

# ECE4893A/CS4803MPG: MULTICORE AND GPU PROGRAMMING FOR VIDEO GAMES



## PlayStation 2 Architecture

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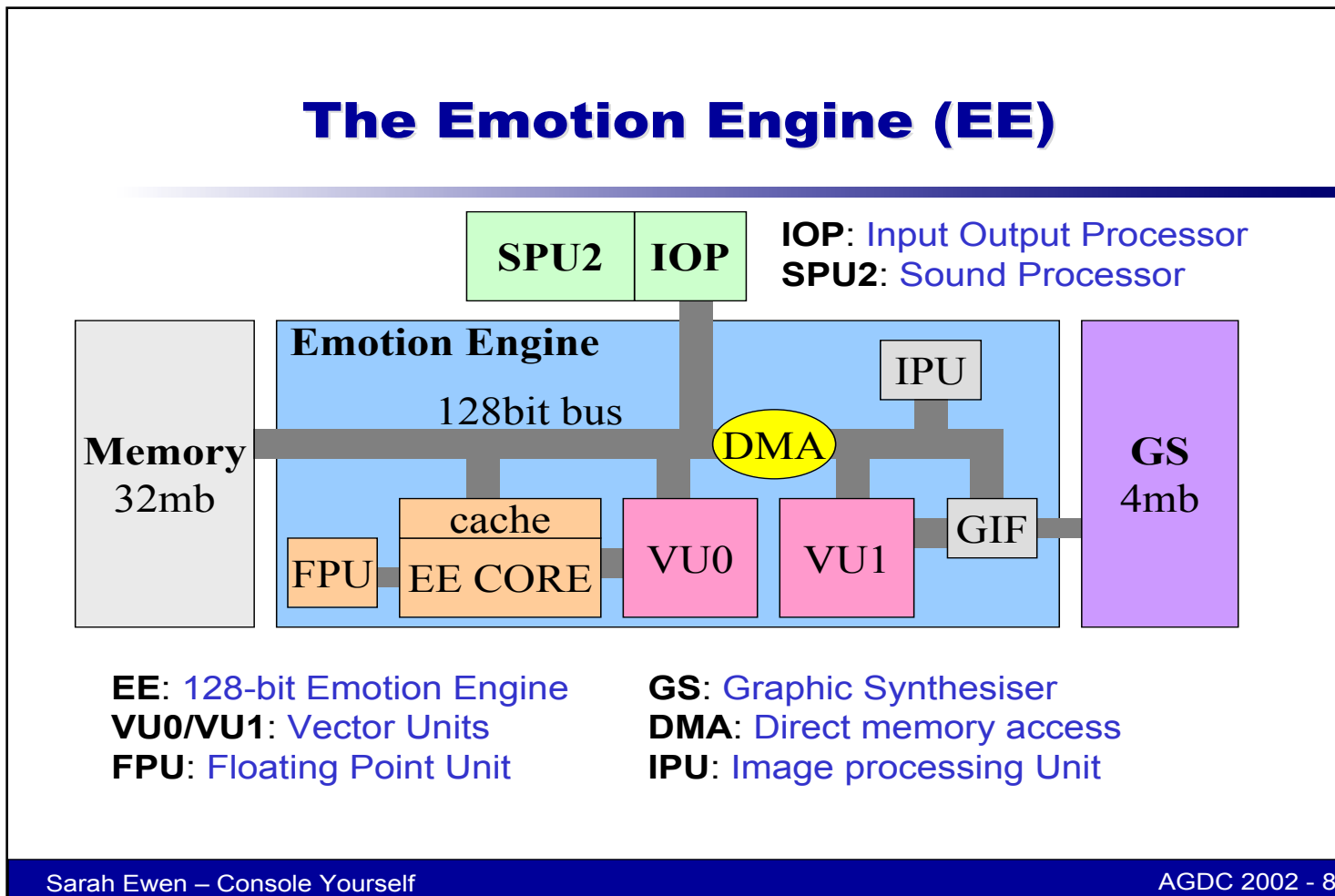
# Why talk about the PlayStation 2?

- Previous generation:
  - Xbox: > 24 million (May 10, 2006)
  - GameCube: 21.66 million (Sept. 31, 2007)
  - PlayStation 2: 117.89 million (March 31, 2007)
- Current generation (Sept 30, 2007):
  - Xbox 360: 13.4 million
  - Wii: 13.17 million
  - PlayStation 3: 5.59 million

# Sega pledges PS2 support until 2010

- “This generation of hardware will have longer legs than any previous generation, and that’s definitely healthy for the industry.”
- “We expect Sony to price manage the PS2’s shelf life for another two or three years at least. PS2 high profile titles, especially ‘wide market’ and licensed titles, will absolutely be part of the Sega portfolio going forwards.”

# PS2 high-level structure



# Special subprocessors

- IOP Input/Output Processor
  - Contains R3000 (provides PS1 compatibility)
  - 2 MB memory (same as PS1)
  - Controllers, memory cards, SPU2, DVD drive, USB, “Firewire”
- SPU2 Sound Processing Unit
  - 2 DSP cores, 48 channels
  - 2 MB sound memory

# Emotion Engine

- 300 MHz
- MIPS III core
- Two “Vector Units”
- Graphics Interface (GIF) for talking to Graphics Synthesizer (GS)
- Image Processing Unit
  - MPEG2 decoder
  - Macroblock decoding
  - Vector quantization

# Emotion Engine - high-level structure

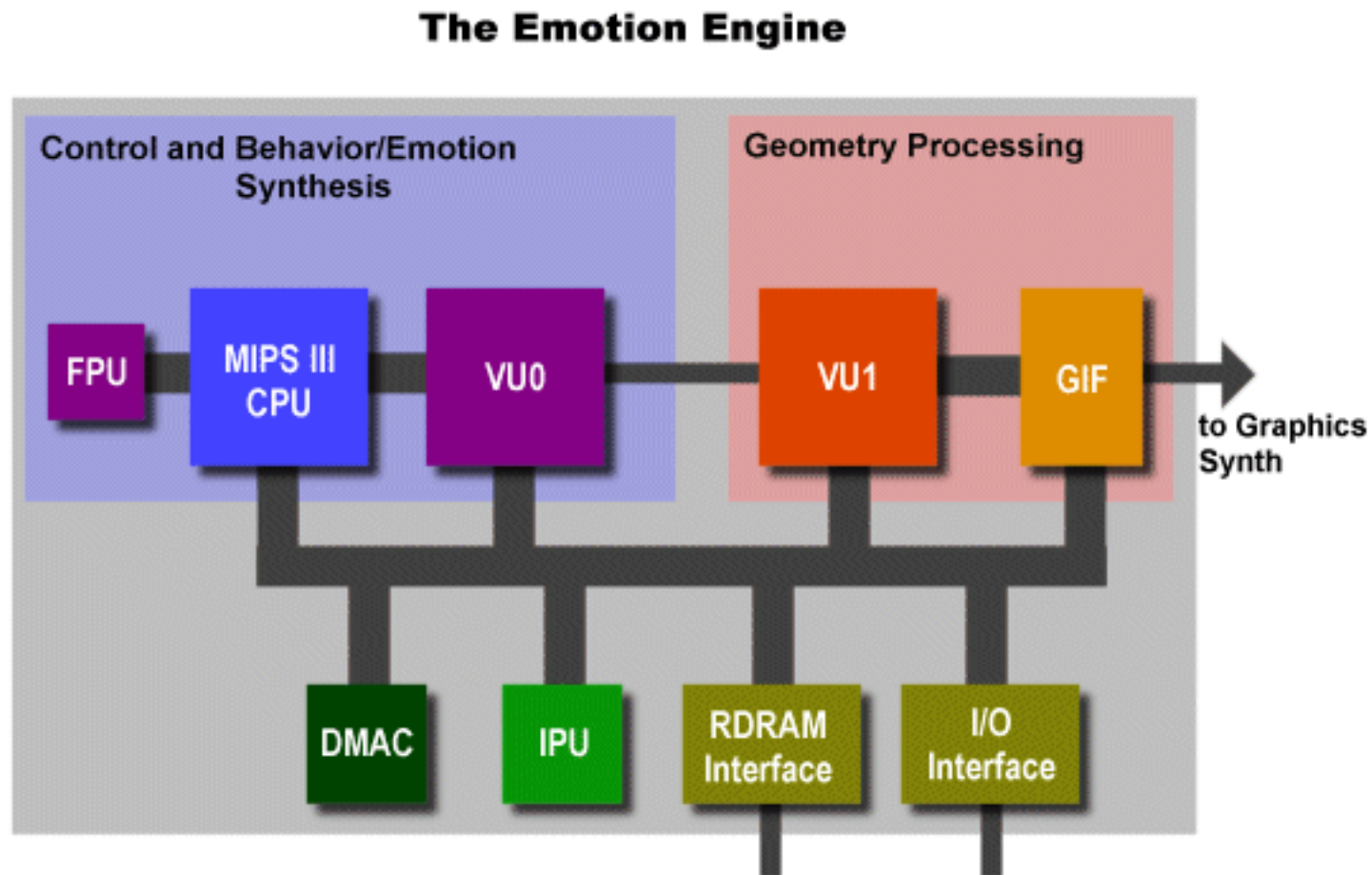


Image from J. Stokes, "Sound and Vision: A Technical Overview of the Emotion Engine," *ars technica*, Feb. 16, 2000, [arstechnica.com/reviews/hardware/ee.ars](http://arstechnica.com/reviews/hardware/ee.ars)

# Vector Processing Units - capabilities

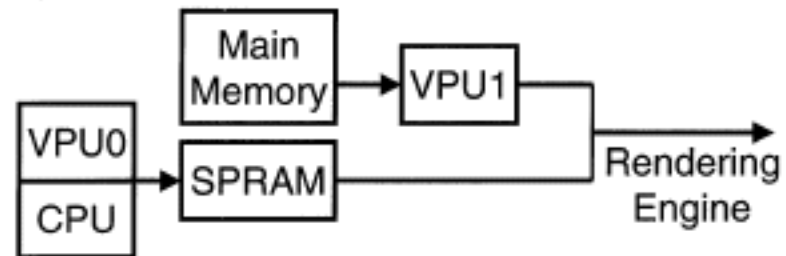
- 16, 16-bit integer registers
- 32, 128-bit floating point registers
  - Split into 32 bit words (x,y,z,w)
- Four FMACs in one clock cycle
- 1 floating-point division unit
- 1 integer ALU

# Vector Processing Units - roles

- VPU0: intended for “thought simulation and physical simulation”
  - Outputs to ScratchPad RAM (SPR) for use by GS for VPU1
  - 4K data/4K instruction
- VPU1: intended for graphics pipeline
  - Geometry transformation
  - Vertex lighting
  - Outputs triangles (display list) to Graphic Synthesizer
  - 16K data/16K instruction

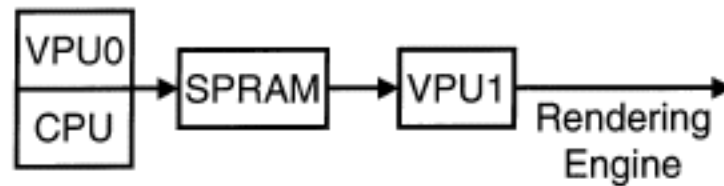
# Connection styles

## Parallel Connection



(c) IEEE 1999 1999 ISSCC Slide Supplement / Copyright IEEE

## Serial Connection



(c) IEEE 1999 1999 ISSCC Slide Supplement / Copyright IEEE

# Vector Unit 0

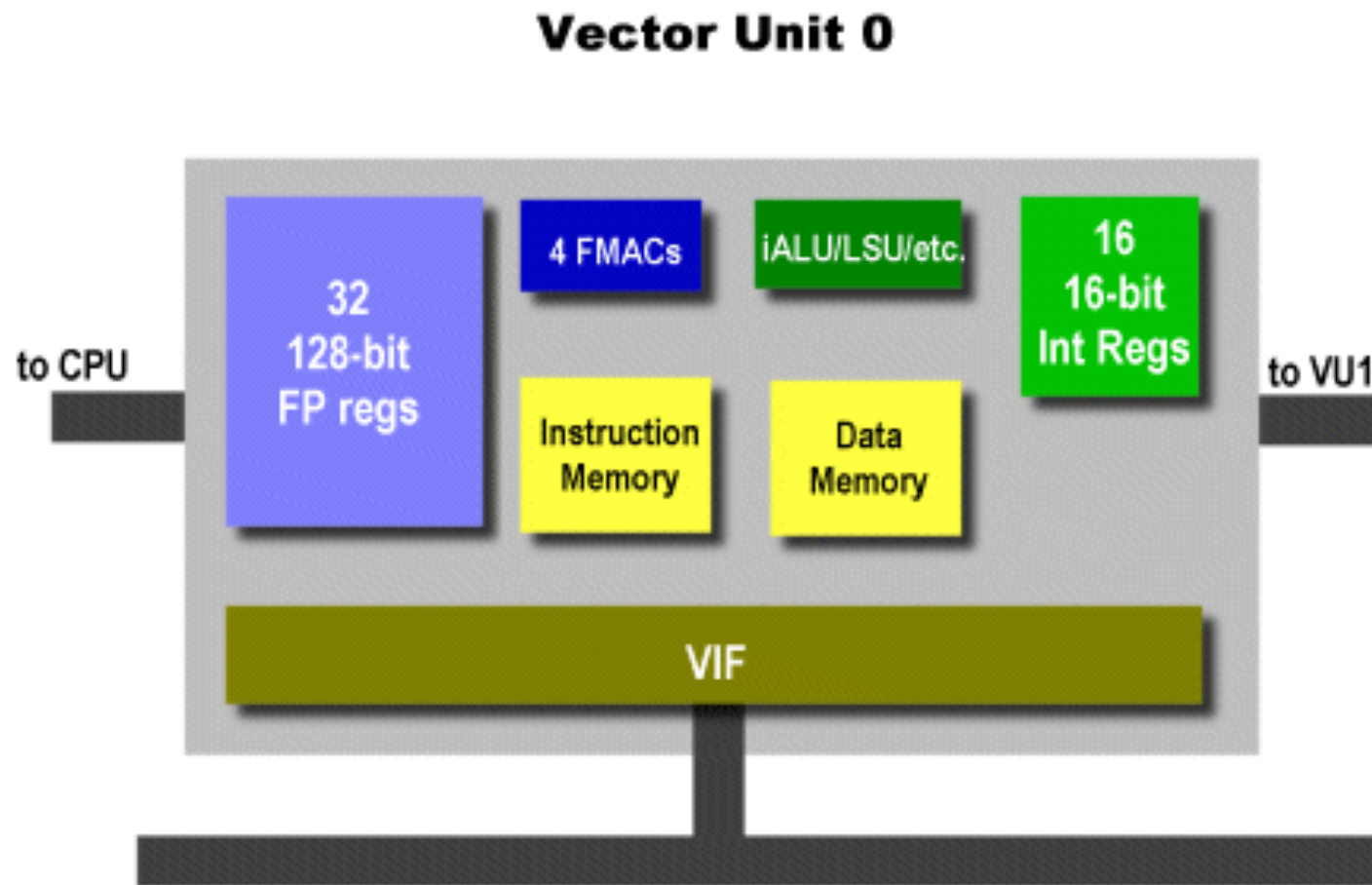


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# Vector Unit 1

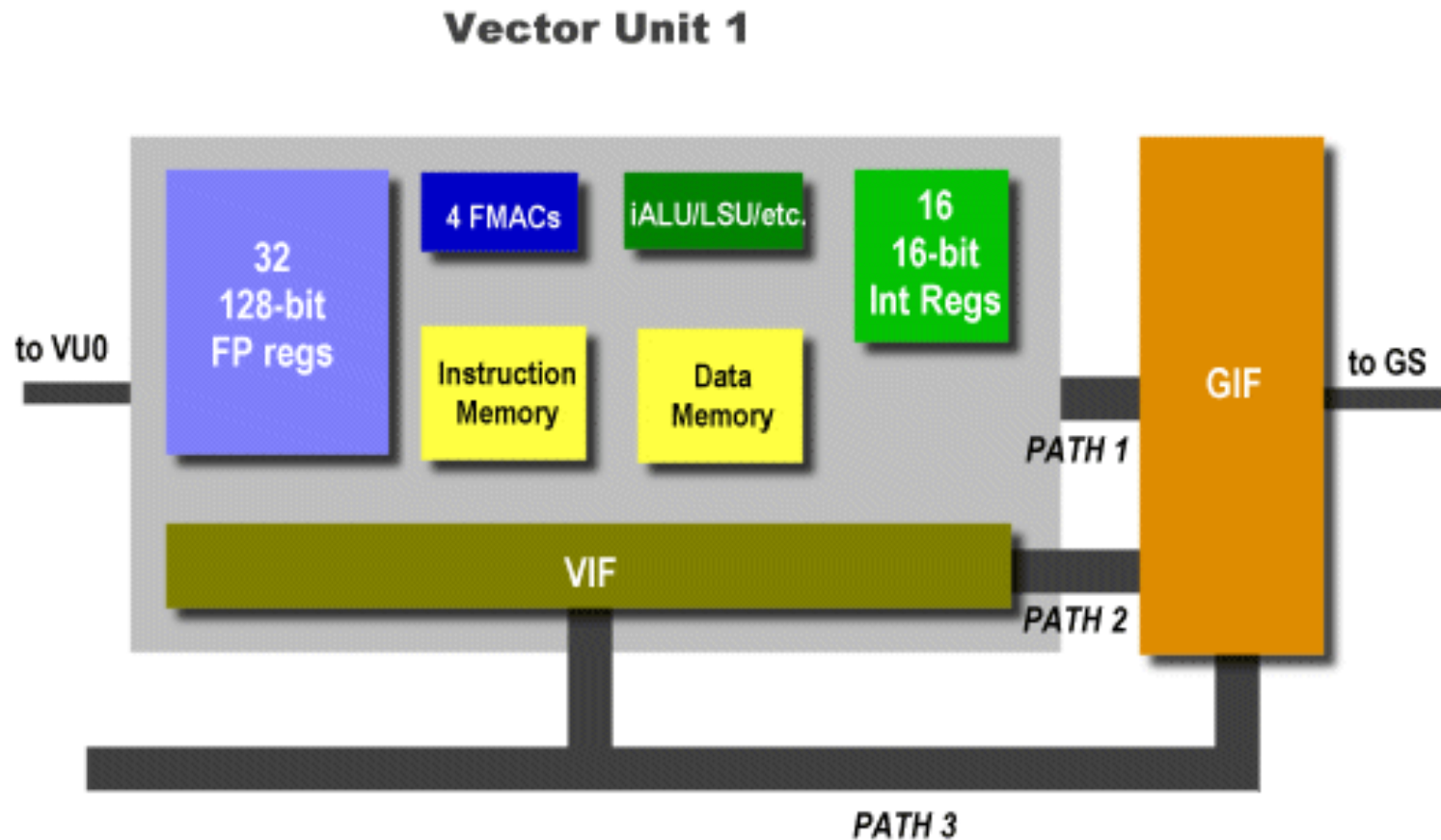
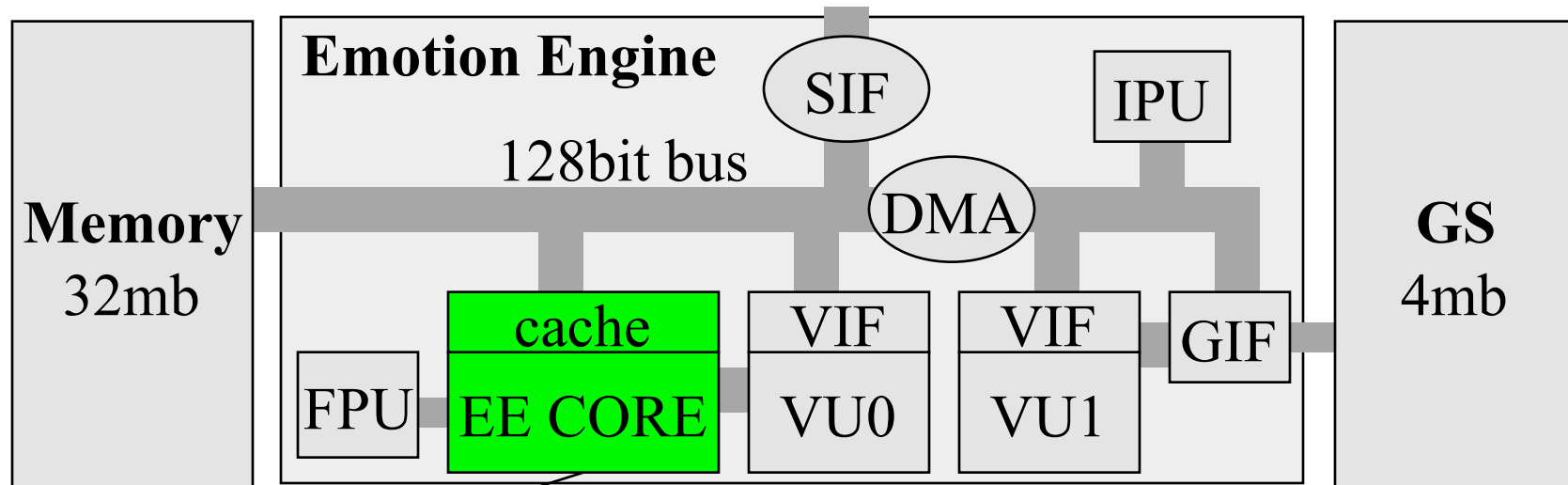


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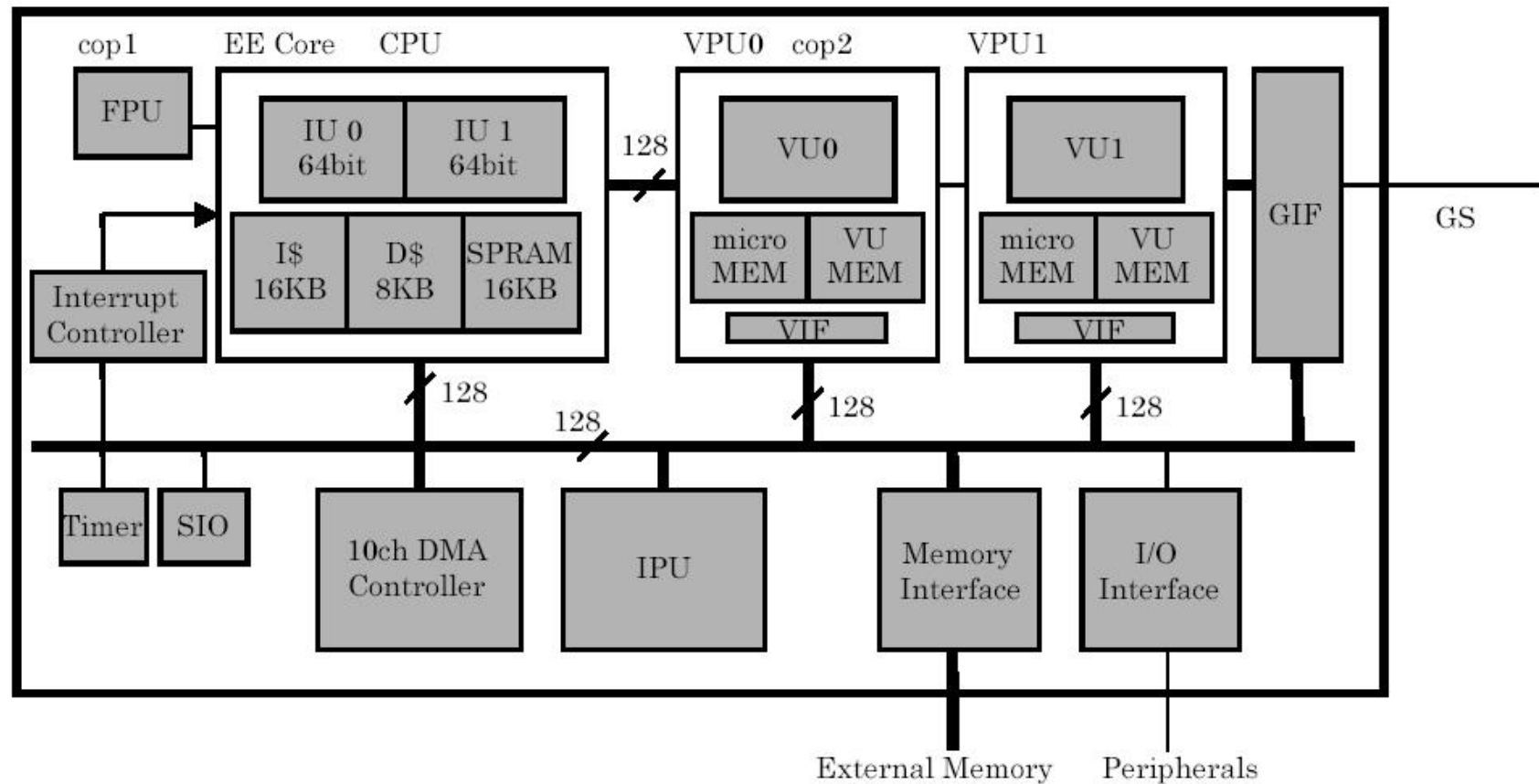
# Caches and scratchpad



|         |     |     |
|---------|-----|-----|
| I\$     | D\$ | SPR |
| 16k     | 8k  | 16k |
| EE CORE |     |     |

- Similar to old style PC L1 cache
- PS2 has small caches, as it was felt that a lot of dynamic data would not be in the cache for any length of time

# Vector Processing Units



# Typical vsm assembly (dual stream)

|           |                 |        |                      |
|-----------|-----------------|--------|----------------------|
| NOP       |                 | lq     | VF06,7(VI02)         |
| mulax     | ACC,VF02,VF06x  | iaddiu | VI01,VI01,0x00000001 |
| madday    | ACC,VF03,VF06y  | iaddiu | VI02,VI02,0x00000002 |
| maddaz    | ACC,VF04,VF06z  | NOP    |                      |
| maddw     | VF06,VF05,VF06w | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| mulaw.xyz | ACC,VF01,VF00w  | div    | Q,VF00w,VF06w        |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| mulq.xyz  | VF06,VF06,Q     | waitq  |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |
| NOP       |                 | NOP    |                      |

# Typical VCL (single stream)

```
loop:
    lq                      Vert, StartVert(iVertPtr)

    MatrixMultiplyVertex    Vert, fTransform, Vert

    div                    q,  vf00[w], Vert[w]
    mul.xyz                Vert, Vert, q

    mula.xyz               acc, fScales, vf00[w]
    madd.xyz               Vert, Vert, fScales
    ftoi4.xyz              Vert, Vert
```

# Graphics Synthesizer (GS)

- Receives display list of triangles from GIF
- Rasterizes triangles into frame buffer
- Handles z-buffering, alpha blending, texture mapping
- Outputs frame buffer to video
- Two sets of drawing environments (internal contexts)
  - GS knows which instructions came from VPU0 and VPU1
  - Merges sequences

# PS2 Linux



- \$200-\$400 on ebay

Picture from powerpoint presentation by H.S. Fortuna, "Video Game Programming Using The PlayStation2 Games Console,"  
[www.ics.heacademy.ac.uk/events/presentations/91\\_BCSTalk.ppt](http://www.ics.heacademy.ac.uk/events/presentations/91_BCSTalk.ppt)