Course Memo, Spring 2020

SSY145 – Wireless Networks, 7.5 credits

Introduction

The course focuses on wireless communication networks including wireless Internet. The aim is for students to acquire insights into the current state-of-the-art and of what technology is likely to be used in future systems. Another aim is to gain understanding of the impact of commercial, political as well as regulatory factors on the design and operations of wireless networks.

Course Website

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

Course Staff

Tommy Svensson, *Electrical Engineering (6413),* examiner, tommy.svensson@chalmers.se
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Course Representatives

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Guest Lecturers (alphabetical order)

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Lectures

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. All lectures are given using the Zoom online meeting number **9259762080**, direct link: https://chalmers.zoom.us/j/9259762080. The list of lectures is at the end of this document.

Group Project

The mandatory project is worth 60% of the final course grade. All groups should have one mandatory 1.5-hour consultation session (two groups at the time) with Kathryn Strong Hansen from the Centre for Language and Communication. The time of the sessions will be decided later.

Evaluation

The final grade consists of three parts:

a) Group project – 60% (min 30%)
   a. Planning report – 5%
   b. Progress report – 5%
   c. Final report – 30%
   d. Presentation – 15%
   e. Logbook – 5%
b) Quizzes – 15% (min 5%)
c) Final exam – 25% (min 10%)

Grade 3: ≥ 45% and < 65%
Grade 4: ≥ 65% and < 80%
Grade 5: ≥ 80%

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. In particular, the Project topic priority list should be submitted in Canvas to: "Quizzes>>Surveys>>Submit your priority list".

Supplementary Reading

- 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[1].
- 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.

[1] 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.

The Different Steps in the Project:

1. **Choosing a topic:** Each student should choose four preferred topics, with priority 1 (highest), 2, 3, and 4 (lowest). The priority list should be submitted in **Canvas "Quizzes>>Surveys>>Submit your priority list"** before the deadline. The groups (of three students) will be assigned as fair as possible based on their priorities.
2. **Planning report:** Each group should present what main objectives the group has set up for the project, what delimitations and scope that have been established. Furthermore, the document should also give account for the planning of the project, including a time chart for different tasks to be completed. ***Requirements*:** 2-3 pages based on the below mentioned guidelines. The report should be uploaded on the course website before the deadline. ***Guidelines*:** The document should at least contain the following. (i) *Title*: A preliminary informative title should be stated. (ii) *Background/Introduction*: The background should introduce to the topic and motivate why the topic is interesting to study from a research[2] point of view. (iii) *Main Objective*: The aim of this part is to identify the research question that will be treated in the project. It should also state the likely outcome of the project. (iv) *Scope*: The scope should specify the parts of the research question that will be covered and which parts that will not be covered. (v) *Time chart*: A detailed time plan indicating various tasks of the project.
3. **Progress report:** Each group should describe the progress of the project. Findings, ideas, and problems with the progress of the project should be part of the document as well as an outline of the final report and a list of references. ***Requirements*:** 2-5 pages based on the below mentioned guidelines. The report should be uploaded on the course website before the deadline. ***Guidelines*:** The document should at least contain the following. (i) *Title*: A reasonable title that is specific to the research question under study (ii) *Background/Introduction*: A more matured introduction to the topic based on the literature survey done so far. (iii) *Progress*: The aim is to describe the accomplished tasks, acknowledged problems (technical or non-technical), and planned activities (iv) *Findings*: It should state the proposed solutions/methods to the research problem based on the literature (v) Outline of the final report with brief description of each section including proper references.
4. **Final report:** The report should be in IEEE format and should give readers a clear picture of the scope, objectives as well as the results/findings of the project. Target readers are your class mates. Together with the report, each group should also define at least one review question that brings up a central issue of the project (will be used as a basis for the exam). The final reports will be made available on the course website in order to be read by all students attending the course. ***Requirements*:** The report should be written in IEEE format using word or latex (maximum of 5 double column pages). The report and review question(s) *with motivated answer* should be uploaded on the course website as two separate documents before the deadline. ***Guidelines*:** The quality of the final report should be similar to that of an IEEE conference publication.
5. **Presentation:** All group members should present the finalized project at a mini conference. The presentation should be using PowerPoint-slides (or equivalent). Note that all the materials used in the presentation should be prepared by the group. This means that it is not possible to use any previously published pictures, illustrations, or simulation results. ***Requirements*:** PowerPoint slides (or equivalent) for 20 minutes plus questions. The slides should be uploaded on the course website before the deadline.
6. **Logbook:** The logbook should include a description of how the group has worked with the project, what meetings have been held and what decisions have been taken. What has been done by each individual should be clearly stated. ***Requirements*:** The report should be uploaded on the course website before the deadline.

[2] 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.

Proposed Project 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, …)

Quizzes

Many lectures will start with a 10 min quiz that can be found in **Canvas "Assignments>>Quiz>>Ax"** (all lectures marked with a **blue Ax** (Answer quiz number *x*) in the schedule on the next page) with four multiple-choice answers (a maximum of four points). One week before these lectures an article(s) that is connected to the lecture (or lectures if the quiz is on a Monday) is made available on the course website. The questions in the quiz can be from the article(s), or from the previous lecture (or the two previous lectures on Monday if the quiz is on a Thursday). Solutions to Quiz "Ax" can be found in **Canvas** "Modules>>Quiz solutions>>Ax_solutions"

The students also receive one point if they submit one “reasonable” quiz question with four multiple-choice answers from each of the lectures marked with a **green Cx** (Create quiz question *x*) in the schedule on the next page. *The correct answer should also briefly be motivated.* The quiz question should be submitted in **Canvas "Assignments>>Quiz question submission>>Cx ...”.** It is **mandatory** for the students to use the **latex template** provided on the course website for creating their quiz question. The question together with the four multiple-choice answers (with motivation) should be uploaded to the course website **within 24 hours** after the lecture.

All questions used as the basis for the quiz (from the articles and from the lectures provided by the lecturer or submitted by the students) without answer will be posted on the course website before the quiz (as soon as they become available).

There is a maximum of 15 points (*tbc*) from submitted questions and a maximum of 4 points on each of the 11 quizzes. In total the quizzes can therefore give 59 points (*tbc*), which is equivalent to 15% of the final grade. A minimum of 20 points on the quizzes (5% of the final grade) is therefore required to pass the course.

Exam

The exam consists of questions from the articles, the lectures (provided by the students and the lecturer), and the final reports (provided by the students).

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

Please note the times in red!

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

4 A3	Thu Apr 16 09:00-11:45	Stefan Parkvall Ericsson	**From 4G to 5G and Beyond – part 1**	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**	C5
7 A6	Mon Apr 27 13:15-15:00	Tommy Svensson E2, Chalmers	**Cellular-V2X and Integrated moving networks**	C6
8	Mon Apr 27 15:15-17:00	Per Hjalmar Lehne Telenor	**Spectrum management concepts for mobile and wireless communications**	C6’
9 A7	Mon May 4 13:15-15:00	Mikael Coldrey Ericsson	**Wireless backhaul – introduction and evolution**	C7
10	Mon May 4 15:15-17:00	Joakim Johansson RUAG Space	**Space Communications**	C7’
11 A8	Thu May 7 10:00-11:45	Paolo Monti E2, Chalmers	**Slicing in 5G Transport Networks**	C8
12 A9	Mon May 11 13:15-15:00	Tomas Olovsson CSE, Chalmers	**Wireless Security**	C9
13 A10	Thu May 14 08:00-09:45	Klas Arvidsson Bluetest	**Testing of Wireless Devices – the Past, the Present, and the Future**	C10
14	Thu May 14 10:00-11:45	Kathryn Strong Hansen Language, Chalmers	**Presentation Skills**	C10’
15	Mon May 18 (tbc) 13:15-17:00	Håkan Lönnqvist, Jan Palmqvist Ericsson	**(Virtual) Visit Ericsson, Lindholmen**	
16	Mon May 25 13:15-17:00	Students	**(Virtual) Mini conference – Presentations of projects**	
17 A11	Thu May 28 10:00-11:45	Henk Wymeersch E2, Chalmers	**Basics of Positioning in Wireless Networks**	C11
18	Tue June 2 08:00-12:00	Students	**Exam**	

*Note: Quiz questions from **C6** and **C6’** will both be part of **A7**, **C7** and **C7’** will both be part of **A8, C10** and **C10’** will both be part of **A11**. Quiz questions from **C11** will be part of the Exam.*