

Parallel and Distributed Systems – Introduction

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1/12/2011

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1

General Course Information

- Course Web page
 - <http://www.cs.rochester.edu/~kshen/csc258-spring2011>
- Contact through broadcast emails
- Text and references
- Accounts in computer science research lab
- Assignments/project/participation/presentation

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2

Parallel Computing

- Parallel computing
 - Process sub-tasks simultaneously so that work can be completed faster.
 - Example applications?

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3


Parallel Application Examples

- Scientific simulations
 - heat propagation on a surface
 - weather system interaction and evolution
- Google PageRank - sparse matrix computation
- SETI@home
- Internet servers
- I/O parallelism

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4



Parallel & Distributed Computing

- Parallel computing
 - Process sub-tasks simultaneously so that work can be completed faster.
- Distributed computing
 - A set of autonomous computers (connected through network) work together to achieve unified goals.
 - Examples?
- Mutually exclusive?


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Parallel & Distributed Systems

- "General-purpose" hardware and software systems that support parallel & distributed computing
- Hardware?
- Operating systems?
- Programming systems?

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Why Parallel Computing?

The speed of uniprocessor will catch up with the need of computing?

- Moore's law (1965, with later revisions) - circuit complexity doubles every one year (18 months, 2 years)
- Some argue that it is a self-fulfilling prophecy
- Moore said in 2005:
"In terms of size [of transistors] you can see that we're approaching the size of atoms which is a fundamental barrier, ..."

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Why Parallel Computing?

Not always desirable to use the fastest hardware

Example:

- A machine with four 3GHz processor cores, 2GB memory, and hard drives consumes about 250 Watts
- A machine with a 500MHz CPU, 128MB memory, and a CompactFlash drive consumes about 5 Watts
- It may be more energy-efficient to use multiple low-power machines in parallel

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Why Parallel Computing?

Multiprocessors are increasingly ubiquitous

- Commodity processors contain multiple computing cores because they are cost-effective to produce
- Traditionally sequential software (e.g., desktop applications) should take advantage of it

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9

Arguments against Parallel Computing?

- Parallel programming is too difficult
- Performance isn't important

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10

Why Distributed Systems?

- With advances in networking, including local-area network, Internet, and wireless sensor network
 - Distributed computers and people are increasingly connected
- Desired services in networked world:
 - information exchange and sharing,
 - resource sharing,
 - collaboration,
 - ...

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11

Why Distributed Systems?

- Scalability
- Availability
- Durability

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12

Problems with Distributed Systems?

- Distributed systems are too complex, unpredictable
- Security vulnerabilities

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13

What will be covered?

- Unscientific poll (Google hits)
 - "Parallel computing" 2.5M
 - "distributed computing" 12.8M

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14

Parallel Programming

- Challenges:
 - Control dependencies
 - Data sharing
- Parallel algorithms:
 - Identification of parallelisms in applications
 - Design control flow and data sharing mechanism
- Parallel programming:
 - Shared memory
 - Distributed memory

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15

Shared Memory Parallel Systems

- In shared memory parallel computers, multiple processors can access the memory simultaneously
 - Examples (large and small)
- Problems:
 - One processor's cache may contain a copy of the data that was just modified by another processor
 - ⇒ hardware support for cache coherence
 - Two processes' (semantically) atomic operations may be interleaved
 - ⇒ system support for mutual exclusion

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16

Multicore Resource Management

- Multicore systems contain critical, shared resources
 - Memory bandwidth
 - Cache space in cache-sharing multicores
- Management of shared resources
 - Goals - efficiency, fairness (DoS attacks possible)
 - Means - limited in software level

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17

Distributed Memory Parallel Systems

- Parallel systems that do not share memory
 - Examples
- Less requirement on the system support
 - Little or no hardware support
 - Software system support for communications (point-to-point, group)
- More trouble with writing applications
 - Data must be explicitly partitioned and transferred when needed
 - Hard to do dynamic workload management

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18

Distributed Computing

- Consistency in distributed systems with failures
 - Models: fail-stop, Byzantine
- Problems:
 - Distributed consensus
 - Replication
- Data durability
- Distributed systems without centralized control (sometimes parties are not trusted)
 - Security and trust
 - Distributed reputation

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19

Cluster-based Servers

- Large Internet data centers (Google, Microsoft, ...)
 - Thousands of machines clustered together to serve online requests
- A form of parallel computing
 - Often embarrassingly parallel workload, but extremely large scale
 - Customized parallel programming model (MapReduce)
- Distributed system
 - Consistency, reliability, ...
- Additional issues
 - Power management, network topology, error monitoring

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20