DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Master Practical Course
Computer Network Simulation

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Assignment 4
Part 1 - Theoretical Questions

Group 2

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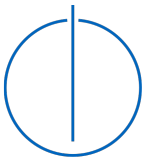

Question-1: How can the paradigm of edge computing be summarized? What are the benefits that come with edge deployments?

- Similar to Cloud computing, edge computing offers data, computation, storage, and application services to end users. Edge Computing is a paradigm that extends Cloud Computing and services to the network. Edge computing enhances QoS (Quality of Service), decreases service latency, and provides a better user experience.
- Edge computing allows scaling the applications by distributing the loads to the edges.
- Edge computing allows keeping the data near to the users, which can be an important aspect in terms of data privacy and the data regulations of the governments.
- Edge computing reduces the risk of attacks against the data delivered over the network.
- It decreases the latency by bringing the resources closer to the end user.
- Since it brings the resources closer to the end user, it decreases the overall load in the network. Hence, it can decrease traffic congestion by eliminating bottleneck links.
- Additionally, by moving computing resources closer to the edge, edge computing can improve the reliability of applications and services by reducing the dependence on the availability of a central data center or cloud.

Question-2: What are the challenges of deploying applications on the edge of the network? Can cloud solutions directly get used? If not, why?

Challenges:

- Limited resources: Edge devices typically have limited processing power, storage, and memory compared to cloud-based solutions. This makes it difficult to run complex applications on the edge.
- Limited connectivity: Edge devices are often located in remote or hard-to-reach areas, which can make it difficult to establish and maintain a reliable connection to the cloud or other network resources.
- Limited security: Edge devices are often less secure than cloud-based solutions, making them more vulnerable to hacking and other security threats.
- Limited scalability: Edge devices are typically deployed in small numbers, making it difficult to scale up an application to meet changing demands.
- Limited management: Edge devices are often deployed in environments where there is little or no IT staff available to manage them, making it difficult to ensure that they are properly configured and maintained.

Can cloud solutions directly get used?

- While cloud solutions can be directly used on the edge, it's not always the best fit, as they may require a reliable and fast internet connection, which might not be available on the edge. Additionally, edge devices are usually limited in terms of resources and power, which cloud solutions might not be able to accommodate. Therefore, Edge computing solutions are designed to run on low-power devices with low resources and are optimized for low latency and high bandwidth, which cloud solutions might not be able to provide.

Question-3: Do you think your application can benefit from an edge deployment? Explain briefly.

- Actually, the answer is: it depends.
- Our application has a centralized server that acts as an address book for all of the users in all of the bunkers, which opens the whole system to a single point of failure risk. So, distributing the load to the edges can be a good idea to eliminate the load and the risks.
- On the other hand, our server acts as a stateful database that carries the status of the users by updating their availability info of them by receiving heartbeat signals. If we distribute the load to the edges, then we need to create a synchronization mechanism among these deployments to keep the records of the servers up-to-date, which is not feasible 100% of the time. Therefore, it would cause some misses in the lookups between sync times. Another problem would be the overhead of the synchronization mechanism. There would be additional messages in the networks that carry sync data.
- By the way, we added a warning alert messaging mechanism to our system, which uses edge deployments. In this system, bunker admins can send alert messages to the people in their bunkers over a mec-enabled host. When an admin wants to publish a warning, he/she asks for a mec resource and sends it message to this mec host in his/her bunker. Then, this mec host connects to our lookup server to get a list of the people in the bunker and sends this warning message to the people in the bunker. Therefore, we can say that we already benefited from edge deployments.

Question-4: What are the main components of ETSI MEC Reference Architecture? Explain briefly.

1. Mobile Edge Platform (MEP): This component provides the computational and storage resources for edge applications and services.
2. Application Function (AF): This component hosts the actual edge applications and services. It communicates with the MEP and the end-user devices to provide the required functionality.
3. User Plane Function (UPF): This component is responsible for the user plane data forwarding between the end-user devices and the MEP.
4. Control Plane Function (CPF): This component is responsible for the control plane signaling between the end-user devices and the MEP.
5. Management and Orchestration (MANO): This component is responsible for the management and orchestration of the entire MEC infrastructure, including the MEP, AF, UPF, and CPF.
6. EPC: Evolved Packet Core which is responsible for the control of the signaling and data traffic between the end-user devices and the MEC and also connects to the internet.

Ref: `https://www.etsi.org/deliver/etsi_gs/MEC/001_099/003/03.01.01_60/gs_MEC003v030101p.pdf`

Ref: `https://telcocloudbridge.com/blog/beginners-guide-to-mec-architecture-multi-access-edge-computing`

Question-5: Imagine you are a network engineer working for TUM. You are tasked with deploying edge servers to enhance your networks' capabilities and serve students with various applications of different types (entertainment, education, research, etc.). In order to verify the orchestration methods' you use, and the applications' performance in your network, you decide to model it first with a simulation using Simu5G's Mobile Edge Computing extensions.

1. **What can be suitable applications to deploy at the edge of the campus network?**
2. **What design considerations do you need to make so that your edge deployment simultaneously supports connectivity over 5G, as well as WiFi and Ethernet cable?**
3. **How are the applications modeled and described? (i.e., How would the orchestrator view the applications?)**
4. **Which metrics should be evaluated to assess the performance of the deployment and to optimize the deployment costs?**

1. TUM BBB would be a good example of a suitable application since it can be configured to use MEC hosts as relay servers to serve different local parts of the campus network. A mec host in a building can receive one video stream from a main server and stream this stream to every user in the building. In this case, the number of video streams coming to the building will be decreased.

2. The network protocols used for MEC hosts should also be supported by WiFi and Ethernet to make the MEC hosts accessible to devices from outside of the cellular network. If it is not the case, some gateways should be placed that acts as an adapter between WiFi/Ethernet traffic and the MEC deployment (a component that talks the language of both areas). Then, the access can be managed by the control plane functions since all of the networks are managed by TUM.

3. The applications are modeled and described using the Mobile Edge Computing (MEC) Application Programming Interface (API), which defines the interface between the application and the MEC platform. The orchestrator views the applications as a set of services, which can be deployed, configured, and managed on the edge servers. The applications may also be described in terms of the service level agreements (SLAs) that the MEC platform must meet.

4. Metrics that can be evaluated to assess the performance of the deployment and to optimize the deployment costs include:
    - Latency and throughput of the network: According to the bottleneck links, the location of the MEC deployments can be optimized.
    - Quality of experience (QoE) of the applications: Similarly, the location and the number of resources required for the MEC hosts can be decided to meet the required QoE of the applications.
    - Resource utilization of the edge servers: It affects the cost directly.
    - Costs associated with deploying and maintaining the edge servers.
    - Number of users and devices supported: It affects the cost directly.

- Network reliability and availability: Since MEC deployments are used to bring the resources closer to the end users, they can be deployed to the parts of the network, which have reliability and availability problems with the core of the network.