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EMC requirements for next generation network equipment

Recommendation ITU-T K.88

ITU-T

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Summary

Recommendation ITU-T K.88 specifies the emission and immunity requirements for next generation network equipment, based on IP packet technologies. It also describes operational conditions for emission and immunity testing. Performance criteria for immunity tests are also specified.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T K.88	2011-11-13	5

Keywords

EMC, NGN.

FOREWORD

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Recommendation ITU-T K.88

EMC requirements for next generation network equipment

1 Scope

This Recommendation specifies the emission and immunity requirements for switching, transmission and media gateway equipment based on Internet protocol (IP) in the next generation network (NGN). It also describes operational conditions for emission and immunity testing. Performance criteria for immunity tests are also specified. The general operational condition and performance criteria are recommended in [ITU-T K.48]. This Recommendation describes the specific testing conditions to be applied to NGN equipment.

An example of equipment under this scope is presented in Annex A.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.27] Recommendation ITU-T K.27 (1996), *Bonding configurations and earthing inside a telecommunication building*.

[ITU-T K.34] Recommendation ITU-T K.34 (2003), *Classification of electromagnetic environmental conditions for telecommunication equipment – Basic EMC Recommendation*.

[ITU-T K.38] Recommendation ITU-T K.38 (1996), *Radiated emission test procedure for physically large systems*.

[ITU-T K.43] Recommendation ITU-T K.43 (2009), *Immunity requirements for telecommunication network equipment*.

[ITU-T K.48] Recommendation ITU-T K.48 (2006), *EMC requirements for telecommunication equipment – Product family Recommendation*.

[ITU-T K.76] Recommendation ITU-T K.76 (2008), *EMC requirements for telecommunication network equipment (9 kHz-150 kHz)*.

[ITU-T K.80] Recommendation ITU-T K.80 (2009), *EMC requirements for telecommunication network equipment (1 GHz-6 GHz)*.

[IEC CISPR 22] IEC CISPR 22, ed 6.0 (2008), *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 next generation network (NGN) [b-ITU-T Y.2001]: A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

3.1.2 immunity (to a disturbance) [ITU-T K.48]: The ability of a device, equipment, or system to perform without degradation in the presence of an electromagnetic disturbance.

3.1.3 quality of service (QoS) [b-ITU-T G.1000]: The collective effect of service performances which determine the degree of satisfaction of a user of the service.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 IP packet delay variation (IPDV): Variations in IP packet transfer delay are important. Streaming applications might use information about the total range of IP delay variation to avoid buffer underflow and overflow. Variations in IP delay will cause TCP retransmission timer thresholds to grow and may also cause packet retransmissions to be delayed or be retransmitted unnecessarily. One or more parameters that capture the effect of IP packet delay variations on different applications may be useful. It may be appropriate to differentiate the (typically) small packet-to-packet delay variations from the potentially larger discontinuities in delay that can result from a change in the IP routing.

3.2.2 IP packet loss ratio (IPLR): The ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest.

3.2.3 IP packet transfer delay (IPTD): IP packet transfer delay is defined for all successful and errored packet outcomes across a basic section or an network service entity (NSE). IPTD is the time, $(t_2 - t_1)$ between the occurrence of two corresponding IP packet reference events, ingress event $IPRE_1$ at time t_1 and egress event $IPRE_2$ at time t_2, where $(t_2 > t_1)$ and $(t_2 - t_1) \leq T_{max}$. If the packet is fragmented within the NSE, t_2 is the time of the final corresponding egress event. The end-to-end IP packet transfer delay is the one-way delay between the measurement point at the source host and destination host.

3.2.4 latency (store and forward devices): The time interval starting when the last bit of the input frame reaches the input port and ending when the first bit of the output frame is seen on the output port.

3.2.5 latency (bit forwarding devices): The time interval starting when the end of the first bit of the input frame reaches the input port and ending when the start of the first bit of the output frame is seen on the output port.

3.2.6 packet/frame loss ratio: Percentage of packet/frames that should have been forwarded by a network device under steady state (constant) load that were not forwarded due to lack of resources.

3.2.7 port: Particular interface of the specified equipment with the external electromagnetic environment. See Figure 1.

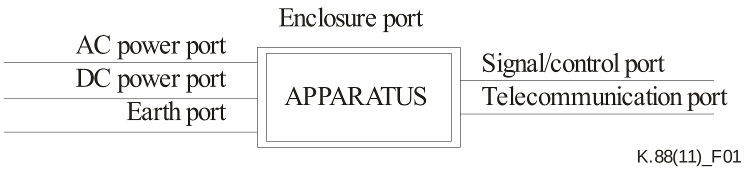

Figure 1 – Ports of the specified equipment

3.2.8 telecommunication port: Point of connection for voice, data and signalling transfers intended to interconnect widely-dispersed systems via such means as direct connection to multi-user telecommunication and similar networks.

3.2.9 throughput: The maximum rate at which none of the offered frames are dropped by the device.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AMN	Artificial Mains Network
CDN	Coupling and Decoupling Network
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EUT	Equipment Under Test
IP	Internet Protocol
IPDV	Internet protocol Packet Delay Variation
IPLR	Internet protocol Packet Loss Ratio
IPRE	Internet protocol Packet Reference Event
IPTD	Internet protocol Packet Transfer Delay
ISN	Impedance Stabilization Networks
NGN	Next Generation Network
NSE	Network Service Entity
QoS	Quality of Service
TCP	Transmission Control Protocol
VoIP	Voice over Internet Protocol
VTC	Video Transcoder Channel

5 Test methods and limits

Both emission and immunity should be tested in accordance with [ITU-T K.48] or the appropriate basic standards. Electromagnetic compatibility (EMC) requirement for the equipment in the range of 1 to 6 GHz should be tested in accordance with [ITU-T K.80]. EMC requirements for the equipment in the range of 9 kHz to 150 kHz are covered by [ITU-T K.76].

5.1 Emission

The general requirements for test methods and limits apply, according to [IEC CISPR 22]. Tables A.3 and A.4 in [ITU-T K.48] are recommended for equipment in telecommunication centres and outdoor locations. [ITU-T K.38] should be applied to large equipment tests.

[ITU-T K.80] should be applied to radiated emission from the equipment above 1 GHz.

[ITU-T K.76] should be applied to conducted emission from the equipment in the range of 9 kHz to 150 kHz.

Conduction emission measurement at power input and/or output should be made using the artificial mains network (AMN) at each port.

Conduction emission from telecommunication ports should be made using the impedance stabilization networks (ISN), if available, as detailed in document [IEC CISPR 22].

5.2 Immunity

The immunity test requirements for NGN equipment are given on a port-by-port basis.

For immunity testing, the general test methods and test levels in [ITU-T K.43] apply. Test levels for NGN are in accordance with Tables A.1 and A.2 in [ITU-T K.48]. Test levels for specific installation should be selected based on the electromagnetic environment referred to in [ITU-T K.34].

Radiated immunity between 2 GHz and 6 GHz should be performed in accordance with [ITU-T K.80].

Conducted immunity between 9 kHz and 150 kHz should be performed in accordance with [ITU-T K.76]. The conducted immunity test shall be applied to one port at a time. Conducted immunity testing shall be performed on power input and output ports, and on signal ports.

During immunity testing using continuous phenomena, some selected discrete frequencies, such as internal clock, bus signal frequencies, etc., shall be investigated in addition to the sweep.

If a mesh bonding network or mesh isolated bonding network according to [ITU-T K.27] is used throughout the installation, only ports connected to intersystem cables are to be tested. The manufacturer remains responsible for ensuring that no degradation in system immunity results from internal cabling (where the manufacturer controls both ends); this internal cabling is not subjected to the immunity test.

If requested, it is allowed to test equipment with the primary protection installed. The test condition should be added in the test report.

If the specified maximum length of the connected line is less than 3 m, no conducted immunity test is necessary. For surge tests on indoor signal lines, no test is necessary if the specified maximum length is less than 10 m.

One signal port of each type found on the equipment shall be tested. If, in normal installation practice, multiple pair cables (e.g., 64 × balanced pairs) and/or composite cables (e.g., a combination of fibre and copper) are used, they are to be tested as one single cable. Cables bundled for aesthetic or routing purposes are to be tested individually.

For multiple pair cables where a multiple pair coupling and decoupling network (CDN) does not exist, the test shall be applied to a single pair using an appropriate CDN; the remaining pairs should be considered to have been tested indirectly.

During the surge test, the equipment under test (EUT) and all ports (other than the one connected to the surge generator) shall comply with the given compliance criteria. After the surge has been applied, the generator shall be disconnected from the port and the port checked against the compliance criteria. The compliance criteria shall contain functional aspects.

For screened cable, surges are applied directly to the screen.

6 General operational conditions and test configuration

The EUT has to be configured and operated in accordance with relevant basic EMC standards and clause 6 of [ITU-T K.48].

EUT with different components/cards mounted in the enclosure should be configured with all the units necessary to obtain the maximum system configuration and/or expansion. As an alternative, it is possible to use less than the maximum system configuration if it is technically demonstrated that the insertion of other units or cards in the configuration under test does not change the emission level significantly, for example 2 dB or the grade of immunity of the EUT.

The equipment test conditions have to be as close as possible to the installed conditions. Wiring should be consistent with the specifications. The signal or control ports have to be correctly terminated, either by auxiliary equipment necessary to exercise the ports, or in their nominal impedance.

A sufficient number of ports have to be correctly terminated to ensure that the test is representative of normal operating conditions.

Only cables that are permanently connected have to be included.

The test configuration and mode of operation have to represent the intended use and have to be recorded in the test report.

The test conditions and test configuration have to be recorded in the test report.

The earth connections of the EUT shall be connected to a reference earth according to the manufacturer's specifications.

The following information has to be recorded in the test report:

– the primary functions of the equipment to be assessed during and after the EMC exposure;
– the intended functions of the equipment which has to be in accordance with the documentation accompanying the equipment;
– the user control functions and stored data that are required for normal operation and the method to be used to assess whether these have been lost after the EMC exposure;
– an exhaustive list of ports, with the maximum cable lengths allowed, classified as either power or telecommunication/signal/control. Power ports have to be further classified as a.c. or d.c. power;
– the method to be used to verify that a communication link is established and maintained (if appropriate);
– any equipment thermal limitation which prevents continuous testing of the EUT;
– the environment(s) in which the equipment is intended to be used;
– the types of cables connected to the EUT and the types of ports connected to the cables.

7 Specific test configurations and operational conditions

Key parameters, such as throughput, latency, or packet/frame loss ratio from the packet input reference point (port) to the packet output reference point (port), impacting the QoS for users, should be measured during the EMC continuous test. The specific test configurations and operational conditions are shown below.

7.1 Specific test configurations

The test configuration is shown in Figure 2. The test signal is derived from the test equipment and looped through the EUT. The other ports need to be connected to auxiliary equipment or looped back.

During the immunity test, the performances of the EUT's application such as throughput, latency, packet/frame loss ratio from packet input reference point to packet output reference point should be measured by the test equipment.

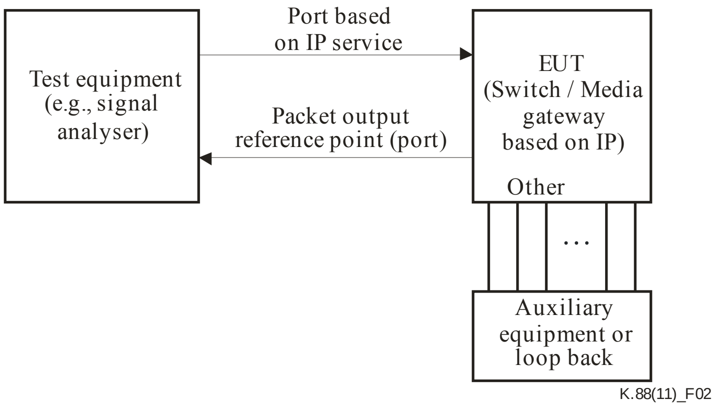

Figure 2 – Test configuration of the equipment based on IP

7.2 Specific operational conditions

The performance of the EUT, e.g., throughput, latency and packet/frame loss ratio, depend on the size of frame; so for simplicity, an immunity test shall be performed for frame sizes of 64-bit and 1518-bit, as well as that of the typical protocol specified for the equipment under test.

Connections have to be established before the start of the tests and maintained during the tests. Then, the performances have to be checked whether they are normal.

7.3 Special test methods

7.3.1 Throughput test method

Send a particular number of frames at a specific rate through the EUT and then count the frames that are transmitted by the EUT. If the count of offered frames is equal to the count of received frames, the rate of the offered stream is increased and the test is rerun. If fewer frames are received than were transmitted, the rate of the offered stream is reduced and the test is rerun.

The throughput is the fastest rate at which the count of test frames transmitted by the EUT is equal to the number of test frames sent to it by the test equipment.

Because of randomicity of packet loss, the duration of each test is recommended to be 60 s to determine the actual performance.

Tests should be conducted multiple times during the whole continuous immunity test to check the throughput performance over the frequency range.

7.3.2 Latency test method

For store-and-forward devices, latency is defined as the time interval starting when the last bit of the input frame reaches the input port and ending when the first bit of the output frame is seen on the output port.

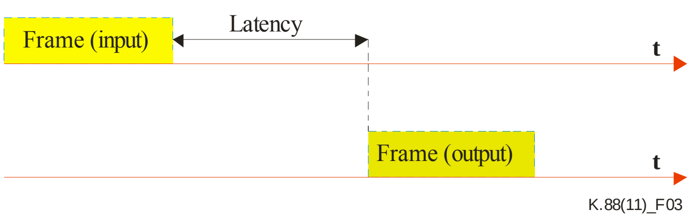

Figure 3 – Latency for store and forward devices

For bit forwarding devices, latency is defined as the time interval starting when the end of the first bit of the input frame reaches the input port and ending when the start of the first bit of the output frame is seen on the output port.

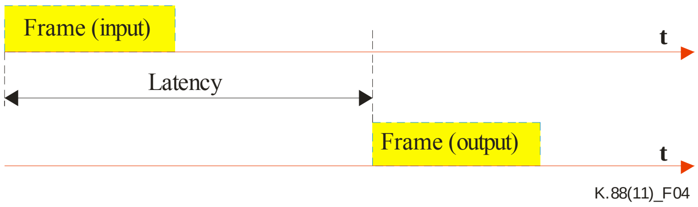

Figure 4 – Latency for bit forwarding devices

Send a stream of frames at a particular frame size through the EUT at the determined throughput rate to a specific destination. The stream should be at least 120 s in duration.

An identifying tag should be included in one frame after 60 s, the type of tag being implementation dependent. The time at which this frame is fully transmitted is recorded (timestamp A). The receiver logic in the test equipment must recognize the tag information in the frame stream and record the time at which the tagged frame was received (timestamp B).

The latency is timestamp B minus timestamp A as per the relevant definition above, namely, latency as defined for store and forward devices or latency as defined for bit forwarding devices.

The test must be repeated at least 20 times with the reported value being the average of the recorded values.

Tests should be conducted multiple times during the whole continuous immunity test to check the latency performance over the frequency range.

7.3.3 Packet/frame loss ratio test method

The packet/frame loss ratio at each point is calculated using the following equation:

$$(\text{input\_count} - \text{output\_count}) / \text{input\_count} \times 100\%$$

Send a particular number of frames at 100% of the maximum rate for the frame size through the EUT and count the frames that are transmitted and received by the EUT, and calculate the packet/frame loss ratio. The throughput is the fastest rate at which there is no packet/frame loss.

8 Performance criteria

8.1 General performance criteria

The general performance criteria of clause 6 of [ITU-T K.43] apply. The QoS of the NGN system is affected by many factors, not only by the EMC performance of the individual equipment, but also by the system configuration of the whole service network. Appendix I gives some information of how the system parameters affect the QoS.

Performance criterion A

The equipment shall continue to operate as intended. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and what the user may reasonably expect from the equipment if used as intended.

Performance criterion B

After the test, the equipment shall continue to operate as intended. No degradation of performance is allowed after the application of the phenomena below a performance level specified by the manufacturer, when the equipment is used as intended. In some cases, the performance level may be replaced by a permissible loss of function. During the test, degradation of performance or loss of function is allowed. However, no change of actual operating state or stored data is allowed. If the minimum performance level or the permissible function loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and what the user may reasonably expect from the equipment if used as intended.

Performance criterion C

Loss of function is allowed provided the function is set recoverable or can be restored by the operation of the controls by the user in accordance with the manufacturer's instructions. Functions and information protected by a battery backup shall not be lost.

8.2 Special performance criteria

8.2.1 Performance criteria for switching equipment based on IP

For the switching equipment based on IP, the performance criteria for the digital port in clause 8.1 of [ITU-T K.48] apply.

The performance of the equipment shall be verified for digital signal ports:

– by measuring the number of induced bit errors on the main signal port during all exposures;

– by testing the functionality of the main signal port and the other signal ports during selected frequency tests and after the exposures;

– by verifying that corruption of software and data held in memory has not occurred.

8.2.1.1 Performance criterion A

i) The established connections shall be maintained throughout the testing.

ii) The number of bit errors at the end of each individual disturbance exposure shall not exceed the maximum number of errors expected for normal operation.

iii) Throughput, latency and packet loss ratio during and at the end of each individual disturbance exposure shall not exceed the maximum values defined by the manufacturer.

At selected frequencies:

– it should be possible to establish a connection between any two ports;

– it should be possible to clear a connection in a controlled manner.

8.2.1.2 Performance criterion B

i) The established connection shall be maintained throughout the testing.

ii) It shall be possible to establish a connection between two ports after the end of transient disturbances.

iii) It shall be possible to clear a connection in a controlled manner after the end of a test signal.

8.2.1.3 Performance criterion C

i) The general performance criterion C applies.

8.2.2 Performance criteria for media gateway equipment

For the media gateway equipment based on IP, the performance criteria for the digital port in clause 8.1 of [ITU-T K.48] apply.

8.2.2.1 Performance criterion A

i) The same as performance criterion A listed under clause 8.2.1.

8.2.2.2 Performance criterion B

i) The same as performance criterion B listed under clause 8.2.1.

8.2.2.3 Performance criterion C

i) The general performance criterion C applies.

8.2.3 Performance criteria for transmission equipment based on IP

For the transmission equipment based on IP, the performance criteria for the digital port in clause 8.2.3.5 of [ITU-T K.48] apply.

8.2.3.1 Performance criterion A

i) For interfaces which are intended for the transmission of third party data traffic, a selected port shall be connected to test equipment (e.g., a data communications analyser) as a single point-to-point data link. This will avoid excessive failed transmission attempts caused by data collisions and bus contention problems.

ii) The interface shall be suitably exercised and monitored throughout the test period for erroneous frames.

iii) Throughput and latency during and at the end of each individual disturbance exposure shall not exceed the maximum values defined by the manufacturer.

iv) No more than 5% additional erroneous frames above the quiescent level shall be permitted during the exposure.

v) The established transmission data rate shall not degrade more than 1%.

8.2.3.2 Performance criterion B

i) The data link connection shall be maintained.

Annex A

Example of equipment within the scope of the present Recommendation

(This annex forms an integral part of this Recommendation.)

Switching equipment based on IP

This category covers, for example, softswitches, layer 2, and layer 3 switches.

Transmission equipment based on IP

This category covers, for example, packet transport networks, routers and Ethernet switches.

Media gateway equipment

This category covers, for example, gateway equipment between public switched telephone networks and IP-based networks.

Appendix I

Parameters of NGN system based on IP related to QoS

(This appendix does not form an integral part of this Recommendation.)

From the viewpoint of the user, the QoS parameters of IP-based NGN network equipment are transfer delay, delay variation and loss ratio. In practical application, the effects of environmental electromagnetic interference (EMI) on these parameters are most important.

I.1 Transfer delay

Delay manifests itself in a number of ways, including the time taken to establish a particular service from the initial user request and the time to receive specific information once the service is established. Delay has a very direct impact on user satisfaction depending on the application, and includes delays in the terminal, network and any servers. Note that from the viewpoint of a user, delay also takes into account the effect of other network parameters such as throughput.

In IP networks, transfer delay can be called IP packet transfer delay (IPTD).

I.2 Delay variation

Figure I.1 demonstrates a part of delay variation.

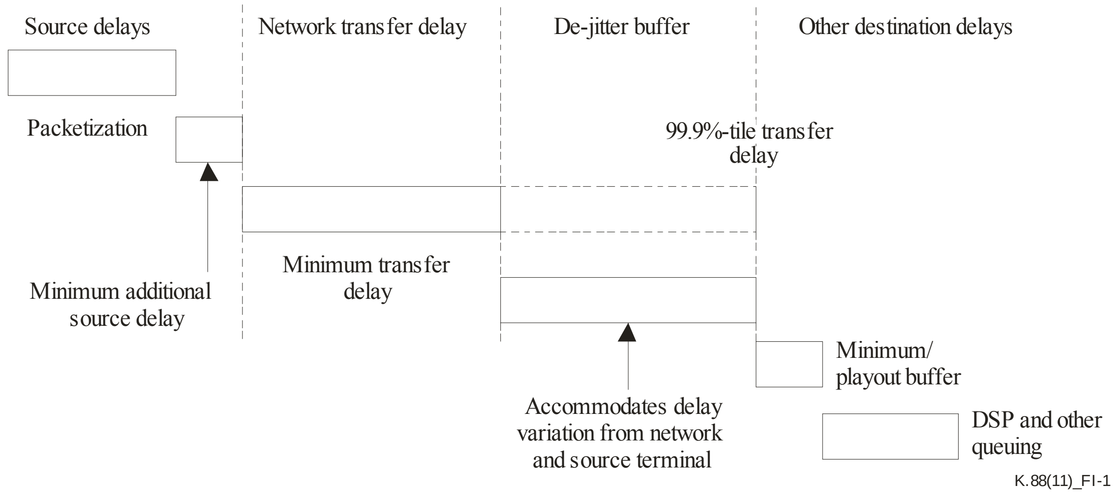

Figure I.1 – Example of delay variation

Delay variation is generally included as a performance parameter since it is very important at the transport layer in packetized data systems due to the inherent variability in arrival times of individual packets. However, services that are highly intolerant of delay variation will usually take steps to remove (or at least significantly reduce) the delay variation by means of buffering, effectively eliminating delay variation as perceived at the user level (although at the expense of adding additional fixed delay).

Buffering always occurs at the destination side, in so-called ‘de-jitter’ buffers. The design of the size of the de-jitter buffer is a trade-off between minimizing application level delay and loss and minimizing delay variation. In effect, a threshold is defined for delay variation, which is applied by the de-jitter buffer to either accommodate or discard packets. Packets with delay variation in the "white" range are accommodated, while packets with larger variation (in the "black" range) would be discarded. A larger de-jitter buffer can accommodate packets with greater delay variation; hence, fewer packets would be lost overall at the expense of larger overall delay. Conversely, a smaller de-jitter buffer will produce less overall delay, but expose a larger fraction of packets to be discarded by the terminal and increase the overall loss.

Design of de-jitter buffers differs from one manufacturer to the next, as indicated in [b-ITU-T G.1020]. There are two main types of de-jitter buffers: fixed length and adaptive length. De-jitter buffers can be constructed in many different ways and include the attributes identified in Table I.1. The values of applicable de-jitter buffer parameters must be known when assessing the performance of a system.

Table I.1 – De-jitter buffer types and parameters

Type	Attributes	Possibilities	
Fixed (and adaptive)	Size (configure maximum and nominal or minimum)	Integral number of packets	Fractional number of packets
Adaptive	Control	Timed decay if no over/under flow	Evaluate loss ratio (configure lowest acceptable threshold, and minimum packet count between adjustments)
	Adjustment	Timed	Silence gaps only
	Initialization	First packet	Small sample
	Adjustment granularity	Packet size	Fraction of packet size
	Restores packet order	Yes	No
	Voiceband data mode	Detect 2100 Hz tone, set to maximum length	None

I.3 Loss ratio

Information loss has a very direct effect on the quality of the information finally presented to the user, whether it is voice, image, video or data. In this context, information loss is not limited to the effects of bit errors or packet loss during transmission, but also includes the effects of any degradation introduced by media coding for more efficient transmission (e.g., the use of low bit-rate speech codecs for voice).

I.4 QoS requirements for different services on NGN based on IP

Based on the target performance requirements, the various applications can be mapped onto axes of packet loss and one-way delay, as shown in Figure I.2 (taken from [b-ITU-T G.1010]). The size and shape of the boxes provide a general indication of the limit of delay and information loss tolerable for each application class.

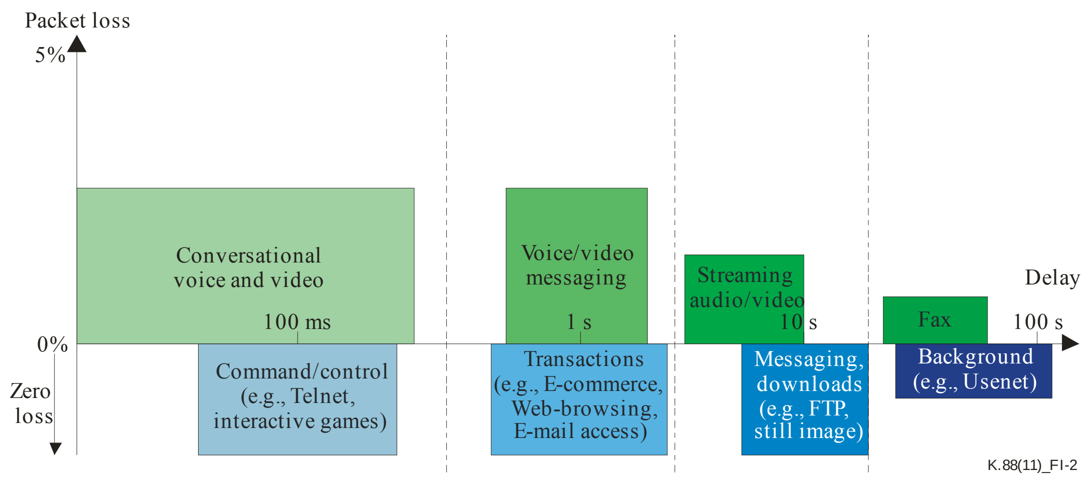

Figure I.2 – Mapping of user-centric QoS requirements

IP network QoS class definitions and network performance objectives are shown in Table I.2 (taken from [b-ITU-T Y1540]):

Table I.2 – IP network QoS class definitions and network performance objectives

Network performance parameter	Nature of network performance objective	QoS classes					
		Class 0	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5 Un-specified**
IPTD	Upper bound on the mean IPTD (Note 1)	100 ms	400 ms	100 ms	400 ms	1 s	U (Note 5)
IPDV	Upper bound on the 1 – 10^{-3} quantile of IPTD minus the minimum IPTD (Note 2)	50 ms (Note 3)	50 ms (Note 3)	U	U	U	U
IPLR	Upper bound on the packet loss probability	1×10^{-3} (Note 4)	1×10^{-3} (Note 4)	1×10^{-3}	1×10^{-3}	1×10^{-3}	U

NOTE 1 – Very long propagation times will prevent low end-to-end delay objectives from being met. In these and some other circumstances, the IPTD objectives in Classes 0 and 2 will not always be achievable. Every network provider will encounter these circumstances and the range of IPTD objectives in Table 1 provides achievable QoS classes as alternatives. The delay objectives of a class do not preclude a network provider from offering services with shorter delay commitments. According to the definition of IPTD in [b-ITU-T Y.1540], packet insertion time is included in the IPTD objective. This Recommendation suggests a maximum packet information field of 1500 bytes for evaluating these objectives.

NOTE 2 – The definition of the IPDV objective (specified in [b-ITU-T Y.1540]) is the 2-point IP Packet Delay Variation. See [b-ITU-T Y.1540] and Appendix II of [b-ITU-T Y.1541] for more details on the nature of this objective. For planning purposes, the bound on the mean IPTD may be taken as an upper bound on the minimum IPTD and, therefore, the bound on the 1 – 10^{-3} quantile may be obtained by adding the mean IPTD and the IPDV value (e.g., 150 ms in Class 0).

Table I.2 – IP network QoS class definitions and network performance objectives

NOTE 3 –This value is dependent on the capacity of inter-network links. Smaller variations are possible when all capacities are higher than primary rate (T1 or E1), or when competing packet information fields are smaller than 1500 bytes (see Appendix IV of [b-ITU-T Y.1541]).

NOTE 4 – The Class 0 and 1 objectives for IPLR are partly based on studies showing that high quality voice applications and voice codecs will be essentially unaffected by a 10^{-3} IPLR.

NOTE 5 – "U" means "unspecified" or "unbounded". When the performance relative to a particular parameter is identified as being "U", ITU establishes no objective for this parameter and any default ITU-T Y.1541 objective can be ignored. When the objective for a parameter is set to "U", performance with respect to that parameter may, at times, be arbitrarily poor.

Table I.3 gives some guidance for the applicability and engineering of the network QoS classes.

Table I-3 – Applicability and engineering of the network QoS Classes

QoS class	Applications (examples)	Node mechanisms	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Separate queue with preferential servicing, traffic grooming	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC).		Less constrained routing and distances
2	Transaction data, highly interactive (Signalling)	Separate queue, drop priority	Constrained routing and distance
3	Transaction data, interactive		Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Long queue, drop priority	Any route/path
5	Traditional applications of default IP networks	Separate queue (lowest priority)	Any route/path

I.5 An example of transfer delay and delay variation

Transfer delay and delay variation in gateways will dominate in the total transfer delay and delay variation of the NGN system. Figure I.3 shows transfer delay and delay variation occurring at a destination terminal (taken from [b-ITU-T G.1020]):

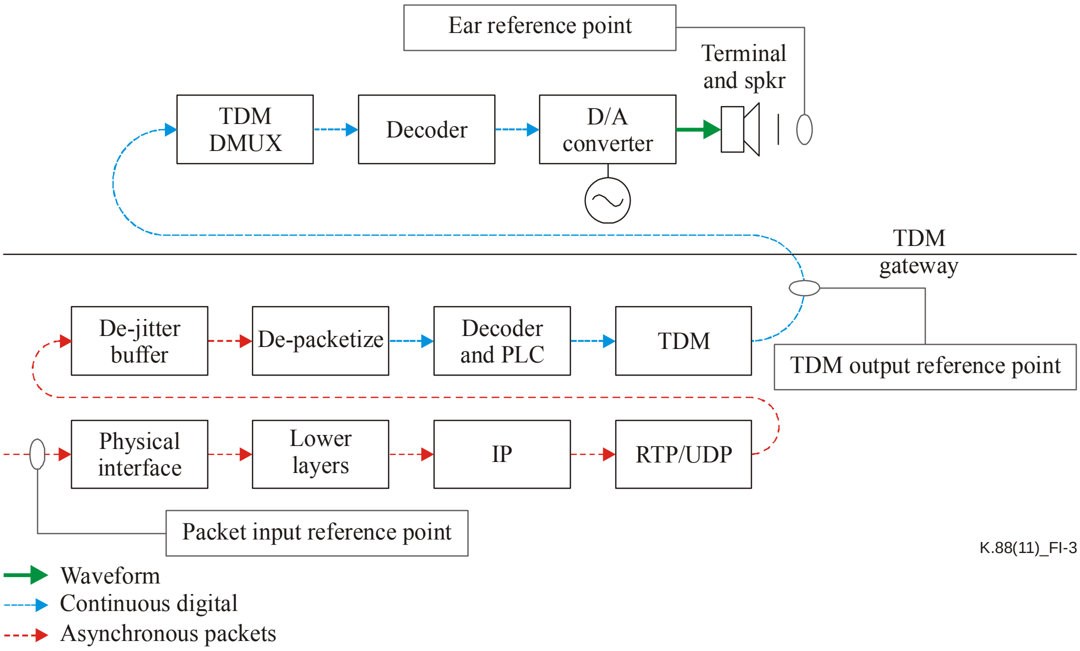

Figure I.3 – Transfer delay and delay variation at destination terminal

Items under the black line in Figure I.3 can be regarded as gateway equipment. Transfer delay and delay variation mainly occur at the sections of "De-jitter buffer" and "De-packetize", so transfer delay and delay variation parameters need to be measured during the EMC test to judge if electromagnetic interference has influenced the gate equipment.

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