



FACULTY OF ELECTRICAL department
ENGINEERING of telecommunications
AND COMMUNICATION

MPA-KPM Project

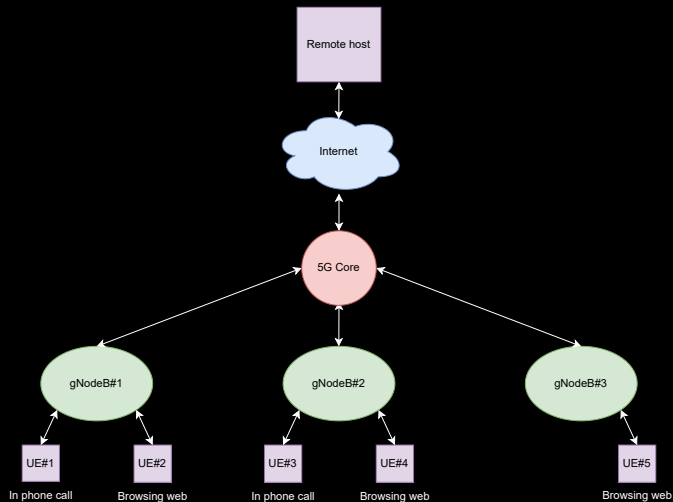
5G NR Simulation in NS-3

Assignment 11

MATĚJ BARANYK, JAKUB LEPIK, SLÁVEK RYLICH, MARTIN DOLÁK

- **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



- **Adjustable Parameters:** Command-line arguments for flexible setup (e.g., REM direction, UDP packet sizes, traffic rates).
- **NR Setup:**
 - mmWave frequency (24-100 GHz), two BWPs: 28 GHz (50 MHz) and 28.2 GHz.
 - Transmission power: 35 dBm.
- **Traffic Types:** Voice call and web browsing, with adjustable parameters for traffic and packet sizes.
- **Network Setup:** Static IP addresses, routing configured for communication between UEs, SGW/PGW, and a remote host.

- **Traffic Types:**
 - **Voice Call:** Managed by UDP with dedicated bearer
`NrEpsBearer::GBR_CONV_VOICE`.
 - **Web Browsing:** Managed by UDP with dedicated bearer
`NrEpsBearer::NGBR_LOW_LAT_EMBB`.
- **Traffic Flow Templates (TFTs):** Different TFTs for web browsing and voice call to ensure proper QoS.
- **UDP Clients:** Configured for interaction with the remote host, with traffic starting and stopping at designated times.
- **Simulation Goal:** Simulate voice calls and web browsing traffic to observe network performance under different conditions.

- Used FlowMonitor for network metrics: throughput, packet loss, delay.
- Focus on a single flow: voice call between two eNodeBs.
- **Changes made:**
 - Transmission power: 35 dBm (Listing 1) vs 25 dBm (Listings 2 & 3).
 - Traffic levels: low (Listing 1) vs high (Listings 2 & 3, 422.4 Mbps).
 - Traffic Flow Templates: voice call (GBR) and web browsing (NGBR).
- **Results:**
 - Listing 1: 6.22 Mbps, 0.24% loss, 1.88 ms delay (low traffic).
 - Listings 2 & 3: 51.5 Mbps, 87.8% loss, 396.5 ms delay (high traffic).
- Detailed logs available for all flows.

Listing 1 (Low Traffic - 35 dBm)

Tx Packets: 9000
Tx Bytes: 702000
Throughput: 6.22 Mbps
Packet Loss: 0.24%
Mean Delay: 1.88 ms
Mean Jitter: 0.16 ms
Rx Packets: 8978

Listing 2 (High Traffic - 35 dBm)

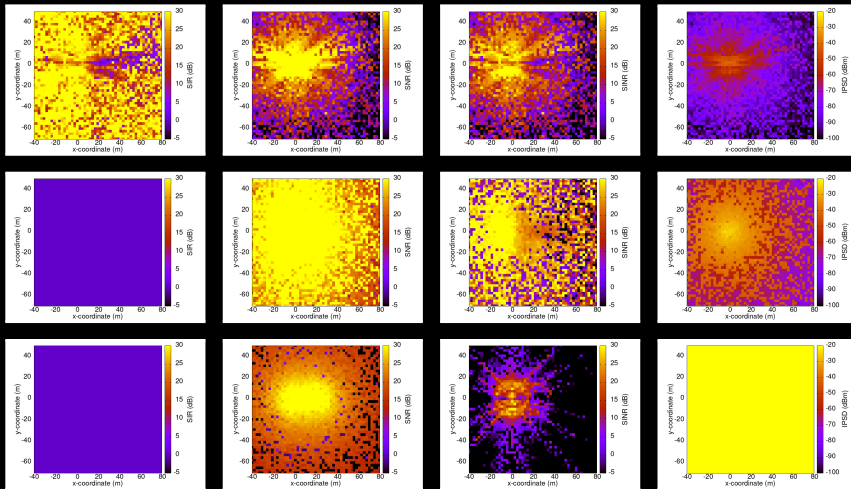
Tx Packets: 90000
Tx Bytes: 47520000
Tx Offered: 422.4 Mbps
Rx Bytes: 5794800
Packet Loss: 87.8%
Throughput: 51.5 Mbps
Mean Delay: 396.5 ms
Mean Jitter: 0.09 ms
Rx Packets: 10975

Listing 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
Rx Packets: 10975

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

Radio Environment Map (REM) Analysis



¹12 plots showing metrics (SIR, SNR, SINR, IPSD) for DL in Beam Shape, Coverage Area, and UE Coverage.

■ **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.

Děkuji za pozornost!