FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

department of telecommunications

MPA-KPM Project

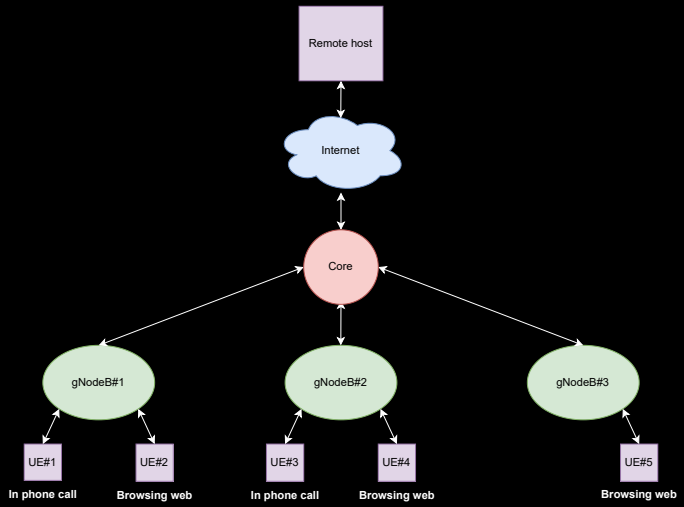
5G NR Simulation in NS-3
Assignment 11

MATĚJ BARANYK, JAKUB LEPÍK, SLÁVEK RYLICH, MARTIN DOLÁK

5G NR Simulation in NS-3 – Assignment 11

- **Objective**: Simulate a 5G NR network using the 5G-LENA module in NS-3 to explore network performance.
- **Network Scenario**:
  - 5 UEs: 2 on phone calls (different gNodeBs), 3 browsing the web (connected to a remote server).
  - 3 gNodeBs: 2 connected to 2 UEs, 1 connected to 1 UE.
  - Stationary mobility with GridScenarioHelper.

5G NR Simulation in NS-3 – Assignment 11



Settings & Configuration

- **Adjustable Parameters**:
  - command-line arguments for flexible setup.
- **NR Setup**:
  - mmWave frequency (24-100 GHz),
  - two BWPs: 28 GHz (50 MHz) and 28.2 GHz.
  - Total transmission power: 35 dBm.
- **Traffic Types**:
  - voice call,
  - web browsing,
  - adjustable traffic and packet sizes.
- **Network Setup**: Static IP addresses, routing configured for communication between UEs, SGW/PGW, and a remote host.

Traffic Generation

- **Objective**: Simulate voice calls and web browsing traffic to observe network performance under different conditions.
- **Voice Call**: Managed by dedicated bearer:
  - `NrEpsBearer::GBR_CONV_VOICE`.
- **Web Browsing**: Managed by dedicated bearer:
  - `NrEpsBearer::NGBR_LOW_LAT_EMBB`.
- **Traffic Flow Templates (TFTs)**: Filtering based on port numbers for both types of traffic.
- **UDP Clients & Servers**:
  - Configured for between UEs and the remote host.

Network Simulation Results Analysis

- **Objective**: Measure network metrics:
  - throughput,
  - packet loss,
  - delay.
- **Done using `FlowMonitor`**:
  - logging,
  - outputting to CLI.
- **Adjusted parameters**:
  - `udpPacketSizeVoiceCall = 50`,
  - `totalTxPower = 35 or 25`.
- **More comprehensive logs**:
  - Logs for all components of the simulation are provided in project repository.

Network Simulation Results Analysis

- **Focus on one flow**: Call traffic between two nodes on different eNodeBs.

Sim 1 (Low Traffic – 35 dBm)
Tx Packets: 9000
Tx Bytes: 702000
Tx Offered: 6.24 Mbps
Rx Bytes: 700284
Packet Loss: 0.24%
Throughput: 6.22 Mbps
Mean Delay: 1.88 ms
Mean Jitter: 0.16 ms
Lost Packets: 22
Rx Packets: 8978

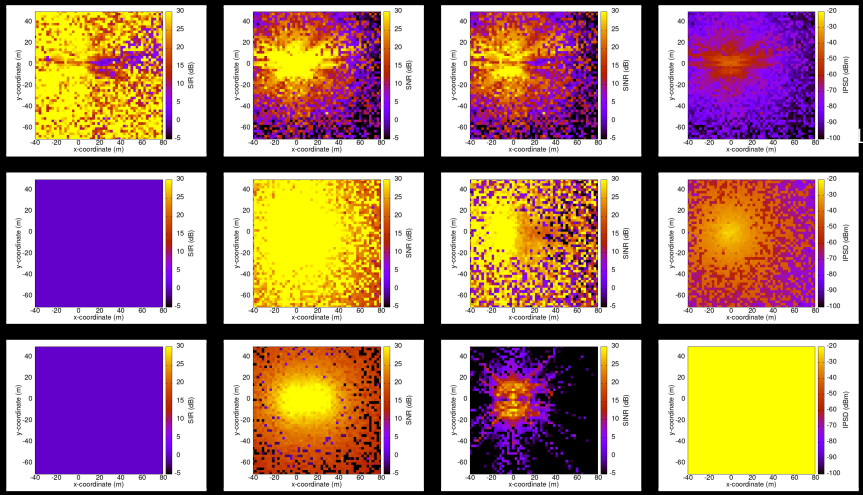
Sim 2 (High Traffic – 35 dBm)
Tx Packets: 90000
Tx Bytes: 47520000
Tx Offered: 422.4 Mbps
Rx Bytes: 5794800
Packet Loss: 87.8%
Throughput: 51.5 Mbps
Mean Delay: 396.5 ms
Mean Jitter: 0.09 ms
Lost Packets: 79025
Rx Packets: 10975

Sim 3 (High Traffic – 25 dBm)
Tx Packets: 90000
Tx Bytes: 47520000
Tx Offered: 422.4 Mbps
Rx Bytes: 5794800
Packet Loss: 87.8%
Throughput: 51.5 Mbps
Mean Delay: 396.5 ms
Mean Jitter: 0.09 ms
Lost Packets: 79025
Rx Packets: 10975

Radio Environment Map (REM) Analysis

- **Objective**: Generate REMs to visualize 5G signal propagation, coverage, and interference.
- **REM Modes**:
  - Beam Shape: Visualizes beam configurations.
  - Coverage Area: Worst-case SINR and best-case SNR.
  - UE Coverage: Uplink with downlink interference in TDD.
- **Figures**: 12 plots for DL and UL.
  - Organized in 3 modes: Beam Shape (top), Coverage Area (middle), UE Coverage (bottom).
  - Metrics: SIR, SNR, SINR, IPSD.

Radio Environment Map (REM) Analysis



[1]For **DL**, Organized in 3 modes: Beam Shape (top), Coverage Area (middle), UE Coverage (bottom), Metrics: SIR, SNR, SINR, IPSD.

Final Words

- **Simulation Setup**:
  - 5G NR network with 2 UEs on voice calls, 3 UEs browsing the web.
  - Adequate for analysis but doesn't reflect real-world complexity (more UEs, dynamic mobility, etc.).
- **Simplified Models**:
  - Static mobility, idealized propagation, interference, and traffic.
  - No consideration for obstacles, weather, device variability, or hardware limitations.
- **Challenges**:
  - Debugging difficulties due to lack of line-by-line debugging tools in ns-3.
- **Future Work**:
  - Incorporate real-world factors for more accurate simulations.

Thank you!