Introduction to PlayStation®2 Architecture

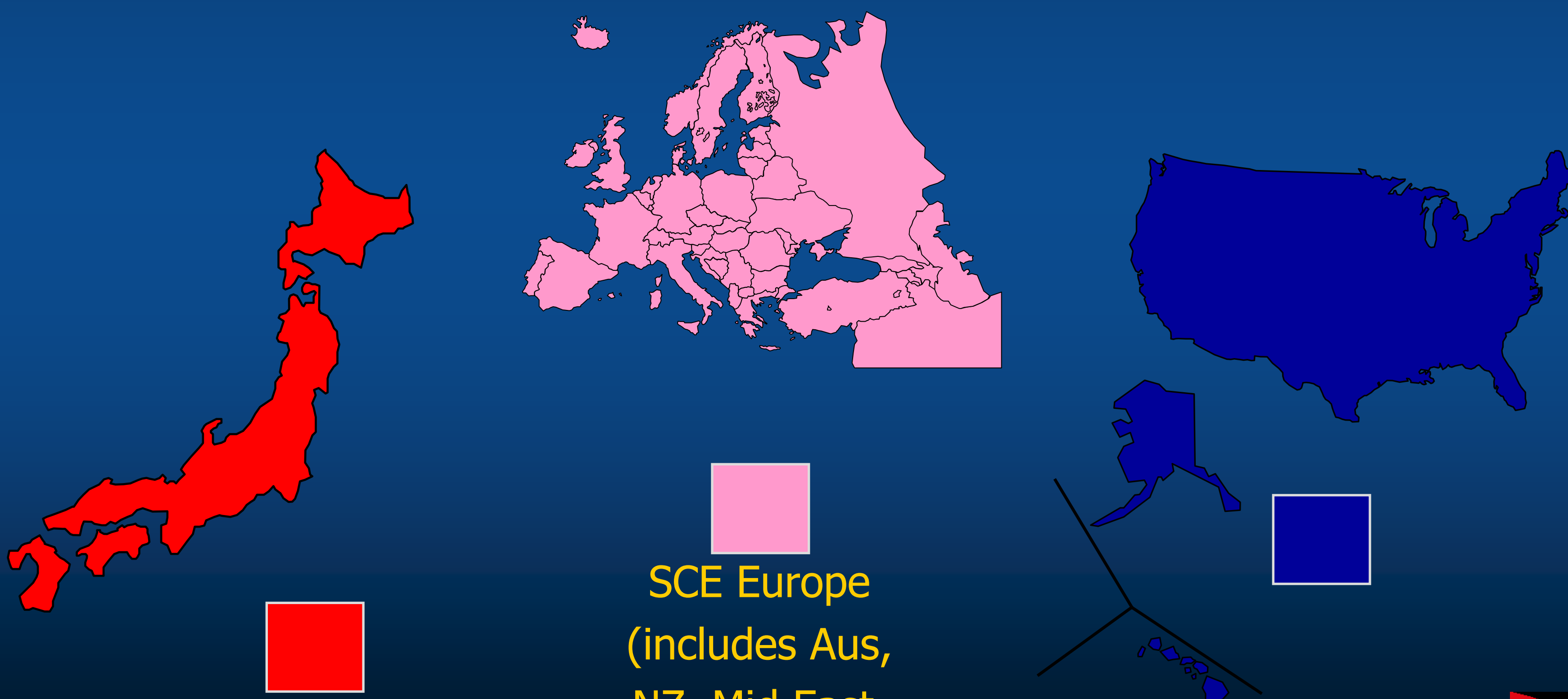
James Russell
Software Engineer

SCEE
Technology Group

In this presentation

- Company overview
- PlayStation 2 architecture overview
- PS2 Game Development
- Differences between PS2 and PC.

1) Sony Computer Entertainment Overview



Sales

- 40 million sold world-wide since launch
  - Since March 2000 in Japan
  - Since Nov 2000 in Europe/US
- New markets: Middle East, India, Korea, China
- Long term aim: 100 million within 5 years of launch
- Production facilities can produce 2M/month.

Design considerations

- Over 5 years, we'll make 100,000,000 PS2s
- Design is very important
  - Must be inexpensive (or should become that way)
  - Technology must be ahead of the curve
- Need high performance, low price.

How to achieve this?

- Processor yield
  - High CPU clock speed means lower yields
- Solution?
  - Low CPU clock speed, but high parallelism
- Nothing readily available
  - SCE designs custom chips.

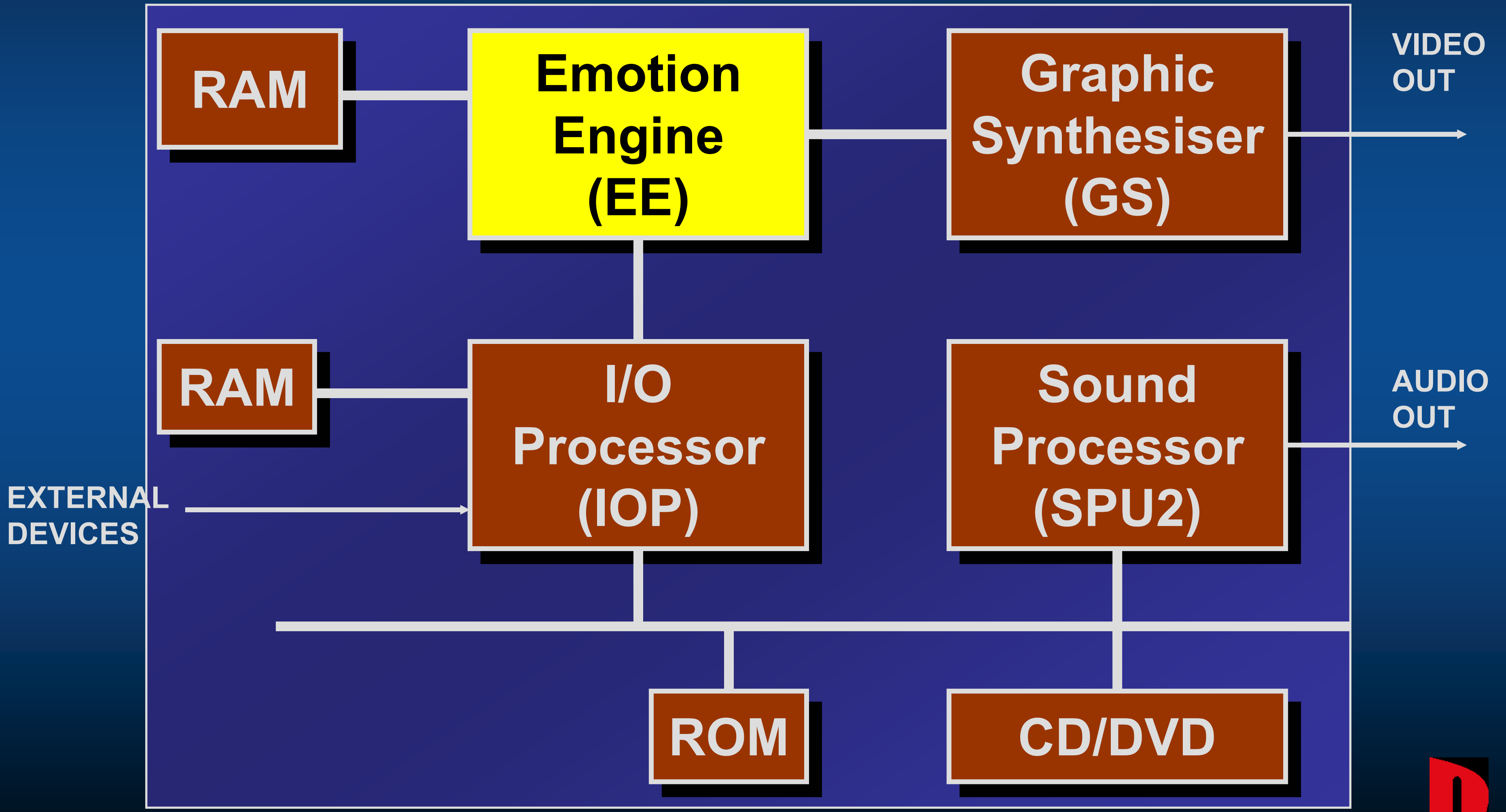
2) Technical Aspects of PlayStation 2

- 128-bit CPU core “Emotion Engine”
  - + 2 independent Vector Units
  - + Image Processing Unit (for MPEG)
- GS - “Graphics Synthesizer” GPU
- SPU2 - Sound Processing Unit
- I/O Processor (CD/DVD, USB, i.Link).

"Emotion Engine" - Specifications

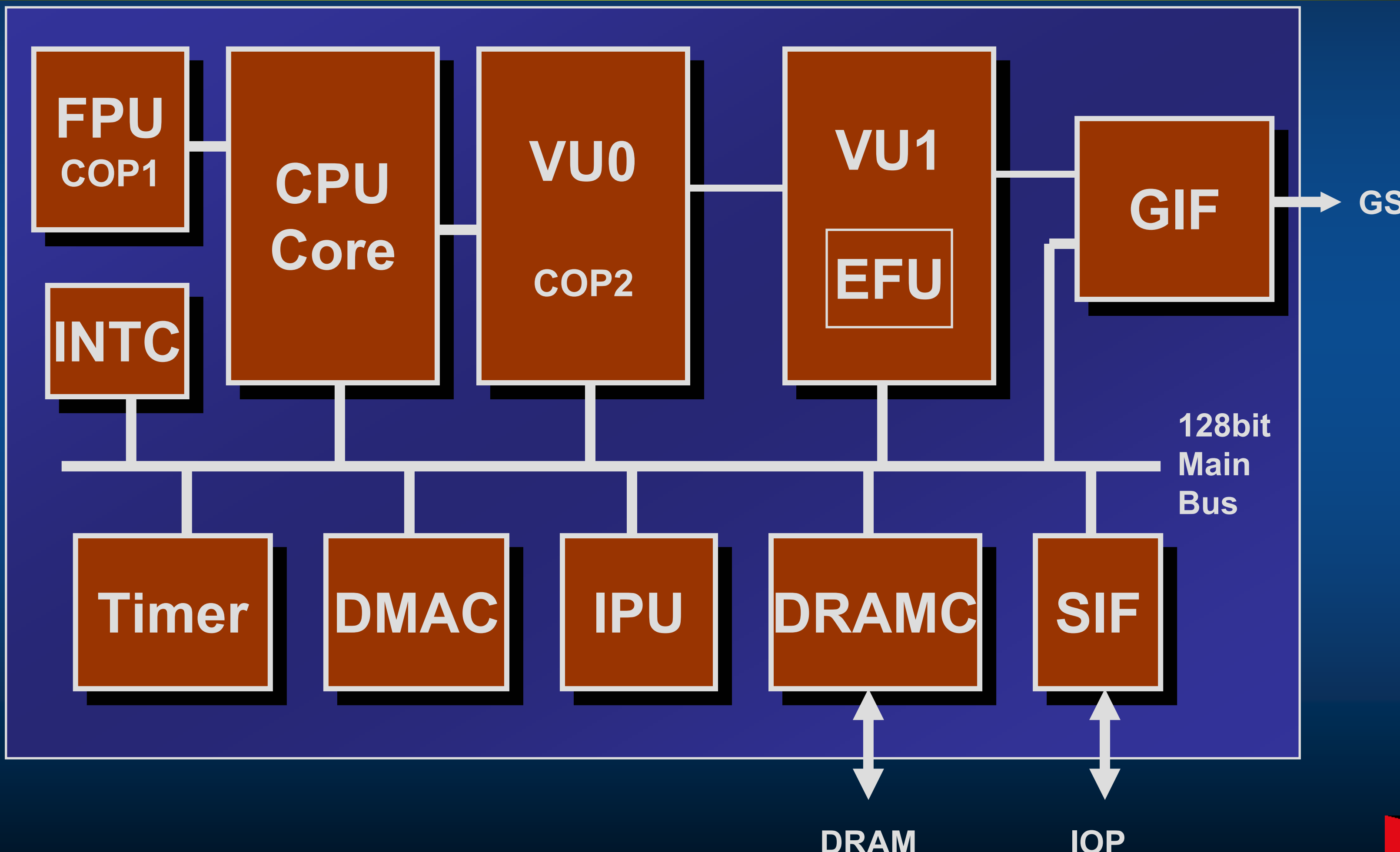
CPU Core	128 bit CPU
System Clock	300MHz
Bus Bandwidth	3.2GB/sec
Main Memory	32MB (Direct Rambus)
Floating Point Calculation	6.2 GFLOPS
3D Geometry Performance	66 Million polygons/sec.

System Architecture



Emotion Engine architecture

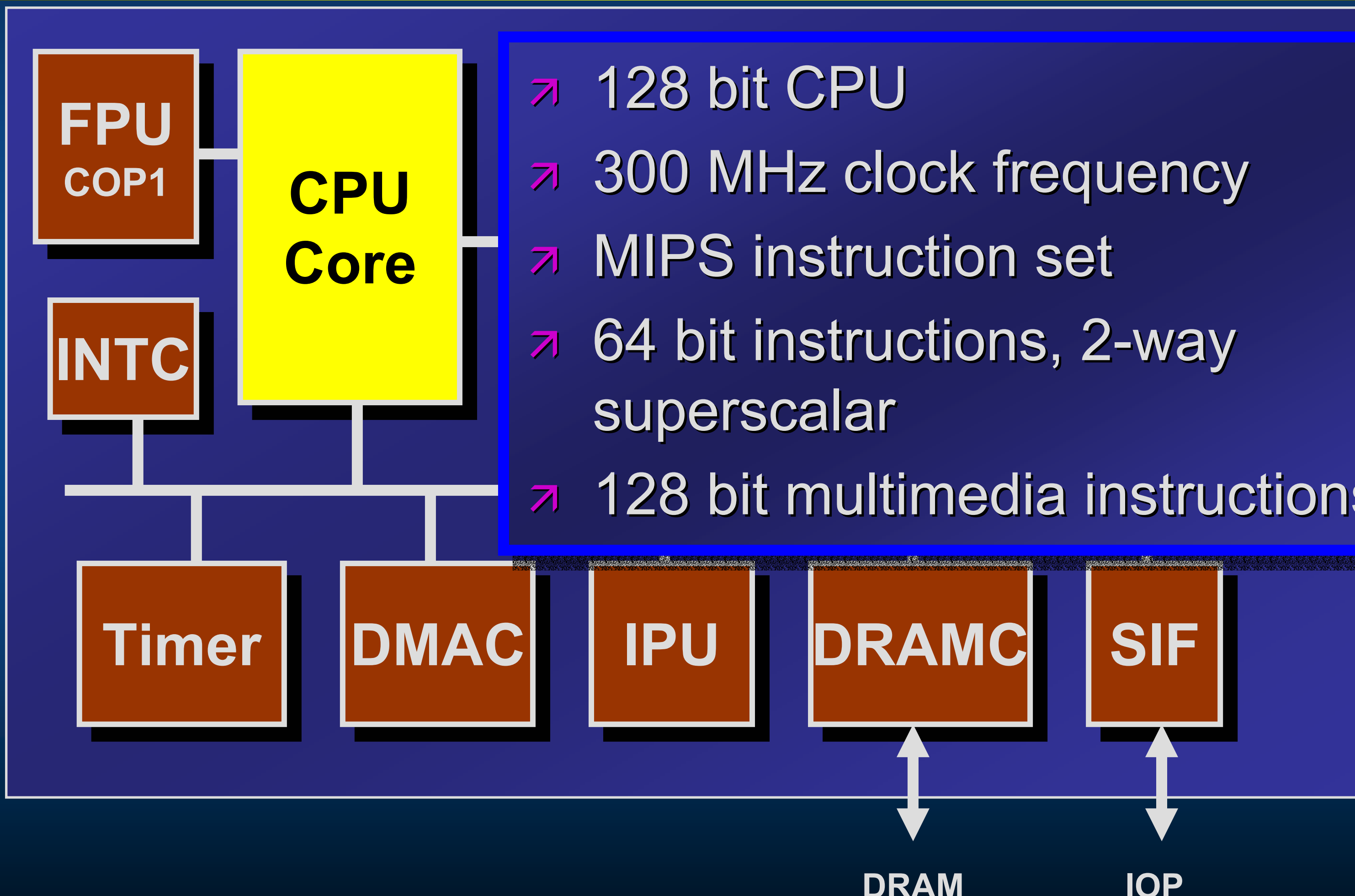
Overview



Emotion Engine architecture

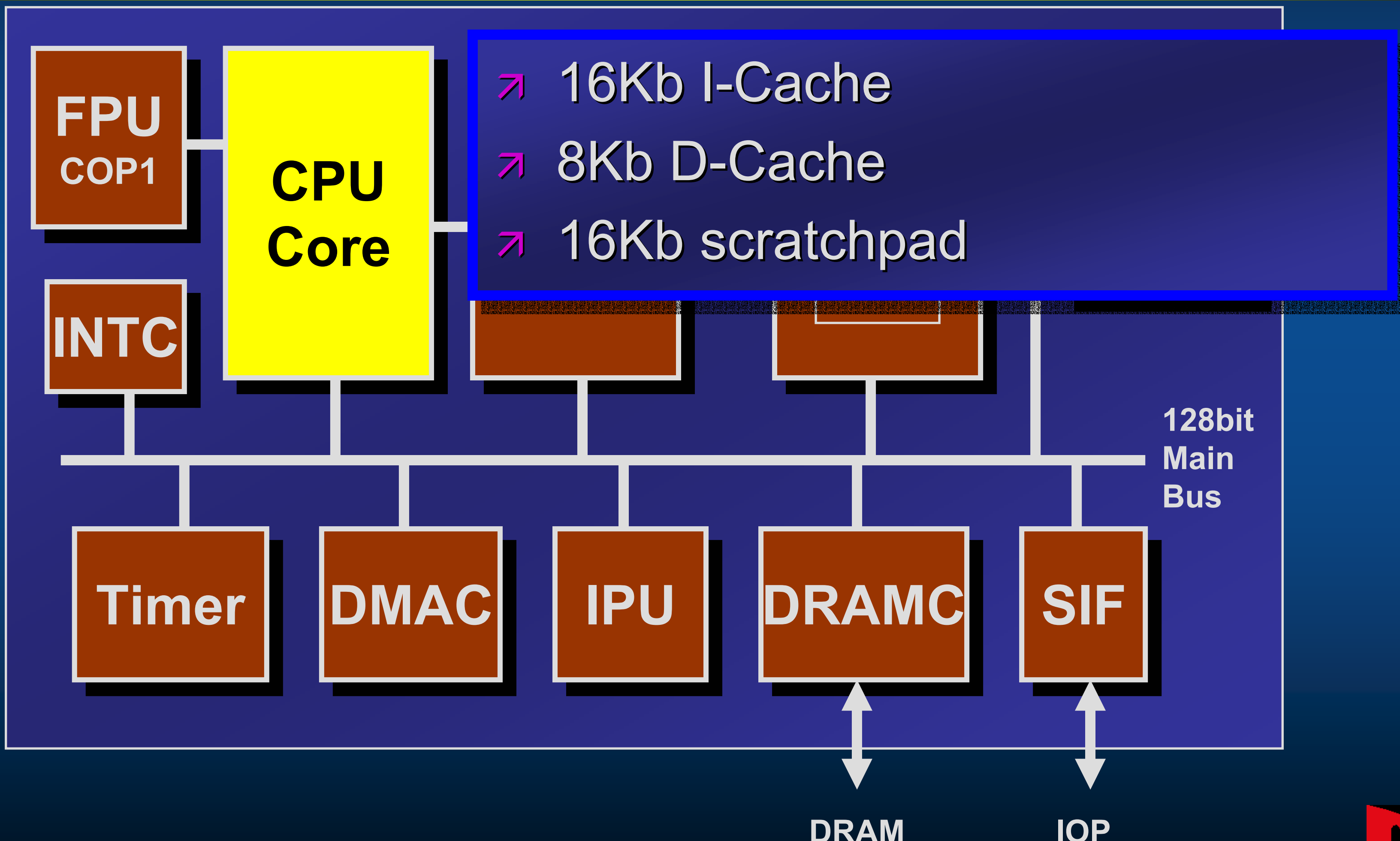
CPU Core

- 128 bit CPU
- 300 MHz clock frequency
- MIPS instruction set
- 64 bit instructions, 2-way superscalar
- 128 bit multimedia instructions



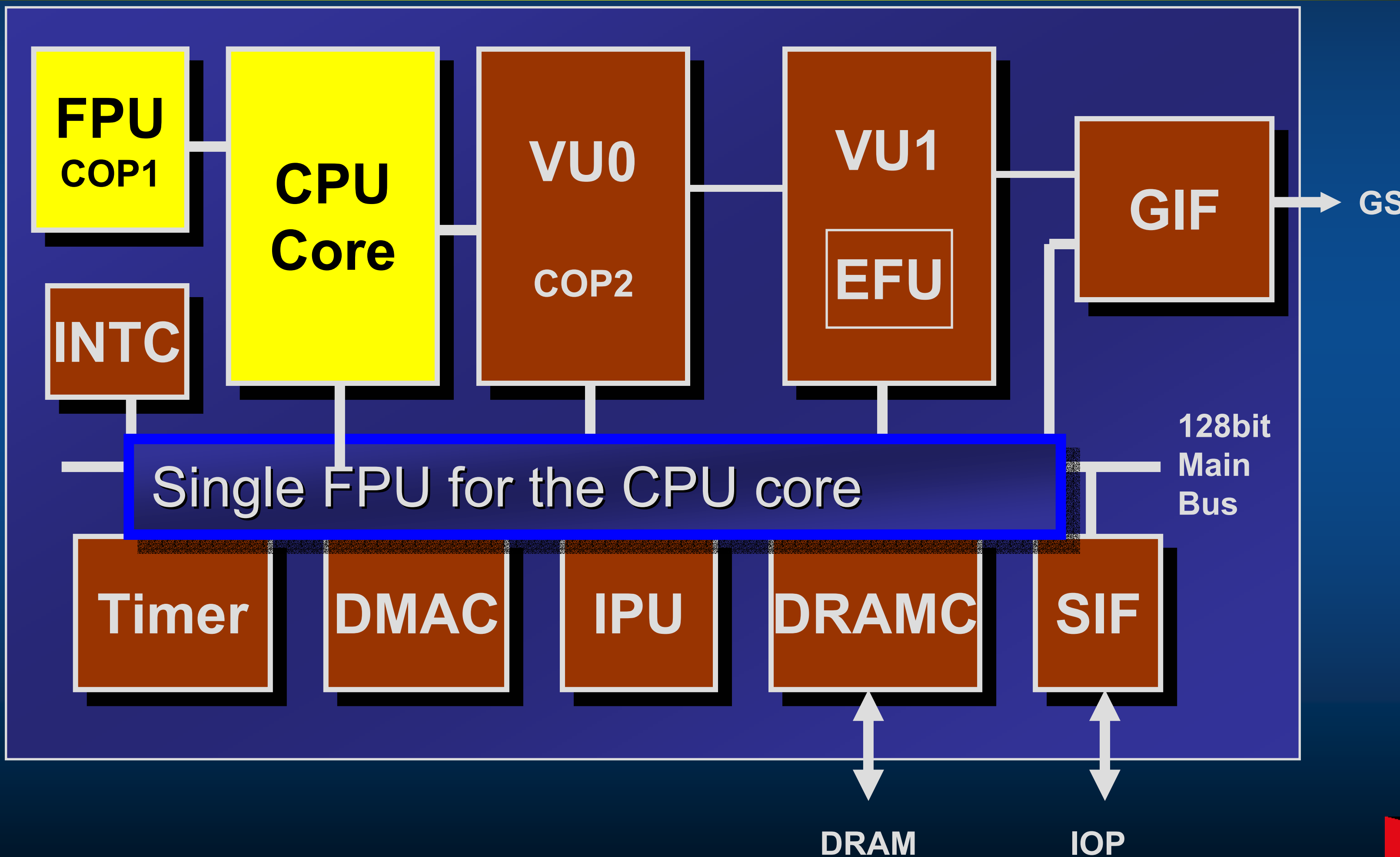
Emotion Engine architecture

CPU Core



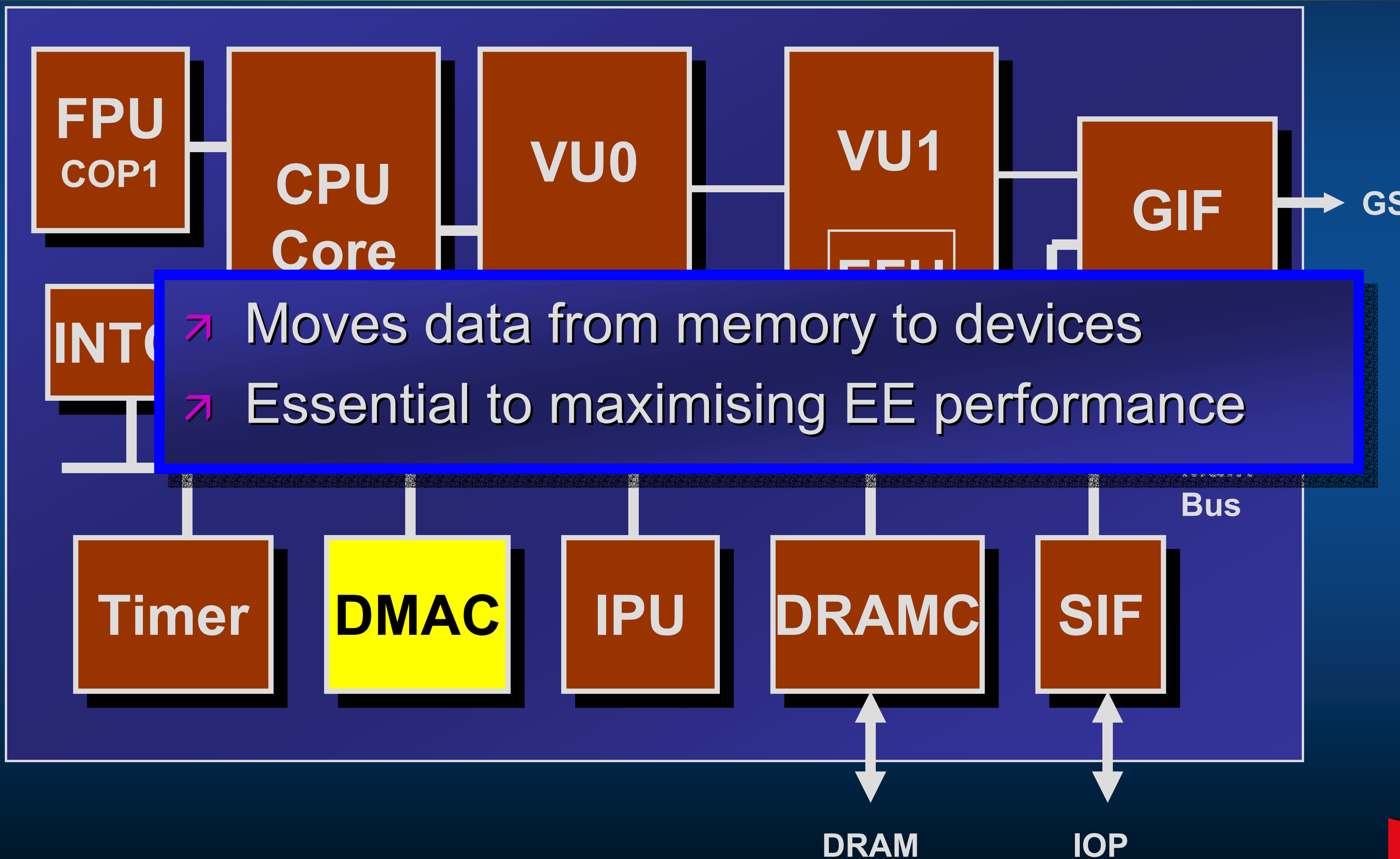
Emotion Engine architecture

Floating Point Unit (FPU)



Emotion Engine architecture

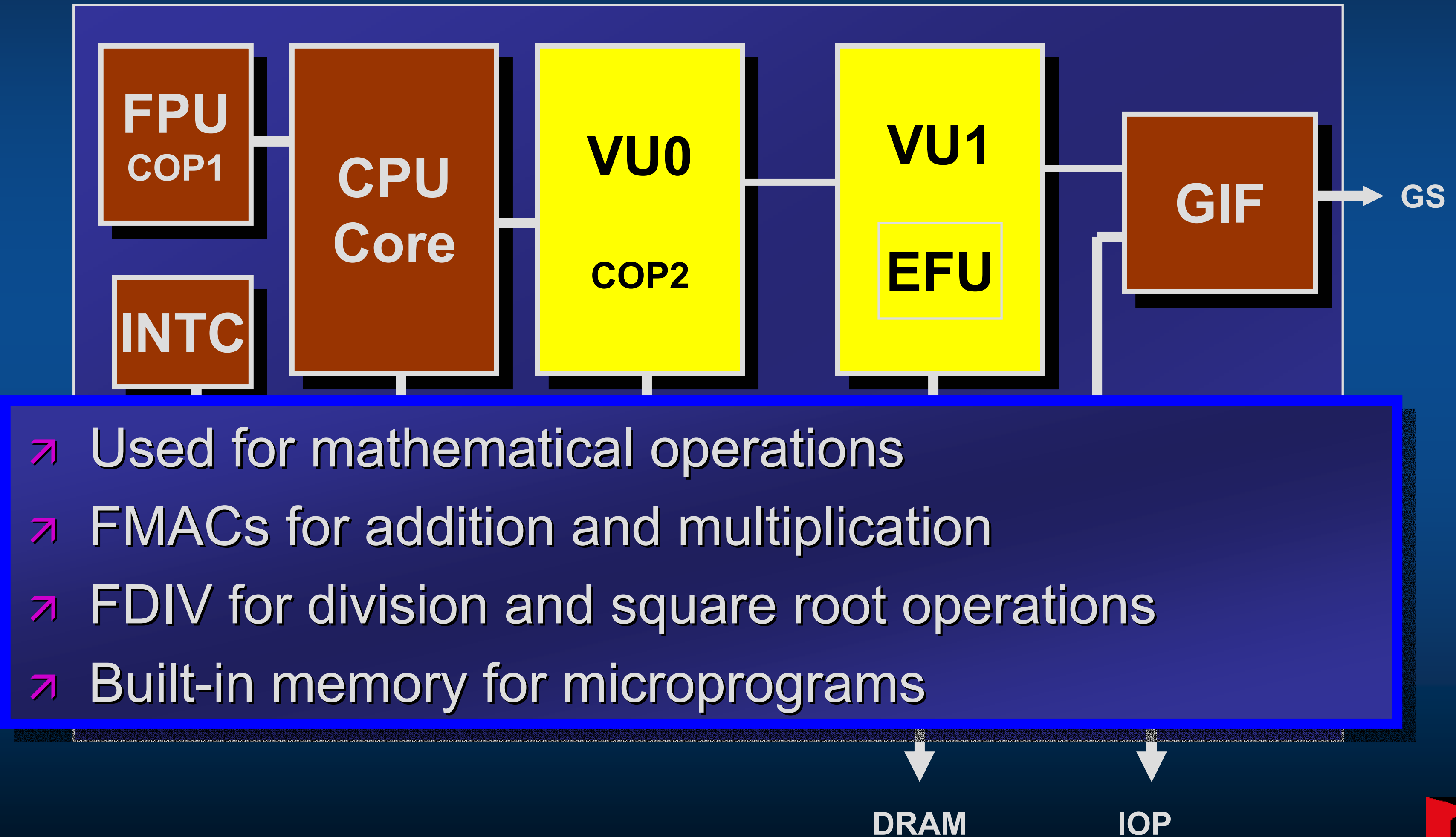
DMA Controller (DMAC)



- Moves data from memory to devices
- Essential to maximising EE performance

Emotion Engine architecture

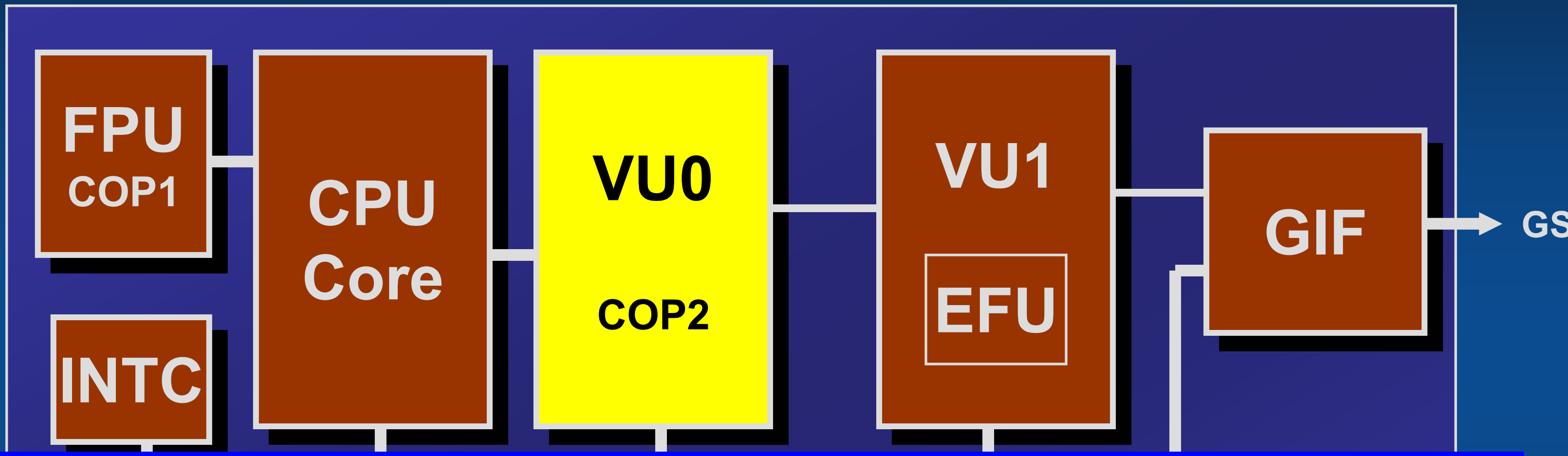
Vector Units (VU0 & VU1)



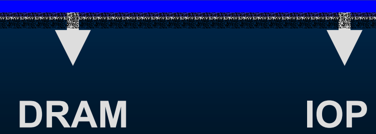
- Used for mathematical operations
- FMACs for addition and multiplication
- FDIV for division and square root operations
- Built-in memory for microprograms

Emotion Engine architecture

Vector Unit 0 (VU0)

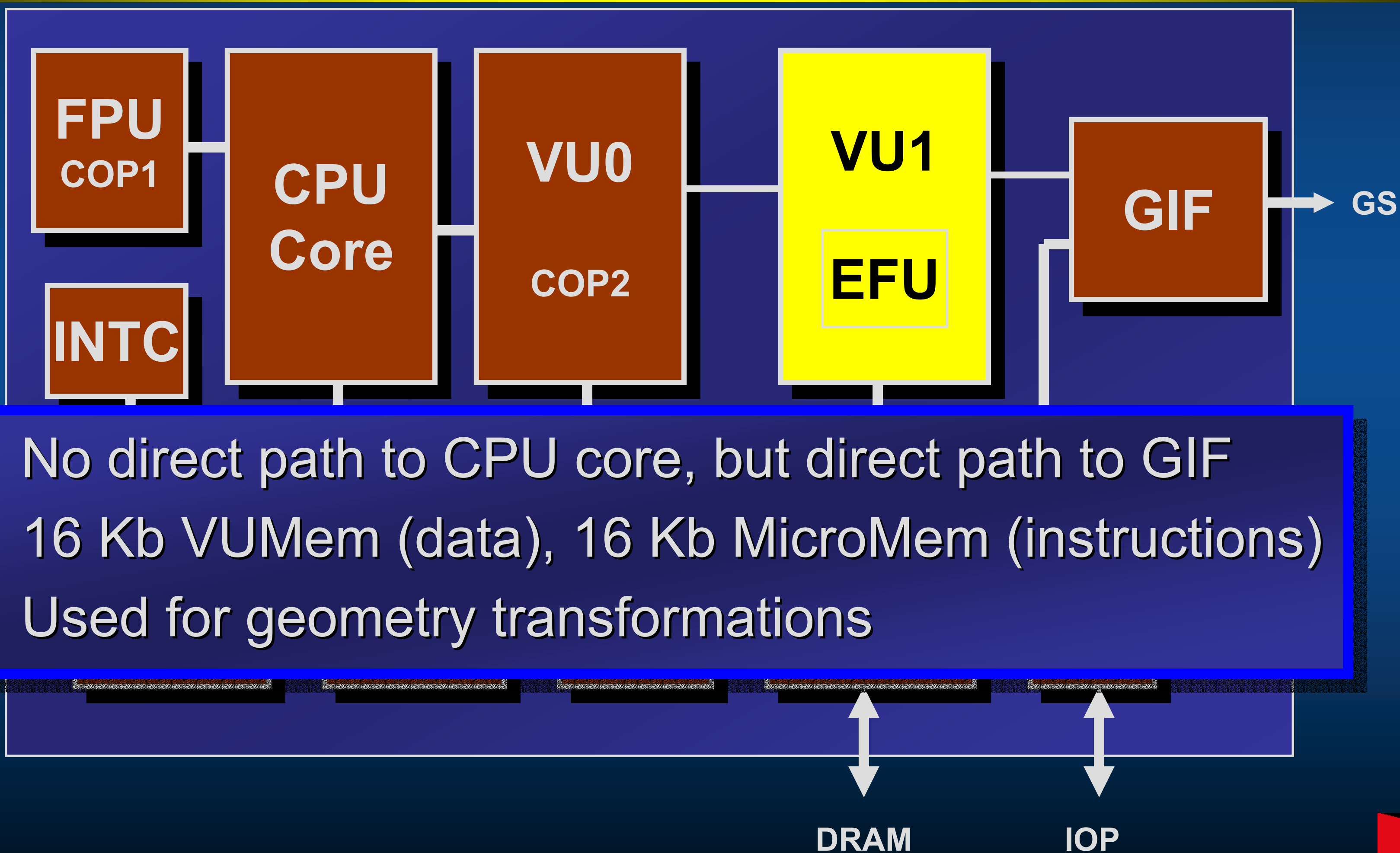


- 4 FMACs, 1 FDIV
- Connected to the CPU, executing macroinstructions
- 4 KB VUMem (data), 4 KB MicroMem (instructions)
- Usually used for animation and physics.



Emotion Engine architecture

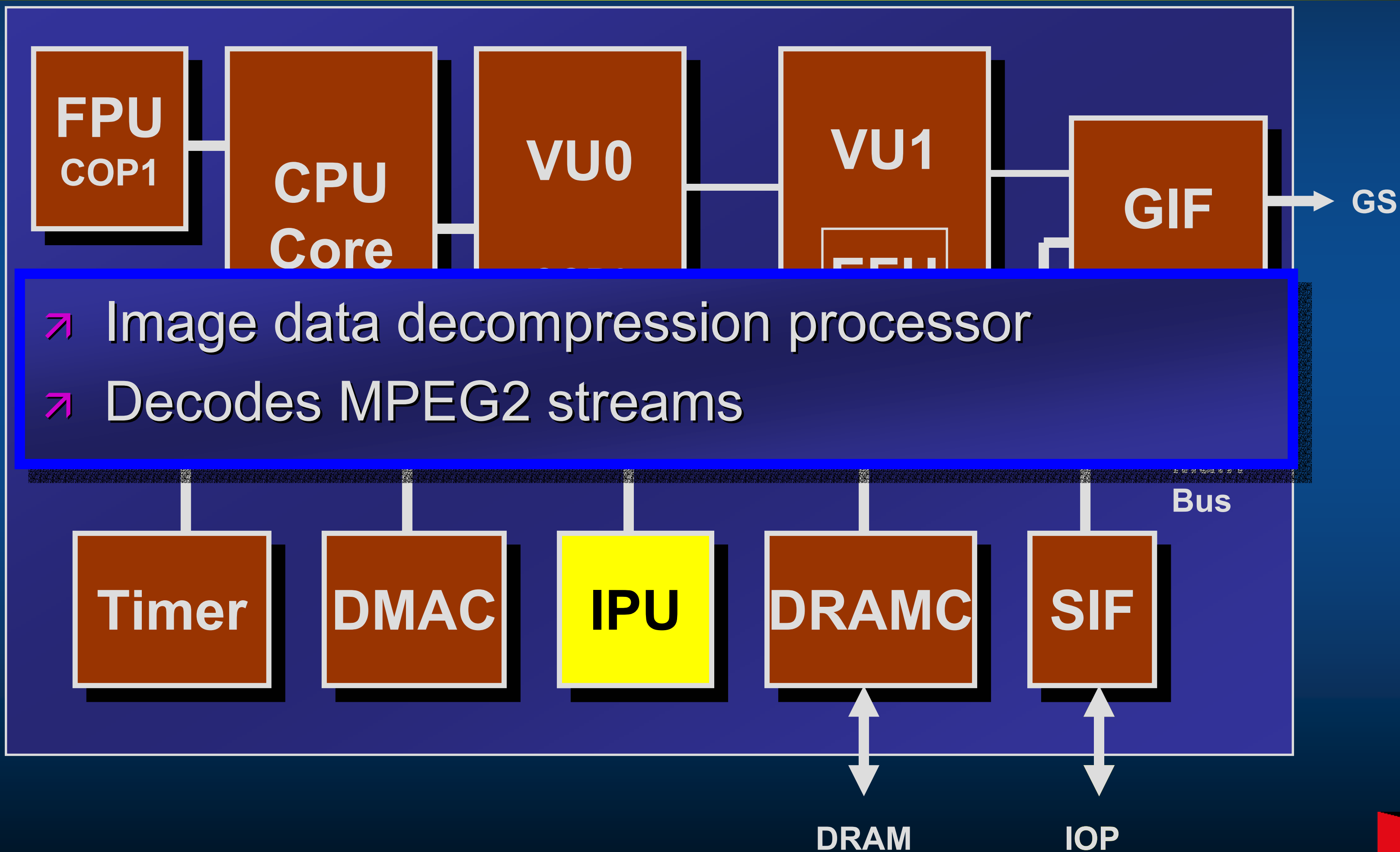
Vector Unit 1 (VU1)



- No direct path to CPU core, but direct path to GIF
- 16 Kb VUMem (data), 16 Kb MicroMem (instructions)
- Used for geometry transformations

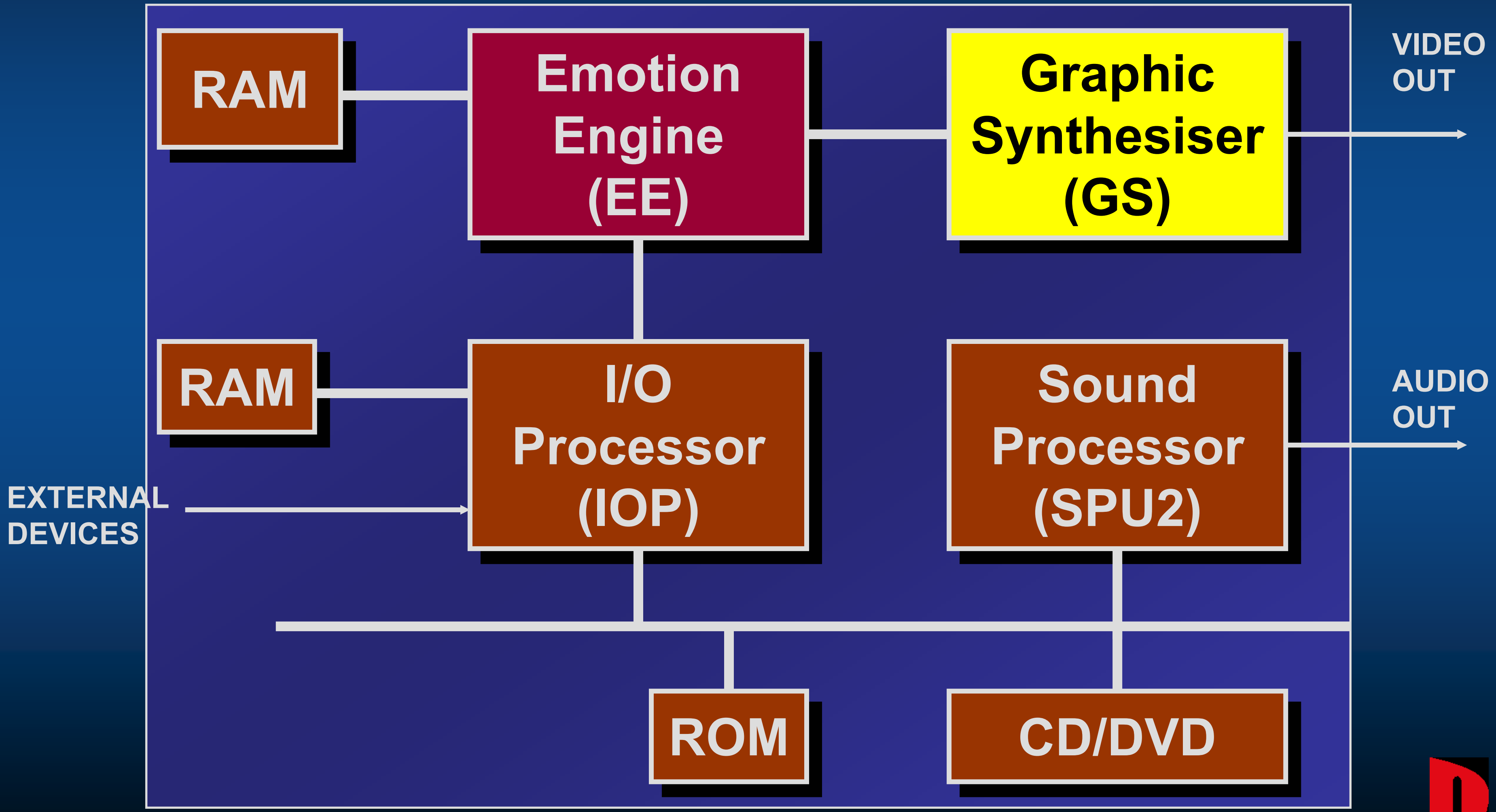
Emotion Engine architecture

Image Processing Unit (IPU)



- Image data decompression processor
- Decodes MPEG2 streams

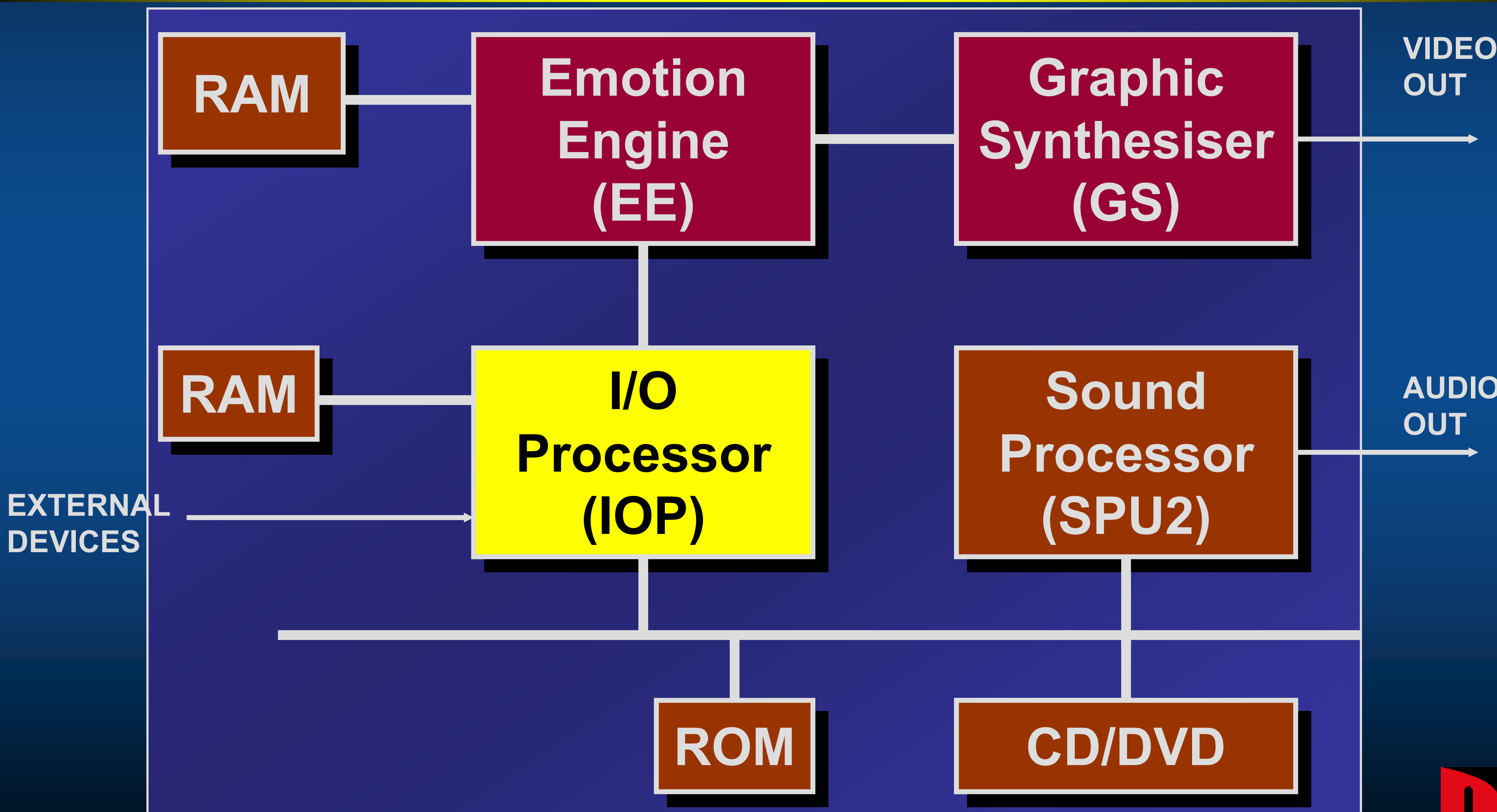
System Architecture



GS specifications

Clock Frequency	150 Mhz
Embedded DRAM	4MB
Total memory bandwidth	1.2Gb/sec
Pixel fill rate	2.4GPixel/sec.

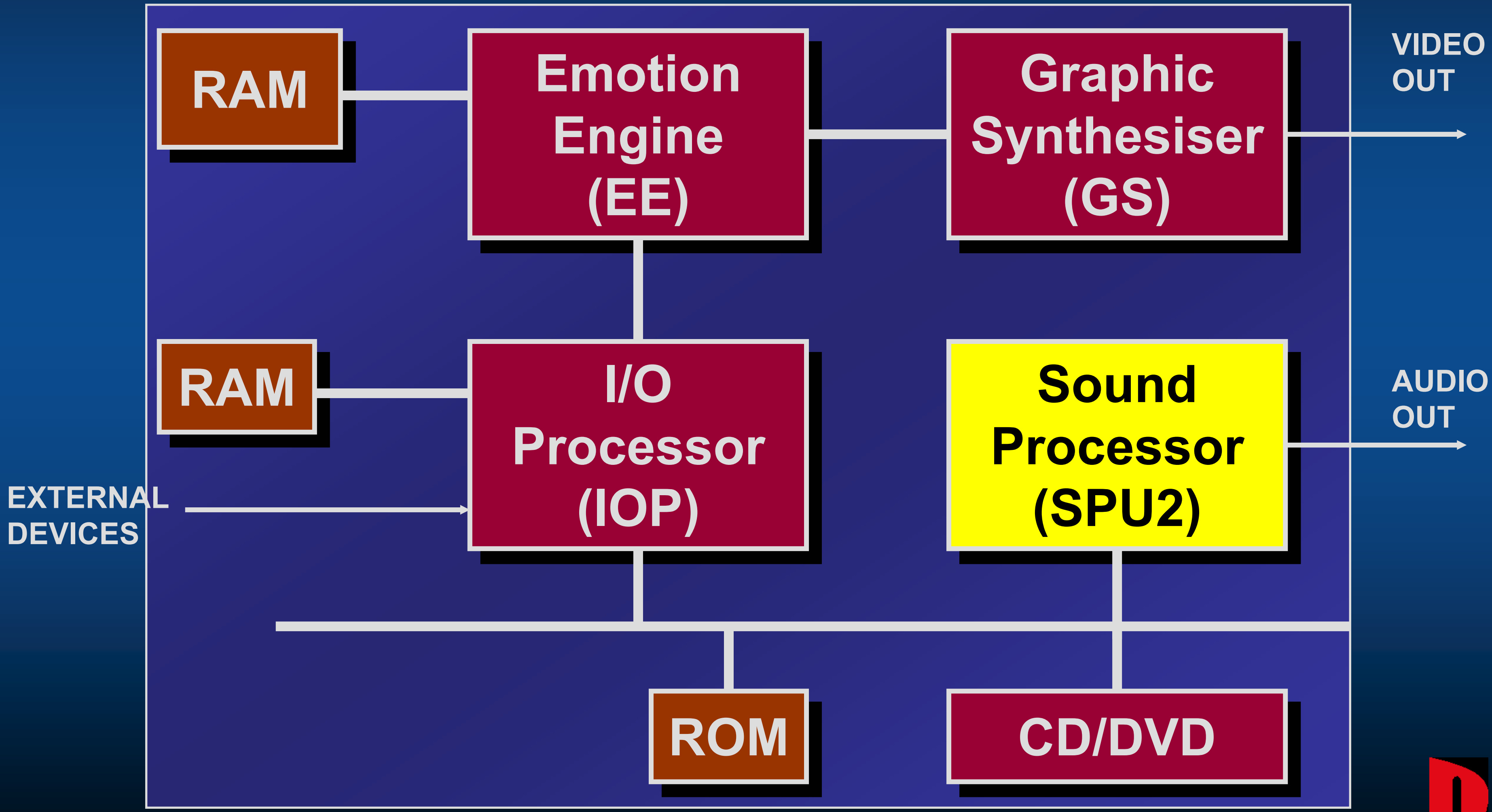
System Architecture



IOP (Input/Output Processor)

- Contains an R3000 (PlayStation CPU+)
- Used for backwards compatibility
- 2 MB of RAM
- Handles all external devices
  - Controllers
  - USB
  - SPU 2
  - CD/DVD unit
  - IEEE1394
  - Hard disc, ethernet/modem.

System Architecture



SPU 2

- 48 Channels
- 2MB sound memory
- Output to DAC or Optical digital output (Dolby 5.1)
  - Realtime DTS 5.1 is possible.

Coming Soon..

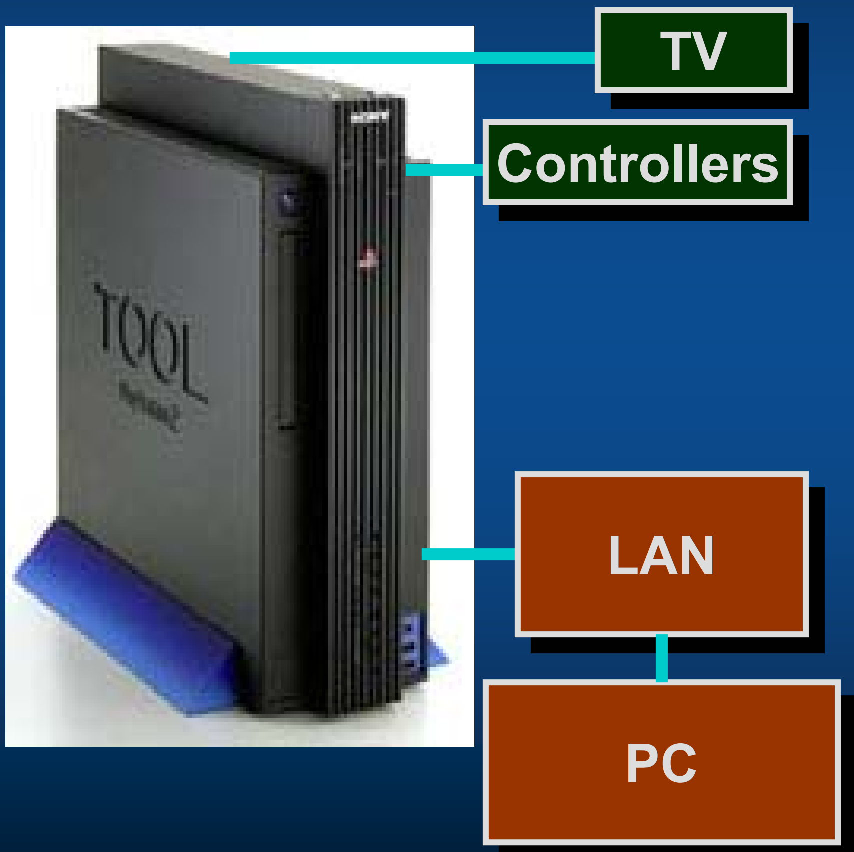
- Broadband Adaptor
  - HDD interface & 100/10 Ethernet port
  - Ethernet allows access to broadband (via ADSL/CATV/Satellite/etc)
  - HDD used by game for local storage, or downloadable content.

3) Game Development

- Programming a game on the PS2.

PS2 Development Environment

The TOOL



- TOOL = PlayStation 2 with more RAM, and network
- A separate Linux/Windows box runs the compilers and debuggers
  - Connects over the network to the TOOL.
- Use Linux-based tools (provided), or 3rd-party Windows development tools

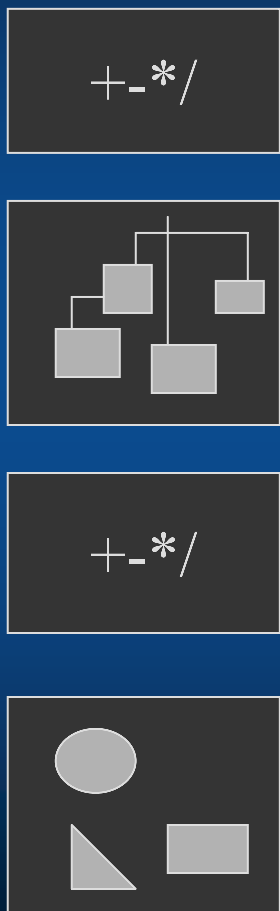
Console programming

- Halfway between embedded system and PC.
  - Small & basic OS
  - Large amount of control
- Low level coding
  - No drivers
  - Standard hardware means you can optimise for the system
  - Performance analysis has benefit.

Differences between PS2 and PC

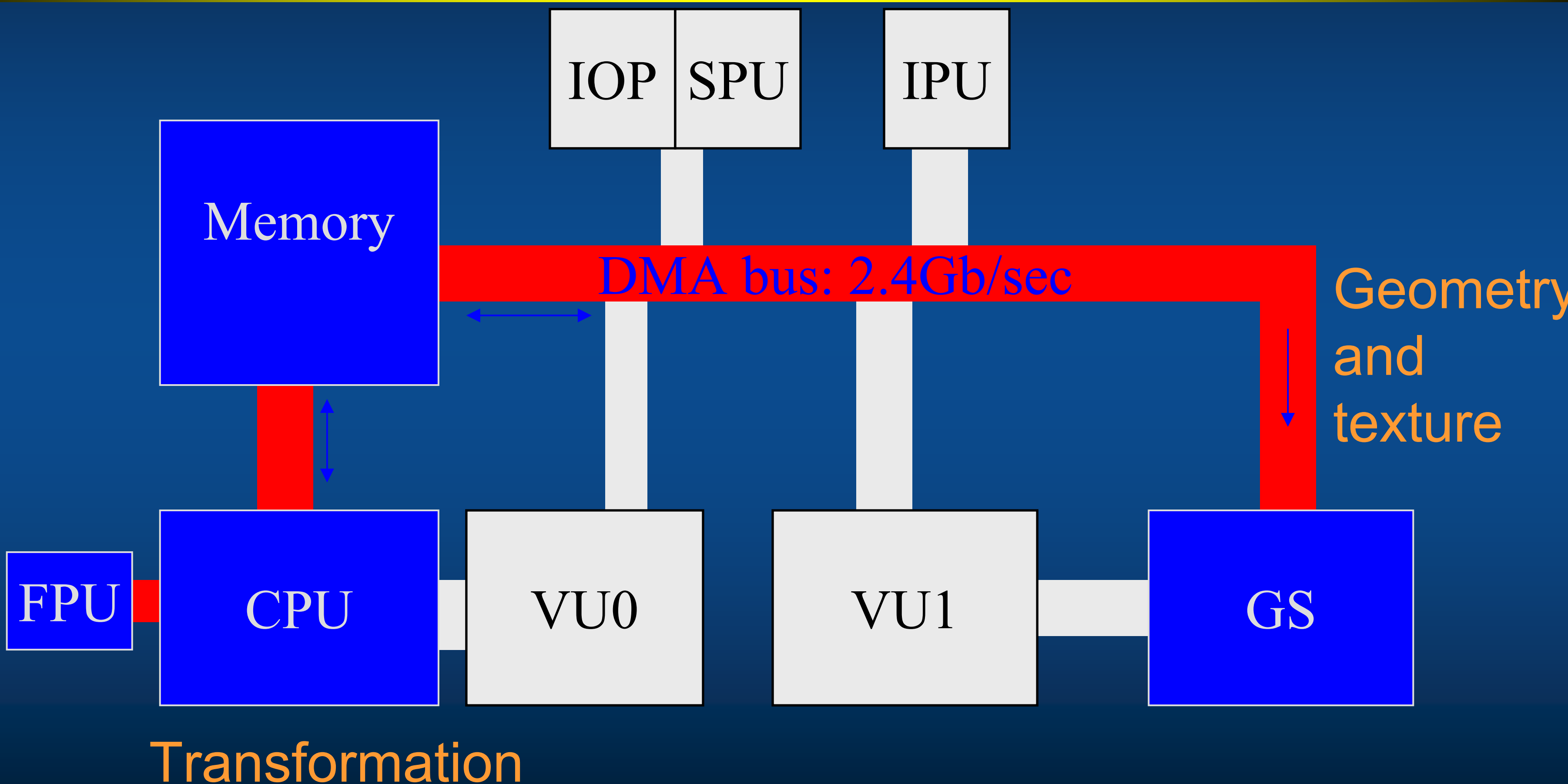
- Uses parallelism
  - Information should ‘stream’ through the system
  - But not all algorithms are parallelisable
- Random memory access hits hard
  - Data must be reorganised so that related parts sit together
- Optimisation is easier on PS2
  - Standard hardware means optimisation works on all machines.

Basic Rendering Pipeline

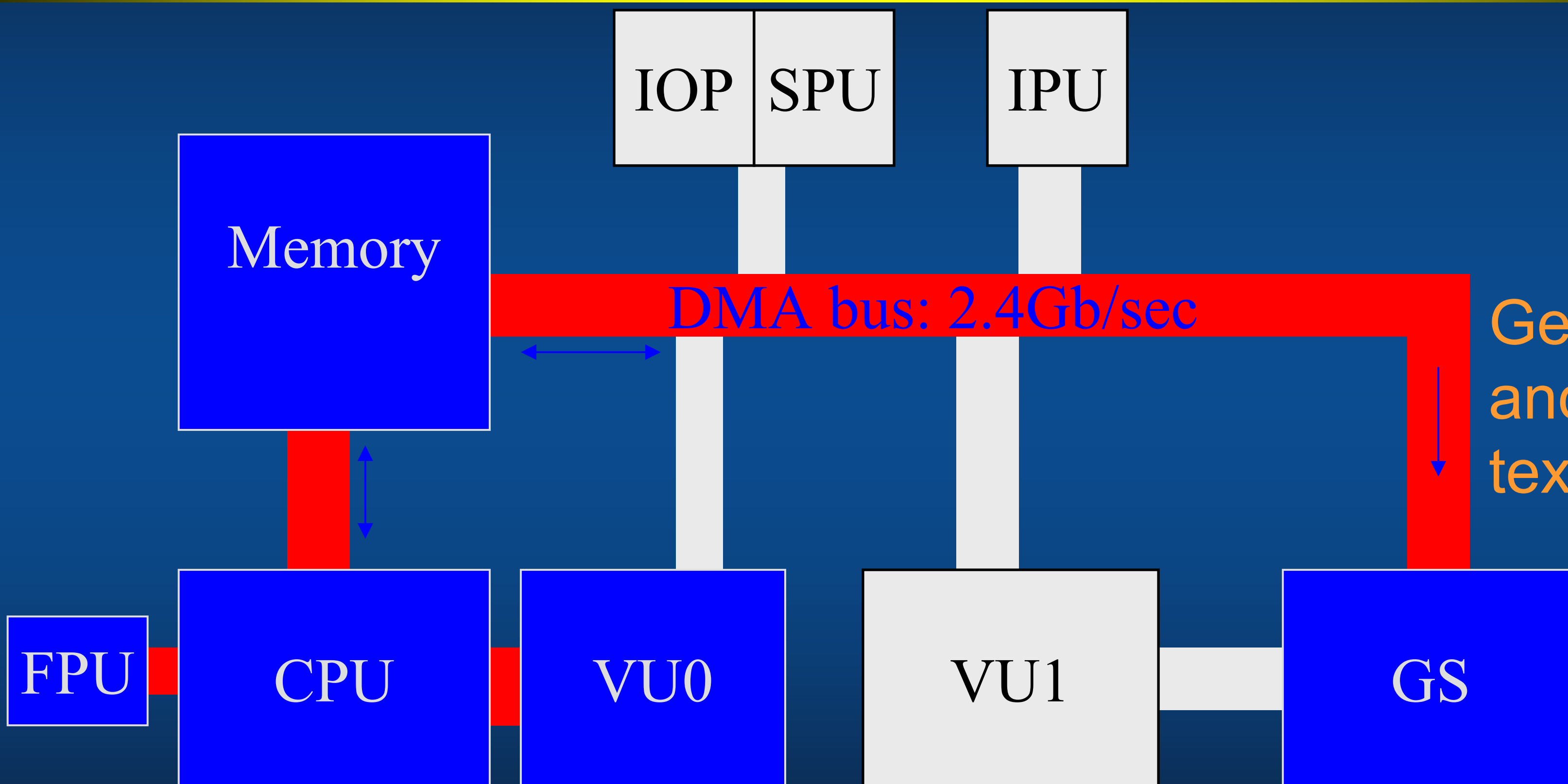


Calculate animation	CPU + coprocessor VU0
Traverse scene	List processing DMA
Transform to 2D	VU1
Rasterisation	GS

1st Attempt At A PC Port (max 0.5 million polys)



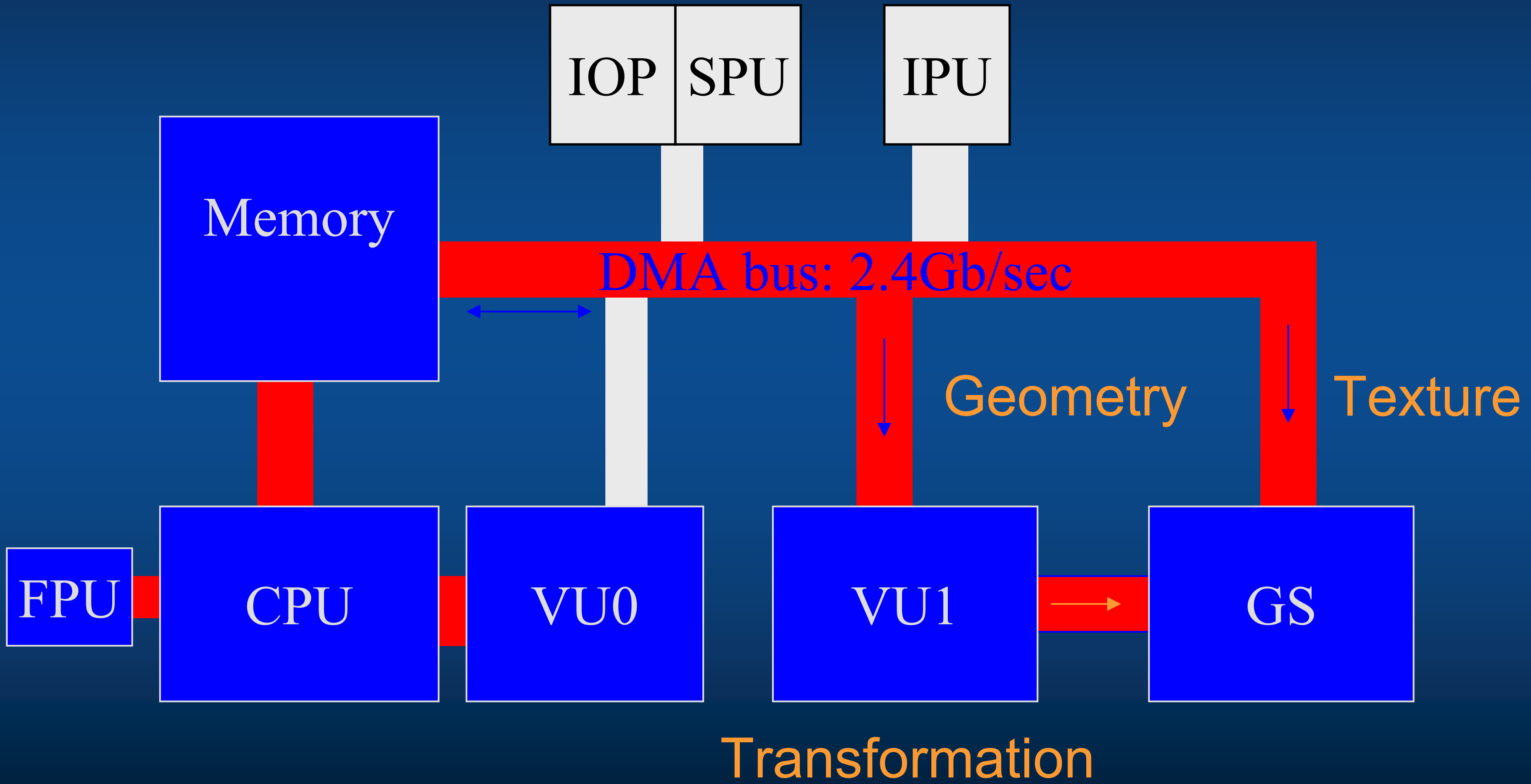
2nd Attempt At A PC Port (max 1.5 million polys)



Geometry and texture

Transformation
in parallel with CPU

Complete Game (lighting, animation) (typical 5-10 million polys)



How To Improve PS2 Performance

- By not treating the PS2 as a PC
- Think parallel – think ‘assembly line’
- Code for small Instruction and Data Cache

Summary

- PS2 is a state-of-the-art machine
- Achieves high performance and low cost through high parallelism
- But it requires a different way of programming
- Question Time!