



2110412

Parallel Computer Architecture: Multi-core Tech.

1: Introduction to Parallelism

Krerk Piromsopa, Ph.D.

Department of Computer Engineering
Chulalongkorn University

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Today's Goal:

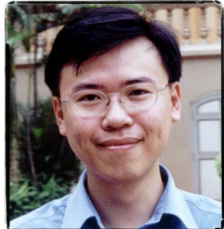
- Overview of this class
 - Grading, Outline, etc
- Introduction to Parallel Computer Architecture
- Basic Terminology
- Introduction to Parallelism

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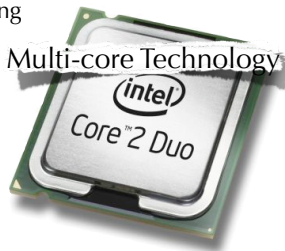
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Who is in charge?

Mr. Grid
Algorithm/Programming



Multi-core Technology



Mr. Architecture
Architecture

Mr. Cluster
Performance / Systems / Cases



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Grading

- Assignments
 - Krerk: Experiments/Assignments 10%
 - Natawut: Benchmarks Lab 10%
 - Veera: Programming Lab 20%
- Midterm 25%
- Final 35%

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What is Parallel Architecture?

- What do the GURUs say about it?
 - A parallel computer is a collection of processing elements that cooperate to solve large problems fast.
 - Parallel computing is a form of computation in which many instructions are carried out simultaneously.

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Why Parallel Computing?

- A large problem can be divided into several smaller problems, which can then be solved concurrently.
- Have been used for many years, mainly in high-performance computing.
- Why it is more interesting now?
 - physical constraints of frequency scaling (e.g. power wall)
 - emerging of parallel scaling
- Cheaper (comparing to SuperComputer)

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Known Issues

- Performance ?
- Memory Wall
- Parallelism
- Power Consumption
- Etc.

See

Amdahl's law

$$S = 1 / (1 - P)$$

and
Gustafson's law

$$S(P) = P - \alpha(P-1)$$

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About performance

- Given
 - Execution Time =
#Instructions x CPI x Cycle Time
- How does parallel computing make it faster?

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Products

- intel Core / Core2
- IBM Xenon - 3 cores, 2 SMT each (Xbox 360)
- STI Cell Broadband Engine Architecture - (Sony PS3 - 1 PPE + *7 SPEs)
- Sun microsystems' Ultra SPARC T1 (Niagara)

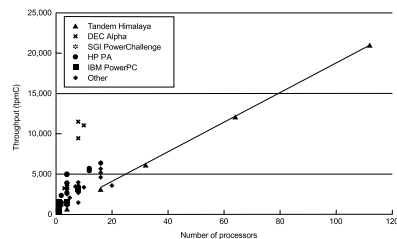
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Why Parallel?

TPC-C Results for March 1996



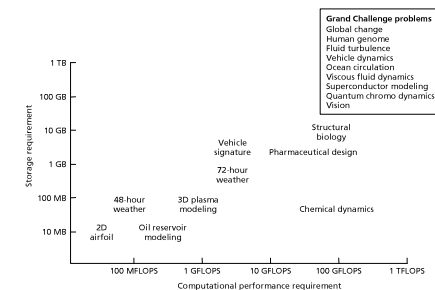
- Parallelism is pervasive
- Small to moderate scale parallelism very important
- Difficult to obtain snapshot to compare across vendor platforms

Slide is taken from David Culler's.

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Why Parallel?

Scientific Computing Demand

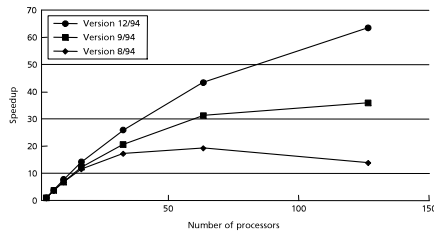


Slide is taken from David Culler's.

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Is it perfect?

Is better parallel arch enough?



- **AMBER molecular dynamics simulation program**
- Starting point was vector code for Cray-1
- 145 MFLOP on Cray90, 406 for final version on 128-processor Paragon, 891 on 128-processor Cray T3D

Slide is taken from David Culler's.

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Terminology

- Chip Multi-core processor (CMP)
- Massive Parallel Processing (MPP)
- Simultaneous Multi-Threading (SMT)
- SuperScalar processor
- Symmetric Multiprocessing (SMP)
- VLIW
- Distributed Computing
- Dynamic scheduling
- Cluster Computing
- etc..
- Grid Computing

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Parallelism

- Bit-level parallelism
- Instruction-level parallelism
- Thread-level parallelism
- Data-level parallelism
- Task-level parallelism

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Flynn's Taxonomy

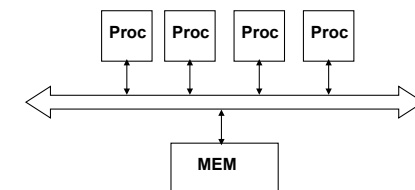
instruction x # Data

Single Instruction Single Data (SISD)

Single Instruction Multiple Data (SIMD)

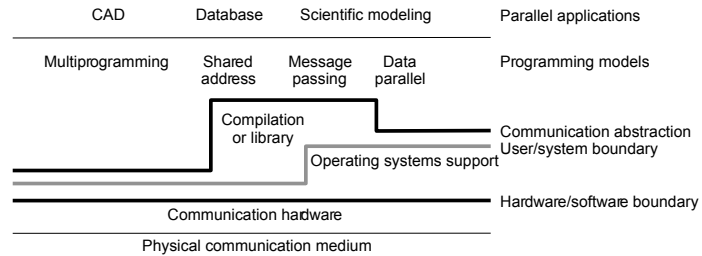
Multiple Instruction Single Data (MISD)

Multiple Instruction Multiple Data (MIMD)



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Parallel Computer



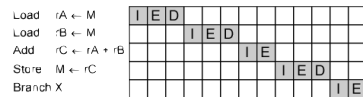
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Approaches to ILP

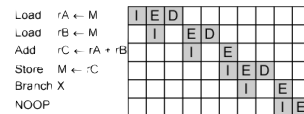
- Vector Instruction
- Instruction Pipelining
- Superscalar
- Out-of-order Execution
- Register renaming
- Speculative Execution
- Multithreading
- Multiprocessing

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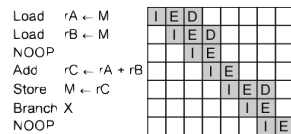
Pipeline



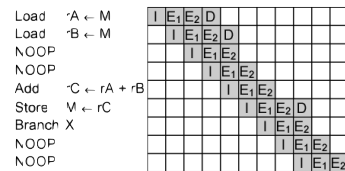
(a) Sequential execution



(b) Two-stage pipelined timing



(c) Three-stage pipelined timing

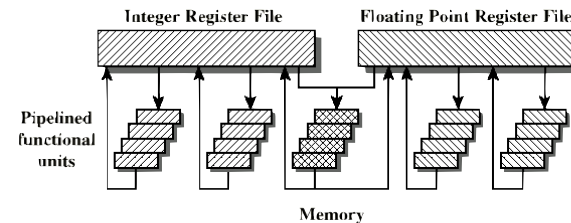


(d) Four-stage pipelined timing

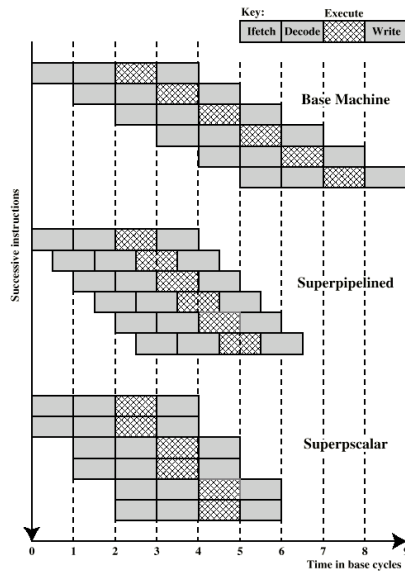
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What is SuperScalar?

- Common instructions (arithmetic, load/store, conditional branch) can be initiated and executed independently
- Equally applicable to RISC & CISC
- In practice usually RISC



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Limitation

- Instruction level parallelism
- Compiler based optimization
- Hardware techniques
- Limited by
 - True data dependency
 - Procedural dependency
 - Resource conflicts
 - Output dependency
 - Antidependency

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