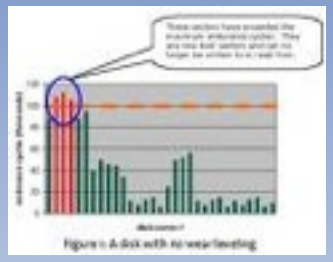
Wear-Leveling vs. Write-Performance: Simulation Based Controller Design



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Distribution of Operations

- Flash Memory manager
  - Read, write and erase to Array
  - ECC, Wear Leveling, Bad block management
- Flash Controller
  - File IO emulation, Managing super blocks
  - Device Select, address and data routing
  - Cache and buffer management
- Device Manager (USB, SATA, PCIe, etc.)
  - Routing, protocol conversion
- Others

Growing Complexity of NAND

- SLC, MLC, QLC, SLC+MLC+QLC
- Application-aware wear leveling
- Intelligent file I/O and data management for file type
- Geometry shrinks increases the operational issues for ECC, data, data logging and partial page ops
- Variable page sizes and interface speeds
- Static vs. dynamic wear leveling based on data

Performance Impact of Controller

- Behavior processing
  - Offloaded to Host CPU or GPU for high speed designs
  - Multi-core vs. higher processor frequency
  - Multi-threaded vs. sequential code processing
- Software operation
  - Garbage collection
  - Multi-level read/Write
  - Future treads of interrupting Erase
- Buffer
  - Optimal data buffering- Page size per interface or more?
  - Intelligent data pipelining
- Interfaces
  - Number of Channel, Transfer rates, data and Channel priority

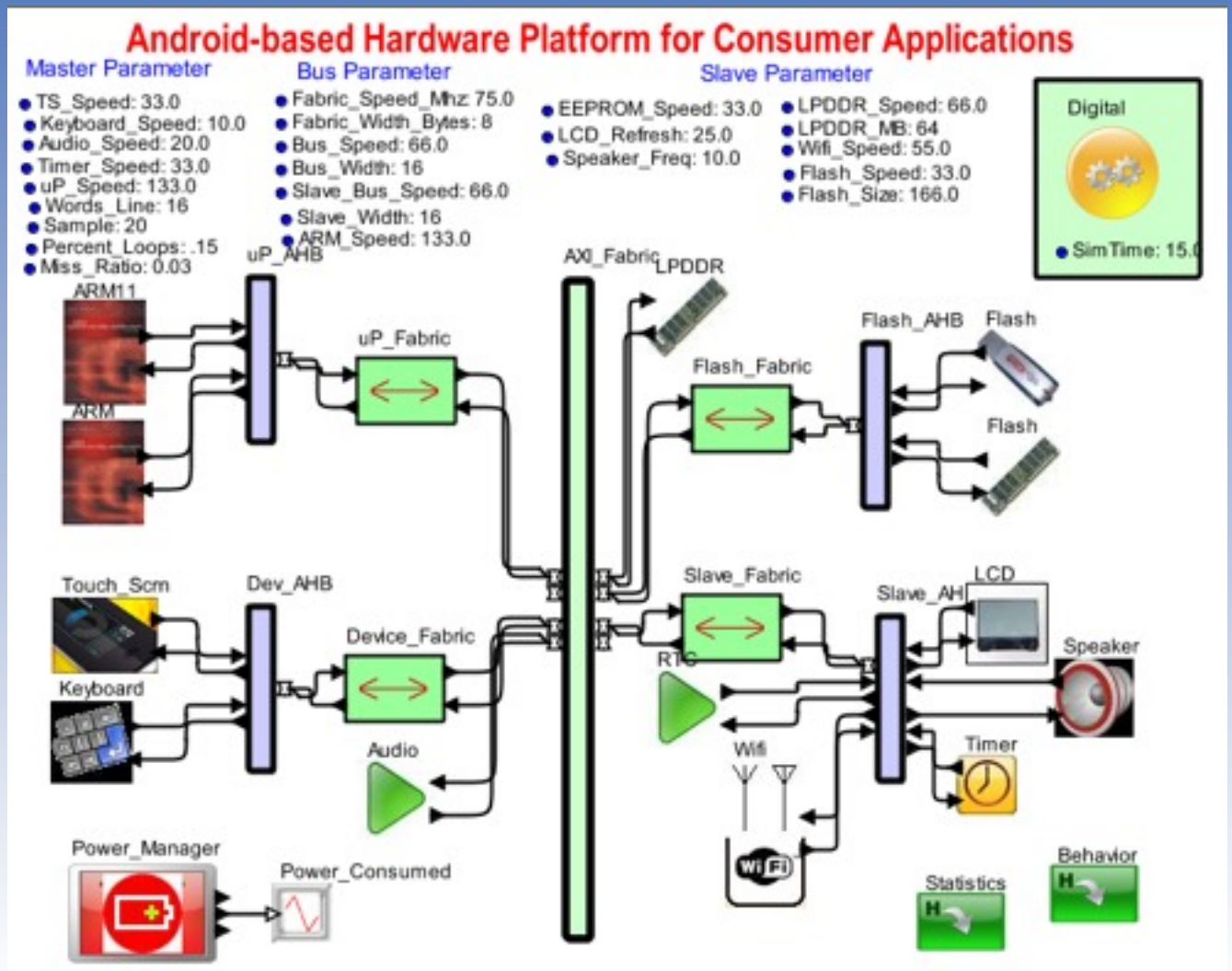
Power Consideration in designing with Flash and SSD

- Most power consumption is in I/O transfer from device to Flash
- As array gets larger, leakage is a bigger factor
- Control processing is focused on number of processor cores and active scheduling
- Lower power supply voltage reduces memory cell power and lowers the operating frequency

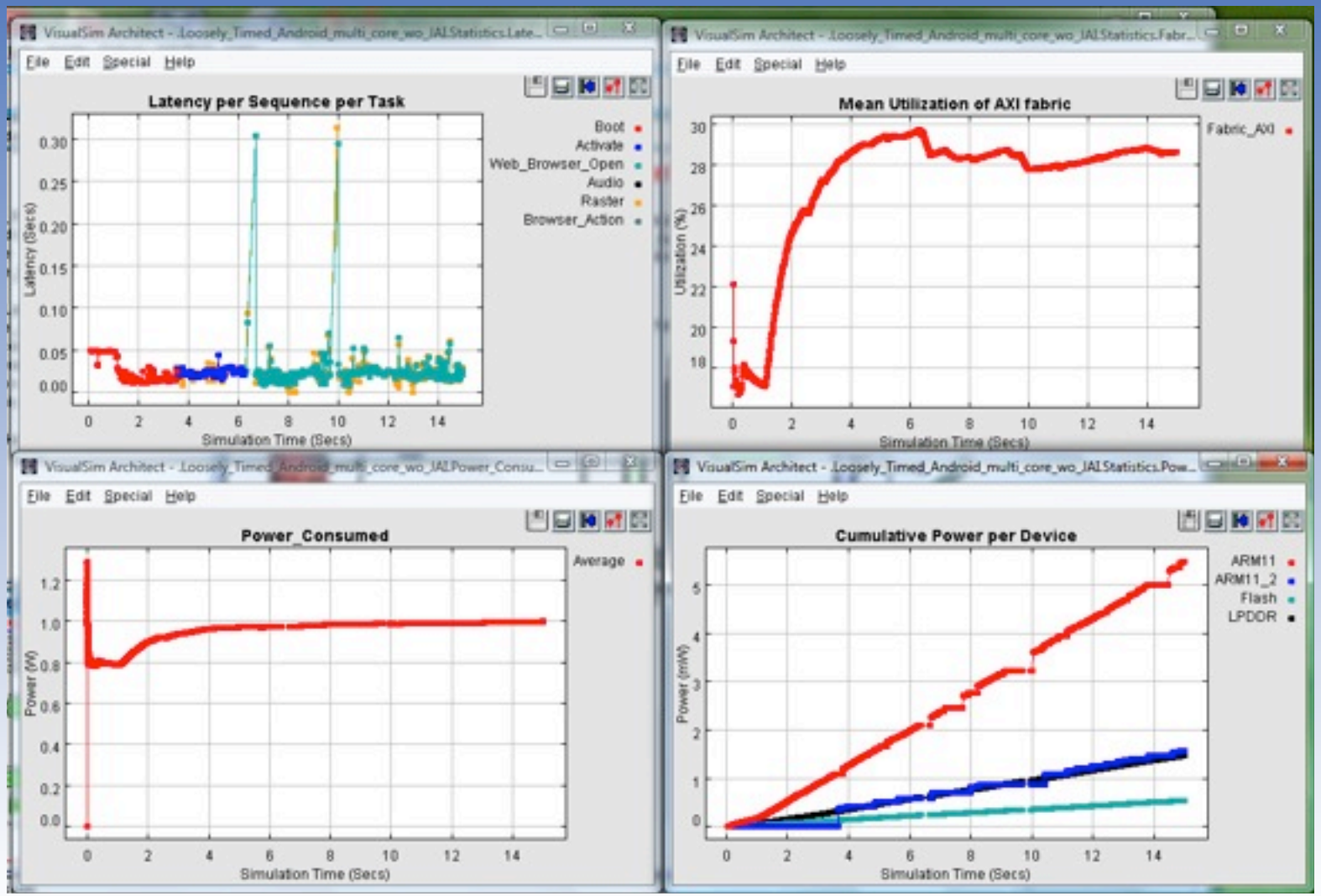
Early Virtual Prototyping to Optimize Controller Design

- Software model of the controller
- Model generates statistics for
  - Power (instant, average, battery)
  - Performance (response time, throughput)
- Application Traffic Attributes
  - Request rate, command sequence, data size, priority, file type, source and destination address
- System Level Attributes
  - Clock speed, Width, processing resource,
- Controller Attributes
  - Cache arbitration, Buffering, Virtual Channels, CrossBar

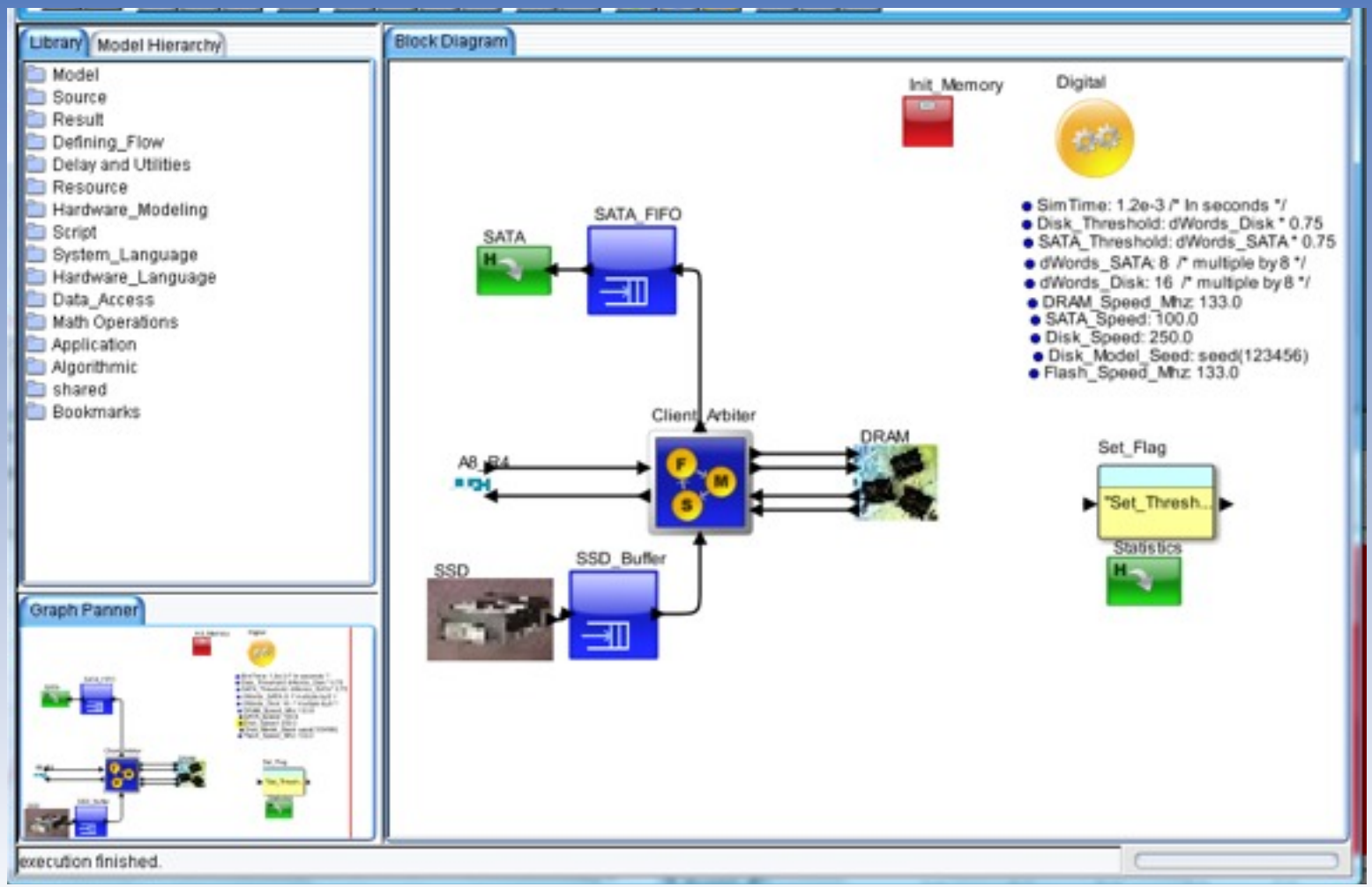
Architecture Consideration- Flash-based Consumer Device



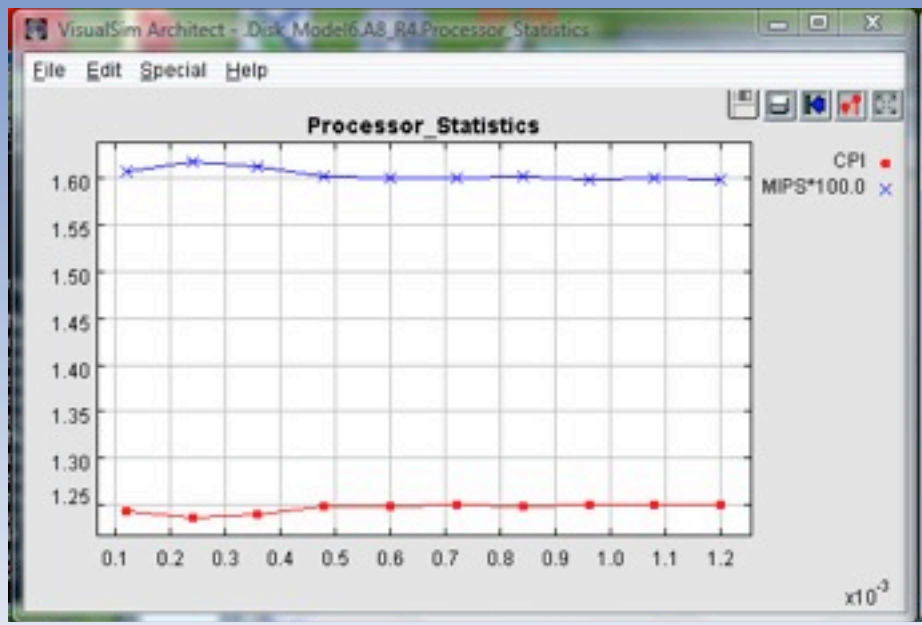
Modeling Statistics- Flash-based Consumer Device

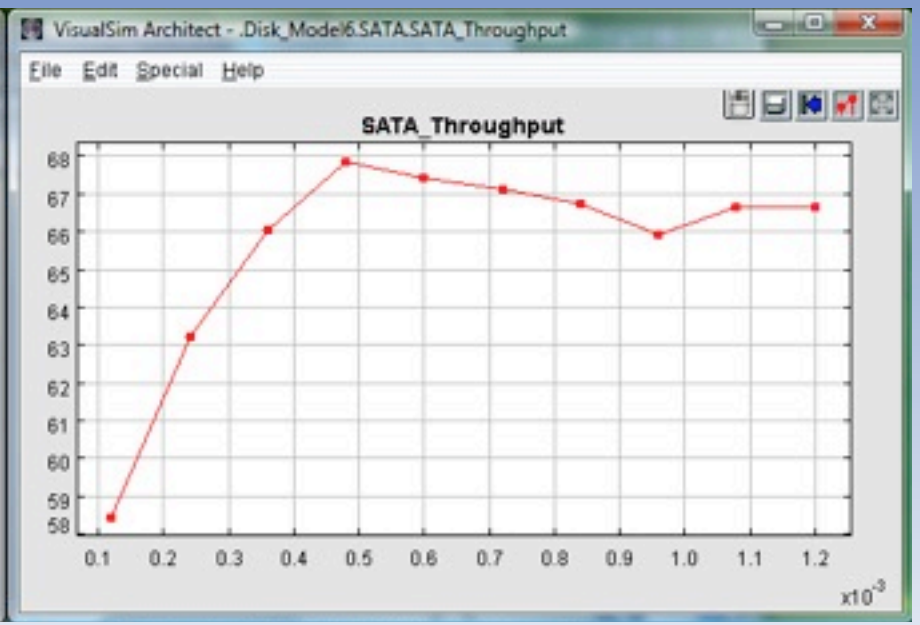


Architecture Consideration- Hybrid Drives



Hybrid Drive- Performance Statistics





Summary

- Lots of opportunity for cost, power and performance optimization
- Growing complexity requires more architecture studies using software, hardware and system activity
- Virtual Prototype can provide visibility into the system operation
- Simulation model can be used for designing the software very early in the design cycle