Welcome to
SSY145 – Wireless Networks

Tommy Svensson

(Full) Professor, PhD, Leader Wireless Systems

Communication Systems Group

Department of Electrical Engineering

Chalmers University of Technology, Sweden

tommy.svensson@chalmers.se

EDIT building, floor 6, room 6413

www.chalmers.se/en/staff/Pages/tommy-svensson.aspx

CHALMERS

Course Staff

- **Tommy Svensson**, *examiner and lecturer*
  Electrical Engineering (room 6413)
  tommy.svensson@chalmers.se

- **Shen Li**, *lecturer and TA*
  Electrical Engineering (room 6439)
  shenl@chalmers.se

- **Kathryn Strong Hansen** *lecturer and consultation sessions*
  Centre for Language and Communication
  strong@chalmers.se
  Two lectures, one 1.5-hour consultation per group

About us

Tommy Svensson, http://www.chalmers.se/en/staff/Pages/tommy-svensson.aspx

- PhD from Chalmers in 2003 (Information theory), MSc from 1995 (Engineering Physics)
- Worked at Ericsson AB with wireless packet data systems and microwave radio links/networks
- Currently (Full) Professor with the Communication Systems Group at the Department of Electrical Engineering, Leading the Wireless Systems research
- Research: design and analysis of physical layer algorithms, multiple access, beamforming, resource allocation and cooperative multi-antenna systems for access and wireless backhaul networks, as well as moving networks (cellular-V2X) and satellite networks

Shen Li, https://www.chalmers.se/en/Staff/Pages/shenl.aspx

- PhD Student in Communication Systems Group since Oct 2018
- MSc in Communication Engineering, Chalmers
- Research: modulation and shaping for fiber-optic communication systems

Kathryn Strong Hansen, https://www.chalmers.se/en/staff/Pages/strong.aspx

- Senior lecturer at Chalmers, teaching team member in the Division for Language and Communication since 2016.
- Associate Professor 2015 – 2016, tenued professor of English at The Citadel, the Military College of South Carolina, USA.

Zoom Online Teaching

- Mute when not talking

- Turn off video when not talking

- Please upload your picture in Zoom

- Ask questions:
  - Use the Raise hand function in Zoom to ask questions
  - Use the chat function to post questions, Shen will respond/summarize and ask me
  - Ask directly by talking

- Use peer to peer chatting in the class to keep the collaboration alive outside the online meetings – tell if you want me to organize these chat channels

- Ask me for individual meetings over Zoom if you feel the need

Let's make this work together!

21-26 Students

Adare, Olalekan Peter	MPCOM
Aguilar Romero, Maria	MPCSN
Auer, Joachim	ER00000060
Babbili, Haitham	MPCOM
Bosi, Raphaël	ER00000111
Claeson, Oskar	MPCOM
Dahlin, Emma	*MPCOM*
De Carvalho Folkemark, Michel	MPCSN
Gunnarsson, Alice	*MPHPC*
Hossen, Saddam	*MPCSN*
Jang, Myeongjin	*MPCSN*
Kruse, William	MPCOM
Lee, Ander	BI00000017
Lönn, Joakim	MPCOM
Markovic, Stefan	MPCOM
Marzi, Elena	
Muller, Sylvain	ER00000111
Rosberg, Påhl	MPNET
Rådahl, Emma	MPCOM
Saltykova, Ekaterina	MPCOM
Seto, Tsz Kin	BI00000006
Sjö, Amanda	MPCSN
Tilly, Erik	MPEES
Torstensson, Sarah	MPCOM
Wang, Han	MPCOM
Zhang, Yuling	MPCOM

Aim

- Wireless communication networks including wireless Internet.

- Acquire **knowledge** of the current and insights into future state-of-the-art of technology in the field of wireless communications.

- Explain the impact of commercial, political, and regulatory factors on the design and operations of wireless networks.

Learning Outcome

- Explain how wireless systems should be designed to successfully carry various information.

- Explain the fundamentals about wireless security.

- Describe the main technologies used in modern wireless network to provide QoS and fairness.

- Describe the most important standardization and spectrum regulation bodies.

- Write a report about a current hot topic by identifying and studying the appropriate literature.

- Orally present an overview of the literature covering a current hot topic.

Content

- Short introduction to wireless communications
- Limitations imposed by the wireless channel
- Countermeasures to overcome these limitations
- Overview and analysis of modern wireless networks
- Overview of spectrum regulation bodies
- Overview of wireless system standardisation bodies
- Effective techniques for oral presentations
- Current hot topics (will change from year to year)

Outline

- Lectures

- Consultation sessions

- Project and deliverables

- Quizzes

- Exam and grades

- Schedule

- Course representatives

Lectures

- Guest lectures given by experts from academia and industry
- **Block C:** Mon 13:15-17:00, Thu 08:00-11:45, Fri 15:15-17:00
- All lectures are online in Zoom **9259762080**, direct: https://chalmers.zoom.us/j/9259762080.

2020	Week 1			Week 2			Week 3		
	Mon 23/3	Thu 26/3	Fri 27/3	Mon 30/3	Thu 2/4	Fri 3/4	Mon 13/4	Thu 16/4	Fri 17/4
08:00 - 09:45								09-11:45: L4	
10:00 - 11:45		L2 Zoom 9259762080			L3 Zoom 9259762080			Zoom 9259762080	
LUNCH									
13:15 - 15:00	L1 Zoom 9259762080			13:15-14: Consultation on projects Zoom 9259762080					
15:15 - 17:00									

Confirmed Guest Lecturers

- Klas Arvidsson, Bluetest
- Mikael Coldrey, Ericsson
- Joakim Johansson RUAG Space
- Per Hjalmar Lehne, Telenor
- Paolo Monti, Chalmers
- Tomas Olovsson, Chalmers
- Stefan Parkvall, Ericsson
- Tommy Svensson, E2 Chalmers
- Henk Wymeersch, E2 Chalmers

Writing and Presenting

- Kathryn Strong Hansen
  Centre for Language and Communication

- **Thu March 26 10:00-11:45**: Academic Technical Writing

- **Thu May 14 10:00-11:45**: Presentation Skills

- Each group should book one mandatory 1.5-hour consultation session (two groups at the time) with Kathryn

- Book time in doodle (to be announced),
  or preferably directly on **Thu March 26** in the lecture break of Kathryn's first lecture.

Project

- Deeper knowledge of a specific topic
- Improving your research[1] and presentational skills
- A literature study combined with your investigations
- Three students per group
- Worth 60% of the final course grade
- Presentations at a (virtual) Mini conference on **Wed May 25**

[1]*Note that with the word 'research' we here mean to make an in-depth, targeted study of a hot topic, i.e. not to create new knowledge in that field of research.*

Choosing a Project topic

- Each student should choose **four** preferred topics, with priority 1 (highest), 2, 3, and 4 (lowest).

- The Project topic priority list should be submitted in Canvas to: "Quizzes>>Surveys>>Submit your priority list" no later than **13:00 on Wed March 25** (in less than two days!).

- The groups (of three students) will be assigned as fair as possible based on the priority lists.

Proposed Topics

1. **Access procedures in cellular networks** (scheduling, power control, mm-wave initial access, NOMA, ...)
2. **Cooperative communications in cellular networks** (Relaying, Coordinated Multi-point Transmission (CoMP), Cell-free Massive MIMO)
3. **Heterogeneous Networks** (HetNet, femtocell, Integrated Access and Backhaul, (IAB))
4. **Localization & sensing** (cooperative localization and sensing using wireless networks, location-aided communications)
5. **WiFi** (the IEEE 802.11 family).
6. **Multi-antenna techniques in wireless networks** (massive MIMO, mm-wave, THz, Reconfigurable intelligent surfaces)
7. **Machine-to-machine communications** (M2M, MMC, IoT, V2V, etc.)
8. **Energy efficiency and sustainability in wireless networks** (Green Communication)
9. **Cognitive radio** (including Intelligent radios)
10. **Satellite and high altitude platforms for communications** (GEO, LEO, UAV, …)
11. **Optical wireless communications** (LiFi, Free Space Opics, Visible Light Communication)
12. **5G New radio** (NR)
13. **5G Network slicing** (in the core network, machine learning based)
14. **Backhauling and fronthauling** (fiber, microwave, mm-wave, THz, networking aspects)
15. **Wireless communications in Industry 4.0** (5G networks, Zigbee, …)
16. **Vehicular communications** (V2X, Cellular-V2X, VLC, …)
17. **…<Your proposal>**

Project Deliverable 1

- ***Planning report*** (by **Wed April 1**)

- Scope and main objectives of the project.

- Limitations

- Intended working process of the project

- Time chart for different tasks

- 2-3 pages

- Uploaded on the course website in Canvas

- 5% of the final grade

- See course memo for guidelines

Project Deliverable 2

- ***Progress report*** (by **Wed April 24**)

- Progress so far

- Findings, ideas, and problems

- Outline of the final report

- Reference list

- 2-5 pages

- Uploaded on the course website in Canvas

- 5% of the final grade

- See course memo for guidelines

Project Deliverable 3

- ***Final report*** by **Wed May 18**

- Scope and main objectives

- Results/findings

- References

- IEEE Conference paper format (max. 5 pages)

- Add a few review questions at the end
    - based on the central theme of the project
    - will also be used as a basis for the exam

- Uploaded on the course website in Canvas

- Be careful to follow Chalmers' plagiarism policy!

- 30% of the final grade

- See course memo for guidelines

Project Deliverable 4

- ***Presentation*** by **Mon May 25**

- Presented by all group members

- PowerPoint-slides (or equivalent)

- All the materials/illustrations used in the presentation should be prepared by the group

- 20 minutes plus questions

- Slides uploaded on the course website at PingPong **Mon May 25**

- 15% of the final grade

- See course memo for more guidelines

Project Deliverable 5

- ***Logbook*** by **Mon May 25**
- A record of group and individual activities and workload related to the project
- What contributions each member has given to the joint work
- Meetings and meeting minutes
- Uploaded on the course website at PingPong
- 5% of the final grade
- See course memo for guidelines

Deadlines

Wed March 25 at 13:00	Submission deadline for *Project topic priority list* by each student.
Wed April 1	Submission deadline for the *Planning report.*
Fri April 24	Submission deadline for the *Progress report.*
Mon May 18	Submission deadline for the *Final report and review question(s).*
Mon May 25	Oral presentations (20 minutes plus up to 10 minutes for questions).
Mon May 25	Submission deadline for the *Presentation slides*.
Mon May 25	Submission deadline for the *Logbook*.
Tue June 2	Final exam at 08:00-12:00.

All above submissions should be uploaded to the course website in Canvas.

Answer Quiz Questions

- 12(tbc) of the lectures will start with a 10 min quiz with four multiple-choice answers (48 points).

- One week before most lectures an article (sometimes two) that is connected to the lecture is made available on the course website together with some questions.

- The questions can be from:
  - the article
  - the previous lecture(s)

Create Quiz Questions

- One point for one (reasonable) quiz question with multiple-choice answers from each lecture.

- The correct answer should also briefly be motivated.

- The question together with the four multiple-choice answers (with motivation) should be uploaded to the course website in Canvas **within 24 hours** after the lecture.

- The submitted questions will be posted on the course website and used as the basis for the quiz at the next lecture.

- 15% of the final grade = maximum 59 points (*tbc, at the moment*)

- A minimum of 5% = 20 points (of 59 points, *tbc*) required

Exam

- 25% of the final grade
- Consists of questions from:
  - the articles,
  - the lectures (provided by the students and the lecturer),
  - the final reports (provided by the students)
- A document with all questions (not answers) will be provided during the course
- You are allowed to bring the questions including any added information (for example the answers)

Evaluation

- Group project – 60% (min 30%)
  - Planning report   – 5%
  - Progress report   – 5%
  - Final report   – 30%
  - Presentation   – 15%
  - Logbook   – 5%
- Quizzes   – 15% (min 5%) = (21 p. of 61 p.)
- Final exam   – 25% (min 10%)
- *Grade 3:* ≥ 45% and < 65%
- *Grade 4:* ≥ 65% and < 80%
- *Grade 5:* ≥ 80%

Schedule (Study Week 1 & 2)

Answer quiz (Ax), Create quiz question (Cx)

Ax	Zoom online: 9259762080	Speaker	Content	Cx
1	Mon Mar 23 13:15-15:00	Tommy Svensson E2, Chalmers	**Introduction, course organization, overview of wireless networks**	
2 A1	Thu Mar 26 10:00-11:45	Kathryn Strong Hansen Language, Chalmers	**Academic Technical Writing**	C1
	Mon Mar 30 13:15-14:00	*No lecture – Work on Technical scope of project. Consultation available online in Zoom.*	*No lecture – Work on Technical scope of project. Consultation available online in Zoom.*	
3 A2	Thu Apr 2 10:00-11:45	Tommy Svensson E2, Chalmers	**Basic Principles of Wireless Networks**	C2

Re-exam week and Easter break

Schedule (Study Week 3 & 4)

Answer quiz (Ax), **Create quiz question (Cx)**

4 **A3**	Thu Apr 16 09:00-11:45	Stefan Parkvall Ericsson	**From 4G to 5G and Beyond – part 1 (tbc)**	**C3**
5 **A4**	Mon Apr 20 13:15-15:00	Tommy Svensson E2, Chalmers	**Challenges and Opportunities with mmWave Communications in 5G**	**C4**
6 **A5**	Thu Apr 23 09:00-11:45	Stefan Parkvall Ericsson	**From 4G to 5G and Beyond – part 2 (tbc)**	**C5**

Tentative Schedule (Study Week 5 - 7)

Answer quiz (Ax), **Create quiz question (Cx)**

6 A6	Mon Apr 27 13:15-15:00	Tommy Svensson E2, Chalmers	**Cellular-V2X and Integrated moving networks**	**C6**
7 A6	TBD	*Henk Wymeersch E2, Chalmers*	***Basics of Positioning in Wireless Networks***	**C7**
8 A7	TBD	*Klas Arvidsson Bluetest*	***Testing of Wireless Devices – the Past, the Present, and the Future***	**C8**
9 A8	TBD	*Joakim Johansson RUAG Space*	***Space Communications***	**C8'**
10 A9	TBD	*Per Hjalmar Lehne Telenor*	***Spectrum management concepts for mobile and wireless communications***	**C9**
11	TBD	*Tomas Olovsson CSE, Chalmers*	***Wireless Security***	**C9'**
12 A10	TBD	*Paolo Monti E2, Chalmers*	***Slicing in 5G Transport Networks***	**C10**
13	Thu May 14 10:00-11:45	Kathryn Strong Hansen Language, Chalmers	**Presentation Skills**	**C11**

Tentative Schedule (Study Week 8 & 9, Exam week)

Answer quiz (Ax), **Create quiz question (Cx)**

14	Mon May 18 (tbc) 13:15-17:00	Håkan Lönnqvist, Jan Palmqvist Ericsson	**(Virtual) Visit Ericsson, Lindholmen**	
16 *A12*	*TBD*	*Mikael Coldrey Ericsson*	*Wireless backhaul – introduction and evolution*	*C12*
17	Mon May 25 13:15-17:00	Students	**(Virtual) Mini conference – Presentations of projects**	
18	Tue June 2 08:00-12:00	Students	**Exam**	

Course Representatives

1. Alice GUNNARSSON (MPHPC) galice@student.chalmers.se
2. Saddam HOSSEN (MPCSN) saddam.ruetete08@yahoo.com
3. Ander LEE (EXCH) leea@student.chalmers.se
4. Emma RÅDAHL (MPCOM) radahl@student.chalmers.se
5. ~~Yaxi XIE (MPCOM) 1610306995@qq.com~~

As a course representative it is your responsibility to:

- Inform yourself about the views of your fellow students.
- Pass these on together with your own views in the meetings.
- Suggest course-specific questions, if needed.
- Inform your fellow students about discussions and recommendations at the meetings.

Let's book the mid-course meeting during the break today!

Canvas and Course Memo

- Canvas: https://chalmers.instructure.com/courses/9368.

- Read your Chalmers email and messages from Canvas.

- All documents will be uploaded in Canvas.

- There is always a Canvas message if there is a new document.

- Please update your Canvas profile with a photo.

- Download the Canvas app.

- All information (including definition of the project, deadlines, and the list of guest lecturers) can be found in the Course Memo – ***Please check the latest version for updates on the schedule for the Guest Lectures.***

Supporting Books

- Erik Dahlman, Stefan Parkvall, Johan Sköld, "4G: LTE/LTE-Advanced for Mobile Broadband," Academic Press, 2011, ISBN 978-0-12-385489-6. Can be accessed at: http://www.sciencedirect.com/science/book/9780123854896[2].

- Andrea Goldsmith, "Wireless Communications," Cambridge University Press, 2005, ISBN-13: 9780521837163.

- Stefania Sesia, Issam Toufik, Matthew Baker, "LTE, The UMTS Long Term Evolution: From Theory to Practice", John Wiley and Sons, 2009.

- Theodore S. Rappaport, "Wireless Communications: Principles and Practice (2nd Edition)," Prentice Hall PTR, 2002, ISBN 0130422320.

- Dave Wisely, "IP for 4G," Wiley, 2009, ISBN 9780470510162

- William Stallings, "Data and Computer Communications (8th Edition)," Prentice Hall, 2006, ISBN-10: 0132433109.

[2]In case this direct link does not work: Go to www.sciencedirect.com, choose "BIBSAM Chalmers University of Technology, Library" and then search on 4G LTE/LTE-Advanced for Mobile Broadband as journal/book title.