Unit-V

Session Meta Data

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Reviewer	

Revision History

Date of Revision	Details	Version Number

Session Objectives

- ❖ GPU Architectural details are discussed.

Session Objectives

- ❖ Features of GPU processor
- ❖ CPU Vs GPU

Session Outcomes

- At the end of the session, students will be able to understand

❖ Features of GPU processor

❖ CPU Vs GPU

Graphics Processing Unit

- **A graphics processing unit** (GPU), is similar CPU
- Designed specifically for performing the complex mathematical and geometric calculations that are necessary for graphics rendering.

Graphics Processing Unit

- A graphics processing unit (GPU) is a computer chip that performs rapid mathematical calculations, primarily for the purpose of rendering images.
- occasionally called **visual processing unit** (**VPU**)
- GPU is able to render images more quickly than a CPU because of its parallel processing architecture
- Nvidia introduced the first GPU, the GeForce 256, in 1999
- Others include AMD, Intel and ARM.
- In 2012, Nvidia released a virtualized GPU, which offloads graphics processing from the server CPU in a virtual desktop infrastructure.

Graphics Processing Unit

- GPUs are used in
  - Embedded Systems
  - Mobile phones
  - Personal computers
  - Workstations
  - Game consoles

GPU Vs CPU

- A GPU is tailored for highly parallel operation while a CPU executes programs serially
- For this reason, GPUs have many parallel execution units and higher transistor counts, while CPUs have few execution units and higher clock speeds
- A GPU is for the most part deterministic in its operation
- GPUs have much deeper pipelines (several thousand stages vs 10-20 for CPUs)
- GPUs have significantly faster and more advanced memory interfaces as they need to shift around a lot more data than CPUs

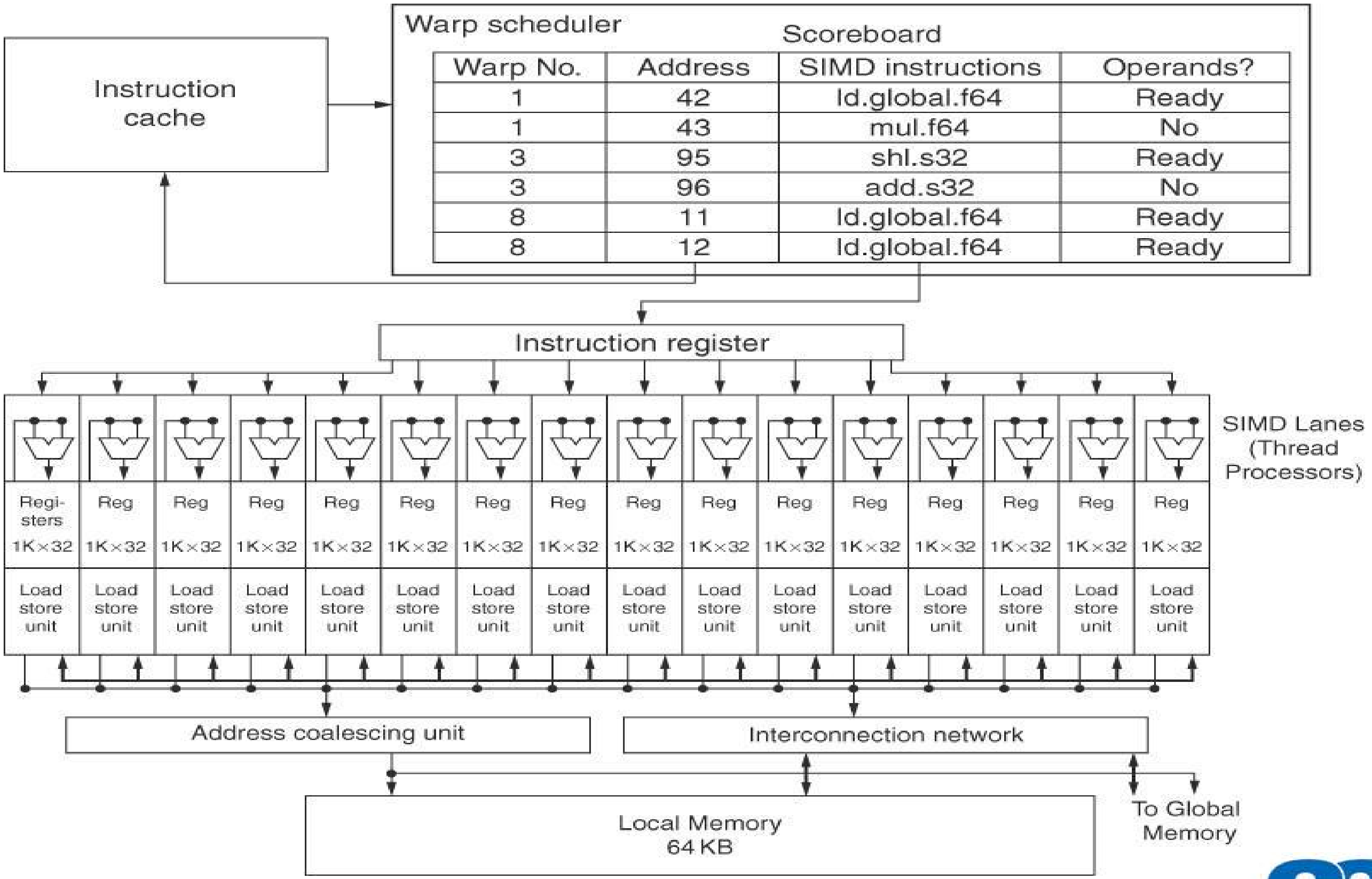
What are GPU's Growth?

- Entertainment Industry has driven the economy of these chips?
  – Males age 15-35 buy $10B in video games / year
- Moore's Law ++
- Simplified design (stream processing)
- Single-chip designs

GPU

- Very Efficient For
  - Fast Parallel Floating Point Processing
  - Single Instruction Multiple Data Operations
  - High Computation per Memory Access
- Not Efficient For
  - Double Precision
  - Logical Operations on Integer Data
  - Branching-Intensive Operations
  - Random Access, Memory-Intensive Operations

NVIDIA GPU – MTSIMD



Warp No.	Address	SIMD instructions	Operands?
1	42	ld.global.f64	Ready
1	43	mul.f64	No
3	95	shl.s32	Ready
3	96	add.s32	No
8	11	ld.global.f64	Ready
8	12	ld.global.f64	Ready

NVIDIA GPU- MTSIMD

- GPU is a multiprocessor composed of MTSIMD processors.
- It is similar to vector processor but with many parallel FU's that are deeply pipelined.
- MTSIMD is a processor that executes code in the form of thread blocks.
- GPU H/W contains a collection of MTSIMD Processors execute a Grid of Thread Blocks.

NVIDIA GPU- MTSIMD

- GPU H/W has two levels of H/W schedulers

1. Thread Block Scheduler:

- Thread block scheduler is similar to control unit in Vector processor
- det the no of thread blocks for a loop and allocates them to diff MTSIMD processors.
- ensures that thread blocks are assigned to the processors whose local memories have the corresponding data.

NVIDIA GPU- FERMI MTSIMD

2. SIMD Thread Scheduler:

- SIMD Thread scheduler has scoreboard logic
- It keeps track of 48 threads of SIMD instructions
- It tells that which thread of SIMD instructions are ready to run
- It sends those instructions to dispatch unit to be run on MTSIMD processor
- within a SIMD Processor, which schedules when threads of

SIMD instructions should run

NVIDIA GPU- MTSIMD

- It has many parallel functional units
- SIMD Processors with separate PCs and are programmed using threads.
- Each MTSIMD Processor is assigned 512 elements of the vectors to work on
- SIMD processors have 32,768 registers
- Like vector processor these registers are logically divided across SIMD lanes.

NVIDIA GPU- MTSIMD

- Each SIMD Thread has 64 vector registers of 32 elements with 32 bit each.
- FERMI has 16 physical lanes each contain 2048 registers
- Thread Blocks would contain 512/32 = 16 SIMD threads.
- Each thread of SIMD instructions in this example compute 32 of the elements of the computation.

NVIDIA GPU- MTSIMD

- GPU applications have so many threads of SIMD instructions that multithreading can
  - hide the latency to DRAM
  - increase utilization of multithreaded SIMD Processors

NVIDA GPU ISA

- PTX(Parallel Thread Execution) provides a stable instruction set for GPUs
- H/W instruction set is hidden from the programmer
- PTX instructions describe the operations on a single CUDA thread
- PTX uses virtual registers
- Translation to machine code is performed in software

NVIDA GPU ISA

- Format of a PTX instruction is

opcode.type d, a, b, c;

– where d is the destination operand; a, b, and c are source operands

- Source operands are 32-bit or 64-bit registers or a constant value. Destinations are registers, except for store instructions.

NVIDA GPU ISA

- the operation type is one of the following:

Type	.type Specifier			
• Untyped bits 8, 16, 32, and 64 bits	. b8,	b16,	. b32,	b64
• Unsigned integer 8, 16, 32, and 64 bits	.U8,	. U16,	U32,	u64
• Signed integer 8, 16, 32, and 64 bits	.S8,	. S16,	. S32,	S64
• Floating Point 16, 32, and 64 bits	.J16,	J32,	J64	

Conditional Branching

- Like vector architectures, GPU branch hardware uses internal masks
- Also uses
  - Branch synchronization stack
  - Entries consist of masks for each SIMD lane
  - i.e. which threads commit their results
- Per-thread-lane 1-bit predicate register, specified by programmer

• Summary

- ❖ GPU Architectural details are discussed

References

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Thank you