Amrita Vishwa Vidyapeetham
Amrita School of Engineering, Coimbatore

Department of Electrical and Electronics Engineering

Course Plan

Academic year:	***2023-24***	Semester	: *II*
Department :	*Electrical & Electronics Engineering*	Program	: M.*Tech. Embedded Systems*
Course Code :	21ES614	Course Title	: *Internet of Things*

Syllabus:

Unit 1

Introduction to IoT - Definitions, frameworks and key technologies. Functional blocks of IoT systems: hardware and software elements- devices, communications, services, management, security, and application. Challenges to solve in IoT.

Unit 2

Basics of Networking & Sensor Networks - Applications, challenges - ISO/OSI Model, TCP/IP Model. Sensor network architecture and design principles. IoT technology stack -overview of protocols in each layer. Communication Protocols. Communication models, Application protocols for the transfer of sensor data. Infrastructure for IoT: LoRa-Wan, 6LoWPAN, 5G and Sigfox. Operating systems and programming environments for embedded units (Contiki).

Unit 3

Introduction to Cloud, Fog and Edge Computing- Modern trends in IoT – Industrial IoT, Wearable. Applications of IoT - Smart Homes/Buildings, Smart Cities, Smart Industry, and Smart Medical care, Smart Automation etc.

Text Book/ Reference Materials:

1. Andrew S. Tanenbaum and David J. Wetherall, “Computer Networks”, 5th Edition, Pearson Education, 2011.
2. Holger Karl and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks”, John Wiley and Sons Ltd., 2005.
3. Olivier Hersent, David Boswarthick and Omar Elloumi, “The Internet of Things: Key Applications and Protocols”, Wiley, 2012.
4. Rayes, Ammar, Salam, Samer “Internet of Things from Hype to Reality” 2nd edition
5. Boris Adryan, Dominik Obermaier, Paul Fremantle “The Technical Foundations of IoT” Artech House 2nd edition.

Additional References

1. https://nptel.ac.in/courses/106105166 or https://archive.nptel.ac.in/courses/106/105/106105166/
2. https://nptel.ac.in/courses/106105195

Session No:	Experiment	Date	COs	Remarks
	Introduction	9 Dec 2024		
1	Familiarization of various communication networks in NetSim and Wireshark	14 Dec 2024	CO1, CO2, CO3, CO4	Practice
2	**IoT end nodes with Ubidots, Adafruit, ThingSpeak** Sensing – Data – Analog, Digital, via protocol; Processing; Actuation – On/Off, Continuous; Signal conditioning circuit; Communication. Platforms – Data display, control initiation.	16 Dec 2024		Practice
		23 Dec 2024		Practice
		30 Dec 2024		**Evaluation**
3	Simulation study on IEEE 802.3/802.11 networks using NetSim	6 Jan 2024		Practice
4	Simulation study on ZigBee/Wireless Sensor Networks using NetSim	20 Jan 2024		Practice
5	**IoT networks simulation in NetSim & Wireshark packet data extraction**	25 Jan 2024		**Evaluation**
6	Familiarization of socket connection using microcontroller board and PC/Laptop	27 Jan 2024	CO1, CO2, CO3, CO4	Practice
7	IoT edge node – Data aggregation and communication	17 Feb 2024		Practice
8	IoT edge node – Edge computing and communication	24 Feb 2024		Practice
9	**Demonstration of IoT edge device – aggregation, edge computing & communication**	3 March 2024		**Evaluation**
10	Implementation of UI for data visualization & remote control	10 March 2024		Practice
11	Implementation of database for edge/end node data storage	17 March 2024		Practice
12	**Implementation of a server with database and UI**	24 March 2024		**Evaluation**
13	Project Implementation	5 April 2024	CO1, CO2, CO3, CO4	**Evaluation**

Lab Experiments - Evaluation Details:

Session No:	Experiment	Marks
	Introduction	NA
1	Familiarization of various communication networks in NetSim and Wireshark	NA
2	**IoT end nodes with Ubidots, Adafruit, ThingSpeak** Sensing – Data – Analog, Digital, via protocol; Processing; Actuation – On/Off, Continuous; Signal conditioning circuit; Communication. Platforms – Data display, control initiation.	Sensing – digital, analog – 0.5 each, via protocol – 1; Processing – 1; Actuation – 1; Signal Conditioning – 1; Remote control – 1; Ubidots, Adafruit, Thingspeak – 1 each. **9 marks**
4	Simulation study on IEEE 802.3/802.11 networks using NetSim	NA
5	Simulation study on ZigBee/Wireless Sensor Networks using NetSim	NA
6	**IoT networks simulation in NetSim & Wireshark packet data extraction**	Knowhow on network simulation and results – 3 Knowhow on Wireshark, packet data format and results – 3 **6 marks**
7	Familiarization of socket connection using microcontroller board and PC/Laptop	NA
8	IoT edge node – Data aggregation and communication	Aggregation – 2.5, Computing – 2.5, Communication – 2.5 **7.5 marks**
9	IoT edge node – Edge computing and communication	
	Demonstration of IoT edge device – aggregation, edge computing & communication	
10	Implementation of UI for data visualization & remote control	Server – 2.5, UI – 2.5, Database – 2.5 **7.5 marks**
11	Implementation of database for edge/end node data storage	
12	**Implementation of a server with database and UI**	

1. Microcontrollers - Getting started with different boards in the Lab
    a. RPi, Arduino, NodeMCU, Pico, Bluepill, Nano, Nucleo, mbed, ESP32 (ARM-2148, Arduino Uno, Pico already familiarized).
    b. https://www.arduino.cc/en/Tutorial/HomePage
    c. https://randomnerdtutorials.com/getting-started-with-esp8266-wifi-transceiver-review/
    d. https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started
    e. https://learn.sparkfun.com/tutorials/headless-raspberry-pi-setup/ethernet-with-static-ip-address
    f. https://www.raspberrypi.com/tutorials/
    g. https://projects.raspberrypi.org/en/projects/getting-started-with-the-pico
    h. https://projects.raspberrypi.org/en/projects/get-started-pico-w
    i. https://docs.arduino.cc/retired/getting-started-guides/ArduinoLilyPad
    j. https://docs.arduino.cc/retired/getting-started-guides/ArduinoLilyPadUSB
    k. https://www.sgbotic.com/index.php?dispatch=pages.view&page_id=48
    l. https://maker.pro/arduino/tutorial/how-to-program-the-stm32-blue-pill-with-arduino-ide
    m. https://www.arduino.cc/en/Guide/ArduinoNano/
    n. https://wiki.st.com/stm32mcu/wiki/STM32StepByStep:Getting_started_with_STM32_:_STM32_step_by_step
    o. https://circuitdigest.com/microcontroller-projects/getting-started-with-stm32-nucleo64-using-stm32cubemx-and-truestudio
    p. https://stm32f4-discovery.net/2018/09/getting-started-with-stm32-step-by-step/
    q. https://learnembeddedsystems.co.uk/stm32f4-discovery-beginners-tutorial-blink-leds
    r. https://os.mbed.com/docs/mbed-studio/current/getting-started/index.html
    s. https://os.mbed.com/docs/mbed-os/v6.16/tutorials/index.html
    t. https://www.keil.com/appnotes/files/apnt_207_v2.0.pdf
    u. http://www.ocfreaks.com/create-new-lpc1768-project-in-keil-5-tutorial/
    v. https://www.electronicshub.org/setting-up-keil-mdk-for-lpc1768/
    w. https://randomnerdtutorials.com/getting-started-with-esp32/
    x. https://esp32io.com/

2. Communication Modems- ZigBee, nrf, lora, Wi-Fi, Bluetooth/BLE, CAN, Ethernet.
    a. https://docs.arduino.cc/retired/getting-started-guides/ArduinoEthernetShield
    b. https://www.instructables.com/Arduino-Ethernet-Shield-Tutorial/
    c. https://www.instructables.com/Configuring-the-Raspberry-Pi-ethernet-port-for-rem/

d. https://www.circuitbasics.com/how-to-connect-to-a-raspberry-pi-directly-with-an-ethernet-cable/
e. https://www.instructables.com/Add-WiFi-to-Arduino-UNO/
f. https://42bots.com/tutorials/esp8266-wifi-tutorial-arduino-ide/
g. https://randomnerdtutorials.com/esp32-useful-wi-fi-functions-arduino/
h. https://www.digikey.com/en/maker/tutorials/2016/raspberry-pi-wi-fi-bluetooth-setup-how-to-configure-your-pi-4-model-b-3-model-b
i. https://core-electronics.com.au/guides/raspberry-pi-pico-w-connect-to-the-internet/
j. https://projects.raspberrypi.org/en/projects/get-started-pico-w/2
k. https://projecthub.arduino.cc/NeilChaudhary/arduino-bluetooth-basic-tutorial-9cff12
l. https://www.instructables.com/ESP32-Bluetooth-Tutorial-How-to-Use-Inbuilt-Blueto/
m. https://circuitdigest.com/microcontroller-projects/hc-05-bluetooth-module-interfacing-with-esp8266-to-control-an-led
n. https://electrocredible.com/raspberry-pi-pico-w-bluetooth-ble-micropython/
o. https://www.hackster.io/Neutrino-1/xbee-zigbee-setup-with-arduino-and-nodemcu-81f7fa
p. https://www.rhydolabz.com/wiki/?p=10868
q. https://www.zigbee2mqtt.io/guide/getting-started/#connect-a-device
r. https://circuitdigest.com/microcontroller-projects/arduino-lora-sx1278-interfacing-tutorial
s. https://circuitdigest.com/microcontroller-projects/raspberry-pi-with-lora-peer-to-peer-communication-with-arduino
t. https://how2electronics.com/interfacing-mcp2515-can-bus-module-with-arduino/
u. https://www.hackster.io/youness/how-to-connect-raspberry-pi-to-can-bus-b60235
v. https://arduino.ah-oui.org/user_docs/dos11/NRF24L01-tutorial.pdf
w. https://thezanshow.com/electronics-tutorials/raspberry-pi/tutorial-32-33

3. IoT platforms- ubidots, thingspeak, IFTTT, Adafruit, BLYNK, Arduino Cloud.
   a. https://help.ubidots.com/en/articles/2033398-setting-up-the-arduino-ide-for-ubidots
   b. https://help.ubidots.com/en/articles/928457-control-an-led-remotely-with-an-arduino-and-ubidots
   c. https://help.ubidots.com/en/articles/513309-connect-the-raspberry-pi-with-ubidots
   d. https://help.ubidots.com/en/articles/5097358-connect-a-raspberry-pi-pico-with-ubidots-using-an-esp8266
   e. https://docs.arduino.cc/tutorials/generic/WiFi101ThingSpeakDataUploader
   f. https://nothans.com/thingspeak-tutorials/arduino/send-data-to-thingspeak-with-arduino
   g. https://randomnerdtutorials.com/esp8266-nodemcu-thingspeak-publish-arduino/

h. https://www.instructables.com/Air-Monitoring-System-Using-NodeMCU-and-IOT-Things/
i. https://github.com/mathworks/thingspeak-arduino
j. https://www.digikey.com/en/maker/tutorials/2019/how-to-use-adafruit-io-with-an-esp8266-and-the-arduino-ide
k. https://learn.adafruit.com/adafruit-io/arduino
l. https://www.woolseyworkshop.com/2019/06/06/adafruit-io-connecting-your-arduino-to-the-outside-world/
m. https://www.jeremymorgan.com/tutorials/raspberry-pi/how-to-iot-adafruit-raspberrypi/
n. https://www.woolseyworkshop.com/2019/05/31/adafruit-io-connecting-your-raspberry-pi-to-the-outside-world/
o. https://learn.adafruit.com/raspberry-pi-physical-dashboard/adafruit-io
p. https://learn.adafruit.com/quickstart-rp2040-pico-with-wifi-and-circuitpython/usage-with-adafruit-io
q. https://diyprojectslab.com/ws2812-led-with-raspberry-pi-pico-w-adafruit-io/
r. https://blynk.io/blueprints/blink-an-led-with-arduino-ethernet
s. https://www.instructables.com/Control-Arduino-Uno-Using-ESP8266-WiFi-Module-and-/
t. https://iotdesignpro.com/projects/control-arduino-remotely-using-blynk-app
u. https://www.thetips4you.com/raspberry-pi-and-blynk-how-to-use-blynk-app-with-raspberry-pi/
v. https://www.instructables.com/Internet-of-Things-Raspberry-Pi-3-Blynk-App/
w. https://docs.arduino.cc/arduino-cloud/guides/overview
x. https://www.circuits-diy.com/ifttt-webhook-arduino-tutorial/
y. https://arduinogetstarted.com/tutorials/arduino-ifttt
z. https://support.arduino.cc/hc/en-us/articles/360013896199-How-to-integrate-the-Arduino-IoT-with-IFTTT

4. Database.
a. https://www.geeksforgeeks.org/python-database-tutorial/
b. https://www.geeksforgeeks.org/employee-management-system-using-python/
c. https://www.tutorialspoint.com/read-and-write-to-an-excel-file-using-python-openpyxl-module
d. https://www.datacamp.com/tutorial/python-excel-tutorial
e. https://www.cytron.io/tutorial/send-data-to-firebase-using-raspberry-pi
f. https://medium.com/@varuldcube100/store-temperature-sensor-data-in-firebase-real-time-database-through-raspberry-pi-d16e2086718f
g. https://randomnerdtutorials.com/esp8266-nodemcu-firebase-realtime-database/
h. https://www.javatpoint.com/iot-project-google-firebase-nodemcu

i. https://www.hackster.io/ahmedibrrahim/iot-using-raspberry-pi-and-firebase-and-android-dbe61d
j. https://wolles-elektronikkiste.de/en/using-ifttt-and-webhooks-with-the-esp8266
k. https://docs.arduino.cc/arduino-cloud/features/webhooks

5. UI (Mobile App)
    a. https://appinventor.mit.edu/explore/get-started
    b. https://blynk.io/
    c. https://www.kodular.io/
    d. https://flutter.dev/
    e. https://play.google.com/store/apps/details?id=com.cinetica_tech.thingview&hl=en&gl=US
    f. https://www.instructables.com/IoT-Made-Easy-With-UNO-ESP-01-ThingSpeak-and-MIT-A/

6. UI (Web App)
    a. https://streamlit.io/
    b. https://realpython.com/python-web-applications/
    c. https://www.freecodecamp.org/news/how-to-use-python-and-flask-to-build-a-web-app-an-in-depth-tutorial-437dbfe9f1c6/
    d. https://flask.palletsprojects.com/en/3.0.x/
    e. https://www.djangoproject.com/
    f. https://flutter.dev/
    g. https://www.w3schools.com/html/
    h. https://www.php.net/

7. Webserver- Embedded and Xampp.
    a. https://www.javatpoint.com/xampp
    b. https://www.ionos.com/digitalguide/server/tools/xampp-tutorial-create-your-own-local-test-server/
    c. https://www.freecodecamp.org/news/how-to-get-started-with-php/
    d. https://randomnerdtutorials.com/esp32-web-server-arduino-ide/
    e. https://www.tomshardware.com/news/raspberry-pi-web-server,40174.html
    f. https://www.instructables.com/Turning-your-Raspberry-Pi-into-a-personal-web-serv/
    g. https://www.instructables.com/Make-Your-Computer-Into-A-Server-in-10-Minutes-fr/

h. https://xlinesoft.com/phprunner/docs/how_to_install_local_server.htm

8. NetSim.
    a. https://www.tetcos.com/file-exchange.html
    b. https://www.tetcos.com/netsim-documentation.html
    c. https://www.youtube.com/user/Tetcos/videos

9. Communication model-client server. (implement in python).
    a. https://www.digitalocean.com/community/tutorials/python-socket-programming-server-client
    b. https://realpython.com/python-sockets/
    c. https://www.circuits-diy.com/communication-between-two-arduino/
    d. https://microcontrollerslab.com/esp32-server-client-wi-fi-communication-arduino-ide/

10. IoT specific Protocol- MQTT, COAP.
    a. https://randomnerdtutorials.com/esp32-mqtt-publish-subscribe-arduino-ide/
    b. https://bytebeam.io/blog/getting-started-with-mqtt-on-raspberry-pi-using-python/
    c. https://xiaozhon.github.io/course_tutorials/Coap_tutorial_RPi.pdf
    d. https://www.engineersgarage.com/client-server-communication-over-coap-protocol-iot-part-33/