DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Master Practical Course
Computer Network Simulation

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Assignment 3
Part 1 - Theoretical Questions

Group 2

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Question-1: What is the improvement of 5G (except higher bit-rates and more advanced radio) over previous mobile network technologies? Explain these improvements and their benefits briefly.

- Improved reliability: 5G networks are intended to be more dependable than 4G networks, with higher availability and a lower rate of dropped connections.
- Network slicing: 5G networks enable "network slicing," which allows different types of traffic to be handled by various virtual networks configured to fulfill specific demands. This means that distinct users or applications can be assigned to a specialized area of the network, ensuring that they get the resources they require.
- Increased capacity: 5G networks are designed to accommodate significantly more devices and traffic, resulting in faster data transfer and higher network efficiency.
- Lower latency: 5G networks offer substantially lower latency (the time it takes between sending a request and receiving a response) than 4G networks, making them more suited for real-time communication applications like gaming, remote surgery, and self-driving cars.

Ref : https://www.raconteur.net/technology/5g/4g-vs-5g-mobile-technology/

Question-2: What are the capabilities of the Simu5G framework (name at least 4) and what are its limitations (name at least 2)? Describe briefly.

Capabilities:

1. Dual stack of protocols: Allows dual connectivity with LTE and NR (5G).
2. Simu5G can also run in real-time emulation mode, making it possible to communicate with real devices.
3. Multi-access Edge Computing (MEC) support: It allows to test application offloading scenarios.
4. Device-to-Device Transmission support: It allows testing device-to-device communications under network control.

Limitations:

1. Only the user plane only is modeled, the control plane is not modeled.
2. No EPS bearer support.
3. Radio bearers are not implemented.

Ref : https://ieeexplore.ieee.org/document/9211504
Ref : https://github.com/Unipisa/Simu5G

Question-3: What is the reason for ping-pong handover? What is the counteraction developed to prevent it?

- Device mobility: If the device is moving quickly, handovers may occur more frequently as the device enters and exits different cells.
- Interference: Interference from other wireless devices or signals can degrade signal quality and increase the frequency of handovers.
- Poor handover algorithm quality: The algorithm used to govern the handover process may be malfunctioning, resulting in needless handovers.
- The preventative measure devised is known as "Hysteresis". Hysteresis is a handover technique that introduces a threshold for assessing the signal strength of a device's present base station as well as the signal strength of surrounding base stations. When a device's signal strength falls below a specific threshold, it is transferred to a nearby base station with a better signal. If the signal strength of the device rises again, it will not be returned to the prior base station until it falls below a second, higher threshold. This reduces unwanted handovers and the ping-pong effect. Other techniques, such as multi-criteria decision-making and enhanced measurement reporting, can also be utilized to improve the handover process by utilizing past data and predictions. Other strategies, such as historical data analysis and prediction, can also be used to improve the handover process.

Ref : https://ieeexplore.ieee.org/document/652300

Question-4: Imagine you are a network engineer working for TUM. You are tasked with the design of a campus-wide network that must support the needs of 50000 students at once. To verify the functionality of your network you decide to model it first with a simulation in OMNeT++. During development, you receive an additional requirement stating that your network should support connectivity over 5G since every student will be receiving a TUM-branded sim card.

Answer the following questions:

1. **What design considerations do you need to make to simultaneously support connectivity over 5G, as well as WiFi and Ethernet cable?**
2. **Do you see any challenges concerning the coexistence of these various deployments?**
3. **How would you solve the seamless migration of users between parts of your network using different technologies? E.g., a user switches from WiFi to a 5G connection.**
4. **What simplifications do you need to make in your simulations to simulate this new campus network?**
5. **What statistics would you consider most valuable to assess the network's performance?**

Justify each of your answers!

1. Tech stack should meet the requirements of 5G, WiFi, and wired connection at the same time. The network should support the handovers among these different types of connections not to cause disruptions. We should select the carrier frequencies of WiFi and 5G carefully. Since they are close to each other and can cause interference which would decrease the quality of the service significantly. Since 5G supports Multi-Access Edge Computing (MEC), it can be used to distribute campus-related services like TUMOnline to the edge servers.
2. If we do not handle the handover among these different types of connections, there would be disruptions during switching between connections and it would decrease the user experience. In addition, we would be careful with the carrier frequencies of WiFi and 5G since they can interfere.
3. First of all, the end device should support this. For example, mobile phone hardware should have support for both Wi-Fi and 5G. And the operating system of the phone should allow us to get the signal status of both 5G and WiFi networks (Proactive Handover). Accordingly, we can connect users to other infra (5G or WiFi) at the same time and transfer their sessions to other infra before closing their connections from the already connected infra. Since we control both networks, we would have access to both of 5G and WiFi connections of the user. We can benefit from Multi-access Edge Computing (MEC) support of 5G. If we bring the core network functionalities closer to the edges the handover can be processed faster.
4. We may need to decrease the number of hosts in the simulator to make it faster to simulate. Or we can split the simulation building by building to limit the area that we are simulating. Analyzing each sector separately we may put some raw traffic generators for these sections and use them as single components. E.g. we would use a building component that generates

traffic of 100 users instead of adding 100 different user components. So we can also make a separate simulation to see the interaction of the building networks. We can simplify the simulation in a divide-and-conquer manner.

5. This can change according to requirements. For example, if users are entering online lectures, they will need high bandwidth, high throughput with low latency. However, if the users are IoT devices that need to communicate from time to time with really fewer data they won't gonna need high bandwidth, or high throughput. Since we are implementing this network for campus we can assume that a lot of people will enter online lectures, even professors stream lectures to other people. So for this scenario to make a sustainable network, high bandwidth, high throughput, and low latency are the most crucial parameters.