Cell Broadband Engine

Presented by Kyle Malaguit

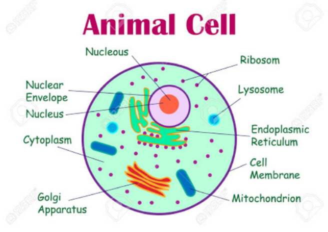
The 2000s

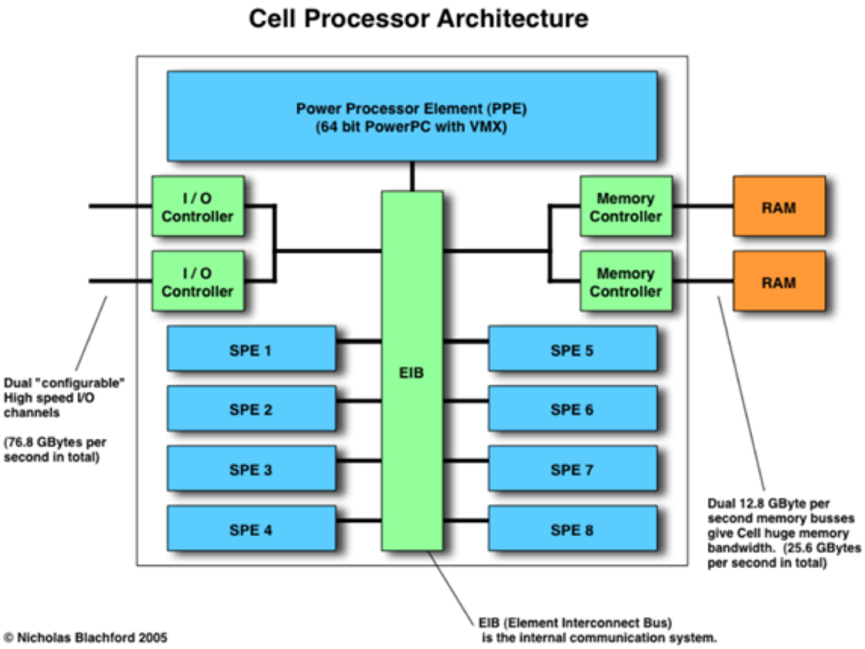
Beginnings of the Cell

Ken Kutaragi, "the Father of the PlayStation"

Came up with the idea for Cell's structure by receiving inspiration from biological cells.

Development started in 2001 by the coalition of Sony, Toshiba, and IBM. They called themselves STI.





Dual "configurable" High speed I/O channels

(76.8 GBytes per second in total)

Dual 12.8 GByte per second memory busses give Cell huge memory bandwidth. (25.6 GBytes per second in total)

EIB (Element Interconnect Bus) is the internal communication system.

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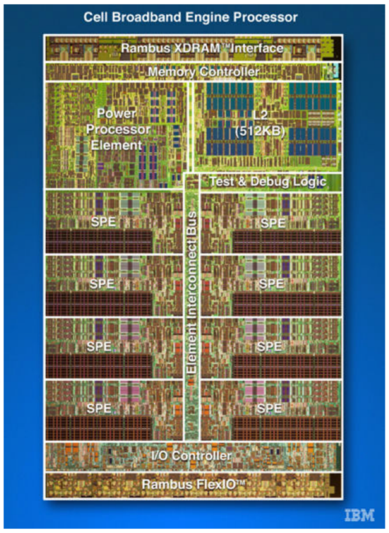
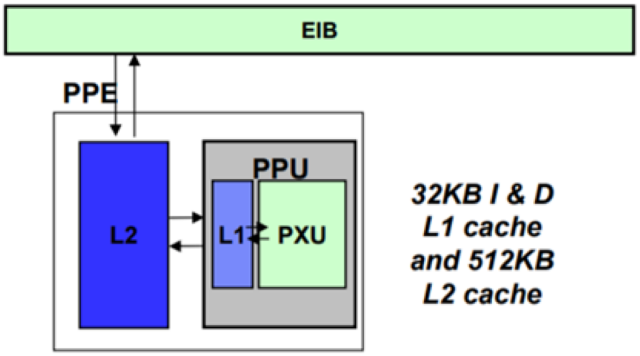
- 1 Power Processor Element (PPE)
- 8 Synergistic Processor Elements (SPEs)
- Element Interconnect Bus (EIB)
- Direct Memory Access Controller (DMAC)
- 2 Rambus XDR memory controllers
- Rambus FlexIO (Input / Output) interface



Power Processing Element

- Dual threaded and dual issue
- 512 Kb cache
- 3.2 GHz
- No forwarding
- Executes instructions in-order
- 32-bit instruction format
- RISC architecture

Handled the bulk of the operating system, and distributed instructions for the SPEs to carry out via the Element Interconnect Bus.

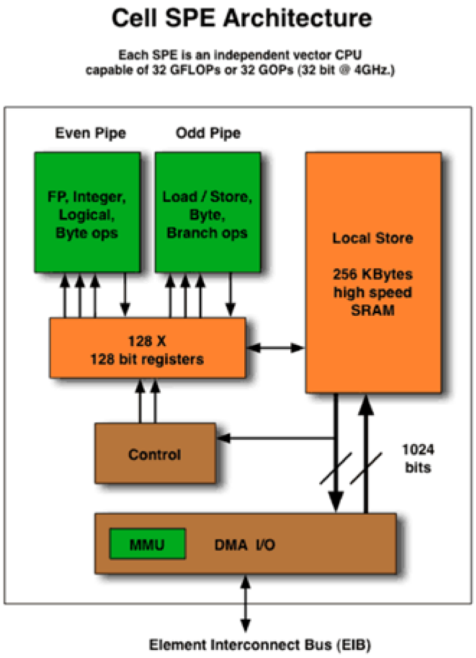


32KB I & D L1 cache and 512KB L2 cache

Synergistic Processing Element

- Dual threaded and dual issue
- Synergistic Processing Unit
- 3.2 GHz
- No forwarding
- Executes instructions in-order
- 32-bit instruction format
- RISC architecture
- Single Instruction, Multiple Data
- 0 branch prediction hardware
- No cache
  - Direct Memory Access
  - 256KB Local Store

The SPU does not access memory directly.


Cell SPE Architecture
Each SPE is an independent vector CPU capable of 32 GFLOPs or 32 GOPs (32 bit @ 4GHz.)
Even Pipe
Odd Pipe
FP, Integer, Logical, Byte ops
Load / Store, Byte, Branch ops
Local Store
256 KBytes high speed SRAM
128 X 128 bit registers
Control
1024 bits
MMU
DMA I/O
Element Interconnect Bus (EIB)

Bro can you spot me? Sorry bro, I don’t have cache.

Advantages

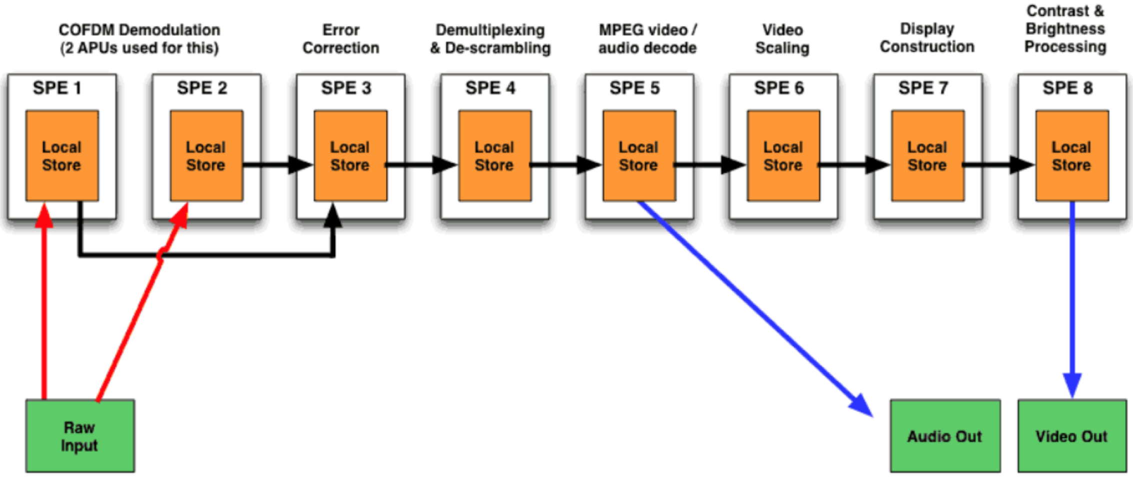
- The local store cannot directly access memory
  - Processors at this time spent 80% of the time waiting for memory access
- On chip memory
  - Acts as a second level of registers
- As it’s not a cache, no need for cache coherency
- Deliver data at 16 bytes per cycle (64 GB/s) for large cycle lengths
  - Caches can deliver comparable data but only in short cycle bursts

Disadvantages

- The local store cannot directly access memory
  - It is up to the DMA
- Contention when SPU and DMA both try to access the local store
- Can make programming more difficult
  - Bigger burden on compiler

Stream Processing

Decoding digital TV is a complex process
but it can be broken into a stream



COFDM Demodulation
(2 APUs used for this)

Error
Correction

Demultiplexing
& De-scrambling

MPEG video /
audio decode

Video
Scaling

Display
Construction

Contrast &
Brightness
Processing

SPE 1

SPE 2

SPE 3

SPE 4

SPE 5

SPE 6

SPE 7

SPE 8

Local
Store

Raw
Input

Audio Out

Video Out

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Programming is hard

Due to various factors, Cell was rather difficult to program with.

> **"We don't provide the 'easy to program for' console that (developers) want, because 'easy to program for' means that anybody will be able to take advantage of pretty much what the hardware can do, so then the question is, what do you do for the rest of the nine-and-a-half years?"**
>
> --Kaz Hirai, CEO, Sony Computer Entertainment

Programmers needed to produce code while keeping in mind the cacheless, non-forwarding, in-order-only, minimal branch prediction, Godless architecture that Cell is.

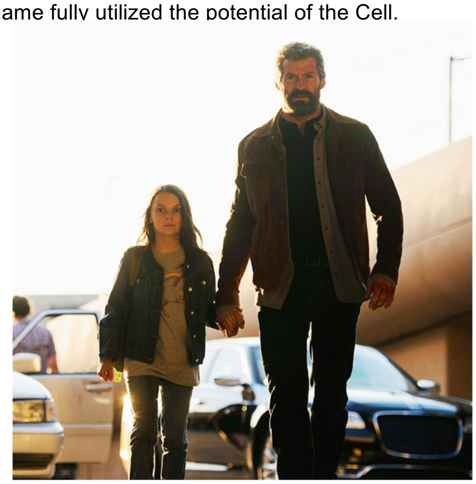
Code that has been optimized for the Cell is "vectorized," This job that is mostly just handed to the compiler. The compiler handles most of the scheduling work.

...It's a feature

Difficulty to program is evident in the performance disparity between first party and cross platform titles.

Games like skyrim could not take full advantage of the SPEs, and they had to rely mostly on the PPE. This caused frames to average about 25fps

The Last of Us was one of the last games to be released on the PS3. The game developers, Naughty Dogs, stated that this game fully utilized the potential of the Cell.



I Lied but only a little

While the PS3 has 8 SPEs, effectively. only 6 are accessible for developers.
The 7th SPE is used primarily for Operating System tasks.
The 8th is shut off because developers could not even begin to imagine that much power and potential.

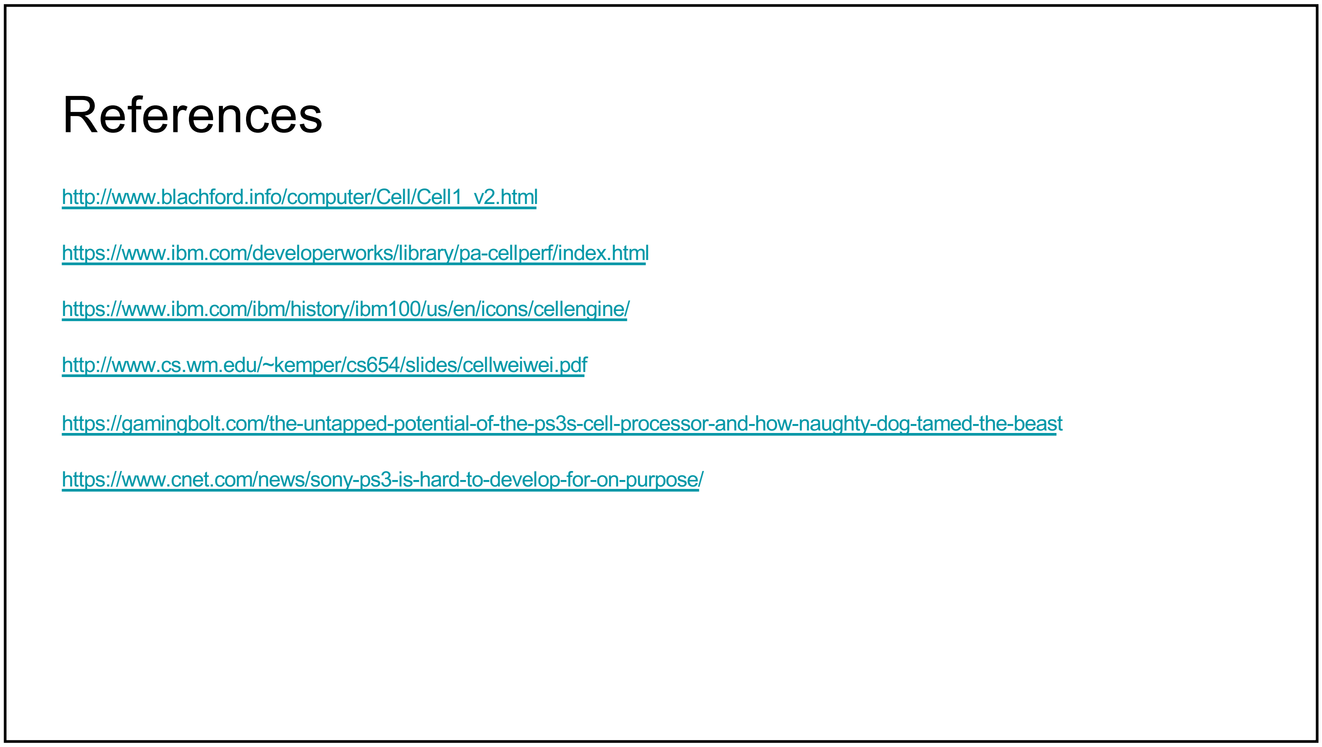
Too much potential

An individual Cell has a theoretical computing capability of 256 GFLOPS (billion floating point operations per second)

> “The Cell’s hardware has been specifically designed to provide sufficient data to the computational elements to enable such performance. This is a rather different approach from the usual way which is to hide the slower parts of the system. All systems are limited by their slowest components **[Amdahl's law]** , Cell was designed not to have any slow components!”

IBM’s supercomputer, Roadrunner, which uses an updated version of Cell reached a top performance of 1.456 PetaFLOPS.
As of 2009, IBM is still developing cell models, but there has been nothing new as of now.

Thank you Dr. Nelson



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