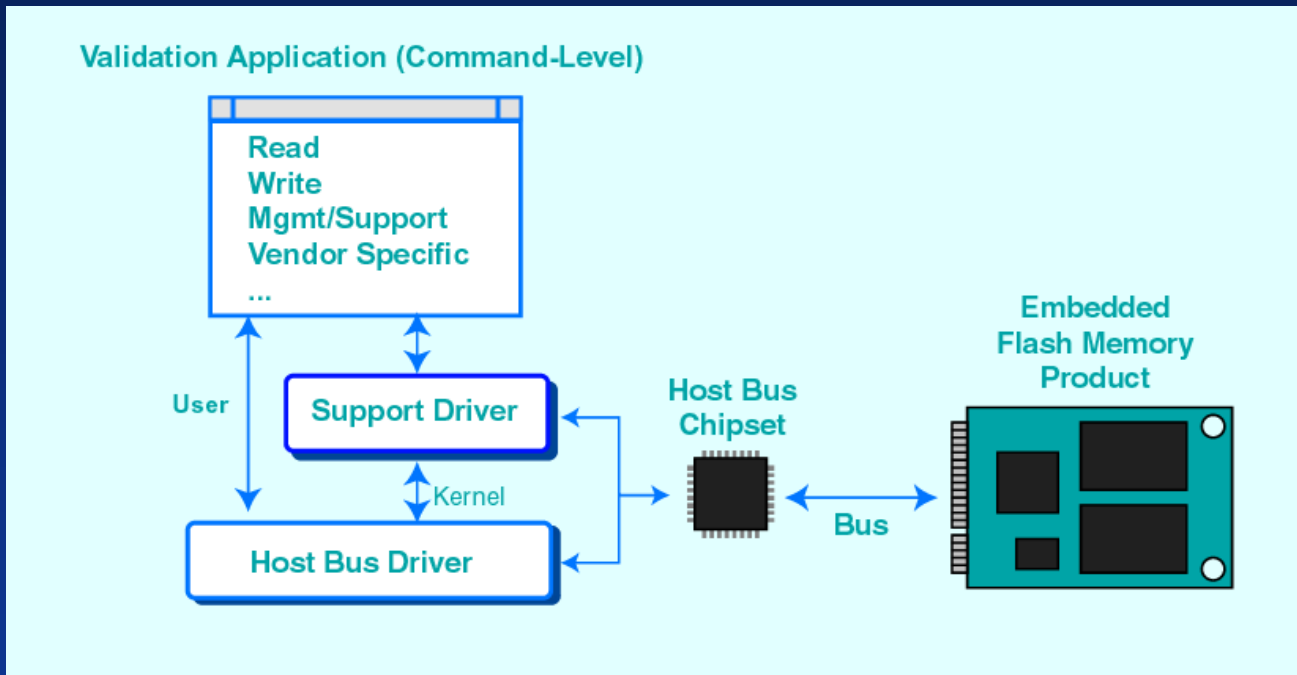
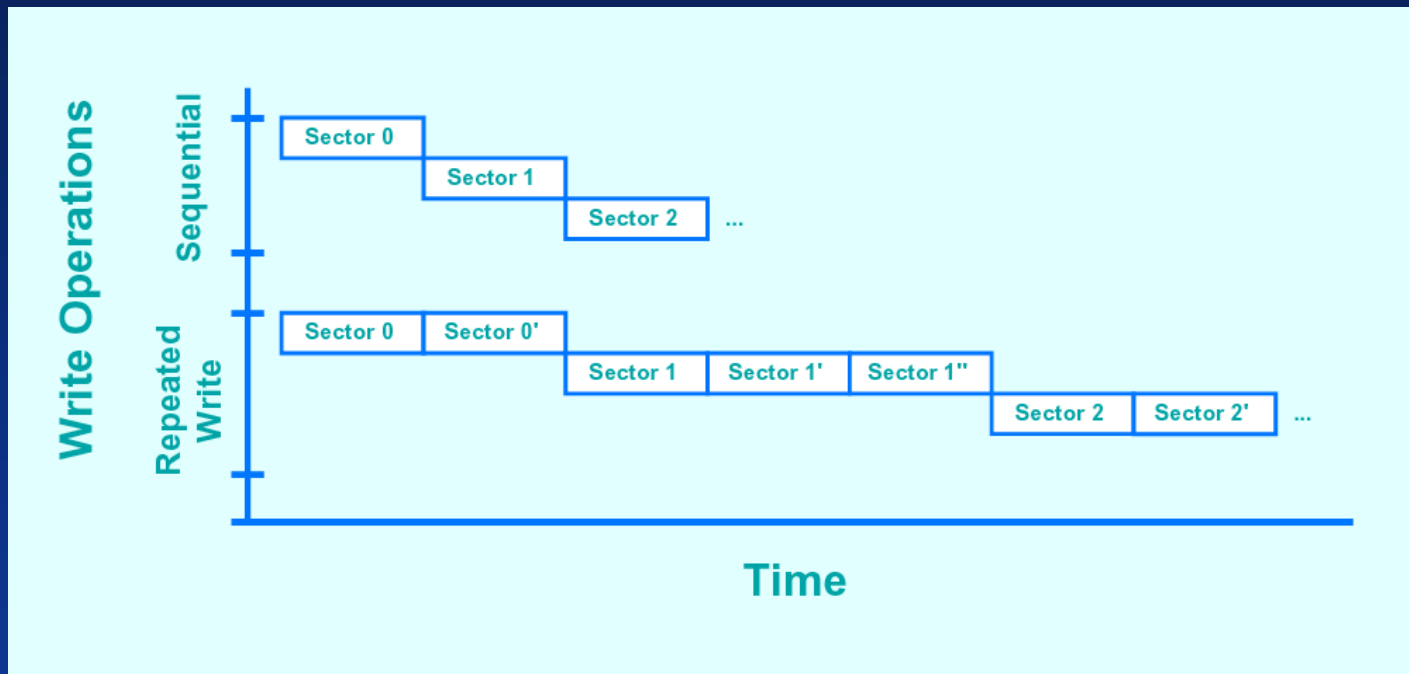- Ex: USB MSC Reset, USB Enumeration...

Case Study – Power Faults

- PC System for Asynchronous Power Fault Resilience Verification

- Ex: Significant improvements with supply chain feedback
    Before: 1-3 cycles to failure
    After: Over 20K cycles successfully
- Ex: Flash challenge 60 nm -> 40 nm

Case Study – Co-Design

- Supply chain feedback (end-user)

- Ex: "Fail Safe" File-System -> "Repeated Writes"

Case Study – Co-Design

- Supply chain feedback (controller)

		Activity	
		Read	**Write**
	File System Data	Moderate	Moderate
	Firmware (Static)	High	-
Flash User Data Area	**Data Files (Static)**	Very High	-
	Log Files (Dynamic)	Low	Moderate
	(Free Space)	-	-

- Ex: Read-mostly applications (40 nm)

Conclusions

- Embedded systems are a diverse ecosystem
  - Unique demands on flash
  - Unique challenges on flash product suppliers
- NAND dynamics causing special challenges
  - Retention
- Responses
  - Product adaptability
  - Testing, characterization, & research
  - Supply chain feedback ("co-design")
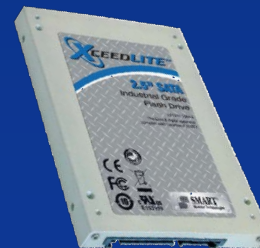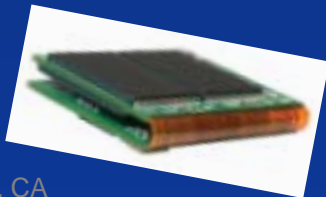
Call To Action

- Flash System Designers
  - Understand uniqueness of embedded systems
  - Understand dynamics of flash market
  - Connect with embedded systems designers
  - Test, test, test, ...
- Embedded Systems Designers
  - Understand flash memory capabilities and limitations
  - Involve flash system vendors early – "co-design"