5G Overview

1.5 Day Course

1. Service based Architecture The entire 5G approach takes advantage of containers, virtualization, SDN and NFV. This section covers the design motivation and underlying technology of 5G service based architecture as well as new vocabulary terms you must learn.

- Definition of a Service Based Architecture
    - Tracks current computer science trends of container and network orchestration
    - Immutable infrastructure-driven service delivery
    - Control Plane Network Function can provide one or more NF Services
    - A NF Service consist of operations based on either a request-response or a subscribe-notify model
    - Common control protocol using e.g. HTTP based API, replacing protocols like e.g. Diameter
    - Basic 5G vocabulary of new terms is covered here
- 5G Goals
    - Interfaces support Multi-vendor integration
    - Control place and User plane scale independently
    - Allow for a flexible deployment of UP separate from the CP
    - Support authentication for both IMSI-based and non IMSI-based identities
    - Allows for different network configuration and control for different network slices
    - Maintain 4G connectivity by abstract transport layer from 3GPP NFs
- Network Slice Definition
- Federated Network Slicing
- Self-containment of network functions
- Intrinsic interoperability
- Container-friendly
- Collapsed core
- Service Operation Naming
- Common Core Network
- Application Support
- Fits the new cloud orchestration model
- Release 15 overview and timeline
- Release 16 overview and timeline
- 3GPP activity towards IMT-2020

2. 5G NR (New Radio) We will cover enough about 5G radio to understand the differences between 4G and 5G. All concepts will be explained with intuitive graphics. Each of the radio access methods explained below directly impacts specific components in the 5G core, so it is important to have a fundamental understanding of 5G radio prior to learning the 5G core.

- 3GPP Timeline
- Massive MIMO
- Spectrum allocation using millimeter waves
    - World Radio Conference (WRC)-15
- Low Latency requirements
    - Why do we need this?
    - How did they do that?
- Why OFDM?
    - TDD subframe
    - Windowed OFDM
- Non-orthogonal RSMA
    - Xmit tiny packets asynchronously (power meter, temperature
    - Low device cost and battery life
- enhanced mobile broadband (eMBB)
    - Trains, planes, holograms, augmented virtual reality
- massive machine type communications (mMTC)
    - Wearables, Inventory, eHealth, eFarm, eCity
- ultra-reliable low latency communications (URLLC).
    - Drones, Robotics, Self driving cars
- Small Cell Networks
- Beamforming
- NR Dual Connectivity technology
- Making a case for DAS (Distributed Antenna Systems)
    - over 80% of mobile data is being consumed indoors - *Cisco VNI 2020 Estimates of Mobile Data Consumption*

3. The 5G core Architecture The 5G core is designed to support a service-based network architecture, so it looks very different than the 4G core. Nevertheless, we will assume that students are familiar with the 4G core, so this section will be taught in a fashion that constantly compares 5G core functions with an analogous 4G function. Each component in the 5G core will be covered from the perspective of what it is for, why it is there, and what it permits 5G to do that 4G could not. Please note the cheat sheet provided at the end of this section to post on your wall to help you keep track of all the new components and their function.

- The 4G core pre-release 14
- The 4G core release 14 control and User Plane separation (CUPS)
- The 5G network core (continuously contrasted with the 4G core in the presentation)
    - 5G UE

- gNodeB
- UPF User Plane Function [N3]
  - Why there can be more than one
- DN Data Network [N6]
- SMF Session Management Function [N4]
  - Why there can be more than one
  - One per slice
- AMF Access and Mobility Management Function [N1 and N2]
  - Why there can be more than one
  - Only ONE will handle NAS
- NSSF Network Slice Selection Function [Nnssf]
- NEF (Network Exposure Function)
  - vs 4G SCEF
- NRF (network Repository Function)
- NF Services
  - Service based Interface
- UDC Reference Architecture
- UDC User Data Convergence
  - UDM Unified Data Management
    - UDR Unified Data Repository
    - FE Front End [Nudm]
  - AUSF Authentication Server Function [Nausf]
  - PCF Policy Control Function Npcf
- AF Application Function
  - The IMS core is an example
- 4G to 5G evolution
- Cheat sheet mapping of 4G functions into 5G functions
- Multi-slice attachment (URLLC slice and eMBB slice)

4. 5G Message Flow Now we take a look at the 5G core in action. Sample message flows of typical 5G processes are covered message by message. The analysis will be done using east-west diagrams that show how the components actually interact. The goal is to more clearly see how the 5G accomplishes its goals by observing how it actually works.

- 3GPP defined 5G control plane stack
  - Next Generation-Application Protocol
  - Stream Control Transmission Protocol (SCTP)
- General Registration Message Flow
- Registration with AMF re-allocation
- DeRegistration
- Network-initiated Deregistration
- UE Triggered Service Request procedure
- PDU Session Establishment

- Non-roaming and Roaming with Local Breakout
- UE-requested PDU Session Establishment for home-routed roaming scenarios