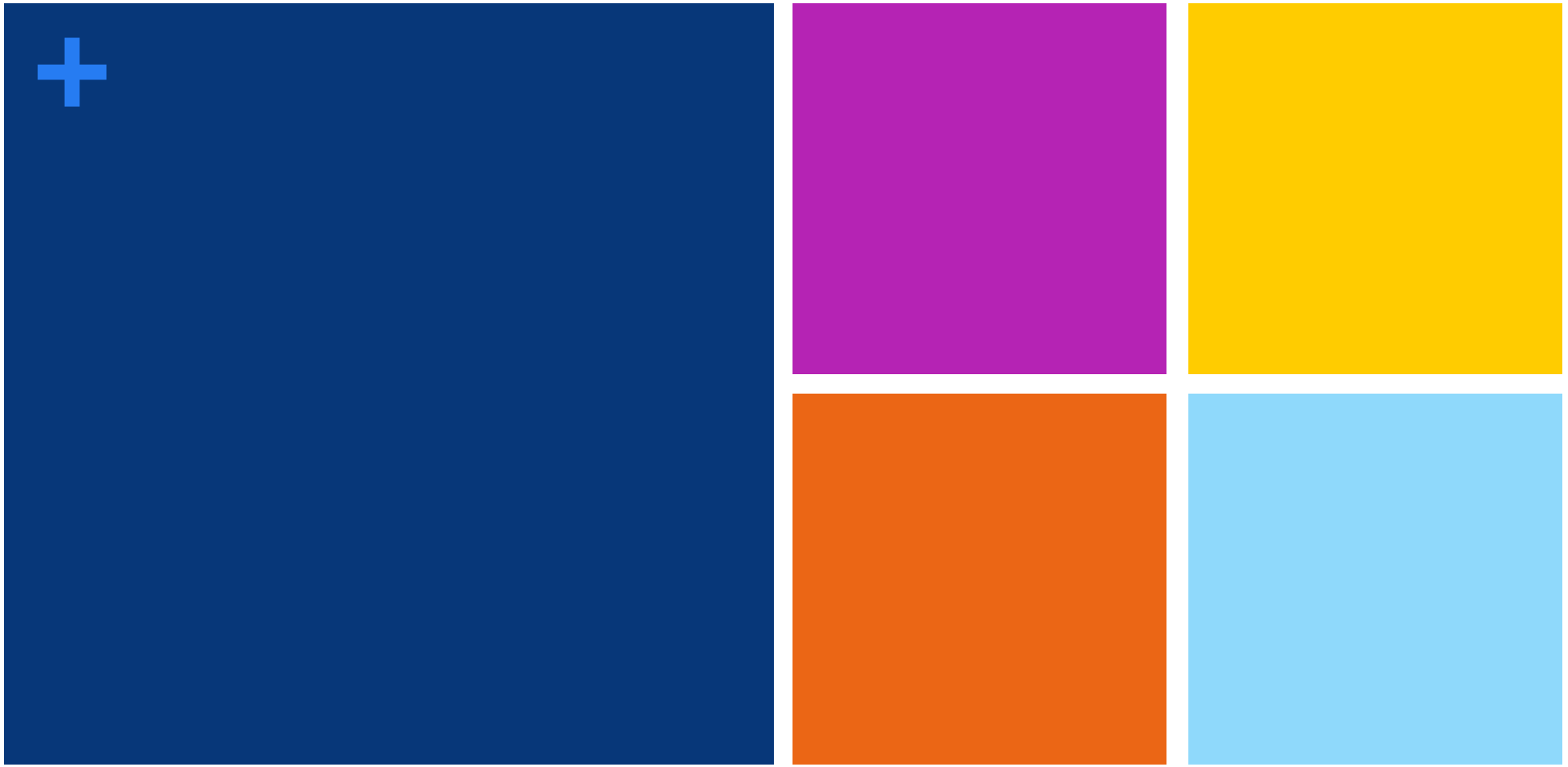

Distributed Systems

Academic Year 2021-22

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Faculty

- **José María Foces Morán**
  - ***Part I (Architecture of Distributed Systems, Sept-Nov)***
  - ***ds.cs.unileon@gmail.com, chema.foces@unileon.es***
  - Technology II bldg., office 363, phone ext. 5390
  - Tutor assistance hours:
    - Announced on Google calendar at ***http://paloalto.unileon.es/ds/calendar.html***
    - Habitually, office hours will be held on tuesdays from 16:30 thru 17:30
    - Office no. 363/Lab B6
    - Unileon Google Meet room **DistributedSystems_CS_ULE**
  - Notes, presentations, etc
    - ***http://paloalto.unileon.es/ds***
- **Antonio Sánchez Vargas**
  - ***Part II (Hadoop, Nov-Jan (2022)***

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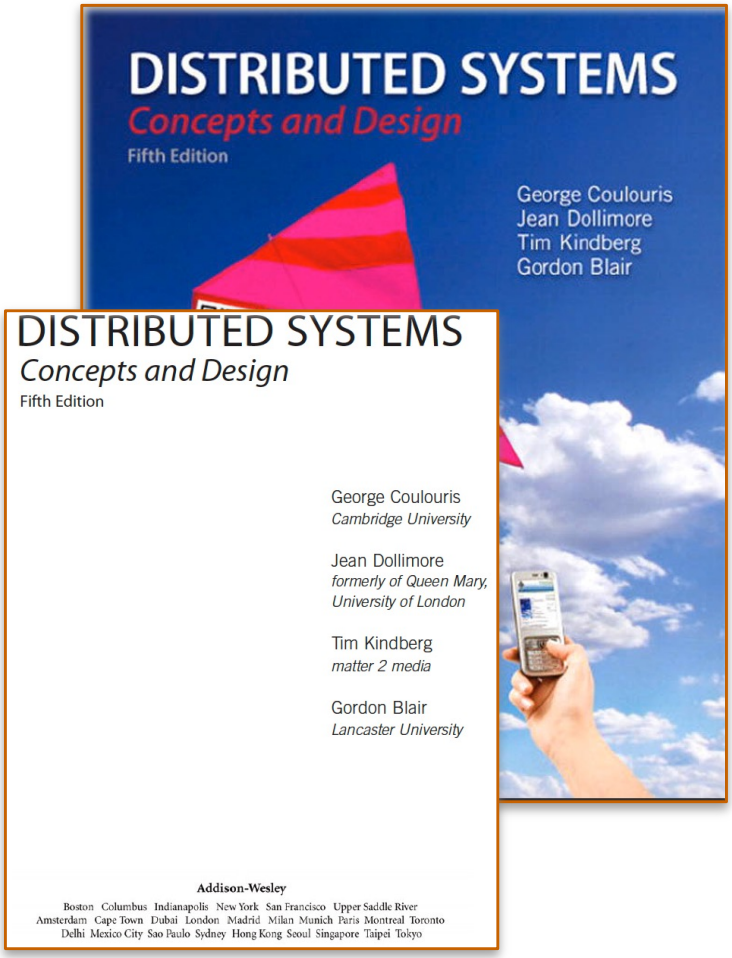
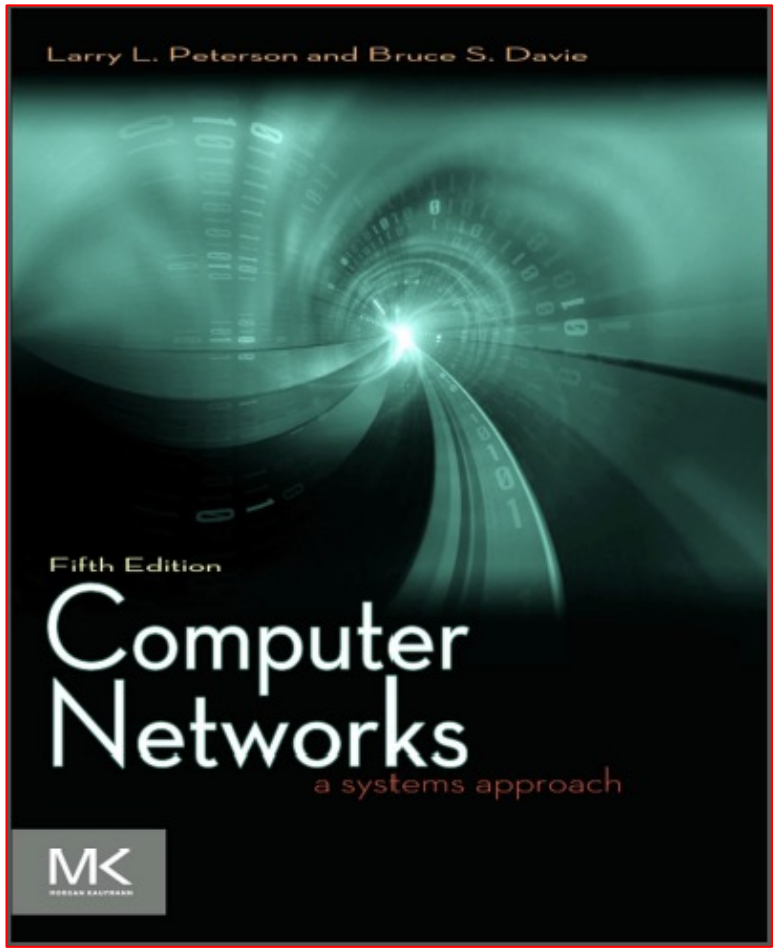
Main Reference books





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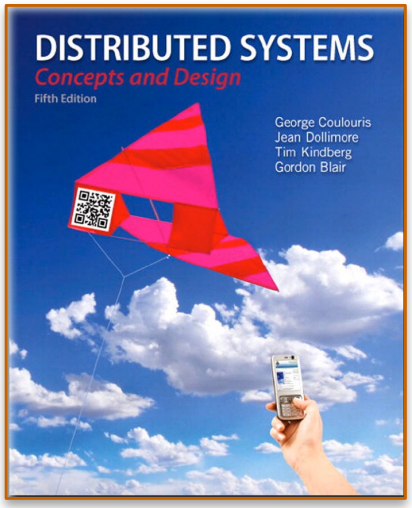
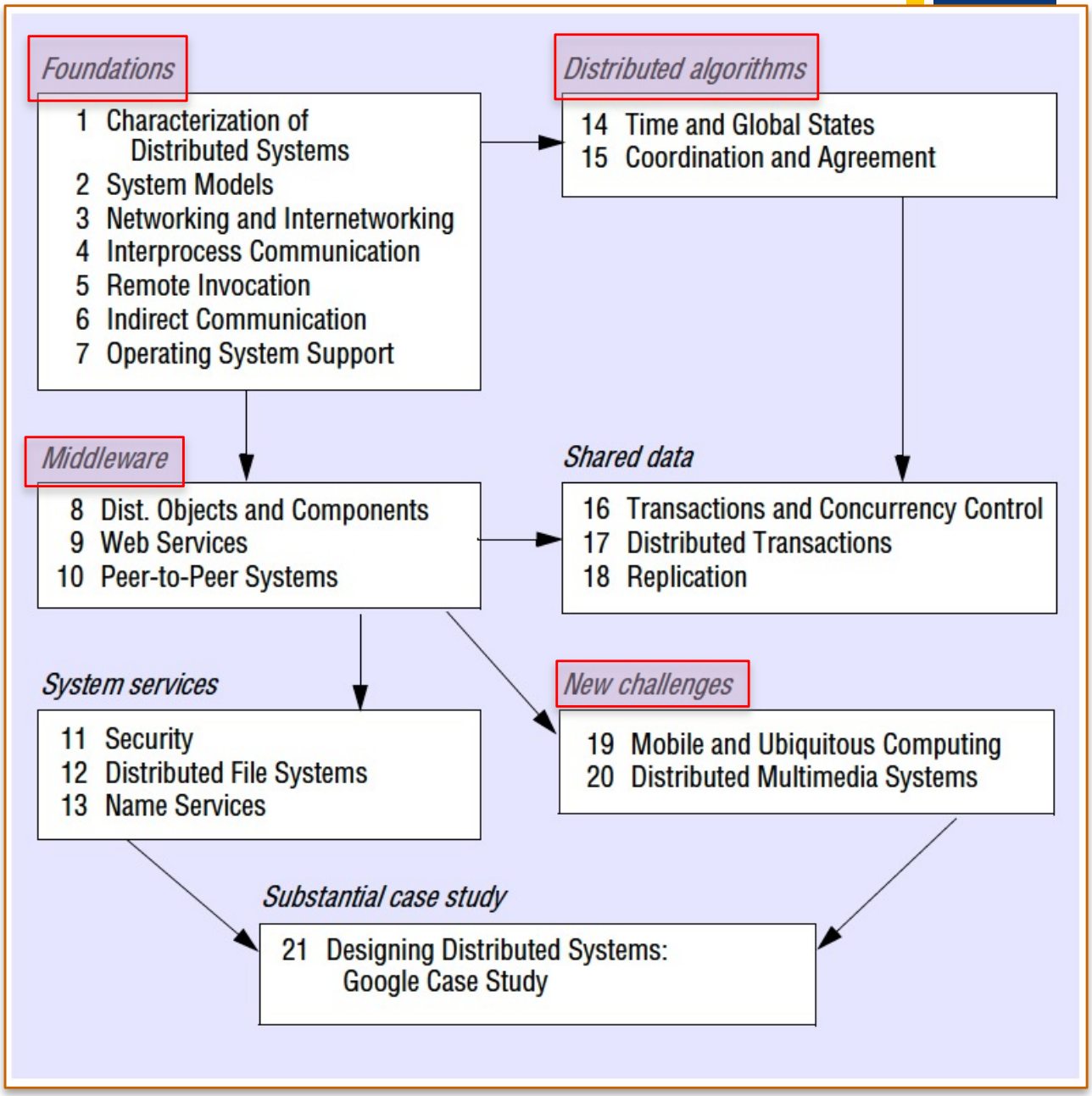
Course contents

- Main blocks
  1. Foundation
  2. Architecture of DS
  3. Middleware
  4. Distributed computing with Hadoop, etc.





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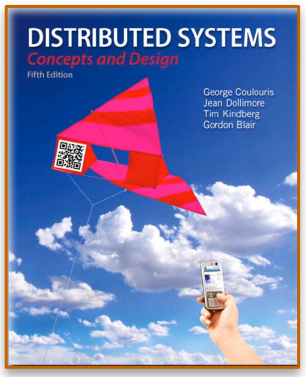
Course contents



1. Foundation

a) Networking summary
b) Faults in distributed systems: Reliable transmission with TCP
c) Socket programming
d) Clocks and states: Crstian's algorithm, clock synchronization with ICMP and NTP, Lamport clocks

2. Architecture of DS

a) Layered and tiered models
b) The C/S and peer-to-peer models

3. **Middleware**

a) RPC
b) RMI/Distributed objects

4. Distributed computing technologies (Hadoop and others)

a) Concepts and possibilities of today's distributed system technologies

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Exams and homework

Essential responsibilities

- Participation
- Note taking
- Attendance to lectures AND labs!

Exams

- **Term Exam 1 (TE1)**
  - 8/Nov/2021
- **TE2**
  - 17/Jan/2021

Homework

- Weekly questionnaires
- Questionnaire solutions published shortly after Q. pub. date
- Some questionnaire may be assessed

Aptitude vs. actitude?

Equally important

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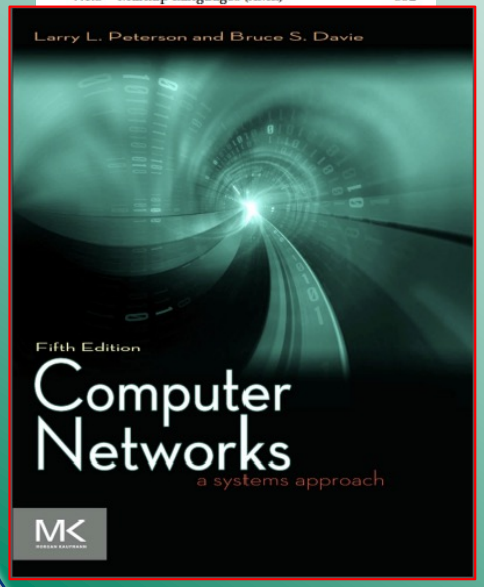
Chapters of each book

4 Advanced Internetworking
Problem: Scaling to Billions 307
4.1 The Global Internet 308
4.1.1 Routing Areas 310
4.1.2 Interdomain Routing (BGP) 313
4.1.3 IP Version 6 (IPv6) 324
4.2 Multicast 338
4.2.1 Multicast Addresses 340
4.2.2 Multicast Routing (DVMRP, PIM, MSDP) 341
4.3 Multiprotocol Label Switching (MPLS) 354
4.3.1 Destination-Based Forwarding 355
4.3.2 Explicit Routing 362
4.3.3 Virtual Private Networks and Tunnels 364
4.4 Routing among Mobile Devices 369
4.4.1 Challenges for Mobile Networking 369
4.4.2 Routing to Mobile Hosts (Mobile IP) 372
4.5 Summary 379
What's Next: Deployment of IPv6 380
Further Reading 381
Exercises 382

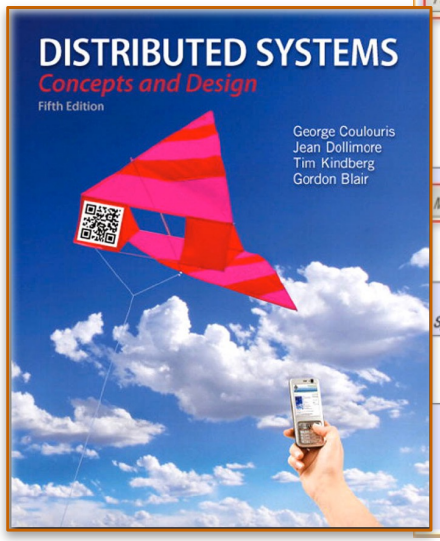
5 End-to-End Protocols
Problem: Getting Process to Communicate 391
5.1 Simple Demultiplexer (UDP) 393
5.2 Reliable Byte Stream (TCP) 396
5.2.1 End-to-End Issues 397
5.2.2 Segment Format 400
5.2.3 Connection Establishment and Termination 402
5.2.4 Sliding Window Revisited 407
5.2.5 Triggering Transmission 414
5.2.6 Adaptive Retransmission 418
5.2.7 Record Boundaries 422
5.2.8 TCP Extensions 423
5.2.9 Performance 425
5.2.10 Alternative Design Choices 428
5.3 Remote Procedure Call 431
5.3.1 RPC Fundamentals 431
5.3.2 RPC Implementations (SunRPC, DCE) 440
5.4 Transport for Real-Time Applications (RTP) 447
5.4.1 Requirements 449
5.4.2 RTP Design 452
5.4.3 Control Protocol 456
5.5 Summary 460
What's Next: Transport Protocol Diversity 461
Further Reading 462
Exercises 463

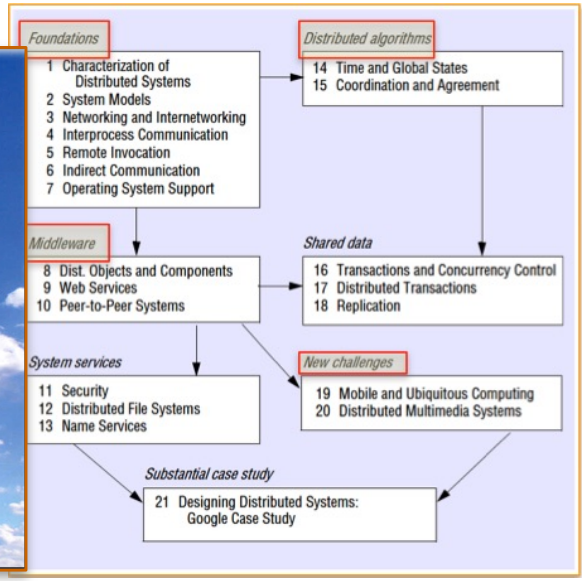
7 End-to-End Data
Problem: What Do We Do with the Data? 579
7.1 Presentation Formatting 581
7.1.1 Taxonomy 583
7.1.2 Examples (XDR, ASN.1, NDR) 587
7.1.3 Markup Languages (XML) 592

9 Applications
Problem: Applications Need their Own Protocols 697
9.1 Traditional Applications 698
9.1.1 Electronic Mail (SMTP, MIME, IMAP) 700
9.1.2 World Wide Web (HTTP) 708
9.1.3 Web Services 718
9.2 Multimedia Applications 727
9.2.1 Session Control and Call Control (SDP, SIP, H.323) 728
9.2.2 Resource Allocation for Multimedia Applications 739
9.3 Infrastructure Services 744
9.3.1 Name Service (DNS) 745
9.3.2 Network Management (SNMP) 756
9.4 Overlay Networks 759
9.4.1 Routing Overlays 762
9.4.2 Peer-to-Peer Networks 769
9.4.3 Content Distribution Networks 783
9.5 Summary 789
What's Next: New Network Architecture 790
Further Reading 791
Exercises 793



- **Topic blocks:**
  1. Foundations
  2. Architecture
  3. Middleware
  4. Distributed computing
- We will inform you about the book section relevant to each book chapter





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Languages and OS for practicals

- **Linux (Preferrably Ubuntu or Debian) or UNIX (OS-X)**
- **Windows ≈**
- **C and Java SE**
- **Lab B6 (Networks and Distributed Systems)**
  - Raw and Berkeley Sockets
  - Client/Server with Sockets and RMI (Remote Method Invocation)
  - Remote Objects, concurrency
  - Protocol Analysis for DS (Distributed Systems)
    - IP, TCP, UDP, http, NTP
  - Real-time clock synchronization with Raw Sockets
- **Lab B3 (ATC)**
  - Distributed Programming with Hadoop

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Schedule and locations

- **Lectures: A single, on-site attendance group (A)**
  - **Classroom Building, classroom no. 18**
  - **Monday 13:00 – 15:00**
- **Problem and exercises sessions (B1)**
  - **Monday 12:00 – 12:40**
  - **Classroom Building, classroom no. 10**
- **Lab Practices (B3)**
  - **Technology II bldg., Lab B6**
  - **4 groups every *other* week**
    - G1 (Mondays)09:00 – 10:30
    - G2 10:30 – 12:00
    - G3 16:30 – 18:00
    - G4 (Tuesdays) 13:00 – 14:30

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Assessment

- Term Exam 1
  - Passing this exam is a **necessary condition** for passing the course
  - If passed, the weight of this exam on the final grade is 45%
- Term Exam 2
  - Passing this exam is a **necessary condition** for passing the course
  - If passed, the weight of this exam on the final grade is 25%
- Regular completion of practices and DSPro : 15%
- LabBook: 10%
- Other: 5% (Questionnaires, etc)

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Questions?

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