Distributed Computing

Lesson 2: Distributed Systems

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Outline

1. Distributed Systems
2. General Features
3. Pros and Cons
4. Design Principles

website

Introduction

- We will get an understanding of what distributed systems are

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- We will get an understanding of opportunities and challenges in distributed systems

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- We will get an understanding of opportunities and challenges in distributed systems
- We will learn some of the basic design principles for distributed systems

Distributed Systems

What is a distributed system?

What are distributed algorithms?

Distributed Systems

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- A distributed system is a set of autonomous systems (nodes, computers) which are connected by a network and communicate via the exchange of messages.
- Distributed algorithms are algorithms which can be executed by multiple computers in a distributed system and cooperatively try to solve a given problem.

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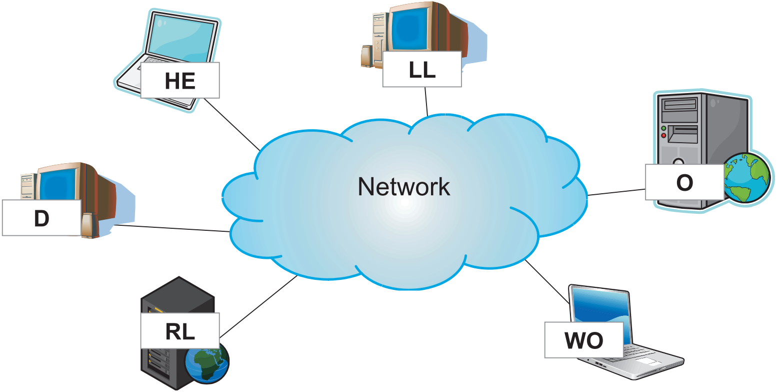
- Yes, this is going to get scary, be prepared.

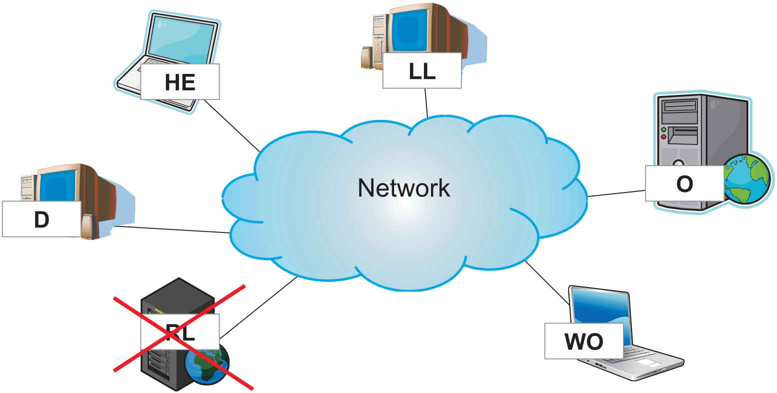
Network of Computers

- Multiple independent computers connected by communication network



Computers/Links Fail

- Computers and communication links may fail independently from each other (and without obvious reason)



Latency and Unreliability

- Information exchange only via message exchange

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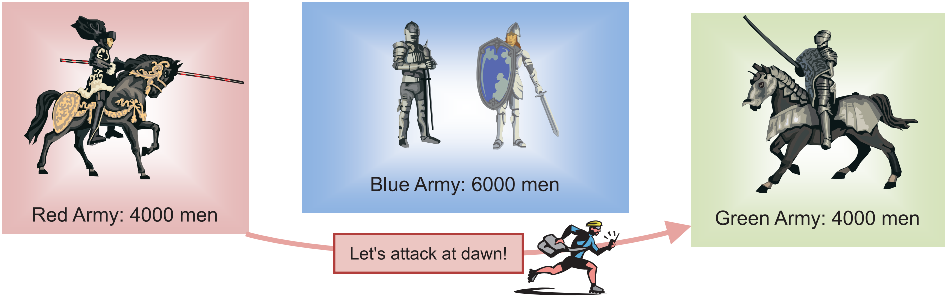

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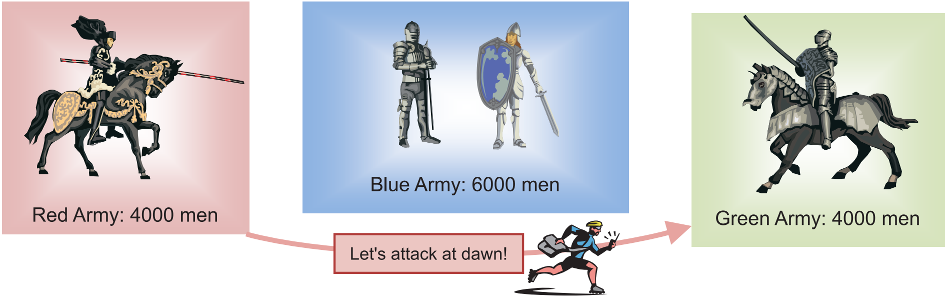

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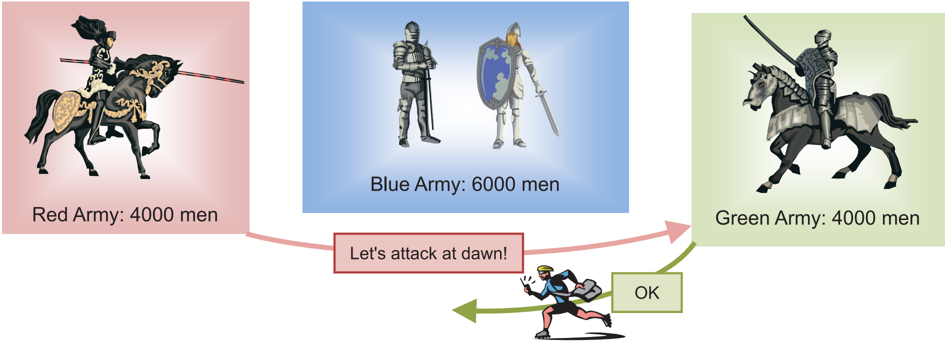
- Network may be unreliable, messages may get lost/modified



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OK

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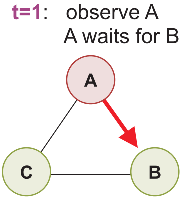

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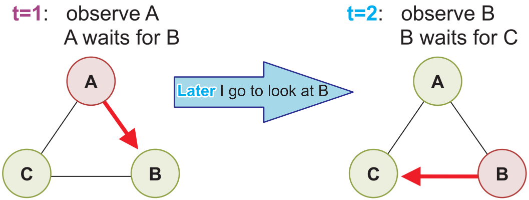

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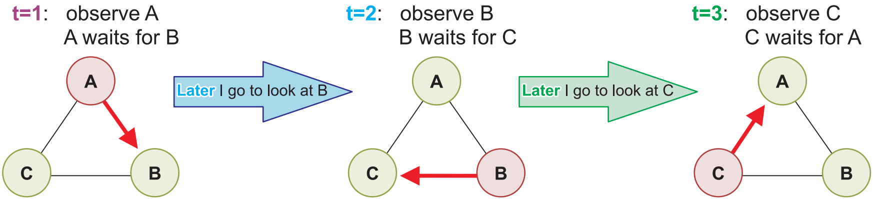

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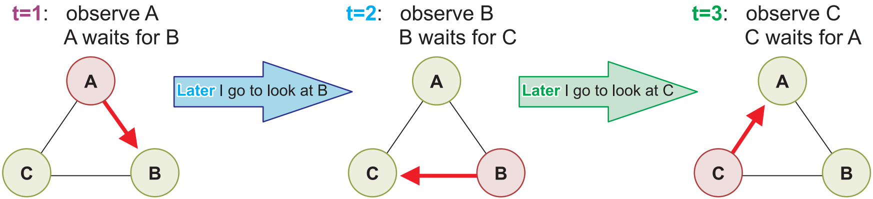

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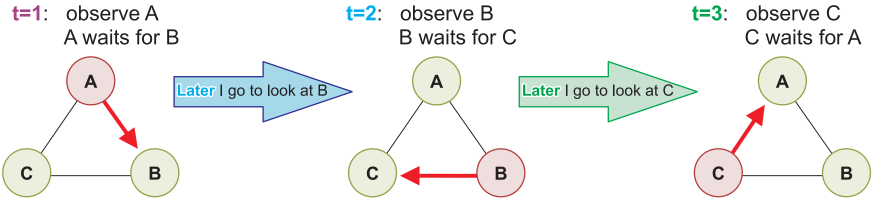

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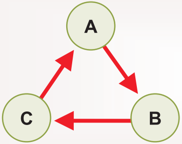

Phantom Deadlock

delays in observation lead to possibly wrong conclusion:
Deadlock
System may actually be OK.

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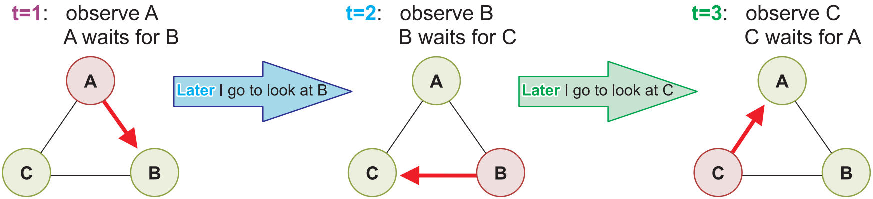
  3. Nodes have no global information and act only based on local information → dangerous.



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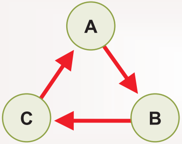

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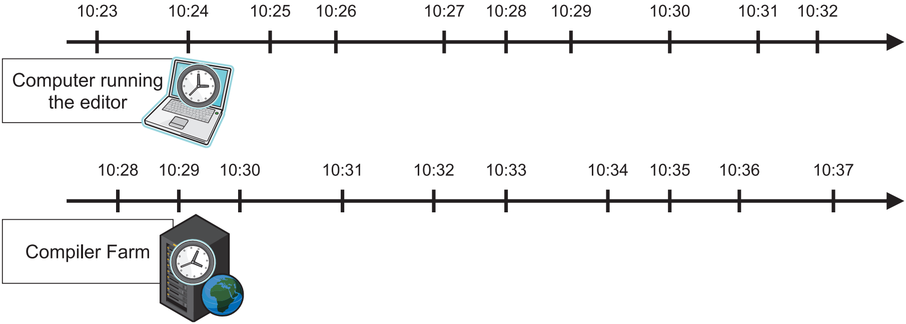

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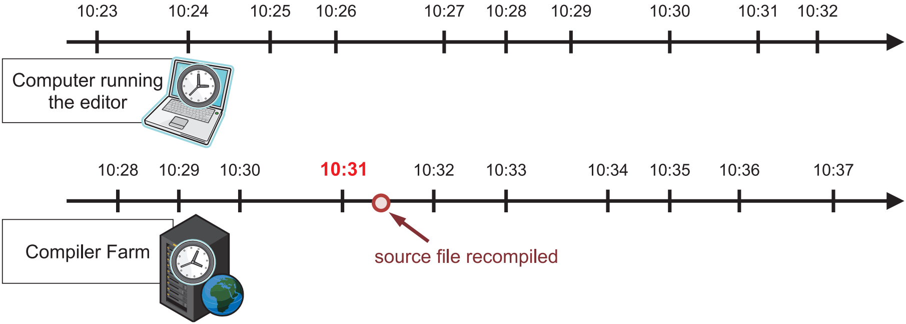

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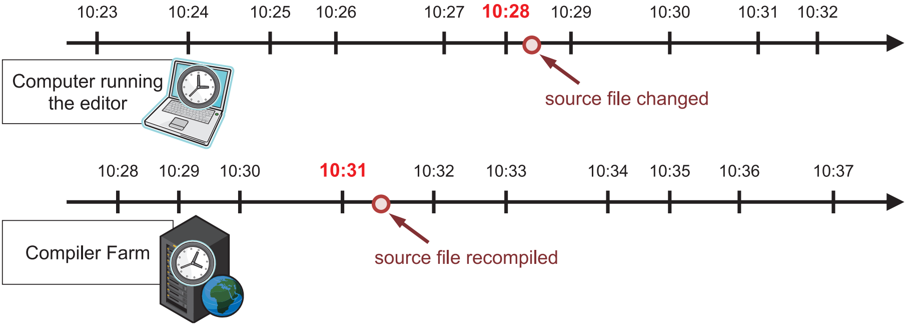

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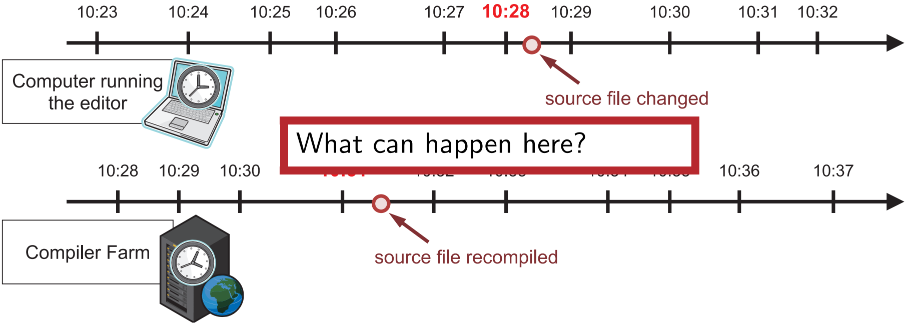

What can happen here?

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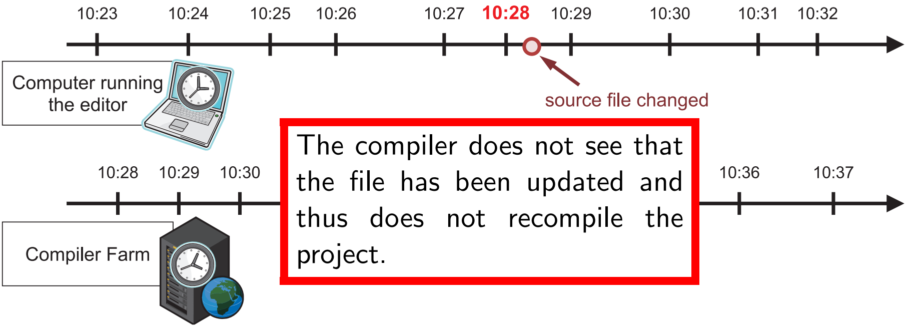

The compiler does not see that the file has been updated and thus does not recompile the project.

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  - in asynchronous distributed systems without upper bound for communication delay, it is impossible to distinguish failed from slow processes[6]

Pros and Cons

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Surely, these are the only bad things that I have to consider when building a distributed application, right?

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  - Failures are often not reproducible.

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. . . Anyway, what does he have to say? [14]

Leslie Lamport's Statement

Received: by jumbo.dec.com (5.54.3/4.7.34) id AA09105; Thu, 28 May 87 12:23:29 PDT
Date: Thu, 28 May 87 12:23:29 PDT
From: lamport (Leslie Lamport)[14] To: src-t
Message-Id: <8705281923.AA09105@jumbo.dec.com>
Subject: distribution

There has been considerable debate over the years about what constitutes a distributed system. It would appear that the following definition has been adopted at SRC:

> A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable.

The current electrical problem in the machine room is not the culprit--it just highlights a situation that has been getting progressively worse. It seems that each new version of the nub makes my FF more dependent upon programs that run elsewhere.

Having to wait a few seconds for a program to be swapped in is a lot less annoying than having to wait an hour or two for someone to reboot the servers. I therefore propose a development project to make our system more robust. I am not proposing any particular approach (enabling stand-alone operation is just one possibility).

I will begin the effort by volunteering to gather some data on the problem. If you know of any instance of user's FF becoming inoperative through no fault of its own, please send me a message indicating the user, the time, and the cause (if known).
Leslie

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Why am I taking this course?

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    - Access of websites/information created at different locations

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    - Elastic cloud services can be replicated to more computers/virtual machines added to applications when more computational power becomes necessary

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    - Adding of sensors to an existing manufacturing surveillance plant system

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    - Seti@home [21], BOINC [22]

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    - Replication of web servers
    - Access node of cluster decides where the job should be done

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  - Infrastructure in US is rarely used at night → which is daytime in India

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- Decentralization, e.g.,
    - Content “closer” to destination (see Content Delivery Networks)
    - Services can be carried out in different locations: less computational load on central hardware

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Design Principles

- Only distribute if there is a striking benefit, otherwise use centralized solutions.

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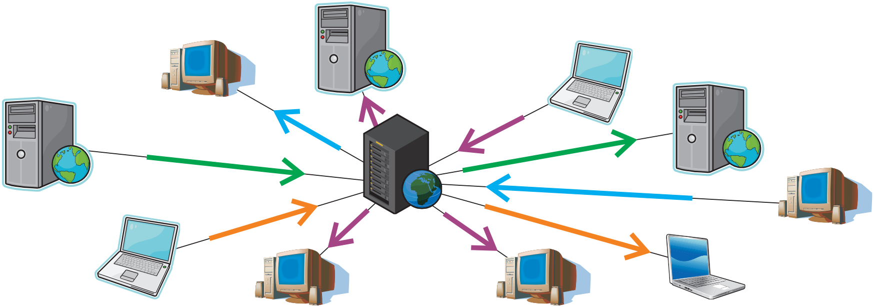
- What else?

Single Point of Failure?

- One central server dealing with all requests and forwarding all messages between the nodes. Is this good or bad?



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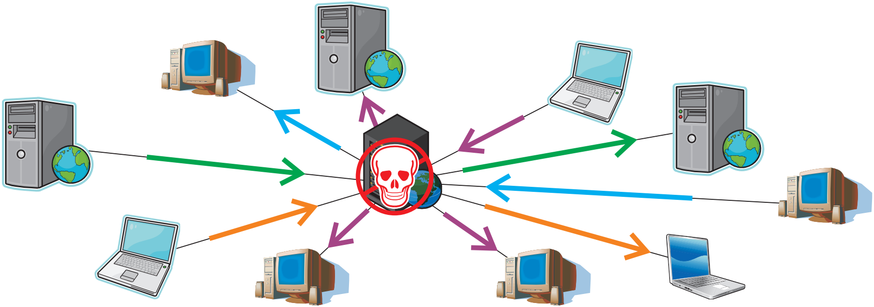

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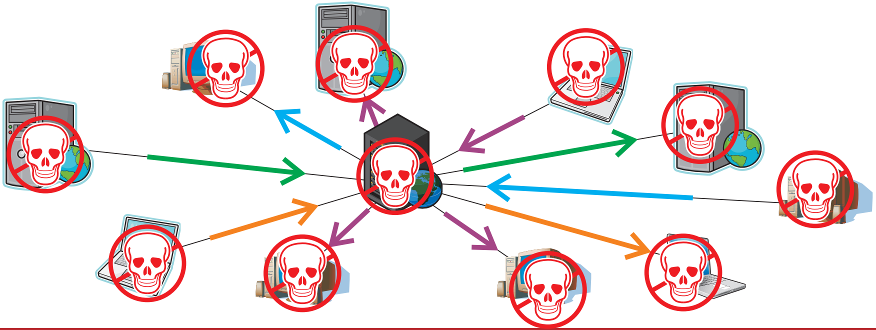

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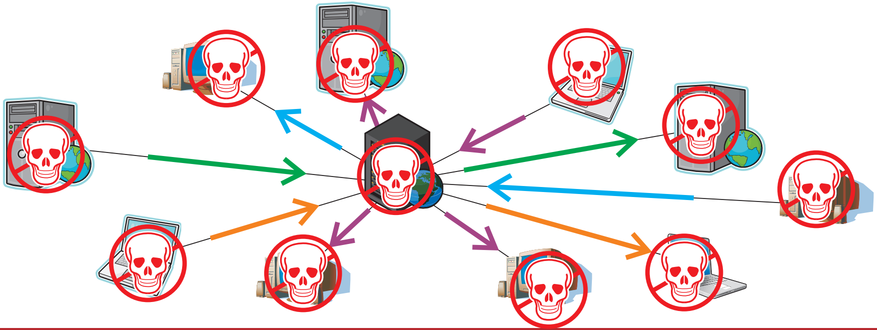

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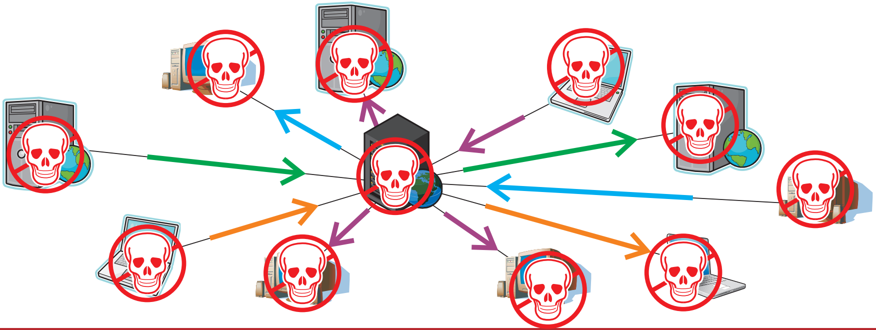

Single Point of Failure?

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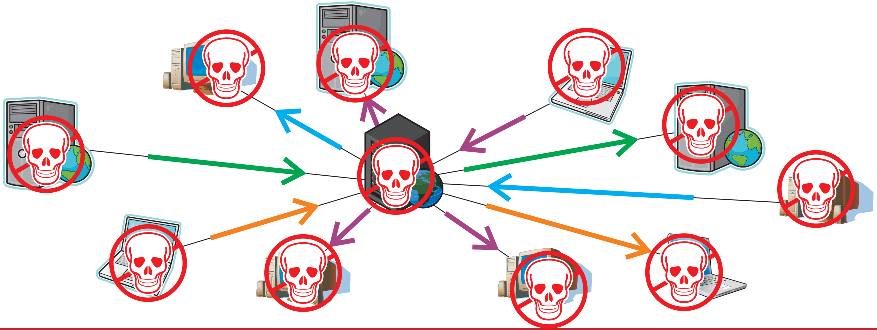
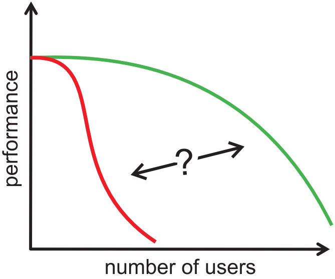
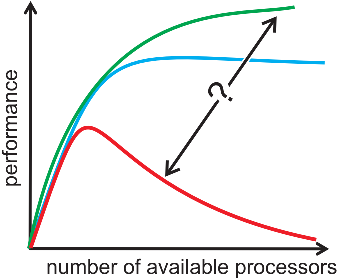
  - bottlenecks should be avoided



Scalability

- How should a system behave when the numbers of users or processors increase?





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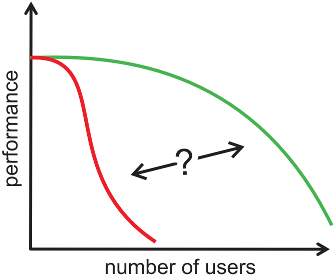

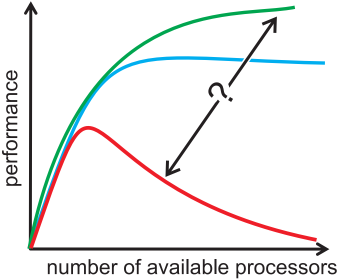

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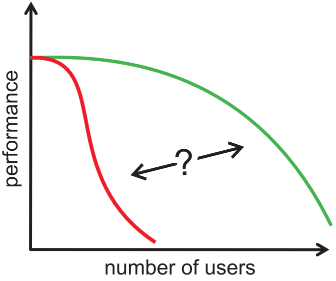

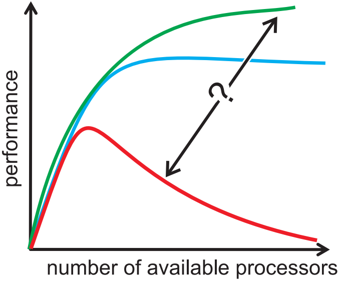

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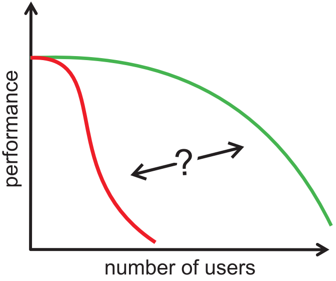

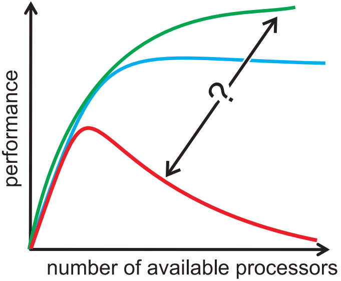

Scalability

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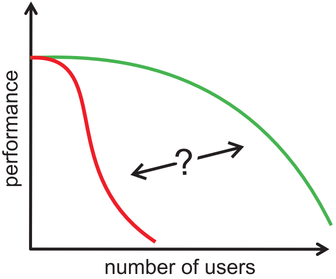
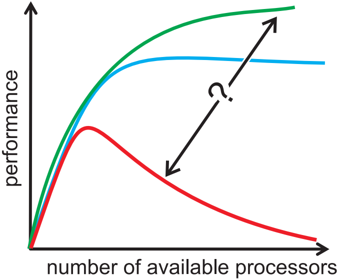
  - growth of number of tasks / users / work load / available nodes should be anticipated
  - system performance should rise in case of more computing power
  - system performance should degenerate gently in case of higher work load





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- Maybe you should also take an information systems security course as well...

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  - hide complexity (for instance: protocol stack, middleware)
  - many applications of transparency in distributed systems (distribution, location, machine, fault, replication, migration, . . .)
  - sometimes not appropriate (system management, context aware systems, adaptive systems, . . .)

Summary

- Distributed System = autonomous nodes communicating via messages
- Several advantages and drawbacks: distributed computing only if necessary
- Several design principles to consider
- Scalability is always limited
- Message complexity should be low

谢谢

Thank you

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Institute of Applied Optimization
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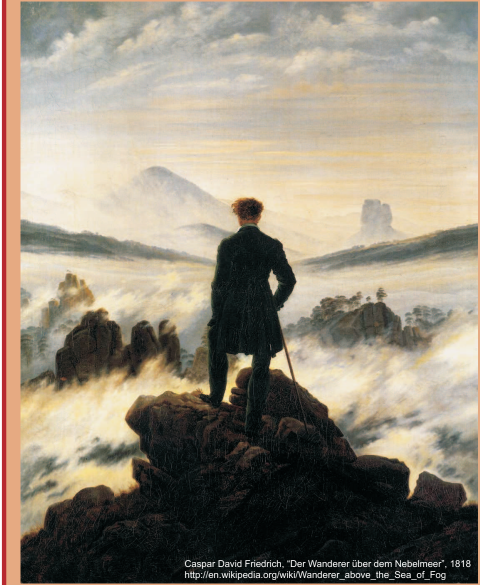

Caspar David Friedrich, “Der Wanderer über dem Nebelmeer”, 1818
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