Flash and the Embedded Space

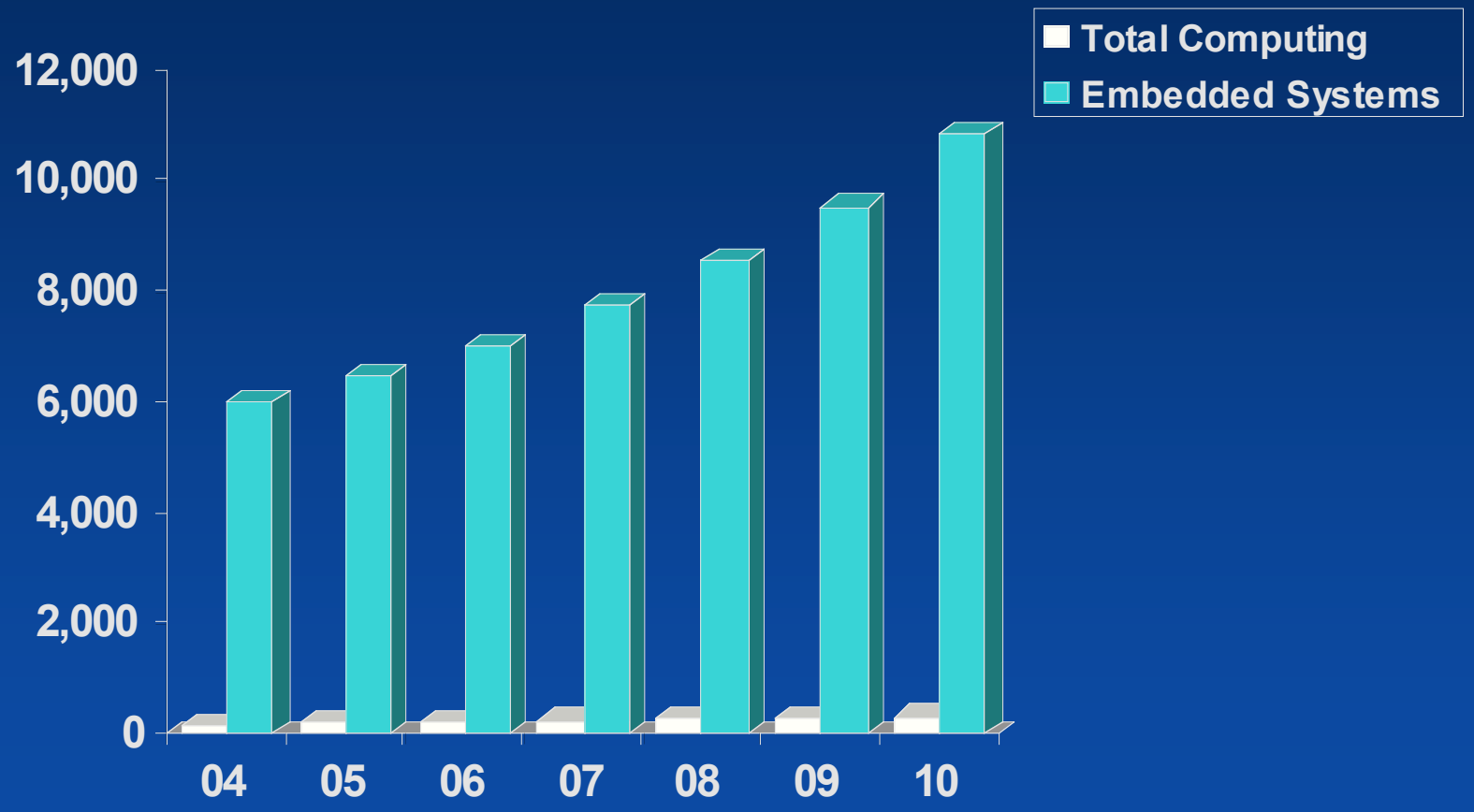
Prepared by: Grady Lambert
SMART Modular Technologies
grady.lambert@smartm.com

San José, CA USA
August 2006

Outline

- Embedded Computing Market Outlook
- Embedded System Defined
  - Basic Computing Architecture (Yesterday and Today)
  - Moore's Law
- Embedded Systems Transformation
  - Component to Component, Board to Board, Box to Box
  - Multi-drop Parallel buses replaced by Point to Point Serial buses
- Emergence of high speed Serial Protocols & Modules
  - Protocols - 1394, USB, SATA, PCIe
  - Modules – USB MK, Express Card, SD/MMC, SSD
- Factors driving Non-Volatile Mass Storage Requirements
  - Low Power, Zero Latency, Improved MTBF
- Benefits & Threats to NAND based Serial Modules
  - Benefits – Density, Cost/bit
  - Threats – Retail sector drives production – MLC vs. SLC, Hybrid Drives
- Solution Set Examples
  - USB – uDOC, eUSB
  - SSD – SATA, SAS
- Future Trends and Applications
  - Bootability, Hot Swap, MS Vista Ready Boost Drive

Embedded Systems Market Outlook



Source: Semico Research 2006

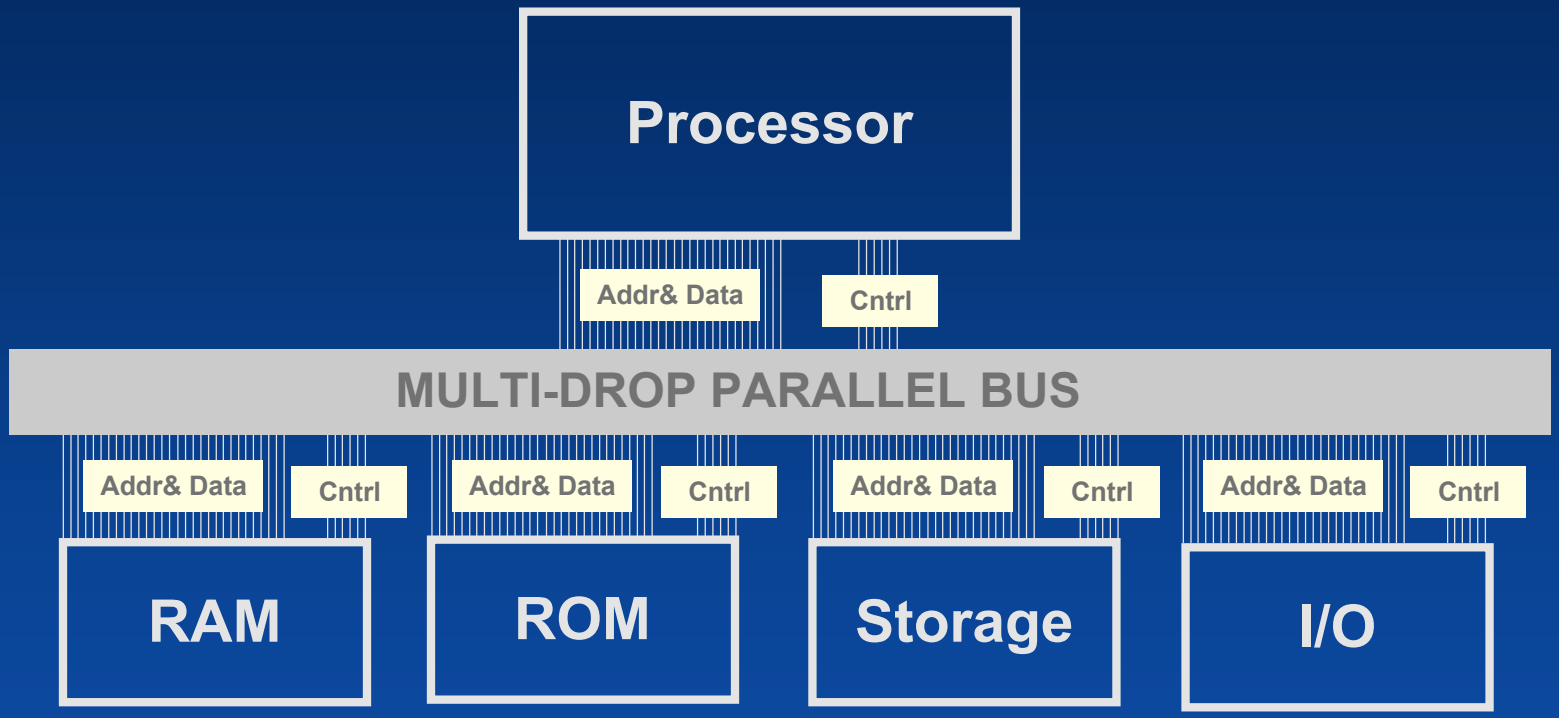
San José, CA USA
August 2006

Embedded System Defined

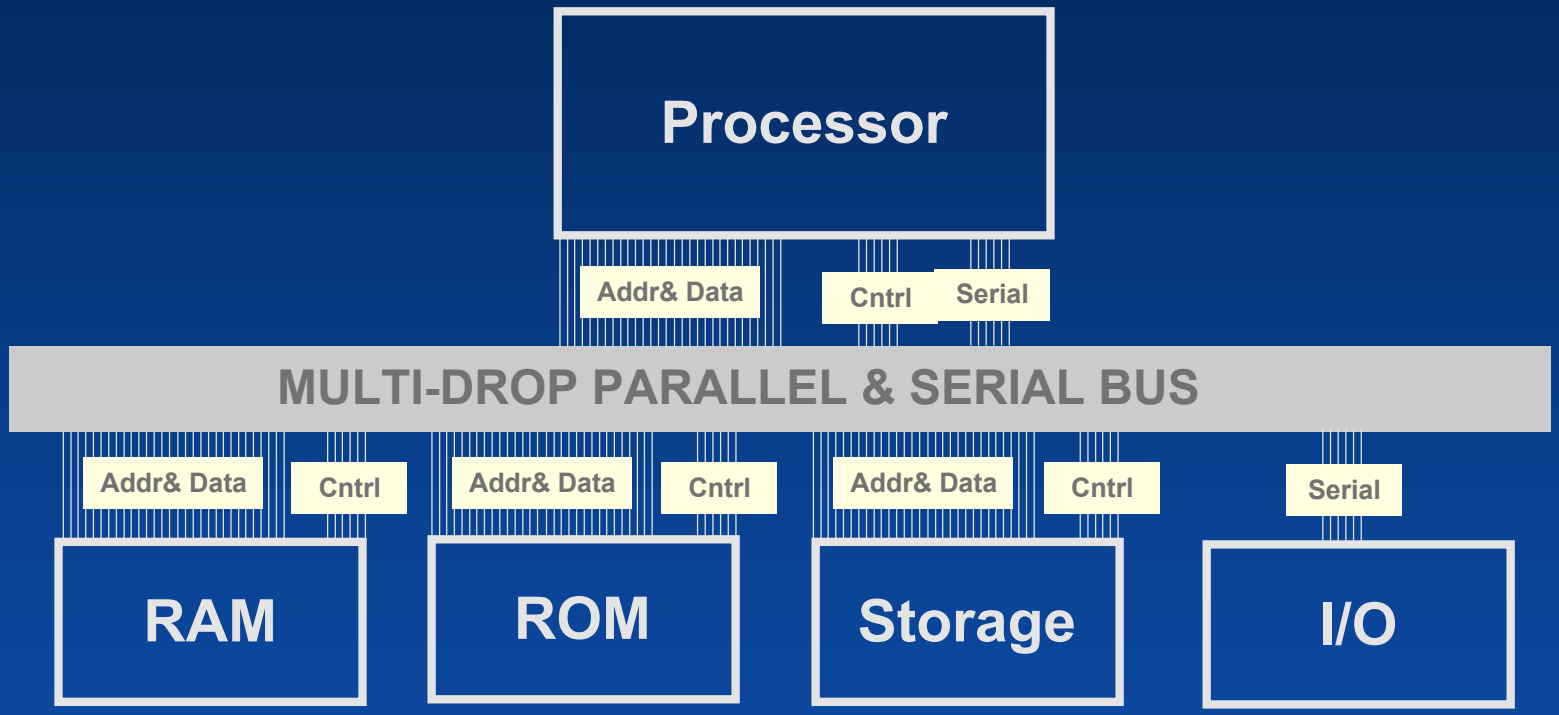
- Embedded Systems – Hardware & Software based platforms used to Compute, Control and Communicate.

- Examples – Application Specific PC's/PDA's, Servers, Telecom, Storage, etc.

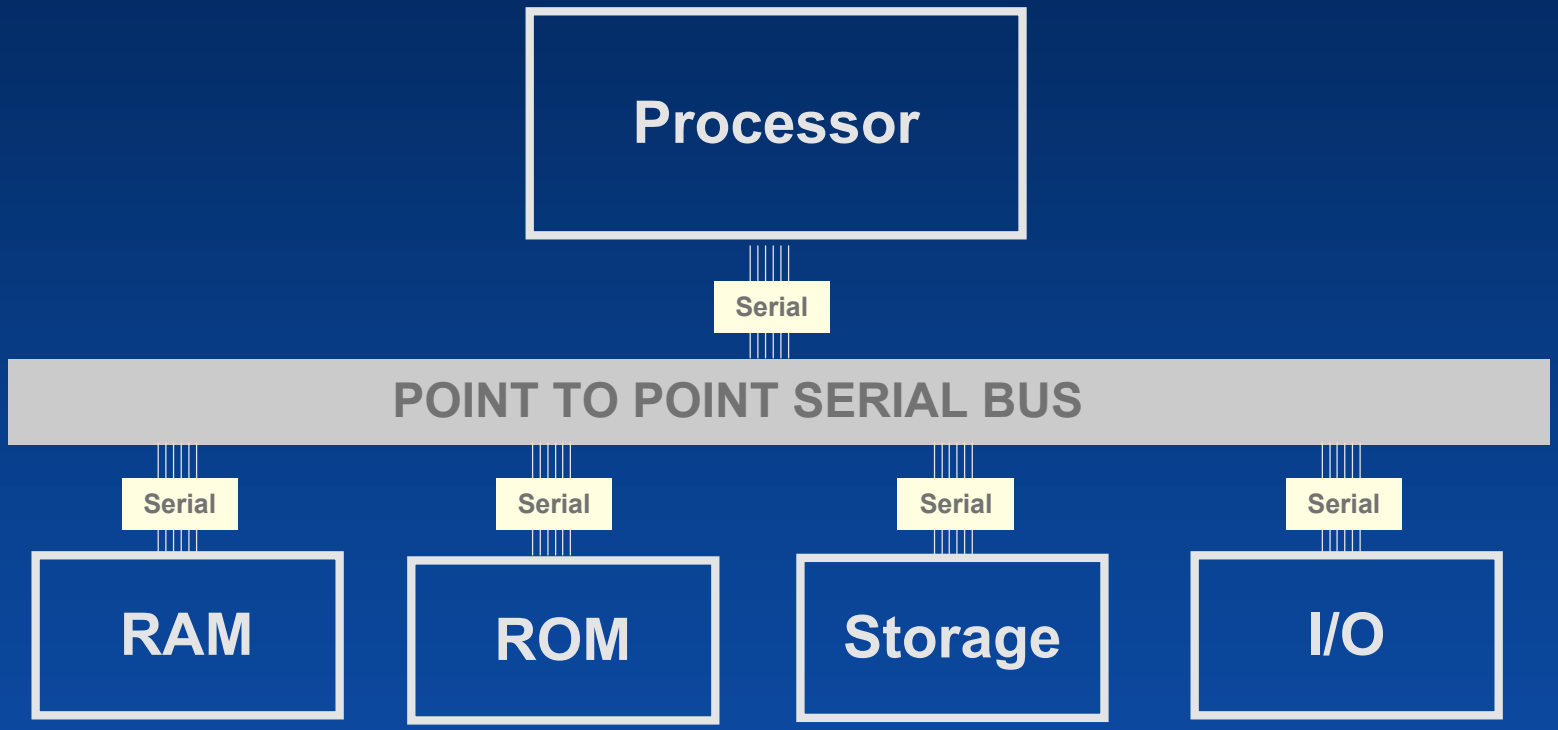
Embedded System Transformation



Embedded System Transformation



Embedded System Transformation



Emergence of High Speed Serial Bus Protocols

- Transformation from Multi-drop Parallel Bus to Point to Point Serial Bus realized at all levels:
  - Chip2Chip – SPI, I2C,
  - Device2Device - PCIe, sRIO
  - Board2Board (Backplane) – ASI
  - Box2Box – USB, 1394, SATA, SAS
- Box2Box embedded transformation leverages path paved by Desktop/Laptop market demand – USB/1394 established
- Embedded Design moving toward modular integration – SBCs' follow consumer PC trends
- Mass Storage requirements – ever increasing need to satisfy speed, cost and density

Factors Driving Flash based Mass Storage Needs

- High Performance Read/Write Operations
- High System Clock Speeds – avoid noise and crosstalk associated with High Speed Parallel
- Low Power
- High Density
- Plug-n-Play
- Non Volatile
- MTBF

Benefits & Threats to Serial Flash Memory based Mass Storage Devices

- Benefits
  - Reduced IO count
  - Improved HW Interoperability
  - High Read/Write Performance
- Threats
  - Retail Market drives Flash NAND Component Requirements
    - SLC 10x endurance vs MLC
    - MLC long term endurance TBD
    - MLC offers lowest cost, highest density

Solution Set Examples

Standard Memory Card Form-factors

- CompactFlash (legacy)
- USB Flash Drive
- Secure Digital (SD)
- MultiMedia (MMC)
- ExpressCard

Embedded Memory Modules

- uDOC
- eUSB

SSD Form-factors

- Mini-IDE (legacy)
- 1.8”, 2.5” & 3.5” SATA SSD

OS Influence on Serial based Flash Protocols

- MS Windows Vista –
  - ReadyBoost – use Flash Memory as System Cache
  - ReadyDrive – Mechanical drive uses flash as Cache to avoid latency of spin-up
- RTOS Readiness

RTOS	USB 2.0	IEEE-1394	SATA	PCIe
Integrity	✓	x	x	x
Linux	✓	✓	✓	✓
LynxOS	✓	x	x	x
Nucleus	✓	x	x	x
OS-9	✓	x	x	x
QNX	✓	✓	✓	Planned
VxWorks	✓			
WinCE/XPe	✓	✓	✓	✓

Grady Lambert is responsible for SMART Modular Technologies' Flash Memory Product Line. A member of the SMART team for nine years, Lambert has more than 12 years of engineering and management experience in Non-Volatile Memory Technology.

San José, CA USA
August 2006