Distributed Systems & Network Principles

Introduction

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School of Information Technologies

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Outilne

- Administration
  Syllabus, goal, plagiarism, etc.
- Definition
  What is a distributed system?
- Examples
  Several distributed systems you might have heard of
- Challenges
  Scalability, Consistency, Fault-Tolerance

Administration

Timetable

- Title: Distributed Systems & Network Principles
- UOS code: COMP2121
- Credit point: 6
- Lecture:
  - Wednesday 12h-14h, weeks 1-13
  - School of IT Lecture Theatre
- Lab:
  - Wednesday 15h-16h, weeks 2-13
  - W15A Link Building 222 (north and south)

Myself

- Vincent Gramoli
  - Office: 417
  - Phone: (02) 903 69270
  - Vincent.Gramoli@sydney.edu.au
  - http://sydney.edu.au/engineering/it/~gramoli/
  - Office hour: Wednesday 14h-15h

- Background
  - Distributed storage, multicore programming.
  - France: IRISA, INRIA Futurs, Univ Rennes
  - USA: U. Connecticut, MIT, Cornel U.
  - Switzerland: U. Neuchatel, EPFL

eLearning

- eLearning: https://elearning.sydney.edu.au/
- Do not send email to the lecturer, but post questions online
- Notify us in advance if something unexpected will happen
- Usual things otherwise: notify us 7 days in advance
- Send proof (certificate) and you will be evaluated through an alternative mark assessment

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Description

- The unit will provide a broad introduction to the principles of distributed systems and their design; provide students the fundamental knowledge required to analyse and construct various types of distributed systems; explain the common architectural principles and approaches used in the design of networks at different scales (e.g. shared medium access and routing); introduce the programming skills required for developing distributed applications, and will cover the use of Java class libraries and APIs; cover common approaches and techniques in distributed resource management (e.g. task scheduling).

What you need to know

Distributed systems

- What is a distributed system?
- How it works?
- How to run yours?

Programming

- Most labs will require some programming
- All programming will be done in Java

Overall Goal

Distributed systems

- W5: Programming assignment 1: 10%
- W11: Programming assignment 2: 20%
- W7: Mid-semester exam: 20%
- Exam period: Final exam: 50%

- You must have at least 40% of each.

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Prerequisites

- Prerequisites: Java (INFO1103 or INFO1903) and (INFO1105 or INFO1905)
- Corequisites: Algorithms and complexity (COMP2007 OR COMP2907)

- You must have passed INFO1103 Introduction to Programming
- INFO1105 Data structures is not required but would help

- COMP2129 would help for concurrency

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Advice

- Lectures notes are for help
- You should understand in-depth
- Practice your reasoning by re-doing the examples at home
- Think about implications, ask questions
- Re-read your notes or the lecture notes at home after the class to memorize easily

Syllabus

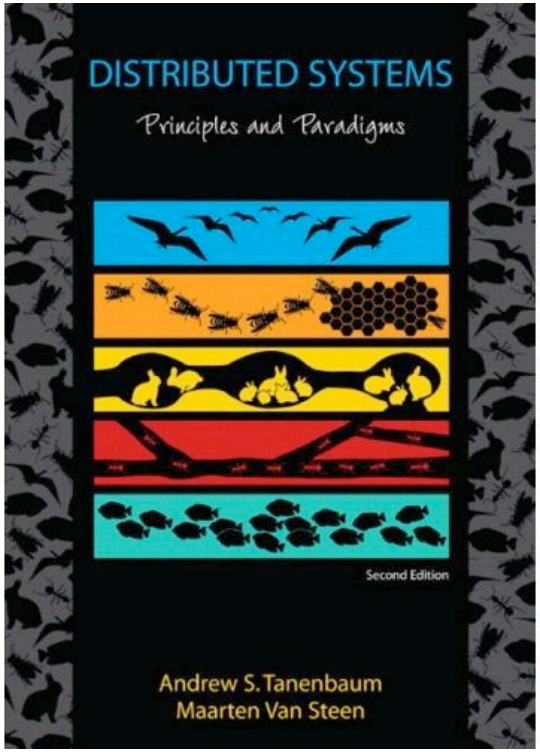
1. Introduction (Motivations) and architecture
2. Concurrency (Processes and Java threads)
3. Communication 1/2 (Network layers, routing, sockets)
4. Communication 2/2 (TCP/IP, RPC, RMI)
5. Naming (DNS, distributed file system)
6. Synchronization 1/3 (Physical time, logical time)
7. Synchronization 2/3 (Mutual exclusion, leader election, atomic broadcast)
8. Consistency (Causal consistency, database transactions)
9. Synchronization 2/3 (Chip Multiprocessors, transactional memory)
10. Failures (Crash and Byzantine failures, consensus problem)
11. Dynamism (Gossip-based protocols)
12. Security (Cryptography secured channels)
13. Review

Plagiarism

- *Plagiarism:* Copying all or parts of another work with or without their knowledge
- Time consuming
- Unfair to other students
- Do not encourage plagiarism, showing your own work makes you guilty
- Make sure to cite your source appropriately, so that one can have a look

Textbook

Distributed Systems – Principles and paradigms Tanenbaum and Van Steen. 2nd Edition.



Definition

What is a Distributed System?

A collection of independent computers that appears to its users as a single coherent system.

What is a Distributed System?

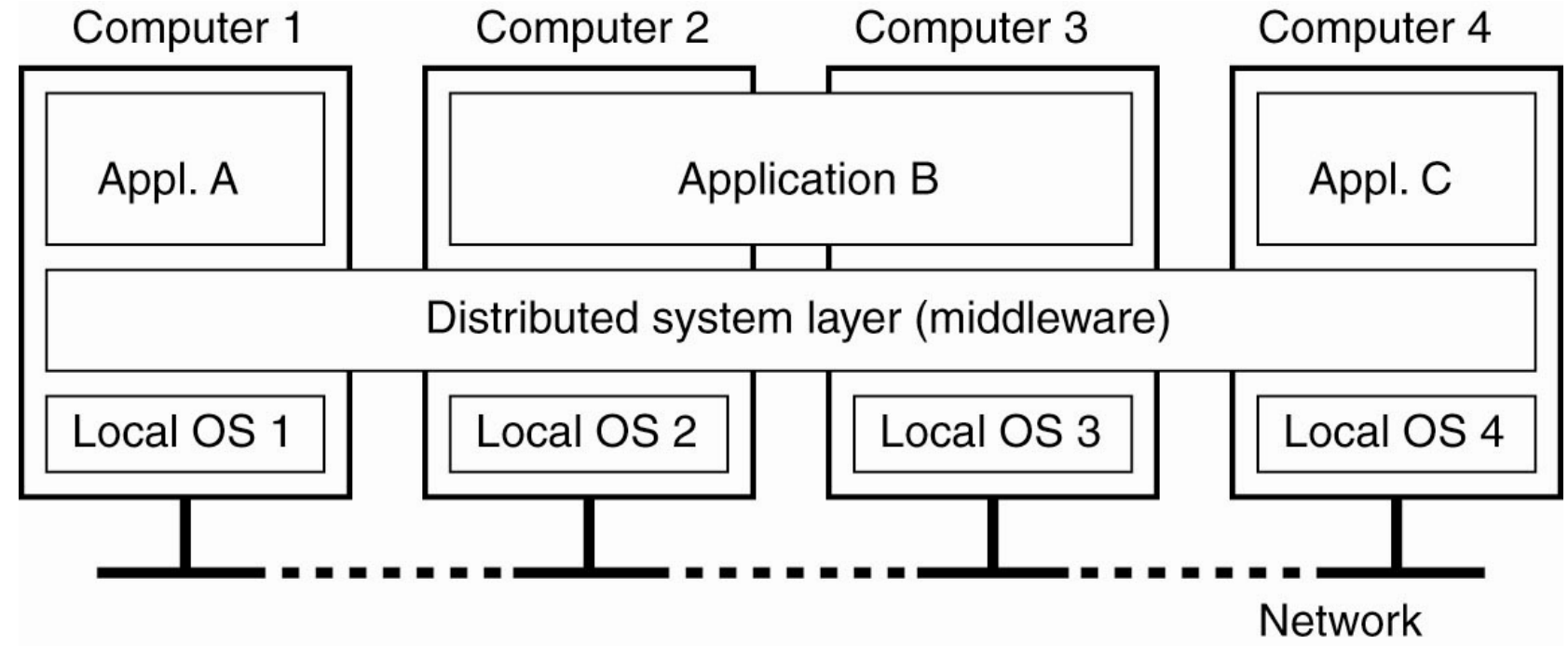
Transparency helps the users observe a single coherent system

Transparency	Description
Access	Hide differences in data representation and how a resource is accessed
Location	Hide where a resource is located
Migration	Hide that a resource may move to another location
Relocation	Hide that a resource may be moved to another location while in use
Replication	Hide that a resource is replicated
Concurrency	Hide that a resource may be shared by several competitive users
Failure	Hide the failure and recovery of a resource

› The different forms of transparency in a distributed systems

Middleware

A distributed systems can be viewed as a *middleware*



› The middleware layer extends over multiple machines and offers each application the same interface

Examples

Cloud computing

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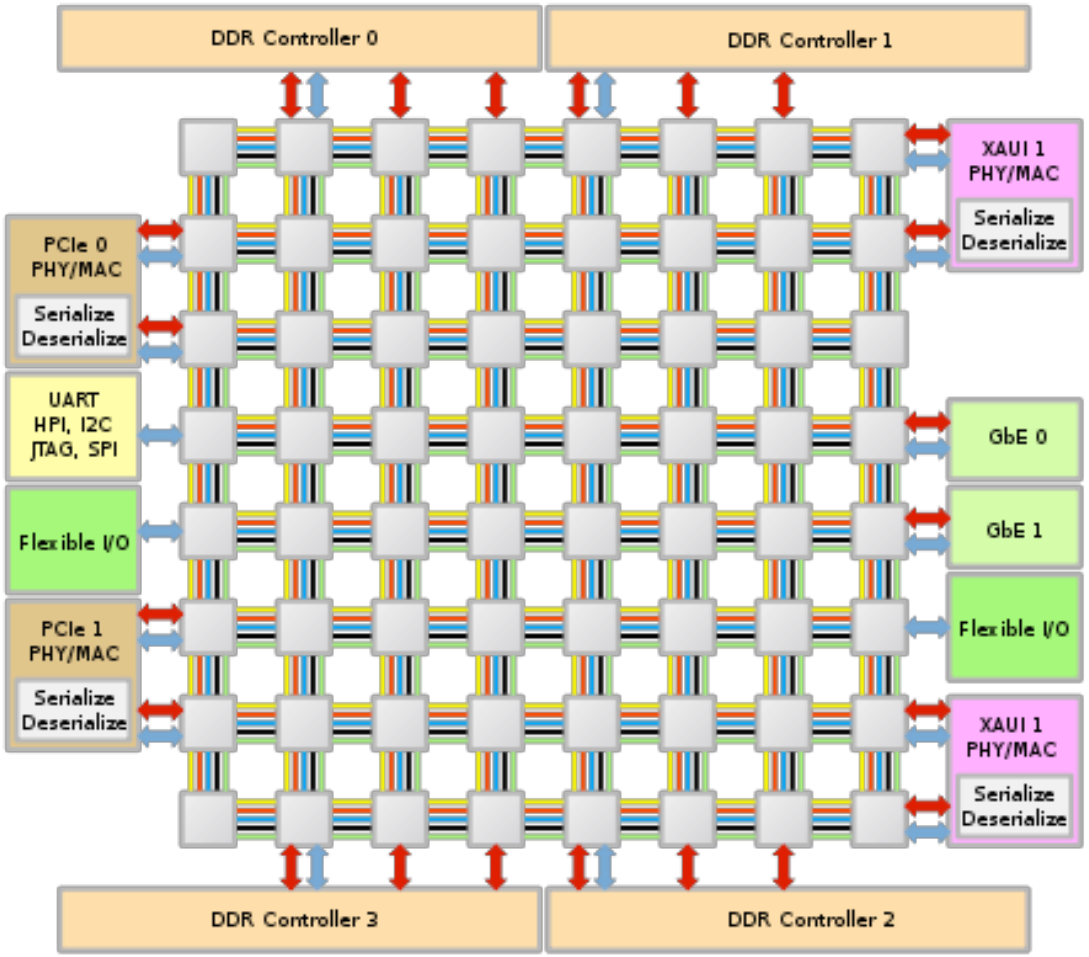
Cluster

Chip Multiprocessors

TILERA®



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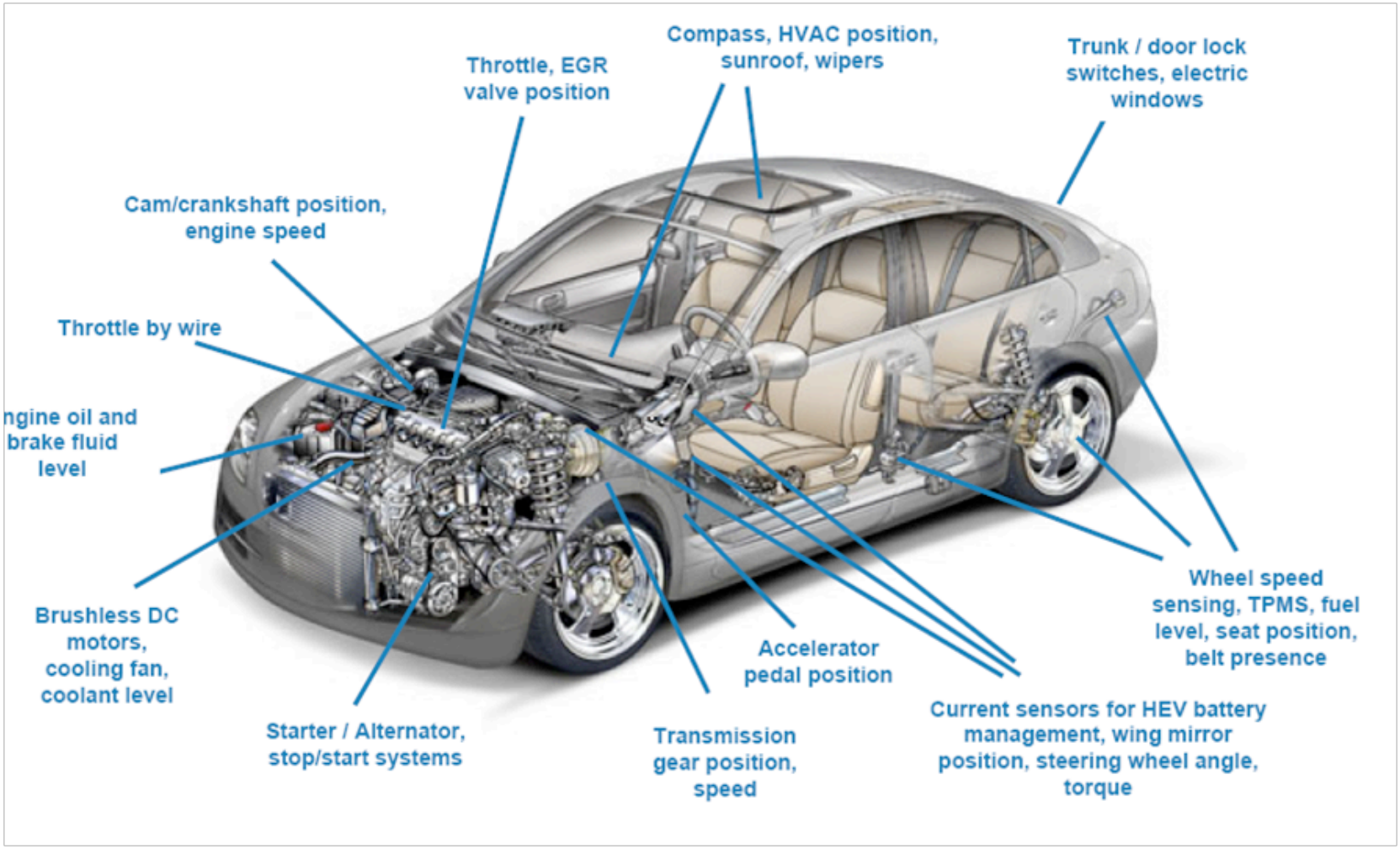
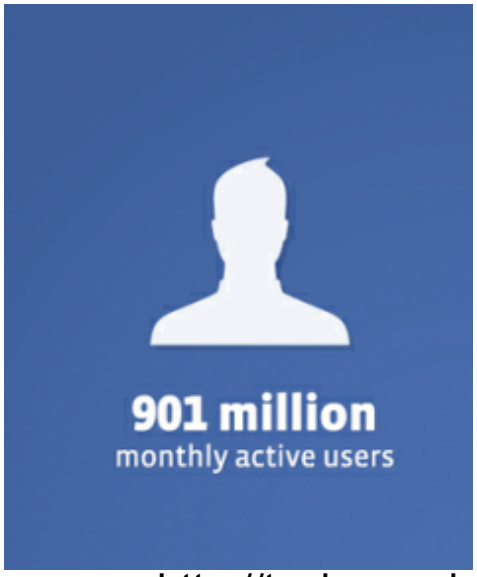
Sensor Networks



Social Networks



source: http://techcrunch.com/2012/04/23/

INTERNET USERS AND POPULATION STATISTICS FOR OCEANIA

SOUTH PACIFIC REGION	Population (2011 Est.)	% Pop. of World	Internet Users, 31-Dec-11	Penetration (% Population)	Users % World	Facebook 31-Dec-11
Total for Oceania	35,426,995	0.5 %	23,927,457	67.5 %	1.1 %	13,353,420
Rest of the World	6,894,628,159	99.5 %	2,243,306,285	32.5 %	98.9 %	785,738,740
WORLD TOTAL	6,930,055,154	100.0 %	2,267,233,742	32.7 %	100.0 %	799,092,160

source: http://internetworldstats.com/stats.htm

Challenges

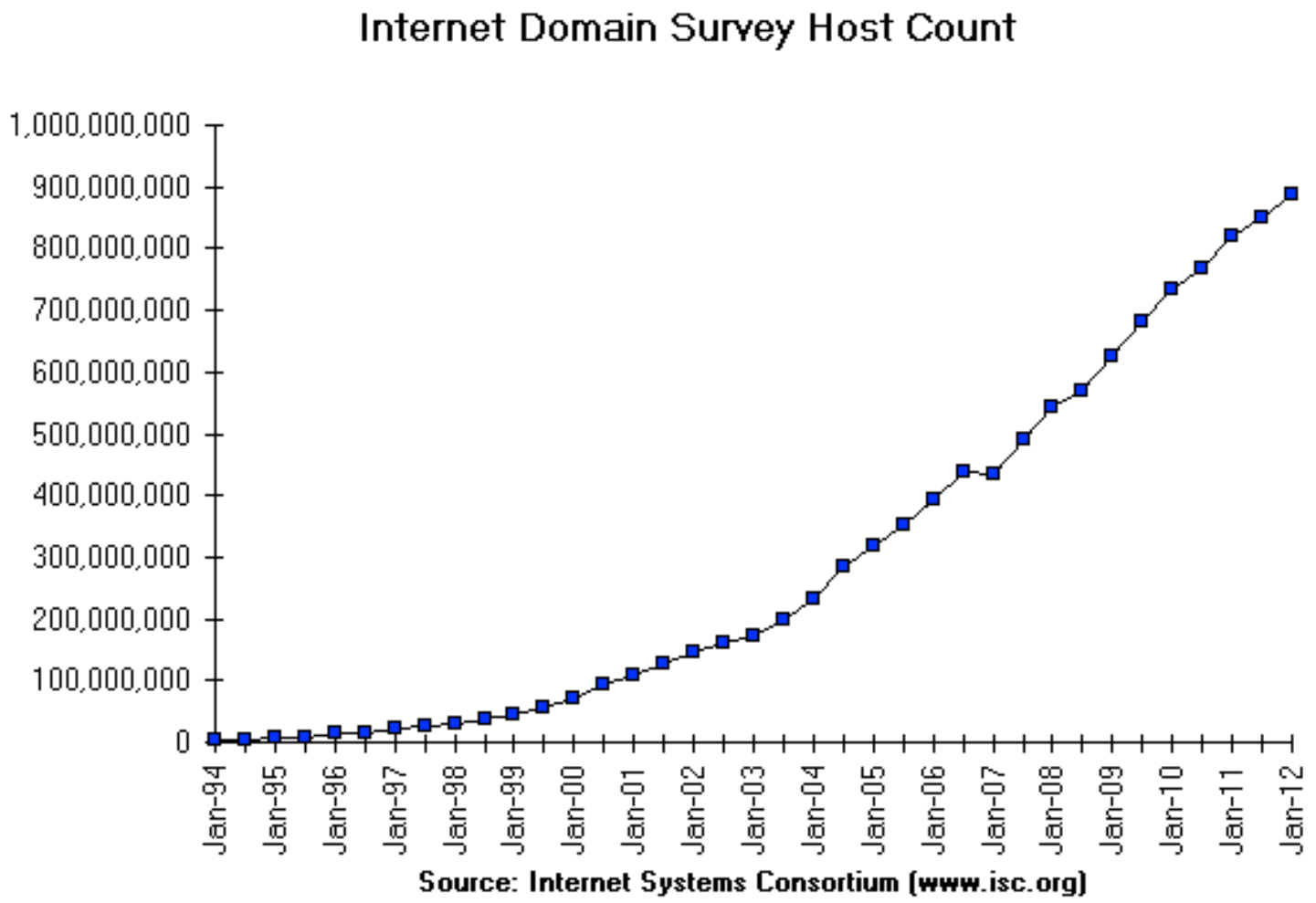
Scalability

- *Scalability of a distributed system:* the ability for the system to preserve some properties as the system grows in
  - the number of requests or participants,
  - the distance between resources and users, or
  - the heterogeneity.

- Scalability limitations:

Concept	Example
Centralized services	A single server for all users
Centralized data	A single on-line telephone book
Centralized algorithms	Doing routing based on complete information

Scalability



Scalability

- **Burst of load:**
  - **456** tweets per second (TPS) when Michael Jackson died (June 25, 2009).
  - **6,939** TPS after midnight in Japan on 2011 New Year's day.
- **Increase in participation:**
  - **+182%**: Increase in number of mobile users in 2010.
  - **>500,000** new accounts created on a single day.

Source: http://blog.twitter.com/2011/03/numbers.html

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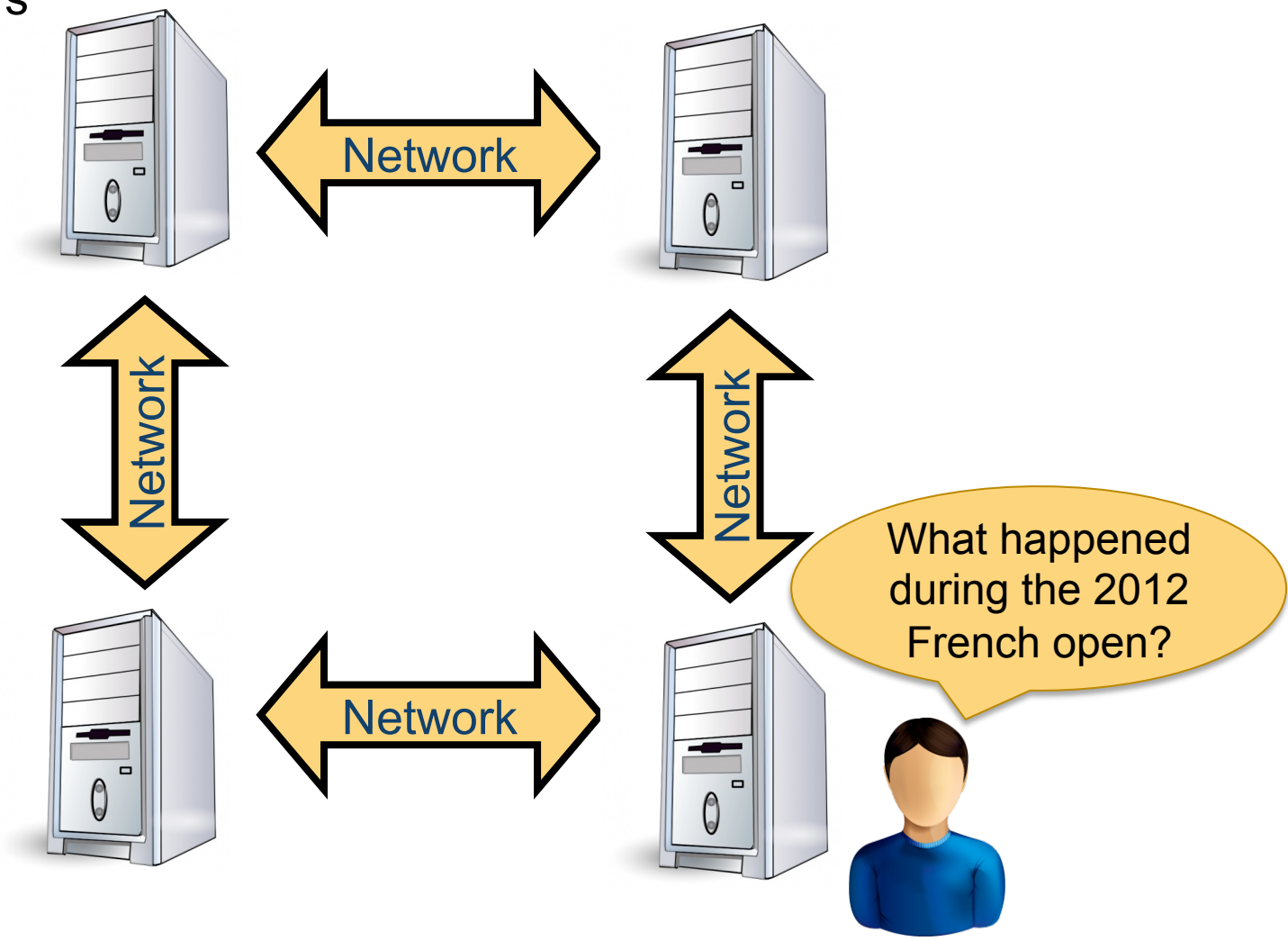
Consistency

- *Consistency;* a property applying to a collection of data items that are accessed by distributed participants.

- Examples of inconsistencies: As a participant, I observe that Djokovic lost against Nadal but then Djokovic won against Federer in the 2012 French Open.

Consistency

Commodity clusters



Consistency

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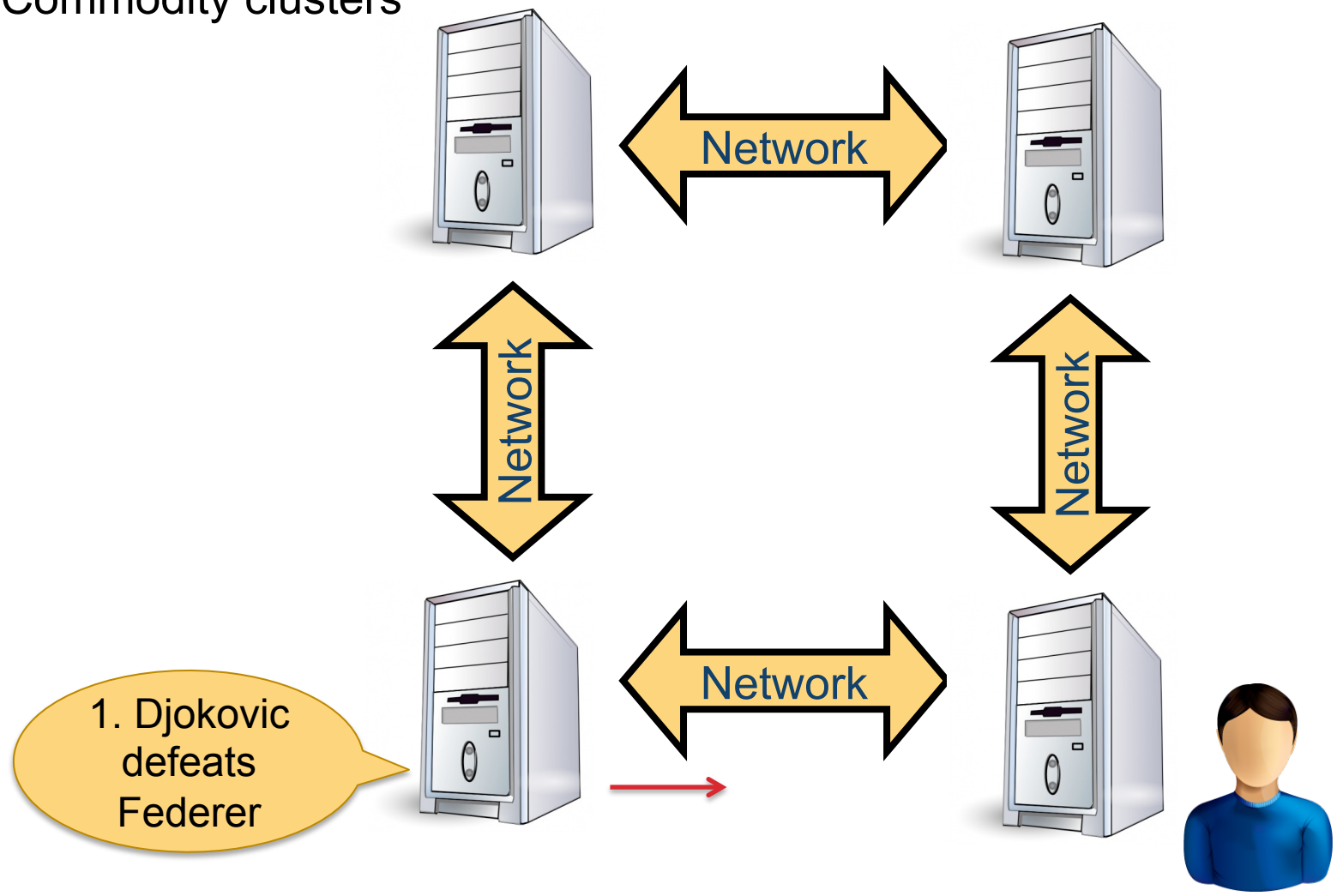

Consistency

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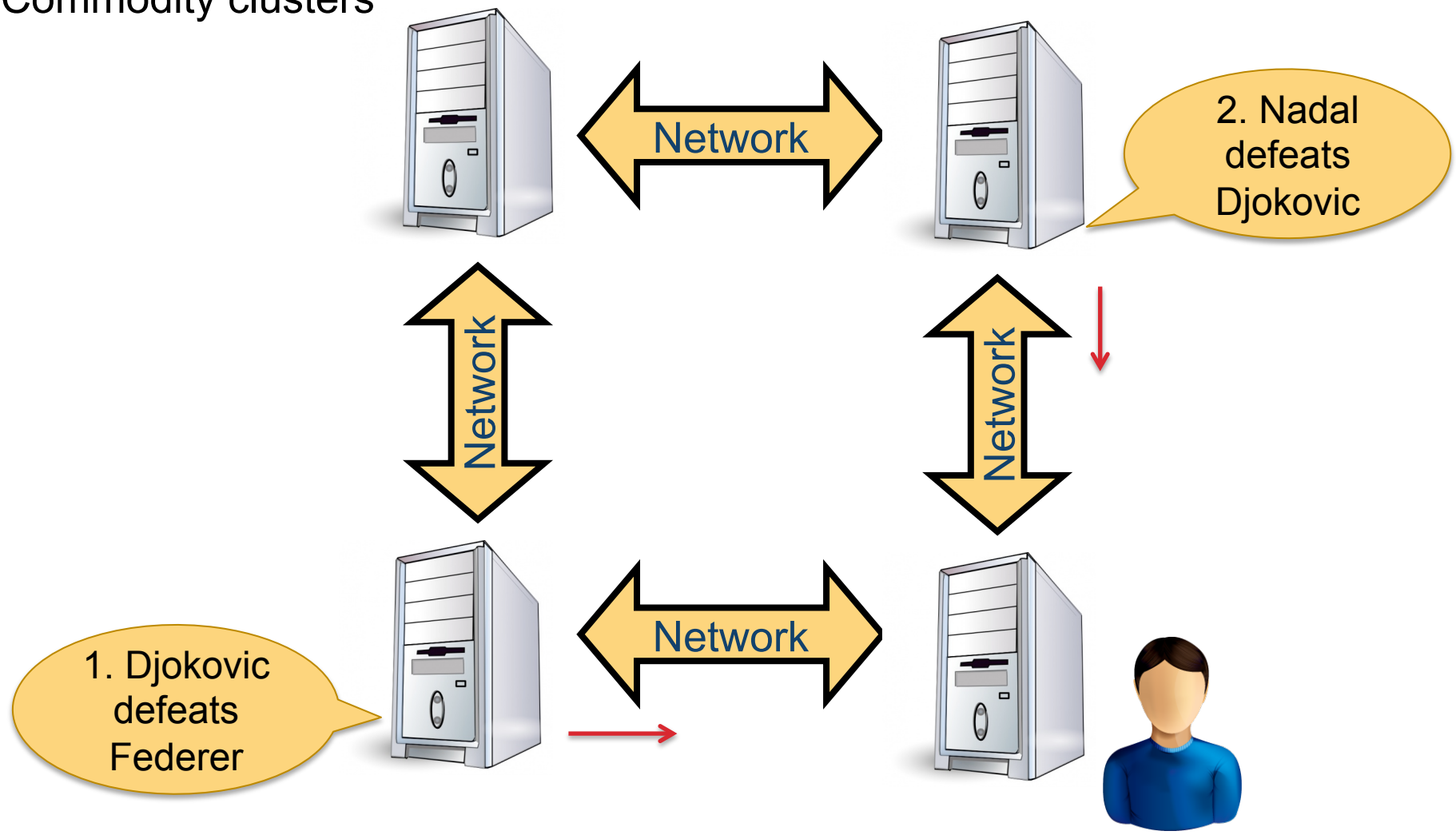

Consistency

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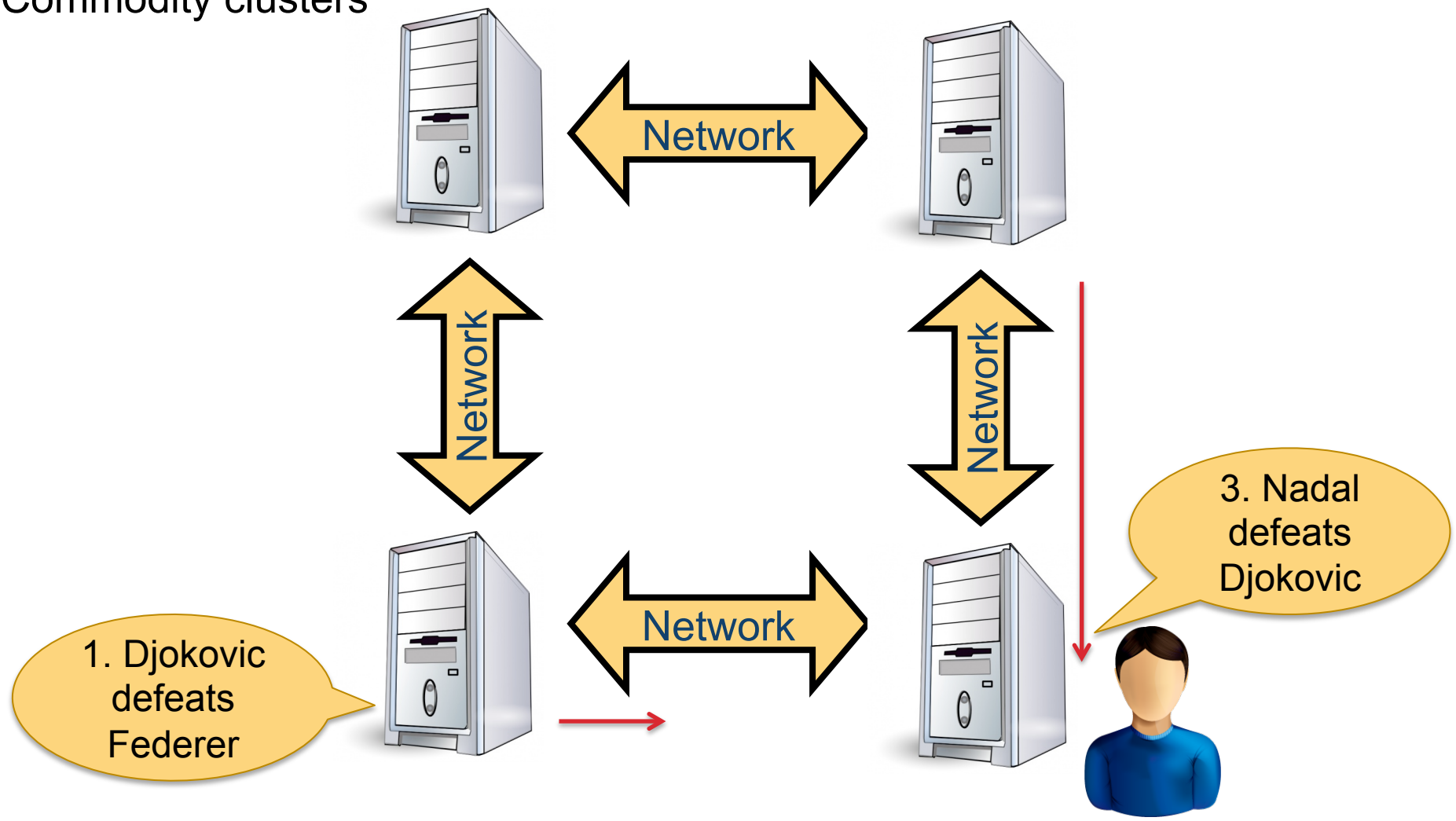

Consistency

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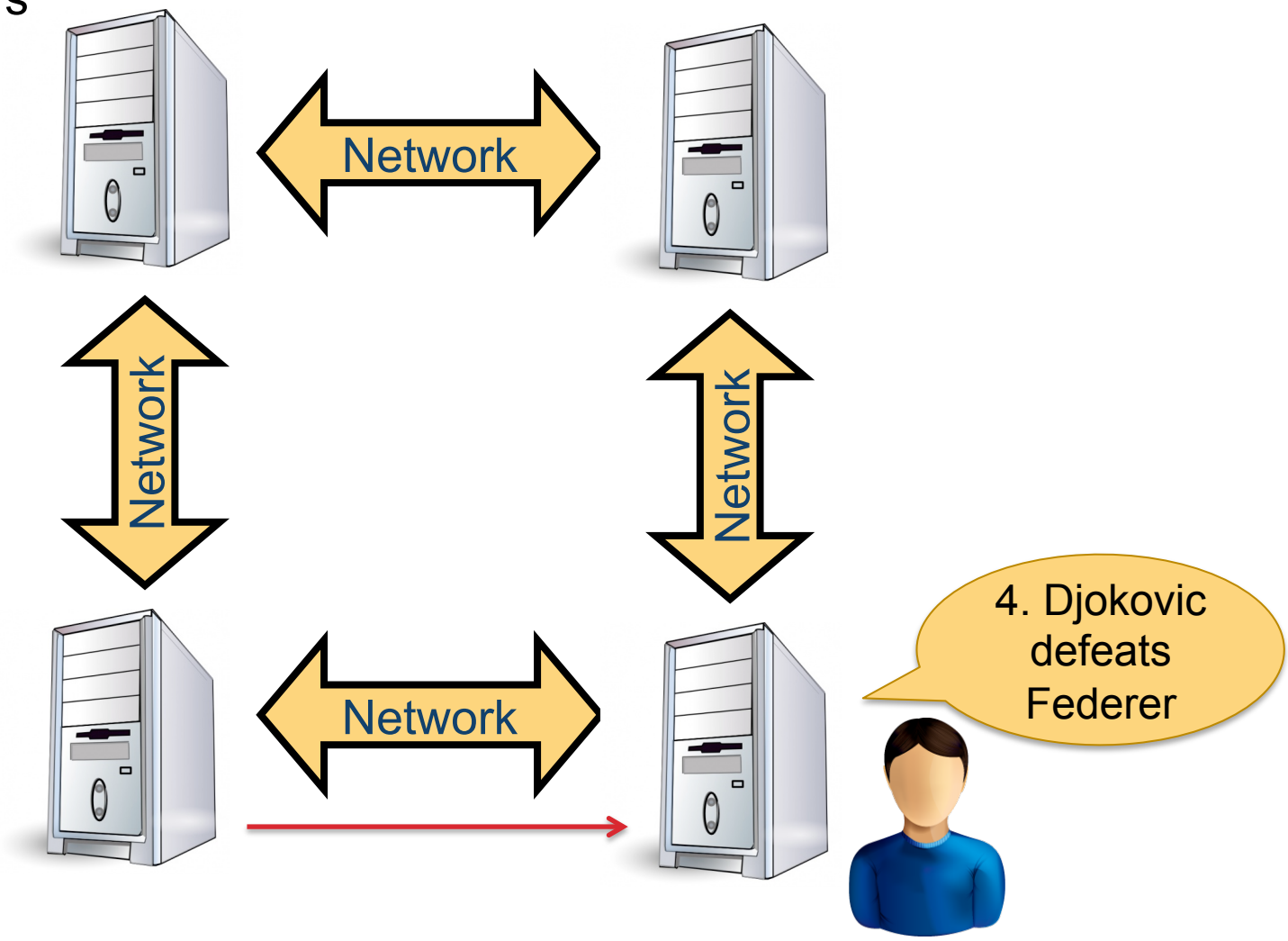

Consistency

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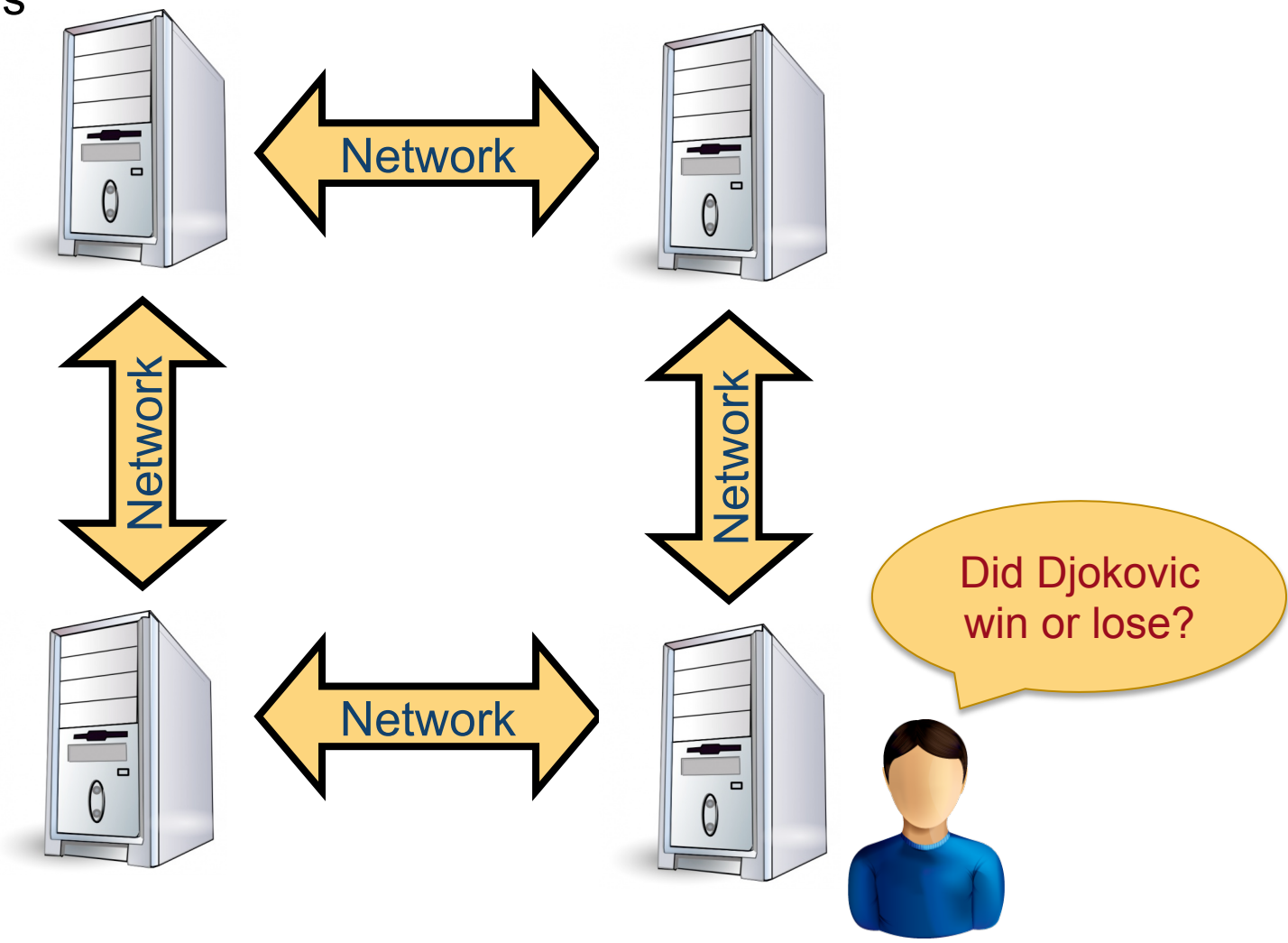
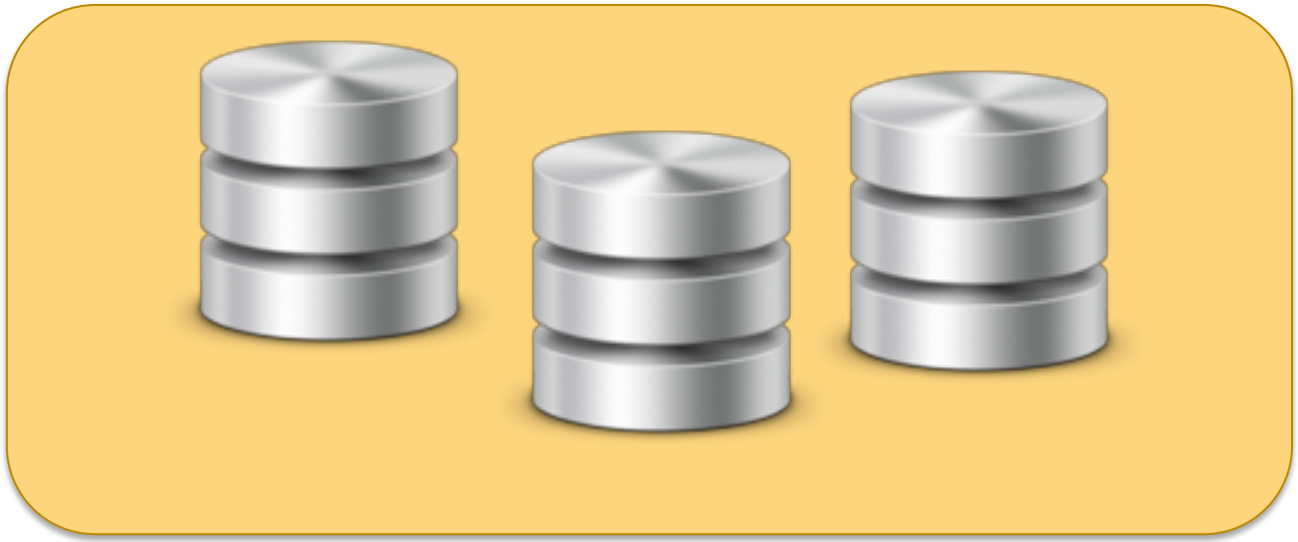


Fault-Tolerance

› *Fault-tolerance of a distributed system:* the ability for the system to recover from partial failures.



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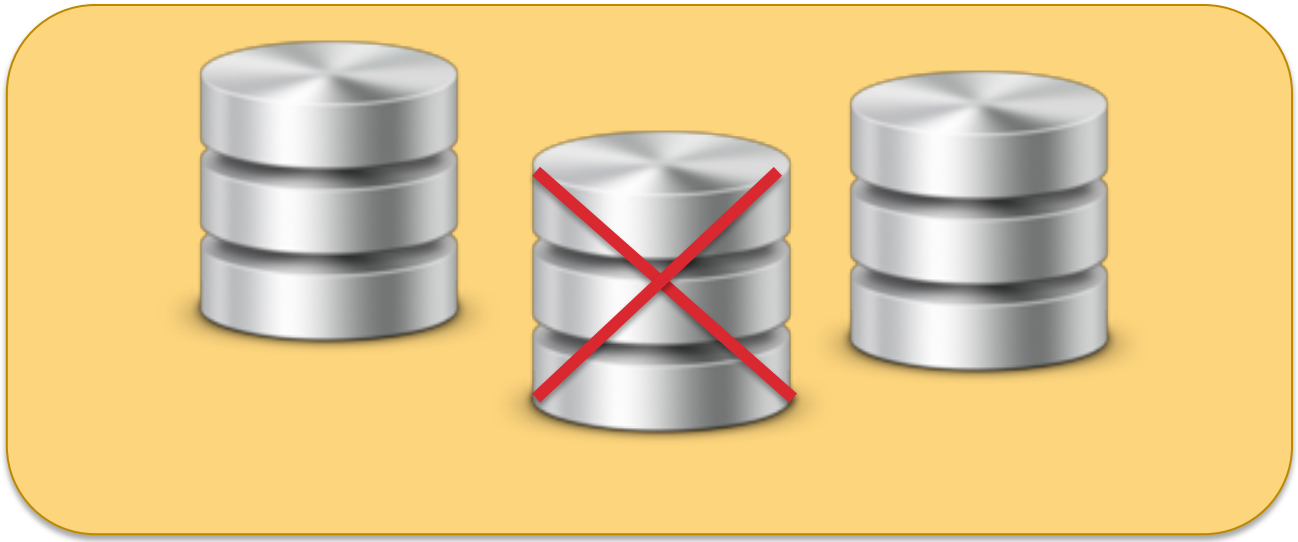
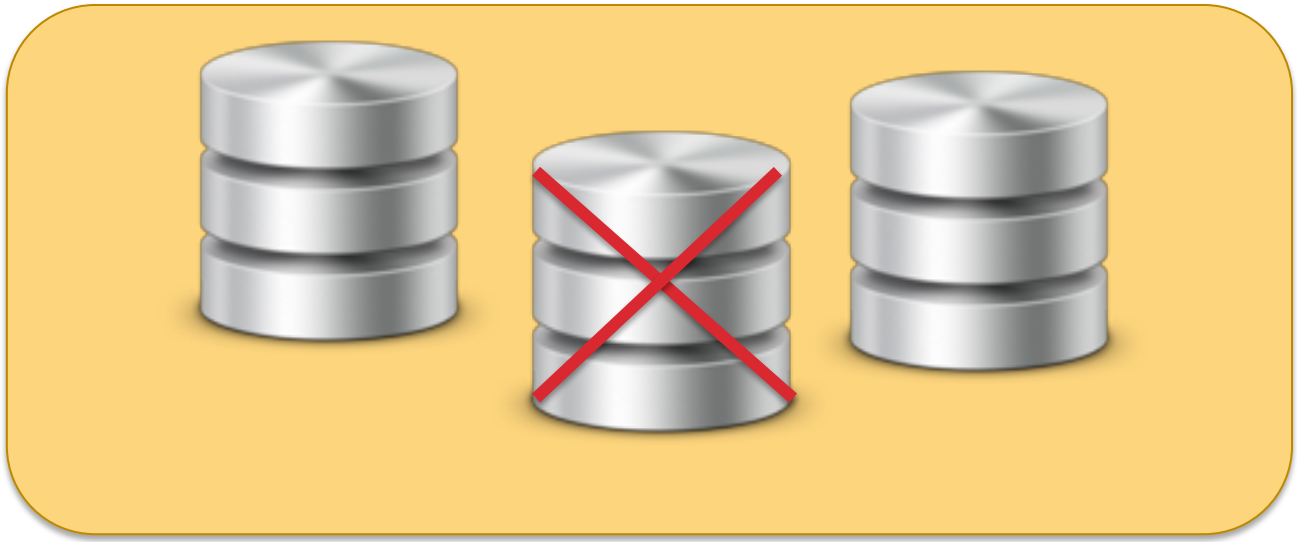
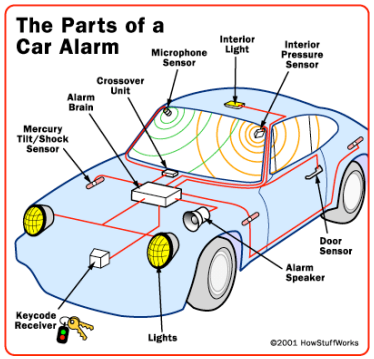


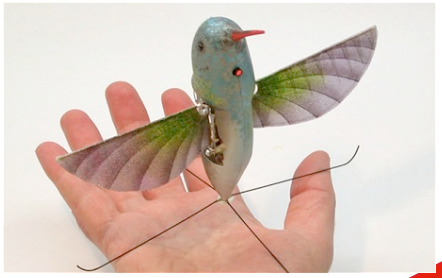
Fault-Tolerance

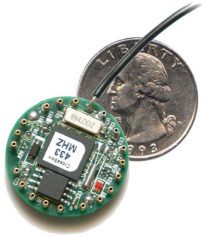
- *Fault-tolerance of a distributed system:* the ability for the system to recover from partial failures.
- How to keep the distributed system up and running, thereby appearing as a single running system to its users?

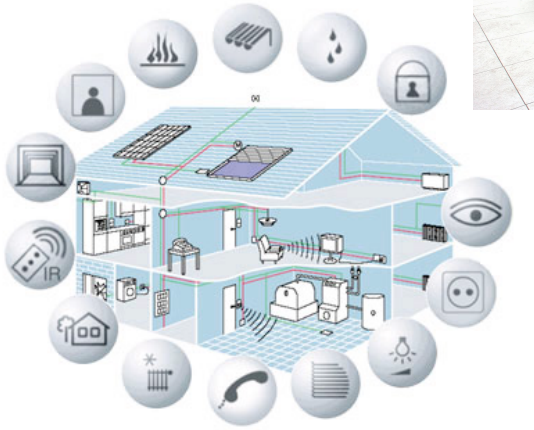


Societal Scale









Conclusion

- A distributed system comprises multiple entities but appears as a single system
- There are various kinds of distributed systems
- There are three main challenges to address in distributed systems:
  - Scalability
  - Consistency
  - Fault-tolerance