Network as a Service (NaaS) Data Analysis, Business, and Operational Efficiency Methodology

TIP White Paper

Network as a Service (NaaS) Solution Project Group

June 2021

Document version: v1.0

Confidentiality Level: Green [Public Access]

Authors

Amit Dubey

Facebook

adubey@fb.com

Gustavo Castellanos

Network Engineer, Connectivity Deployment, Facebook

gustacaste@fb.com

TIP Document License

Table of Contents

1

Abstract

Abstract

This whitepaper describes a practical methodology to help mobile operators collect, process, and extract valuable information by mining statistical data from the RAN and Transport and management network. Understanding this data will allow service providers to accelerate the integration of new network access technologies and, at the same time ensure high levels of quality of experience (QoE) and optimal TCO of Network as a Service (NaaS) offerings implemented with Site/RAN sharing technologies.

2

Motivations, Challenges, Methodology, and KPIs

Motivations, Challenges, Methodology, and KPIs

Motivation for NaaS and MNOs

As service providers' networks move to use newer technologies in the access, for example introducing 4G or 5G (and ultimately Network Slices), network densification becomes a challenge. In order to operate hundreds or even thousands of new sites in rural/ultra-rural (i.e., small communities) or urban areas (i.e., buildings, malls, airports), service providers need to adapt their operation and business to a more efficient model.

Network as a service (NaaS) brings a new business model in the telecommunications ecosystem to help Service Providers, not only to dramatically reduce the Time to Deploy (TTD) and to optimize CAPEX and OPEX.

By sharing active and passive elements among multiple Service Providers (e.g., Site Sharing, MultiOperator Radio Access Network - MORAN, MultiOperator Core Network - MOCN) NaaSCo can optimize the cost structures by leveraging multi tenancy, site and RAN sharing technologies.

Definitions and responsibility model

NaaSCo: NaaS Company. Owns the access network and might include site, active, and passive components also can provide backhaul network services.

MNO: Mobile Network Operator. This is the NaaSCo customer, own the customer and provide mobile services to end users.

Service Provides: Any company providing telecommunication services to the NaaSCo and MNOs.

3rd Parties: Any company providing services (logistics, project management, consulting) to NaaSCo, MNOs and Service providers.

NaaS Challenges

Even though NaaS fulfills a gap in the service ecosystem, it has its own challenges:

Dealing with multiple access and backhaul networks, different Services Providers, variety of coverage areas, multiple access and core network parameters, multiple service level agreements and having healthy economics imposes their own goals to be satisfied.

This whitepaper describes a practical approach to help NaaSCo with the building blocks to succeed in this market and allows MNOs to understand the main considerations while they are deploying networks via Service Providers or 3rd parties as they are consumed as a service.

This document is based on a real NaaS Provider using MORAN sharing, currently offering rural neutral host services in Latin America for major mobile network operators (MNOs).

Participating Teams

The methodology described in this document was developed in conjunction with the following teams at the NaaS provider:

- **Planning team**. Responsible for all planning and forecasting activities such as site selection and capacity planning.
- **Deployment Team.** Responsible for installing, configuring, and running the acceptance test protocols to bring sites up and running in the network. NaaSCo can also use System Integrators to fulfill this role.
- **Operations team.** Responsible for managing the network, implementing the operation changes or corrective actions, and monitoring the network for data acquisition, testing and verification.
- **Data Analysis team.** Responsible for data analysis, summarization, and presentation via dashboards.
- **Project Management team.** Responsible for tracking project evolution and defining milestones and responsibilities.

Engaging the proper teams to execute the mentioned activities is key to guarantee the success of this methodology.

Methodology description

The methodology used to support the technical and business aspects is based in the following three (3) phases to build a continuous improvement workflow:

1. KPI Definition and Data Collection
2. Analysis and Corrective Actions
3. Results observation via reporting and visualization dashboards

KPI Definition

Selecting the proper KPIs to measure business and performance KPIs not only is key but also challenging in a NaaS environment.

In MORAN scenarios, when the MNO itself provides and owns the Core Network, NaaS provider doesn't have access to charging interfaces (i.e., Gy, Gz) available in the core, hence it is challenging to define business KPIs that provide visibility to user level contribution since this depends on the user profile, service packages and charging models (prepaid, postpaid), so a special set of KPIs must be selected in this case to support Performance and Business KPIs/metrics for the network.

Performance KPIs

3GPP has defined user agnostic KPIs for performance such as:

- Integrity
- Utilization
- Retainability
- Mobility
- Energy efficiency
- Availability
- Quality of Experience (QoE) - End User QoE
- Voice Traffic
- Data Traffic

These KPIs can be used as a baseline but can be modified as required by the NaaS operator to fulfil particular needs. Please refer to Reference [1] for further details about these KPIs. In Reference [3] there is a comprehensive list of KPIs that can be used to expand the current selected KPIs.

Performance KPIs are focused in measuring the health of the network characteristics internally and at user level.

Business KPIs

The second part of the KPI definition is composed of Business KPIs. This set of KPIs is intended to provide information about the business side of the operations giving insights about site economics and profitability for the whole network.

The following KPIs can be used as a reference:

- Area covered
- Total Population Covered
- Number of voice calls
- Data Volume
- OPEX per sector
- Revenues per sector
- OPEX per technology per sector
- Revenues per technologies per sector
- Revenues per Data Traffic
- Revenues per Voice Traffic
- TCO per site (Capex, Opex Analysis) per Service Provider (customer MNO)
- Network TCO for a holistic approach

NaaS should establish well-defined, measurable Business and Performance KPIs to attract more Service Providers to use their infrastructure, and this information should be shared with Commercial and Marketing teams as a sales tool.

See also Reference [2].

3

Data and Analysis

Data and Analysis

Data Collection

Data Collection is the second component in the first step of the methodology and the goal is to define and agree on the data to support and extract the selected Key Performance and Business Indicators to characterize the network.

NaasCo should be able to gather raw data from the following sources:

- From their own management systems (e.g. via reports in NMSs)
- Directly from the Network Elements (e.g., via SNMP or syslog messages)
- From MNOs management systems (e.g., via reports)

Cadence

All supporting data should be collected in the selected cadence/frequency (Daily, weekly, monthly). Cadency/Frequency can be increased as the network operation model gets more maturity, and the final goal is to achieve real time data collection. For example, starting with a bi-weekly collection in the initial phase of network operations and increasing to a daily or near real time collection in further stages. It is up to the NaaS provider to select the cadence that adjusts to the maturity model.

So, as the methodology's implementation evolves in its lifecycle, two data processing approaches can be used:

- **Batch processing.** Since the origin for the different data is sourced from different management systems in SPs and NaaS Networks, the data processing pipeline can be implemented in batch mode and executed in the selected cadence.
- **Realtime processing.** In later stages, real time data processing pipelines can be implemented either on premises or by using the latest services from Cloud providers.

For the NaaS Provider, where this methodology was developed, data collection was based on one (1) week periods. This cadence is recommended when all Network Operation subsystems are in place. However, in the initial phases of the project deployment batch processing with a cadence of (1) month was used.

During the writing of this document, a real time approach using a selected Cloud provider is being deployed with a cadence of 5 mins.

Data Normalization

This activity secures that the data to be processed follows the same format, units, formulas even if they come from different network management systems (i.e., different vendors) so data redundancy and inconsistency are avoided. The most important goal is to normalize the data to support each KPI, so the units, periods, etc., are consistent across the network (same for each SP).

The following parameters should be normalized to use the same units:

- Data Collection Intervals. How often the data is collected.
- Data accuracy, outlier, and unavailable data detection.
- Calculation parameters. i.e., formula used to calculate the KPI.
- Data harmonization. Different equipment vendors might have similar KPIs, but they can be calculated differently.
- Units in term on how the KPI is described. Another important component for data normalization is to select the proper unit with the required granularity to provide meaningful information. For example, KPIs per site can be misleading since bigger infrastructure footprint (higher CAPEX with multiple technologies) trends to have better cumulative indicators than smaller sites (lower CAPEX with single technology). In this case, this analysis suggest using the following normalization factors:
    - Per technology per Sector level
    - Per technology per Power level
    - Per technology per Sector and power level

This will allow to have a fair comparison between sites and will support the classification algorithms more accurately.

Data Disaggregation

Consolidated (Totals/Aggregated) and per-Service Provider (Disaggregated) statistical information should be produced per each individual KPI. Since each Service Provider included in the Site/RAN sharing network has independent life cycles for the technology adoption, starting with data disaggregated per technology and service provider will help to understand the information better, also will allow to create different analysis activities and take different corrective actions per each technology independently in later stages of this methodology.

Site Heatmaps

This methodology proposes to use a simple heatmap to classify the sites based on both Performance and Business KPIs. These heatmaps can be used for each individual KPI or as a holistic view for an aggregated summary for all KPIs.

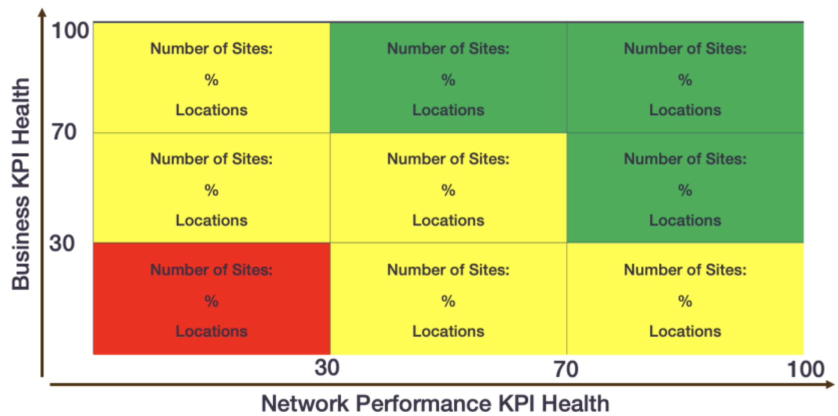

Figure 1 - Network Heatmap

Heatmaps are a great tool to have a view on how the sites are performing and helps in selecting the corrective actions to move the sites from one quadrant to another as the NaaS operator deploys corrective actions depending on the observed distribution.

It is recommended to have heatmaps per technology, per service provider and overall/totals to visualize different views for the KPIs.

Analysis and Corrective Actions

Analysis

The main activities for the analysis are:

- Group the different network nodes per technology in the corresponding heatmap quadrants for each KPI under review.
- Identify the root cause analysis and possible corrective action(s)
- Canary Deployment. Select a few sites to validate the selected corrective action(s).
- Corrective Action Implementation (Massive deployment)

Classification

Depending on the maturity level on implementing this methodology, manual and/or automated activities can be used. It is up to the NaaS provider to select the most appropriate method. The end target of this activity is to classify each site in its corresponding quadrant based on the current performance and business KPIs.

The initial recommendation is to group the sites in two axis (performance and business) and distribute each KPI in their groups (<=30%, >30% and <=60, >60 and <=100%), this approach will have nine (9) quadrants to distribute the nodes, however in early stages a lower granularity heatmap can be used, for example <=50% and >50% to simplify the process. This scenario will have lower granularity with only four (4) quadrants.

Note 1: the ranges will vary depending on the units defined for each KPI. In this example a KPI with percentage unit has been used as a reference.

Note 2: heatmaps can be created on a per KPI basis however the NaaSCo is free to create an aggregated heatmap by combining different KPIs in one chart. This can be achieved by giving the same weight to the KPIs under review or giving different weights to the KPIs for a prorated analysis.

Root Cause Analysis and Corrective Action

Once the heatmap has been defined, the data analysis should lead into identifying the root cause for the low performing sites. In this particular case as shown in Figure 2, the operations team managed to identify an issue with the QoS profiles applied to these 693 3G sites. In this particular case, different traffic flows with different priorities were being sent to the same output queue. Where congestion was present, some packets from the higher priority traffic were discarded.

Figure 2 - Actual Heatmap for 3G Sites

Performing root cause analysis is a complex task and needs multiple iterations to identify and segregate the core issue. Since there may be several factors contributing to the degradation on any particular site, we have to consider a layered approach and define a methodology. Analytics helps us identify failures and mapping failure signatures with related KPIs is what we plan as an end deliverable for an RCA.

The heatmap above highlights 286 sites in the lower left quadrant (shown in red). This data is an example from a live NaaS network. The heatmap describes and implies the following:

- **Problem**: Accessibility and availability are severely degraded on several 3G sites, the majority of them using satellite backhaul.
- **A Temporary Workaround**: The operations team had been resolving most of the issues by restarting the VLANs. However, this was not a sustainable solution and the core issue diagnosis remained out of reach.
- **Strategy and RCA details**: There were few transmission and energy issues to identify. But more broadly, this was a network-wide problem on 3G sites. The analysis initially sought to understand the 3G traffic flow and identify any bottleneck contributing to loss of traffic.

Control plane and user plane traffic distribution were evaluated, along with DSCP markings. Packets were analyzed to be sure the RNCs were correctly marking them. Wireshark logs were captured and analyzed to debug the issue. This captured and confirmed the volume of traffic being routed using different DSCP markings. The mapping between PHB (Per Hop Behavior) to DSCP was verified. Finally, the packet inspection revealed that DSCP48 was being used for signaling carrying more than 50% of total inbound traffic.

The analysis of the data determined that the same VLAN was being used for Control and User plane traffic depending on the protocol. Control Plane (CP) traffic was using DSCP48 on COS1, and User Plane (GTP-U) was also DSCP 48. Hence, the mixing of user and control plane traffic in the same traffic queue on COS1 resulted in destabilization of site availability and accessibility KPIs. There were 2 options proposed in the solution statement:

1. Mark GTP-U used for UP with another DSCP
2. Create rule based on combination of IP, DSCP and VLAN ID to make the target Destination IPs in CoS2

A new QoS profile was defined and validated to secure the proper QoS treatment for the 3G control traffic in the network. This corrected the issue. This profile was designed to send higher priority traffic (3G Control Traffic) to a higher priority queue and keep the lower priority traffic (3G User Plane Traffic) in the current queue.

Canary Deployment

The proposed new QoS profile was fine-tuned and validated initially in a few sites. It is NaaS responsibility selecting the number of sites for Canary deployment. This varies depending on the number of total sites in the network or the technology mix where action will be taken.

Corrective Actions Implementation

Once the heatmap describing the current network state is defined, the next step is to implement the corrective action and track how the heatmap changes during the implementation of the fix.

This phase will deploy the corrective action in the target population of nodes for the whole network.

Figure 2 above shows an actual heatmap for the mentioned 3G sites during the implementation of a corrective action (applying a new QoS profile) indicating:

- Quadrant 1 - 41% (286) of the sites still to be migrated with the new QoS Profile having low performance and business KPIs (<30%).
- Quadrant 5 - 57% (397) of the sites still to be migrated with the new QoS profile having average performance and business KPIs (>30% - <=60%).
- Quadrant 9 - 2% of the sites already migrated (>60%)

Target KPIs for nodes after the migration (Quadrant 9) will offer the following improvements:

- Accessibility KPI of 95+%
- Unavailability KPI of 0 sec
- Connected Users KPIs with an increase of 100%

The affected three KPIs are used as an example.

It is expected that after completion, all sites should be part of the top performing nodes for the specified KPIs, in this case, accessibility, unavailability, and connected users.

If heatmap is not showing any improvement, a new root cause analysis would be required, and new corrective actions would need to be implemented until the affected KPIs achieve the desired levels.

Pre and Post Corrective Action Analysis

Besides tracking the heatmaps, it is also important to track how the corrective action is impacting the particular KPI. This can be executed in the following steps, and it is applicable to all affected KPIs:

1. Capturing current data (before implementing corrective action)
2. Implementing changes in a specific date and time
3. Capturing new data (after implementing corrective action)

Figure 3 below shows an actual data capture and visualization for the availability KPI in a site with multiple sectors (each sector with an specific color) before and after the recommended corrective action. The black dotted line identifies the exact time when it was applied.

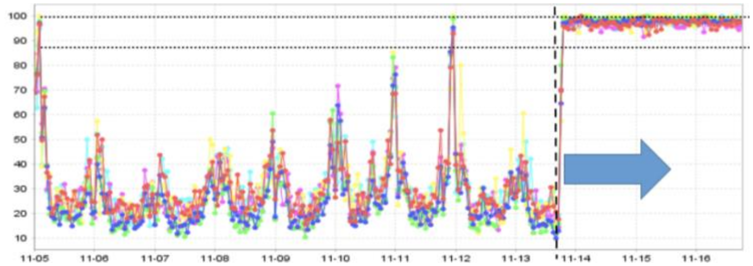

Figure 3 - Pre and Post Data analysis after corrective actions

By using these visualization dashboards, it is easy to identify the impact of the changes in the specific KPI and translate a performance KPI into a business KPI to assess the economic impact in the TCO.

Heatmaps should be recalculated after a set of changes have been made in the network for tracking purposes, for example, during the implementation and after finishing the implementation.

Other factors considered in the analysis phase are:

- Site Economics
- Site Selection

Site Economics

Site economics cover all relevant aspects to improve Business KPIs and its impact on the TCO.

Given its extension, the authors have covered this topic in a different document [7], so this document has a technical approach to Performance KPIs and its direct impact on Business KPIs. The reference document explains in detail all business aspects considered in this methodology and how to improve Business KPIs.

Performance KPIs Corrective Actions

Degradation and Improvement of Performance KPIs are based mostly in how the packet network is performing at radio and transport network levels.

Here the most relevant components that impact the Performance KPIs:

- End to End quality of service schema. [4]
- Power consumption.
- Radio Interference and coverage.
- Backhaul Traffic Engineering.
- Quality of Experience (QoE)

End to End Quality of Service Schema

One of the most significant challenges NaaS operators face is dealing with a very fragmented network when it comes to end to end quality of service approach. Multiples backhaul and IP transport networks (Microwave, Satellite, Fiber, NLOS) need to work together to guarantee all flows and their quality of service are preserved and enforced in all interfaces and nodes as the frames/packets flow through the network. Hence in this methodology the End to End Quality of Service Schema is treated as a separated item to take care of, since it will require participation and agreement from different parties such as: vendors, backhaul service providers and the service providers.

This methodology used the “Quality of Service Recommendations for Mobile Networks” [4] publication available in the TIP NaaS website as a reference design.

NaaS Providers can use this reference to develop their own E2E QoS Schema that fits a particular network architecture and network segments.

Power Consumption

Power consumption affects the OPEX and site economics for the site and for the whole network and also the Radio performance. During the development of this methodology the following alternatives were considered to lower the power consumption on the sites to improve Business KPIs:

- Lowering radiated power over low utilization periods (i.e., from 10Watts to 1Watt)
- Turning the site off during zero utilization periods

Looking at the other side of the coin, some alternatives were considered to improve the network utilization during these low utilization ranges such as:

- Working with Service providers marketing teams to create Service Plans to encourage network utilization at nights or low utilization periods
- Transfer all collected statistical data during the day over these periods and avoid doing it during high utilization periods to improve the capacity for the actual user traffic during rush hours
- Distribute new software images and network patches and other activities that can be scheduled on during these periods
- Delay Smartphone/UE OS or App updates during low utilization periods

Radio Interference and coverage

After the RAN shared site is installed and all components are up and running, it is important to guarantee all radio parameters (Power, Interference, antenna alignment and coverage) are properly validated so optimal network KPIs can be achieved and monitored per site.

During the development of this methodology, two references main were used to secure the best radio and backhaul performance, these are:

- Total Site Solution Site Installation Runbook (SIR) [5] and
- Total Site Solution - Field Trial Plan SSD, SSV and Soak testing [6]

Extract the relevant sections that are applicable to a particular use case and execute the site verification and drive test to achieve optimal performance and use this as baseline for future analysis.

These documents use 4G RAN and Satellite backhaul, but the testing and acceptance protocols can be easily extrapolated to other technologies such as 2G, 3G and Microwave or Fiber among others.

Backhaul Traffic Engineering

Backhaul Network engineering is crucial for a NaaS operator to secure a good business case since it is one of the most important components of the site's OPEX.

Regardless the backhaul technology, here there is a list of major activities that NaaS need to develop:

- Capacity planning
- Fair Usage
- Bandwidth Throttling
- Peak allocation (CIR, EIR)
- Congestion Management

Once a NaaS provider is able to define the technical requirements to secure a proper capacity on their transport networks, a fine granularity analysis should be done to correlate the traffic usage with the different charging models offered by their transport service providers including:

- Flat rate charging (i.e., used for 2G or voice services)
- Volume based charging (i.e., used in 4G data services)
- Guaranteed and Excess charging (i.e., CIR and EIR volume costs)

Deeper review on this topic is out of the scope of the methodology and it is the responsibility of the Naas to define it.

Quality of Experience (QoE)

All the corrective actions will have an impact on how the network is perceived from the user's perspective. This methodology also considers measurements for Quality of experience to track how the services are impacted in a positive or negative way by the corrective actions.

Some of the parameters than can be measure at user level are:

- Average Throughput

- Average latency

This information can be captured for the different planes in the network such as Control Plane (Signaling Traffic) and Data Plane (User Data traffic).

The NaaS provider in this methodology used TEMS (Test Mobile System) devices to capture the relevant information.

Reporting and Visualization Dashboards

Most of the time, providing a good idea of the meaning of the data in a visual form is challenging and in some other cases can lead to misinterpretation, so selecting the proper data and visual representation is a key factor to succeed when this methodology is used.

For example, when the data is changing often selecting the proper time scale will give a better understanding of the collected data and the information behind it.

Data Presentation

Each NaaS provider will be interested in having different views of the collected data. After few iterations, during developing this methodology the authors found relevant to segregate the data in the following main groups:

- **MNO View.** It is ideal to have a view for each KPI for each individual Service Provider participating in the RAN sharing model. This will allow each MNO to manage their own view about the network and also will show to the NaaS operator, the particular contribution in the overall performance and business KPIs. This information should be shared with the MNOs in periodic reviews.
- **Consolidated View**. This is an aggregated view mainly focused on summarizing, to the NaaS provider, the overall network and business performance.

This cover the following areas:

- KPI visualization
- Heatmaps
- Pre/Corrective Action/Post dashboards

Reporting and Visualization Scope

In the beginning of the methodology implementation, NaaS providers can be overwhelmed to get relevant information for all available KPIs. To support a smooth process, it is recommended to start looking at the data backwards and only for a selected group of KPIs.

By analyzing the data of the last week, last month, last quarter, the NaaS provider can execute the proper network optimization activities and as the process goes, keep adding two or three new KPIs every month. Depending on the resources available to implement the methodology, this process can take one or two months or can be extended to a maximum recommended period of six (6) months.

In the final phase of the deployment of this methodology supported with a near real time data collection cadence, new goals are being defined on the reporting and visualization scope to cover event prediction and forecasting in the following areas:

- Near real time reaction (Closed loop management) to external events that impact the network utilization such as special events, special dates, people gatherings, weather conditions, natural disasters among others
- Site selection forecasting based on population growth
- Network Failures Prediction (Alarms, failures)
- Bandwidth growth planning (Capacity planning)
- Revenue growth

4

Summary

Summary

NaaS providers can achieve their business objectives by following a systematic approach to optimize the network at performance and business.

This methodology is a foundation on implementing planning and operation activities between different stakeholders to successfully manage a network deployment via Site and RAN sharing and it can be scaled down or scaled up to meet the particular needs of a Service Provider interested in deploying an offering with the NaaS concept.

References

[1] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Management and orchestration; 5G end to end Key Performance Indicators (KPI) (Release 16)

[2] 100 KPI’s for Mobile Telecom Operators

[3] The Ultimate Guide to Mobile App KPIs in 2021

[4] Quality of Service Recommendations for Mobile Networks. Telecom Infra Project NaaS. Jan 2021.

[5] Total Site Solution - Site Installation Runbook (SIR). Telecom Infra Project.

[6] Total Site Solution - Field Trial Test Plan SSD, SSV and Soak Testing. Telecom Infra Project.

[7] NaaS - Site Economics. Telecom Infra Project.

Glossary

A

AAA – Authentication, Authorization and Accounting

APN – Access Point Name

Apps – Applications

ACL – Access Control List

B

BA – Behavior Aggregate

BGP – Border Gateway Protocol

BTS – Base Transceiver Station

BW – Bandwidth

C

CBH - Catalyzer Bed Heaters

CBS – Committed burst size

CP – Control Plane

CIR – Committed information Rate

CoS – Class of service

CS – Circuit Switching

CSC – Carrier Supporting Carrier

CSR – Cell Site Router

CSG – Cell Site Gateway

CSPF – Constrained Shortest path First

D

DEI – Discard Eligibility Indicator bit

DHCP – Dynamic Host Configuration Protocol

DP – Data Plane

DSCP – Diff Service Code Point Field/Architecture

E

EBS – Excess Burst Size

EIR – Excess Information Rate

eNodeB – Evolved Node B in 3GGP 4G architectures

EPC – Evolved Packet Core

EVPN – Ethernet Virtual Private Network

EXP – Experimental Bits in MPLS Label

F

FACH – Forward Access Channel

FCS – Frame Check Sequence

FEC – Forward Error Correction

G

3GPP – 3rd Generation Partnership Project

GBR – Guarantee Bit Rate Service

GGSN – Gateway GPRS Support Node

GPRS – General Packet Radio Service

GRE – Generic Routing Encapsulation

GTP – GPRS Tunneling Protocol

GWCN – Gateway Core Network

H

H-QoS – Hierarchical Quality of service

I

IETF – Internet Engineering Task Force

IMS – IP Multimedia Subsystem

IP – Internet Protocol

IpT – Internet Para Todos in Peru

Ipsec – Internet Protocol Security

IS-IS – Intermediate System to Intermediate System Protocol

K

Kbps – Kilobits per second

KB – Kilo bytes

L

LDAP – Lightweight Directory Access Protocol

LBM – Loopback Messages

LBR – Loopback Replay Messages

LTM – Link Trace Messages

LTR – Link Trace Reply messages

LTE – Long Term Evolution (3GPP 4G Architecture)

M

MAC – Media Access Control

MEP – Management End Point

MEF – Metro Ethernet Forum

MetroE – Metro Ethernet Network

MME- Mobility Management Entity

MOCN – Multi Operator Core Network

MORAN – Multi Operator Radio Access Network

MPLS – Multiprotocol Label Switching

Msec – Milliseconds

MSS – Maximum Segment Size

MTU – Maximum Transmit Unit

N

NTP – Network Time Protocol

O

OSPF – Open Shortest Path First Protocol

O&M – Operations and Maintenance

OML – Organizational and Maintenance Link

P

PCH – Paging Channel

PCP – Priority Code Point

PCRF – Policy Control and Resource Function

P Router – Provider Router in a MPLS architecture (Core Node)

PE Router – Provide Edge Router in a MPLS architecture (Edge Node)

P-GW – Packet Gateway

PHP – Per Hop Behavior

Prio – Priority

PTP – Precision Time Protocol

PQ – Priority Queueing

Q

QCI – QoS Class Identifier

QoS – Quality of Service

QoE – Quality of Experience

R

RAN – Radio Access Networks (3GPP 2G, 3G, 4G, 5G, IEEE Wi-Fi)

RACH – Random Access Channel

RBS – Radio Base Station

RED – Random Early Discard

RFC – Request for Comments

RTN – Return Channel, Retro Television Network

RTC – Real time communications

RCS – Rich Communication System

RSL – Radio Signaling Link

RSVP – TE – Resource Reservation Protocol – Traffic Engineering

S

SIP – Session Initiation Protocol

SIP-I – Session Initiation Protocol - Interworking

S-GW – Serving Gateway

SGSN – Serving GRPS Support Node

SFTP – Secure File Transfer Protocol

SLA – Service Level Agreement

Sync – Synchronization

T

TCP – Transmission Control Protocol

3PP – Third Party Product

U

UE – User Equipment

UDP – User Datagram Protocol

V

VoD – Video on Demand

VoIP – Voice Over IP Protocol

VoQ – Virtual Output Queueing

VLAN – Virtual Local Area Network

VPLS – Virtual Private Line Service

VSAT – Very Small Aperture Terminal

W

Wi-Fi – Wireless Fidelity

WFQ – Weighted Fair Queuing

WRED – Weighted Random Early Discard

WRR – Weighted Round Robin

X

X2 – X2 3GPP Interface