

Introduction to Distributed Systems

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CS 553: Cloud Computing
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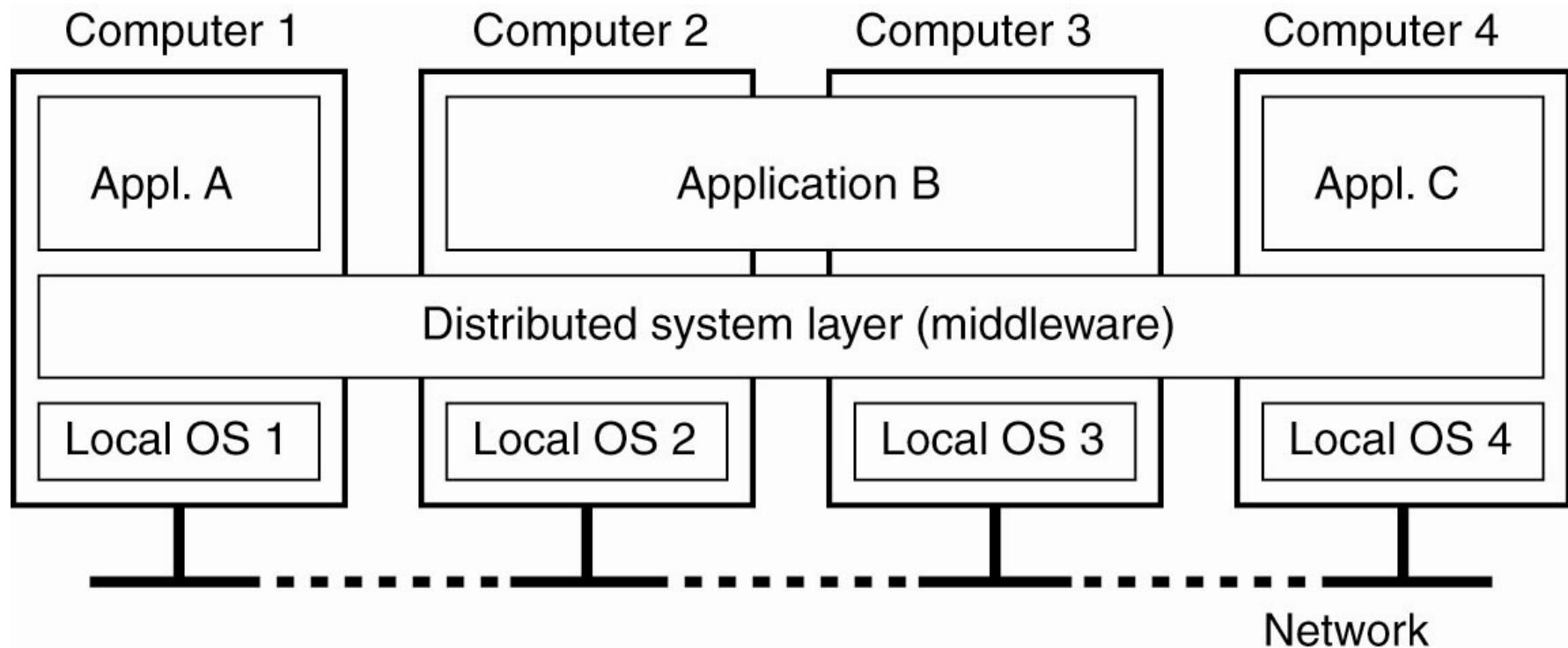
Distributed Systems

- What is a distributed system?

**“A collection of independent computers
that appears to its users as a single
coherent system”**

-A. Tanenbaum

Distributed Systems



A distributed system organized as middleware. The middleware layer extends over multiple machines, and offers each application the same interface.

Distributed vs. Centralized Systems

- Economics
 - Microprocessors have better price/performance than mainframes
- Speed
 - Collective power of large number of systems
- Geographic and responsibility distribution
- Reliability
 - One machine's failure need not bring down the system
- Extensibility
 - Computers and software can be added incrementally

Disadvantages of Distributed Systems

- Software
 - Little software exists compared to PCs
- Networking
 - Still slow and can cause other problems (e.g. when disconnected)
- Security
 - Data may be accessed by unauthorized users

Concurrency

- In a single system several processes are interleaved
- In distributed systems: there are many systems with one or more processors
 - Many users simultaneously invoke commands or applications
 - Many servers processes run concurrently, each responding to different client request

Scalability

- Scale of system
 - Few PCs servers ->dept level systems->local area networks->internetworked systems->wide are network...
 - Ideally, system and application software should not change as systems scales
- Scalability depends on all aspects
 - Hardware
 - Software
 - networks

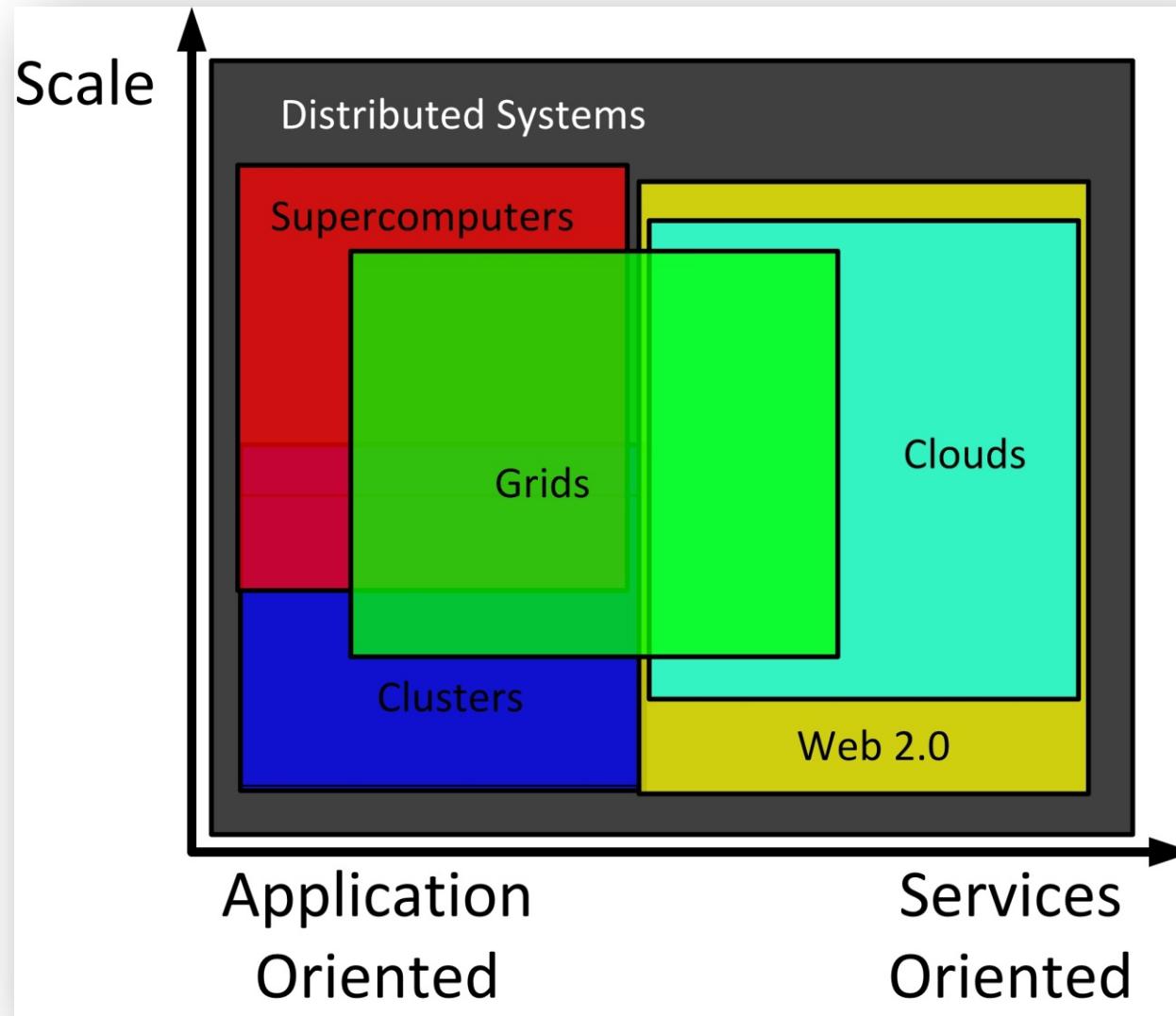
Fault Tolerance

- Definition?
- Two approaches:
 - Hardware redundancy
 - Software recovery
- In distributed systems:
 - Servers can be replicated
 - Databases may be replicated
 - Software recovery involves the design so that state of permanent data can be recovered

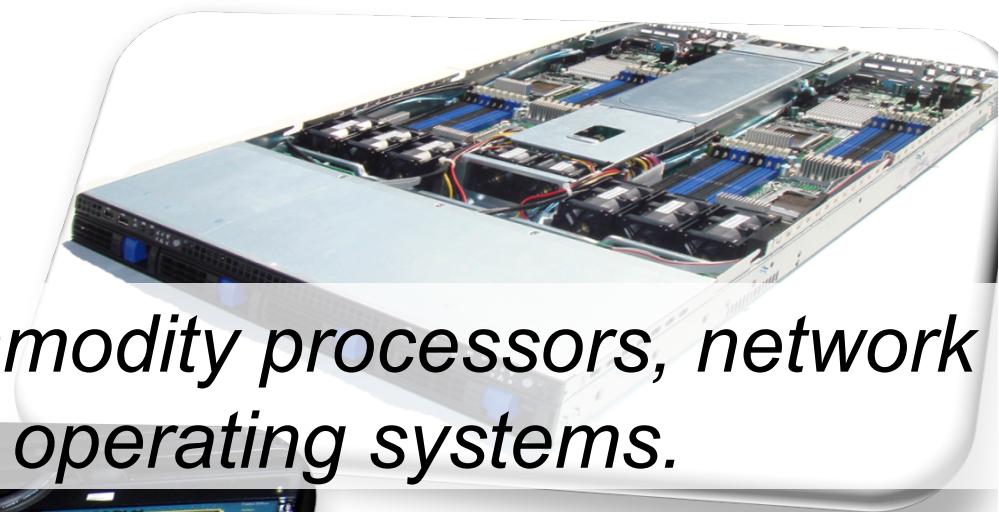
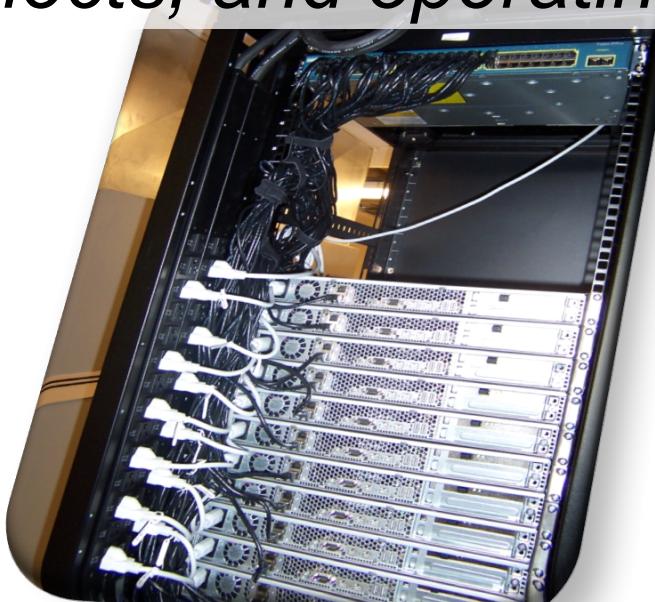
Pitfalls When Developing Distributed Systems

- False assumptions made by first time developer:
 - The network is reliable.
 - The network is secure.
 - The network is homogeneous.
 - The topology does not change.
 - Latency is zero.
 - Bandwidth is infinite.
 - Transport cost is zero.
 - There is one administrator.

Distributed Systems: Clusters, Grids, Clouds, and Supercomputers



Cluster Computing



Computer clusters using commodity processors, network interconnects, and operating systems.

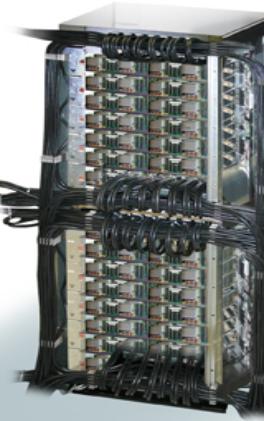
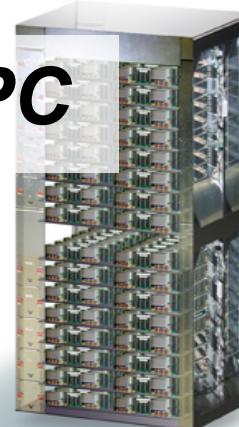
Supercomputing

Supercomputing ~ HPC

32 Node Cards

Rack Cabled 8x8x16

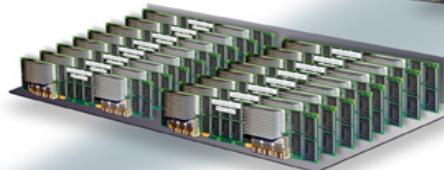
Baseline System
32 Racks



500TF/s
64 TB

Node Card

(32 chips 4x4x2)
32 compute, 0-4 IO cards



14 TF/s
2 TB

Compute Card

1 chip, 1x1x1

435 GF/s

64 GB

Chip

4 processor cores



13.6 GF/s

8 MB EDRAM

13.6 GF/s

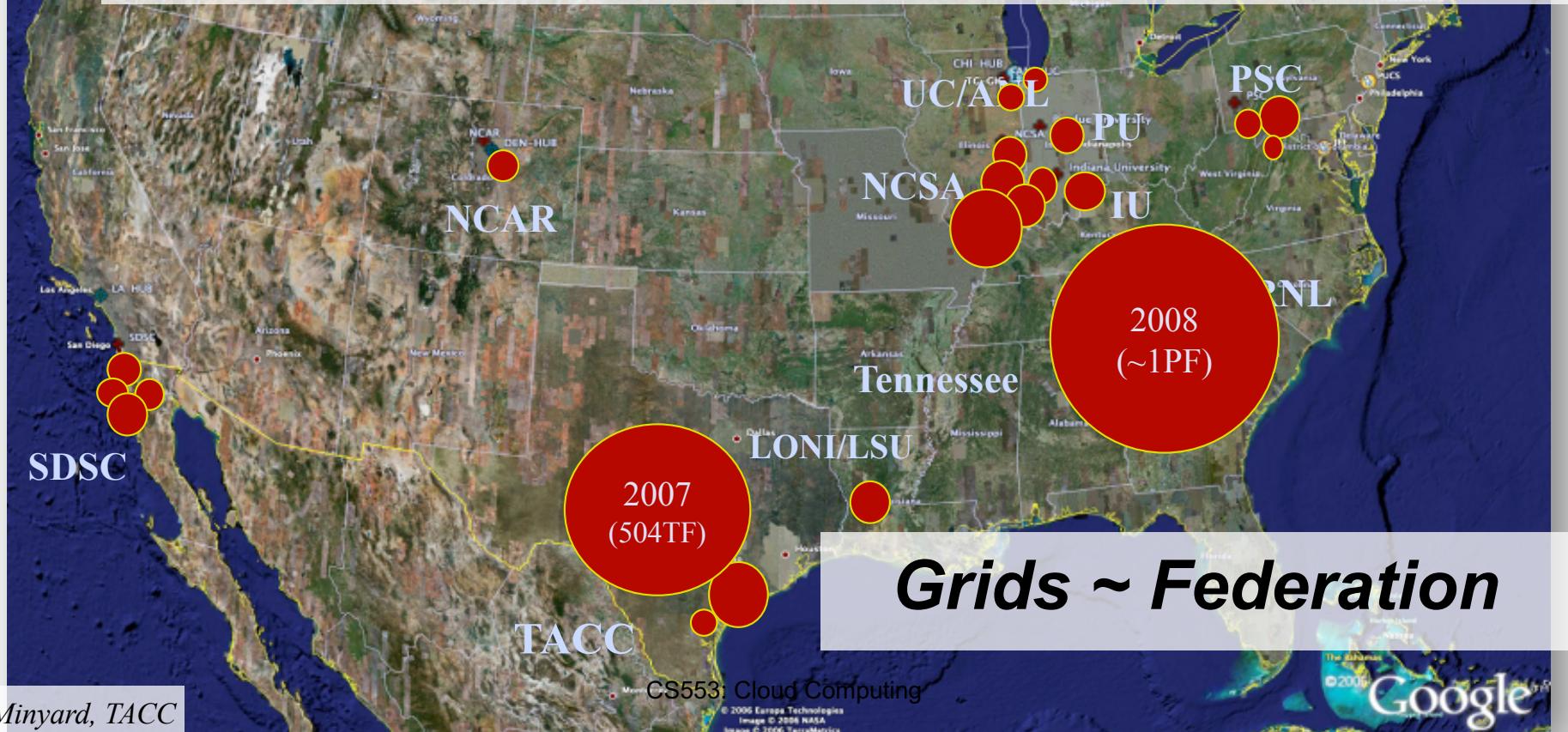
256 MB EDRAM

GS553 Quad Computing

Highly-tuned computer clusters using commodity processors combined with custom network interconnects and customized operating system

Grid Computing

Grids tend to be composed of multiple clusters, and are typically loosely coupled, heterogeneous, and geographically dispersed

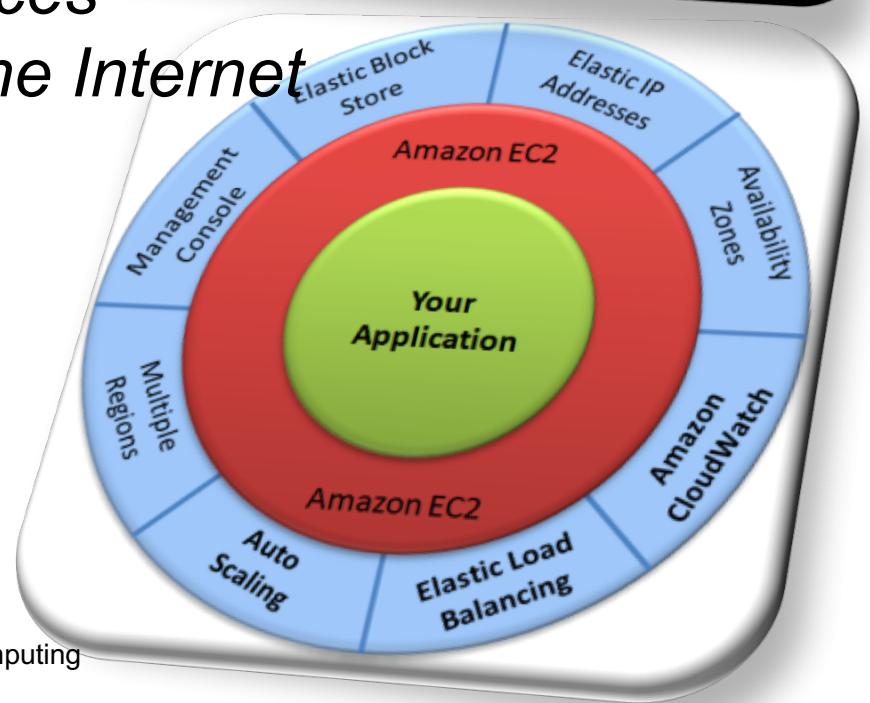


Cloud Computing

- A *large-scale distributed computing paradigm driven by:*
 1. *economies of scale*
 2. *virtualization*
 3. *dynamically-scalable resources*
 4. *delivered on demand over the Internet*



Clouds ~ hosting



Major Clouds

- Industry
 - Google App Engine
 - Amazon
 - Windows Azure
 - Salesforce
- Academia/Government
 - FutureGrid
 - Chameleon
- Opensource middleware
 - Nimbus
 - Eucalyptus
 - OpenNebula
 - OpenStack
 - CloudStack

Logistics

- PA1 (Performance Evaluation) will be out next Monday
- Tutorial for PA1 will be next Wednesday
- Friday next week is the last day to add/drop classes
- Read chapter 1 from textbook

Questions

