



Carleton University
Department of Systems and Computer Engineering

SYSC 5804 Advanced Topics in Communications Systems
COMP 5900 Selected Topics in Computer Science
ITEC 5910W Selected Topics in Network Technologies
(Equivalent to ELG 6184 Advanced Topics in Communication Systems)

5G Networks – Winter 2023

Course Outline

Instructor Information and Office hours

Name: Jun (Steed) Huang, PhD.

Office: ARISE Building (AB) 5400

Email: jun.huang@carleton.ca

Phone: +1-775-391-8001

Office hours: half hour after the class time or by appointment

Lectures: Jan 10, 2023 to Apr 7, 2023

Days: Wed Fri, Time: 11:35 - 12:55

Building: Mackenzie Building Room: 3165

TA: Mohammed A.A. Abuibaid

<https://brightspace.carleton.ca>

Calendar Information

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

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 post quantum encryption 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 and homework book (focusing on all odd chapters), Book 2 is used as your project source (any combination of even chapters):

1. William Stallings, 5G Wireless: A Comprehensive Introduction, Addison-Wesley Professional, 2021.
2. Erik Dahlman, Stefan Parkvall, Johan Skold, 5G NR: The Next Generation Wireless Access Technology, Academic Press, 2018.

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 code implementation. Students are responsible for forming and managing their groups. Instructor and TA will include two hands-on sessions on Matlab, Python or Q# 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. 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. Specification of 5G in 3GPP and NR.

Week 2. The 5G Use Cases.

Week 3. Machine-Type Communication with PQC.

Week 4. 5G Core Network.

Week 5. 5G Core Network priority, QoS, and policy control.

Week 6. Dynamic Time-Division Duplex and PTP/GNSS.

Week 7. Beam Centric Design and Mu-MIMO.

Week 8. Radio-Access Network.

Week 9. SDN and NFV in Slicing.

Week 10. Downlink Blind Decoding and Uplink Multi-antenna Precoding.

Week 11. Densification and Small Cells.

Week 12. 6G, ML and AI.

Pandemic Measures

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you should follow Carleton's symptom reporting protocols.

Masks: Masks are no longer mandatory in university buildings and facilities. However, we continue to recommend masking when indoors, particularly if physical distancing cannot be maintained. We are aware that personal preferences regarding optional mask use will vary greatly, and we ask that we all show consideration and care for each other during this transition.

Vaccines: While proof of vaccination is no longer required to access campus or participate in in-person Carleton activities, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible and submit their booster dose information in [cuScreen](#) as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus. All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the [University's COVID-19 website](#) and review the [Frequently Asked Questions \(FAQs\)](#). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

ACADEMIC ACCOMMODATION

You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:

Pregnancy 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, visit the Equity Services website carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf.

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, visit the Equity Services website carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf.

Academic Accommodations for Students with Disabilities:

If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the Paul Menton website carleton.ca/pmc.

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 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, visit <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

ACADEMIC INTEGRITY_

The University Senate defines plagiarism in the regulations on instructional offenses as "to use and pass off as one's own idea or product work of another without expressly giving credit to another." Borrowing someone else's answers, unauthorized possession of tests or answers to tests, or possession of material designed in answering exam questions, are also subject to university policy regarding instructional offences. Students who post their code online are making themselves a potential party to plagiarism and are subject to the consequences. For more information on Carleton University's

Academic Integrity Policy, consult <https://carleton.ca/secretariat/wp-content/uploads/Academic-Integrity-Policy-2021.pdf>

COURSE COPYRIGHT

Student or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

IMPORTANT DATES TO REMEMBER – Academic Year 2022-2023

WITHDRAWALS

The last day to withdraw from winter term courses with a full fee adjustment is **January 31, 2023**. Withdrawals after this date will create no financial change to winter term fees and will result in a permanent notation of WDN appearing on your official transcript.

The last day to withdraw from winter term courses is **March 15, 2023**.

OFFICIAL FINAL EXAMINATION PERIOD

Winter term: **April 15-27, 2023** – Examinations are normally held all seven days of the week.

For a complete listing of academic and financial dates and deadlines for the 2022/2023 academic year, please visit <https://carleton.ca/registrar/registration/dates/academic-dates/>