Course Description

Course name	**#093 - 5G RAN Design – Radio Planning and Dimensioning for NSA & SA Architectures**
Duration	**3 days**
Format	**Public classroom, Inhouse events and Online**

Overview

Dr. Spiros Louvros, PhD in Wireless Communications, Radio Access Network (RAN) Telecom Engineer, 3GPP technical recommendation group member, Greece.

5G has introduced a new way to offer services in the mobile industry. It has created a new way to represent the 3GPP cellular technology for accessibility, quite similar and competitive to WiFi for short range cells (mmWave sectors), as well fully compliant with the previous LTE technology for short and long range cell coverage (small, macro micro pico etc cells) in low and mid band frequencies. Its 3GPP standardized procedures will have a big impact on the next generation network planning and deployment for both coverage, capacity and IP transport network connectivity. Consequently, an advanced understanding of how the evolutionary changes and improvements from previous LTE technology will impact the radio coverage, capacity (number of devices, different services requirements and throughput considerations), IP backhaul networking transmission and service quality will provide a powerful tool to create successfully new scenarios and subsequent planning methodologies to optimize and fully exploit the 5G capabilities.

This course differentiates from other similar topics in the market by introducing the attendant into basic principles of RAN design based in realistic simulation results for recommended parameter configurations. Moreover, it emphasizes into mathematical models resulting into useful formulas to be used for excel calculators. It suggests further vendor equipment behavior analysis based on machine learning methodologies and algorithms, resulting into realistic tools for each individual network and vendor equipment. Finally, it provides adequate explanation into the existing proposed 3GPP optional features, which if activated would result in 5G RAN performance improvements.

In order for the attendant to better understand the content of this topic and to gain further insight into the 5G RAN design, it is also recommended to have prior attended following courses:

– 5G Network Overview – recommended
– 5G Network Protocols & Signaling Procedures - recommended but not essential

It is also strongly recommended to complete the knowledge on 5G RAN planning and design by attending the course on 5G RAN Optimization

Finally, it is worth mentioning that this course could be customized, tailored into specific customer needs and requests. Special topics could be also added and discussed, like 5G RAN design over satellites, 5G over LiFi and/or indoor design, using specific features and methodology. Of course the overall course duration would be impacted.

Technical Focus

5G Radio Access Network (RAN) must be properly designed to operate in a wide range of spectrum bands with diverse standards characteristics and operator specific requirements, such as channel bandwidths and propagation conditions according to ICT-671680 METIS-II, Deliverable 1.1, "Refined scenarios and requirements, consolidated test cases, and qualitative techno-economic assessment", January 2016.

From Operator's perspective it is equally important to develop and deploy a network which would be capable of being scaled up to extremes in capacity and coverage as well as throughput, number of devices, connections etc. This is achievable only if RAN design differentiates and separately focus into the so-called user plane (UP), related to the transmission of actual application payload, and control plane (CP), related to control functionality and signaling.

This course will introduce participants on the methodology and algorithms into how to properly design the 5G RAN for two separate cases. The first case will explain the smooth migration of LTE-A into the so called Non Stand-Alone architecture (also known as EN-DC connectivity). The second case will explain the most difficult part related to the Stand Alone (SA) deployment. Special consideration will be also given into 3GPP optional features for performance enhancements as well as general vendor agnostic parameters for the initial design.

The overall course will be further supported by excel tool calculator, for exercises and practical presentation of the design process. Finally, it is worthwhile to mention that the overall RAN design will be supported by simulation results and non-linear regression algorithms to introduce the scheduler behavior and the beam management into the design process.

Course Content

5G has introduced a new way to offer services in the mobile industry. It has created a new way to represent the 3GPP cellular technology for accessibility, quite similar and competitive to WiFi for short range cells (mmWave sectors), as well fully compliant with the previous LTE technology for short and long range cell coverage (small, macro micro pico etc cells) in low and mid band frequencies. Its 3GPP standardized procedures will have a big impact on the next generation network planning and deployment for both coverage, capacity and IP transport network connectivity. Consequently, an advanced understanding of how the evolutionary changes and improvements from previous LTE technology will impact the radio coverage, capacity (number of devices, different services requirements and throughput considerations), IP backhaul networking transmission and service quality will provide a powerful tool to create successfully new scenarios and subsequent planning methodologies to optimize and fully exploit the 5G capabilities.

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Who Should Attend

This course presents the principles of initial 5G RAN design including all topics related to coverage, RACH accessibility, capacity and throughput estimations in different scenarios. Consequently it is considered to be a valuable topic mainly for Radio Network Planners who have the daily duty to successfully plan for 5G RAN deployment, provide the best RAN QoS by contributing to the overall E2E QoS performance, as well as estimate the necessary throughput capacity and subsequent expansions for different services (URLLC, xMBB, mMTC) with the goal to minimize the overall congestion and blocking probability and maximize the RAN accessibility.

Moreover, it is also considered to be equally useful for Radio Network Optimizers whose daily job is to optimize the network performance. Prior knowledge of the RAN design principles will facilitate their effort to gain a deep insight into the initial planning principles and functional RAN performance contribution, guiding them into the root of unexpected network performance problems from all accessibility, retainability as well as throughput point of view.

Radio Network Managers will also find this course interesting, acquiring a good and solid understanding of the 5G RAN deployment requirements and restrictions. This experience will result in better understanding of necessary HW and equipment mobile sector business negotiations with vendors and equipment providers as well as further insights into the future 5G network expansion needs.

Finally, it is considered to be a valuable help for 5G System Architects, 3GPP consultants, 5G R&D Researchers, 5G System Analysts and 5G network consultants, contributing into further insight to the 5G technology and requirements for services, optional feature enhancements and general E2E performance in the pathway towards 6G.

Course Daily Schedule

Section 1 – 5G NR Physical Layer
5G New Radio (NR) technology review

- 3GPP rel 15 and Rel 16 overview
- FR1 and FR2 spectrum
- Scalable numerology
- OFDM techniques
- NR frame structure
- FDD – TDD modes
- NR signals and channels
- Non Stand Alone (NSA) vs. Stand Alone (SA) architecture
- 5G Services – eMBB, massive IoT, URLLC

Massive MIMO technology

- 3GPP Massive MIMO stabdardization
- Beam-forming principles and Massive MIMO Gain margins
- Existing market mMIMO antennas (AAS-AAU units)

5G Wireless Channel Considerations

- FR1 & FR2 3D-Channel models
  - Non-Line of Site and Rayleigh modeling
  - LoS and Rice modeling
- Shadow modeling
- Doppler effects
- Pathloss models for FR1 and FR2 mmW bands
- Link Budget analysis supported by excel calculator
  - Rural macro scenario,
  - Urban macro & micro scenario,
  - Dense Urban pico scenario,
  - Outdor to Indor (O2I) scenario
  - Indoor scenario

Section 2 – Stand-Alone (SA) Planning
Uplink Planning

- General UL requirements
  - Equipment HW requirements
  - Operator Performance requirements
- NR Power control (PC) description
  - NR UL PC factor
  - PC factor configuration recommendations
- Uplink Interference factor
  - UL Interference estimation using mathematical modeling
  - UL Interference estimation using simulations
- Coverage UL Channel planning
  - PUSCH (based on simulation results)
  - PUCCH (based on simulation results for SINR target),
  - PRACH (based on simulation results for SINR target)
  - PRACH accessibility success probability (based on mathematical models)
- Coverage UL Signal planning
  - SRS (based on simulation results)
  - DMRS (based on simulation results for SINR target),
  - CSI-RS (based on simulation results for SINR target),
- Capacity (UL Throughput) calculations – single service
  - URLLC average and cell edge
  - xMBB average and cell edge
  - mMTC average and cell edge
- Capacity calculation – combined services
- UL Cell Throughput calculation
- UL Throughput calculation – NR Carrier Aggregation
- IP Transport Network UL capacity requirements
- Practical Examples using excel tool calculator

Downlink Planning

- General DL requirements
  - Equipment HW requirements
  - Operator Performance requirements
- NR Power Spectral Density
- Downlink Interference factor
  - DL Interference estimation using mathematical modeling
  - DL interference estimation using simulations

- Coverage DL Channel planning
  - PDSCH (based on simulation results)
  - PDCCH (based on simulation results for SINR target),
- Coverage DL Signal planning
  - PSS/SSS (based on simulation results)
  - PBCH (based on simulation results)
  - DMRS (based on simulation results for SINR target),
  - CSI-RS (based on simulation results for SINR target),
- Capacity (DL Throughput) calculations – single service
  - URLLC average and cell edge
  - xMBB average and cell edge
  - mMTC average and cell edge
- Capacity calculation – combined services
- DL Cell Throughput calculation
- DL Cell Throughput calculation – NR Carrier Aggregation
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5G NR Sector Planning

- PCI Planning
- Random Access Planning

- RACH Root Planning

1. Process description
2. Excel Tool calculator

- PRACH Preample selection

1. 3GPP recommendations
2. PRACH preample tables

- R Power Spectral Density
- TA Planning
- RNA Planning

Section 3 – non Stand-Alone (NSA) Planning
Dual Carrier review

- NSA EN-DC (most common Option 3x) overview
  - EN-DC setup procedure - Signaling Flow
  - EN-DC setup requirements

- EN-DC setup configuration parameters
- NR Secondary node scenarios – the hot spot and the LTE collocation

- NSA EN-DC fallback to LTE
  - EN-DC release procedure - Signaling Flow
  - EN-DC release requirements
  - EN-DC release configuration parameter

Uplink Planning

- General LTE & 5G UL requirements
  - Equipment HW requirements
  - Operator Performance requirements

- LTE & NR Power control (PC) description
  - UL PC factor
  - PC factor configuration recommendations

- LTE Uplink Interference factor
  - UL Interference estimation using mathematical modeling
  - UL Interference estimation using simulations

- NR Uplink Interference factor
  - UL Interference estimation using mathematical modeling
  - UL Interference estimation using simulations

- Coverage UL Channel planning
  - LTE/NR PUSCH (based on simulation results)
  - LTE/NR PUCCH (based on simulation results for SINR target),
  - LTE PRACH (based on simulation results for SINR target)
  - LTE PRACH accessibility success probability (based on mathematical models)

- Coverage UL Signal planning
  - LTE/NR SRS (based on simulation results)
  - LTE CRS TM1-7 (based on simulation results for SINR target),
  - LTE CSI-RS TM8-10 (based on simulation results for SINR target),

- Capacity (UL Throughput) calculations – single service
  - EN-DC MBB hot spot scenario
  - EN-DC NB-IoT hot spot scenario
  - EN-DC MBB collocation scenario
  - EN-DC NB-IoT collocation scenario

- UL EN-DC Cell Throughput calculation

- UL capacity consideration in LTE

- UL Throughput calculation – EN-DC Carrier Aggregation

- UL Throughput calculation – EN-DC and LTE TM10 CoMP

- IP Transport Network UL capacity requirements

- Practical Examples using excel tool calculator

Downlink Planning

- General LTE & 5G DL requirements
  - Equipment HW requirements
  - Operator Performance requirements
- LTE & NR Power Spectral Density
- LTE Downlink Interference factor
  - DL Interference estimation using mathematical modeling
  - DL interference estimation using simulations
- NR Downlink Interference factor
  - DL Interference estimation using mathematical modeling
  - DL interference estimation using simulations
- Coverage DL Channel planning
  - LTE/NR PDSCH (based on simulation results)
  - LTE/NR PDCCH (based on simulation results for SINR target),
- Coverage DL Signal planning
  - NR PSS/SSS (based on simulation results)
  - LTE/NR PBCH (based on simulation results)
  - NR DMRS (based on simulation results for SINR target),
  - LTE DMRS TM8-10 (based on simulation results for SINR target)
  - LTE CRS TM1-7 (based on simulation results for SINR target),
  - LTE CSI-RS TM8-10 (based on simulation results for SINR target),
- Capacity (DL Throughput) calculations – single service
  - EN-DC MBB hot spot scenario
  - EN-DC NB-IoT hot spot scenario
  - EN-DC MBB collocation scenario
  - EN-DC NB-IoT collocation scenario
- DL EN-DC Cell Throughput calculation
- DL capacity consideration in LTE
- UL Throughput calculation – EN-DC Carrier Aggregation
- UL Throughput calculation – EN-DC and LTE TM10 CoMP
- IP Transport Network DL capacity requirements
- Practical Examples using excel tool calculator

Instructor Biography

Dr. Spiros Louvros holds a PhD Diploma in Wireless & Mobile Communications, a Master (Msc) in RF system design for RF Engineering and Radio Communications, and a Bachelor in Applied Physics. He has an extensive working experience in both Industry and Academia for more than 25 years in many related technical fields.

Dr. Louvros is included in the list of "Who is Who" of Onalytica, as one of the Academics & Researchers influencers in the area of 5G technology and networks. For further reference please be kindly referred to Onalytica, 'Who is Who in 5G - Influencial Voices & Brands' full report https://lnkd.in/eRj3YAsG

He has worked as MW Link Planner, Mobile switching engineer, Section Manager Operational & Maintenance for well-known Mobile Operators as Siemens, Vodafone, CosmOTE Deutsche Telecom Group. He has extensive experience of more than 15 years in the Cellular Technologies starting from early GSM and extending up to LTE/LTE-A and 5G RAN technologies, working as RAN Optimizer, Planner and 3GPP Standards consultant. The last 5 years is working as LTE-A/5G system architect and Technical Consultant Leader for RAN technologies, leading research and implementation projects related to 5G NSA & SA smooth migration as well as preliminary 6G Radio technologies consultancy projects.

In the Academic sector Dr. Louvros held for 08 years the Tenure Track position of Assistant Professor in the Technical University of Western Greece in the technical field of Wireless and Mobile Communications. During his professorship he has conducted several courses in graduate and undergraduate level in the area of Mobile Communications, Satellite Communications, Optical network infrastructure and Information Theory. He was leading a laboratory for advanced Antennas and MIMO technology with emphasis in EU Research Projects and Industrial collaborations. He finally conducted several lectures in IEEE summer schools and special Academia-Industry collaborative events

Dr. Louvros offers for more than 15 years exclusive technical trainings on collaborative technologies of GSM, 3G, LTE/LTE-A (including MTC NB_IoT), 5G and preliminary 6G with reference to contemporary 3GPP standards and vendor specific features and architectures. He also conducts and provides technical report authorships and network deployment consultancy to operators and customers worldwide.

Dr. Louvros has been a member of the Continuing Education Institute-Europe faculty since 2020.