Chapter 06: Instruction Pipelining and Parallel Processing

Lesson 14:
Example of the Pipelined CISC and RISC Processors

Objective

- To understand pipelines and parallel pipelines in CISC and RISC Processors by Examples

Most modern processors

- Improve performance —SunSparc, Pentiums, PowerPCs are the superscalars and examples of pipelining and parallel processing of instructions

Pentium and PowerPC pipelines in parallel

- Performance improves in processors by allowing independent instructions to execute simultaneously (instruction-level parallelism)
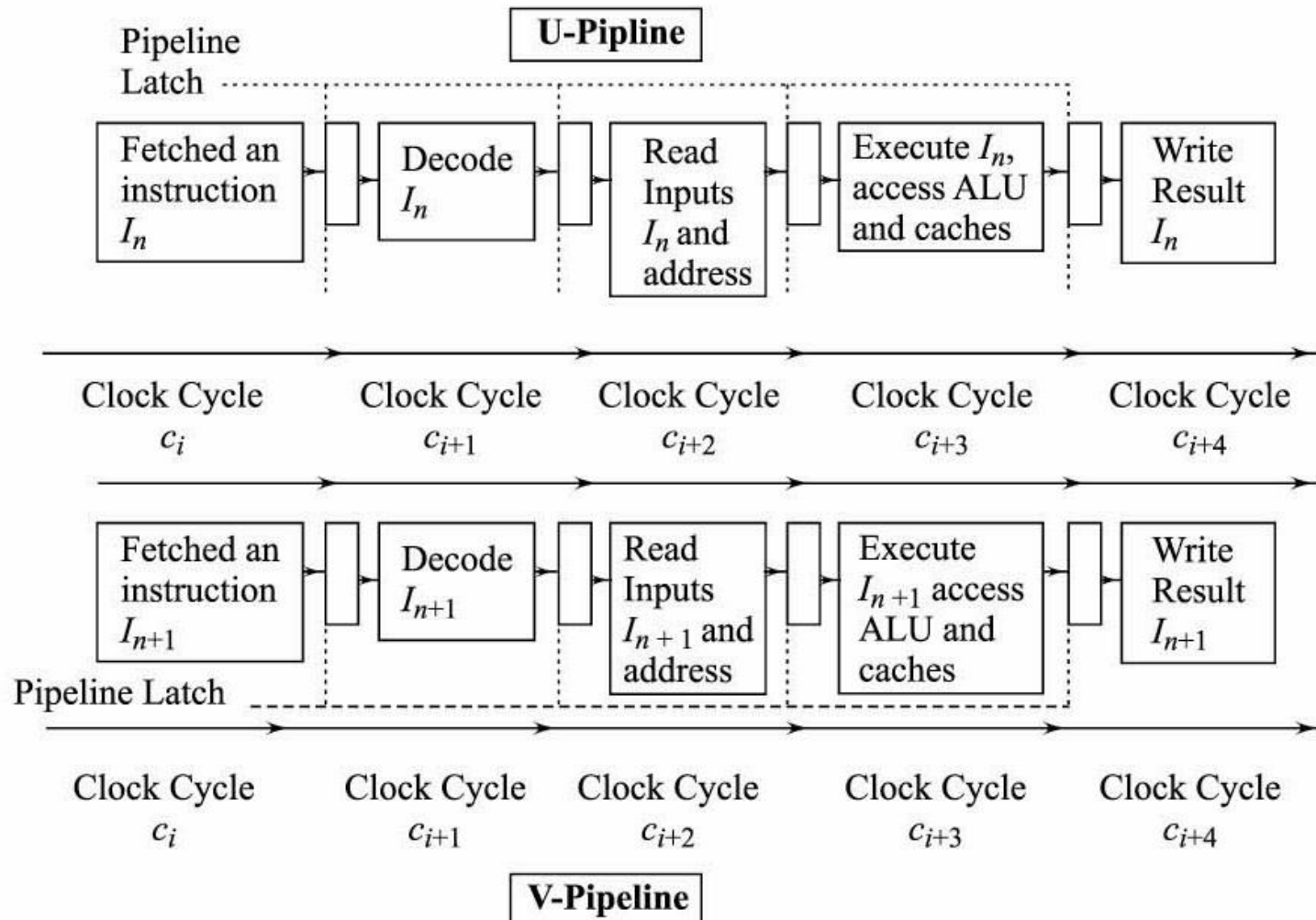
Pentiums

Pentiums

- The superscalar processors

- Have simple I-bit-technique─ based dynamic branch prediction

Pentiums Two pipelines

- Named as U and V
- V pipeline─ for simple instructions and
- U─ for any instruction
- 64-bit wide external data bus
- The conditional jump was made a second instruction among the two running in parallel

Pentium U and V pipelines

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Two instructions proceed through the parallel pipelines

- Two instructions proceed through the parallel pipelines at one stage per cycle, until they reach the register (result) write-back (WB) stage

- At WB the execution of instruction I_n is complete in pipeline 1 and I_{n+1} in 2

Pentium U and V pipelines

- In earlier versions, Pentium processors executed two integer instructions or two floating-point instructions in parallel

Pentium U and V pipelines

- Pentium's later versions had three independent units, two for integer operations and one for floating-point operations

- Pentium Pro version had an additional pipeline and supported two integer operations and two floating-point operations in four pipelines

- **Pentium II** versions had additional MMX instructions

Pentium MMX

(a) 128-bit MMX registers, each for two packed 64-bit floating-point operations and pipelines has 20-stages

(*b*) 128-bit MMX registers, each for two packed 64-bit floating-point operations and pipelines has 10-stages

(*c*) Two number 64-bit MMX registers, each for one packed 64-bit floating-point operations and pipelines has 5 stages

(*d*) Four number 32-bit MMX registers, each for two packed 64-bit floating-point operations and pipelines has four sets of 5-stage pipelines.

Pentium III versions

- Introduced single instruction multiple data SIMD instructions with extension for execution of streaming floating point operations in pipelines

- Pipelines had 10 stages

Pentium IV versions

- **I**ntroduced in the twenty-first century with 1GHz plus clock cycles

- 128-bit XMM (extended multi media) registers, each for two packed 64-bit floating-point operations

- The 128-bit registers handle long integers also

- Pipelines have 20 stages

PowerPC Processor

PowerPC

- IBM, Motorola, and Apple developed the PowerPC superscalars

- An RISC design but provides for more than 200 instructions at the instruction set

Schaum's Outline of Theory and Problems of Computer Architecture
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PowerPC

- Load and store architecture (only the LD and ST access the memory and not the arithmetic and logic instructions)

- Separate GPRs and floating-point registers

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PowerPC

- PowerPC 601 and 603 have three pipelines each— one for branch processing, one for integers (E-integer Pipeline), and one for floating-point (E-floating point Pipeline) operations

Uneven number of Stages in Pipelines

- There are five stages in the integer-processing pipeline, six in the floating-point pipeline, and two in the branch-processing pipeline stages
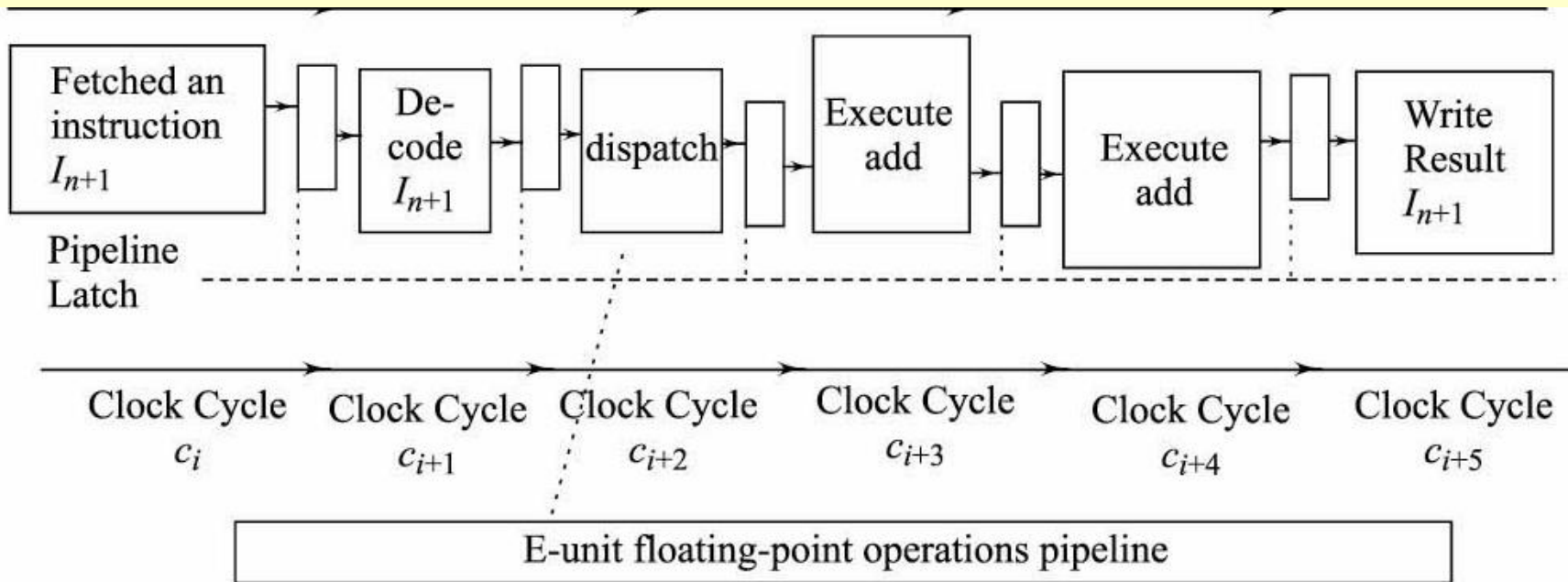
Stages in Pipelines

- The second stage in E-integer line decodes, reads, and dispatches operands

- The third stage in E-integer line executes and computes memory addresses

- The fourth stage is cache access
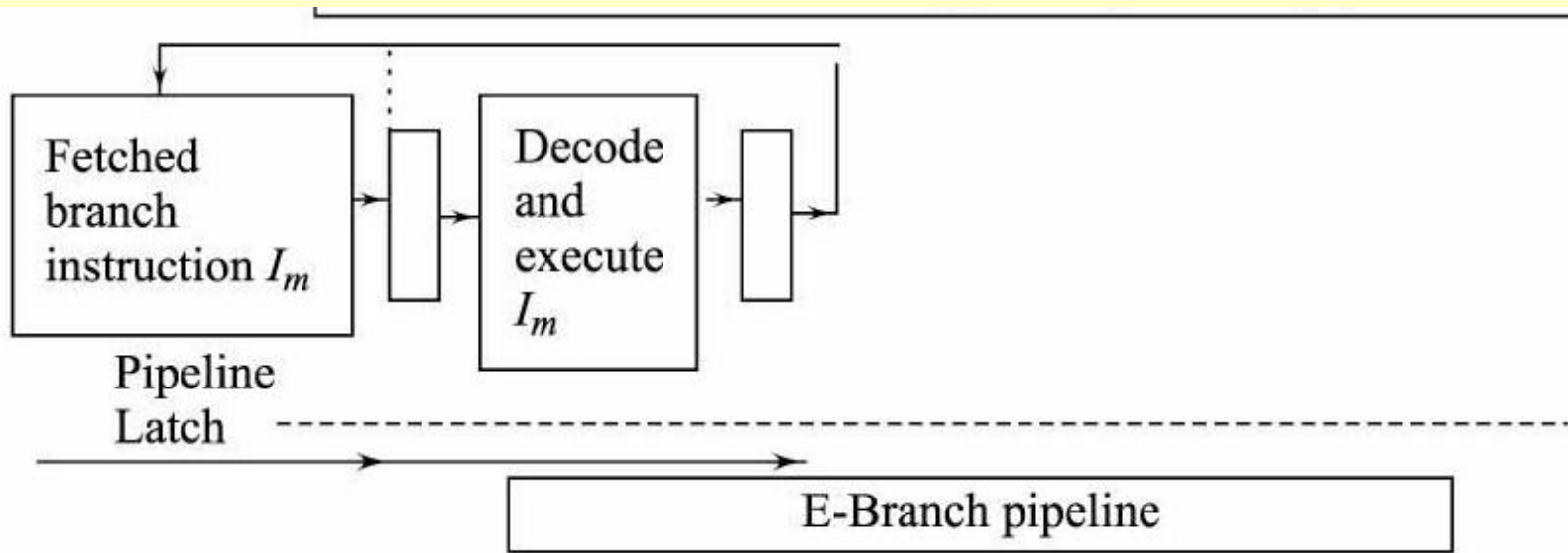
E-unit Integer Operations Pipeline

E-unit Floating point operations pipeline
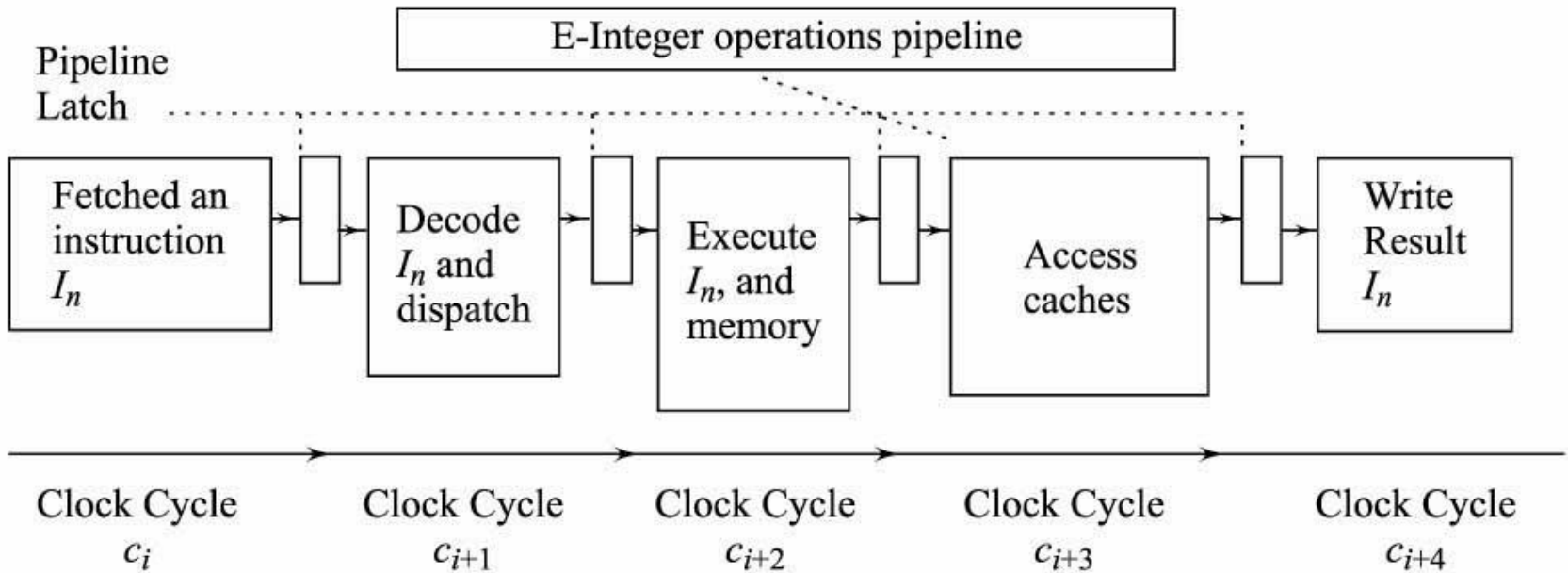
E-unit floating-point operations pipeline

E-branch pipeline

PowerPC version 604

- Six pipelines
- Three integer and one floating-point instruction in parallel per clock cycle.
- There were six independent units, two for integer operations, two for floating-point operations, and two for branch processing

PowerPC version 620

- PowerPC 620 had 64-bit operations. It also had six pipelines and three integers and one floating-point instruction in parallel per clock cycle

PowerPC 750 series

- Introduced in twenty-first century and has many features.

- MPC7XXX has eleven independent pipeline units— load and store processing unit, branch-processing unit, floating-point unit, four integer operations, and two for floating-point operations and packed data operations.

ARM

ARM (Advance RISC Machines)

- ARM (Advance RISC Machines) developed the large variations in superscalars as per application-specific needs
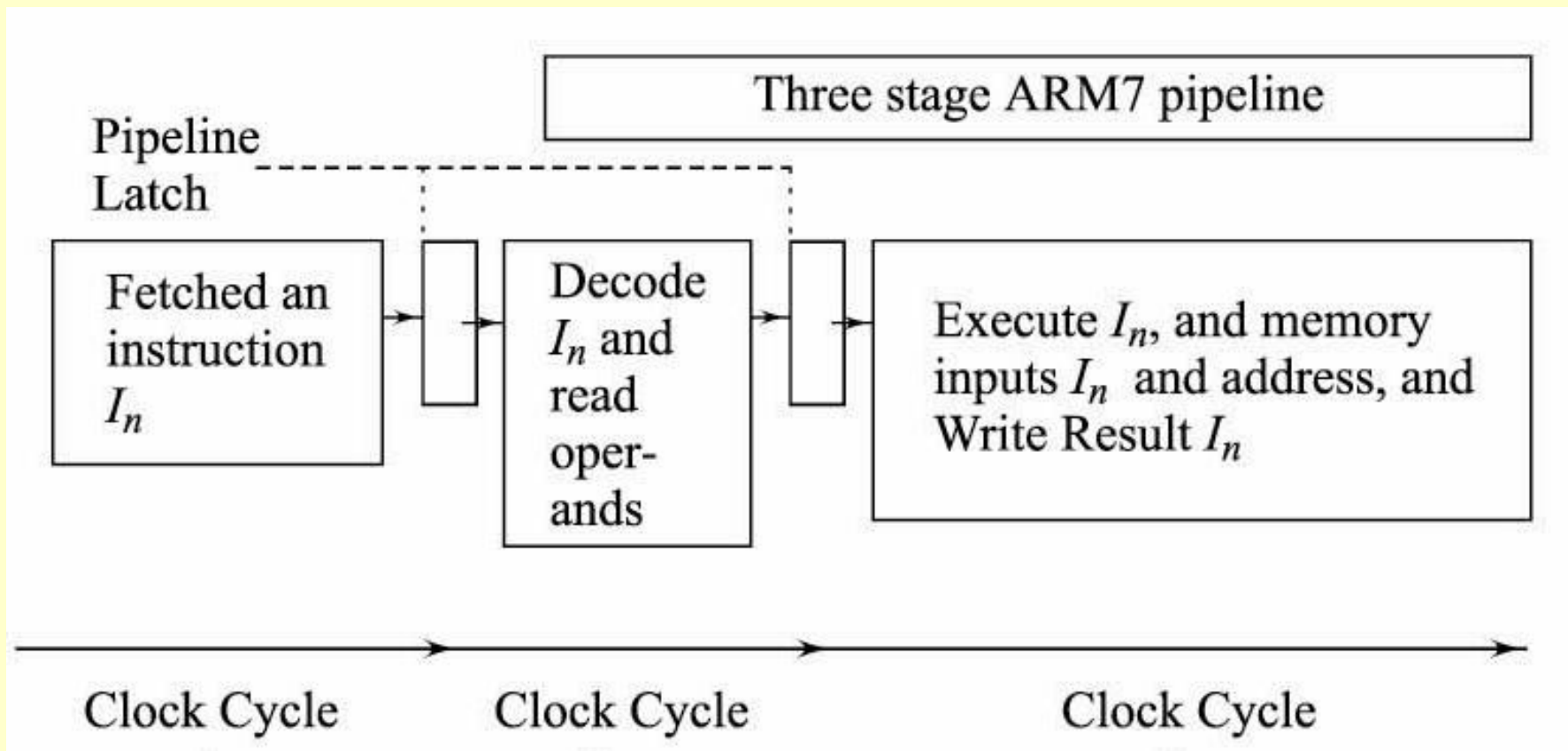
ARM (Advance RISC Machines)

- It has separate 16 GPRs, CPSR, and SPSR (Current Process Saved Status Register and Saved Process Status Register)

ARM RISC design
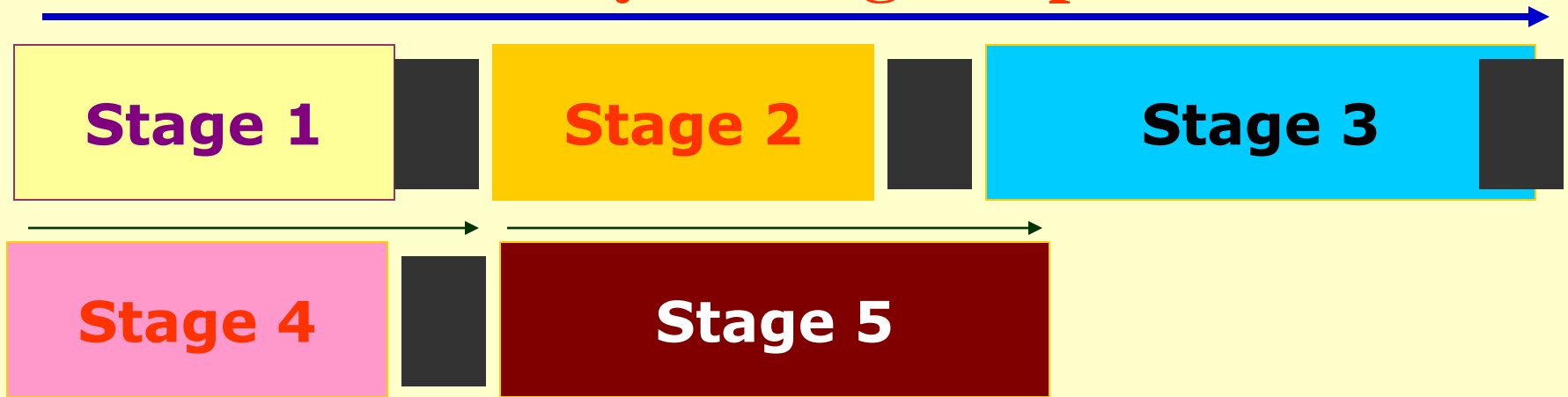
- ARM7TDMI had three stages pipeline

ARM7 three stage pipeline

Three stage ARM7 pipeline

Pipeline Latch

Fetched an instruction I_n

Decode I_n and read oper-ands

Execute I_n, and memory inputs I_n and address, and Write Result I_n

Clock Cycle   Clock Cycle   Clock Cycle

Five Clock Cycle Stages Pipeline

Stage 1		Stage 2		Stage 3

Stage 4		Stage 5

- StrongARM has 5-stage pipeline and a high-speed multiplier circuitry

- ARM9 has 5-stage pipeline

Pipelines in ARM 10

Five Stages Clock Cycle Pipeline

Stage 1	Stage 2	Stage 3
Stage 4	Stage 5	Stage 6
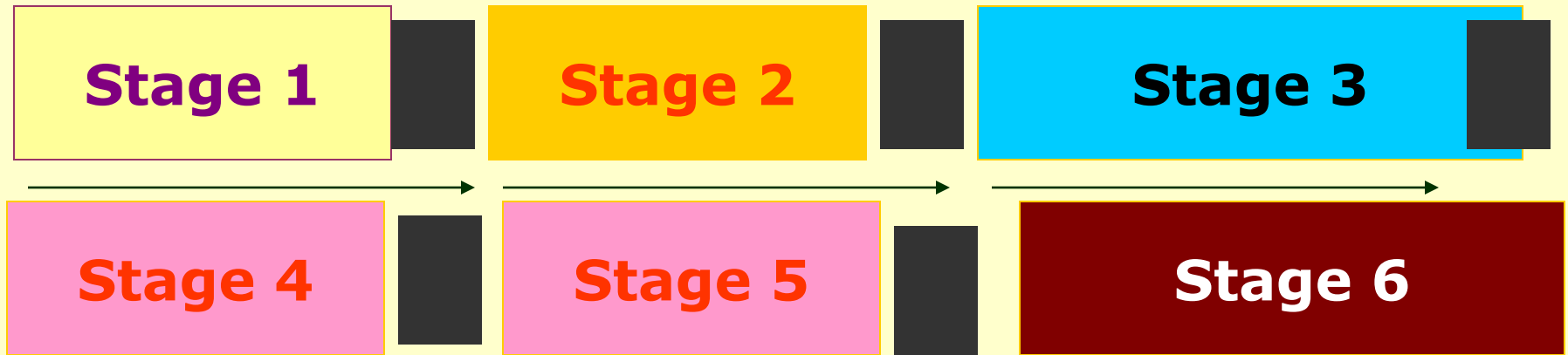
ARM10 has 6-stage pipelines

Summary

We learnt

- Superscalar Processors Pentium, PowerPC
- ARM pipelines

End of Lesson 14 on
Example of the Pipelined CISC and RISC Processors