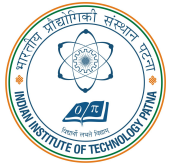
Embedded Processors



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Processor

- General purpose computing
  - Processor is capable of doing different kind of computations
- Embedded computing
  - Typically used for a dedicated function
  - More customizations are possible
  - Can reduce power, size, etc.
- Instruction set architecture - X86, ARM, etc.
- Processor realization

Types of processor

- Microcontrollers
- DSP processors
- Graphics processor
- Need to choose appropriate processor depending on application domain
  - Small,
  - Slow
  - Inexpensive
  - Low power
  - High performance
  - Special purpose, etc.

Microcontrollers

- Small computer on a single integrated circuit
- Usually have single CPU
- Have peripheral devices such as memories, input/output devices, timers, etc.

DSP processor

- Typically many applications read different parameters in a certain interval
  - Motion control - few hertz to few hundred hertz
  - Audio - 8KHz to 44.1KHz
  - Video - 25-30 Hz for common devices
  - and many other applications
- Processor designed for numerical intensive signal processing

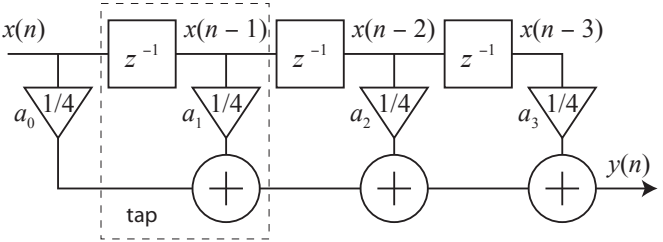

image source: Introduction to Embedded Systems book

Graphics processor unit (GPU)

- Specialized processor designed to perform the calculation requires in graphics rendering
- Usage:
  - Rendering text and Graphics
  - Combining multiple patterns
  - 3D graphics, shading
  - Digital video games, etc.
- Usually power hungry

Parallelism

- Affect significantly the execution time of a program
- **Concurrent** - if different parts of program conceptually execute simultaneously
- **Parallel** - if different parts of the program physically execute simultaneously on distinct hardware
- Non-concurrent programs specify a sequence of instruction to execute
  - Imperative program - C
  - Thread library
- Example:

```
double pi, piSquared, piCubed;
pi = 3.14159;
piSquared = pi * pi ;
piCubed = pi * pi * pi;
```

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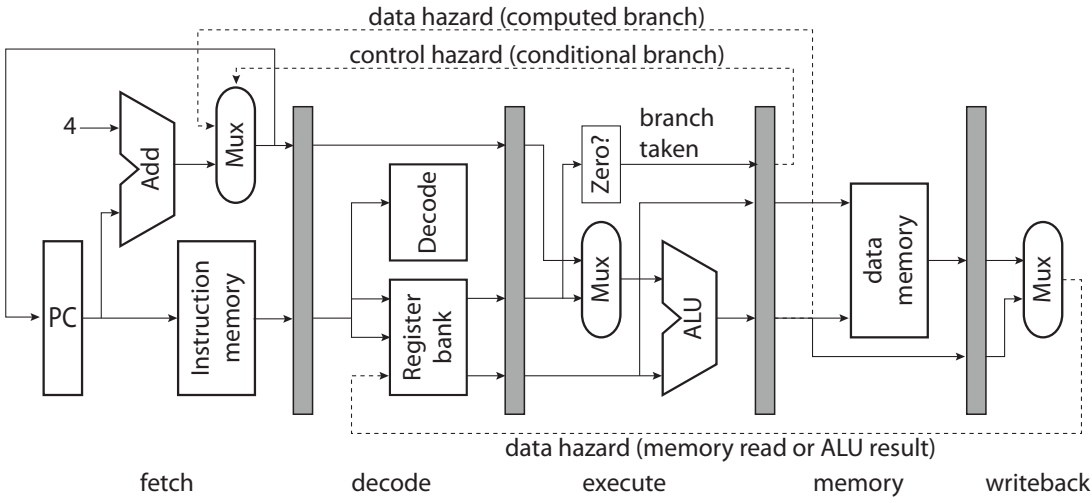
Parallelism (contd.)

- Compiler may analyze the dependencies between operations in a program and produce parallel code
  - It does data flow analysis
- Parallel execution using multi issue streams VLIW (very large instruction word) architecture
- Independent instructions can be executed in parallel
- Goal is to improve performance
- Timeliness is important for concurrent program
- Multitasking program

Pipelining



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Instruction level parallelism

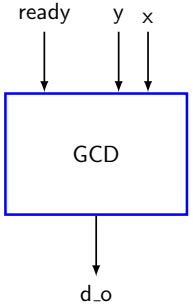
- CISC - Complex instruction set computer
  - Usually DSP processor - supports FIR filtering, FFT etc.
  - All instruction may not have same length
  - Code optimization is difficult
- Subword parallelism - Enables simultaneous arithmetic or logical operations on smaller words
- Superscalar - Hardware dispatches multiple instructions to distinct hardware when there is no issue
- VLIW - Combines multiple independent operations into single instruction

Multicore architecture

- Combination of several processor on a single chip
  - Heterogeneous in nature
  - Cell phone - radio and speech processing
- FPGA

Custom processor design

```
int x, y;
  while(1){
    while(!ready);
    x=x_i;
    y=y_i;
    while(x!=y){
      if(x<y) y=y-x;
      else x=x-y;
    }
    d_o=x
  }
```



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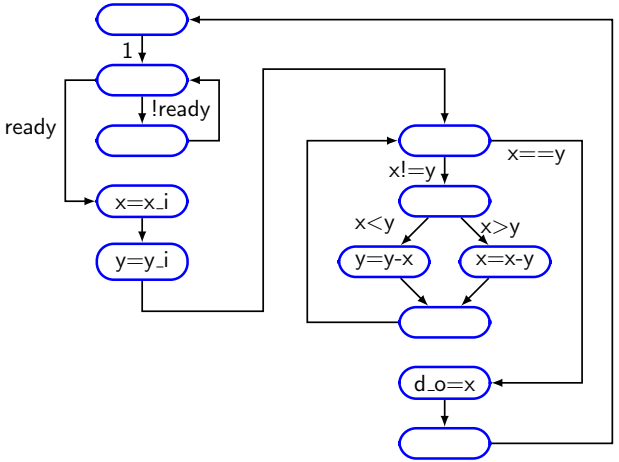

Custom processor design