Vector(Array) Processing and Superscalar Processors

A **Scalar processor** is a normal processor, which works on simple instruction at a time, which operates on single data items. But in today's world, this technique will prove to be highly inefficient, as the overall processing of instructions will be very slow.

What is Vector(Array) Processing?

There is a class of computational problems that are beyond the capabilities of a conventional computer. These problems require vast number of computations on multiple data items, that will take a conventional computer(with scalar processor) days or even weeks to complete.

Such complex instructions, which operates on multiple data at the same time, requires a better way of instruction execution, which was achieved by Vector processors.

Scalar CPUs can manipulate one or two data items at a time, which is not very efficient. Also, simple instructions like **ADD A to B, and store into C** are not practically efficient.

Addresses are used to point to the memory location where the data to be operated will be found, which leads to added overhead of data lookup. So until the data is found, the CPU would be sitting ideal, which is a big performance issue.

Hence, the concept of **Instruction Pipeline** comes into picture, in which the instruction passes through several sub-units in turn. These sub-units perform various independent functions, **for example**: the **first** one decodes the instruction, the **second** sub-unit fetches the data and the **third** sub-unit performs the math itself. Therefore, while the data is fetched for one instruction, CPU does not sit idle, it rather works on decoding the next instruction set, ending up working like an assembly line.

Vector processor, not only use Instruction pipeline, but it also pipelines the data, working on multiple data at the same time.

A normal scalar processor instruction would be $\mathrm{ADD\ A, B}$, which leads to addition of two operands, but what if we can instruct the processor to ADD a group of numbers(from 0 to n memory location) to another group of numbers(lets say, n to k memory location). This can be achieved by vector processors.

In vector processor a single instruction, can ask for multiple data operations, which saves time, as instruction is decoded once, and then it keeps on operating on different data items.

Applications of Vector Processors

Computer with vector processing capabilities are in demand in specialized applications. The following are some areas where vector processing is used:

1. Petroleum exploration.
2. Medical diagnosis.
3. Data analysis.
4. Weather forecasting.
5. Aerodynamics and space flight simulations.
6. Image processing.
7. Artificial intelligence.

Superscalar Processors

It was first invented in 1987. It is a machine which is designed to improve the performance of the scalar processor. In most applications, most of the operations are on scalar quantities. Superscalar approach produces the high performance general purpose processors.

The main principle of superscalar approach is that it executes instructions independently in different pipelines. As we already know, that Instruction pipelining leads to parallel processing thereby speeding up the processing of instructions. In Superscalar processor, multiple such pipelines are introduced for different operations, which further improves parallel processing.

There are multiple functional units each of which is implemented as a pipeline. Each pipeline consists of multiple stages to handle multiple instructions at a time which support parallel execution of instructions.

It increases the throughput because the CPU can execute multiple instructions per clock cycle. Thus, superscalar processors are much faster than scalar processors.

A **scalar processor** works on one or two data items, while the **vector processor** works with multiple data items. A **superscalar processor** is a combination of both. Each instruction processes one data item, but there are multiple execution units within each CPU thus multiple instructions can be processing separate data items concurrently.

While a superscalar CPU is also pipelined, there are two different performance enhancement techniques. It is possible to have a non-pipelined superscalar CPU or pipelined non-superscalar CPU. The superscalar technique is associated with some characteristics, these are:

1. Instructions are issued from a sequential instruction stream.
2. CPU must dynamically check for data dependencies.
3. Should accept multiple instructions per clock cycle.