COMPUTER ARCHITECTURE ASSIGNMENT 1

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1.1 FUNDAMENTALS OF QUANTITATIVE DESIGN ANALYSIS

Computer technology has made incredible progress over time, but although that, progressing from computer architecture has been less consistent. The late 1970s saw the emergence of the microprocessor delivering performance improvement.

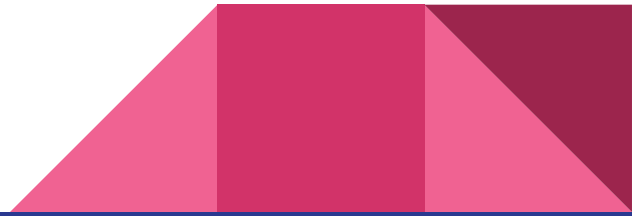
The virtual elimination of assembly language programming and creation of vendor independent OS such as UNIX and LINUX lowered cost and risk of bringing out new architecture.

These changes made it possible to develop a new set of architecture known as RISC (Reduced Instruction Set Computer)

RISC

RISC-based computers raised the performance bar, forcing previous architecture to keep up or disappear. It replaced the Digital Equipment Vax, and with this Intel rose to the challenge by adopting RISC designs.

In low-end applications, such as cell phones, cost of power and silicon area overhead helped RISC architecture, ARM, become dominant.

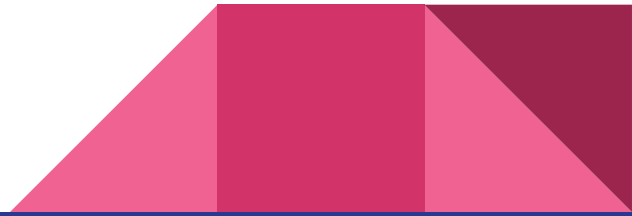


1.2 Classes of Computers

These changes in computer use have led to five different computing markets each characterized by different applications, equipments and computing technologies.

The mainstream classes of computing environments are:

- Feature
- Personal Mobile Device
- Server
- Clusters/ Warehouse-scale Computer
- Embedded

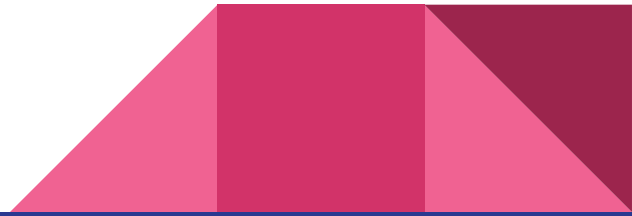


Personal Mobile Device

This is the term we apply to a collection of wireless devices with multimedia user interfaces such as cell phones.

Applications on PMDs are often web based or media oriented, energy and size requirements lead to use of flash memory instead of magnetic disks.

PMDs have a characteristic of energy efficiency due to their small size, lack of a cooling fan, and less packaging.

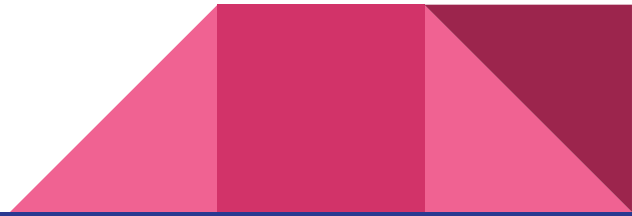


Desktop Computing

It is the largest market in dollar terms, since it spans from low-end netbooks to heavily configured workstations.

The desktop market tends to be driven to optimize price-performance, as a result, the newest, high-performance microprocessors and cost-reduced microprocessors often appear first in desktop systems.

Increased use of web-centric, interactive applications poses new challenges to the performance evaluation.



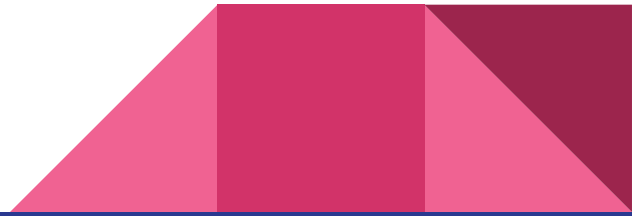
Servers

As the shift to desktop computing occurred, the role of servers grew to provide larger scale and more reliable file and computing services.

Such servers have become a backbone to large-scale enterprise computing, replacing the traditional mainframe.

Characteristics of servers:

- Availability
- Scalability
- Efficient Throughput

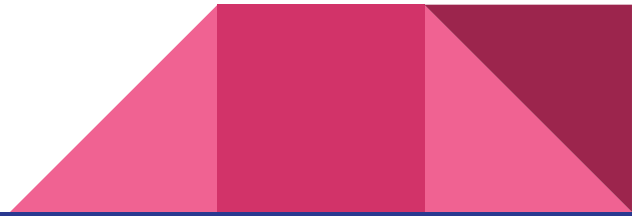


Clusters/ Warehouse-scale Computers

The growth of Software as a Service (SaaS) for applications has led to growth of a class of computers called clusters.

Clusters are a collection of desktop computers or servers connected by a LAN to act as a single larger computer. The largest clusters are called Warehouse-scale Computers and they are designed so that tens of thousands of servers act as one.

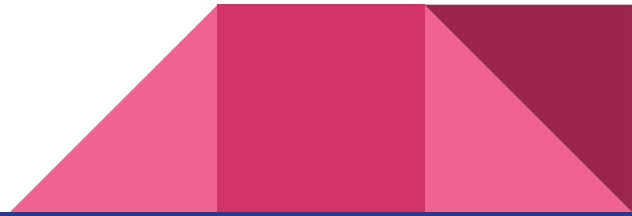
Price-performance is critical since they are so large and they are related to servers hence availability is important.



Embedded Computers

They are mostly found in everyday machines for example, microwaves.

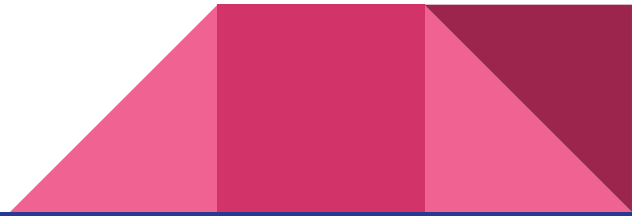
They are limited in hardware and software sophistication since they perform a specific task.



1.3 Defining Computer Architecture

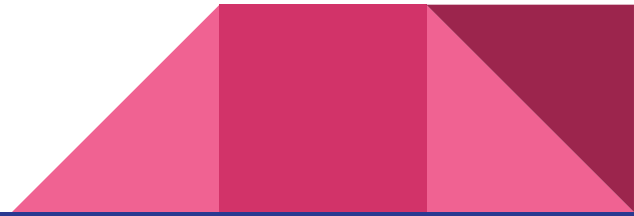
This refers to the design and organization of a computer system, encompassing the structure, functionality and interaction of its components.

Computer Architecture is more than an instruction set design and a computer designer has a more complex task than what is thought.



Instruction Set Architecture (ISA)

ISA refers to the actual programmer visible instruction sets. It serves as the boundary between the software and hardware, a good example being 80x86, ARM and MIPS.



The Seven Dimensions of ISAs

- Class of ISAs
- Memory Addressing
- Addressing Models
- Types and Sizes of Operands
- Operations
- Control Flow Instructions
- Encoding an ISA

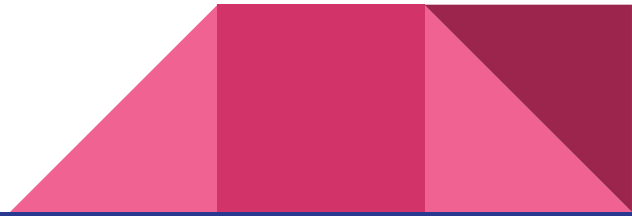
1.4 Trends in Technology

If an ISA is to be successful, it must be designed to survive rapid changes in computer technology.

To plan for an evolution of a computer, the design must be aware of rapid changes in the implementation technology.

Five implementation technologies which change at a rapid pace are:

- Integrated circuit logic technology
- Semiconductor DRAM
- Semiconductor flash
- Magnetic disk technology
- Network Technology



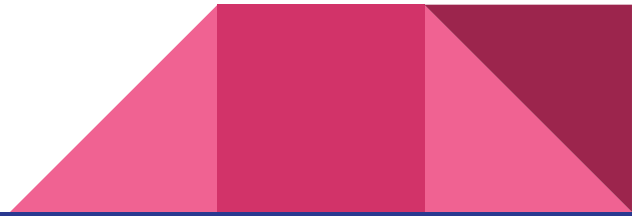
1.5 Trends in Power and Energy in Integrated Circuits

Today, power is the biggest challenge facing the computer designer for every class of computer.

First power is brought in and distributed around the chip and secondly the power is dissipated as heat and must be removed.

Demands to be met:

- Maximum processor power
- Sustained power consumption
- Energy and energy efficiency



Energy and Power within a Microprocessor

For CMOS chips, the traditional primary energy consumption has been in switching transistors also called dynamic energy. The energy required per transistor is proportional to the product of the capacitive load driven by the transistor and the square of the voltage i.e:

Energy (dynamic) α Capacitive load x Voltage^2

This equation is the energy of pulse of the logic transition of 0 to 1 to 0 or 1 to 0 to 1. The energy of a single transition (0 to 1 or 1 to 0) is then:

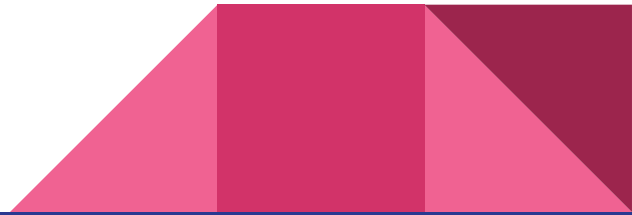
Energy (dynamic) α ½ x Capacitive load x Voltage^2

Power required per transistor

Power (dynamic) α ½ x Capacitive load x Voltage^2 x Frequency switched

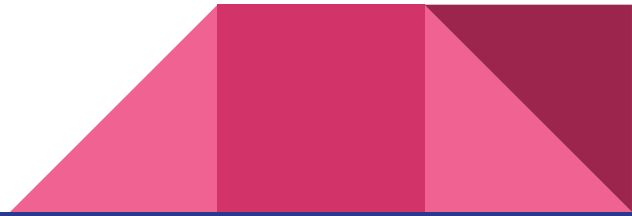
For a fixed task, slowing clock rate reduces power, not energy

As we move from one process to the next, the increase in the number of transistors switching and the frequency with which they switch dominate the decrease in load capacitance and voltage.



Microprocessor techniques to improve energy efficiency

- **Do nothing well:** Turn off the clock of inactive modules
- **Dynamic voltage-Frequency Scaling (DVFS):** offering few clock frequencies and voltages
- **Design for typical case:** Different devices and computer classes built in different ways for improved energy efficiency
- **Overclocking**: Chip decides it is safe to run at a higher clock rate for a short time until temperature starts to rise.



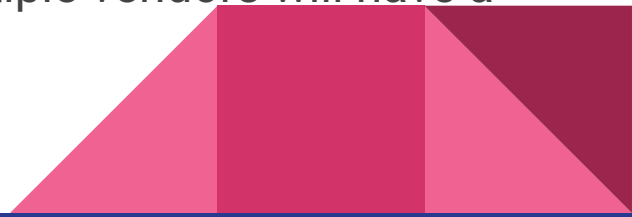
1.6 Trends in Cost

The cost of a manufactured computer component decreases over time even without major improvements in the basic implementations technologies.The learning curve is what drives cost down.

Microprocessor prices also drop over time because they are less standardized than DRAMs.

Volume is also key since increasing volume lowers the cost.

Commoditization is key in that a commodity sold by multiple vendors will have a lower cost than that sold by specific vendors.



Cost versus Price

With the commoditization of computers, the margin between the cost to manufacture a product and the price of the product has been shrinking.

Those margins pay for a company’s various expenditures.

Cost of operation and cost of manufacturing should be at a stable margin and to lower operational costs in a warehouse-scale computer, computer architects need to use energy efficiently.