Integrating StratusWorX Workspace App with 5G Services

Fifth-generation wireless (5G) is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. With 5G, data transmitted over wireless broadband connections could be communicated at rates as high as 20 Gbps by some estimates -- exceeding wireline network speeds -- as well as offer latency of 1 millisecond or lower for uses that require real-time feedback. 5G will also enable a sharp increase in the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology.

In addition to improvements in speed, capacity and latency, 5G offers network management features, among them network slicing, which allows mobile operators to create multiple virtual networks within a single physical 5G network. This capability will enable wireless network connections to support specific uses or business cases and could be sold on an as-a-service basis.

This document provides an overview of the Quality of Service (QoS) components offered by 5G networks, and how the Stratus Workplace App can leverage these 5G QoS capabilities to *better offer ultra-secure, high performance & cost-effective cloud compute services on a anytime, anywhere and on any device (any-any-any) basis.*

5G System Architecture

The following figure illustrates the 5G System architecture in the non-roaming case, using the reference point representation showing how various network functions interact with each other.

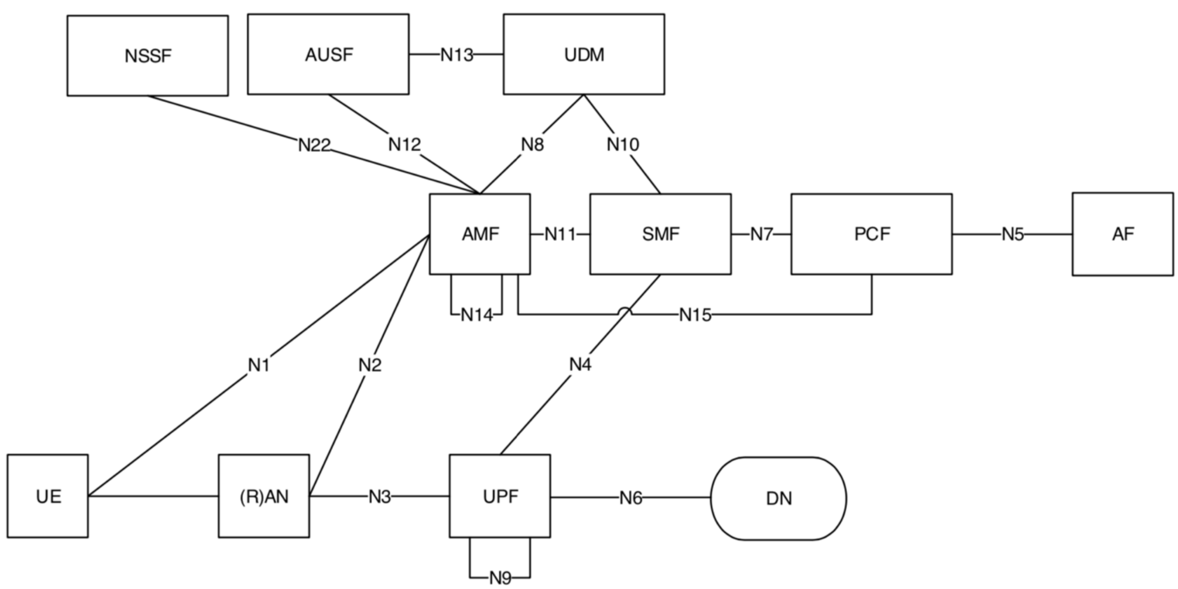

Figure 4.2.3-2: Non-Roaming 5G System Architecture in reference point representation

Abbreviation:

AUSF: Authentication Server Function

NSSF: Network Slice Selection Function

UDM: Unified Data Management

AMF: Access and Management Mobility Function

SMF: Session Management Function

PCF: Policy Control Function

AF: Application Function

UE: User Equipment (UE)

(R)AN: (Radio) Access Network

UPF: User Plane Function

DN: Data Network

5G QoS Model

The 5G QoS model is based on QoS flows. There are two major kinds of QoS flows, which are ones that require guaranteed flow bit rate (GBR QoS flows) and ones that do not require guaranteed flow bit rate (Non-GBR QoS Ffows).

The QoS Flow is the finest granularity of QoS differentiation in the Protocol Data Unit (PDU) Session. A QoS Flow ID (QFI) is used to identify a QoS Flow in the 5G System, which means User Plane traffic of the same QFI in a PDU Session receives the same forwarding operations. The QFI does not change the E2E packet header but is encapsulated in the header of N3 (or N9) packet. The QFI shall be used for all PDU Session Types and be unique within a PDU Session.

QoS Flow

A QoS flow is controlled by the Session Management Function (SMF). It may be preconfigured, or established via the PDU Session Establishment procedure, or the PDU Session Modification procedure.

Any QoS Flow is characterized by

- A QoS profile provided by the SMF to the Access Network (AN) via the AMF over N2 or preconfigured in the AN;
- One or more QoS rule(s) which can be provided by the SMF to the UE via the AMF over N1 and/or derived by the UE by applying Reflective QoS control; and
- One or more UL and DL Packet Detection Rules (PDRs) provided by the SMF to the UPF.

QoS Profile

A QoS Flow may be either GBR or Non-GBR depending on its QoS profile. The QoS profile of a QoS Flow is sent to AN and the QoS parameters within include the followings:

For each QoS Flow, the QoS profile shall include

- A 5G QoS Identifier (5QI),
- An Allocation and Retention Priority (ARP).

For each Non-GBR QoS Flow, the QoS profile may include

- Reflective QoS Attribute (RQA).

For each GBR QoS Flow, the QoS profile shall include

- Guaranteed Flow Bit Rate (GFBR) - UL and DL,
- Maximum Flow Bit Rate (MFBR) – UL and DL.

For each GBR QoS Flow, the QoS profile may also include

- Notification control,
- Maximum Packet Loss Rate - UL and DL.

Each QoS profile has one corresponding QFI which is not included in the QoS profile itself.

QoS Rule [1,2]

The UE classifies and associates UL traffic to QoS Flows, based on QoS rules. These QoS rules may be explicitly provided to the UE, pre-configured in the UE, or implicitly derived by the UE by applying Reflective QoS. A QoS rule contains the QFI of the associated QoS Flow, a Packet Filter Set, and a precedence value. An explicit QoS rule contains a QoS rule identifier which is unique within the PDU Session and is generated by SMF.

There can be more than one QoS rule associated with the same QoS Flow. When the UE informs the network about the number of supported Packet Filters for explicit QoS rules for the PDU Session, the SMF shall ensure that the sum of the Packet Filters used by all signaled QoS rules for a PDU Session does not exceed the number indicated by the UE.

A default QoS rule is required to be sent to the UE for every PDU Session establishment and it is associated with a QoS Flow. For IP type PDU Session or Ethernet type PDU Session, the default QoS rule is the only QoS rule of a PDU Session. For Unstructured type PDU Session, the default QoS rule does not contain a Packet Filter Set.

QoS Flow Mapping

The SMF performs the binding of Service Data Flows (SDFs) to QoS Flows based on the QoS and service requirements. The SMF assigns the QFI for a new QoS Flow and derives its QoS profile, corresponding UPF instructions and QoS Rule(s) from the Policy and Charging Control (PCC) rules and other information provided by the PCF.

The SMF provides the QoS related information to

- (R)AN
- UPF
- UE

The principle for classification and marking of User Plane traffic and mapping of QoS Flows to AN resources is illustrated in the following figure.

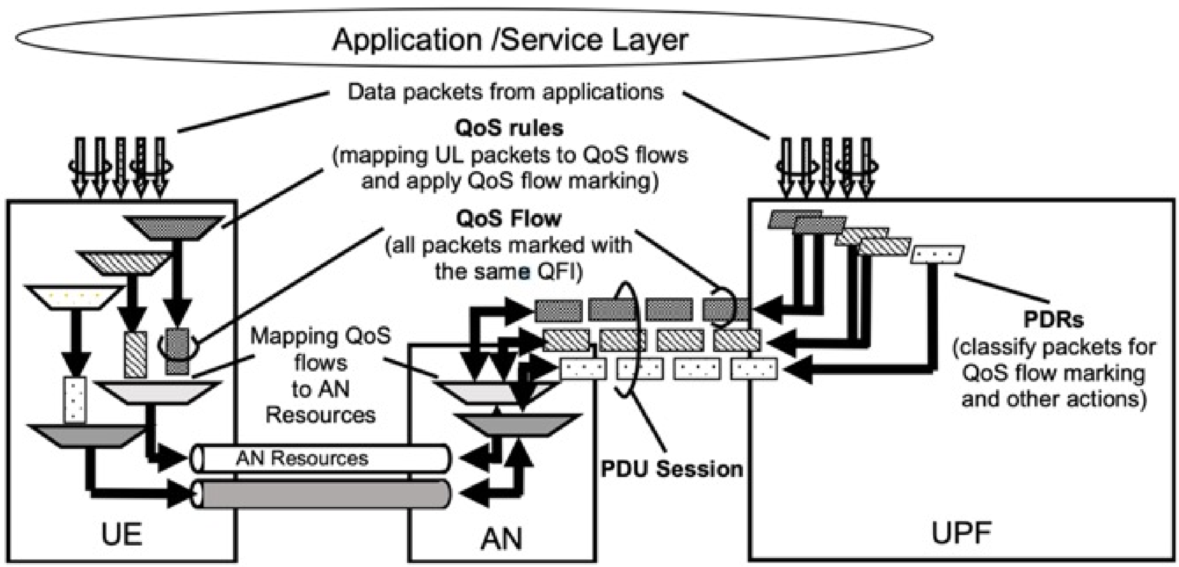

Figure 5.7.1.5-1: The principle for classification and User Plane marking for QoS Flows and mapping to AN Resources

Figure: Diagram from 5G System Architecture document [1].

5G QoS Parameters

The 5G QoS parameters include the followings.

- 5QI: a scalar that is used as a reference to 5G QoS characteristics
- ARP: contains information about the priority level, the pre-emption capability and the pre-emption vulnerability.
- Reflective QoS Attribute (RQA): an optional parameter which indicates that certain traffic carried on this QoS Flow is subject to Reflective QoS
- Notification control: indicates whether notifications are requested from the NG-RAN when the GFBR can no longer (or can again) be guaranteed for a QoS Flow during the lifetime of the QoS Flow.
- Flow Bit Rates: for GBR QoS Flows only, include Guaranteed Flow Bit Rate (GFBR) - UL and DL, and Maximum Flow Bit Rate (MFBR) -- UL and DL.
- Aggregate Bit Rates: include per Session Aggregate Maximum Bit Rate (Session-AMBR) for each PDU Session of a UE, and per UE Aggregate Maximum Bit Rate (UE-AMBR) for each UE.
- Default values: for the 5QI and the ARP priority level and optionally, the 5QI Priority Level
- Maximum Packet Loss Rate (UL and DL): indicates the maximum rate for lost packets of the QoS flow that can be tolerated in the uplink and downlink direction.

5G QoS Characteristics

The 5G QoS characteristics are associated with 5QI. They describe the packet forwarding treatment that a QoS Flow receives edge-to-edge between the UE and the UPF.

- Resource type: can be either GBR, Delay critical GBR, or Non-GBR.
- Priority level: It indicates a priority in scheduling resources among QoS Flows. It is used to differentiate between QoS Flows of the same UE and differentiate between QoS Flows from different UEs. The lowest Priority level value corresponds to the highest Priority.
- Packet Delay Budget (PDB): It defines an upper bound for the time that a packet may be delayed between the UE and the UPF.
- Packet Error Rate (PER): It defines an upper bound for the rate of PDUs that have been processed by the sender of a link layer protocol but that are not successfully delivered by the corresponding receiver to the upper layer. The purpose of the PER is to allow for appropriate link layer protocol configurations.
- Averaging Window: It is for GBR QoS Flows only. It represents the duration over which the GFBR and MFBR shall be calculated.
- Maximum Data Burst Volume (MDBV): Each GBR QoS Flow with Delay-critical resource type shall be associated with an MDBV. It denotes the largest amount of data that the 5G-AN is required to serve within a period of 5G-AN PDB.

Standardized 5QI to QoS characteristics mapping

Standardized 5QI values are specified for services that are assumed to be frequently used and thus benefit from optimized signaling by using standardized QoS characteristics. Dynamically assigned 5QI values can be used for services for which standardized 5QI values are not defined. The following table shows the one-to-one mapping of standardized 5QI values to 5G QoS characteristics.

5QI Value	Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default MDBV	Default Averaging Window	Example Services
1	GBR	20	100ms	10^-2	N/A	2000ms	Conversational Voice
2		40	150ms	10^-3	N/A	2000ms	Conversational Video (Live Streaming)
3		30	50ms	10^-3	N/A	2000ms	Real Time Gaming, V2X messages, Electricity distribution-medium voltage, Process automation-monitoring

4		50	300ms	10^-6	N/A	2000ms	Non-Conversational Video (Buffered Streaming)
65		7	75ms	10^-2	N/A	2000ms	Mission Critical user plane Push to Talk voice
66		20	100ms	10^-2	N/A	2000ms	Non-Mission-Critical user plane Push To Talk voice
67		15	100ms	10^-3	N/A	2000ms	Mission Critical Video user plane
75							
5	Non-GBR	10	100ms	10^-6	N/A	N/A	IMS Signalling
6		60	300ms	10^-6	N/A	N/A	Video (Buffered Streaming), TCP-based
7		70	100ms	10^-3	N/A	N/A	Voice, Video (Live Streaming), Interactive Gaming
8		80	300ms	10^-6	N/A	N/A	Video (Buffered Streaming), TCP-based
9		90					
69		5	60ms	10^-6	N/A	N/A	Mission Critical delay sensitive signaling
70		55	200ms	10^-6	N/A	N/A	Mission Critical Data
79		65	50ms	10^-2	N/A	N/A	V2X messages
80		68	10ms	10^-6	N/A	N/A	Low Latency eMBB applications, Augmented Reality

82	Delay Critical GBR	19	10ms	10^-4	255bytes	2000ms	Discrete Automation
83		22	10ms	10^-4	1354bytes	2000ms	Discrete Automation
84		24	30ms	10^-5	1354bytes	2000ms	Intelligent transport systems
85		21	5ms	10^-5	255bytes	2000ms	Electricity Distribution-high voltage

Reflective QoS

Reflective QoS enables the UE to map UL User Plane traffic to QoS Flows without SMF provided QoS rules. It applies for IP PDU Session and Ethernet PDU Session and is achieved by creating UE derived QoS rules in the UE based on the received DL traffic. It is possible to apply Reflective QoS and non-Reflective QoS concurrently within the same PDU Session.

If a UE supports Reflective QoS functionality, the UE shall create a UE derived QoS rule for the uplink traffic based on the received DL traffic if Reflective QoS function is used. The UE shall use the UE derived QoS rules to determine mapping of UL traffic to QoS Flows.

If a UE supports Reflective QoS functionality, the UE should indicate support of Reflective QoS to the network (i.e. SMF) for every PDU Session.

Packet Filter Set

The Packet Filter Set is used in the QoS rule and the PDR to identify one or more packet (IP or Ethernet) flow(s). The Packet Filter Set may contain one or more Packet Filter(s). Every Packet Filter is applicable for the DL direction, the UL direction or both directions. There are two types of Packet Filter Set, i.e. IP Packet Filter Set, and Ethernet Packet Filter Set, corresponding to those PDU Session Types.

An Approach to integrate the Stratus Workplace App with 5G Systems

1. QoS management approach

Suppose there is a UE that is using the Stratus Workplace App, connected to the Internet over a 5G network. To best leverage the QoS properties that this application desires, ideally we would need a Service Data Flow (SDF), which corresponds to a QoS flow, configured for the application's traffic flow. These flows will be mapped to specific PDU sessions by the SMF. The SMF derives the QoS profile of each QoS flow based on the PCC rules and other information provided by the PCF. For these flows, its QoS profile says it is a GBR QoS Flow with assigned 5QI equals to 2, specified ARP, uplink and downlink GFBR and MFBR, notification control, and uplink and downlink Maximum Packet Loss Rate. The appropriate QoS profiles is provided to the AN via the AMF by the SMF.

The SMF then provides the UPF with the Packet Detection Rules (PDRs) for mapping SDFs to the QoS flows. The PDRs include the information of UE IP address, Application ID, QoS Flow ID, etc. The video conferencing application and the remote desktop application have different Application ID and QoS Flow ID, hence can be distinguished at UPF. After the next-generation Node B (i.e., gNB) of AN receives the two QoS profiles, the gNB can map the QoS Flows to two different Data Radio Bearers (DRBs) of the radio interface, i.e., the AN resources in Figure 1. The AMF conveys the QoS rules to the UE to aid in mapping SDF flows to 5G QoS Flows and correct DRBs.

The DRBs at AN can be considered as multiple (priority) queues with a scheduler. The scheduler guarantees that the video conferencing flow receives its desired GFBR, MFBR, etc. If the resources cannot guarantee the performance required by the video conferencing application, it will pre-empt the resource allocated to remote desktop application, according to the ARP of the QoS profile of the video conferencing flow and that of the remote desktop flow. If the resources are still not enough to fulfill the requirements, the AN will be notified that the desired performance cannot be satisfied.

2. Network slicing approach

Different from the network setting in the previous method, in a network slicing based approach, we have an opportunity to create multiple network slices. For example, one slice could be reserved for mobile broadband service with SST (Service Slice Type) value equals to 1, and the other slice for ultra-reliable low latency communications service with SST value equals to 2. The AMF instance that is serving the UE is common (or logically belongs) to all the Network Slice instances, but other network functions, such as the SMF or the UPF, may be specific to each Network Slice.

As part of the UE registration procedure, the AMF receives the registration request from the UE and retrieves the slices that are allowed by the user subscription. The AMF interacts with the NSSF and the NSSF returns the two aforementioned Network Slices.

The process to setup two QoS Flows and the corresponding PDU sessions is the same as the previous method, but here each PDU Session is associated to one S-NSSAI (Single Network Slice Selection Assistance Information) and one DNN (Data Network Name). Using our examples of multiple flows, e.g., one supporting a video conferencing application and another being the Stratus Workplace application, we can map them to the two different network slices.

The establishment of a PDU session within the selected instances-NSSAI is triggered when the AMF receives a Session Management message from UE. The AMF discovers candidate SMF using multiple parameters including the S-NSSAI provided in the UE request and selects the appropriate SMF. The selection of the UPF is performed by the SMF and uses the S-NSSAI. The NRF (Network Repository Function) is used for the discovery of the required NFs (Network Functions) using the selected Network Slice instance. The data transmission can take place after a PDU session to a DN is established in a network slice. The S-NSSAI associated with a PDU Session is provided to the AN, and to the policy and charging entities, to apply slice specific policies. By separating the two services to different network slices, contention and preemption between the different contending applications due to resource shortage within a network slice is mitigated. This is the benefit of utilizing network slicing in addition to QoS features within the 5G networks.

Thus, overall it is possible to combine the two approaches in interesting ways to create new ways of realizing even greater benefits.

References

[1] ETSI T S. 123 501 V15.5.0 (2019-04) 5G[J]. System Architecture for the 5G System (Release 15).

[2] ETSI T S. 124 501 V15.4.0 (2019-07) 5G[J]. Non-Access-Stratum (NAS) protocol for 5G System (Release 15).

[3] https://www.awardsolutions.com/portal/shareables/what-is-5G/5G-Training-Online/quality-service-model-5g-prasad-govindarajan

[4] https://news.itu.int/why-end-to-end-network-slicing-will-be-important-for-5g/

[5] https://sdn.ieee.org/newsletter/december-2017/network-slicing-and-3gpp-service-and-systems-aspects-sa-standard