CET3126C – Independent Study Assignment

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Computer Architecture

1) What is Computer Architecture?

Computer architecture refers to the design and organization of a computer system's fundamental components. It encompasses the Instruction Set Architecture (ISA), which defines the commands a processor is able to execute. The microarchitecture that implements the ISA in hardware, and the broader system design includes the memory and I/O. Together, these layers define how the software is able to interact with the hardware and determine performance and efficiency.

2) Historical Milestones (Timeline)

Some key milestones in computer architecture include: 1) The ENIAC (1945) as one of the first electronic computers, 2) Introduction of the transistor (1947), 3) Development of integrated circuits (1958), 4) Intel's 4004 microprocessor (1971), 5) Rise of RISC processors in the 1980s, 6) Transition to multi-core CPUs in the 2000s. Each milestone improved speed, efficiency, and scalability.

3) Classes of Computing Systems

Computing systems are often classified as desktop, server, and embedded systems. Desktop systems can balance performance and cost for general users. Servers prioritize reliability, throughput, and scalability to handle many users or processes simultaneously. Embedded systems are designed for specialized tasks in devices like cars and appliances, where constraints include power consumption and real-time operation.

4) Classic Components of a Computer

A computer consists of input, output, memory, Datapath, and control. Input and output allow for communication with the external world, while memory is able to store the instructions and data. The Datapath executes operations under the guidance of the control unit, which directs the flow of instructions. Together, these components form the instruction execution cycle.

5) Transistor Scaling & Moore's Law

Moore's Law predicted that the number of transistors on a chip would double approximately every two years, leading to exponential performance growth. Dennard scaling complemented this by ensuring that smaller transistors consumed less power per area. These trends enabled faster and more efficient processors for decades, though physical limitations are now slowing progress.

6) The Power Wall

The power wall refers to the thermal and energy limits encountered as clock frequencies increased. Beyond a certain point, chips generated too much heat to be cooled economically, making further frequency scaling impractical. This challenge forced the industry to pursue other performance strategies such as multi-core architectures and power-efficient designs.

7) From Uniprocessors to Multiprocessors

As clock speed scaling plateaued, chipmakers turned to multi-core processors. By integrating multiple cores, systems could achieve parallel execution of tasks, improving throughput. This shift also required software to adopt parallel programming models, placing greater emphasis on concurrency and thread-level parallelism.

8) IC Manufacturing (Overview)

Integrated circuit (IC) manufacturing begins with design and proceeds through fabrication steps such as lithography, deposition, etching, and doping. These processes create transistor layers on silicon wafers. After fabrication, chips undergo testing and are packaged for integration into systems. This complex pipeline requires precision to ensure high yields and reliable performance.

References

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