




ECE4893A/CS4803MPG:
MULTICORE AND GPU PROGRAMMING FOR VIDEO GAMES

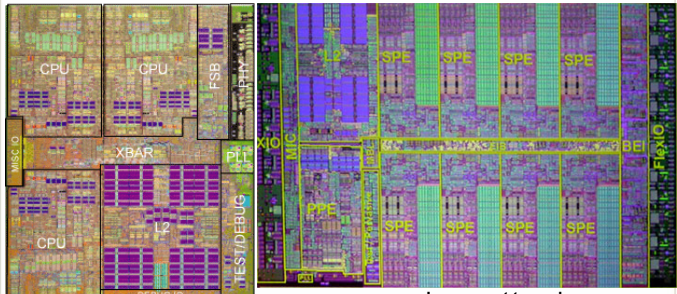
Architectural Comparison: Xbox 360 vs. Playstation 3

Prof. Aaron Lanterman
 School of Electrical and Computer Engineering
 Georgia Institute of Technology

Xbox 360's Xenon vs. Playstation 3's Cell


Both chips clocked at a 3.2 GHz



Images not to scale


Xenon CPU image from "The Microsoft Xbox 360 CPU story"
www-128.ibm.com/developerworks/power/library/pa-ftfxbox

Cell processor image from "IBM's Cell Processor: Preview to Greatness?"
www.pcstata.com/articleview.cfm?articleid=1727

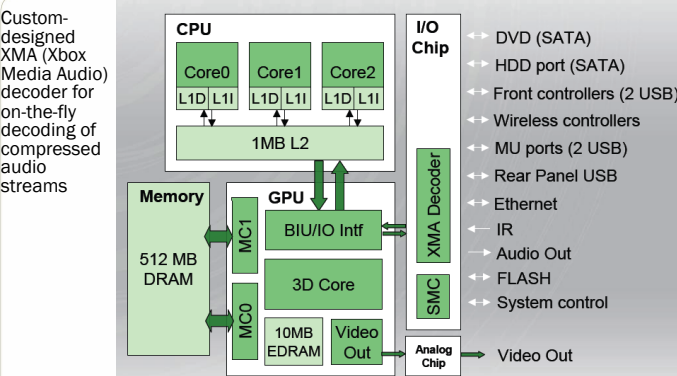


Memory: Xbox 360 vs. Playstation 3

- Xbox 360 - 512 MB, 700 MHz, GDDR3, shared by CPU and GPU
- CPU accesses memory through the GPU!
- GPU has 10 MB RAM embedded frame buffer
- PS3 - 512 MB total
- 256 MB 3.2 GHz XDR main RAM for the CPU
- 256 MB 700 MHz GDDR3 video RAM for the GPU




Xbox 360 high-level architecture



Custom-designed XMA (Xbox Media Audio) decoder for on-the-fly decoding of compressed audio streams

Image from J. Andrews and N. Baker, "Xbox 360 System Architecture," *Hot Chips* Presentation



Xenon architecture

Front Side Bus runs at 10.8 Gbit/sec read/write

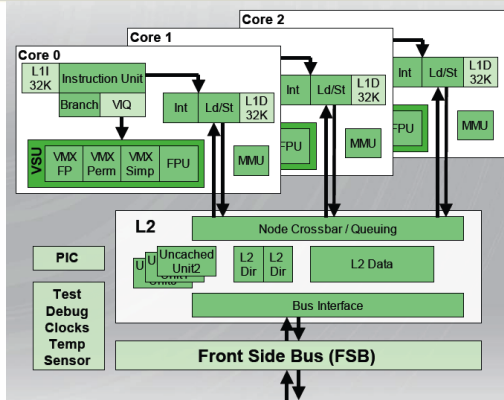


Image from J. Andrews and N. Baker, "Xbox 360 System Architecture," *Hot Chips* Presentation



Cell BE architecture

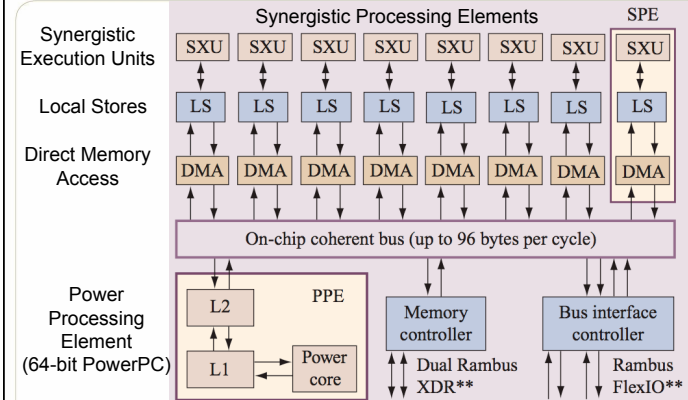


Image from J. Andrews and N. Baker, "Xbox 360 System Architecture," *Hot Chips* Presentation



What the PowerPC cores have in common

PPE on Cell, and each core on the Xbox 360 have:

- 64-bit PowerPC architecture
- Two symmetric multithreading (SMT), fine-grained hardware threads (6 total in Xbox 360)
- Integer arithmetic, single and double precision floating point, single cycle for most instructions
- VMX128 "AltiVec" vector processor

Information from Andrews & Baker and Kahle *et al.*



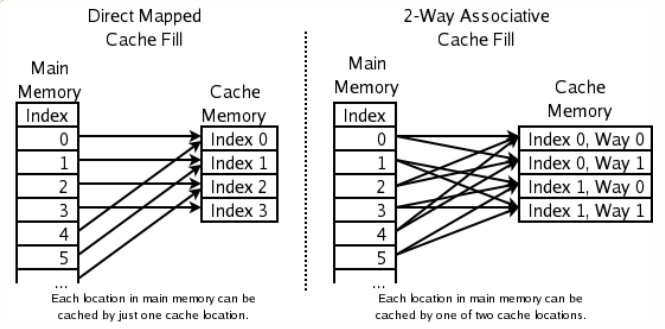
VMX128 "AltiVec" vector processor

- 128, 128-bit registers (4-element single-precision) per hardware thread
 - 6 total AltiVec-style register files in Xbox 360
- Floating point arithmetic, dot product, permute
- On Xbox 360, CPU can convert 3D data to Direct3D compressed data formats before storing in L2 cache or main memory
 - Typically 50% in bandwidth and memory footprint

Information from Andrews & Baker and Kahle *et al.*



Set-associative caches



From Wikipedia entry on "cache algorithms"



Caches

- Each PowerPC core on Xenon has:
 - 32 KB L1 two-way set-associative instruction cache
 - 32 KB L1 four-way set-associative, write-through data cache
 - xDCBT "extended data cache block touch" instruction for prefetching data direct into L1 cache, but not L2 cache as usual; avoids thrashing L2 cache
- PowerPC core on Cell has:
 - 32 KB L1 instruction cache
 - 32 KB L1 data cache
 - 512 KB L2 cache

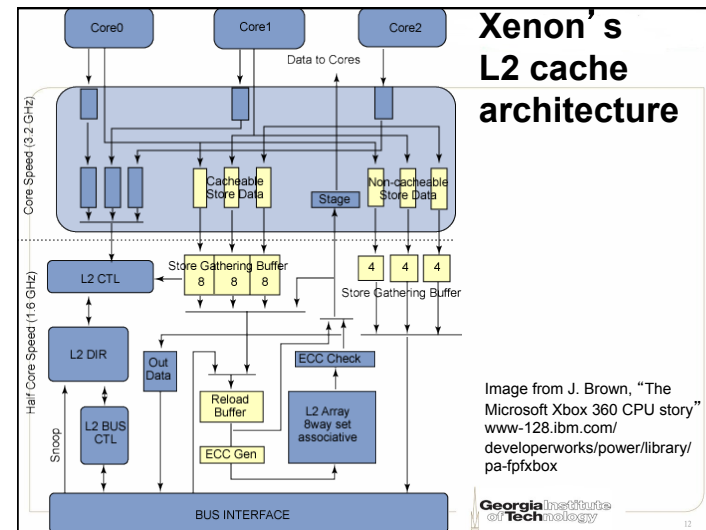
Information from Andrews & Baker and Kahle et al.

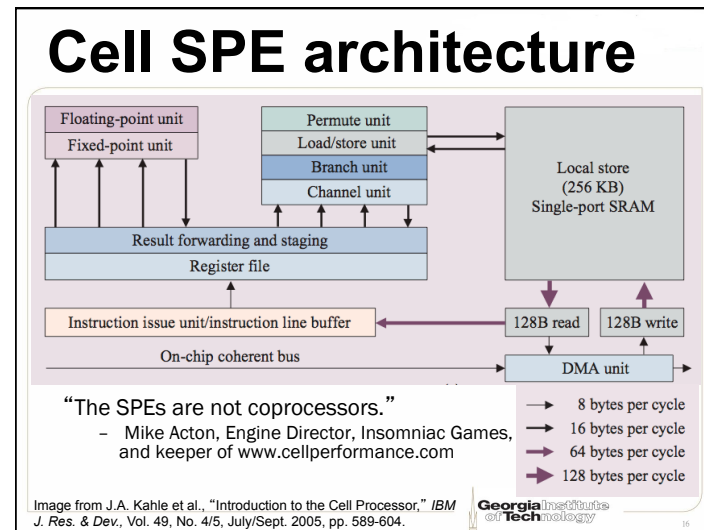
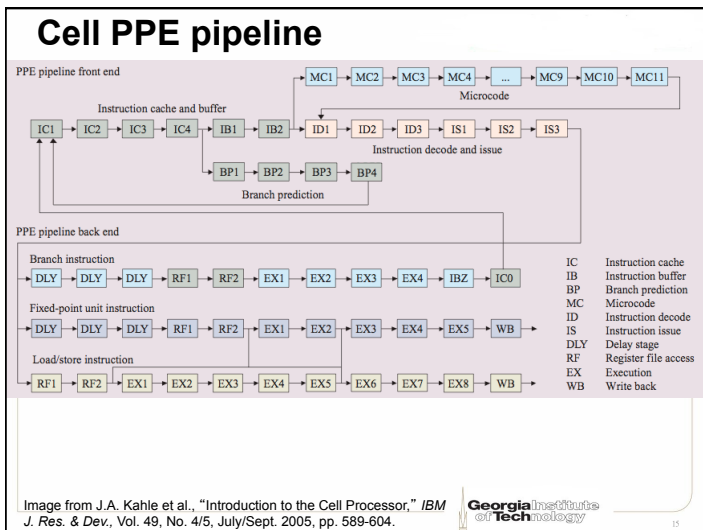
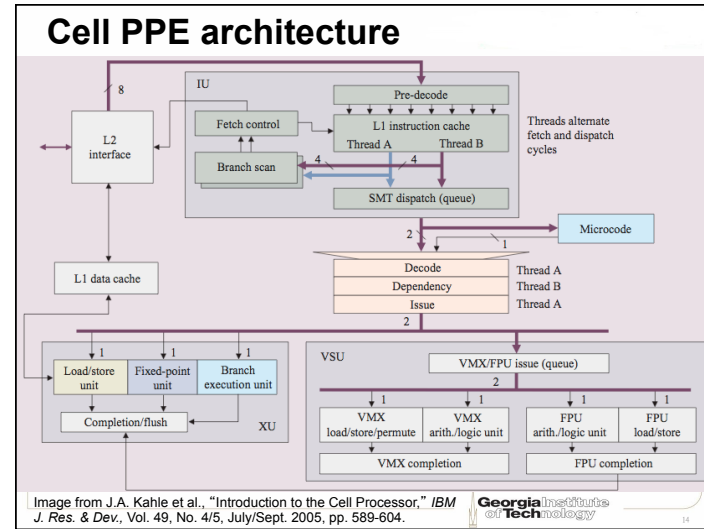
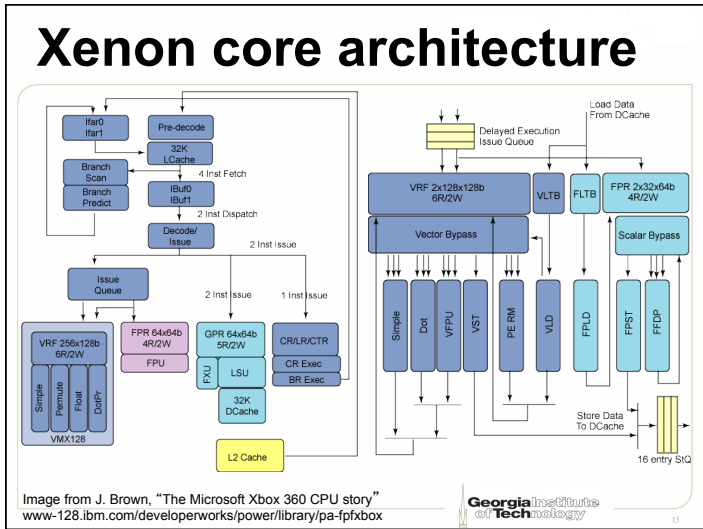


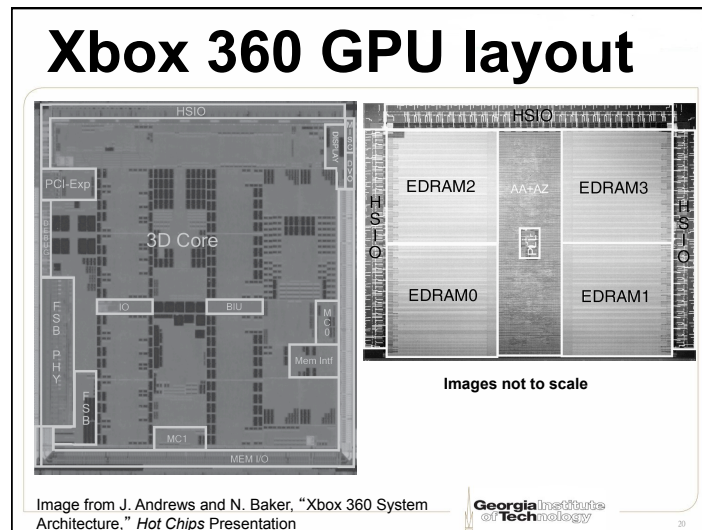
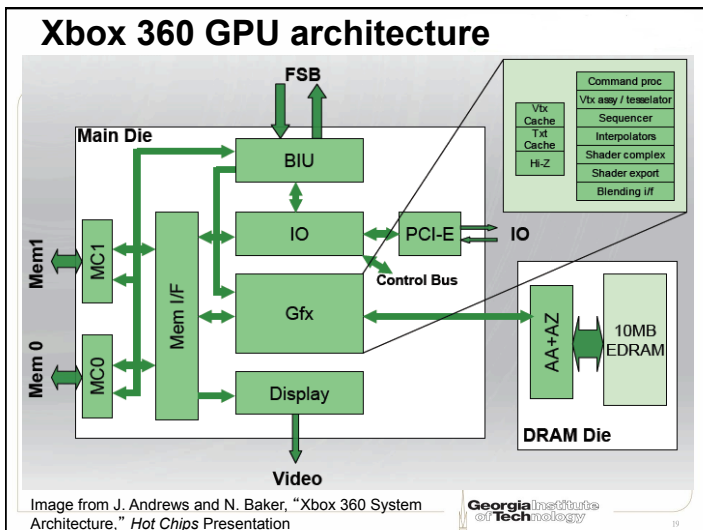
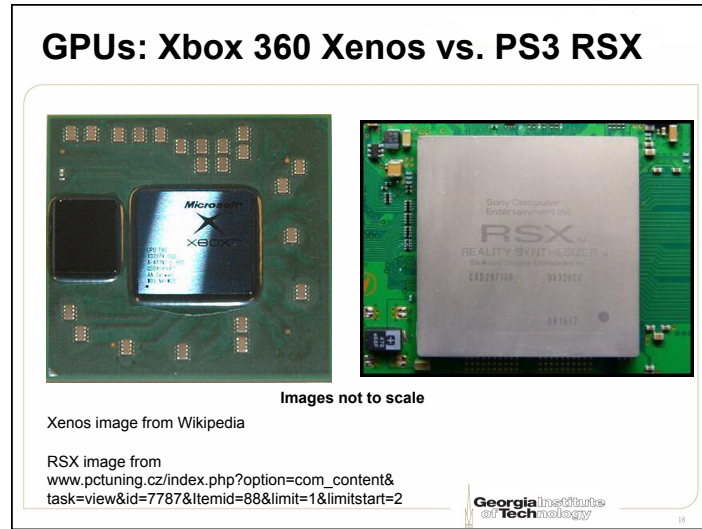
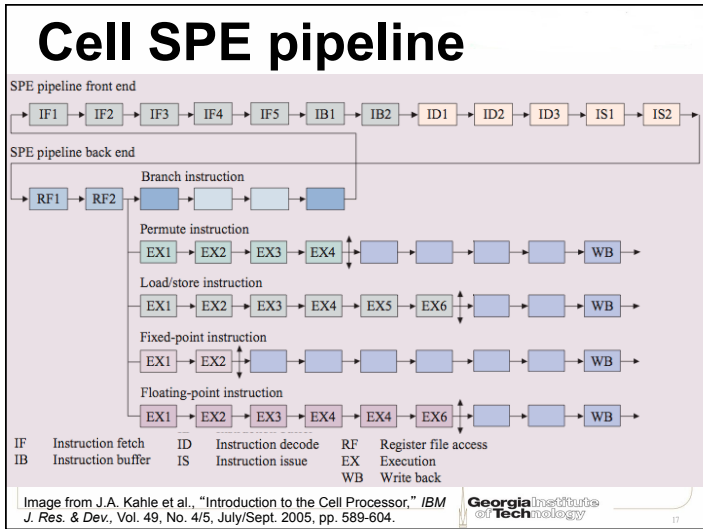
Xenon's L2 cache

- All three PowerPC cores share a 1 Megabyte, 8-way set-associative L2 cache
- Cache set locking: "common in embedded systems, but not PCs"
- Lets the cores dynamically allocate L2 usage
- Facilitates communication between cores
- GPU can read directly from the L2 cache

Information from J. Andrews and N. Baker, "Xbox 360 System Architecture," *IEEE Micro*, March-April 2006, pp. 25-37.







GPUs: Xbox 360 Xenos vs. PS3 RSX (1)

- | | |
|---|---|
| <ul style="list-style-type: none"> • Xbox 360: ATI Xenos • 500 MHz • Precursor to Radeon HD 2000 series • 16 vertex fetch units with built-in tessellation • 48 unified shaders (can do vertices or pixels) <ul style="list-style-type: none"> - All 48 have to be doing either vertices or pixels in one clock cycle - Can change from cycle to cycle - Rumored to have more than 48 per chip; gets higher yields • 16 texture interpolating (filtering) units • 16 texture fetch (addressing) units • 8 render output units | <ul style="list-style-type: none"> • PS3: NVIDIA RSX "Reality Synthesizer" • 550 MHz • Somewhat like 7800 (G70) • 24 pixel shaders • 8 vertex shaders • 24 texture filtering units • 8 texture addressing units • 8 render output units |
|---|---|

GPUs: Xbox 360 Xenos vs. PS3 RSX (2)

- | | |
|---|---|
| <ul style="list-style-type: none"> • 10 MB video buffer eRAM die includes some custom logic for color, alpha compositing, Z/stencil buffering, and anti-aliasing <ul style="list-style-type: none"> - Does not include textures - 256 GB/sec bandwidth to GPU - Currently on separate die on same package - Guess will later probably put on same die - Buffer in eRAM is copied to main memory for output | <ul style="list-style-type: none"> • Video buffer part of 256 MB video RAM • Cell FlexIO bus interface <ul style="list-style-type: none"> - 20 GB/s read to the Cell and XDR memory - 15 GB/s write to the Cell and XDR memory |
|---|---|

Xbox 360 CPU/GPU/memory synergy

- GPU can read data directly from CPU's L2 cache through the FSB without going through main memory
- Facilitates XPS (Xbox Procedural Synthesis), in which CPU decompresses 3D data for the GPU

Xbox 360 CPU/GPU/memory synergy

- "For render-to-texture, GPU must first 'flush' appropriate buffer to main memory before using it as a texture"
- Shaders can output directly to main memory instead of frame buffer (good if need to use GPU for physics, etc.)

