

**Carleton University**  
**Department of Systems and Computer Engineering**  
**SYSC5804 Advanced Topics in Communications Systems**  
**COMP 5900 Selected Topics in Computer Science**  
**ITEC 5910W Selected Topics in Network Technologies**

**5G Networks – Winter 2021**

**Course Outline**

**Instructor Information and Office hours**

Name: Jun (Steed) Huang, PhD.

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Office hours: 1 hour before the class time or by appointment

**Calendar Information**

<http://calendar.carleton.ca/grad>

<https://www.carleton.ca/culearn/>

**Assumed Knowledge**

Senior undergraduate familiarity with computer communications, wireless networks, and communications systems.

**Course Description**

Principles enabling 5G communications; physical, link and network layer protocols used for 5G communications and networking. Topics include: evolution from 1G to 5G, standardization, spectrum planning, 4G LTE Fundamentals, 5G New Radio enhancements, 5G Core and beyond 5G.

**Course Objectives**

As part of this course, students will:

- Become familiar with mobile network evolution from 1G to 5G.
- Learn the 5G use cases families: EMBB, URLLC, mMTC, V2X, D2D.
- Understand principles enabling 5G communications.
- Identify the deployment scenarios (DRAN, CRAN, ERAN, VRAN).
- Study tools for the design or deployment of 5G networks.
- Describe Network Evolution proposals from LTE - NSA, SA.

- Explain Network Slicing across Core, Transport and Access.
- Overview the NFV/SDN and management infrastructure.
- Address block chain as a key security topic in a growing MTC ecosystem.
- Know synchronization options for New Radio NSA: PTP and GNSS.
- Simulate massive MIMO, beam forming, spectrum planning and dynamic TDD.
- Examine 5G/6G network complexity and the role of AI to reduce TCO.

### **Learning Outcomes**

- Plan, design, develop and manage 5G networks by applying and contributing the best practices, standards, algorithms and tools.
- Understand research papers and perform research within the area of 5G network planning using a variety of resources.
- Communicate 5G subject matters effectively to a range of audiences, orally, in writing and visually.

### **Textbooks**

Book 1 is used as a main lecture book (focusing on Chapter 1 to 7), Book 2 is used as a homework and project source (focusing on Chapter 5 & 10):

1. Erik Dahlman, Stefan Parkvall, Johan Skold, 5G NR: The Next Generation Wireless Access Technology, Academic Press, 2018.
2. Saad Z. Asif, 5G Mobile Communications - Concepts and Technologies, Taylor & Francis Group LLC - CRC Press, 2019.

*Both textbooks are available through the Carleton University Library.*

### **Evaluation and Grading Scheme**

Homework 15%

Lab project 25%

Midterm 25%

Final 35%.

### **Breakdown of course requirements (labs, assignments, quizzes, exams, etc.)**

Homework and Midterm: There will be three homework assignments and one midterm; they will be all returned to students for further studying.

Lab Project: Students will be required to work on a group project related to the simulation aspects of 5G networks. Projects will involve a literature review and implementation. Students are responsible for forming and managing their groups. Instructor and TA will include two hands-on sessions on MATLAB, Ansible or HFSS for simulation, 1 virtual tour visit to Ericsson Kanata facility, with an invited expert talk.

Final: There will be one final exam. The final exam will be formally scheduled by online Exam Services. Since the final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangement with the instructor or with the department office to see your marked final examination after the final grades have been made available.

### **Week-by-Week breakdown**

#### Tentative Lectures Schedule

Week 1. The 5G Use Cases.

Week 2. Specification of 5G in 3GPP and NR.

Week 3. Densification and Small Cells.

Week 4. Beam Centric Design and Mu-MIMO.

Week 5. 5G Core Network.

Week 6. Radio-Access Network.

Week 7. Dynamic Time-Division Duplex and PTP/GNSS.

Week 8. Downlink Blind Decoding and Search Spaces.

Week 9. NR Uplink Multi-antenna Precoding.

Week 10. Machine-Type Communication with Blockchain.

Week 11. SDN and NFV in Slicing.

Week 12. 6G, ML and AI.

### **General Regulations**

**Student Responsibility:** It is the student's responsibility to remain informed of all rules, regulations and procedures required by their program and by the Faculty of Graduate and Postdoctoral Affairs. Ignorance of regulations will not be accepted as a justification for waiving such regulations and procedures.

**Academic Integrity:** Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at:

<https://carleton.ca/registrar/academic-integrity/>. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

**Plagiarism:** Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

**Deferred Term Work :** Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current *Graduate Calendar, Academic Regulations of the University, Section 9.3*.

**Academic Accommodation:** You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at <http://www.carleton.ca/equity/>. For an accommodation request, the processes are as follows:

**Pregnancy or Religious obligation:** Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see <https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>

**Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your **Letter of Accommodation** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website ([www.carleton.ca/pmc](http://www.carleton.ca/pmc)) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).

**Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/sexual-violence-support/>.

**Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

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**Health and Safety:** Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: <http://sce.carleton.ca/courses/health-and-safety.pdf>

**Students from the University of Ottawa:** You can request to have access to cuLearn: please see <http://gradstudents.carleton.ca/forms-policies/>