

Summary and examinable material

INF5040 autumn 2007

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Learning goals

- Provide a basic understanding of
 - fundamental principles, concepts and state-of-the-art
 - key technologies for realising distributed interactive systems of the future
- Gain practical experience of crafting a distributed application with a state-of-the-art platform
- Provide knowledge about today's challenges to open distributed processing technology, including
 - multimedia
 - mobility

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Overview examinable material

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From Coulouris et al (1/2)

- Chap 1: all
- Chap 2: all
- Chap 4: 4.1, 4.3, 4.4
- Chap 5: all
- Chap 6: 6.4, 6.5, main focus on 6.4.3
- Chap 10: all
- Chap 11: all except 11.3 and 11.6
- Chap 12: all

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From Coulouris et al (2/2)

- ❑ Chap 13: 13.1 – 13.4
- ❑ Chap 14: 14.1 – 14.4.1:
(14.5, 14.6 cursory knowledge)
- ❑ Chap 15: 15.1 - 15.3
- ❑ Chap 16: all
- ❑ Chap 17: all
- ❑ Chap 19.1-19.4, 19.6
- ❑ Chap 20: all

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From Tanenbaum and van Steen

- ❑ Chapter 4: 4.1.2, 4.3-4.5
- ❑ Chapter 6: All except 6.1 and 6.4
- ❑ Chapter 7: All except 7.3
- ❑ Chapter 8: 8.4, 8.5
- ❑ Chapter 12: 12.1-12.4, 12.6
- ❑ Chapter 13: 13.4.1

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Other ...

- ❑ G. T. Heineman, W.T. Councill: *Component-based Software Engineering - Putting the Pieces Together*, 2001. Addison Wesley. Ch. 1 & 3.
- ❑ P. Eugster et. al.: *The Many Faces of Publish/Subscribe*.
- ❑ P. Eugster et. al.: *Epidemic Information Dissemination in Distributed Systems*
- ❑ All lectures and lecture slides

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Student presentations and mandatory programming assignment

- ❑ Detailed knowledge about own group's presentation and opposition topics
- ❑ cursory knowledge [at the level I was there, I know what it was about] is sufficient for the rest of the presentations
- ❑ Knowledge related to the mandatory programming assignment *can* be tested during the exam

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On examination 17. and 18. December

- ❑ The exam will be conducted in the following way:
 - ❑ Each student will be assigned a time and place (room) to meet. It is important that you meet at the precise time and place.
 - ❑ You will be given a set of written questions that you have 30 minutes to prepare answers to (e.g., by making notes, diagrams, keywords or similar). You may not use any kind of aid (written or otherwise).
 - ❑ After 30 minutes you will be brought to the examination room, where you will be allowed 15 minutes to present your answers to the written questions, followed by an additional 15 minutes of questioning from other parts of the examinable material.
- ❑ Bring picture id!
- ❑ Ifiadm will prepare a schedule for the exam (time and place for each student).
 - If you have particular wishes wrt your scheduling, contact IFI studadm (Mozhdeh Sheibani Harat)

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Summary of lectures

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Introduction and design

- ❑ What is a distributed system
- ❑ Implications of distributed systems:
 - ❑ partial failures, unreliable and unsecure comm, ...
- ❑ Requirements leading to distributed systems:
 - ❑ resource sharing, scalability, fault tolerance, ...
- ❑ Distribution transparency
- ❑ Design of distributed objects is different from design of programs where all objects are in the same process
- ❑ Distributed systems organized as middleware

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System models

- ❑ Two types of system models
- ❑ **Architecture models**: defines the components of the system, the way they interact, and the way they are deployed in a network of computers
 - ❑ client-server models (many variants)
 - ❑ peer processes (P2P)
 - ❑ spontaneous networks (mobility)
- ❑ **Fundamental models**: formal description of the properties that are common to all architecture models
 - ❑ interaction models
 - ❑ failure models
 - ❑ security models (not covered in this course, but see e.g., INF3190)

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Distributed objects and object-based middleware

- ❑ Distributed objects execute in different processes.
 - ❑ remote interfaces allow an object in one process to invoke methods of objects in other processes located on the same or on other machines
- ❑ Object-based distribution middleware:
 - ❑ middleware that models a distributed application as a collection of interacting distributed objects (e.g., CORBA, Java RMI)
 - ❑ some middlewares (as CORBA) allow objects in the same application to be implemented in different programming languages

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Object interaction using RMI

- ❑ Implementation of RMI
 - ❑ proxies, skeletons, dispatcher
 - ❑ interface processing, binding, location, activation
- ❑ Invocation semantics (under partial failure)
 - ❑ maybe, at-least-once, at-most-once
 - ❑ Reliability of RMI is at best “at-most-once”
- ❑ Multi-threaded servers
 - ❑ can in some cases be used to increase the throughput (method calls/time unit) if, e.g., I/O is the bottleneck
- ❑ Principles of CORBA
 - ❑ Clients may invoke methods of remote objects without worrying about: object location, programming language, operating system platform, communication protocols, or hardware.
- ❑ Principles of Java RMI
 - ❑ Similar to CORBA but limited to a Java environment

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Software components and distributed systems

- ❑ Rationale for components
- ❑ Implicit and explicit middleware
- ❑ Components
 - ❑ Programming according to LEGO-principle
 - ❑ Contractually specified interfaces and composition
 - ❑ Support for connection oriented programming
- ❑ Component architecture
 - ❑ Contractually specified interfaces between components and application servers
 - ❑ Realizes "implicit middleware"
 - ❑ Java: EJB, CORBA: CCM, Microsoft: COM+/.NET
- ❑ Basis for third generation middleware

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Communication paradigms

- ❑ Communication properties
 - ❑ Persistence, synchrony, time and space decoupling
- ❑ MPI
 - ❑ Motivation, main ideas, and uses
- ❑ MOM
 - ❑ Architecture, routing, applications
- ❑ Publish-subscribe
 - ❑ Architecture and properties
 - ❑ Subscription semantics and content-based routing
- ❑ Overview of overlay-based multicast
 - ❑ Desired properties
 - ❑ Small-world phenomenon
- ❑ Epidemic-based dissemination
 - ❑ Concepts and ideas
 - ❑ Push-based and pull-based mechanisms
 - ❑ Applications

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Time and coordination

- ❑ Logical time
 - ❑ Implementations: logical clocks & vector clocks
- ❑ The snapshot problem
 - ❑ Consistent global states
 - ❑ [Chandy,Lamport] protocol
- ❑ Distributed consensus
 - ❑ Known impossibility results
- ❑ Distributed mutual exclusion
 - ❑ Requirements
 - ❑ 3 Algorithms: centralised, ring-based, and [Ricart,Agrawala]
- ❑ Distributed leader election
 - ❑ Bully and ring-based algorithms

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Distributed transactions

- ❑ Transactions
 - ❑ Motivation, interface, etc.
 - ❑ Desirable properties of a transaction (ACID)
- ❑ Distributed transactions
 - ❑ Atomic commitment problem
 - ❑ 2PC protocol
 - State diagram
 - Recovery

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Replication

- ❑ Motivation and objectives
- ❑ Placement of replicas
- ❑ Propagation of updates among the replicas
 - ❑ Consistency guarantees
- ❑ Replication schemes
 - ❑ Active and passive replication
- ❑ Group communication
 - ❑ Group membership, view synchrony, ordered message delivery

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Peer-to-peer

- ❑ P2P systems distribute processing load and network traffic between all nodes that participate in an distributed information system
- ❑ P2P systems are self-organising and independent of any central entity
- ❑ The efficiency critically depends on algorithms for distributing the data among a high number of nodes and subsequently locating the data
- ❑ P2P middleware is an application-independent software layer that implements a "routing overlay"
- ❑ Case study and evaluation: Pastry

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Mobile and ubiquitous computing

- ❑ Mobile and ubiquitous systems are volatile
- ❑ Applications in mobile and ubiquitous environments are
 - ❑ Integrated with the physical world through sensing and context awareness
 - ❑ Adaptive to changes in the physical circumstances by changing behavior
- ❑ Common system model for mobile and ubiquitous computing (and their subfields). Elements of the model
 - ❑ smart spaces
 - ❑ device model
 - ❑ volatile connectivity
 - ❑ spontaneous interoperation
- ❑ Sensors and sensor software architectures, wireless sensor networks, directed diffusion

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Distributed multimedia systems

- ❑ Multimedia applications require mechanisms that enable them to handle large amounts of time dependent data
- ❑ Most important mechanism: QoS management
- ❑ QoS is a question of resource management
- ❑ Resource management implies
 - ❑ admission control
 - ❑ scheduling function
- ❑ When resources cannot be reserved, adaptation is the (only) alternative

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Web-based systems

- ❑ Communication architecture
 - ❑ Web proxies
 - ❑ Proxy-based caching (hierarchical and cooperative)
 - ❑ Server-side backend
 - Content-distribution networks
- ❑ Web Services
 - ❑ Applications
 - ❑ Architecture
 - URIs, WSDL, SOAP
 - ❑ Comparison with CORBA