

Operating Systems

Lecture 3

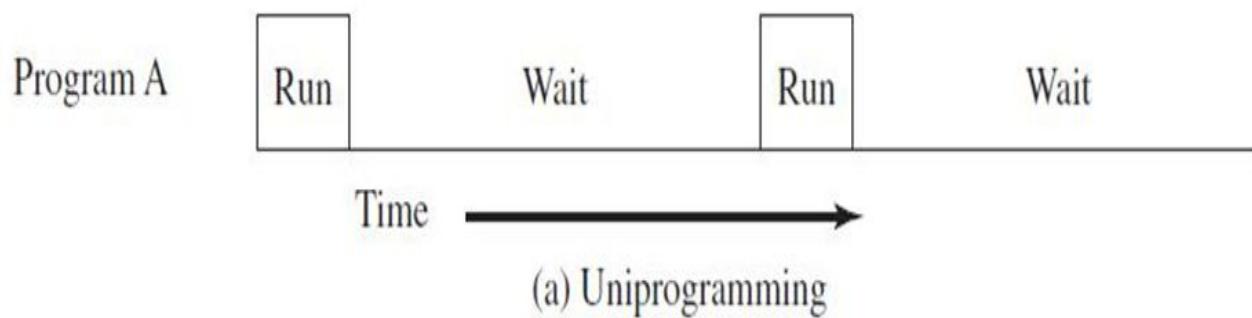
Multi Program Batch Operating Systems

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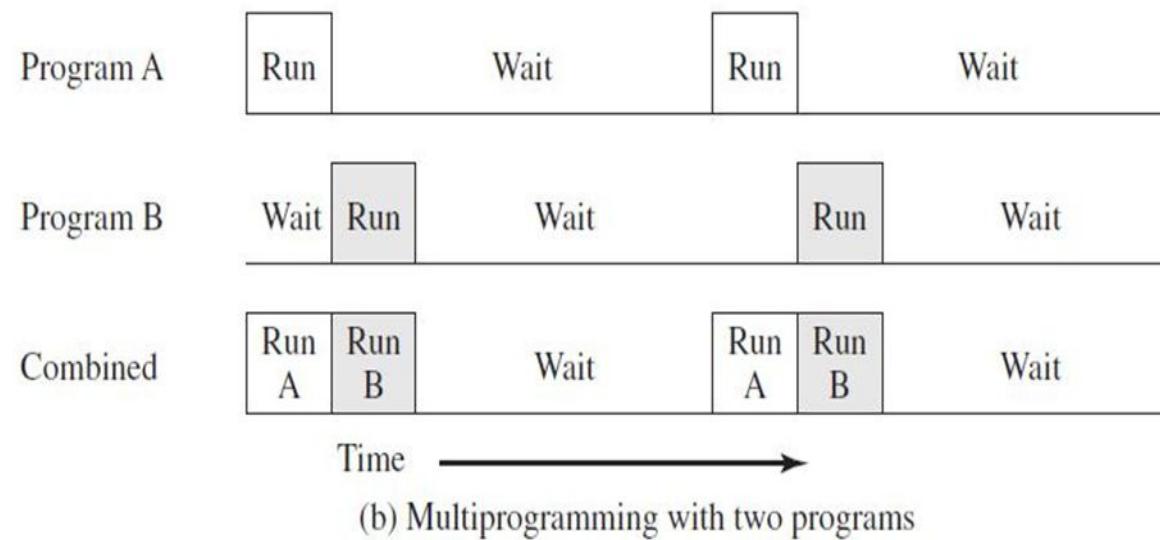
Introduction to Multiprogramming

- Even with the automatic job sequencing provided by a simple batch operating system, the processor is often idle. The problem is that I/O devices are slow compared to the processor. Figure below illustrates a situation where we have a single program, referred to as uniprogramming. The processor spends a certain amount of time executing, until it reaches an I/O instruction. It must then wait until that I/O instruction concludes before proceeding.



Introduction to Multiprogramming

- Suppose that there is enough memory for OS and two user programs. When one job needs to wait for I/O, the processor can switch to the other job, which is likely not waiting for I/O. This is shown below



Advantages for Multiprogramming

- Early batch systems left CPU **idle** during I/O.
- Multiprogramming emerged to **overlap I/O of one job with CPU of another.**
- **Objective:** Maximize CPU utilization, minimize idle time

Characteristics Multiprogramming

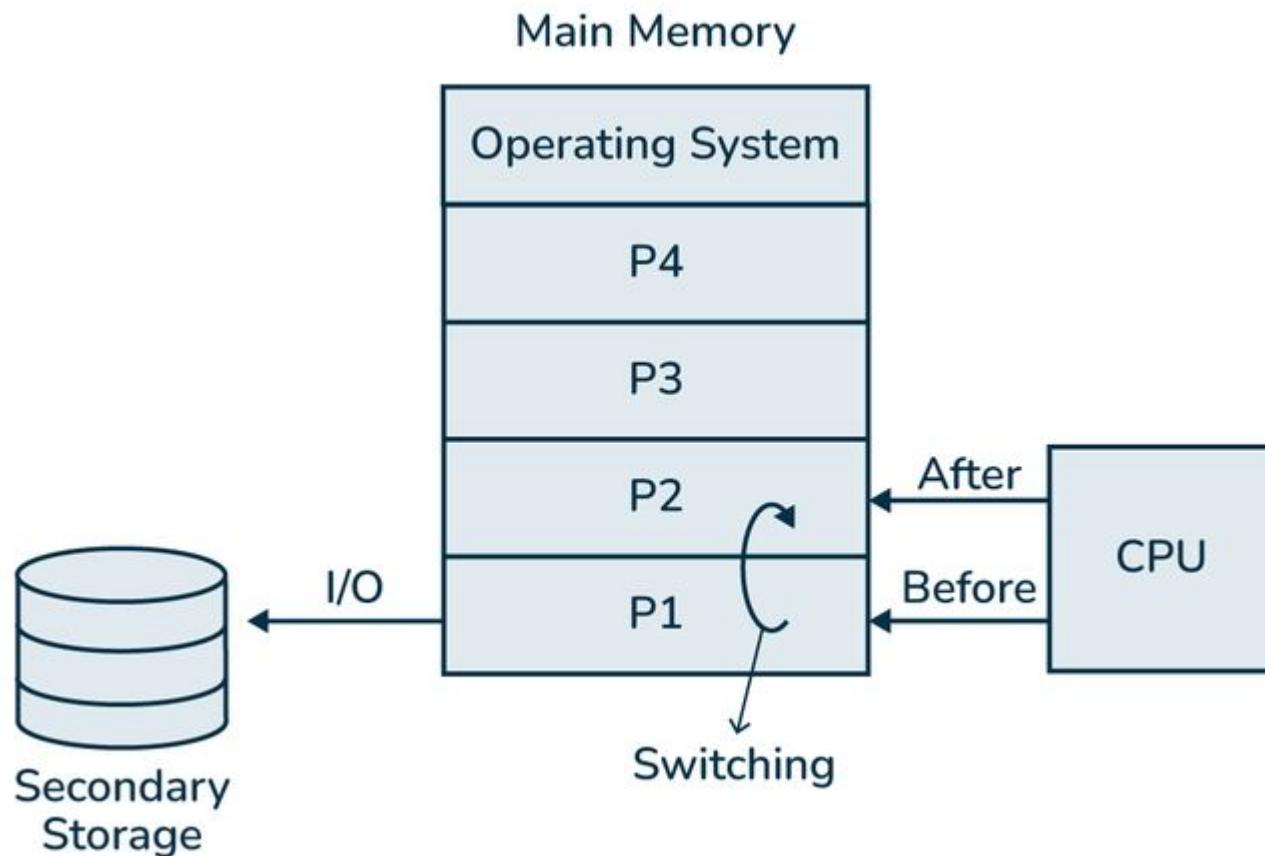
- Many jobs in memory.
- **Job Scheduling:** Only one job runs on the CPU at a time
- **Memory Management** is essential
- **State tracking** of each job: ready, running, waiting
- Jobs are usually **independent** and **non-interactive**



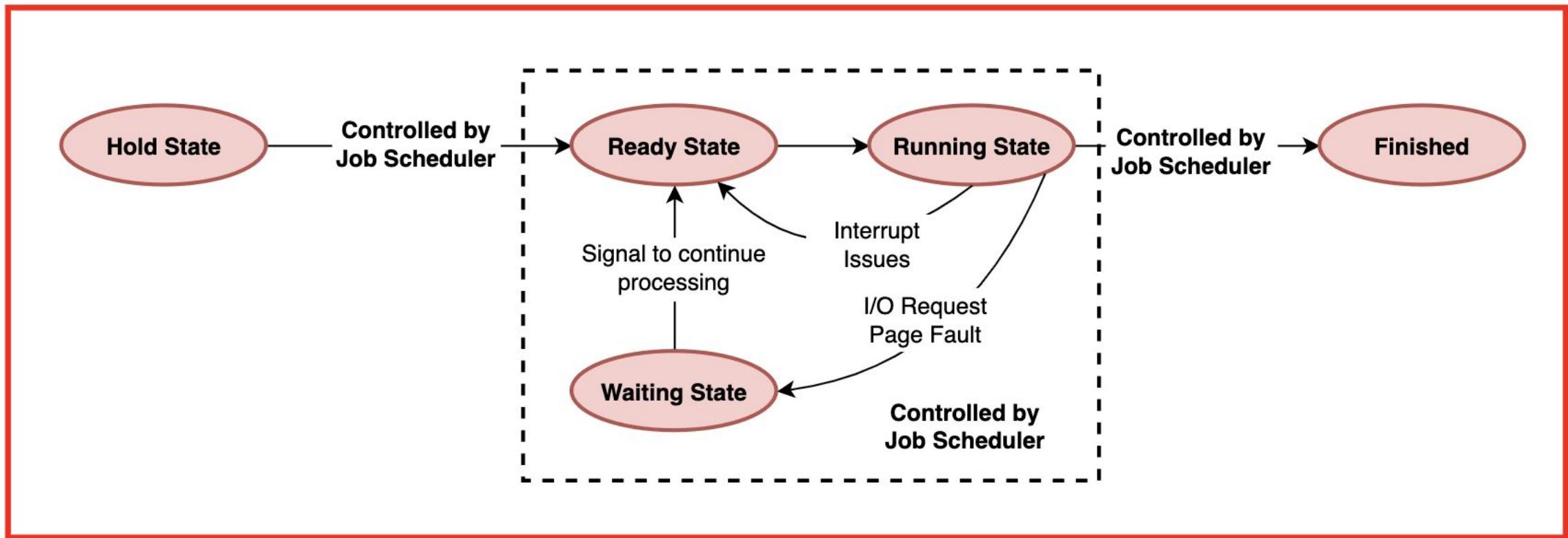
Multiprogramming vs. Simple Batch Systems

Feature	Simple Batch	Multiprogramming
Jobs in memory	One at a time	Multiple jobs
CPU Utilization	Often idle	High utilization
Scheduling	Sequential	Based on algorithm
Memory use	Not optimized	Efficiently shared

Architecture of Multiprogram Batch OS



Job States and Transitions



Job States and Transitions

Ready: Waiting for CPU

Running: Using CPU

Waiting: Waiting for I/O

Terminated: Finished execution

Scheduling in Multiprogramming OS

- **Scheduling** is crucial to decide which job gets the CPU
- Scheduler selects a job from the **ready queue**
- Happens when:
 - Running job finishes
 - Job requests I/O
 - Another job with higher priority arrives

Types of CPU Scheduling Algorithms

- FCFS (First-Come-First-Served)
- SJF (Shortest Job First)
- Round Robin

Advantages of Multiprogramming

- **Better CPU utilization** – keeps CPU busy
- Overlaps I/O and computation
- **Higher throughput** – more jobs completed per hour
- **Reduces waiting time** for shorter jobs

Limitations and Challenges

- More **complex OS design**
- Requires **efficient memory allocation and protection**
- **Scheduling overhead** and **context switching**
- Risk of **deadlocks** if multiple jobs wait on resources

Real-World Usage and Evolution

- Used in **mainframe systems** like **IBM OS/360**
- Forms basis for **modern multitasking OS** (Windows, Linux, UNIX)
- Concepts used in **cloud batch processing** and **job schedulers** (e.g., Kubernetes, cron).

Quiz

- What is multiprogramming?
- Why do we need CPU scheduling?
- Name two CPU scheduling algorithms.
- What happens when a job waits for I/O?