# TELE 6510: Fundamentals of IoT (Internet of Things)
## FALL 2024

**Course Information**
Course Title: Fundamental Internet of Things
Course Number: TELE 6510
Term and Year: Fall 2024
Credit Hour: 4
CRN: 20842
Course Format: Traditional

**Instructor Information**
Full Name: Haitham Tayyar
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Office Hours: Friday 5:35 to 6:05 pm

**Instructor Biography**
Dr. Haitham Tayyar holds a PhD in Electrical Engineering from the University of British Columbia in Vancouver. He has over 15 years of experience working at various academic institutions across the world in the fields of Electrical Engineering, Computer Engineering, and Information Technology. In his professional career, Dr. Tayyar worked as a software engineer, a micro-electronics failure analyst, as well as a telecommunications engineer.

**Teaching Assistant Information**
Full Name: Click or tap here to enter text.
Email Address: Click or tap here to enter text.
Office Hours: Click or tap here to enter text.

**Course Prerequisites**
None
**Course Description**
Explores the foundations and technologies involved in Internet of Things
(IoT) from an industry perspective. Topics include Machine to Machine (M2M) communication and Wireless Sensor Networks (WSNs) and their relationship with IoT as well as their evolution. This involves all three main elements: (1) devices, (2) communications/networks and (3) analytics/ applications. Specifically, it introduces technologies and interfaces associated with embedded devices and presents the fundamentals of IoT analytics including machine learning and rule-based AI. The bulk of the content presented in the class is focused on the industry led standardization of IoT networking mechanisms. In this context, it examines fundamental components of the IoT

architecture and presents a large array of real life applications and case studies. Focuses on different LPWAN and WPAN wireless technologies that are relevant to meet requirements of IoT including WiFi, Bluetooth Low Energy, IEEE 802.15.4, ITU G.9903, ITU G.9959, LoRa and LTE-M/NB-IoT among others. Explores 6Lo adaptation mechanisms like 6LoWPAN. Discusses the most common IoT application technologies with special emphasis on MQTT, CoAP and AMQP. Introduces routing mechanisms like RPL and resource identification protocols like mDNS, SD-DNS and UPnP. Also explores special issues that affect IoT networks including security and privacy considerations as well as reliability mechanisms intended to overcome network impairments. It also presents new trends like the use of blockchain technologies to enable transactive IoT applications.

**Course Learning Outcomes**

At the completion of this course, students will be able to:

1. Understand the different components involved in IoT architectures.
2. Know the most common IoT protocols and standards.
3. Be familiar with state-of-the-art technologies associated with IoT like machine learning and blockchain.

**Required Tools and Course Textbooks.**

No Required Text
Recommended Text(s):
1. "Fundamentals of IoT Communication Technologies", Herrero, 1th Edition, Springer-Nature; 2021
2. "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", Holler et al, 1th Edition, Academic Press; 2014
3. "Internet of Things: A Hands-On Approach", Bahga, Madisetti, 1th Edition, VPT; 2014
4. "Internet of Things", Buyya, Dastjerdi, 1th Edition, Morgan Kaufmann Pub; 2016
5. "Designing the Internet of Things", McEwen, Cassimally, 1th Edition, Wiley; 2014
6. "Learning Internet of Things", Waher, 1st Edition, Packt Publishing; 2015
7. "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", daCosta, 1st Edition, APress; 2014
8. "Computer Networking", Kurose, Ross, 8th Edition, Pearson; 2019
9. "Wireless Networking Technology", Rackley, Steve , 1th Edition, Newnes; 2007
10. "6LoWPAN", Shelby, Zash, 1th Edition, Wiley; 2010
11. "Wireless Sensor Networks", Sohraby, Kakeem, , 1th Edition, Wiley; 2010

**Course Schedule/Topics Covered.**

| Week | Date | In Class Topic | Assignment Due |
|------|------|----------------|----------------|
| 1 | 09/06 | IoT Preview [1][2]:<br>- M2M and the evolution of IoT<br>- Components and use case examples<br>- Functional Layers of IoT<br>- The Data → Information → Knowledge Transformation | |

| 2 | 09/13 | Overview of Data Network Concepts [8]:<br>- Computer Networking Concepts (Internet, ISPs, Delay, Loss)<br>- Session/App Layer: HTTP, HTTPs | |
|---|---|---|---|
| 3 | 09/20 | Overview of Data Network Concepts [8]:<br>- Transport UDP/TCP<br>- IPv4/IPv6/NAT<br>- Basics of Routing<br>- Security: Encryption/Authentication/Integrity, Intro to Blockchains | |
| 4 | 09/27 | Device Side of IoT [1][2]:<br>- Devices and Gateways. Architectures. Interfaces<br>- IoT Data Management. Purpose and Considerations<br>- Sensors and Actuators<br>- Accelerometers. Position and Velocity. Rotation. Leds. Motor Control | |
| 5 | 10/4 | Application Side of IoT [1][2]:<br>- Everything as a service (XaaS)<br>- IoT Analytics<br>- Intro to Machine Learning<br>- State of Art: ETSI, ITU and IETF standardization efforts<br>- Architecture Reference Model | |
| 6 | 10/11 | Wireless Technologies for IoT [1][2][9][12]:<br>- IEEE 802.11 and IoT (IEEE 802.11p, IEEE 802.11ah and IEEE 802.11ba)<br>- IEEE 802.15.4<br>- BLE and IoT (Bluetooth 5.2) | |
| 7 | 10/18 | 6LoWPAN [9]:<br>- IPv6 to 6LoWPAN<br>- Header Compression<br>- Mesh Routing<br>- Fragmentation | |
| 8 | 10/25 | Application Technologies for IoT [1][2][6][12]:<br>- WoT. REST Architectures.<br>- EDA Architectures.<br>- HTTP<br>- MQTT | |
| 9 | 11/1 | • Pre-midterm Exam Review<br>• Pre-midterm Assessment Quiz (Not for Grade)<br>• Wireless Sensor Networks [1][11]:<br>  - Applications<br>  - Scalability and adaptability<br>  - Power Considerations<br>  - Communication Patterns. Routing | |
| 10 | 11/8 | Catch up! | |
| 11 | 11/15 | Midterm Exam (classes 1 to 8) | |
| 12 | 11/22 | • Wireless Sensor Networks [1][11]: | |

| | | | |
|---|---|---|---|
| | | - Routing: Flooding, Gossiping, SPIN, LEACH, PEGASIS, Directed Diffusion<br>• RPL [RFC6550][11]:<br> - DODAG creation<br> - Storing/Non-storing modes | |
| 13 | 11/29 | NO CLASS (Thanksgiving/Fall Break Recess) | |
| 14 | 12/6 | • Identification Mechanisms; mDNS [1][RFC6762][12]:<br> - Querying/Responses<br> - Negative Responses<br> - Answer/Question Suppression<br><br>• Identification Mechanisms; SD-DNS [1][RFC6763][12]<br> - Service/Instance Names<br> - Records | |
| 15 | 12/13 | | |

**Assignment Grading**

- Midterm Exam 30%
- Final Exam 30%
- Quizzes 15%
- Assignments 15%
- Project 10%

**Grading Scale**

| | 87-89.9% B+ | 77-79.9% C+ | |
|---|---|---|---|
| | 84-86.9% B | 74-76.9% C | |
| 95-100% A | | | |
| 90-94.9% A- | 80-83.9%B- | 70-73.9% C- | 69.9% or below F |

**Attendance/Late Work Policy**

Attendance Policy

Students registered in MGEN courses (INFO, CSYE, and DAMG) are allowed **a maximum of 2 absences per course, with 3 or more absences resulting in an automatic 'F' for that course.** Students are expected to inform their instructors of any absences in advance of the class; if a student is sick long-term or experiences a medical issue that prevents class attendance, it is strongly encouraged that they speak with their Academic Advisor (coe-mgen-gradadvising@northeastern.edu) to learn more about the Medical Leave of Absence. Should a student anticipate being unable to attend 3 or more classes, they should discuss their situation with their Academic Advisor to explore other types of leave in accordance with the University's academic and global entry

expectations. International students should review the Office of Global Services webpage to understand their visa compliance requirements.

Teaching Assistants (TAs) or Instructional Assistants (IAs) will be present at each class to collect student attendance.

Late Work Policy

Students must submit assignments by the deadline in the time zone noted in the syllabus. Students must communicate with the faculty prior to the deadline if they anticipate work will be submitted late. Work submitted late without prior communication with faculty will not be graded.

**End-of-Course Evaluation Surveys**
Your feedback regarding your educational experience in this class is particularly important to the College of Engineering. Your comments will make a difference in the future planning and presentation of our curriculum.

At the end of this course, please take the time to complete the evaluation survey at **https://neu.evaluationkit.com**. Your survey responses are **completely anonymous and confidential**. For courses 6 weeks in length or shorter, surveys will be open one week prior to the end of the courses; for courses greater than 6 weeks in length, surveys will be open for two weeks. An email will be sent to your Northeastern University Mail account notifying you when surveys are available.

**Academic Integrity**
A commitment to the principles of academic integrity is essential to the mission of Northeastern University. The promotion of independent and original scholarship ensures that students derive the most from their educational experience and their pursuit of knowledge. Academic dishonesty violates the most fundamental values of an intellectual community and undermines the achievements of the entire University.

As members of the academic community, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, examinations of whatever kind, collaborative work, the use of study aids, the appropriateness of assistance, and other issues. Students are responsible for learning the conventions of documentation and acknowledgment of sources in their fields. Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments of any kind according to the highest ethical standards, as set forth either explicitly or implicitly in this Code or by the direction of instructors.

Go to http://www.northeastern.edu/osccr/academic-integrity-policy/ to access the full academic integrity policy.

**MGEN Student Feedback**
Students who would like to provide the MGEN unit with anonymous feedback on this particular course, Teaching Assistants, Instructional Assistants, professors, or to provide general feedback regarding their program, may do so using this survey: https://neu.co1.qualtrics.com/jfe/form/SV_cTIAbH7ZRaaw0Ki

**University Health and Counseling Services**
As a student enrolled in this course, you are fully responsible for assignments, work, and course materials as outlined in this syllabus and in the classroom. Over the course of the semester if you experience any health issues, please contact UHCS.

For more information, visit https://www.northeastern.edu/uhcs.

**Student Accommodations**
Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.

For more information, visit https://drc.sites.northeastern.edu.

**Library Services**
The Northeastern University Library is at the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals.

For more information and for education specific resources, visit https://library.northeastern.edu
Network Campus Library Services: Northeastern University Library Global Campus Portals

**24/7 Canvas Technical Help**
For immediate technical support for Canvas, call 617-373-4357 or email help@northeastern.edu

Canvas Student Resources:  https://canvas.northeastern.edu/student-resources/

For assistance with my Northeastern e-mail, and basic technical support:
Visit ITS at https://its.northeastern.edu
Email: help@northeastern.edu
ITS Customer Service Desk: 617-373-4357

**Diversity and Inclusion**
Northeastern University is committed to equal opportunity, affirmative action, diversity, and social justice while building a climate of inclusion on and beyond campus.  In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration, and an awareness of global perspectives on social justice.

Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion

**Title IX**
*Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance.*

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty, and staff.

In case of an emergency, please call 911.

*Please visit https://www.northeastern.edu/ouec for a complete list of reporting options and resources both on- and off-campus.*