

# **Computer Networks (Datanet)**

## **Course Outline - Student Version**

Kenneth Skovhede  
DIKU

**2013/2014**  
**Block: 4**  
**Schedule Group: B**

# Lecture 1: Tuesday 22 April, Week 1 (17)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- General introduction to the course
- Introduction to the Internet, networks, and protocols
- Identification of causes of delay, loss and throughput
- Introduction to the assignments

## Learning Goals

- Describe the overall structure of the course
- Describe the general structure of the assignments
- Describe the concept of a protocol and identify protocols used on the Internet
- Describe what a client and a server program is
- Identify access network technologies and summarise their benefits and drawbacks
- List different types of physical media and summarise their characteristics
- Compare and contrast circuit and packet switching
- List the different sources of delays in packet switching networks
- Calculate delays in different kinds of packet switching networks
- Describe under what conditions queueing delay occurs
- Differentiate between average and instantaneous throughput
- List the layers in the Internet and OSI protocol stacks and summarise the role of each layer
- Describe the overall structure of the assignments for the course

## Reading

Chapter 1, Pages 27—81:

- 1.1 What is the internet?
- 1.2 The Network Edge
- 1.3 The Network Core
- 1.4 Delay, Loss, and Throughput in Packet-Switched Networks
- 1.5 Protocol Layers and Their Service Models

## Lecture Plan

15	10	15	5	10	20	15
Course info	Internet and protocols	Network edge	Network core	Network core (cont)	Delay, loss, and throughput	Intro to assessments

# Lecture 2: Friday 25 April, Week 1 (17)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Generally introduce distributed applications on the Internet
- Introduce and discuss the protocols used in delivering webpages
- Description of HTTP protocol and message formats
- Introduction to Socket programming

## Learning Goals

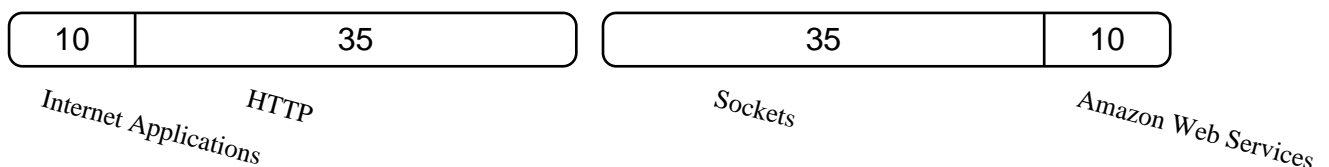
- Briefly describe the general network application architectures
- Identify the interfaced used between application processes and a computer network
- Identify and summarise the characteristics of the transport services available on the Internet, as well as describe under which circumstances a particular transport service would be used
- Identify how computers and processes are addressed in computer networks
- Describe the benefit of *persistent connections*
- Describe the format of a URL
- Identify and use the source of the HTTP standard
- Describe the general format of an HTTP message and the difference between requests and responses
- List and describe the most important HTTP responses
- Describe the use of headers, list and describe the most important headers
- Describe the use and need for the *Host* header

## Reading

Chapter 2, Pages 109—142:

- 2.1 Principles of Network Applications
- 2.2 The Web and HTTP

## Lecture Plan



## Notes

For this lecture you may also want to skim the sections on Socket programming from the book (section 2.7), especially if you are planning on programming in Python. For other languages you might be better off looking at a Socket programming tutorial on the Internet specifically for that language.

## **Practical 1: Monday 28 April, Week 2 (18)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 3: Tuesday 29 April, Week 2 (18)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Present the most predominant application layer services FTP, SMTP, DNS, POP, IMAP
- The basic of FTP transfers and how evolution has made FTP less attractive
- A glance of the SMTP evolution
- A thorough look at DNS, what it is and what it provides

## Learning Goals

- Understand the basics of SMTP
- Describe how SMTP, FTP, POP and other protocols resemble human conversation
- Identify FTP and SMTP messages from a network trace
- Understand how an application layer service, such as DNS, can provide features to other application layer
- Understand how DNS can be a critical component in internet structure
- Compare HTTP with SMTP and FTP protocols

## Reading

Chapter 2, Pages 142—170:

2.3 File Transfer FTP

2.4 Electronic Mail in the Internet

2.5 DNS — The Internet's Directory Service

## Lecture Plan

30	15	15	30
<i>FTP</i>	<i>SMTP</i>	<i>SMTP (cont)</i>	<i>DNS</i>

# Lecture 4: Friday 2 May, Week 2 (18)

*Location: Lille UP1 - 04-1-22 (DIKU)*

*Lecturers: Kenneth Skovhede*

## Outline

- Transport Layer (1)
- The UDP Protocol
- Building a reliable transport from an unreliable network

## Learning Goals

- Describe the basic purpose of the transport layer
- Describe how the transport layer enables and implements multiplexing
- List the primary sources of packet loss
- Describe how a reliable transport service can be implemented on top of an unreliable service
- Explain how receive windows can improve performance of a network

## Reading

Chapter 3, Pages 211—256:

- 3.1 Introduction and Transport Layer Services
- 3.2 Multiplexing and Demultiplexing
- 3.3 Connectionless Transport: UDP
- 3.4 Principles of Reliable Data Transfer

## Lecture Plan

45

*Transport layer*

45

*Transport layer (cont)*

## Notes

If you try the nmap port scanner, mentioned on page 222, be sure that you own the server you are scanning. Many service providers will consider a port scanning a hostile attack!

## **Practical 2: Monday 5 May, Week 3 (19)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 5: Tuesday 6 May, Week 3 (19)

*Location: Lille UP1 - 04-1-22 (DIKU)*

*Lecturers: Kenneth Skovhede*

## Outline

- Transport Layer (2)
- TCP protocol

## Learning Goals

- Describe how sequence numbers and acknowledgement numbers are used in TCP
- Describe how TCP ensures reliable transfers
- List limitations of the TCP protocol
- List the different cases of package loss and corruption that TCP handles
- Describe the startup and shutdown phases in a TCP connection

## Reading

Chapter 3, Pages 257—284:

3.5 Connection-Oriented Transport: TCP

## Lecture Plan

45

*Transport Layer 2*

45

*Transport Layer 2 (cont)*



# Lecture 6: Friday 9 May, Week 3 (19)

*Location: Lille UP1 - 04-1-22 (DIKU)*

*Lecturers: Kenneth Skovhede*

## Outline

- Transport Layer (3)
- Congestion control
- Fairness

## Learning Goals

- Explain why congestion is inevitable
- List causes of congestion
- Describe approaches to controlling congestion
- List basic mechanisms of congestion control in TCP
- Describe optimizations proposed for TCP congestion control
- Compare the goals of congestion with the goals of fairness
- Explain how UDP interferes with TCP's fairness and congestion algorithms

## Reading

Chapter 3, Pages 285—308:

3.6 Principles of Congestion Control

3.7 TCP Congestion Control

## Lecture Plan

45

*Transport Layer 3*

45

*Transport Layer 3 (cont)*

## **Practical 3: Monday 12 May, Week 4 (20)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 7: Tuesday 13 May, Week 4 (20)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Description of the network service models and their guarantees
- Different types of routers and how they work
- The internet protocol IPv4 in detail
- Routing with IPv4, subnets and suffix matching
- DHCP and ISPs as IP assigners
- NAT based IP communication
- Description of the ICMP and what we can use it for
- Description of problems with IPv4 and the transition to IPv6
- Basic internet routing (inter-AS and intra-AS)
- Broadcasting and multicasting with the IP protocol

## Learning Goals

- Identify benefits and drawbacks from different network service models
- Describe the differences between switching technologies
- Describe the differences between store-and-forward and worm-hole routing
- Describe key IP issues, such as fragmentation, MTU, addressing, acknowledge
- Apply basic routing based on subnet identification and suffix matching
- Enumerate the four basic DHCP messages
- Describe how IP addresses are allocated to/from an ISP
- Explain what problems NAT based routing solves, and what problems it creates
- Briefly describe what ICMP messages are used for
- Describe problems with IPv4 and IPv6 co-existence
- Enumerate different kinds of multicast/broadcast strategies

## Reading

Chapter 4, Pages 331—389:

- 4.1 Introduction (The Network Layer)
- 4.2 Virtual Circuit and Datagram networks
- 4.3 What's Inside a Router?
- 4.4 The Internet Protocol (IP): Forwarding and Addressing in the Internet

## Lecture Plan

45

*Network layer*

45

*Network layer (cont)*

## **Practical 4: Monday 19 May, Week 5 (21)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 8: Tuesday 20 May, Week 5 (21)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Access Networks
- Parity and Checksums
- Physical Address (MAC)
- Address Resolution (ARP)
- Switches

## Learning Goals

- Describe where the link layer is identified
- Explain the difference between error detection and error correction
- Apply CRC to a practical example
- List different partitioning Protocols
- Explain how ARP works with IP addresses and link-layer routing
- Describe how a switch works
- Describe the differences between switches, hubs and routers

## Reading

Chapter 5, Pages 459—512:

- 5.1 Introduction to the Link Layer
- 5.2 Error-Detection and -Correction Techniques
- 5.3 Multiple Access Links and Protocols
- 5.4 Switched Local Area Networks

## Lecture Plan

45

*The link layer*

45

*The link layer (cont)*

# Lecture 9: Friday 23 May, Week 5 (21)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Wireless networks
- GSM and Cellular data
- Mobility

## Learning Goals

- List problems with Mobility
- Describe benefits and drawbacks of various wireless technologies
- Explain the hidden terminal problem
- List the components of the 802.11 protocol
- Describe the basic topology of Bluetooth networks
- Describe the differences between GSM 1G, 2G, 3G and 4G (LTE)
- Describe the handoff protocol for GSM

## Reading

Chapter 6, Pages 539—581, Pages 596—601:

- 6.1 Wireless Links and Network Characteristics
- 6.2 WiFi: 802.11 Wireless LANs
- 6.3 Cellular Internet Access
- 6.4 Managing Mobility in Cellular Networks

## Lecture Plan

45

*Mobile networks*

45

*Mobile networks (cont)*

## **Practical 5: Monday 26 May, Week 6 (22)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 10: Tuesday 27 May, Week 6 (22)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Distributed Systems 1
- Introduction to basic distributed concepts, such as client/server, peer-to-peer, concurrency, scalability, durability and fault tolerance
- Case study: Google as a distributed system
- Distributed systems in eScience
- Introduction to Grid computing
- Introduction to Sensor networks
- Introduction to assignment 3
- Introduction to distributed filesystems
- Case studies: NFS and AFS

## Learning Goals

- Describe basic concepts from distributed systems
- Describe basic concepts of the NFS and AFS filesystems

## Reading

Chapter 2, Pages 179—182:

2.6 Peer-to-Peer Applications

## Lecture Plan

45	10	35
<i>Introduction to distributed systems</i>	<i>Introduction to assignment 3</i>	<i>Distributed file systems</i>



# Lecture 11: Friday 30 May, Week 6 (22)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Distributed hash tables
- Case study: Kademlia
- Case study: Dynamo
- Case study: BigTables

## Learning Goals

- Describe concepts of a distributed hash table, such as overlay and distance metric
- Apply the CAP theorem to own work
- Describe the Kademlia routing protocol
- Describe properties of vector clocks
- Able to read an academic article

## Reading

- 1.1 Kademlia: A peer-to-peer Information System Based on the Xor Metric
- 1.2 Dynamo: Amazon's Highly Available Key-value Store
- 1.3 Bigtable: A Distributed Storage System for Structured Data

## Lecture Plan

15	25	5	20	25
Distributed hash tables	Case study - Kademlia	Case study - Dynamo	Case study - Dynamo (cont)	Case study - BigTables

## **Practical 6: Monday 2 June, Week 7 (23)**

*Location: 1-0-04, 3-1-25, 1-0-37 (DIKU)*

*Supervisors: Teaching Assistants*

# Lecture 12: Tuesday 3 June, Week 7 (23)

*Location: Lille UP1 - 04-1-22 (DIKU)*

*Lecturers: Kenneth Skovhede*

## Outline

- Distributed Systems 3
- Anonymity and privacy
- TOR

## Learning Goals

- Describe how a P2P network works
- Identify situations where anonymity is used
- Mention the key elements in the Tor network
- Describe onion routing

## Lecture Plan

15	30	45
<i>Venture Cup</i>	<i>Distributed Systems 3</i>	<i>Distributed Systems 3 (cont)</i>

# Lecture 13: Friday 6 June, Week 7 (23)

*Location: Lille UP1 - 04-1-22 (DIKU)*

*Lecturers: Kenneth Skovhede*

## Outline

- Test exam

## Lecture Plan

45	45
<i>Test exam</i>	<i>Test exam (cont)</i>

## Notes

This lecture is reserved for a trial-run of the exam. This lecture starts at 15:00 and lasts until 17:00, and is not a traditional lecture. Instead of a lecture, you will receive an exam set from a previous exam, and are asked to solve it within two hours. After the two hours, I will collect your answers and you will get some general feedback.

# Lecture 14: Tuesday 10 June, Week 8 (24)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Security 1

## Learning Goals

- Describe common terms used in cryptography (message integrity, sniffing, man-in-the-middle, etc).
- Describe the key components of cryptography
- Describe the differences between symmetric and asymmetric key cryptography
- Identify situations where cryptography is used to protect data information

## Reading

Chapter 8, Pages 697—731:

- 8.1 What Is Network Security?
- 8.2 Principles of Cryptography
- 8.3 End-Point Authentication
- 8.4 Message Integrity and Digital Signatures

## Lecture Plan

45

*Security 1*

45

*Security 1 (cont)*

# Lecture 15: Friday 13 June, Week 8 (24)

**Location:** Lille UP1 - 04-1-22 (DIKU)

**Lecturers:** Kenneth Skovhede

## Outline

- Security 2
- Wireless
- Firewalls
- Q & A
- Follow up on test exam

## Learning Goals

- Give an overview of WEP and WPA encryption and describe the weaknesses in the two protocols
- Describe the differences between traditional packet filters, stateful packet filters and applications gateways

## Reading

Chapter 8, Pages 752—757, Pages 737—743, Pages 731—737, Pages 757—768:

8.8 Securing Wireless LANs

8.9 Securing TCP Connections: SSL

8.10 Securing E-mail

8.11 Operational Security: Firewalls and Intrusion Detection Systems

## Lecture Plan

45	30	15
<i>Security 2</i>	<i>Security 2 (cont)</i>	<i>Course sunset</i>

# Assignment 1 — Tools of the trade

**Set:** Tuesday 22 April

**Due:** Friday 2 May

## Guesstimated Time Breakdown

1h	Familiarisation
2h	Finding and installing tools
5h	Experiments
5h	Writing report

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Total: 13 hours

## Learning Goals

- Find and install simple tools
- Be able to examine the network using tools

## Notes

In this first assignment you will examine some of the tools that are used every day by network specialists.

# Assignment 2 — Web Server

**Set:** Monday 5 May  
**Due:** Thursday 15 May

## Guesstimated Time Breakdown

1h	Familiarisation
4h	Finding and reading relevant RFCs and documentation
5h	Implementation
5h	Writing report

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Total: 15 hours

## Learning Goals

- Find, read, and understand material used for defining and describing Internet protocols, including RFCs
- Use and understand the socket library
- Be able to implement a simple protocol directly using sockets
- Evaluate the performance of a webserver

## Notes

In this first assignment you will be building a simple webserver that can serve static content from the file system. You will be implementing the HTTP protocol using sockets and will need to research both of these topics. You will also be writing a report on your webserver.



# Assignment 3 — P2P downloader

**Set:** Monday 19 May

**Due:** Monday 2 June

## Guesstimated Time Breakdown

1h Familiarisation

4h Finding and reading relevant RFCs and documentation

10h Implementation

5h Writing report

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Total: 20 hours

# Assignment 4 — WebDAV server

**Set:** Tuesday 3 June

**Due:** Thursday 12 June

## Guesstimated Time Breakdown

2h Familiarisation

6h Finding and reading relevant RFCs and documentation

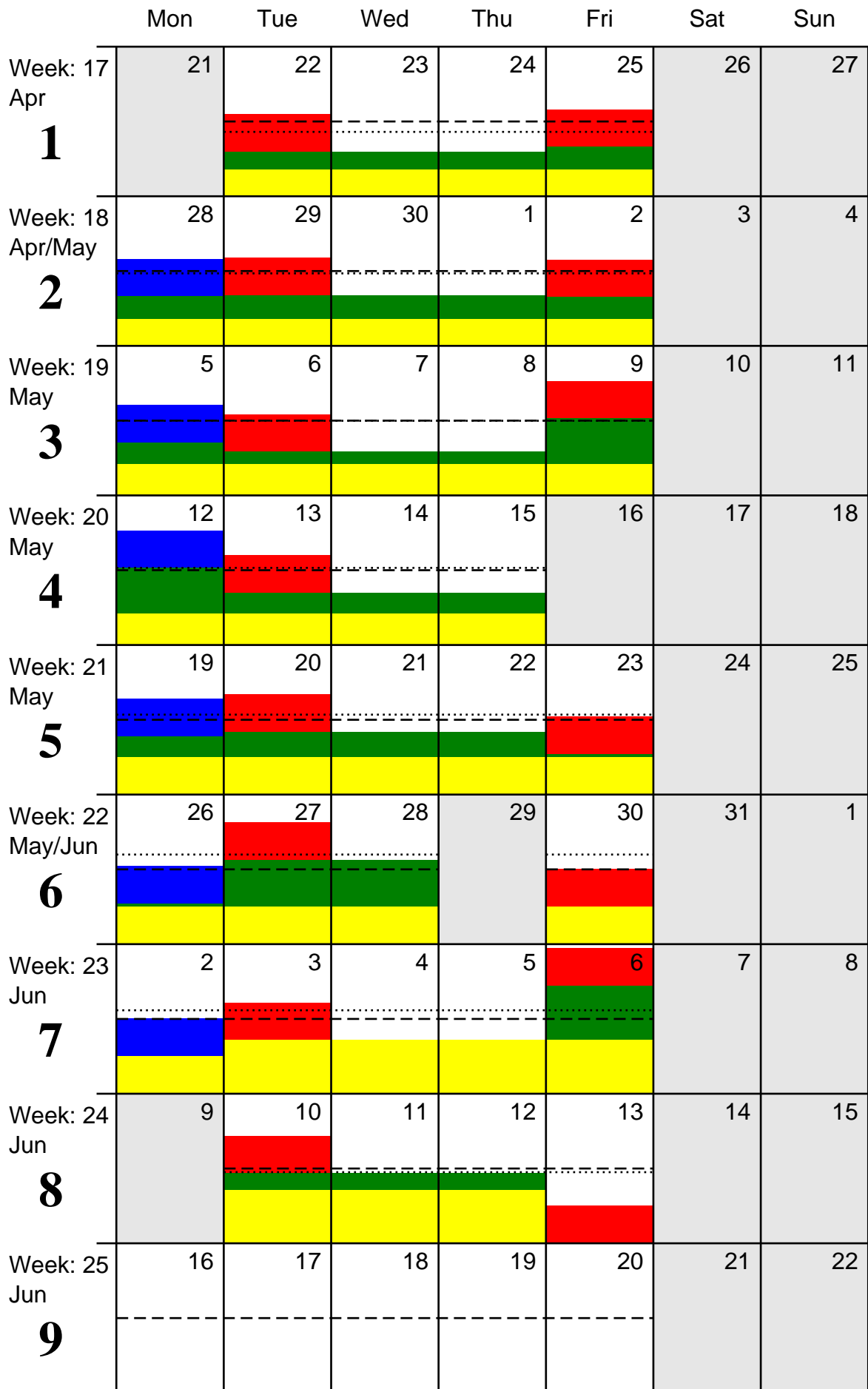
7h Implementation

5h Writing report

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Total: 20 hours

# Guesstimated Work Pressure



Assignments    
  Reading    
 - - 20 hours per week, averaged over weekdays  
 Practicals    
 Lectures    
 27 ..... actual hours, averaged over weekdays

## Using this Document

I have made this document to help me (the lecturer) prepare the course. I have also, however, made it as a tool to communicate to you (the students) what I expect you to get out of the course, the individual lectures, practical session, and assignment. Thus, I have presented the overview of the content covered in each lecture and practical session, together with a number of learning goals. At the end of a lecture or practical session you can use these learning goals to take stock of what you have learnt and what you need to work on. Do not expect to have the learning goals covered by just going to the lectures without doing any auxiliary work, such as reading the textbook. The lectures will not be a recital of the material in the textbook and you will therefore have to read it in order to be able to check off all the learning goals. Attempting some of the *Further Reading* as well as doing independent study will also help you to fully understand the material, and thereby being able to tick off all the learning goals.

## Updates

I will from time to time make updates to this document. You should check regularly on Absalon to see if you have the latest version. The version of the document can be seen on the front page of this PDF.

## The Assignments

I have made some guesses as to how long the assignments should as a whole should take and provided an estimate of how you may want to consider dividing your time amongst the individual parts of an assignment. These are *guesstimates* and should be taken as a *guide* only. I would however appreciate if you could make a note of roughly how much time you spent on a particular assignment so that I may improve guesstimates in future versions of this document. I will provide a section on the end-of-course evaluation, but you can also put a note in Absalon with this information when you hand in your assignment, or you can add it to the report that you hand in.

## The Guesstimated Work Pressure

The guesstimated work pressure is divined by taking the time you are going to spend attending lectures and practical sessions, working on your assignments, and reading the set material in the book every week (with a sgenerous amount of time allocated to read a page in the textbook). Work on the assignments and required reading has been split evenly over the days from when it was set to when it is due. The assumption made in the diagram is that you work a five day week and do not work on the weekends. This may or may not reflect reality and you may of course work however and whenever you like.

You should note that the title of the diagram contains the word *guesstimate*, which my dictionary (*The New Oxford American Dictionary, Second Edition*) defines as: "an estimate based on a mixture of guesswork and calculation." This is exactly what it is, an estimate of how much time I think you need to spend on the course, it is not a prescription! You may use more time or less, this is fine. Thus, the *Guesstimated Work Pressure* is there for you to be able to visualise the workload in the course and thereby help you arrange your work schedule. Please don't throw a fit if our guesstimates turn out to be somewhat inaccurate, but do let me know so I can adjust them in future iterations of the course.

## Providing us with Feedback

At the end of the course I will be asking for your feedback. I would like to know how useful this document was to you and how I could improve it. As already mentioned, I will be asking you how much time you spent on different parts of the course to see how they match up with our expectations as to how long I think they should take you. It would therefore be useful if you can keep (rough) notes on the time you spend, for example on reading and your assignments. There will be a space to comment on this aspect on the end-of-course evaluation.