Welcome to
SSY145 – Wireless Networks

Tommy Svensson

(Full) Professor, PhD, Leader Wireless Systems

Communication Systems Group, Department of Electrical Engineering

EDIT building, floor 6, room 6440

Chalmers University of Technology, Sweden

tommy.svensson@chalmers.se, www.chalmers.se/en/persons/tommys/

CHALMERS

Course Staff

- **Tommy Svensson**, *examiner and lecturer*
  Electrical Engineering (room 6440)
  tommy.svensson@chalmers.se

- **Charitha Madapatha**, *TA and supervisor*
  Electrical Engineering (room 6333)
  charitha@chalmers.se

- **Baraa Khuder,** *lecturer and consultation sessions*
  Centre for Language and Communication
  khuder@chalmers.se
  Two lectures, one 1.5-hour consultation per group

About us

Tommy Svensson, https://www.chalmers.se/en/persons/tommys/

- Full Professor with the Communication Systems Group at the Department of Electrical Engineering, Leader Wireless Systems
- 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
- Research: design and analysis of physical layer algorithms, multiple access, beamforming, resource allocation and cooperative (distributed) multi-antenna (D-MIMO) systems for access and wireless backhaul networks, as well as moving networks (cellular-V2X) and satellite networks. Actively contributed to the development of 4G, 5G and currently 6G.

Charitha Madapatha, https://www.chalmers.se/en/persons/charitha/

- PhD Student in Communication Systems Group since July 2020
- Licentiate degree in Electrical Engineering, Dec 2022, Chalmers
- MSc in Communication Engineering, June 2020, Chalmers
- Research: Integrated access and backhaul for beyond 5G/6G

Baraa Khuder, https://www.chalmers.se/en/persons/khuder/

- Senior lecturer at the department of Communication and Learning in Science (2023-present).
- Post-doctoral researcher in collaborative writing at Chalmers (2021-2023)
- PhD in Applied Linguistics and Intercultural Communication from Birkbeck, University of London, UK (2021). MA in Language Testing and Program Evaluation from Essex University, UK (2012).
- Research: collaborative writing, writing for publication, AI tools in academic communication, writing assessment.

Lecture Room, Online and Recordings

- A significant number of lectures will be given by experts from academia and industry focusing on the evolution of wireless networks both from technical and commercial viewpoint.

- Most lectures will be in room ES51 (a few in ES53), Linsen, EDIT building. There are big values in interacting with the lecturer and your classmates on campus, so default is that all students attend the lectures at campus in person.

- However, in exceptional cases, for students that cannot attend a given lecture on campus, we will provide an online participation possibility via Zoom. Then you can follow remotely in case you are sick or for other exceptional reasons cannot join on campus.

  Zoom: https://chalmers.zoom.us/j/66661043586

  Passcode for first Lecture: 406360.
  Passcode for following lectures: the Passcode will be provided for exceptional cases upon motivated request by email to TA Charitha Madapatha charitha@chalmers.se, at least an hour before the lecture.

- All lectures will be recorded and posted on Canvas (no password) to assist your learning by being able to go back to the lecture.

- Mute 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, Charitha will respond/ summarize and ask the lecturer
  - Ask directly by talking

Name	Program
Fotios Petros Amaxopoulos	MPEES
Jahanvi Bhadrashetty Dinesh	MPICT
Erik Bolminger	MPEES
Hongren Chen	MPICT
Leonard Fröling	Electrical Engineering
Lakshmi Priya Gandla	MPEPO
Emma Monique Hallantie	MPCSN
Liam Jardine	MPICT
Lisa Mårtensson	TKMED
Tiago Narciso Costa	ERASMUS
Lean Tong Ng	MPICT
Frida Olofsson	Microtechnology and Nanoscience
Susanne On Huang	MPIDE
Jacopo Puccini	MPICT
Galo Sanchez Granja	MPEES
Davide Segna	ERASMUS
Pontus Söderström	ELECTRICAL ENGINEERING
Muhammad Uzair	MPICT
Ming-Hsueh Yang	EXCHANG
Ehsan Etezadi	PhD student E2

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.

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

- Describe the most important standardization and spectrum regulation bodies.

- Explain the fundamentals about wireless security.

- 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)
- Most lectures are given in ES51 (a few in ES53), Linsen, EDIT building.

2023	Week 1			Week 2		
	Mon 18/3	Thu 21/3	Fri 22/3	Mon 25/3	Thu 28/3	Fri 29/3
08:00 - 09:45					Easter break	
10:00 - 11:45		L2 ES51				
LUNCH						
13:15 - 15:00	L1 ES51			L3 ES51		
15:15 - 17:00				15:15-16: Consultation on projects ES51		

Guest Lecturers (*to be confirmed*)

- Tommy Svensson   E2, Chalmers
- Stefan Parkvall   Ericsson
- *Mikael Coldrey   Ericsson*
- *Joakim Johansson   Beyond Gravity (just retired)*
- *Per Hjalmar Lehne Telenor*
- *Tomas Olovsson   CSE, Chalmers*
- *Federico Tonini   E2, Chalmers*
- *Henk Wymeersch   E2 Chalmers*
- *Lee Swindlehurst   University of California, Irvine*

Writing and Presenting

- Baraa Khuder
  Centre for Language and Communication

- **Thu March 21 10:00-11:45**: Academic Technical Writing

- **Thu May 16 10:00-11:45**: Presentation Skills

- Each group should book one mandatory 1.5-hour consultation session (two groups at the time) with Baraa, scheduled for Mon April 29.

- Book time in Choodle, to be announced during the lecture on **Thu March 21**.

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 Mini conference on **Mon May 20**

[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 20** (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** (random access, 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. **Converged communication, localization, and sensing** (cooperative localization and sensing using wireless networks, location-aided communications, integrated sensing and communication (ISAC)/ joint communication and sensing (JSAC))
5. **WiFi** (the IEEE 802.11 family, WiFi 6E).
6. **Multi-antenna techniques in wireless networks** (massive MIMO, mm-wave, (sub-)THz, Reconfigurable intelligent surfaces)
7. **Machine-to-machine communications** (M2M, MMC, IoT, LoRa, Sigfox, RFID, IoT applications, ...)
8. **Energy efficiency and sustainability in wireless networks** (Green Communication, Sustainable 6G design, 6G for sustainability)
9. **Cognitive radio** (including Intelligent radios)
10. **Satellite and high altitude platforms for communications** (GEO, LEO, UAV, Starlink, ...)
11. **Optical wireless communications** (LiFi, Free Space Optics, Visible Light Communication)
12. **5G New radio** (NR waveform design, hardware constraints, standardization, ...)
13. **Architecture and network slicing in 5G and Beyond** (in the core network, machine learning based, Data-driven intelligence, ...)
14. **Backhauling and fronthauling** (fiber, microwave, mm-wave, THz, distributed MIMO)
15. **Wireless communications in Industry automation** (Industry 4.0, 5G private networks, Zigbee, Digital twinning...)
16. **Vehicular communications** (V2X, Cellular-V2X, ITS-G5, ...)
17. **Security in wireless communications** (protocols, physical layer security, ...)
18. **...<Your proposal>**

Project Deliverable 1

- ***Planning report*** (by **Wed March 27**)

- 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 **Fri April 19**)

- 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 15**

- 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 20**

- 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 in Canvas by **Mon May 20**

- 15% of the final grade

- See course memo for more guidelines

Project Deliverable 5

- ***Logbook*** by **Mon May 20**

- 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 in Canvas

- 5% of the final grade

- See course memo for guidelines

Deadlines

Wed March 20 at 13:00	Submission deadline for *Project topic priority list* by each student.
Wed March 27	Submission deadline for the *Planning report.*
Fri April 19	Submission deadline for the *Progress report.*
Wed May 15	Submission deadline for the *Final report and review question(s).*
Mon May 20	Oral presentations (20 minutes plus up to 10 minutes for questions).
Mon May 20	Submission deadline for the *Presentation slides*.
Mon May 20	Submission deadline for the *Logbook*.
Tue May 28	Final exam at 08:30-12:30.

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

Answer Quiz Questions

- 13 of the lectures will start with a 10 min quiz with four multiple-choice answers (52 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 67 points

- A minimum of 7,5% = 33 points (of 67 points)

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 7,5%)
- 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	Room ES51	Speaker	Content	Cx
1	Mon Mar 18 13:15-15:00	Tommy Svensson E2, Chalmers	**Introduction, course organization, overview of wireless networks**	
2 A1	Thu Mar 21 10:00-11:45	Baraa Khuder Language, Chalmers	**Academic Technical Writing**	C1
3 A2	Mon Mar 25 13:15-15:00	Tommy Svensson E2, Chalmers	**Basic Principles of Wireless Networks**	C2
	Mon Mar 25 15:15-16:00	*Work on Technical scope of your project.* Consultation available.	*Work on Technical scope of your project. Consultation available.*	

Re-exam week and Easter break

Course Representatives

1. Emma Monique Hallantie	MPCSN	emppahal@gmail.com
2. Susanne On Huang	MPIDE	susselelle@gmail.com
3. Jacopo Puccini	MPICT	jackpuccio9@gmail.com
4. Galo Sanchez Granja	MPEES	galos@student.chalmers.se
5. Muhammad Uzair	MPICT	uzair.munsif@gmail.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/29107.

- 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

- Ö. Bulakçı, M. Gramaglia, A. Gavras, M. Uusitalo, P. Rugeland, M. Boldi, "Towards Sustainable and Trustworthy 6G: Challenges, Enablers, and Architectural Design", Now Publishers, June 2023, Online here.

- Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G/5G-Advanced The New Generation Wireless Access Technology", Elsevier 3rd ed., 2023, Paperback ISBN: 978-0-443-13173-8, eBook ISBN: 9780443131745. Online here.

- M. Fallgren, M. Dillinger, T. Mahmoodi, T. Svensson, "Cellular V2X for Connected Automated Driving", Wiley 2021. ISBN: 978-1-119-69264-5.

- Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", Academic Press, 2018, ISBN: 9780128143230.

- 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.*