

Computer Architecture Midterm Exam Solution

Computer Architecture Midterm Exam Solution Computer Architecture Midterm Exam Solution A Comprehensive Guide This article provides a detailed analysis of common topics covered in a computer architecture midterm exam offering solutions and explanations to help students understand the concepts and prepare for their assessments It covers key areas such as processor design memory systems instruction sets and performance evaluation

I Processor Design

1 Instruction Set Architecture ISA

Explain the difference between RISC and CISC architectures

RISC Reduced Instruction Set Computing Emphasizes a small simple instruction set with a fixed format This allows for faster execution and simpler pipelined designs Examples ARM MIPS

CISC Complex Instruction Set Computing Offers a large complex instruction set with variablelength instructions This can lead to more efficient code for complex tasks but requires more complex decoding and execution Examples x86 Intel 8086

What are the advantages and disadvantages of each architecture

RISC Advantages Faster execution simpler implementation lower power consumption

RISC Disadvantages May require more instructions for complex tasks potentially larger code size

CISC Advantages Can handle complex tasks with fewer instructions may offer better code density

CISC Disadvantages Slower execution due to complex decoding more complex hardware implementation

2 Pipeline Design

Describe the stages of a typical pipelined processor

Instruction Fetch Fetches the next instruction from memory

Instruction Decode Decodes the instruction and fetches operands

Execute Performs the operation specified by the instruction

2 Memory Access

Accesses data from memory read or write

Write Back Writes the result back to the register file

Explain the concept of pipeline hazards and how they are handled

Data Hazards When an instruction needs the result of a previous instruction that has not yet been calculated Solved using techniques like forwarding or stalling

Control Hazards When a branch instruction is encountered and the pipeline needs to decide

which instruction to fetch next Solved using branch prediction techniques Structural Hazards When multiple instructions try to access the same resource simultaneously Solved by designing dedicated hardware for each stage or using techniques like interleaving access 3 Processor Performance Define the terms CPI MIPS and IPC CPI Cycles Per Instruction The average number of clock cycles required to execute one instruction MIPS Millions of Instructions Per Second The rate at which instructions are executed by a processor IPC Instructions Per Cycle The average number of instructions executed per clock cycle Explain the relationship between these metrics CPI and MIPS Inversely proportional Lower CPI leads to higher MIPS IPC and MIPS Directly proportional Higher IPC leads to higher MIPS II Memory Systems 1 Memory Hierarchy Explain the concept of memory hierarchy and its purpose A layered system of memory with different speed and cost characteristics Faster smaller memories cache are used to store frequently accessed data while slower larger memories main memory hold less frequently used data Purpose To provide fast access to data while keeping the overall cost of the system down Describe the different levels of memory hierarchy cache main memory secondary storage Cache Small fast memory that holds frequently accessed data Typically organized in multiple levels L1 L2 L3 with L1 being the fastest and smallest Main Memory RAM Larger slower memory used to hold the currently running program and its data Secondary Storage Hard Disk Slowest and largest memory used for persistent storage of data and programs 2 Cache Memory Explain the principles of cache memory locality mapping replacement Locality The tendency for programs to access data and instructions close to what they recently accessed spatial locality or that they will access again soon temporal locality Mapping Determines how memory locations are mapped to cache lines direct mapping associative mapping setassociative mapping Replacement Determines which cache line to evict when a new line needs to be loaded FIFO LRU random Explain the concept of cache miss and its impact on performance Cache Miss When the requested data is not present in the cache and needs to be fetched from main memory Impact Significantly slows down program execution because main memory access is much slower than cache access 3 Virtual Memory Explain the concept of virtual memory and its advantages A technique that allows a program to use more memory than is physically available in the system by using secondary storage as an extension of RAM Advantages Allows running programs larger than physical memory provides memory protection for different processes

simplifies memory management Describe the role of the page table in virtual memory management Maps virtual addresses used by the program to physical addresses used by the memory hardware Allows for efficient switching between multiple processes in memory

III Instruction Sets

1 Instruction Formats

Describe the common elements of an instruction format opcode operands addressing modes

4 Opcode

Specifies the operation to be performed

Operands

Specify the data values or memory addresses involved in the operation

Addressing Modes

Specify how the operands are accessed immediate register direct indirect indexed

Explain the benefits of different addressing modes

- Immediate** Efficient for constants but limited in flexibility
- Register** Fast access suitable for frequent computations
- Direct** Simple and effective for accessing fixed memory locations
- Indirect** Provides flexibility for accessing data through pointers
- Indexed** Allows for efficient access to elements in arrays

2 Instruction Types

Categorize different instruction types arithmetic logical data transfer control flow

- Arithmetic** Perform mathematical operations addition subtraction multiplication division
- Logical** Perform bitwise operations AND OR XOR NOT
- Data Transfer** Move data between memory and registers
- Control Flow** Control the order of instruction execution jumps branches calls returns

Explain the purpose of each instruction type and provide examples

- Arithmetic** ADD SUB MUL DIV
- Logical** AND OR XOR NOT
- Data Transfer** LOAD STORE MOVE
- Control Flow** JMP CALL RET JZ Jump if Zero JN Jump if Negative

IV Performance Evaluation

1 Performance Metrics

Explain the meaning of performance metrics execution time clock rate CPI MIPS IPC throughput latency

- Execution Time** The total time taken to complete a task
- Clock Rate** The frequency at which the processors clock cycles
- CPI** MIPS IPC Previously defined in the processor design section
- Throughput** The number of tasks completed per unit time
- Latency** The time taken for a single task to complete

Discuss the relationship between different performance metrics

5 Execution Time Determined by CPI clock rate and the number of instructions executed MIPS and CPI Inversely proportional Throughput and Latency Inversely proportional

2 Performance Analysis

Explain how to use performance metrics to compare different computer systems

By comparing metrics like CPI MIPS throughput and latency for different systems we can assess their relative performance for specific workloads

Discuss the importance of benchmark programs in performance analysis

Benchmark programs are standardized tasks used to assess the performance of computer systems under specific conditions

They provide a fair and consistent way to compare different

hardware and software configurations Conclusion This article has provided a comprehensive review of key topics in computer architecture and offered solutions to typical midterm exam questions By understanding the concepts of processor design memory systems instruction sets and performance evaluation students can develop a solid foundation for further exploration in this critical field Remember to practice solving different problems and thoroughly analyze your results to achieve a deep understanding of the material Note This is a general guide and may not cover all topics included in your specific midterm exam Consult your syllabus lecture notes and textbook for a complete understanding of the course content

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