# 8 Requirements for 5G

## 8.1 High level requirements

This chapter describes the requirements related to radio access network, front-haul/backhaul and communication networks.
5G systems should include "Extreme Flexibility", in order to satisfy the end-to-end quality required in each use scene even in extreme conditions. End-to-end context in the ICT environment includes not only UE-to-UE, but also UE-to-Cloud, which implies that the technology focus on flexibility extends beyond 5G radio technology to the backbone networks.

## 8.2 Requirements related to 5G radio access network

### 8.2.1 Definitions of the requirements

The definitions of the requirements related to 5G RAN (Radio Access Network) are given in the following sub-clauses. Subset of the 'candidate' requirements may be applied to each use case. Qualitative or Quantitative requirements will be given in later stages of the study considering corresponding use cases as well as applicable technologies.

(1) Bandwidth
Bandwidth or sum of bandwidths that can be supported by a 5G RAT in order to provide a radio communication link between transmission entities to receiving entities should be defined. Scalable bandwidth which is the ability of 5G RAT to operate with different bandwidth allocations could be defined. The bandwidth may be supported by single or multiple RF carriers. The width of the bandwidths should be defined quantitative manner such as the minimum bandwidth supported or the maximum bandwidths supported.
The purpose of this requirement is to define bandwidth that 5G RAT to utilize. Plural bandwidths of different widths may be defined in conjunction with use cases considered.

(2) Transmission/ Reception Point (TRP) spectrum efficiency
Transmission / Reception Point spectral efficiency is defined as an aggregate throughput of all users divided by the channel bandwidth divided by the number of transmission/reception point. The aggregate throughput can be defined as the number
of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3 over a certain period of time.
The purpose of this requirement is to define spectral efficiency of a 5G RAT. Either or both of peak spectral efficiency or xth percentile (x to be defined) spectral efficiency could be defined. The peak spectral efficiency gives the maximum spectral efficiency achieved under ideal conditions.
The 'xth' of xth percentile spectral efficiency could be fifth for example and to define the boundary of spectral efficiency that 'xth percentile device of the whole devices could be served by a pair of TRP or a set of TRPs in question.

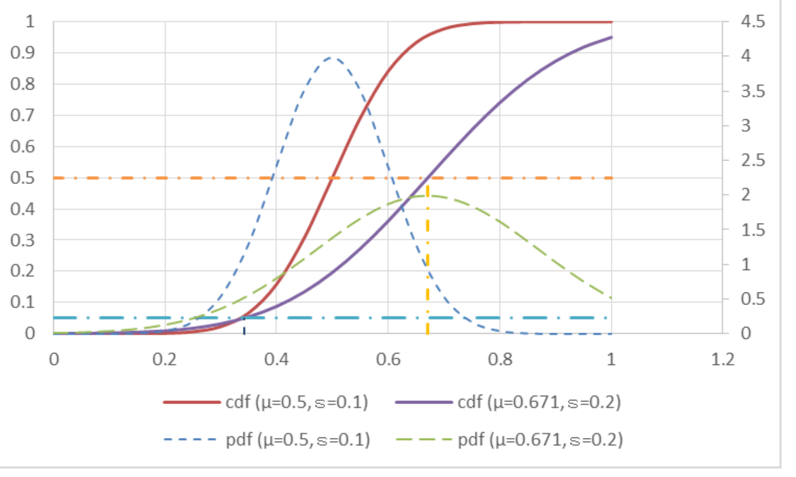


Figure 8.2-1 Example of variety of different normalized distributions and CDFs

(3) Latency
Latency could be defined either for control plane feature or user plane feature. In case control plane (C-Plane) latency is given, it could be measured as the transition time from different connection modes, e.g., from idle to active state. Ultimate requirements may be defined with actual mode states (to be defined) or use scenes (to be defined) between which 'control plane (transfer) latency' will be defined. In case user plane latency (also known as transport delay) is given, it could be defined as the one-way transit time between an SDU packet being available at the IP layer in the TRPs (the user device and the base station) and the availability of this packet (protocol data unit, PDU) at IP layer in the TRPs. User plane packet delay could include delay introduced by associated protocols and control signaling assuming the user terminal is in the active state.

(4) Mobility
Mobility requirements are given as the maximum moving speed of a user device (terminal) at which the device can provide certain quality of communication link to a TRP (aka a base station).

(5) Mobility interruption time
The mobility interruption time could be defined as the time duration during which a user device cannot exchange user plane packets with any base station.

(6) Energy efficiency
Energy efficiency could be defined for TRPs of 5G RAT as their energy consumption ratio (the increase of energy consumption) between no or limited user traffic cases to fully traffic loaded operation cases. For the devices, energy efficiency could be defined as their operational lifetime.

(7) Peak data rate
Peak data rate could be defined as the maximum data rate that a user device transmits or receives under an ideal condition.

(8) User experienced data rate
User experienced data rate could be linked to the CDF of xth percentile user spectral efficiency and the bandwidth for the data transmission.

(9) Area traffic capacity
Area traffic capacity corresponds to the total traffic throughput served per geographic area (in

bit/s/m2). This can be linked to the TRP spectral efficiency and can be derived for a particular use case or deployment scenario based on the achievable TRP spectral efficiency, network deployment (e.g., TRP (site) density) and bandwidth.

(10) Connection density
Connection density is defined as the numbers of mobile device per area that can be connected to the system.

(11) Reliability
The reliability can be defined as a success rate or success probability of data transmission over a certain period of time and gives the reliability of the communication link under certain conditions defined.

(12) Coverage
Coverage is defined as cell range expansion functionality.

### 8.2.2 List of 5G RAN requirements and their mapping to use cases

The mapping between use cases described in section [7] and the requirements are summarized in Table 8.2.2-1 Mapping between Use cases and 5G RAN requirements

Table 8.2.2-1 Mapping between Use cases and 5G RAN requirements

| Required Items | eMBB | URLLC | mMTC | Remarks |
|---|---|---|---|---|
| Bandwidth | X | X | X | |
| TRP spectral efficiency | X | | X | |
| Peak data rate | X | | | |
| Area traffic capacity | X | | | |
| Connection density | | | X | |
| Latency | X | X | | |
| Coverage | | | X | |
| Mobility | X | | | |
| Mobility interruption times | X | X | | |
| Energy efficiency | X | | X | |
| Reliability | | X | | |

Note: ‘x’ denotes corresponding requirement in its row should be applied to the use case in its column. Applying relaxed or general requirements to the use cases that are not denoted by ‘x’ is not precluded.

In February 2017 and June 2017, ITU-R WP5D elaborated Draft New Report ITU-R M.[IMT-2020.TECH PERF REQ] [1] and preliminary Draft New Report ITU-R M.[IMT-2020.EVAL] [2] respectively where technical performance requirements and evaluation method for IMT-2020 radio interface(s) were captured as in Table 8.2.2-2.

Table 8.2.2-1 technical performance requirements (evaluation method) for IMT-2020 radio interface(s) [1][2]

| Test environment | Indoor Hotspot | Dense Urban | Rural | Urban Macro | Urban Macro | Evaluation Method |
|---|---|---|---|---|---|---|
| Usage scenario | eMBB (Enhanced mobile broadband) | | | mMTC (Massive machine type communications) | URLLC (Ultra-reliable and low-latency communications) | |
| Peak data rate | Downlink 20 Gbit/s, Uplink 10 Gbit/s | | | – | – | Analytical |
| Peak spectral efficiency | Downlink 30 bit/s/Hz, Uplink 15 bit/s/Hz | | | – | – | Analytical |
| User experienced data rate | – | Downlink 100 Mbit/s<br>Uplink 50 Mbit/s | – | – | – | Analytical, Simulation |
| 5th percentile user spectral efficiency | Downlink 0.3 bit/s/Hz<br>Uplink 0.21 bit/s/Hz | Downlink 0.225 bit/s/Hz<br>Uplink 0.15 bit/s/Hz | Downlink 0.12 bit/s/Hz<br>Uplink 0.045 bit/s/Hz | – | – | Simulation |
| Average spectral efficiency | Downlink 9 bit/s/Hz/TRxP<br>Uplink 6.75 bit/s/Hz/TRxP | Downlink 7.8 bit/s/Hz/TRxP<br>Uplink 5.4 bit/s/Hz/TRxP | Downlink 3.3 bit/s/Hz/TRxP<br>Uplink 1.6 bit/s/Hz/TRxP | – | – | Simulation |
| Area traffic capacity | Downlink 10 Mbit/s/m$^2$ | – | – | – | – | Analytical |
| Latency (U-Plane) | 4 ms | | | – | 1 ms | Analytical |
| Latency (C-Plane) | 20 ms | | | – | 20 ms | Analytical |
| Connection density | – | – | – | $10^6$ devices/km$^2$ | – | Simulation |
| Energy efficiency | Efficient data transmission in loaded case (average spectral efficiency)<br>Low energy consumption (higher sleep ratio and longer sleep duration) | | | – | – | Inspection |
| Reliability | – | | | | Success probability of transmitting a layer 2/3 packet $1\text{-}10^{-5}$ (L2 PDU of 32byte) | Simulation |
| Mobility | 1.5 bit/s/Hz (10km/h) | 1.12 bit/s/Hz (30km/h) | 0.8 bit/s/Hz (120km/h)<br>0.45 bit/s/Hz (500km/h) | – | – | Simulation |
| Mobility interruption time | 0 ms | | | – | 0 ms | Analytical |
| Bandwidth | The requirement for bandwidth is at least 100 MHz.<br>The RIT/SRIT shall support bandwidths up to 1 GHz for operation in higher frequency bands (e.g. above 6 GHz). | | | | | Inspection |

[1] Draft New Report ITU-R M.[IMT-2020.TECH PERF REQ]
[2] Preliminary Draft New Report ITU-R M.[IMT-2020.EVAL] (5D/TEMP/297)

## 8.3 Requirements for 5G networks

5G networks need extreme flexibility in order to support various applications and services with largely different requirements.
In 5G networks, it is necessary to consider end-to-end application quality and enablement through network softwarization platform.
Mobile networks will need to have the following capabilities in end-to-end connections, because diverse usage scenarios are anticipated towards 2020 and beyond:

・As broadband data traffic will continue to increase while the traffic volume varies dynamically, networks is required to have larger traffic transport capability.

・As traffic volume will vary greatly time by time depending on service type and usage scenario, networks will required to have flexible scalability.

・As a large increase of connections is foreseen due to the rapid emergence of IoT/M2M devices, networks will be required to accommodate those packets traffic characteristics which have different statistics from the other services.

・As the advent of ultra-low latency control services is anticipated in such services as tactile communications, real-time M2M, V2X, and AR, network structures will be required to be capable of lower latency data transmission.

・As various network access technologies are anticipated, the transport network needs to have wide adaptability to those access network connections.

・As some types of service devices may move faster across a wider range than the 4G use cases, mobile networks will be required to have a capability of tracking and connecting those devices with seamless communication in between the service areas.

・Lower energy consumption is expected for 5G mobile networks which has those capabilities above.

Given those aspects, 5G networks will be desired to support the composition of multiple slices, and the control and management of slices over RATs, fronthaul/backhaul, and other fixed network elements in the end-to-end path. Besides, mobile networks should have a sufficient level of scalability in terms of functions, capabilities, and components.

An end-to-end scenario for latency design

Latency is the most susceptible quality that needs careful design of overall networks. Figure 8.3-1 shows a typical end-to-end scenario based on the current mobile network architecture. The end-to-end user data path from UE to a Server is divided into 11 different segments by focusing on the major network functions involved.

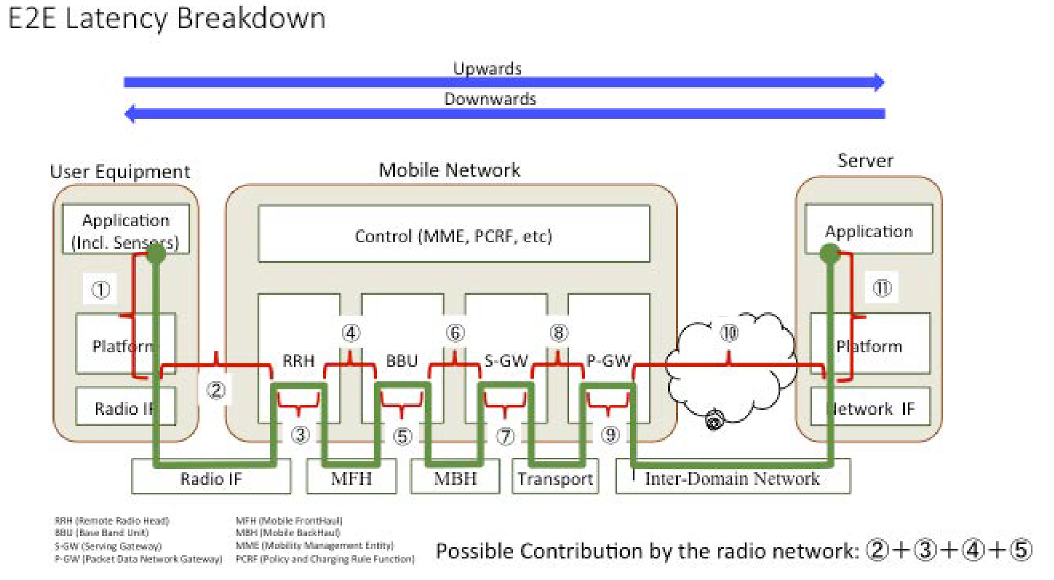


Figure 8.3-1 An end-to-end scenario based on the current mobile (LTE) network

Estimations or guarantees of latency in some form may help in designing a service. Reduction of latency in radio access segment may also help in enlarging the room for design choices. The capability of placing network functions in selected places in the overall network may also help to complete service design, in order to satisfy end-to-end requirement on the latency.

This implies that 5G network architecture must have "Extreme flexibility" in which it must be able to design networks to satisfy user requirements such as latency, capacity, throughput, device connections, and to execute network functions and services at any part along the end-to-end communication considering appropriate level of reliability, security, cost, energy consumption.