DSE Electives:
Guide to Electives for Distributed Systems Engineering students

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Purpose of this Guide

• DSE students usually study 4 semesters
  • 1st semester → attending mandatory courses
  • 4th semester → writing master thesis
  • 2-3 semesters → taking electives & internship ??
Purpose of this Guide

• Many students get confused by electives & internship
  • need 60 credits altogether, i.e., 30 credits/semester
  • electives are very different → how to suit your needs?
  • electives are composed of several „units“
    • lectures, exercises, labs
    • some in summer, some in winter

Purpose of this guide: overview of electives and possible paths in 2 semesters
(up-to-date version at https://bitbucket.org/dimakuv/dse-electives-internship-guide)
You need 60 Credits

60 credits

<table>
<thead>
<tr>
<th>Electives: 48 credits</th>
<th>Internship: 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>[E5] IS: Selected Areas of Internet-based Systems</td>
<td>6</td>
</tr>
<tr>
<td>[E3] DOS: Distributed Operating Systems</td>
<td>6</td>
</tr>
<tr>
<td>[E14] ATDS: Advanced Topics in Distributed Systems</td>
<td>6</td>
</tr>
</tbody>
</table>

* – number of credits depends on courses taken
Be Careful! Module Conflicts!

- **E5** includes the same courses as **E2** and **E10**
- so if you take **E2** and **E10**, you **cannot** take **E5** (because of the conflicts of courses)
- but you can take **E2** and **E5** without **E10**
- or you can take **E10** and **E5** without **E2**

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<thead>
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- **E6** and **E7** include the internship labs 1 and 2 correspondingly
- So if you take, for example, **E6**, you **cannot** take lab 1 (and the other way around)
Electives: Overview

- **ASC: Advanced Security and Cryptography**
  - Recommended for: everyone
  - By: Chair of privacy and data security
  - Description:
    - Topics include ciphers for cryptographic encryption (DES, Diffie-Hellman, RSA), secret keys, different attacks via network, anonymity. Warning: a lot of theory, algorithms, and math
  - Includes:
    - Security and Cryptography II (lectures + exercises)
      - summer semester

NOTE: orange highlightings are clickable links
## Electives: Overview

<table>
<thead>
<tr>
<th>Code</th>
<th>Elective</th>
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<tbody>
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### Recommended for:
- networks path

### By:
Chair of Computer Networks

### Description:
- Many programs require input data from sensors (for example, weather conditions). Usually there are many sensors connected in one network. Topics: how to pass info between sensors? what if some sensors fail? how to efficiently place sensors?

### Includes:
- **Wireless Sensor Networks** (lectures + exercises)
  - summer semester
Electives: Overview

Recommended for:
→ networks path

By: Chair of Computer Networks

Description:
→ How are wide-area (internet) and local-area (wireless) networks arranged. How to program mobile applications that communicate over networks.

Includes (choose any 2 of these 3):
→ Internet and Web Applications (lectures + exercises)
  – summer semester
→ Wireless Sensor Networks (lectures + exercises)
  – summer semester
→ App Development for Mobile & Ub. Comp. (lect + ex)
  – winter semester
Electives: Overview

Recommended for:
- balanced path
- networks path

By: Chair of Computer Networks

Description:
- How to program mobile applications that communicate over networks.

Includes:
- App Development for Mobile & Ub. Comp. (lect + ex) – winter semester
## Electives: Overview

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**Recommended for:**
- balanced path
- theory path

**By:** Chair of Software Technology

**Description:**
> Building complex SW systems is challenging. One way is to build these systems from components. Lecture discusses possible ways to implement and connect these components in one system.

**Includes:**
- **Component-based Software Engineering** *(lec + ex)*
  - summer semester
## Electives: Overview

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**Recommended for:**
- theory path

**By:** Chair of Computational Logic

**Description:**
- Propositional logic, equational logic; machine learning; natural-language processing. Warning: lots of math and theory!

**Includes:**
- Foundations, Module No. MCL-F (lec + ex)
- winter semester
### Electives: Overview

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**Recommended for:** everyone

**Description:**

- Distributed systems are composed of many independently operating nodes (machines, CPU cores, etc.). How to orchestrate all these nodes? How to synchronize information among them? How to enforce security on remote machines?

**Includes:**

- **Distributed Operating Systems** (lec + ex)
  - summer semester

By: Chair of Operating Systems
Electives: Overview

Recommended for: operating systems path

By: Chair of Operating Systems

Description:
- Topics include many low-level OS mechanisms: threads and concurrency, inter-process communication (IPC), device drivers, memory and resource management, virtualization, security, fault tolerance.

Includes:
- Microkernel-based Operating Systems (lec + ex)
  - winter semester
Electives: Overview

Recommended for:
→ operating systems path
→ theory path

By: Chair of Operating Systems

Description:
→ Many SW systems need to operate at real-time (transport control systems, for example). This means that computers must schedule and perform computations to meet deadlines. Theory on scheduling and the concepts on time are explained.

Includes:
→ **Real-Time Systems** (lec + ex)
  – winter semester

**Included Courses:***
- ASC: Advanced Security and Cryptography
- WSN: Wireless Sensor Networks
- IS: Selected Areas of Internet-based Systems
- CBSE: Component-based SW Engineering
- FCL: Foundations of Computational Logic
- DOS: Distributed Operating Systems
- MOS: Microkernel-based Operating Systems
- RTS: Real-Time Systems
- CDS: Concurrent and Distributed Systems
- SFT: Software Fault Tolerance
- PODS: Principles of Dependable Systems
- ATSA: Advanced Topics in Systems Arch.
- ATDS: Advanced Topics in Distributed Systems
Electives: Overview

Recommended for: everyone

Description:
Modern SW systems work on clusters of many machines/CPUs (nodes). To make these systems fast and efficient, it is necessary to parallelize work on all available nodes. This course has a mix of theory on concurrency and practical tasks on parallel programming.

Includes:
- Foundations of Concurrent and Distributed Systems (lecture)
  - summer semester
- Lab: Concurrent and Distributed Systems
  - summer semester

By: Chair of Systems Engineering

Recommended Courses:

- ASC: Advanced Security and Cryptography
- WSN: Wireless Sensor Networks
- IS: Selected Areas of Internet-based Systems
- CBSE: Component-based SW Engineering
- FCL: Foundations of Computational Logic
- DOS: Distributed Operating Systems
- MOS: Microkernel-based Operating Systems
- RTS: Real-Time Systems
- CDS: Concurrent and Distributed Systems
- SFT: Software Fault Tolerance
- PODS: Principles of Dependable Systems
- ATSA: Advanced Topics in Systems Arch.
- ATDS: Advanced Topics in Distributed Systems

Credits:
- CDS: Concurrent and Distributed Systems: 12
- SFT: Software Fault Tolerance: 15
- PODS: Principles of Dependable Systems: 9
- ATSA: Advanced Topics in Systems Arch.: 3
- ATDS: Advanced Topics in Distributed Systems: 6
Electives: Overview

Recommended for: fault tolerance path

By: Chair of Systems Engineering

Description:
- All programs contain bugs. The more complex the program becomes, the more bugs it has. Moreover, some bugs can be very hard to diagnose and can affect people all around the world (like Skype crashes). The course covers techniques how to protect applications against SW bugs.

Includes:
- Software Fault Tolerance (lecture)
  - summer semester
- Lab: Software Fault Tolerance
  - winter semester
- Seminar: Current Topics in Software Fault Tolerance (paper reading)
  - winter semester
Electives: Overview

Recommended for: fault tolerance path

Description:
Computers can (rarely) fail not because of software bugs, but because of their unreliability: aging, manufacturing problems, bad environment conditions (high temperature or radiation). This becomes of serious concern when running SW systems on clusters of thousands of such unreliable computers. This course teaches how to cope with these problems at the hardware and software level.

Includes:
- Principles of Dependable Systems (lectures + exercises)
  - winter semester
- Seminar: Current Topics in Dependable Systems (paper reading)
  - summer semester

By: Chair of Systems Engineering
Electives: Overview

Recommended for: By: Different chairs
→ everyone (depends on taken course)

Description:
→ These two modules include all those courses not embedded in other modules. Depending on the chosen courses, students get different number of credits.

Includes:
→ Compiler construction (lectures) [rec. for balanced and theory path]
   – winter semester, 3 credits
→ iOS programming (lectures) [rec. for balanced and networks path]
   – winter semester, 3 credits
→ Lab: Microkernel-based OS [rec. for operating systems path]
   – winter semester, 6 credits
→ Paper Reading Group OS [rec. for everyone]
   – every semester, 3 credits

E1 ASC: Advanced Security and Cryptography
E2 WSN: Wireless Sensor Networks
E5 IS: Selected Areas of Internet-based Systems
E10 AD: App Development for Mobile & Ub. Comp.
E4 CBSE: Component-based SW Engineering
E12 FCL: Foundations of Computational Logic
E3 DOS: Distributed Operating Systems
E8 MOS: Microkernel-based Operating Systems
E9 RTS: Real-Time Systems
E6 CDS: Concurrent and Distributed Systems
E7 SFT: Software Fault Tolerance
E11 PODS: Principles of Dependable Systems
E13 ATSA: Advanced Topics in Systems Arch.
E14 ATDS: Advanced Topics in Distributed Systems
• Generally, you can follow these paths:
  (but of course, you can choose your own mix of modules)

**Balanced Path**
- **focus**: a bit of everything
- internet, mobile, security, parallel/distributed systems
- emphasis on SW practice

**Networks Path**
- **focus**: Wide/Local Area Networks
- internet, sensors, security, mobile, distributed systems
- emphasis on SW practice

**Fault Tolerance Path**
- **focus**: SW bugs / HW glitches
- dependable/fault tolerant systems, distributed systems, OS
- emphasis on low-level SW/HW

**Operating Systems Path**
- **focus**: Operating Systems (OS)
- operating (real-time, distributed) systems, parallel systems
- emphasis on low-level SW

**Theory Path**
- **focus**: SW theory
- security, software engineering, compilers, logic, real-time
- emphasis on theory/algorithms
**Examples: Balanced Path**

**Balanced Path**

→ focus: a bit of everything
→ internet, mobile, security, parallel/distributed systems
→ emphasis on SW practice

Electives (with their credits):
E1-ASC (6) + E5-IS* (12) + E4-CBSE (6) + E3-DOS (6) + E6-CDS (12) + E14-ATSA** (6) = 48

Internships:
Lab SE (6) + Company (6) = 12

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<tr>
<th>Summer (2nd) semester</th>
<th>Winter (3rd) semester</th>
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<td>E14-ATSA**: Compiler Construction</td>
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<td>E4-CBSE: Component-based SW Engineering</td>
<td>E14-ATSA**: Paper Reading Group OS</td>
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* E5-IS: chosen two courses – “Internet and Web Applications” and “App. Dev. for Mobile...”
** E14-ATSA: chosen “Compiler Construction” and “Paper Reading Group OS” (each 3 credits)
### Networks Path

- **Focus**: Wide/Local Area Networks
- Internet, sensors, security, mobile, distributed systems
- Emphasis on SW practice

Electives (with their credits):

\[
\text{E1-ASC (6) + E5-IS* (12) + E2-WSN (6) + E3-DOS (6) + E6-CDS (12) + E14-ATSA** (6) = 48}
\]

Internships:

2x Lab on Networks (6) = 12

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* E5-IS: chosen two courses – „Internet and Web Applications“ and „App. Dev. for Mobile...“
** E14-ATSA: chosen „iOS programming“ and „Paper Reading Group OS“ (each 3 credits)
Fault Tolerance Path

- focus: SW bugs / HW glitches
- dependable/fault tolerant systems, distributed systems, OS
- emphasis on low-level SW/HW

Electives (with their credits):
E6-CDS (12) + E7-SFT (15) + E11-PODS (9) + E3-DOS (6) + E14-ATSA* (6) = 48

Internships:
2x Lab SE (6) = 12

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* E14-ATSA: chosen „Compiler Construction“ and „Paper Reading Group OS“ (each 3 credits)
**Operating Systems Path**

- **focus**: Operating Systems (OS)
- operating (real-time, distributed) systems, parallel systems
- emphasis on low-level SW

**Electives (with their credits):**


**Internships:**

- Lab OS (6) + Company (6) = 12

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* E13-ATSA: chosen „Paper Reading Group“ (3 credits)
### Theory Path
- **focus**: SW theory
- security, software engineering, compilers, logic, real-time
- emphasis on theory/algorithms

#### Electives (with their credits):

#### Internships:
- Lab SE (6) + Company (6) = 12

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* E13-ATSA: chosen „Compiler Construction“
Internships: Labs at Systems Engineering Chair

[1] Lab: SFT (Software Fault Tolerance)
→ recommended for: **fault tolerance path**
→ winter semester
→ C, C++, Java
→ programming/debugging task every 2 weeks
→ finding software bugs, making tests

[2] Lab: CDS (Concurrent and Distributed Systems)
→ recommended for: **balanced path**
→ summer semester
→ C, C++, Java, Python Go, Rust, Erlang
→ a few big tasks for whole semester
→ writing concurrent, parallel programs

[3] Lab: SE (Systems Engineering)
→ recommended for: **everyone**
→ any semester
→ any language (usually C/C++)
→ you contact a PhD student from SE...
→ ...and work for 6 months under his guidance

* Remember: For complete internship, need 12 credits
Internships: Labs at Computer Networks Chair

[4] Lab on networks
→ recommended for: networks path
→ any semester
→ any language (usually Java/Python)
→ you contact a PhD student from Computer Networks...
→ ...and work for 6 months under his guidance

More info here:

* Remember: For complete internship, need 12 credits
Internships: in Company

- Recommended for: everyone
- Any semester
- You have to find a company for internship...
- ...and work there for 6 months
- Usually professors announce possible internships

Usual companies: SAP, Amazon Dresden

* Remember: For complete internship, need 12 credits
Internships: in Company

- [1] Lab: SFT 6
- [2] Lab: CDS 6
- [3] Lab: SE 6
- [4] Lab on Networks 6
- [5] Company 6

[6] Small thesis (Großerbeleg)
→ recommended for: everyone
→ any semester
→ you contact a PhD student/professor...
→ ...and write a „small thesis“ in 6 months
→ requires a lot of work and written thesis in the end
→ but enough to close the whole internship

* Remember: For complete internship, need 12 credits
Important Links

- Main page for the DSE program
- Web-page with all DSE modules
- Official documents for the DSE program
- PDF with official info on DSE study regulations (only german)

- Chair of Systems Engineering
- Chair of Operating Systems
- Chair of Computer Networks
- Chair of Software Technology
- Chair of Privacy and Data Security
- Chair of Computational Logic
- Chair of Compiler Construction