Module by Module - Self Study Note Guide

Nokia Bell Labs 5G Certification Program

Nokia Bell Labs Distributed Cloud Networks| BL00200-K-2101

Instructions

Research has shown that learning is most effective when understood from one's own personal perspective. As such, we have created this learning guide for you to use as a personal reference and study guide.

For each module, the guide starts with the objectives, lays out the topics, and then concludes with key takeaways. For each topic, space is provided for you to take notes, capture observations and insights, or simply create a study guide for reference in preparation for your certification exam.

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Exam Table

Exam Breakdown – The following table identifies the proportion of questions from each topic area that will appear on the certification examination.

Number of Questions: 60 Questions

Exam Time Limit: 90 Minutes

Topic	% of Exam
DC2.1 Distributed Cloud Description	12%
DC2.2 Cloud Options	10%
DC2.3 Cloud Native Applications	10%
DC2.4 Microservices and Containerization	5%
DC3.1 Cloud Resources	10%
DC3.2 Cloud Network Functions	10%
DC3.3 Network Service Descriptors	8%
DC4.1 Data Center Hardware	5%
DC4.2 Data Center Evolution	3%
DC4.3 Maintenance and Monitoring	3%
DC5.1 Service and Application Automation	3%
DC5.2 Networking Automation	10%
DC5.3 Application Life Cycle and Auto Operations	7%
DC5.4 ML_AI	3%

DC1.1 - Performance Requirements

Key Objectives

Here are our learning objectives for this module.

- Describe the industry market trends that drive the need for dramatically reduced latency and increased reliability.
- Describe a distributed cloud architecture and how it helps supporting this new performance level.
- Describe four iconic industry use cases whose performance depends on Distributed Cloud capabilities.

Notes Section

Topic Names	Your Notes
Industry Trends	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Industry 4.0 is the new playground	
Digitalization is driving evolution	
Need for Distributed Cloud	
Why do we need Distributed Cloud ?	

Admissible round trip time for some of the most common industry applications	
Distributed Cloud in a nutshell	
Layered architecture	
Far Edge Cloud	
Metro/regional Cloud	
Central or Core Cloud	
A Few Use Cases	
Video Analytics	
Cloud Robotics	
Digital Twin	
Data Containment	
Miscellaneous Notes	

Key Takeaways:

- Industries are undertaking a huge digitalization effort, and this raises high network performance expectations.
- This Industry transformation raises network performance expectations. These expectations can only be met by local data centers, thereby paving the way to distributed cloud.
- The key drivers for edge cloud are latency, bandwidth, privacy, locality, and availability.

DC1.2 - Industry Examples

Key Objectives

Here are our learning objectives for this module.

- Identify the main challenges today's industry is facing.
- Explain how digitalization and distributed cloud will help addressing those challenges.

Notes Section

Topic Names	Your Notes
Industry Examples	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Railway	
Background of Industry	
Digital - railway industry	
Mining	
Challenges	
Digital Mining	
Smart Manufacturing	
Smart Factories	
Miscellaneous Notes	

Key Takeaways:

- Heavy industries face several challenges such as safety, costly infrastructure and the need for more flexibility.

- Automation based on fast and reliable networking and Distributed Cloud is key to address these challenges and support evolution toward industry 4.0.

DC1.3 – Case Study Introduction

Key Objectives

Here are our learning objectives for this module.

- Introduce the Case Study

Notes Section

Topic Names	Your Notes
Case Study Into	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Introduction of Mary – CGO Solution Architect	
Introduction of Use Cases	
Introduction to Car Co Use Case & John – Operation Director	
Care Co Challenges	
CarCo Business Imperatives	
How can 5G Help meet challenges of CarCo	
Miscellaneous Notes	

Key Takeaways:

- CarCo faces challenges.
- 5G can help to meet some of these challenges by providing resources at lower cost, high performance, easier maintenance, flexibility and more.

DC2.1– Distributed Cloud Description

Key Objectives

Here are our learning objectives for this module.

- List and describe the key drivers of a distributed cloud.
- Define distributed cloud from examining use cases.

Potential Exam Topics : Distributed Cloud Description

- Know the different cloud deployments for the different drivers such as lowest latency, small coverage area, large coverage area, etc
- Key drivers for different types of Clouds
- Know parts of a distributed cloud that are used for the 5G Core control plane

Notes Section

Topic Names	Your Notes
Distributed Cloud Description	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
What you already know about Distributed cloud	
DC is composed of On-premises edge, Far edge, Metro edge and Core or Central cloud	
Distributed cloud key drivers	
Latency	
Localization	
Convenience	
Privacy	
Availability	
Capacity	

Why On-premises Edge Cloud?	
Why Far Edge Cloud?	
Why Metro Edge Cloud?	
Why Core/Central Cloud?	
Distributed cloud definition driven by use cases	
Example: Mining zero-harm in isolated location	
Example: Facial recognition for logistic company	
Additional Notes	

Key Takeaways:

- On-premise or Far edge cloud fulfills the most demanding latency requirements for 5G and enterprise use cases.
- Metro Edge Cloud has a middle positioning in distributed cloud. When it's coupled with Edge Clouds, the Metro Edge Cloud brings up capacity.
- Core or central cloud provides the largest capacity addressing requirements for web-scale services.

DC2.2– Cloud Options

Key Objectives

Here are our learning objectives for this module.

- List the main cloud options and describe their characteristics.
- Describe the main components of the cloud infrastructure.

Potential Exam Topics: Cloud Options

- Know different properties of private and public cloud options
- Know options for Hybrid Cloud
- Know potential options that CaaS provides.
- Why would you pick public over private cloud and vice versa.

Notes Section

Topic Names	Your Notes
Cloud Options	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
So what are your choices for the Cloud Infrastructure?	
Cloud operation and distribution overview	
Introduction to cloud options	
Structure overview of cloud options	
Cloud service levels	
What is SaaS?	
Main cloud infrastructure layers	
Pros and cons of Cloud options	
Example: Access Control for an isolated mining site	
Example: Robotics across multiple manufacturing sites	
Additional Notes	

Key Takeaways:

- There are three main cloud options available and you can choose any option for your distributed cloud.
  - A private cloud is your own cloud with full control and management.
  - A public cloud is a commercial service with agreements.
  - The hybrid cloud is a combination bringing advantages of both public and private clouds.

DC2.3– Cloud Native applications design

Key Objectives

Here are our learning objectives for this module.

- Describe the evolution that led to cloud native application development.
- Describe the main characteristics of cloud native design.
- Identify the advantages cloud native applications bring to 5G and distributed cloud deployments.

Potential Exam topics

- Development and deployment practices commonly used in cloud native applications
- Differences, characteristics between Stateless service, Dataless service, Stateful service.
- Know what an immutable infrastructure is
- Advantage of development concepts such DevOps and CI/CD used in cloud native applications

Notes Section

Topic Names	Your Notes
Cloud Native applications design	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Why Cloud Native applications?	
Cloud Native Application: New Paradigm	
Requirement for Cloud Native application	
Development and deployment concepts	
Stateful vs stateless	
What is a serverless deployment?	
Application enhancement for high performance	
Application enhancement for high performance	

Operational efficiency and resources allocation	
Monolithic versus Cloud Native	
Example: Industrial IoTs for smart factories	
Additional Notes	

Key Takeaways:

- Traditional applications were monolithic and required dedicated hardware. This was followed by virtualized machines which separated the hardware and software. Efficiency was increase by grouping applications into data centers which opened the door for cloud infrastructure. This paved the way for cloud native applications.
- The cloud native application design targets scalability, resiliency, self-management, and being more programmable. The whole cloud native concept is an enabler for DevOps and "CI/CD".
- Cloud native applications need a new development and operation model.
- New concepts such as DevOps, DevSecOps and CI/CD bring all development phases into one continuous integration and delivery cycle to reduce time and complexity for development and deployment.
- Even if the application design is complex, the cloud native applications provide the best values for based on the key points.

DC2.4– Microservices and Containerization

Key Objectives

Here are our learning objectives for this module.

- Describe microservices and containers in a cloud native service.
- Describe cloud native implementation and requirements on cloud infrastructures.

Potential Exam Topics: Microservices and Containerization

- Know about microservices and containers.
- What are advantages of microservices

Notes Section

Topic Names	Your Notes
Microservices and Containerization	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Toward Microservices in Cloud-native applications	

Cloud-native deployment and requirements	
Container description	
Container resources	
Container details	
Para-virtualization	
ETSI framework for Containerization	
Mutable infrastructure	
Immutable infrastructure	
Why immutable infrastructure for cloud native application?	
Example: Industrial Robotics	
Additional Notes	

Key Takeaways:

- Cloud native applications which address adaptability over a complex environment, need to be created as microservices.
- Automation, containers, APIs, service mesh and immutable infrastructure bring efficiency in cloud native deployments.

DC2.5– Case Study Exercise

Key Objectives

Here are our learning objectives for this module.

- Digging Deeper into CarCo Case Study

Notes Section

Topic Names	Your Notes
Case Study	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
How do we enhance reliability in core networks to meet URLLC requirements?	
On Premise Edge Cloud vs Central Cloud	
Additional Notes	

Key Takeaways:

- Digging Deeper into CarCo Case Study

Unit 3 – Cloud Resource Planning

DC3.1– Cloud Resources

Key Objectives

Here are our learning objectives for this module.

- Describe the types of resources available in the cloud and how they are made available.
- Explain how cloud resources are managed and distributed.

DC3.1– Potential Exam Topics : Cloud Resources

- Describe Multi-tenancy network connectivity
- Understand what Data Center Orchestration provides
- What is the role of the hypervisor
- Name elements of a VNF

Notes Section

Topic Names	Your Notes
Cloud resources	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Your apps need resources in cloud	

Cloud resources: Virtualization layers	
Introduction of cloud resources multi-tenancy	
Resources restriction overview	
Cloud resources management	
VM vs container layers in cloud	
Use cases: Automation/monitoring in mining	
Additional Notes	

Key Takeaways:

- The Software layer makes the cloud resources transparent for usage and allocation.
- A quota, which limits resources, is managed by the cloud resource manager.
- Multi-tenancy allows us to isolate resources between projects and users.

DC3.2– Network Function

Key Objectives

Here are our learning objectives for this module.

- Explain the role of standards in ensuring the compatibility and interoperability of Network Functions.
- Describe how orchestration starts and manages Network Functions.

Potential Exam Topics: Network Function

Here are our learning objectives for this module.

- Understand the evolution of network functions.
- Describe how orchestration starts and manages Network Functions.
- ETSI MANO Model operational stack and what it provides.
- Know what a YAML template files is and does
- Know what manages a Network Service

- Know what Kubernetes is

Notes Section

Topic Names	Your Notes
Network Function	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Telco cloud: a short story of NF	
Why standardization?	
ETSI MANO model	
What will ETSI MANO model brings to you?	
DC orchestrator versus container orchestrator	
Orchestration principle	
NF management: how does it work?	
VNF design and resources: templating needed	
Use cases: customized networks for customers	
Additional Notes	

Key Takeaways:

- Network Functions have evolved to run in the cloud which has added complexity.
- Standards provide structure and interoperability while templates provide repeatability.
- Orchestration of Network Functions provides a single point of management across clouds.

DC3.3– Network Service Descriptor Role

Key Objectives

Here are our learning objectives for this module.

- Explain how orchestration manages network services.
- Describe the mapping from functional to logical views and the standard for NSD definition.

Potential Exam Topics : Network Service Descriptors

- Know Network Service Orchestration
- What is a Network Service Descriptor and what does it do
- Know about Network Forwarding paths and VNF forwarding graphs
- In regards to designing a service using NSD what are the phases of Functional Design, Logical Model, Implementation Model

Notes Section

Topic Names	Your Notes
Network Service Descriptor Role	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Network service and NF domains	
Network service orchestration and on-boarding	
Why network service orchestration?	
What is NSD?	
NSD terminology	
NSD designing	
Use cases: cloud resilience for transport in industry 4.0	
Additional Notes	

Key Takeaways:

- Network service orchestration simplifies network function management.
- The design of the network service is from functional to logical views.
- The network service descriptor is an implementation model as a configuration file.

DC3.4– Case Study

Key Objectives

Here are our learning objectives for this module.

- Dig Deeper into the Case Study

Notes Section

Topic Names	Your Notes
Case Study	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Future considerations for CarCo	
Additional Notes	

Key Takeaways:

- CarCo Case Study continued

Unit 4 – Operating your Cloud

DC4.1– Industry Trends in Data Center Hardware

Key Objectives

Here are our learning objectives for this module.

- Describe the hardware options available to realize your data center needs.
- Understand what data center AI hardware is and its computational power.

Potential Exam Topics : Industry Trends in Data Center Hardware

- What is the Open Compute Project
- What is Hyperscale computing
- Know about SDN Enabled Broadband Access Architecture
- Know about Hyperscale computing and relation to scalable server architecture
- Know about Horizontal Scaling

Notes Section

Topic Names	Your Notes
Industry Trends	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Challenges for data centers	
Open Compute Project	
Open compute for hyperscale efficiency	
Access edge solution for telco central office	
Open cloud AI rack	
What is AI hardware	
AI accelerators	
AI hardware capabilities	
Top 5 AI hardware solutions	
Top concerns to select a right data centre solution	
Additional Notes	

Key Takeaways:

- There are different types and sizes of hardware solutions available.
- AI hardware is shaping the future of Cloud industry.
- AI hardware is a class of microprocessors designed to enable faster processing of AI applications, especially for machine learning, neural networks and computer vision. They are usually designed as manycore processors that focus on low-precision arithmetic, novel dataflow architectures, or in-memory computing capability.
- The most popular current hardware solutions for AI acceleration includes the following:
  - Tensor Processing Unit

- Habana Neural Network Processor
- EyeQ
- Epiphany V
- Myriad 2

DC4.2– Data Center Evolution

Key Objectives

Here are our learning objectives for this module.

- Have a better understanding of a Multi Cloud Environment and its agility.
- Explain distributed cloud architecture with its hardware realization.
- Understand Cloud Infrastructure requirements to meet your solution needs.
- Understand the hardware components required to realize edge and central cloud.

Potential Exam Topics : Data Center Evolution

- Agile data center characteristics like scalability and openness
- Know about multi cloud environments

Notes Section

Topic Names	Your Notes
Data Center Evolution	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Multi cloud environments	
Agility in data centers	
Distributed cloud architecture	
Distributed data centers	
Distributed data centers - hardware	
Distributed data centers - basic enabler for edge cloud success	
Additional Notes	

Key Takeaways:

- Agility is a key requirement in a multi cloud environment. Agility focuses on three factors.
  - Composability. This means one can precisely match hardware to a particular type of workload, down to the specific hardware components.
  - High scalability. This means one can use as many components as needed, even if dispersed across physical racks.
  - Openness. This means you can select and integrate components based solely on those best suited to your workload without artificially imposed compatibility issues.
- A standalone server can function as an independent cloud to multi node data center.
- Demands of edge clouds will force a move from heavy-weight data center clouds to lightweight resources, which will bring the operational costs down.
- Distributed clouds support services targeted to the users that are more agile and leverage 5G.
- It creates a challenge to identify lightweight virtualization. With this increased virtualization we have an increased need to orchestrate the deployment of these services.

DC4.3– Maintenance & Monitoring Tools

Key Objectives

Here are our learning objectives for this module.

- Understand what Cloud Monitoring is, and how it is different from traditional ways of monitoring monolithic telecom applications
- Provide an understanding of the Unified Data Center manager tools and their functions.
- Define how different software components of a Data center manager can be integrated with cloud native application programming Interfaces.

Potential Exam Topics: Maintenance & Monitoring Tools

- Data Center Manager does what
- Know where Data Center managers store logs
- Know what Ansible is

Notes Section

Topic Names	Your Notes
Maintenance & Monitoring Tools	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
What is cloud monitoring?	
How monitoring a traditional data center is different from Cloud Monitoring,	

End-to-end approach to TCO required for lean data center operations	
Effective design of data center infrastructure manager	
Cloud resource monitoring principles	
Optimize and automate your data center manager for best resource utilization	
Data center operations, automation overview	
Components and interfaces of a data center manager	
Automated workflows with ansible	
Additional Notes	

Key Takeaways:

- Cloud monitoring is used to manage, monitor, and evaluate cloud computing architecture, infrastructure, and services.
- Cloud monitoring tools help assess the state of a cloud-based infrastructure. These tools track the performance, safety, and availability of crucial cloud applications and services.
- A unified data center manager tool can be an effective tool to monitor data centers.
- Different software components interface with Data Center manager APIs to automate operations.

DC4.4–Case study exercise

Key Objectives

Here are our learning objectives for this module.

- Dig Deeper into the Case Study

Notes Section

Topic Names	Your Notes

Case Study	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Future considerations for CarCo	
Additional Notes	

Key Takeaways:

- CarCo Case Study continued

Unit 5 – New Service Automation

DC5.1– Service & Application Automation

Key Objectives

Here are our learning objectives for this module.

- Describe a service concept and understand what it is
- Explain the importance of the service concept design
- Describe service automation principles
- Explain how service providers can automate their processes for a better user experience.

Potential Exam Topics : Service & Application Automation

- Key parameters of the service concept
- Benefits of Service Automation
- Role of Cloud Orchestration

Notes Section

Topic Names	Your Notes
Service and Application Automation	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
What is a service concept?	
Why is the service concept important?	
Need for Service Automation	
Solution View	

Transformation of OAM architecture	
Start designing automated services	
Example: AR/VR service Automation	
Additional Notes	

Key Takeaways:

- Different processes are grouped together to make a service available for a user.
- Orchestration is paving the path for automated services for users.
- Automation can leverage cloud native functions to reduce manual processes.
- Automated layer steers control and delivers services to the user.

DC5.2– Network Automation

Key Objectives

Here are our learning objectives for this module.

- Explain why network automation is a crucial element for service deployment.
- Describe SDN architecture and implementation in a distributed cloud.

Potential Exam Topics: Network Automation

Here are our learning objectives for this module.

- Describe the SDN Model
- Know main options for virtual network implementation
- Know main options to interconnect private and public clouds?
- Describe the Data Plane, Control Plane, and Management Plane
- Describe the networking concepts of underlay, overlay and isolation

Notes Section

Topic Names	Your Notes
Network Automation	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Why network automation?	
What is SDN?	
Virtual networking: Underlay/overlay concept	

Network automation architecture operational context	
Private cloud SDN inter-connection	
Private and public cloud inter-connection	
Example: Online smartphone gaming	
Additional Notes	

Key Takeaways:

- Network automation is a key enabler of service automation.
- SDN creates the availability of a new networking model.
- When targeting a hybrid cloud deployment, private cloud is interconnected to the public cloud.

DC5.3– Application Life Cycle & Auto-Operations

Key Objectives

Here are our learning objectives for this module.

- Describe the application life cycle and its associated main stages.
- Describe the main auto-operations workflow of running applications, including auto-scaling, auto-healing, and auto-upgrading.

Potential Exam Topics: Application Life Cycle & Auto-Operations

- Know the application life cycle, characteristics and benefits
- Know policy-based auto-scaling
- Know about auto-healing operations
- What is the instantiation stage and other stages of the application life cycle

Notes Section

Topic Names	Your Notes
Application Life Cycle & Auto-Operations	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Workflow on application life cycle	

Main Auto-operations for Running Service	
Auto-Scaling: how does it work today?	
Auto-Healing: how does it work?	
Auto-Upgrade: how does it work?	
Example : continuous security update	
Additional Notes	

Key Takeaways:

- Life Cycle Management brings a well-defined set of operations that enable service management automation.
- For active cloud native applications, the operations are auto-scaling, auto-healing, and auto-upgrading.
- Auto-operations make cloud native applications' life cycle management dynamic and self-sufficient.

DC5.4– AI/ML in Operation Efficiency

Key Objectives

Here are our learning objectives for this module.

- Explain the need for Artificial Intelligence and Machine Learning driven operations in a Distributed Cloud environment, which is especially important for a properly functioning 5G network.
- Describe the closed loop automation.
- Describe the AI/ML based automation architecture.

Potential Exam Topics: AI/ML in Operation Efficiency

- Know about Machine Learning and Artificial Intelligence
- Know about Closed Loop Automation
- Know importance of AI and ML in Service Operations in a Distribute Cloud.

Notes Section

Topic Names	Your Notes

AI/ML in Operation Efficiency	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
New service automation challenges	
Legacy automation limitations	
Distributed Cloud in 5G context	
Typical manual core slice deployment	
User experience is the key driver	
Closed loop automation principle	
AI/ML based Service Automation	
Zoom on the OSS domain	
Additional Notes	

Key Takeaways:

- Artificial Intelligence and Machine Learning based operations are needed to support new service requirements.
- The Closed loop automation principle includes 4 steps, Observe, Orient, Decide, Act.
  - At each step data is exchanged with the knowledge database, which is continuously updated and enriched for future use.
- The AI/ML based service automation architecture has 5 layers.
  - First, the content provider system delivers the application software and requests its deployment.
  - The Marketplace layer then responds to implement the requested service and monitor its performance.
  - The end-to-end Service management layer overlooks services across several network domains. It is responsible for creating and maintaining the network services, based on their committed SLAs.
  - The Domain Management layer is an evolution of legacy Element Management Systems toward a more standardized and multi-vendor approach. As each domain has specific Network Element configuration, monitoring and optimization rules, dedicated domain managers are provided.

- The Network layer provides network and cloud resources to support both Physical and Virtual Network Functions.

DC5.5– Case study exercise

Key Objectives

Here are our learning objectives for this module.

- Dig Deeper into the Case Study

Notes Section

Topic Names	Your Notes
Case Study	Instructions. Type your notes in here. Box will expand to accommodate your text. Note : Select and Delete this comment.
Future considerations for CarCo	
Additional Notes	

Key Takeaways:

- CarCo Case Study continued

Additional Notes Section	Your Notes

Industry Acronyms

The following Industry relevant acronyms may be referenced during the course and on the certification exam. You should become familiar with these terms as the acronym may be used on the certification exam.

Acronym	Meaning
3GPP	3rd Generation Partnership Project
4IR	Fourth Industrial Revolution
5G	5th generation wireless technology
5G GM	5G Grand Master
5G VN	5G Virtual Network
5G-AN	5G Access Network
5G-BRG	5G Broadband Residential Gateway
5GC	5G Core Network
5G-CRG	5G Cable Residential Gateway
5G-EIR	5G-Equipment Identity Register
5G-GUTI	5G Globally Unique Temporary Identifier
5GLAN	5G Local Area Network
5GNR	5G New Radio
5G-RG	5G Residential Gateway
5GS	5G System
5G-S-TMSI	5G S-Temporary Mobile Subscription Identifier
5GTTH	5G to the home
5QI	5G QoS Identifier
A2P	Application-to-person
ACL	Acces List Control
ADM	Add-drop multiplexer
ADS	Advanced Defense Systems
ADSL	Asymmetric digital subscriber line
AF	Application function
AGV	Automated Guided Vehicle
AI	Artificial intelligence
AI/ML	Artificial Intelligence/Machine Learning
AKA	Authentication and key agreement
AMF	Access and mobility management function
AMR	Autonomous Mobile Robot
AN	Access Network
ANR	Automatic Neighbour Relation
API	Application Programing Interface
AR	Augmented reality
AS	Access Stratum
ASIC	Application-specific integrated circuit
ASICS	Application-Spesific Integrated Circuit
ATC	Automated Train Control
ATO	Automated Train Operation
ATSSS	Access Traffic Steering, Switching, Splitting
ATSSS-LL	ATSSS Low-Layer
AuC	Authentication center

AUSF	Authentication server function
AVVO	Advanced Vital Vehicle Operation
BBU	Base Band Unit
BGP	Border gateway protocol
BMCA	Best Master Clock Algorithm
BPaaS	Business Processes as as Service
BSF	Binding Support Function
BTS	Base transceiver station
BVLOS	Beyond Visual Line of Sight
BWP	Bandwidth Part
C2R	Command and Control Room
CA	Carrier Aggregation
CAG	Closed Access Group
CAPEX	Capital Expenditure
CAPIF	Common API Framework for 3GPP northbound APIs
CCAP	Converged cable access platform
CCPA	California Consumer Privacy Act
CCTV	Closed-Circuit TeleVision
CDI	Composable Disaggregated Infrastructure
CHF	Charging Function
CI/CD	Continous Integration/Continous Delivery
CN	PDB Core Network Packet Delay Budget
CNCF	Cloud Native Computing Foundation
CNF	Cloud Native function
CNI	Cloud-Native Network Interface
CoMP	Coordinated Multi-Point
CP	Control Plane
CPE	Customer premise equipment
CPRI	Common public radio interface
CPU	Central processing unit
C-RAN	Cloud RAN or Centralized RAN
CSFB	Circuit Switched Fall back
CSI	Cloud-Native Storage Interface
CSMF	Communication Service Management Function
cSON	Centralized Self-Organizing Network
C-SON	Centralized Self-Organizing Network
CSP	Communication service provider
CT	Communication Technology
CTI	Co-operative Transport Interface
CU	Centralized unit
CU-CP	Centralized Unit - Control Plane
CUPS	Control and user plane separation
CU-UP	Centralized Unit - User Plane

CWDM	Coarse wavelength division multiplexing
D2D	Device to Device communication
DC	Data center
DÉCOR	Dedicated core network
DevOps	Development Operations
DevSecOps	Development Security Operations
DL	Downlink
DL-AoD	Downlink Angle of Departure
DN	Data network
DNAI	DN Access Identifier
DNN	Data Network Name
DoS	Denial of service
DRB	Data Radio Bearer
DRX	Discontinuous Reception
DSCP	Differentiated service code point
DSL	Digital subscriber line
dSON	Distributed Self-Organizing Network
D-SON	Distributed Self-Organizing Network
DSP	Digital Service Provider
DSS	Dynamic Spectrum Sharing
DS-TT	Device-side TSN translator
DU	Distributed unit
DWDM	Dense wavelength division multiplexing
E2E	End-to-End
EAP	Extensible authentication protocol
EBI	EPS Bearer Identity
ECMP	Equal-cost multi-path
eCPRI	Enhanced Common Public Radio Interface
eLTE	Evolved long-term evolution
EMA	Emergency Management Agency
eMBB	Enhanced mobile broadband
EMS	Element Manager System
EMS	Emergency Management System
eMTC	Enhanced machine-type communication
EN-DC	E-UTRAN New Radio Dual Connectivity
EPC	Evolved packet core
ePDG	Evolved Packet Data Gateway
EPS	Evolved Packet System
eSIM	Embedded Subscriber Identity Module
ETSI	European Telecommunications Standards Institute
EUI	Extended Unique Identifier
E-UTRAN	Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access
eVPN	Ethernet virtual private network

FAR	Forwarding Action Rule
FCAPS	Fault Configuration Accounting Performance Security
FCC	Federal Communications Commission
FDM	Frequency Division Multiplexing
FIP	Floating IP
FMS	Fleet Management System
FN-BRG	Fixed Network Broadband RG
FN-CRG	Fixed Network Cable RG
FN-RG	Fixed Network RG
FPGA	Field-Programmable Gate Array
FQDN	Fully Qualified Domain Name
FR	Frequency range
FRMCS	Future Railway Mobile Communication System
FTTH	Fiber to the home
FTTx	any broadband network architecture using optical fiber to provide all or part of the local loop used for last mile
FWA	Fixed Wireless Acces
g.fast	a DSL protocol
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GEO	Geostationary Earth Orbit
GFBR	Guaranteed Flow Bit Rate
GM	General Motors
GMLC	Gateway Mobile Location Centre
gNB	gNodeB
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
GPGPU	General Purpose Graphical Processing Unit
GPON	Gigabit Passive Optical Network
GPSI	Generic Public Subscription Identifier
gPTP	generic Precision Time Protocol
GPU	Graphics processing unit
GSM A	GSM Association
GSM-R	GSM-Rail
GUAMI	Globally Unique AMF Identifier
GW	Gateway
HAP	High Altitude Platforms
HARQ	Hybrid Automatic Request
HD	High Definition
HDR	High Dynamic Range
HEO	Highly Elliptical Orbits
HLR	Home location register

HMI	Human-Machine Interface
HPLMN	Home public land mobile network
HR	Home Routed (roaming)
H-SON	Hybrid Self-Organizing Networks
HSS	Home subscriber server
http/2	HyperText Transfer Protocol version 2
HW	Hardware
IA	Industrial Automation
IaaS	Infrastructure as a Service
IAB	Integrated access and backhaul
ICP	Internet content provider
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IIOT	Industrial IOT
IKE	Internet key exchange
IMEI/TAC	IMEI Type Allocation Code
IMSI	International mobile subscriber identity
IMT	International Mobile Telecommunications
IOT	Internet Of the Things
IP	Internet Protocol
IPSec	Internet protocol security
IPUPS	Inter PLMN UP Security
IPX	Internetwork packet exchange
IS to IS	Intermediate system to intermediate system
I-SMF	Intermediate SMF
IT	Information technology
ITU	International Telecommunications Union
ITU-T	ITU-telecommunication
I-UPF	Intermediate UPF
KPI	Key Performance Indicator
KVM	Kernel-based Virtual Machine
LAA	Licensed Assisted Access
LADN	Local Area Data Network
LAN	Local area network
LBO	Local Break Out (roaming)
LCM	Life Cycle Management
LEO	Low Earth Orbits
LiDAR	Light Imaging Detection and Ranging
lIoT	Industrial Internet of Things
LMF	Location Management Function
LoA	Level of Automation
LOS	Line of SIght

IoT	Internet of Things
LPP	LTE Positioning Protocol
LPWA	Low-Power Wide-Area
LRF	Location Retrieval Function
LTE	Long-term evolution
LTE-M	Long-term evolution machine-type communication
MAA	Massive antenna array
MAC	Medium Access Control
MANO	Management and network orchestration
MBB	Mobile broadband
MCX	Mission Critical Service
MDBV	Maximum Data Burst Volume
MEC	Mobile Edge Computing
MEO	Medium Earth Orbits
MES	Manufacturing Execution Systems
MFBR	Maximum Flow Bit Rate
MICO	Mobile Initiated Connection Only
MIMO	Multiple Input Multiple Output
MiTM	Man in the middle
ML	Machine learning
MI MO	Multiple-input multiple-output
MME	Mobility management entity
mMIMO	Massive multiple input multiple output
mMTC	massive Machine Type Communications
mmW	millimeterwaves
mmWaves	millimeterwaves
MNO	Mobile network operator
MOCN	Mobile operator core network
MPLS	Multi-Protocol Label Switching
MPS	Multimedia Priority Service
MPTCP	Multi-Path TCP Protocol
MR	Mixed Reality
MRO	Maintenance - Repair - Operation
MSC	Mobile Switching Center
MT	Mobile Termination
MTC	Machine-type communication
MU-MI MO	Multiple-user multiple-input multiple-output
MVNO	Mobile virtual network operator
MW	Microwaves (transmission)
N3IWF	Non-3GPP InterWorking Function
N5CW	Non-5G-Capable over WLAN
NaaS	Network as a Service
NAI	Network Access Identifier

NAS	Non Access Stratum
NASA	National Aeronautics and Space Administration
NAT	Network Address Translation
NB-IoT	Narrowband Internet of Things
NEBS	Network Equipment Building System
NEF	Network exposure function
NESAS	Network element security assurance scheme
NF	Network function
NFMF	NF Management Function
NFV	Network Functions Virtualization
NFV MANO	Network Function Virtualization Management and Orchestration
NFV-O	Network function virtualization orchestration
NFV-I	Network function virtualization infrastructure
NFV-MANO	Network Functions Virtualization-Management and orchestration
NFVO	NFV orchestration
NG RAN	New generation radio access network
NGAP	Next Generation Application Protocol
NG-RAN	Next Generation Radio Access Network
NID	Network identifier
NLRI	Network layer reachability information
NOC	Network Operation Center
NPN	Non-Public Network
NR	New radio
NR-DC	New Radio Dual Connectivity
NRF	Network repository function
NR-U	New Radio Unlicensed
NS	Network service
NSA	Non-standalone
NSI	Network Slice Instance
NSMF	Network Slice Management Function
NSSAA	Network Slice-Specific Authentication and Authorization
NSSAI	Network Slice Selection Assistance Information
NSSF	Network slice selection function
NSSI	Network Slice Subnet Instance
NSSMF	Network Slice Subnet Management Function
NSSP	Network Slice Selection Policy
NTN	Non-Terrestrial Network
NVP	Network visibility poisoning
NW	Network
NWDAF	Network data analytics function
NW-TT	Network-side TSN translator (Time Sensitive Networking Bridge)
O&M	Operation and Maintenance
OAM	Operation Administration and Maintenance

Oauth	Open authentication
OLT	Optical Line Termination
ONT	Optical Network Transmitter
ONU	Optical Network Unit
OPEX	Operational Expenditure
OS	Operating system
OSPF	Open shortest path first
OT	Operational Technology
OTP	One-time password
PaaS	Platform as a Service
PC	Personal Computer
PCE	Path computation engine
PCF	Policy control function
PCI	Physical Cell Identification
PCRF	Policy and Charging Rules Function
PCS	Probabilistic constellation shaping
PDB	Packet Delay Budget
PDCP	Packet Data Convergence Protocol
PDR	Packet Detection Rule
PDU	Protocol Data Unit
PEI	Permanent Equipment Identifier
PER	Packet Error Rate
PFD	Packet Flow Description
PGW	Packet Data Network Gateway
PGW-C	Packet Data Network Gateway - Control
PGW-U	Packet Data Network Gateway -User
PHY	Physical layer
PLC	Programmable Logic Controller
PLMN	Public land mobile network
PNF	Physical network function
PNI-NPN	Public Network Integrated Non-Public Network
POM	Production and Operations Management
PON	Passive Optical Network
PPD	Paging Policy Differentiation
PPF	Paging Proceed Flag
PPI	Paging Policy Indicator
ProSe	Proximity Services
PSA	PDU Session Anchor
PSTN	Public switched telephone network
PTP	Precision Time Protocol
QFI	QoS Flow Identifier
QoE	Quality of Experience
QoS	Quality of Service

RACS	Radio Capabilities Signalling optimisation
RAM	Random access memory
RAN	Radio access network
RF	Radio frequency
RG	Residential Gateway
RHF	Redundancy Handling Function
RIC	RAN Intelligent Controller
RIM	Remote Interference Management
RLC	Radio Link Control
RMG	Rail Mounted Granty cranes
ROADM	Reconfigurable optical add-drop multiplexer
RQA	Reflective QoS Attribute
RQI	Reflective QoS Indication
RRC	Radio Resource Control
RSN	Redundancy Sequence Number
Rt	Realtime
RTT	Round-Trip Time
RU	Radio Unit
SA	Standalone
SaaS	Service/Software as a Service
SA-NPN	Standalone Non Public Network
SBA	Service Based Architecture
SBI	Service Based Interface
SCAS	Security assurance specification
SCP	Service Communication Proxy
SCS	Subcarrier Spacing
SD	Slice Differentiator
SDAN	Software defined access network
SDAP	Service Data Adaptation Protocol
SDM	Spatial Division Multiplexing
SDN	Software Defined Network
SD-WAN	Software-Defined Wide Area Network
SEAF	Security Anchor Functionality
SECAM	Security assurance methods
SEPP	Security Edge Protection Proxy
SGW	Serving Gateway
SIDF	Subscription identifier de-concealing function
SIM	Subscriber Identity Module
SLA	Service level agreement
SMF	Session management function
SMSF	Short message service function
SN	Sequence Number
SNPN	Stand-alone Non-Public Network

S-NSSAI	Single network slice selection assistance information
SOAR	Security orchestration automation and response
SOC	Service Operation Center
SOHO	Small Office Home Office
SON	Self-Organizing Networks
SR	Segment routing
SR-TE	Segment routing-traffic engineering
SSB	Synchronization Signal Block
SSC	Session and Service Continuity
SSCMSP	Session and Service Continuity Mode Selection Policy
SSID	Service Set Identifier or network name
SSM	Synchronization Status Messaging
SST	Slice/Service Type
SUCI	Subscription Concealed Identifier
SUPI	Subscription permanent identifier
SV	Software Version
SW	Software
TAM	Total Addressable Market
TCO	Total cost of ownership
TDM	Time Division Multiplexing
TEU	Twenty-foot equivalent unit
TLS	Transport layer security
TNAN	Trusted Non-3GPP Access Network
TNAP	Trusted Non-3GPP Access Point
TNGF	Trusted Non-3GPP Gateway Function
TNL	Transport Network Layer
TNLA	Transport Network Layer Association
TRP	Transmission-Reception Point
TRX	Transceiver
TSC	Time Sensitive Communication
TSCAI	TSC Assistance Information
TSN	Time Sensitive Networking
TSN-FRER	Time Sensitive Networking Frame Replication for Reliability
TSN-GM	TSN Grand Master
TSP	Traffic Steering Policy
TT	TSN Translator
TTI	Transmission time interval
TWIF	Trusted WLAN Interworking Function
UAS	Unmanned Aerial Systems
UCMF	UE radio Capability Management Function
UDM	Unified data management
UDR	Unified data repository
UDSF	Unstructured data storage function

UE	User equipment
UL	Uplink
UL CL	Uplink Classifier
UL-AoA	Uplink Angle of Arrival
UPF	User plane function
URLLC	Ultra Reliable Low Latency Communication
URRP-AMF	UE Reachability Request Parameter for AMF
URSP	UE Route Selection Policy
V2I	Vehicle-to-Infrastructure
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-everything
vApp	Virtual Application
vDAA	Virtualized Distributed Access Architecture
VDSL	Very high speed digital subscriber line
VID	VLAN Identifier
VIM	Virtual Infrastructure Manager
VIP	Virtual IP
VLAN	Virtual Local Area Network
VM	Virtual machine
VNF	Virtual Network Function
VNFM	VNF management
VNF-M	Virtualized network function manager
VOD	Video on demand
VoIP	Voice over internet protocol
VPLMN	Visited public land mobile network
VPN	Virtual Private Network
VR	Virtual reality
vRAN	Virtualized RAN
VVWC	Voltage, Var and Watt Control
VXLAN	Virtual eXtensible LAN
W-5GAN	Wireline 5G Access Network
W-5GBAN	Wireline BBF Access Network
W-5GCAN	Wireline 5G Cable Access Network
W-AGF	Wireline Access Gateway Function
WAN	Wide area network
WDM	Wavelength division multiplexing
WFA	Wireless Fixed Access
Wifi	Wireless Fidelity
WLAN	Wireless LAN
WTTA	Wireless to the antenna
WWC	Wireline-wireless convergence

xDSL	any Digital subscriber Line technology
XG-Cable	10 Gbit/s capable fiber
XG-Fast	(or XG-PON or 10G-PON) 10 Gbit/s Passive Optical Network
XGS-PON	Symmetric 10 Gigabit Passive Optical Network
X-Haul	or Any-haul - comprehensive transport solution front, mid and backhaul.
XML	eXtensible Markup Language
YAML	Yet Another Markup Language
ZSM	Zero touch network & Service Management (from ETSI)