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Pipeline Hazards and Their Handling in Computer Architecture

Pipeline hazards are issues that arise in instruction pipelines, causing delays or incorrect execution.
There are three main types of hazards:

1. Structural Hazards: These occur when hardware resources are insufficient to execute multiple instructions simultaneously.
2. Data Hazards: These occur when an instruction depends on the result of a previous instruction that has not yet completed.
3. Control Hazards: These arise due to branch instructions, leading to incorrect instruction fetching.

Handling Techniques:
- Structural Hazards: Use more hardware units or stalls.
- Data Hazards: Implement forwarding, pipeline stalls, or register renaming.
- Control Hazards: Use branch prediction, delay slots, or speculative execution.

Effective pipeline design and hazard handling improve CPU efficiency and performance.