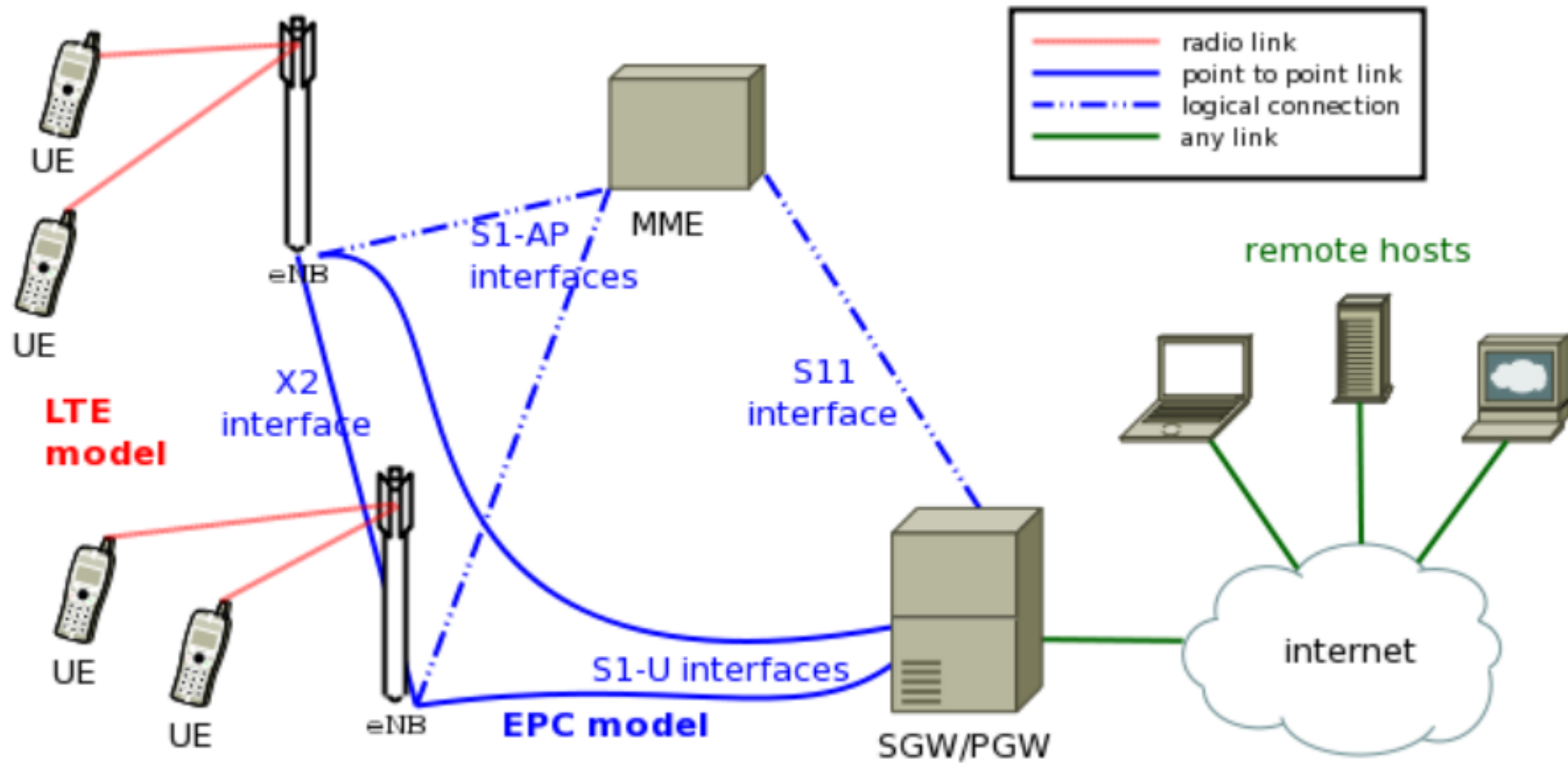


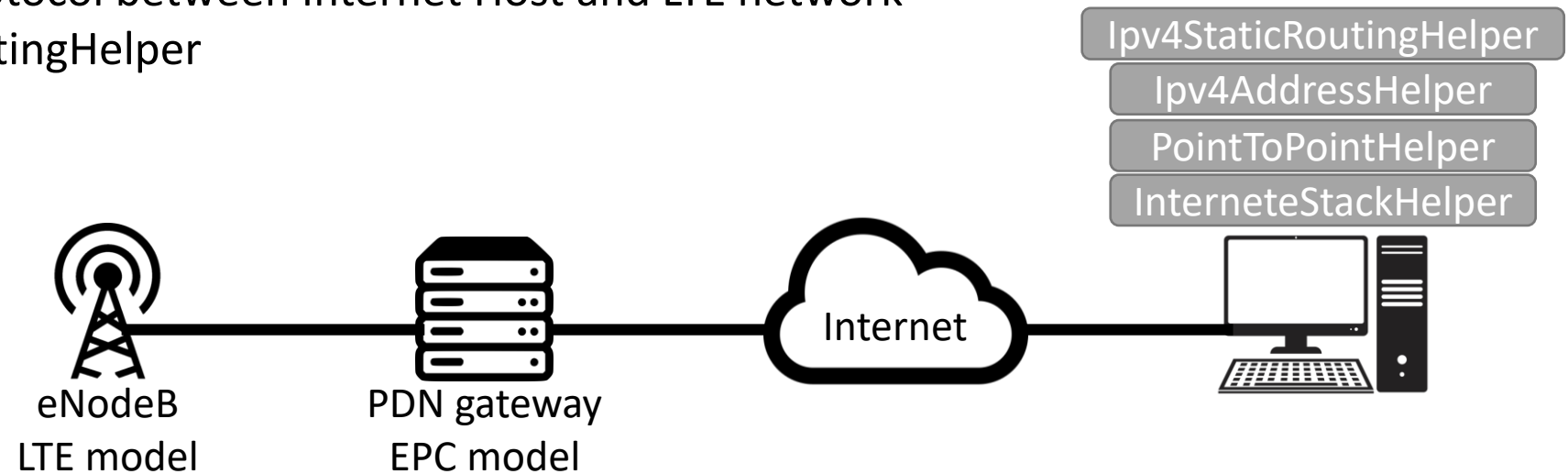
# ns-3 - LTE model



**Overview of the LTE-EPC simulation model**

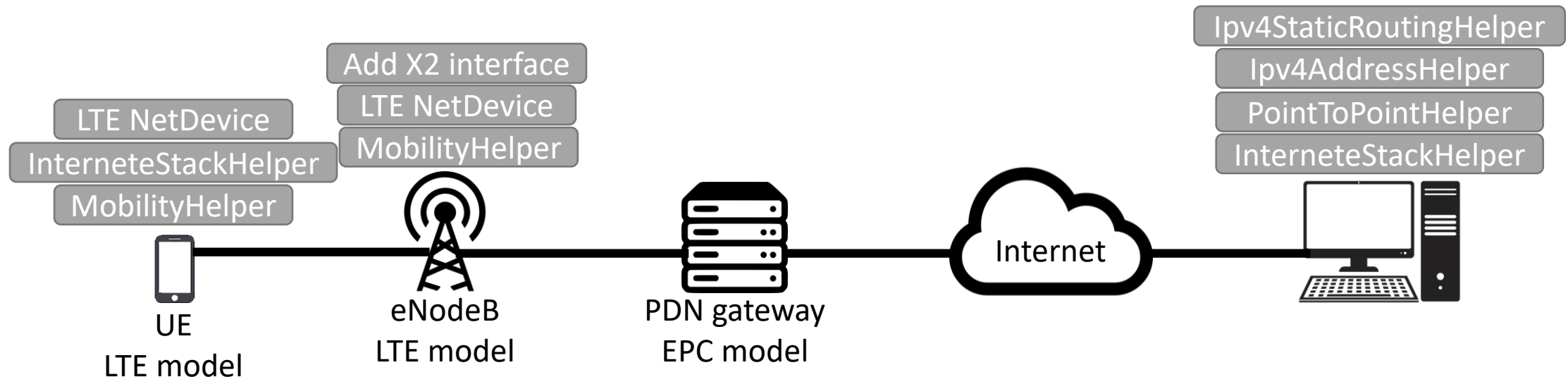
# ns-3 - LTE model

- Topology
  - Build a 4G-Core network
    - lteHelper
      - Set epcHelper, scheduler type, handover algorithm type, handover algorithm attribute
    - epcHelper
      - Connect to LTE
      - Create PDN gateway
  - Remote Host
    - InternetStackHelper, PointToPointHelper (PDN GW and Remote Host), Ipv4AddressHelper
  - Create Routing Protocol between Internet Host and LTE network
    - Ipv4StaticRoutingHelper



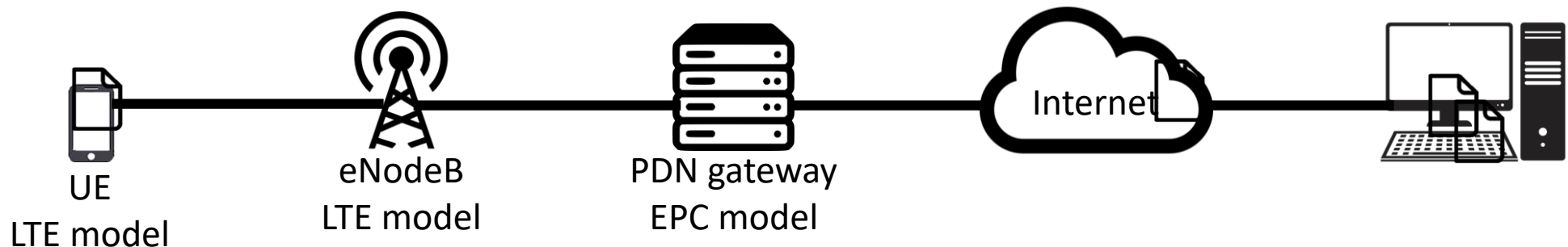
# ns-3 - LTE model

- Topology
  - Build a 4G-Core network
    - Create eNodeB nodes
      - MobilityHelper
    - Create UE nodes
      - MobilityHelper, InternetStackHelper
    - Install LTE device on eNodeB and UE
    - Attach UE nodes to eNodeB node
    - Use lteHelper to add X2 interface between eNodeB



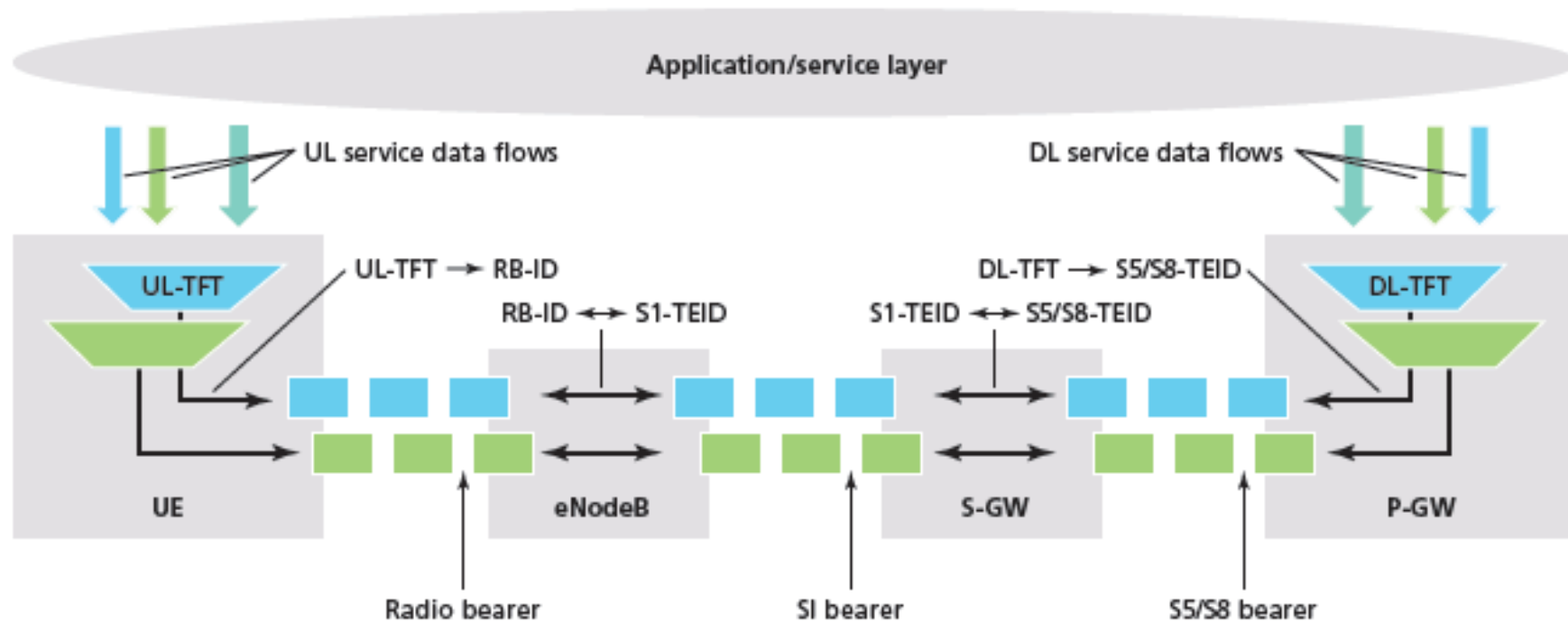
# ns-3 - LTE model

- Application
  - Set the default gateway for each UE (Routing protocol)
  - Install UDP Down Link application
    - UdpClientHelper (from Remote Host to UE) -> clientApps
    - PacketSinkHelper (UE sink the packet) -> ServerApps
  - Install UDP Up Link application
    - UdpClientHelper (from UE to Remote Host) -> clientApps
    - PacketSinkHelper (Remote Host sink the packet) -> ServerApps



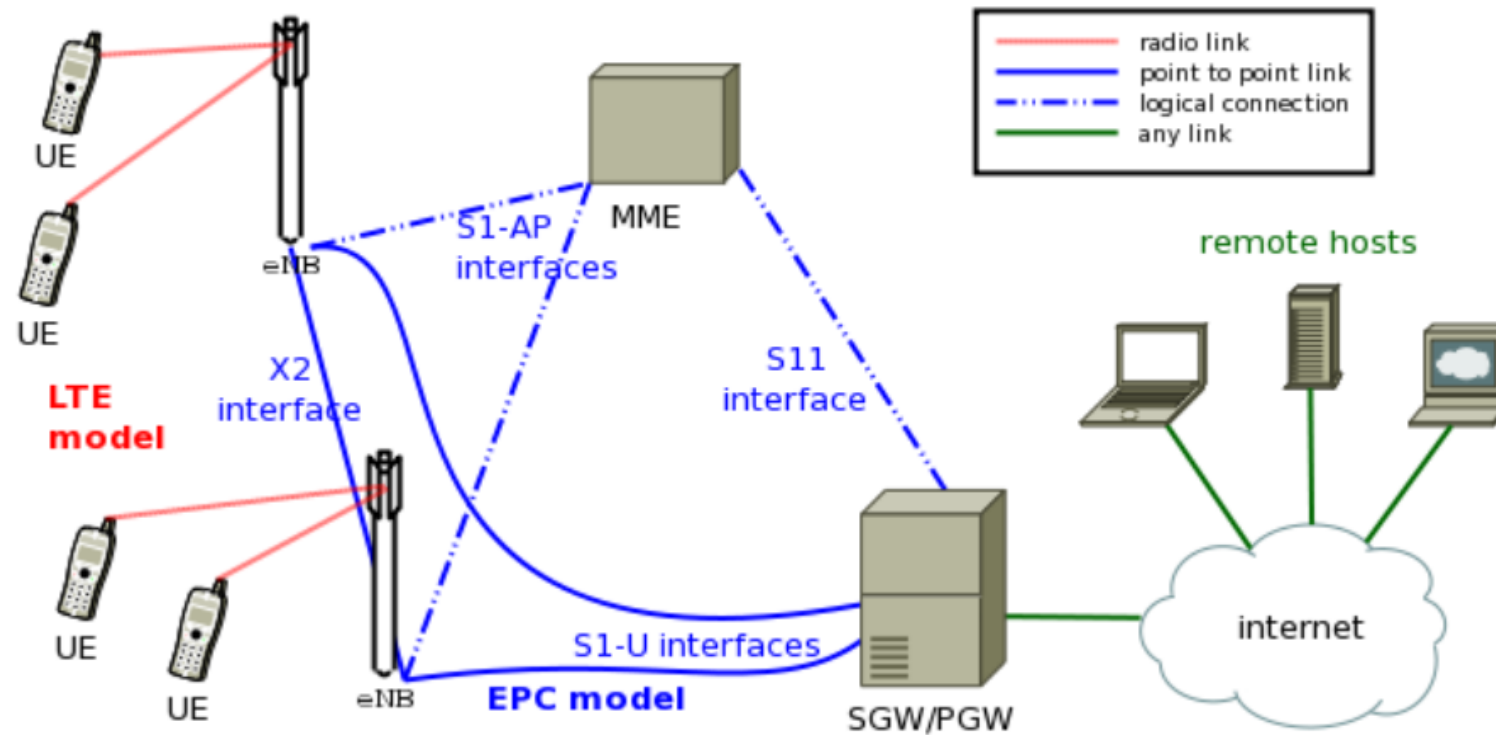
# ns-3 - LTE model

- Application
  - Create a dedicated TFT(traffic flow template) of EPS bearer to PDN GW
    - Set packet filter to corresponding DLport and Ulport, then add to TFT
    - Build a connection between TFT and EPS bearer



# Mini Project 2 - Goal

- Simulate the LTE environment
- Realize the handover procedure
- Learn how to use scheduling function in ns-3



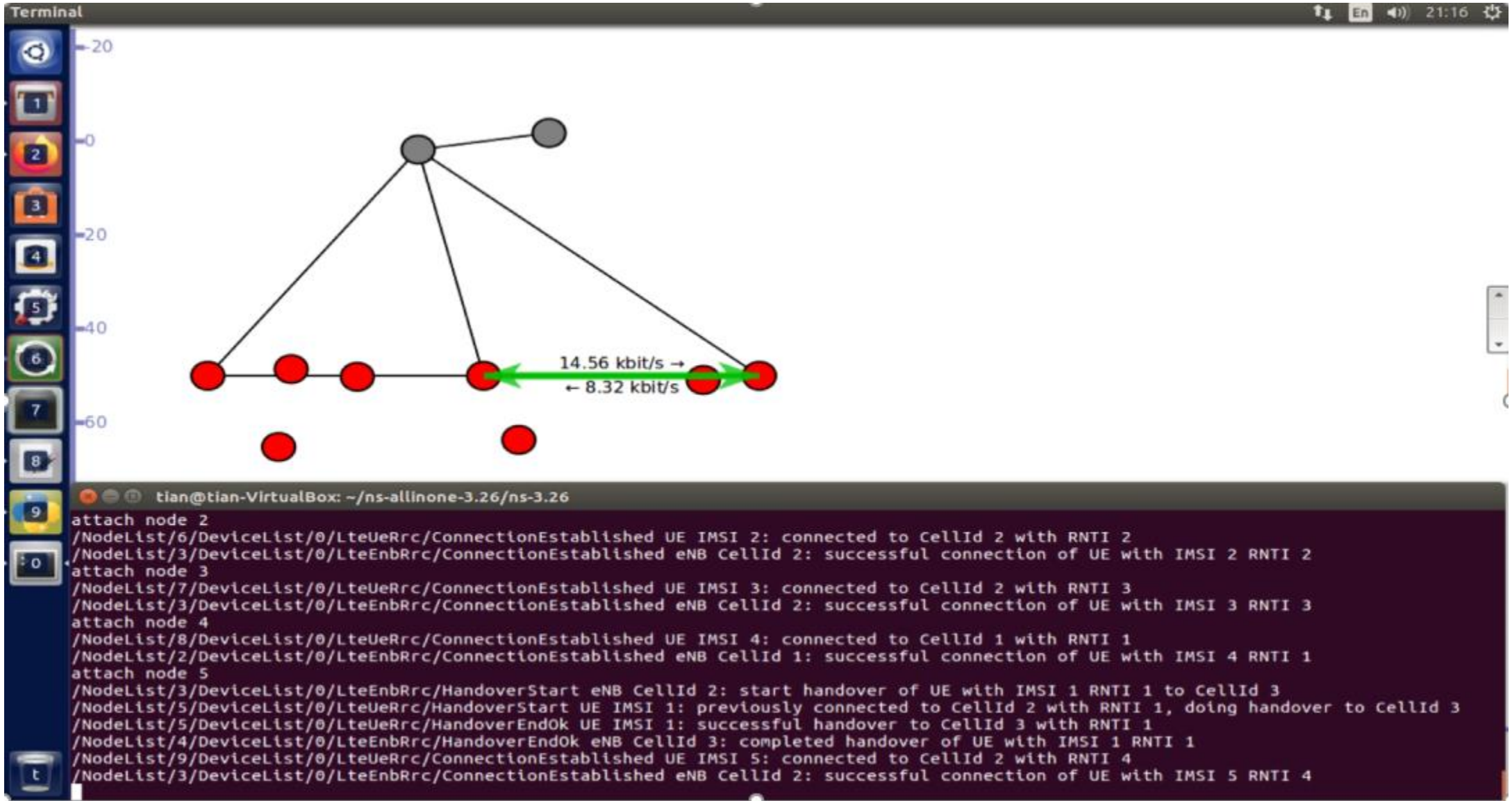
Overview of the LTE-EPC simulation model

# TO-DO

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- Reference code “lena-x2-handover-measures.cc” (ns-3.26/src/lte/examples/)
  - Create five UE and three eNodeB in LTE network
  - Each UE should be scheduled to attach to eNodeB in every second ([Event and Schedule](#))
    - Ex: At the beginning, there is a UE nodes attach to the LTE network. A new UE will be added into LTE network in every second until there are 5 UE nodes in LTE network
  - Every UE node can walk randomly and aim to trigger handover
- Command line arguments (enbTxPowerDbm, simTime, ue, enb)
- Present simulation by visualizer (./waf --run scratch/hw2 --visualize)
- Trace (.txt, .pcap file, AnimNet, Log file)

# Demo





# Demo

```
attach node 1
/NodeList/5/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 1: connected to CellId 2 with RNTI 1
/NodeList/3/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 2: successful connection of UE with IMSI 1 RNTI 1
attach node 2
/NodeList/6/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 2: connected to CellId 2 with RNTI 2
/NodeList/3/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 2: successful connection of UE with IMSI 2 RNTI 2
attach node 3
/NodeList/7/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 3: connected to CellId 2 with RNTI 3
/NodeList/3/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 2: successful connection of UE with IMSI 3 RNTI 3
attach node 4
/NodeList/8/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 4: connected to CellId 1 with RNTI 1
/NodeList/2/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 1: successful connection of UE with IMSI 4 RNTI 1
attach node 5
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 2: start handover of UE with IMSI 1 RNTI 1 to CellId 3
/NodeList/5/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 1: previously connected to CellId 2 with RNTI 1, doing handover to CellId 3
/NodeList/5/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 1: successful handover to CellId 3 with RNTI 1
/NodeList/4/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 3: completed handover of UE with IMSI 1 RNTI 1
/NodeList/9/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 5: connected to CellId 2 with RNTI 4
/NodeList/3/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 2: successful connection of UE with IMSI 5 RNTI 4
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 2: start handover of UE with IMSI 3 RNTI 3 to CellId 1
/NodeList/7/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 3: previously connected to CellId 2 with RNTI 3, doing handover to CellId 1
/NodeList/7/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 3: successful handover to CellId 1 with RNTI 2
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 1: completed handover of UE with IMSI 3 RNTI 2
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 1: start handover of UE with IMSI 4 RNTI 1 to CellId 2
/NodeList/8/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 4: previously connected to CellId 1 with RNTI 1, doing handover to CellId 2
/NodeList/8/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 4: successful handover to CellId 2 with RNTI 5
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 2: completed handover of UE with IMSI 4 RNTI 5
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 2: start handover of UE with IMSI 4 RNTI 5 to CellId 1
/NodeList/8/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 4: previously connected to CellId 2 with RNTI 5, doing handover to CellId 1
/NodeList/8/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 4: successful handover to CellId 1 with RNTI 3
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 1: completed handover of UE with IMSI 4 RNTI 3
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 1: start handover of UE with IMSI 3 RNTI 2 to CellId 2
/NodeList/7/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 3: previously connected to CellId 1 with RNTI 2, doing handover to CellId 2
/NodeList/7/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 3: successful handover to CellId 2 with RNTI 6
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 2: completed handover of UE with IMSI 3 RNTI 6
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 2: start handover of UE with IMSI 3 RNTI 6 to CellId 1
/NodeList/7/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 3: previously connected to CellId 2 with RNTI 6, doing handover to CellId 1
/NodeList/7/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 3: successful handover to CellId 1 with RNTI 4
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 1: completed handover of UE with IMSI 3 RNTI 4
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 2: start handover of UE with IMSI 5 RNTI 4 to CellId 1
/NodeList/9/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 5: previously connected to CellId 2 with RNTI 4, doing handover to CellId 1
/NodeList/9/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 5: successful handover to CellId 1 with RNTI 5
```

# Grading Policy

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- Finish Mini Project 2 (50%)
  - Topology (Mobility) (15%)
  - Schedule function (Event and Scheduler) (20%)
  - Command line arguments (5%)
  - Animation - Visualizer (5%)
  - Explain your main ideas by commenting out the code (5%)

Ex: `./waf --run "scratch/<student_id>_project2 --enbTxPowerDbm=30 --simTime=10 --ue=5 --enb=3" --visualize`

- Report (50%)
  - What you do (10%)
  - Observe the trace file (.txt, .pcap file, animation, Log file) (20%)
  - Results (10%)
  - What you learn (10%)



# Submission

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Please upload your miniproject1 to eLearn.

**Deadline: 2020-11-12(Thu.) 23:59**

- Program
  - Your source file must be named as “<Student\_ID>\_project2.cc”.
- Report
  - The report filename must be “<Student\_ID>\_project2.pdf”.

Note: “Plagiarism Avoidance”

- Discussion is encouraged. However, plagiarism is not allowed. We will use, e.g., “Moss” for similarity comparison and 0 points will be given if plagiarism.