# Design and Development of IoT Applications

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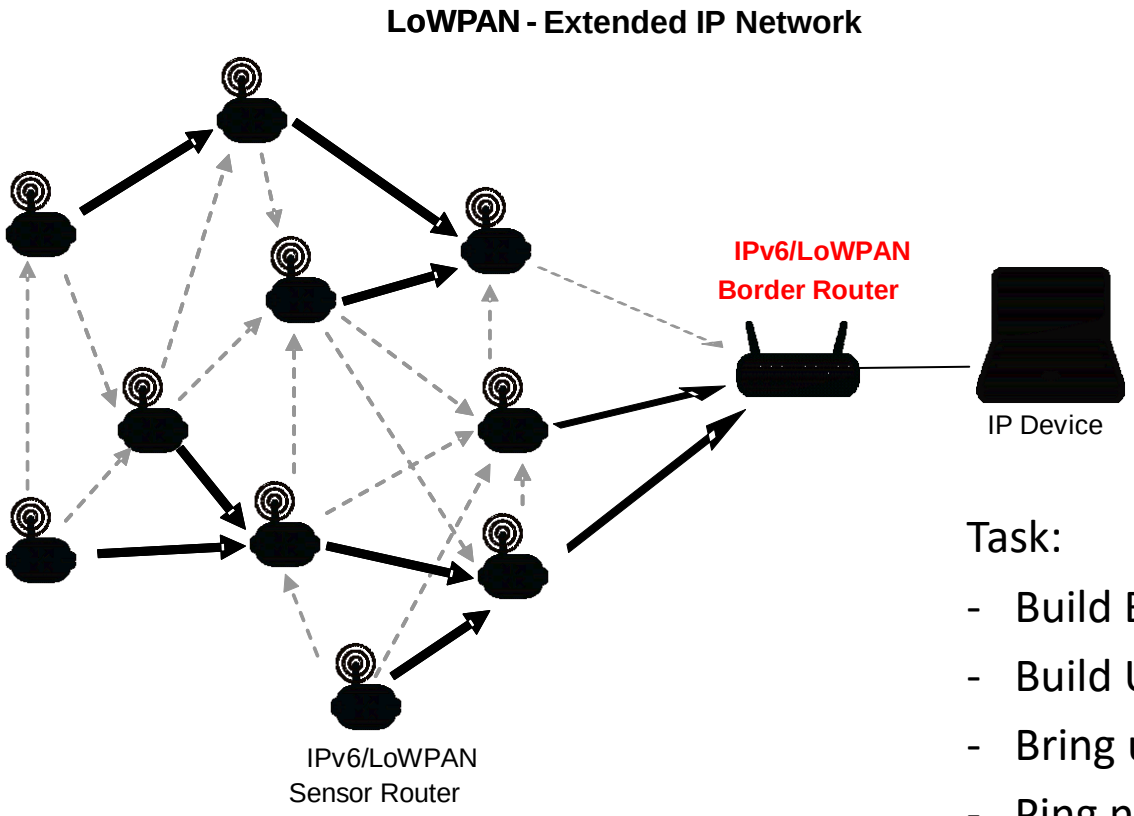
# Content

## ❑ Chapter 10: Labs/Demos and Assignments

- ❖ Basic demos/labs:
  - Hello world, LED Blinking
  - RDC and MAC protocols
  - Routing in WSNs: CTP, RPL
  - IPv6/6LoWPAN UDP Echo server
  - IPv6/6LoWPAN Web Server
  - Communication with 6LoWPAN network
  - CoAP and MQTT
- ❖ Advanced demos: (with HW)
  - I/O interfaces
  - Echo-Server for Multiple Platforms (Cooja, CC2530, CC2538)
  - Multicast IPv6
  - LWM2M
  - Security of IEEE 802.15.4
  - Mobility of nodes
- ❖ Design a controllable 6LoWPAN network with authentication, CRC, Database, web-server interface and can be connected to a client via IPv4 network

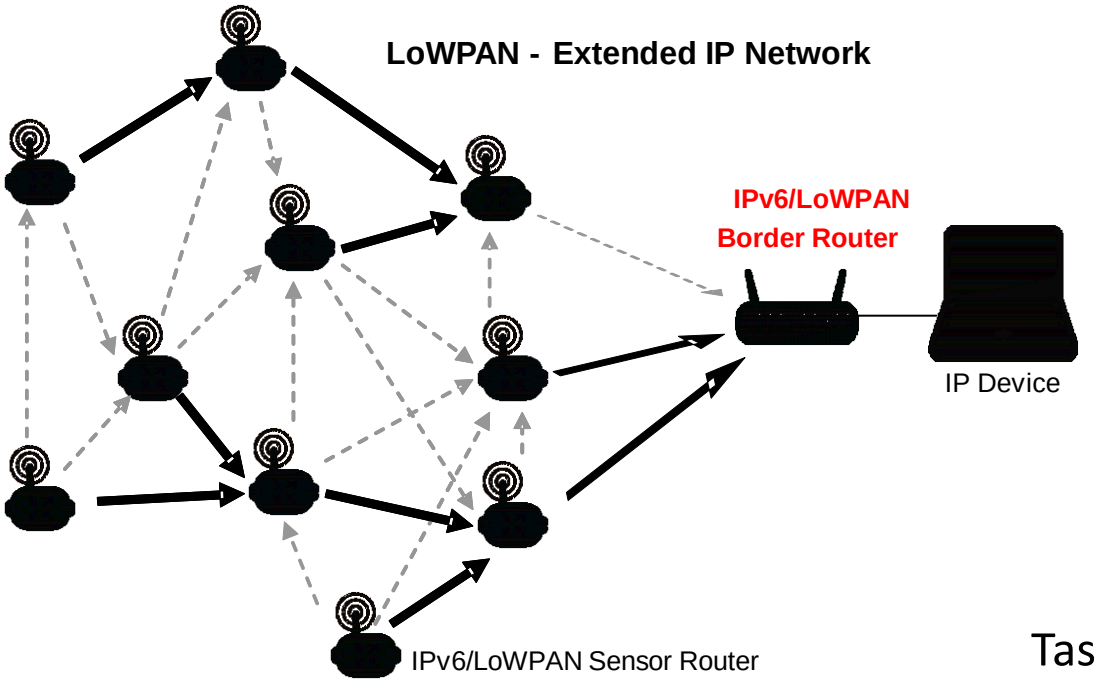
# IPv6/6LoWPAN UDP Echo server

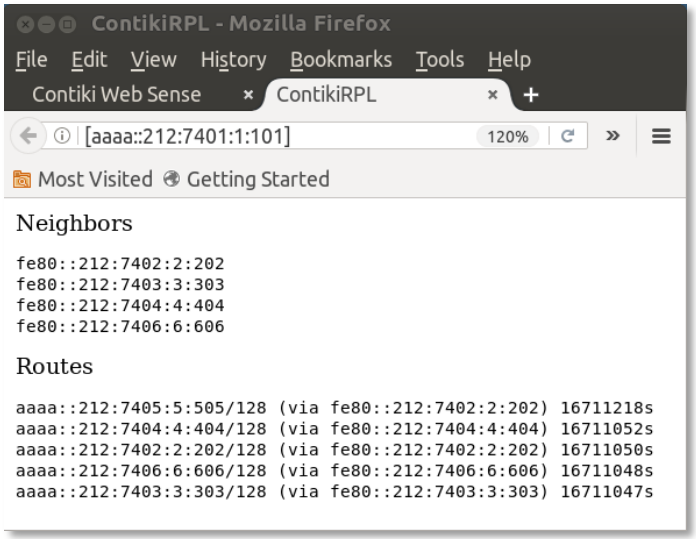



Task:

- Build Border router
- Build UDP Echo server
- Bring up the 6LoWPAN network
- Ping nodes
- Using ***netcat*** command to interact with a node

# Webserver in 6LoWPAN network



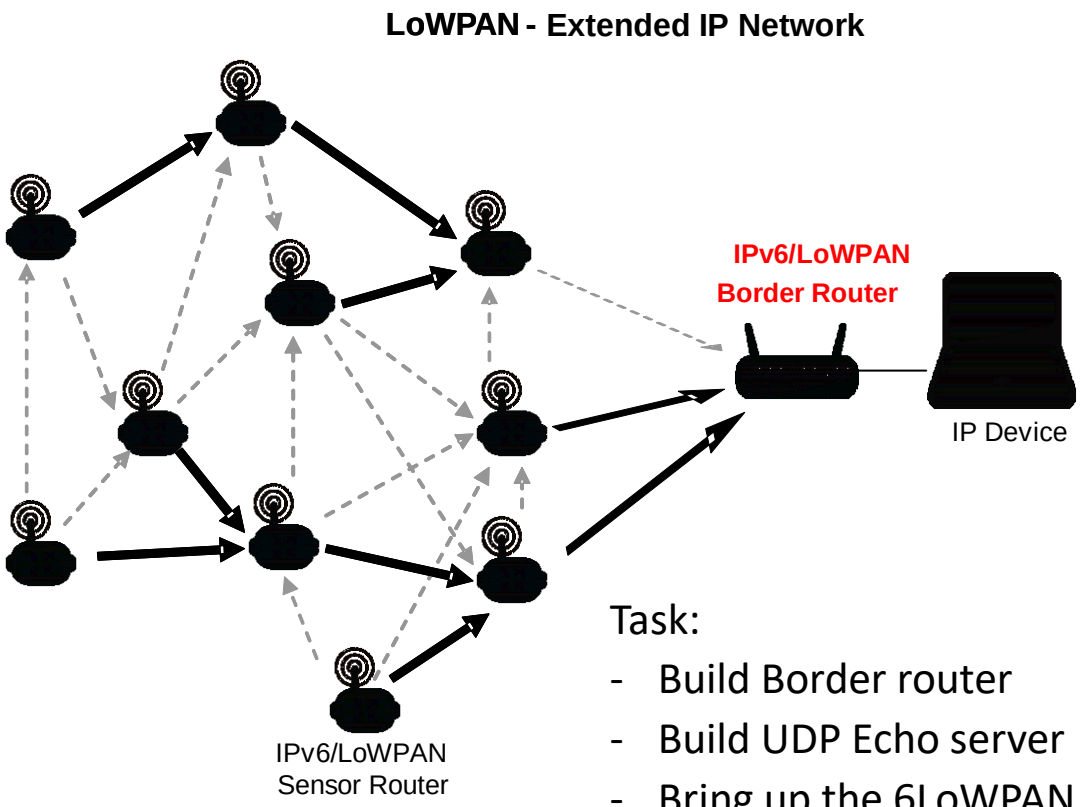


Task:

- Build Border router
- Build Webserver for a node
- Bring up the 6LoWPAN network
- Ping nodes to verify the network
- Using web browser to display sensor readings

# Communication with 6LoWPAN network

User Program to control a node




test-net-client.c (~/Desktop/contiki/examples/cc25

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test-net-client.c ×

```
sin6len = sizeof(struct sockaddr_in6);

sprintf(buffer,"led_on");

if(argc < 2) {
  printf("Specify a command \n"), exit(1);
}
else if (argc==2) {
     sprintf(buffer,"%s",argv[1]);
}

sock = socket(PF_INET6, SOCK_DGRAM,0);
memset(&sin6, 0, sizeof(struct sockaddr_in6));
sin6.sin6_port = htons(3000);
sin6.sin6_family = AF_INET6;
sin6.sin6_addr = in6addr_any;

status = bind(sock, (struct sockaddr *)&sin6, sin6len);
if(-1 == status)
  perror("bind"), exit(1);
```

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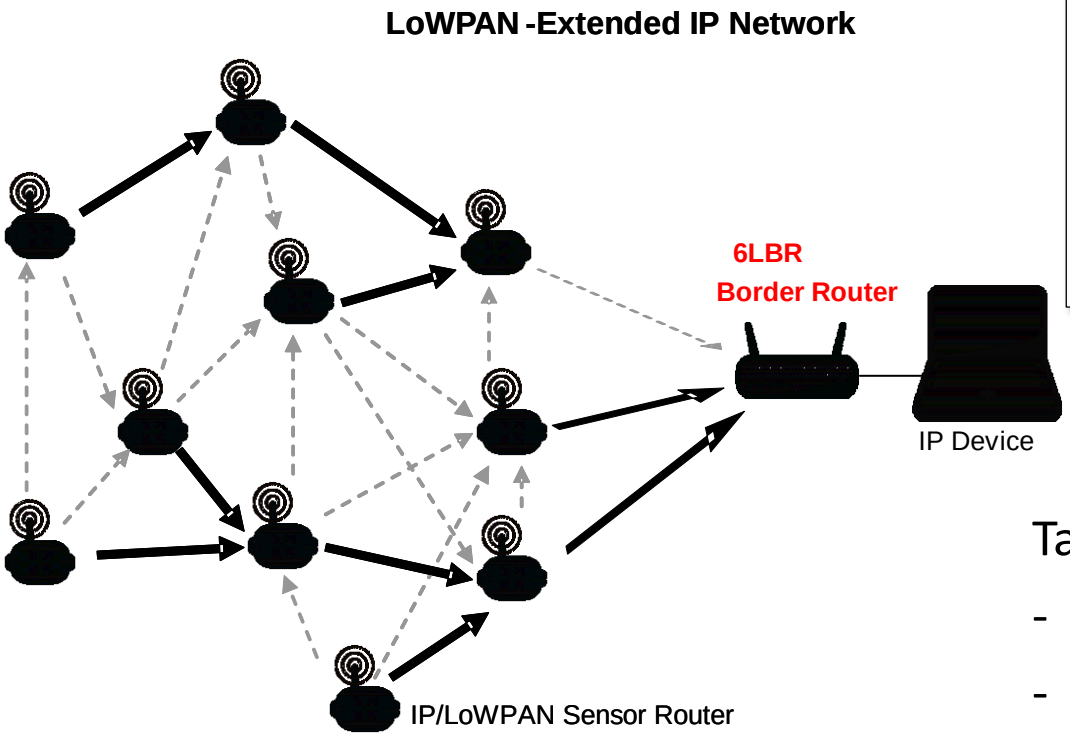
Task:

- Build Border router
- Build UDP Echo server
- Bring up the 6LoWPAN network
- Ping nodes to verify the network
- Write a program to control a node's LED

# 6LoWPAN Border Router (6LBR)



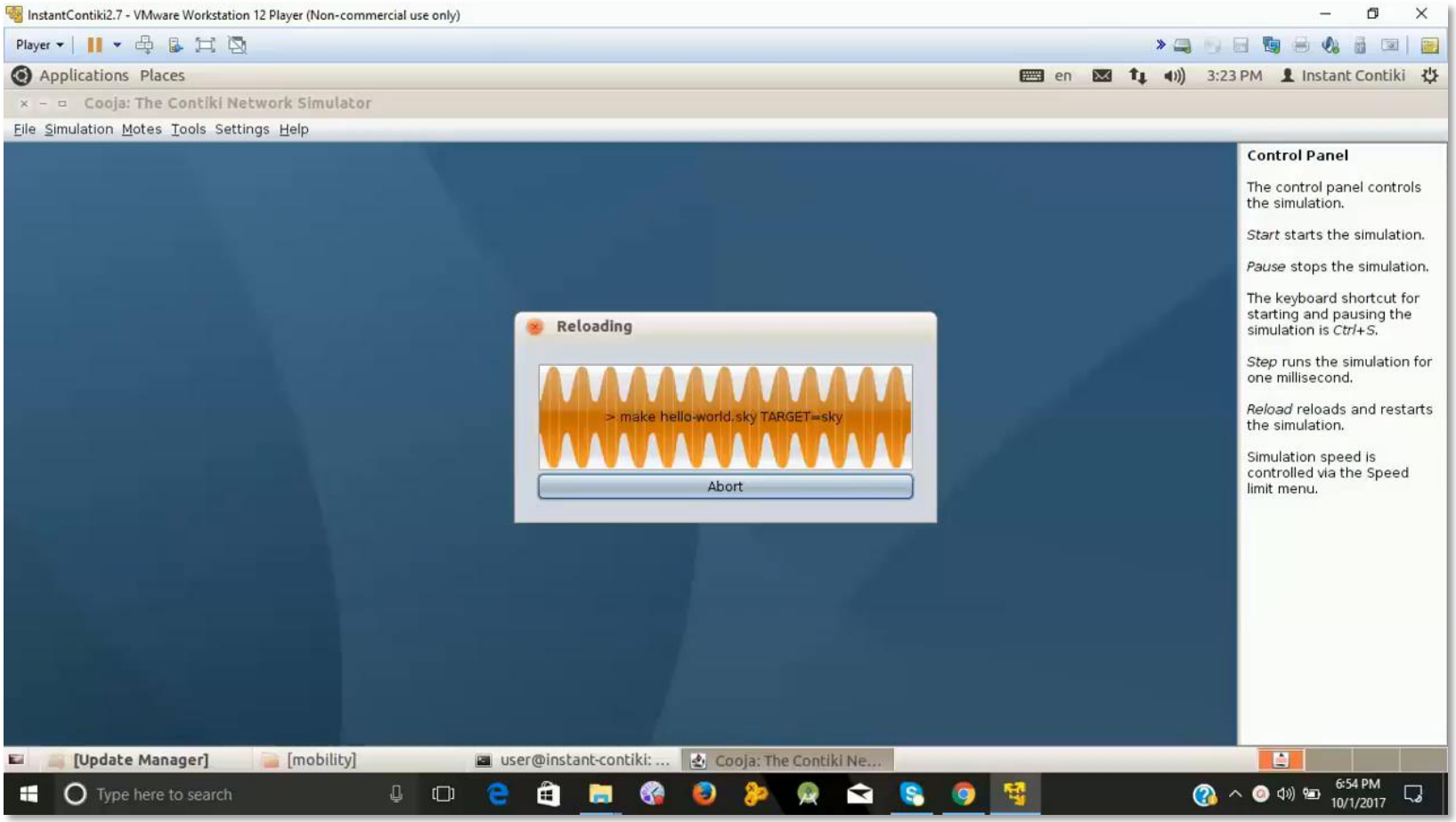


Task:

- Setup 6LBR
- Bring up the 6LoWPAN network
- Access Webserver of 6LBR
- Observe network parameters

*https://github.com/cetic/6lbr/wiki/COOJA-Interface*

# Mobility Simulation

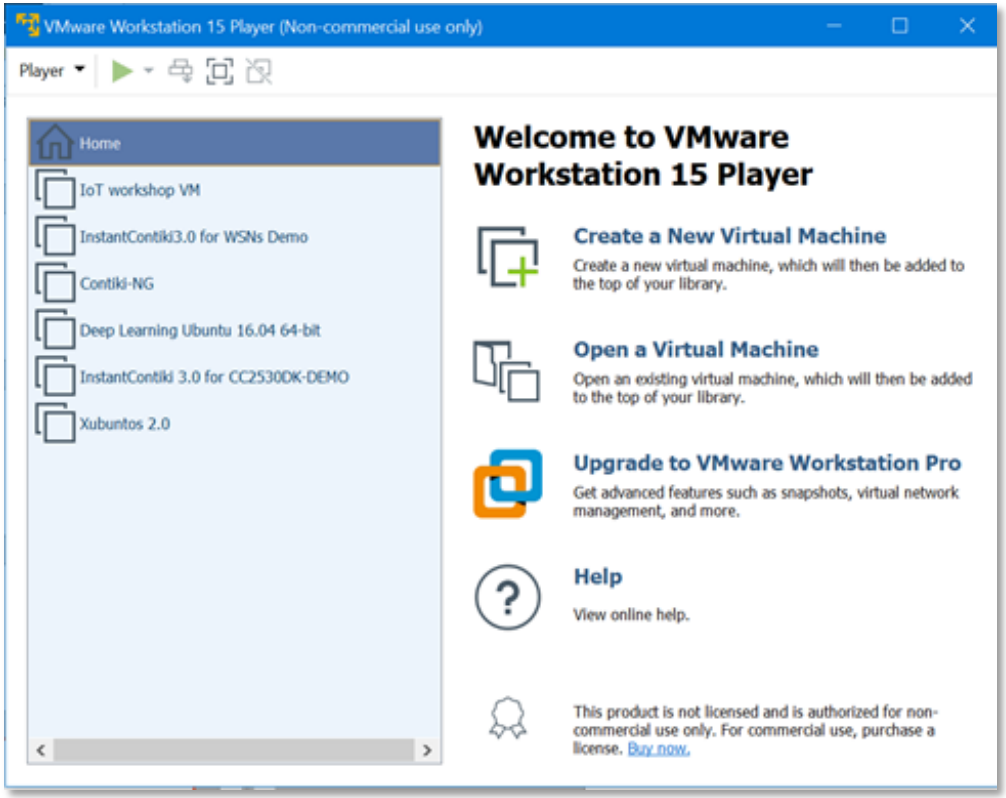


# Assignments

- Available hardware for assignment experiments:
  - CC2530, CC2538, CC2650, Sky-mote
  - LoRa modules
  - Raspberry and MCU Dev. kits
  - UART modules
  - Sensors and Actuators
  - PCs if necessary
- Location and Time:
  - **IoT & Machine Learning Lab** (**B3-114**):
  - From **8h30 – 11h30**; **13h30-16h30** on week days
- Writing a short report for each assignment, then combine all to 1 final assignment report and submit at the end of the course.
- Assignments' score will be used to give bonus to the final score

# Assignment 1: Hello world

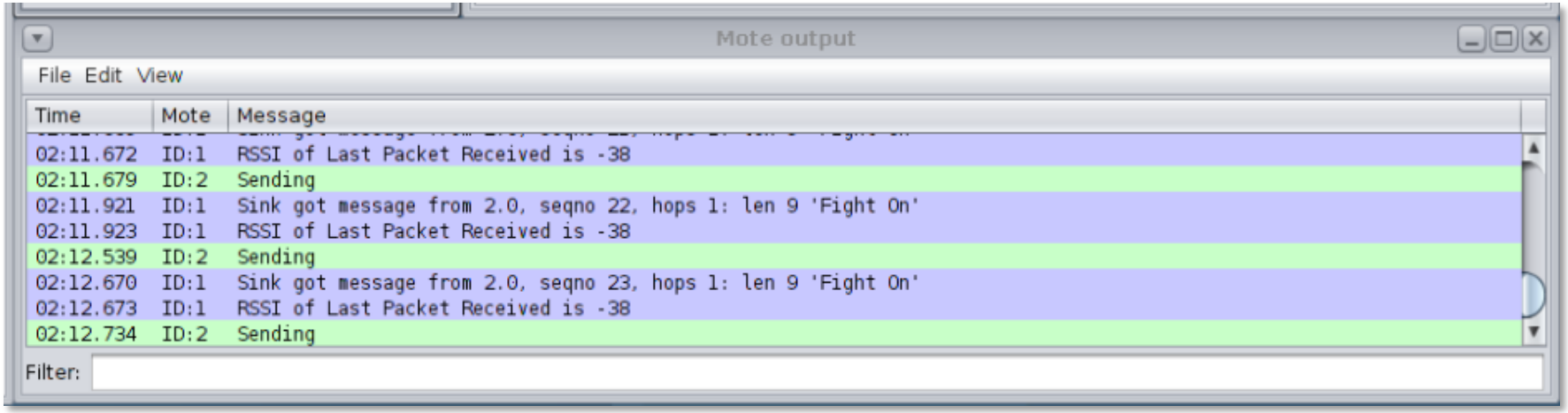
- Install Contiki-OS using Virtual Machine or manually in Ubuntu
- Compile the Hello-world example
- Modify the code so that the node will print out “Hello-world” with period of 3 seconds




https://anrg.usc.edu/contiki/index.php/Installation

# Assignment 2: Choose the BNN

- Using Broadcast example and RSSI reading
- Building an algorithm:
  - Store only 5 nodes with strongest RSSI
  - Choose the BNN in 5 strongest nodes
- Simulate a 15-node network and verify the result and change node's positions to see how the algorithm works

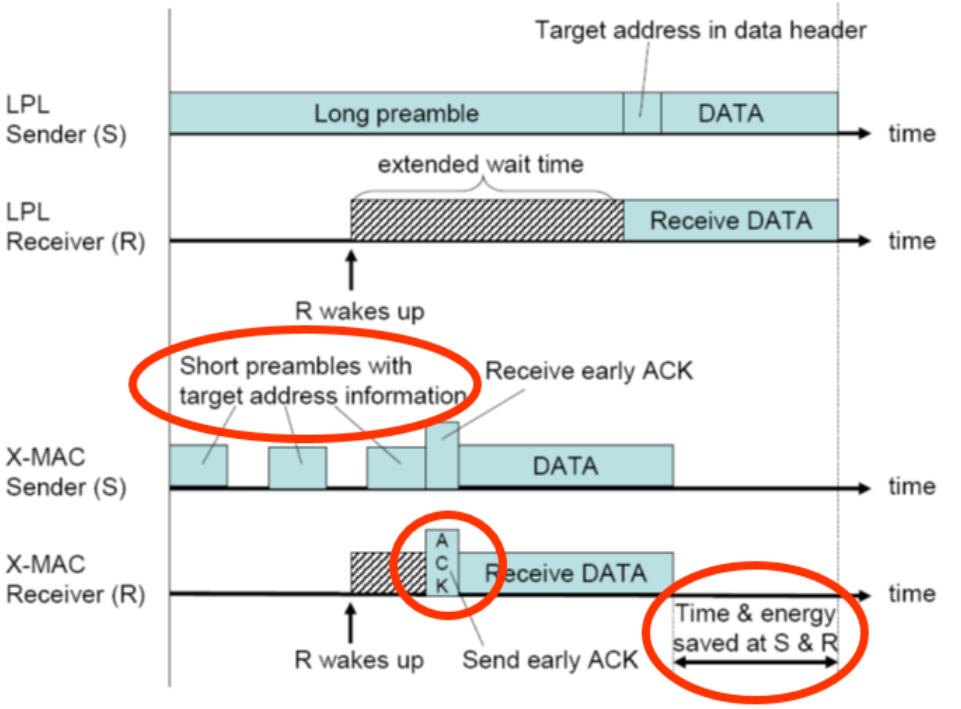



https://anrg.usc.edu/contiki/index.php/RSS_measurement

https://anrg.usc.edu/contiki/index.php/Broadcast_Example

# Assignment 3: MAC Protocols

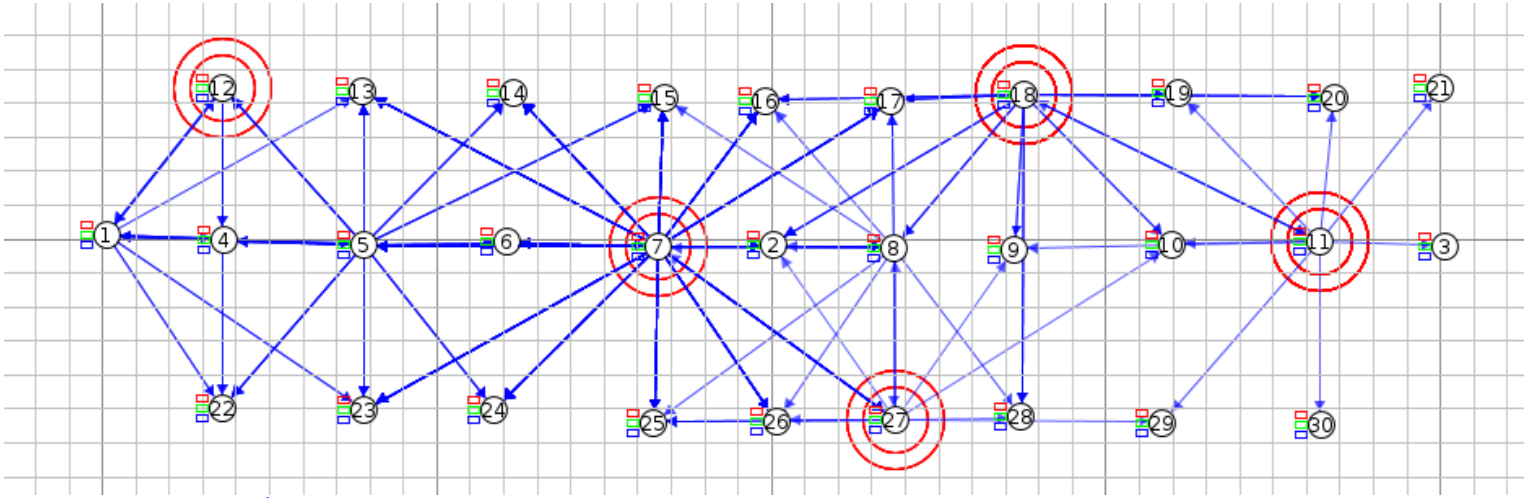
- Evaluation of X-MAC, B-MAC, Contiki-MAC, TSCH protocols
  - Measure RDC, PRR
  - Simulate scenarios in case of dense network, high traffic
  - Simulate scenarios in case of loose network, low traffic




https://anrg.usc.edu/contiki/index.php/MAC_protocols_in_ContikiOS

# Assignment 4: Lighting Networks

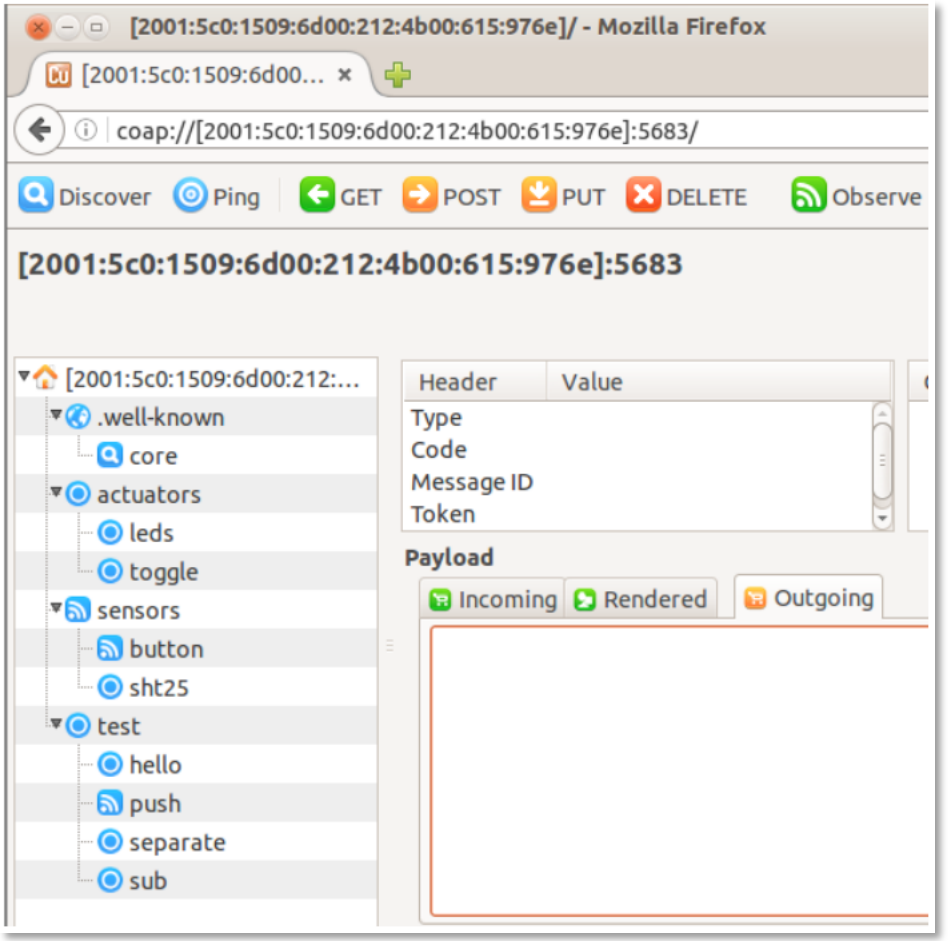
- Design and Implement a Lighting System using 6LoWPAN
  - Consists of 10 nodes with 1 Border router in Cooja simulator
  - Can ping each node to measure the RTT and Packet loss
  - Can use *netcat* command to control a server node
  - Advances:
    - Using *netcat* to control ON/OFF a LED of a specific node
    - Performing an experiment with 2 CC2538 nodes




https://senstools.gforge.inria.fr/doku.php?id=contiki:examples

# Assignment 5: CoAP

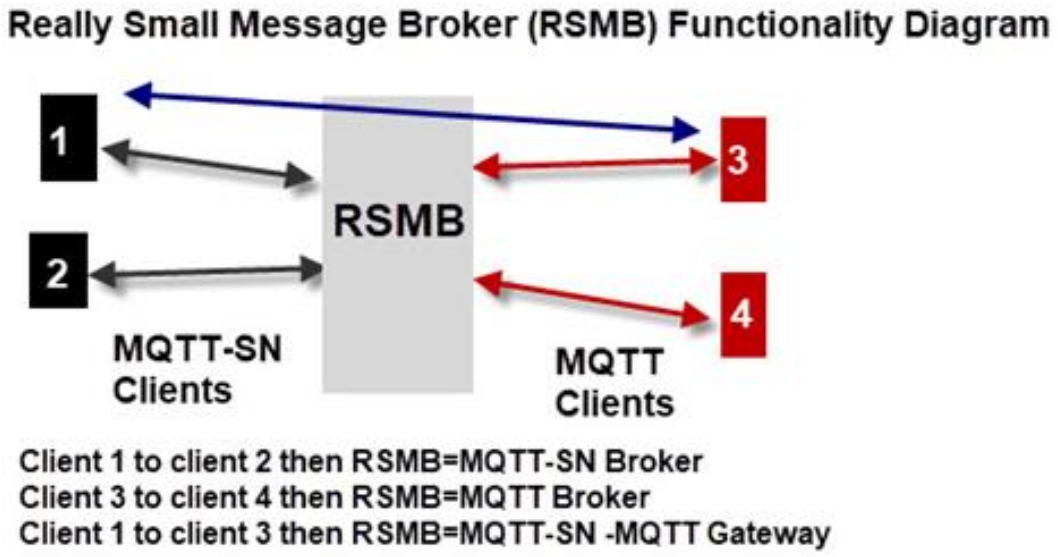
- Design and Implement a 6LoWPAN Networks
  - Consists of 5 nodes with 1 Border router
  - All server nodes use CoAP
  - Can use CU plugin (for Firefox browser) to control a LED ON/OFF of a CoAP node in Cooja Simulator
  - Advances:
    - Implement the application so that can control all LED of a CoAP node.
    - Performing an experiment of 2 Sky nodes.




https://anrg.usc.edu/contiki/index.php/REST_example_running_on_Cooja_and_Sky_motes

# Assignment 6*: MQTT-SN

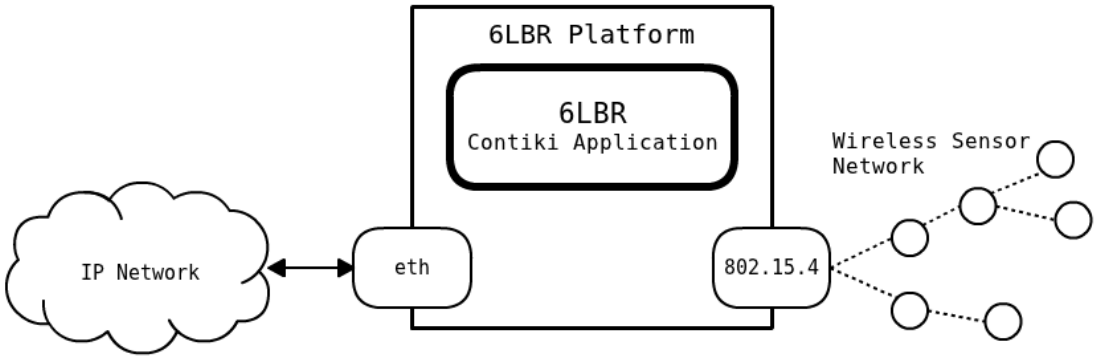
- Design and Implement a 6LoWPAN Networks
  - Consists of 2 nodes with 1 Border router
  - All nodes use MQTT-SN
  - Simulate the network in Cooja
  - Advances: Conducing an experiment using 2 CC2538DK/Sky.




https://github.com/aignacio/homestark_mqtt_6lowpan_port

# Assignment 7*: 6lbr on Embedded PC

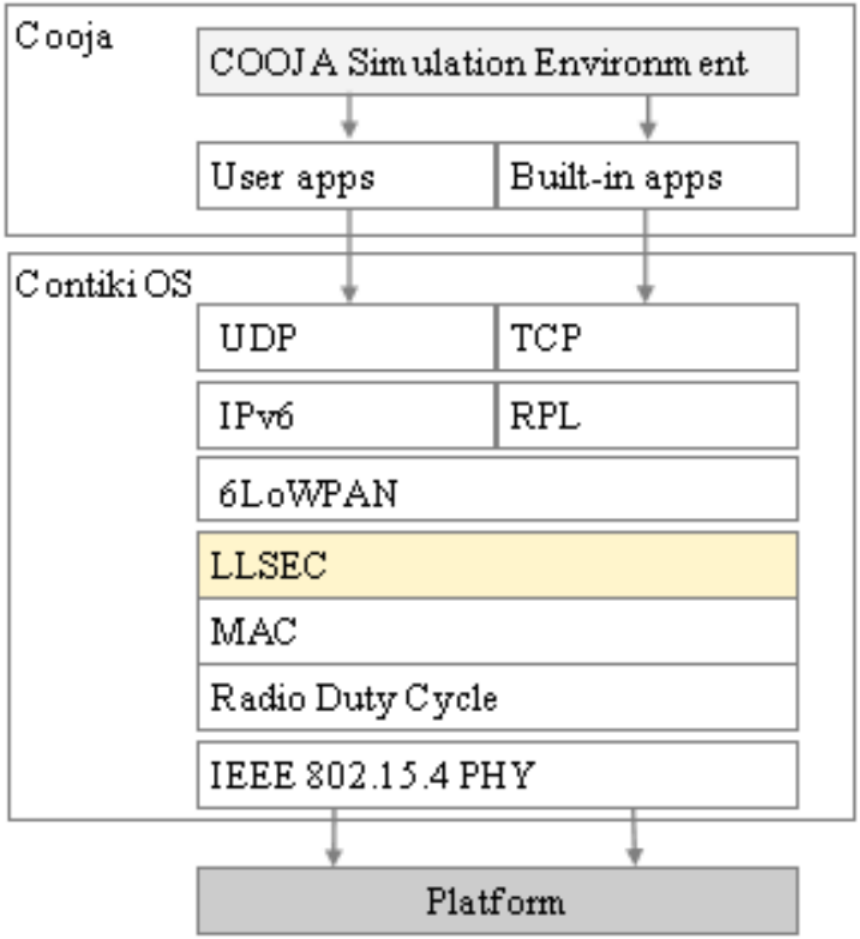
- Design and Implement 6lbr on Raspberry/VM
  - Install 6lbr on a Raspberry (BR-Raspberry)/VM
  - Simulate the 6LoWPAN network on Cooja with the installed 6lbr
  - Running the web interface and monitor the nodes
  - Advances:
    - Deploy a 6LoWPAN networks (2 CC2538DK kits) connecting to the BR-Raspberry/VM


https://github.com/cetic/6lbr/wiki

# Assignment 8**: Link Layer Security

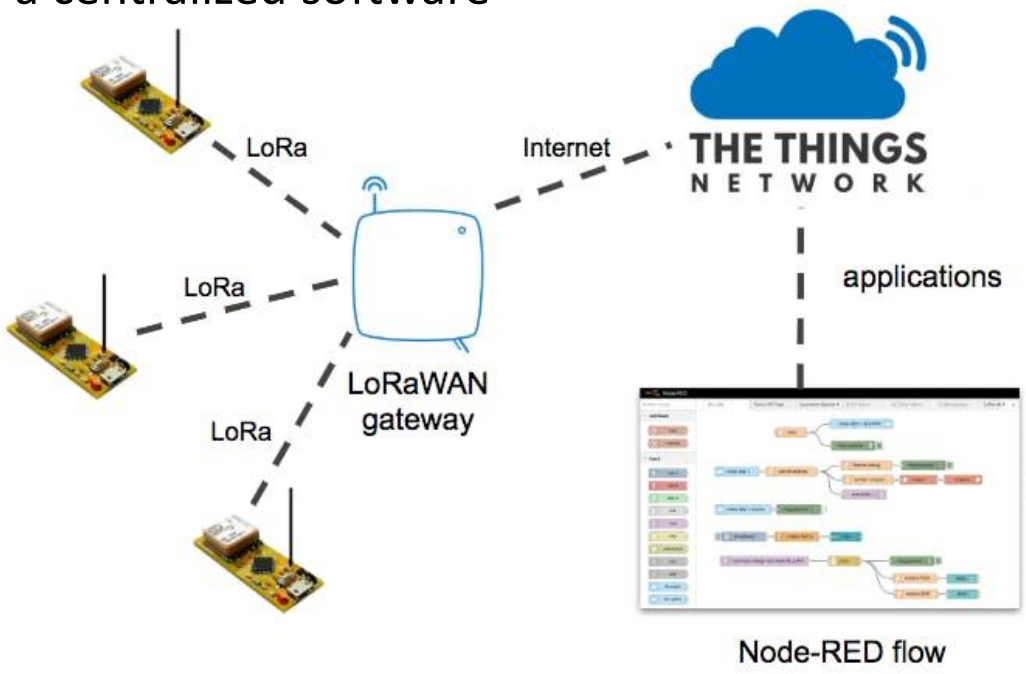
- Design and Implement a 6LoWPAN with levels of LLSEC
  - Simulate a network with 10 nodes: 1 BR, 8 nodes with LLSEC (secured nodes), and 1 node without LLSEC (unsecured node)
  - Verify the communication of unsecured node




*Security Considerations for IEEE 802.15.4 Networks: Naveen Sastry, David Wagner*

# Assignment 9**: LoRa Networking

- Design and Implement a LoRa network which can:
  - Measure the water quality: pH, EC, flow, turbidity, salty
  - Or measure the Power consumption of a house
  - Can report all readings periodically
  - Can control any node from a centralized software



# Assignment 10**: HMI

- Design and Implement a Human-Machine-Interface to control a 6LoWPAN network:
  - Using Alexa or Google Voice
  - Control an LED of a node using voice recognition
  - Using Cooja or HW platforms