Unit-8 : Applications and Trends of Microprocessor Technology

A microprocessor is a computer processor where the data processing logic and control is included on a single integrated circuit, or a small number of integrated circuits. The microprocessor is a multipurpose, clock-driven, register-based, digital integrated circuit that accepts binary data as input, processes it according to instructions stored in its memory, and provides results (also in binary form) as output.

The integration of a whole CPU onto a single or a few integrated circuits using Very-Large-Scale Integration (VLSI) greatly reduced the cost of processing power. Before microprocessors, small computers had been built using racks of circuit boards with many medium- and small-scale integrated circuits. Microprocessors combined this into one or a few large-scale ICs. The first commercially-available microprocessor was the Intel 4004.

The complexity of an integrated circuit is bounded by physical limitations on the number of transistors that can be put onto one chip, the number of package terminations that can connect the processor to other parts of the system, the number of interconnections it is possible to make on the chip, and the heat that the chip can dissipate. Advancing technology makes more complex and powerful chips feasible to manufacture.

A minimal hypothetical microprocessor might include only an arithmetic logic unit (ALU), and a control logic section. The ALU performs addition, subtraction, and operations such as AND or OR. Each operation of the ALU sets one or more flags in a status register, which indicate the results of the last operation (zero value, negative number, overflow, or others). The control logic retrieves instruction codes from memory and initiates the sequence of operations required for the ALU to carry out the instruction. A single operation code might affect many individual data paths, registers, and other elements of the processor.

As integrated circuit technology advanced, it was feasible to manufacture more and more complex processors on a single chip. The size of data objects became larger; allowing more transistors on a chip allowed word sizes to increase from 4- and 8-bit words up to today's 64-bit words. Additional features were added to the processor architecture; more on-chip registers sped up programs, and complex instructions could be used to make more compact programs. Floating-point arithmetic, for example, was often not available on 8-bit microprocessors, but had to be carried out in software. Integration of the floating-point unit, first as a separate integrated circuit and then as part of the same microprocessor chip, sped up floating-point calculations.

Occasionally, physical limitations of integrated circuits made such practices as a bit slice approach necessary. Instead of processing all of a long word on one integrated circuit, multiple circuits in parallel processed subsets of each word. While this required extra logic to handle, for example, carry and overflow within each slice, the result was a system that could handle, for example, 32-bit words using integrated circuits with a capacity for only four bits each.

The ability to put large numbers of transistors on one chip makes it feasible to integrate memory on the same die as the processor. This CPU cache has the advantage of faster access than off-chip memory and increases the processing speed of the system for many applications. Processor clock frequency has increased more rapidly than external memory speed, so cache memory is necessary if the processor is not to be delayed by slower external memory.

Special-purpose designs:

A microprocessor is a general-purpose entity. Several specialized processing devices have followed:

- A **digital signal processor (DSP)** is specialized for signal processing.
- **Graphics processing units (GPUs)** are processors designed primarily for realtime rendering of images.
- Other specialized units exist for **video processing**.
- **Microcontrollers** integrate a microprocessor with peripheral devices in **embedded systems.**
- **Systems on chip (SoCs)** often integrate one or more microprocessor or microcontroller cores with other components such as radio modems, and are used in smartphones and tablet computers.

Speed and power considerations

Microprocessors can be selected for differing applications based on their word size, which is a measure of their complexity. Longer word sizes allow each clock cycle of a processor to carry out more computation, but correspond to physically larger integrated circuit dies with higher standby and operating power consumption. 4-, 8- or 12-bit processors are widely integrated into microcontrollers operating embedded systems. Where a system is expected to handle larger volumes of data or require a more flexible user interface, 16-, 32- or 64-bit processors are used. An 8- or 16-bit processor may be selected over a 32-bit processor for system on a chip or microcontroller applications that require extremely low-power electronics, or are part of a mixed-signal integrated circuit with noise-sensitive on-chip analog electronics such as high-resolution analog to digital converters, or both. Running 32-bit arithmetic on an 8-bit chip could end up using more power, as the chip must execute software with multiple instructions.

Embedded applications

Thousands of items that were traditionally not computer-related include microprocessors. These include household appliances, vehicles (and their accessories), tools and test instruments, toys, light switches/dimmers and electrical circuit breakers, smoke alarms, battery packs, and hi-fi audio/visual components (from DVD players to phonograph turntables). Such products as cellular telephones, DVD video system and HDTV broadcast systems fundamentally require consumer devices with powerful, low-cost, microprocessors. Increasingly stringent pollution control standards effectively require automobile manufacturers to use microprocessor engine management systems to allow optimal control of emissions over the widely varying operating conditions of an automobile. Non-programmable controls would require bulky, or costly implementation to achieve the results possible with a microprocessor.

A microprocessor control program (embedded software) can be tailored to fit the needs of a product line, allowing upgrades in performance with minimal redesign of the product. Unique features can be implemented in product line's various models at negligible production cost.

Microprocessor control of a system can provide control strategies that would be impractical to implement using electromechanical controls or purpose-built electronic controls. For example, an internal combustion engine's control system can adjust ignition timing based on engine speed, load, temperature, and any observed tendency for knocking—allowing the engine to operate on a range of fuel grades.