Course	ECE310 Wireless Communications	Semester	Monsoon Semester 2024
Faculty Name(s)	Dhaval Patel	Contact	dhaval.patel@ahduni.edu.in
School	SEAS	Credits	3
GER Category:	Not Applicable	Teaching Pedagogy Enable:NO	P/NP Course: Can not be taken as P/NP

Schedule

Section 1	11:00 am to 12:00 pm	Mon	01-08-24 to 26-11-24
	12:00 pm to 01:00 pm	Mon	01-08-24 to 26-11-24
	01:00 pm to 02:00 pm	Mon	01-08-24 to 26-11-24

Prerequisite	MAT200 Linear Algebra & MAT202 Probability and Random Processes
Antirequisite	Not Applicable
Corequisite	Not Applicable

Course Description	**Abstract:** The intelligent ad-hoc networks are formed by users or devices wishing to communicate without the necessity or existence of any centralized administration or infrastructure. The field of vehicular applications and inter-networking technologies lies in intelligent ad-hoc networks. The radio-based vehicle-to-vehicle and vehicle-to-infrastructure communication strive to harness the power of ubiquitous communication for the sake of traffic safety and transport efficiency in intelligent transportation systems. Being a subset of the intelligent ad-hoc networks, this course first addresses the applications and technical aspects of vehicular ad-hoc networking (VANET) that can be established by short- and medium-range communication primarily based on wireless local area networks technology. The large data modelling and real-time simulations of mobility with channel models will be carried out for the distinctive set of candidate applications (e.g., collision warning and local traffic information for drivers), resources (e.g., licensed spectrum, rechargeable power source), and the environment (e.g., vehicular traffic flow patterns, privacy concerns). Along with that, the concept of molecular communications and nanonetworks will be introduced as emerging intelligent ad-hoc networks. The simulations, data acquisitions, validation of the modelling will be carried out using high-performance computing (HPC) and Artificial Intelligence (AI) driven models by building an application program interface. **Course Description:** The wireless sector has undergone a paradigm shift from 2G, 2.5G (EDGE), 3G (HSDPA) to 4G (LTE) technology and will extend to 5G (Cognitive Radio) in the recent future. As per the Telecom Regulatory Authority of India (TRAI) report, with a subscriber base of nearly 1185.55 million (more than 100 Cr), India is currently the world's second-largest telecommunications market and has witnessed a massive growth since the evolution of LTE (long term evolution) as 4G technology. Also as per Erickson mobility report, data traffic per active user is expected to increase five-fold from 1.4 GigaByte (GB) per month in 2015 to 7 GB per month by 2021. All credibility of high data rates goes to OFDM (Orthogonal Frequency Division Multiplex), Multiple Input Multiple Output (MIMO) and to the associated multiple accessing schemes like OFDMA (Orthogonal Frequency Division Multiple Access) and SC-FDMA (Single Frequency Division Multiple Access). As an Engineer, it's vital to understand the existing technologies with the fundamentals as a strong foundation to cope up with the requirement of future wireless services. This course is divided into four modules. Module 1, focuses on the fundamentals of wireless communications which built the understanding towards the intelligent ad-hoc networks. Module 2 and 3 are mainly designed to gain insight into emerging ad-hoc networks such as vehicular ad-hoc networks and the internet of bio-nano things. Since all the above-mentioned modules will consist of various modelling, and simulations, the front end application programming interface will be developed as one of the learning objectives of the course. Module 1: Fundamentals of wireless communications

	The objective of this module is to provide knowledge on performance analysis of various digital modulation techniques and the comparison of wired v/s wireless communication systems. Furthermore, an in-depth understanding of wireless standards like 2G, 3G, and 4G is provided. The module is designed in such a way that it provides comprehensive exposure to fast-growing technologies like CDMA, MIMO, and OFDM which are the backbone of 3G and 4G wireless networks. This module will also provide coverage of various digital modulation schemes which are used in Bluetooth, LAN, and Digital Video Broadcasting etc. Also, the modelling of the wireless system and BER performance analysis are incorporated in the course. Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS) This module will utilize the concepts of ad-hoc networks to establish intelligent transportation systems. The general definition of the term vehicular ad-hoc network (VANET) refers to the possibility of having a communication node on-board a vehicle able to establish wireless communication with other surrounding communication nodes visible in the radio range. This module will cover the modelling of vehicular channels, and mobility models that are applicable to build an LTE/DSRC enabled ITS. The module will also apply the simulation techniques to validate and estimate the network requirements for ITS. Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT) This module is focused on the modulation, coding, and detection techniques for anomaly detection. The techniques are basically based on several simplified assumptions regarding molecular propagation. In addition, the integration of intrabody networks with external networks, which is an important part of IoBNT poses severe challenges. In this context, this module will also develop a comprehensive set of analytical frameworks to characterize the impact of realistic models on the accuracy of disease monitoring and validate it by means of bio simulations using discrete-event simulator. This approach will make the course more interesting. At the end of the module, the student will be able to perform analysis and simulations of 3G/4G ad-hoc networks and apply it for molecular communications. Module 4 GPU and Supercomputing access: Application Programming Interface and Development In the last module, students will learn how to deploy/simulate/validate various simulation models by developing application programming interfaces. The student will explore some of the open-source tools like flask and PyCaret along with the mobility tools to develop web-based applications for ITS applications.
Course Objectives	The objectives of this course are: 1. To develop the fundamentals of wireless communication 2. To map theory with the practical applications of ITS and IoBNT. 3. To make student learn analysis and Monte Carlo Simulations for intelligent ad-hoc networks 4. To learn about various mobility and network tools for developing an application program interface 5. To learn about open-source parallel programming structure 6. Project Implementation and teamwork

Learning Outcomes	The following are the expected learning outcomes from this course: 1. Students would attain sufficient maturity to visualize different intelligent ad-hoc networking systems. 2. Students will be able to visualize analysis and simulation view point of the communication problem 3. Understand different fundamentals of a wireless system like SIMO, MIMO with different channel environment and their implementation in ITS. 4. Perform analysis and simulations for molecular communications 5. Apply basic coding skills to the design and implement wireless communication algorithms 6. Design and Implement the wireless services/applications for social context 7. Create a strong basis for the implementation of intelligent ad-hoc networks with open source parallel programming, Digital Communications, Information Theory, Coding Theory etc.
Pedagogy	In class: 1. Use of tools like a document camera, presentation for content delivery. 2. Use of audiovisual aids like simulations, graphics etc. 3. Posing a question or a problem, discussion in pairs and conclusion by a volunteer group. 4. Use debrief session at the beginning of class to collect questions and discuss the most common ones. Online: 1. Use tools like zoom for content delivery. 2. Use of learning management systems/course management systems like campus wire for live polling/ attendance marking during the lecture 3. Providing the recorded video of several hardware-based experiments
Expectation From Students	Regular attendance, pre-reading is advisable.

Assessment/Evaluation	• End Semester Examination:
	  ◦ Written - 25%
	• Other Components:
	  ◦ Quiz - 20%
	  ◦ Project - 40%
	  ◦ Class Activities : Hands on tasks, group work, class discussion - 15%

Attendance Policy	As per Ahmedabad University Policy. Attendance is compulsory (voluntarily and self-decisive) in theory lectures and laboratories. The minimum requirement is 80% of the course. Without attending the lecture sessions, it is almost impossible to clear the grading requirement.
Project / Assignment Details	As part of the evaluation, students are expected to work on the project from the first day of the course. The project can be identified from the areas mentioned in modules 2 and module 3. Students are requested to follow specific guidelines for the successful completion of the project. Each group consists of a max of four students. The students have the autonomy to choose their partners. The project evaluation is strongly based on five points: 1. State of the art study: Current Literature Survey 2. Individual Contribution 3. Minimum viable Product 4. Social Context 5. Impact of your work done: External and Internal The student has to create a poster and website for the project with a working model video. Three sprint reviews will be conducted as a part of the evaluation in collaboration with industry partners as under: Sprint Review 1: Problem Formulation Sprint Review 2: Interim Progress Meeting Sprint Review 3: Final Outcome Sharing

Course Material	Reference Book • Fundamentals of Mobile Data Networks, Guowang Miao, Jens Zander, Ki Won Sung, Slimane Ben Slimane, 1 Edition, Cambridge University Press, ISBN: 1107143217, Year: 2016, • 5G Mobile and Wireless Communications Technology, Afif Osseiran, Jose F. Monserrat, Patrick Marsch, Mischa Dohler, Takehiro Nakamura, 1st Edition, Cambridge University Press, ISBN: 1107130093, Year: 2016, • Signal Processing for 5G: Algorithms and Implementations, Fa-Long Luo, Charlie (Jianzhong) Zhang , 1st Edition, Wiley - IEEE, ISBN: 1119116465, Year: 2016, • Body Area Communications: Channel Modeling, Communication Systems, and EMC, Jianqing Wang , Qiong Wang, Wiley-Blackwell, ISBN: 1118188489, Year: 2013, • Wireless Computing in Medicine: From Nano to Cloud with Ethical and Legal Implications (Nature–Inspired Computing Series), Dr. Mary Mehrnoosh Eshaghian–Wilner, Esq. i, 1st Edition, Wiley-Blackwell , ISBN: 1118993594, Year: 2016, • Body Sensor Networks, Guang-Zhong Yang, Springer London, ISBN: 978-1-4471-6373-2, Year: 2014, • Fading and Shadowing in Wireless Systems, P. Mohana Shankar, 2 Edition, Springer, ISBN: 1493900625, Year: 2014, • Fundamentals of Mobile Data Networks, Guowang Miao, Jens Zander, Ki Won Sung, Slimane Ben Slimane, 1 Edition, Cambridge University Press, ISBN: 1107143217, Year: 2016, • 5G Mobile and Wireless Communications Technology, Afif Osseiran, Jose F. Monserrat, Patrick Marsch, Mischa Dohler, Takehiro Nakamura, 1st Edition, Cambridge University Press, ISBN: 1107130093, Year: 2016, Coursepacks • Jagannatham, Aditya K. Principles of modern wireless communication systems. McGraw-Hill Education, 2015.,

Additional Information	We are going to use High-Performance Computing HW / SW Resources for the project implementation as under: **Hardware Resource:** Name: Supercomputer PARAM Shavak Specifications: 1. Powered with 2 multicore CPUs, each with minimum of 12 cores 2. 64 GB RAM 3. 2 - 5 Tera-Flops peak computing power with 8 TB of storage 4. 2 numbers of accelerator cards - NVIDIA K40 accelerator card and NVIDIA P5000 for deep learning 5. Built in HPC applications for bioinformatics, molecular dynamics, material science, and quantum chemistry **Software for Project / Laboratory Hands-on:** 1. MATLAB VANET Toolbox 2. MATLAB 2021a 3. Compute Unified Device Architecture (CUDA) Programming 4. Julia high-performance computing framework **Developer module:** 1. PyCaret 2. Flask 3. Heroku cloud application platform 4. Traffic interface tools

Session Plan

NO.	TOPIC TITLE	TOPIC & SUBTOPIC DETAILS	READINGS,CASES,ETC.	ACTIVITIES	IMPORTANT DATES
0					
1	Module 1: Fundamentals of wireless communications	Introduction to wireless communication Introduction to 5G Course objectives	Lecture note (L1)	Group Discsusions	
2	Module 1: Fundamentals of wireless communications	Introduction to 2G, 3G and 4G Wireless Technologies: GSM, IS-95, CDMA, UMTS, HSDPA, WCDMA, Wi-Max, Wi-Fi, LTE and LTE-A WRAN. Spectrum allocations and comparison	Text book 1 Chap. 1.2-1.5	Group Discsusions	
3	Module 1: Fundamentals of wireless communications	Performance analysis of wired system (AWGN) channel, Performance analysis of wireless system (1 x 1)	Text book 1 Chap. 2.2, 2.3	Numericals	
4	Module 1: Fundamentals of wireless communications	Performance Analysis and Applications of SIMO Wireless System, Wireless channel and spread delay modeling-I, Wireless channel and spread delay modeling-II	Text book 1 Chap. 3.8 – 3.11, Chap. 4.1-4.5	Tutorial	
5	Module 1: Fundamentals of wireless communications	Doppler fading and concept of coherence bandwidth, Performance analysis of 1 x 2 selection combining	Text book 1 Chap. 4.6 - 4.9	Numericals	
6	Module 1: Fundamentals of wireless communications	Performance analysis of MIMO wireless system, Problem solving for MIMO wireless systems, BER analysis of Zero Forcing receiver	Text book 1 Chap. 6.1-6.2	Tutorial	

7	Module 1: Fundamentals of wireless communications	BER analysis of MMSE receiver	Text book 1 Chap. 6.1-6.2	Numericals	
8	Module 1: Fundamentals of wireless communications	Introduction to CDMA and comparison with TDMA and FDMA	Text book 1 Chap. 5.1,5.2,5.3	Numericals	
9	Module 1: Fundamentals of wireless communications	Generation of PN sequences and its properties, Multiuser CDMA-I	Text book 1 Chapter 5.4, 5.7	Numericals	
10	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	Wireless Communications in Vehicular Environments, Background and History of Vehicular Networking, Vehicular Networking Approaches Vehicular Ad-hoc Networking	Text book 2, Chapter 3	Tutorial	
11	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	Mobility Models for Vehicular Communications	Ref book 3, Chapter 11	Numericals	
12	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	Channel Models for Vehicular Communications	Ref book 3, Chapter 12	Tutorial	
13	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	Simulation Tools and Techniques for Vehicular Communications and Applications	Ref book 3, Chapter 13, 16	Numericals	
14	In Semester Examination	-	-	-	

15	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	LTE for Vehicular Communication	Ref book 3, Chapter 13, 16	Numericals	
16	Module 2: DSRC/LTE enabled Intelligent Transportation Systems (ITS)	Information-Centric Networking for VANETs	Ref book 3, Chapter 13, 16	Numericals	
17	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Passive Molecular Communication Through Absorbers.	Reference book 3: Chapter 2.1, 2.2	Tutorial	
18	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Diffusion of Molecules, Reception of Molecules	Reference book 3: Chapter 2.3, 2.4	Numericals	
19	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Active Molecular Communication, Modeling Approaches for the First Scenario.	Reference book 3: Chapter 4	Group Discsusions	
20	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Communication Theories and Techniques for Active MC with Molecular Motors	Reference book 3: Chapter 4	Group Discsusions	
21	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Active Molecular Communication with Motile Bacteria.	Reference book 3: Chapter 4	Group Discsusions	
22	Module 3: Intelligent Ad-hoc networks for Internet of Bio-Nano things (IoBNT)	Active Molecular Communication Through Contact of Nanomachines	Reference book 3: Chapter 4	Tutorial	

23	Module 4: Developing a front end application and perform client service	Introduction and Handson on PyCaret	Pycaret tutorials https://pycaret.org/	Tutorial	
24	Module 4: Developing a front end application and perform client service	Introduction and Handson on Flask	Flask tutorials	Tutorial	
25	Module 4: Developing a front end application and perform client service	Building backend application and demonstration over clients	Heroku handson https://www.heroku.com/	Tutorial	
26	Module 4: Developing a front end application and perform client service	Testing of APIs and Presentation Phase # 1	-	-	
27	Module 4: Developing a front end application and perform client service	Testing of APIs and Presentation Phase # 2	-	-	
28	Reflections and Reviews	-	-	-	
29	Reflections and Reviews	-	-	-	
30	End Semester Examination	-	-	-	