Introduction to Distributed Systems

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Based on slides by Maarten Van Steen

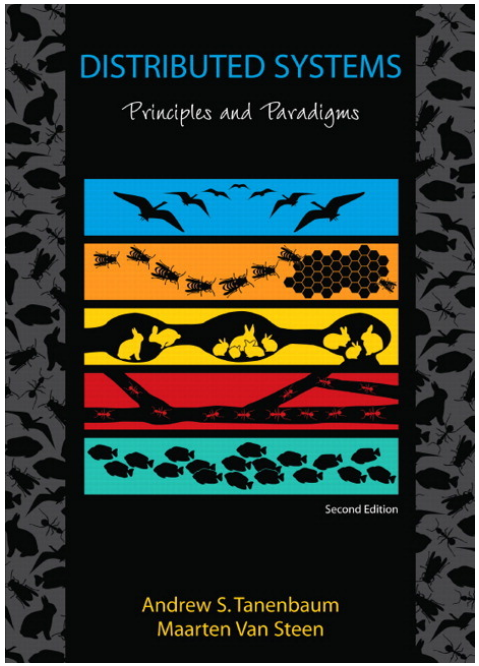
Course Information

Course Objective

- The course covers fundamental models for distributed systems:
  - Inter process communication
  - Synchronization
  - Consistency
  - Replication
  - Fault tolerance
  - Security

Course Material

- Distributed Systems: Principles and Paradigms, 2nd edition, 2007
  Andrew S. Tanenbaum and Maarten van Steen



Course Examination

- Mid term exam: 20%
- Final exam: 20%
- Review questions: 10 assignments 20%
- Lab assignments: four assignments in Java 40%
- The assignments should be done in group of two.

Distributed Systems
Definition and Goals

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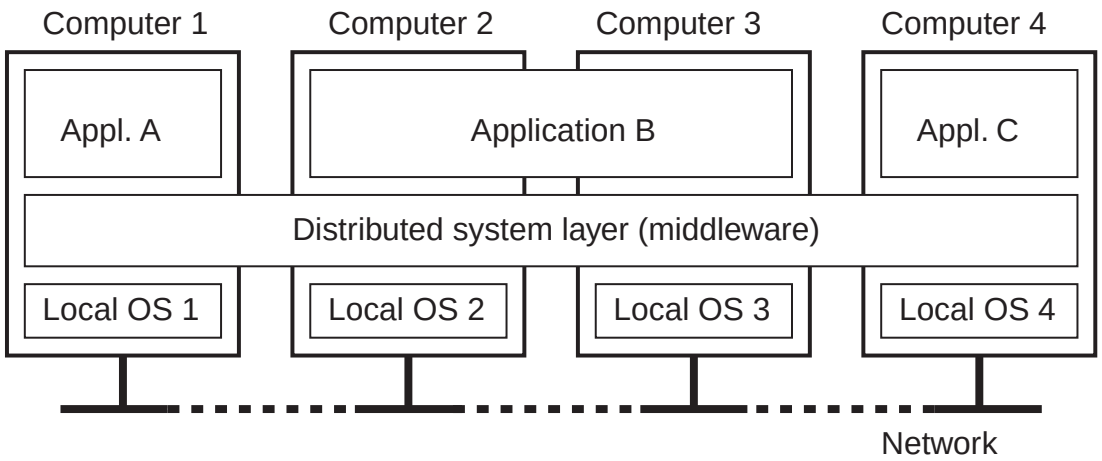
- Two aspects:
  1. Independent computers
  2. Single system $\Rightarrow$ middleware



Goals of Distributed Systems

- Making resources available
- Distribution transparency
- Openness
- Scalability

Resource Availability

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- Resources: printer, computers, storage, data, files, ...

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- Distribution transparency is a nice goal, but achieving it is a different story.

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- In some situations, hiding all distribution aspects from users is not a good idea.
- Trade-off between a high degree of transparency and the performance of a system.
- Completely hiding failures of networks and nodes is impossible.
  - You cannot distinguish a slow computer from a failed one.

Openness

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- Independent from heterogeneity of the underlying environment:
  - E.g., hardware, platforms, languages, ...

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  - Support different levels of trust for mobile code.
  - Provide adjustable QoS parameters per data stream.
  - Offer different encryption algorithms.

Scalability

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  - (Administrative scalability): number of administrative domains

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- Distribution: partition data and computations across multiple machines.
  - E.g., move computations to clients (Java applets), decentralized naming services (DNS), decentralized information systems (WWW)
- Replication/caching: make copies of data available at different machines.
  - E.g., replicated file servers and databases

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- If we can tolerate inconsistencies, we may reduce the need for global synchronization, but tolerating inconsistencies is application dependent.

Developing Distributed Systems: Pitfalls

- There are many false assumptions:
  - 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

Types of Distributed Systems

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- Distributed Computing Systems
- Distributed Information Systems
- Distributed Pervasive Systems

Distributed Computing Systems

Distributed Computing Systems: Cluster

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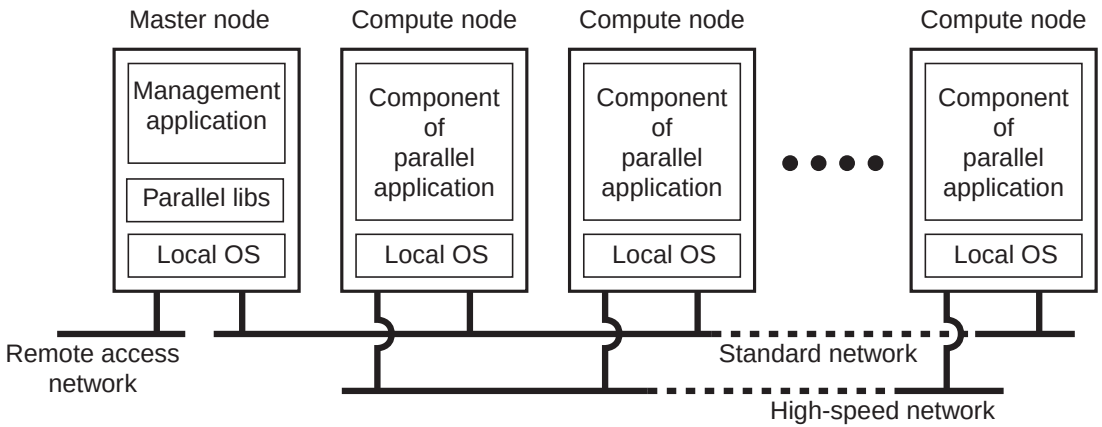
- Many distributed systems are configured for High-Performance Computing.
- Cluster computing: a group of high-end systems connected through a LAN.
  - Homogeneous: same OS, near-identical hardware
  - Single managing node



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- To allow for collaborations, grids generally use virtual organizations.
  - A group of users that will allow for authorization on resource allocation.

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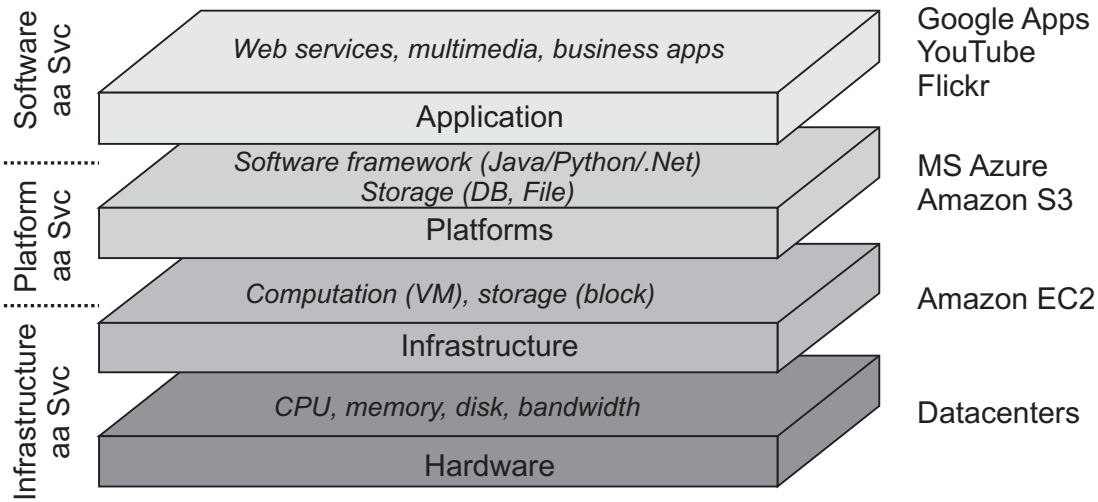
  - Platform: provides higher-level abstractions for storage and such. (PaaS)
  - Application: actual applications, such as office suites, e.g., text processors, spreadsheet applications. (SaaS)

Distributed Computing Systems: Cloud (2/2)



Distributed Information Systems

Distributed Information Systems

- The vast amount of distributed systems in use today are forms of traditional information systems, that now integrate legacy systems.
- Example: transaction processing systems.

```
BEGIN_TRANSACTION(server, transaction)
READ(transaction, file-1, data)
WRITE(transaction, file-2, data)
newData := MODIFIED(data)
IF WRONG(newData) THEN
  ABORT_TRANSACTION(transaction)
ELSE
  WRITE(transaction, file-2, newData)
  END_TRANSACTION(transaction)
END IF
```

- Transactions form an atomic operation.

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- Durability: after the execution of a transaction, its effects are made permanent.

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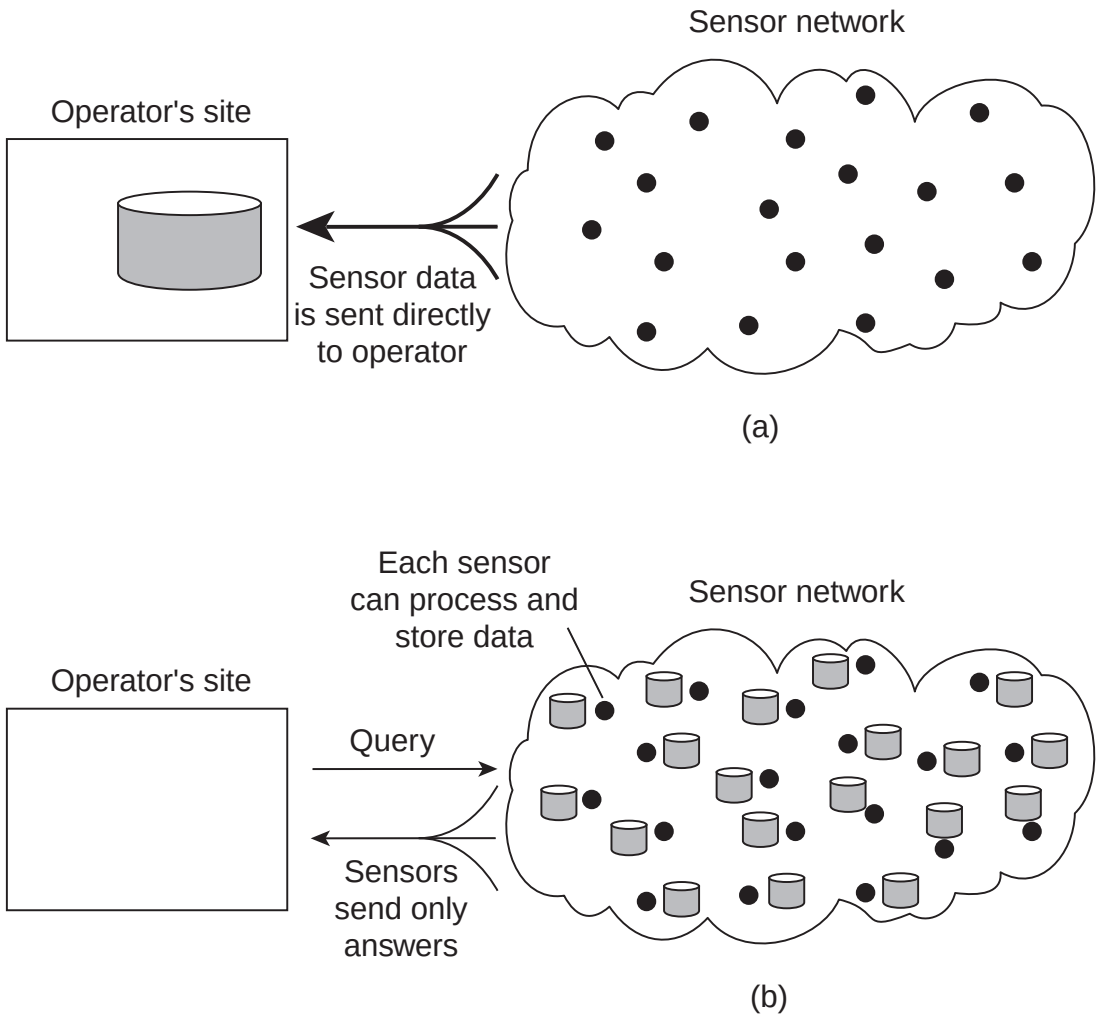
- Some requirements:
  - Contextual change: the system is part of an environment in which changes should be immediately accounted for.
  - Ad hoc composition: each node may be used in a very different ways by different users.
  - Sharing is the default: nodes come and go, providing sharable services and information.

Sensor networks



Summary

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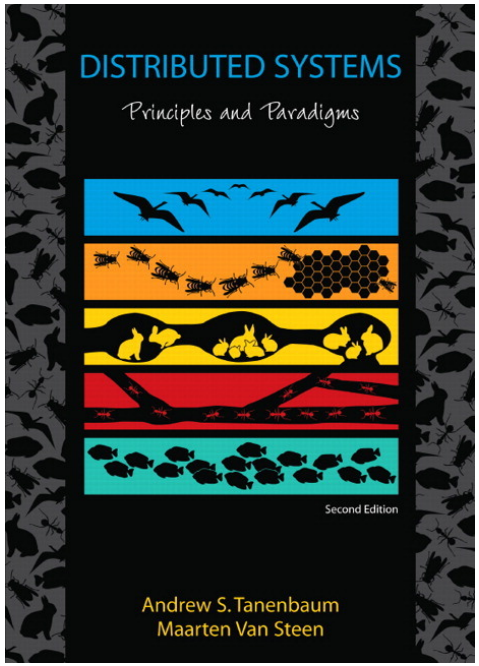
- Distributed system goals
  - Making resources available
  - Distribution transparency
  - Openness
  - Scalability
- Types of distributed systems
  - Distributed computing systems: cluster, grid, cloud
  - Distributed information systems: transaction (ACID)
  - Distributed pervasive systems: sensor networks

Reading

- Chapter 1 of the Distributed Systems: Principles and Paradigms.



Questions?