Iowa State University

Lab 01: 4G LTE Network Emulation and Throughput Testing Utilizing ARA

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1. **Lease details screenshots**
   1. **eNBLease:**

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* 1. **UELease:**

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1. **Container overview screenshots**
   1. **eNBContainer:**

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* 1. **UEContainer:**

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**How do the specifications (e.g., CPU, memory) of the eNB and UE containers influence network performance? What security considerations should be kept in mind when configuring these resources?**

The CPU and memory allocation of the containers directly impact network performance by influencing processing speed, packet handling efficiency, and overall system stability. A higher CPU core count allows for better parallel processing, reducing latency and improved throughput. Similarly, increased memory helps prevent bottlenecks caused by limited buffer space, especially during high-traffic scenarios. If resources are insufficient, the network may experience delays, packet loss, or even connection failures.

From a security perspective, proper resource configuration is essential to prevent vulnerabilities such as denial-of-service (DoS) attacks. Over-provisioning can create inefficiencies and make the system an easier target for attackers, while under-provisioning may leave the network susceptible to performance degradation under high loads. Additionally, ensuring secure SSH access and monitoring for abnormal activity can help mitigate risks associated with unauthorized access or malicious interference.

1. **Screenshot of ping 172.16.0.1 results**

A screen shot of a computer program

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**Why is it crucial to start the EPC before the eNB? How does the interaction between these components affect the overall network functionality?**

The EPC must be started before the eNB because it acts as the central control unit for the 4G LTE network, handling critical functions like user authentication, session management, and IP address allocation. Without the EPC running, the eNB would have no core network to connect to, preventing it from establishing connections with any User Equipment. When the EPC is active first, it ensures that the eNB can properly interface with the core network.

As the eNB serves as the access point for UEs, relaying data between mobile devices and the core network. The EPC manages essential tasks such as mobility, Quality of Service (QoS) enforcement, and data routing, ensuring efficient communication. If the eNB starts before the EPC, devices attempting to connect will fail to authenticate or establish sessions, leading to failed network access. This dependency highlights the importance of a structured startup sequence in maintaining a functional and stable LTE network.

1. **Console trace screenshots**
   1. **eNBContainer:**

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* 1. **UEContainer:**

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**Analyze and discuss what you see in the console trace for the 2 containers.**

On the eNB side of the trace, the Signal-to-Noise Ratio (SNR) of ~19.7 indicates a relatively strong signal, while the Modulation and Coding Scheme (MCS) of 19 suggests a moderate-to-high data rate is being used. The Bitrate (brate) of 17M confirms the network is operating at a decent throughput. Additionally, the Physical Hybrid ARQ Indicator Channel (PHR) of 40 implies the UE is reporting good transmission power, and the Buffer Status Report (BSR) of 133k indicates the UE has data ready to be sent, suggesting active data flow. The 0k=1000 suggests a high number of successfully transmitted packets.

On the UE side, the Reference Signal Received Power (RSRP) of -80 dBm indicates a strong signal reception. The Path Loss (PL) of 80 and Carrier Frequency Offset (CFO) of 3.1k suggest some frequency drift, which could impact performance. The SNR of 16 is slightly lower than the eNB’s perspective, which is expected due to channel conditions. The Timing Advance (ta\_us) of 0.52 means the UE is adjusting its timing to compensate for propagation delay. The MCS of 19 and buffer of 385k align with the eNB readings, confirming consistent data handling. Overall, the brate of 17M on both containers indicates stable network performance, with minimal interference or congestion affecting throughput.

1. **Define the options used by the UEContainer iperf command provided in the lab manual. The** [**iperf man page**](https://linux.die.net/man/1/iperf) **can be used.**

**iperf -c 172.16.0.1 -u -i 1 -b 25M -t 10**

-**c 172.16.0.1** – client *<host>* – run in client mode, connecting to 172.16.0.1

**-u** – udp – use UDP rather than TCP

**-i 1** – interval *n* – pause (1) seconds between periodic bandwidth reports

**-b 25M** – bandwidth *n[KM]* – set target bandwidth to 25M bits/sec (default 1 Mbit/sec). This setting requires UDP (-u).

**-t 10** – time *n* – time in seconds to transmit for (default 10 secs)

1. **Define the brate metric given seen on the console trace.**

The **brate** metric seen in the console trace represents the **bitrate**, or data transmission rate, typically measured in **megabits per second (Mbps).** It indicates how much data is successfully being transferred per unit of time between the **UE** and the **eNB.** The observed **brate=17M** suggests a transmission rate of **17 Mbps**, influenced by factors such as **MCS = 19, SNR, buffer size,** and **available bandwidth.**

1. **Console trace screenshots with different -b value** 
   1. **New -b value:**

100M

* 1. **eNBContainer:**

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* 1. **UEContainer:**

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**How does adjusting the bandwidth allocation affect throughput and latency? Discuss the implications of this in real-world scenarios, such as managing network congestion and ensuring fair resource allocation among users. Analyze and discuss anything else that you see on the console trace worth mentioning.**

Adjusting bandwidth allocation impacts throughput and latency by controlling data rates, higher bandwidth improves throughput, while lower bandwidth increases queuing and latency. In real-world networks, QoS mechanisms help manage congestion by prioritizing critical applications like video calls. From the console trace, the eNB and UE report an SNR of ~19.7 and 16, an MCS of 19, and a bitrate of 17M, indicating stable performance. The UE’s RSRP of -80 dBm and TA of 0.52 µs suggest moderate signal strength and minor delay. These metrics highlight how dynamic bandwidth management optimizes network efficiency and ensures fair resource distribution.

1. **Discuss the effect distance has on throughput in a 4G network. Provide screenshots to back your discussion.**

In a 4G network, increasing the distance between the UE and eNB reduces throughput primarily due to signal degradation. The results show that at greater distances, RSRP dropped to -87 dBm, SNR decreased to 9, and the MCS mostly hovered around 14, indicating lower spectral efficiency. The bitrate also declined to ~11-12M, reflecting reduced data transmission capacity. Even when increasing the bandwidth allocation (b=100 vs. b=25), the throughput remained similar, suggesting that distance, rather than bandwidth, was the primary limiting factor. This demonstrates how real-world networks must balance range and to maintain quality service over long distances.

**Successful Ping:**

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**b-value 25:**

**eNBContainer:**

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**UEContainer:**

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**b-value: 100**

**eNBContainer:**

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**UEContainer**

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1. Empty lease page screenshot

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1. **Summary and Conclusions:**

From my experience this lab highlighted several important core concepts that we have discussed in lecture. Firstly, how important it is to start the EPC before the UE, since the core network needs to be up and running for everything else to function properly. It also showed how key metrics like SNR, MCS, and bitrate affect network performance, stronger signals lead to better data rates, while weaker ones slow things down. Bandwidth allocation played a big role too, with higher bandwidth boosting speeds but requiring smart management to keep the network stable.

For the first time in my experience, I got to see firsthand how distance had a clear impact, with lower SNR, reduced MCS, and slower throughput as the UE moved farther from the eNB. This reflects real-world challenges, where coverage issues in rural areas or interference in crowded spaces can lead to slower speeds. Managing congestion and fairly distributing bandwidth is crucial to keeping networks running smoothly for everyone.

Overall, this lab gave a solid look at how LTE networks handle signal quality, resource allocation, and real-world limitations. Future experiments could explore how multiple users affect performance or how newer 5G networks improve on these challenges.