Chapter 7: Microarchitecture

Multithreading & Multiprocessors

Advanced Architecture Techniques

- **Multithreading**
  - Wordprocessor: thread for typing, spell checking, printing
- **Multiprocessors**
  - Multiple processors (cores) on a single chip

Threading: Definitions

- **Process:** program running on a computer
  - Multiple processes can run at once: e.g., surfing Web, playing music, writing a paper
- **Thread:** part of a program
  - Each process has multiple threads: e.g., a word processor may have threads for typing, spell checking, printing

Architectural State

- A computer architecture is defined by its instruction set and architectural state.
- The architectural state for the RISC-V processor consists of the program counter and the 32 32-bit registers.
- Any RISC-V microarchitecture must contain all of this state.
- Based on the current architectural state, the processor executes a particular instruction with a particular set of data to produce a new architectural state.

Threads in a Conventional Processor

Single-core system:

- One thread runs at once
- When one thread stalls (for example, waiting for memory):
  - Architectural state of that thread stored
  - Architectural state of waiting thread loaded into processor and it runs
  - Called **context switching**
- Appears to user like all threads running simultaneously

Multithreading

- Multiple copies of architectural state
  - This means that you have multiple program counters and multiple register files.
- Multiple threads **active** at once:
  - When one thread stalls, another runs immediately
  - If one thread can't keep all execution units busy, another thread can use them
  - **Intel calls this "hyperthreading"**
- Does not increase instruction-level parallelism (ILP) of single thread, but increases throughput

Multiprocessors

- Multiple processors (cores) with a method of communication between them
- Types:
  - **Homogeneous:** multiple cores with shared main memory
  - **Heterogeneous:** separate cores for different tasks (for example, DSP and CPU in cell phone)
  - **Clusters:** each core has own memory system