

# COSC 511: Computer Architecture

## The Processor (Part 3)

Week 7

Last Week

Nothing.

# Two Weeks Ago

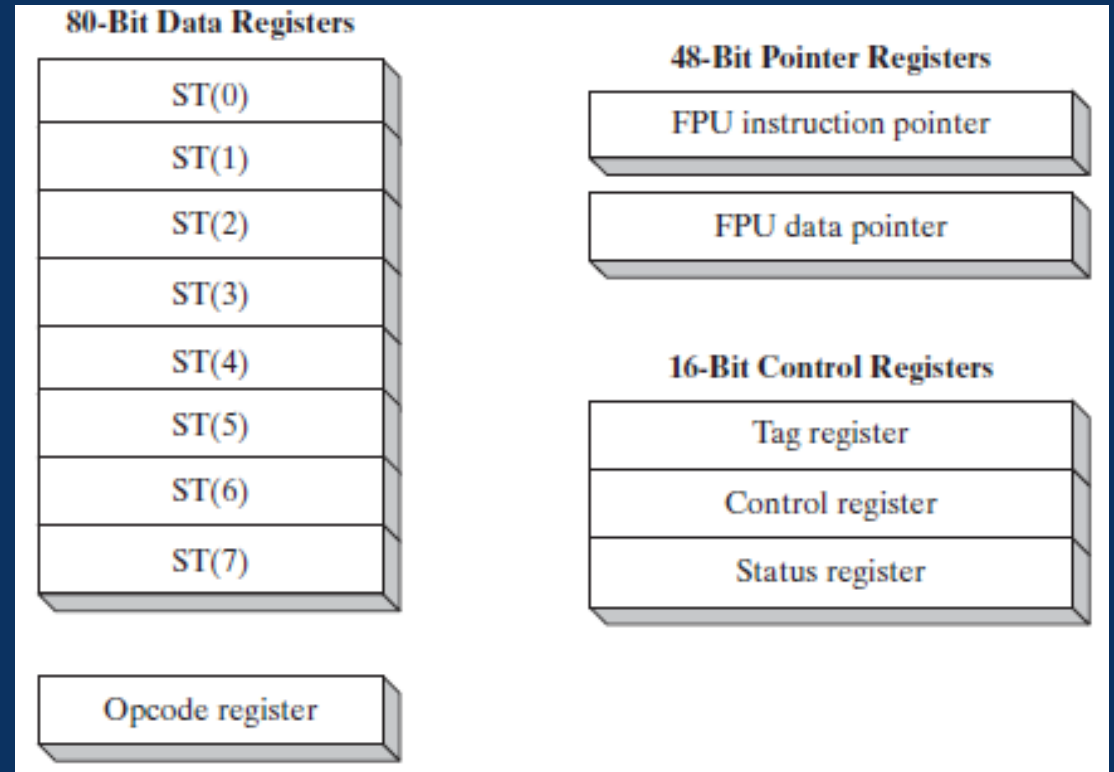
- The Processor (Part 2)
  - Loading and Executing a Program
  - Security risks of allowing unrestricted access to memory
  - Memory Access Modes
    - Real Address Mode – Allows unrestricted access
    - Protected Mode – Applications are restricted to only memory assigned to them
    - Applications can go from higher-level to lower-level access, but not the other way around
  - Memory Management
    - Paging/Swapping
    - Concerns with swapping on modern hardware
    - Memory compression
  - General Purpose 32-bit Registers in the x86 ISA

# Two Weeks Ago

- The Processor (Part 2)
  - Flags
  - Additional Registers
    - MMX (Multi-Media Extension)
      - 8 64-bit registers used for multimedia communications
    - Floating Point Unit (FPU)
    - XMM Registers
      - 128-bit registers for doing work that is performance-critical
  - You had homework. Let's review the answers now.

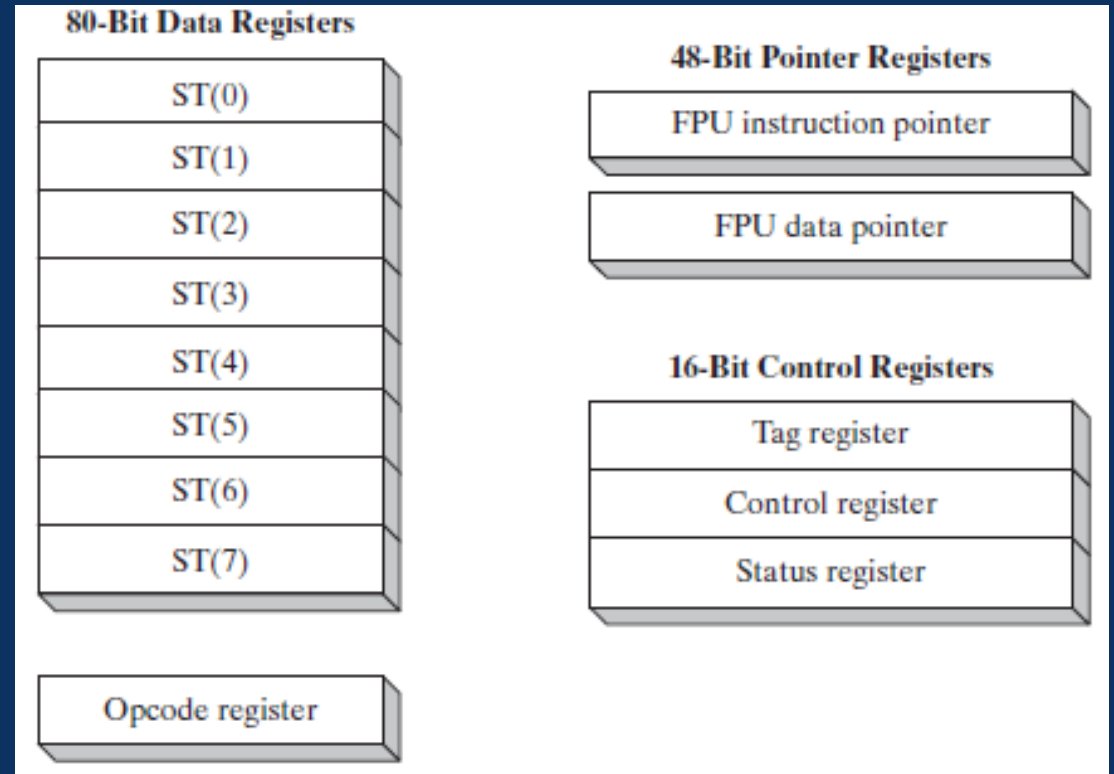
# The Processor

- Floating Point Units (FPUs)
  - ST(0) – ST(7) operate as a stack
    - These are used for storage of data while performing floating point arithmetic.
  - Opcode Register – Stores the opcode of the last executed non-control instruction.
  - FPU Instruction Pointer – Stores the address of the last executed non-control instruction.



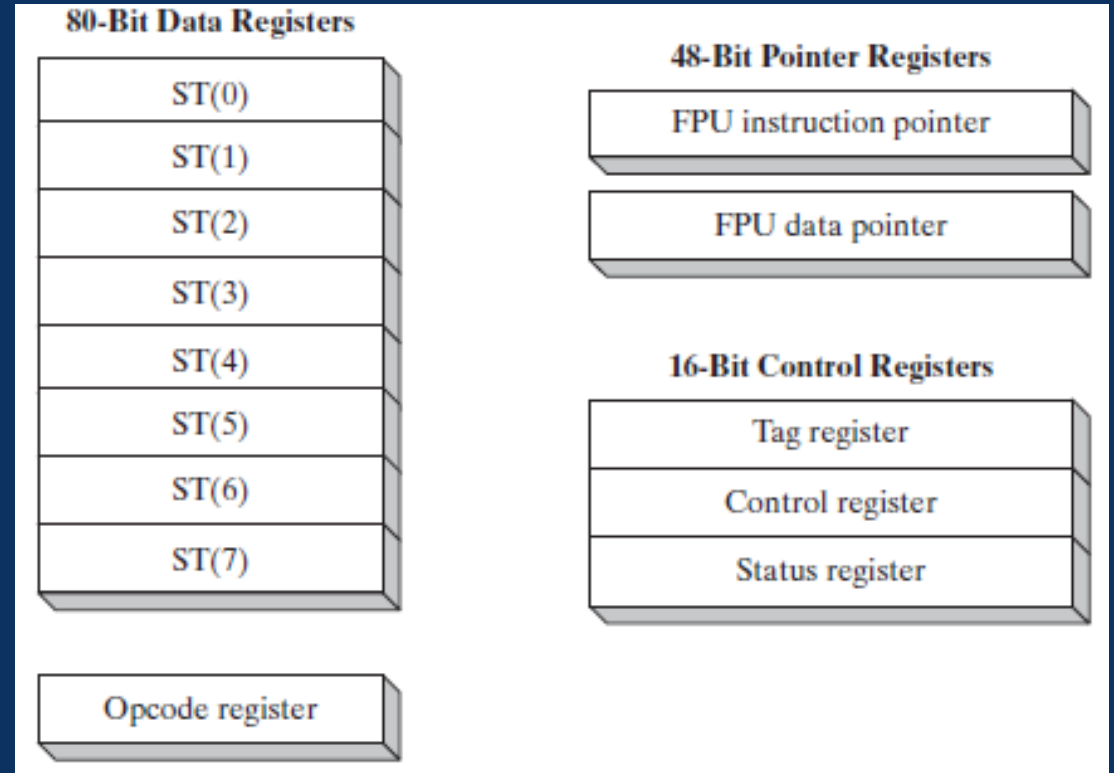
# The Processor

- Floating Point Units (FPUs)
  - FPU Data Pointer – Stores the address of the operand (data) for the last executed non-control instruction.
  - Tag Register – Stores a series of 2-bit indicators regarding the status of the other registers (valid data, zero, infinity, etc.)



# The Processor

- Floating Point Units (FPUs)
  - Control Register – Controls floating point precision and rounding.
  - Status Register – Stores flags indicating various statuses when performing a floating point operation.
    - Examples: warnings, indicating busy states



# The Processor

- More about amd64 Processors
  - Memory addresses are 64 bits
  - amd64 is backwards compatible with x86 (32-bit) CPUs
    - x86 memory addresses are 32 bits
  - Has 8 general purpose 64-bit registers
  - Instructions can have 64-bit integers as operands
  - Theoretically, amd64 supports  $2^{64}$  bytes of virtual address space
    - Most processors limit the address space to  $2^{48}$  bytes



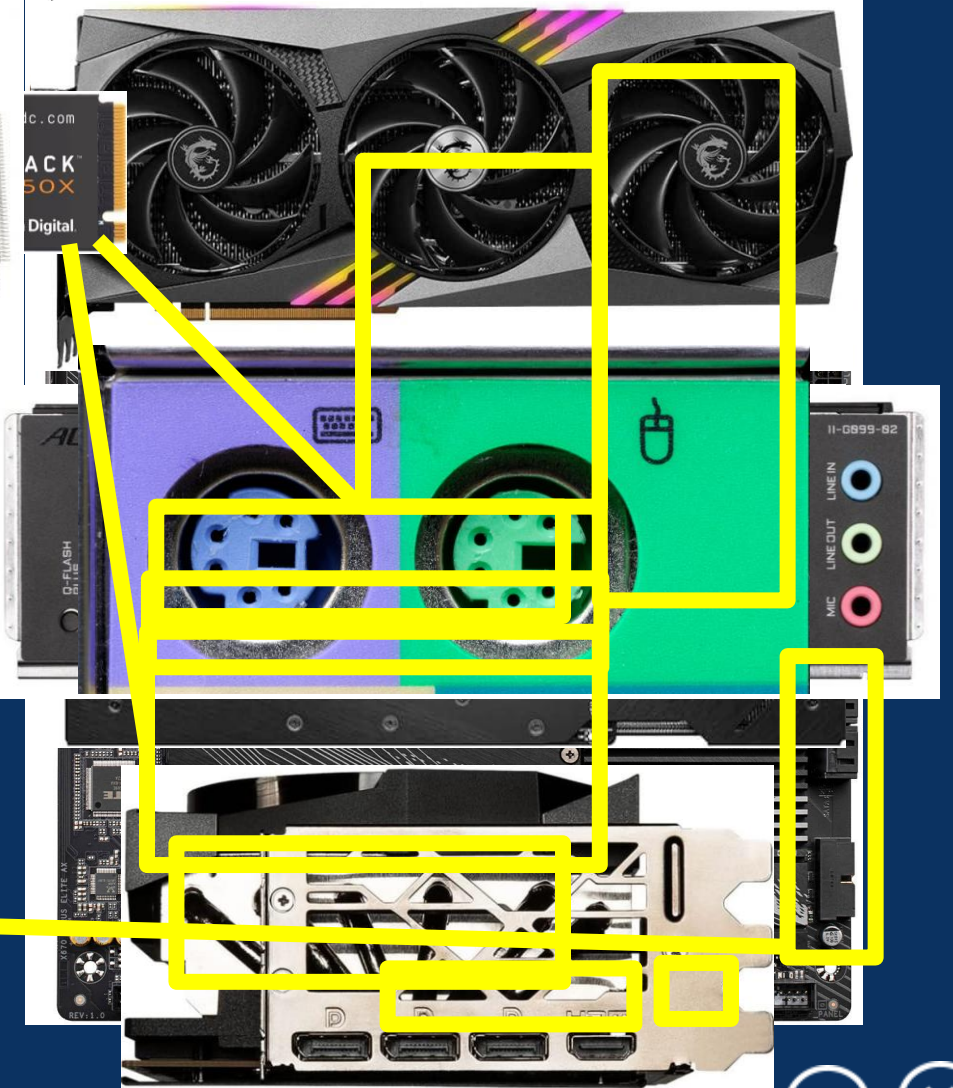
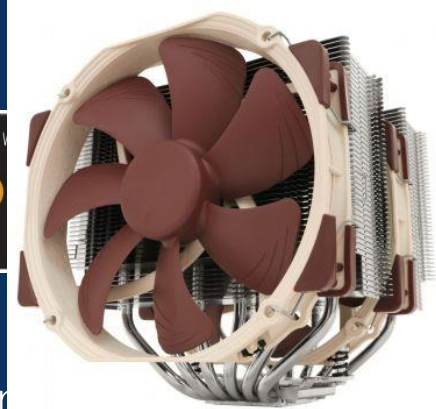
# The Processor

- Theoretically, amd64 supports  $2^{64}$  bytes of virtual address space
  - Most processors limit the address space to  $2^{48}$  bytes. Why?
  - Hint
    - $2^{64}$  is about 18,446,744 terabytes
    - $2^{48}$  bytes is about 281 terabytes
- Answer:
  - Supporting  $2^{64}$  bytes of virtual address space isn't necessary for most users.
  - Supporting the full range requires adding more hardware to the CPU that most users will never need.
  - Adding more hardware means the CPU is more expensive.
  - CPU manufacturers can ~~charge the same price for the CPU and get higher profit margins~~ save you some money by not including unnecessary hardware.



# Components of a Computer

- Motherboard
  - CPU Socket
  - Memory Slots
  - BIOS/UEFI
    - BIOS – Basic Input Output System
    - UEFI – Unified Extensible Firmware Interface
    - Holds the firmware and configuration data for the motherboard.
  - CMOS RAM
  - Storage Device Connectors
  - Universal Serial Bus (USB)
  - Keyboard and Mouse Ports
  - PCI (Peripheral Component Interconnect)



# Components of a Computer

- Motherboard Chipset
  - Collection of chips that aid in controlling the motherboard as well as hardware attached to it.
  - Examples
    - Adjust fan speed
    - Disable power to certain hardware
    - Adjust power draw



# Types of Memory

- Read-Only Memory (ROM)
  - Permanent, cannot be erased
  - Historically used for storing BIOS
- Erasable Programmable ROM (EPROM)
  - Can be slowly erased with UV light and reprogrammed
  - Commonly used for storing BIOS/UEFI now
- Dynamic RAM (DRAM)
  - Main memory used to hold programs and data when running
- Static RAM (SRAM)
  - Expensive, high speed, doesn't need to be refreshed
  - This is what a CPU cache is

# Types of Memory

- Video RAM (VRAM)
  - Holds video and graphics data
  - GPUs use this
- CMOS RAM
  - Stores system setup info and powered by a dedicated battery
  - Stores BIOS configuration



# SIMM vs DIMM Memory

- Single In-Line Memory Module (SIMM)
  - Has a single line of connectors
  - Connectors on each side of the board are the same
  - SIMM can only use a 32-bit bus
- Double In-Line Memory Module (DIMM)
  - Has two lines of connectors
  - Connectors on each side of the board are not connected to each other
  - DIMM can use a 64-bit bus
- SIMM memory could technically be made to work to use a 64-bit bus, but it makes more sense to use DIMM.

# Input/Output Systems

- High-Level Language Functions
  - APIs built into a high-level language for performing I/O operations
  - High portable and not OS-dependent
- Operating System
  - APIs built into the operating system for performing I/O operations
  - Examples:
    - Reading and writing files, capturing keyboard input, memory allocation
  - OS-dependent
- BIOS/UEFI
  - Low-level subroutines that communicate with hardware devices

# Input/Output Systems

- Low-Level Languages can choose from several I/O access levels
  - Level 3 – Application Program
    - Use library functions that perform generic I/O tasks
  - Level 2 – Operating System
    - OS functions that perform generic I/O tasks
  - Level 1 – BIOS/UEFI
    - BIOS functions to control device-specific features
  - Level 0 – Hardware
    - Directly communicate with hardware
- Tradeoff: Control vs Portability
  - Lower levels are faster and allow for more control, but higher levels are more portable.



# Next Week

- Midterm Exam
  - Questions on the midterm will be in the style of Homework #1
  - The exam will be a traditional format
    - In-class, no access to notes or online materials
  - Everything I have talked about since the start of the semester is fair game
    - Yes, that includes the stuff I talked about today.
    - I won't ask super specific questions that would require you to memorize something in great detail.
  - To study, I would recommend using the weekly slides as well as any notes you've taken.
  - If you cannot take the exam on the scheduled day, you must tell me before the exam is given.