International Telecommunication Union

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Radiocommunication Sector of ITU

Recommendation ITU-R F.2113-0
(01/2018)

Error performance and availability objectives and requirements for real point-to-point packet-based radio links

F Series
Fixed service

International Telecommunication Union

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Note*: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R F.2113-0

Error performance and availability objectives and requirements for real point-to-point packet-based radio links

(Question ITU-R 255/5)

(2018)

Summary

This Recommendation describes error performance and availability events and parameters for packet based fixed wireless service equipment and links, provides a formula for link objectives, includes relations between packet and non-packet based systems, and shows examples of applications to real cases.

Scope

This Recommendation provides a method to assign the error performance and availability objectives for proper design of real point to point packet-based radio links, with specific reference to Ethernet based radio links.

Keywords

Fixed service, point-to-point, availability, error performance, packet based, Ethernet

Abbreviations/Glossary

BER	Bit error rate
FWS	Fixed wireless service
FER	Ethernet frame error ratio
FLR	Ethernet frame loss ratio
PEU	Percent Ethernet service unavailability
PEA	Percent Ethernet service availability
SESETH	Severe errored second

Related ITU Recommendations

Recommendation ITU-R F.1668 – Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

Recommendation ITU-R F.1703 – Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

Recommendation ITU-T Y.1563 – Ethernet frame transfer and availability performance

The ITU Radiocommunication Assembly,

considering

a) that the demand for bandwidth need is increasing significantly, the microwave technology has also evolved from supporting low capacity to high capacity which can provide much higher speed data transmission;

b) that packet-based applications constitute major part of existing transport and access networks, and are expected to be strongly increased in near future;

c) that there is a need to establish error performance and availability objectives to assist in link design and development of packet based networks;

d) that no specific reference length is given for end-to-end Ethernet network, and no country based model is available,

recognizing

a) that Recommendation ITU-T Y.1563 defines parameters that may be used in specifying and assessing the performance of speed, accuracy, dependability and availability of Ethernet frame transfer of an Ethernet communication service;

b) that Recommendation ITU-T Y.1563 defines an end-to-end Ethernet network as the set of EL (exchange link) and NS (Network section) that provide the transport of Ethernet frames transmitted from SRC (Source) to DST (Destination). The MPs that bind the end-to-end Ethernet network are the MPs at the SRC and the DST;

c) that the calculation criteria methodology adopted in Recommendations ITU-R F.1668 and ITU-R F.1703 to establish the error performance and availability for real fixed wireless links (SDH and PDH traffic) based on Recommendations ITU-T G.826 and ITU-T G.827,

recommends

1 that the events and parameters to be used for Error performance and availability needs, including design of real links, should be selected within the set described in Annex 1;

2 that error performance and availability objectives for real digital fixed wireless links carrying packet based traffic should be established according to the procedures described in Annex 2.

Annex 1

Events and parameters

This Annex only deals with Ethernet-based packet applications.

1 Events

Following error performance and availability definition are in accordance with Recommendation ITU-T Y.1563.

Severe errored second (SESETH)

A severe errored second (SES_{ETH}) outcome occurs for a block of frames observed during a one-second interval at ingress MP0 when the corresponding FLR (i.e. the ratio of lost frames to total frames in the block) at egress MPi exceeds s1. A provisional value s1 of 0.5 is proposed by ITU-T, and different values may also be chosen depending on the class of service (CoS).

Availability

Availability of Ethernet-based network is described by available state and unavailable state.

Unavailable time begins at the onset of 10 consecutive SES_{ETH} outcomes, and ends at the onset of 10 consecutive non-SES_{ETH} outcomes. During the available time period, the Ethernet network is in available state.

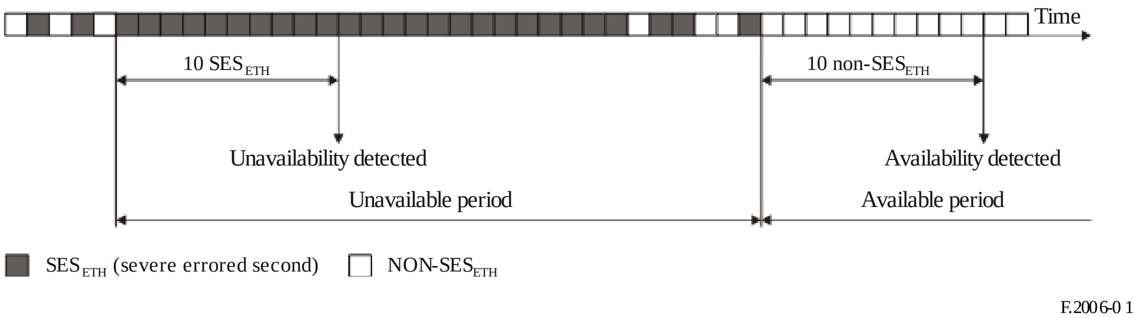
Figure 1 illustrates the definition of criteria for transition to/from the unavailable state.

This definition of availability has been chosen to allow comparison with other link layer techniques.

Because an Ethernet service is bidirectional, an Ethernet network is in the unavailable state if either one, or both directions, are in the unavailable state. The unidirectional availability can be measured by the criteria mentioned above.

FIGURE 1

Example of unavailability determination



2 Parameters

Percent Ethernet service unavailability (PEU)

The percentage when Ethernet network is in unavailable state in total scheduled Ethernet service time (the percentage of one-second intervals).

Percent Ethernet service availability (PEA)

When Ethernet network is in available state in total scheduled Ethernet service time (the percentage of one-second intervals) using the Ethernet service availability function: PEU = 100 – PEA.

Ethernet frame error ratio (FER)

Ethernet frame error ratio is the ratio of total errored Ethernet frame outcomes to the total of successful Ethernet frame transfer outcomes plus errored Ethernet frame outcomes in a population of interest.

Ethernet frame loss ratio (FLR)

The ratio of total lost Ethernet frame outcomes to total transmitted Ethernet frames in a population of interest. In point-to-multipoint configurations, it can also be useful to compare the successful frame transfers among destinations using the destination with the largest number of successful frame transfers as the reference.

Annex 2

Objectives

This Annex only deals with Ethernet-based packet applications.

1 Apportionment of objective

Error performance and availability objectives for any real point-to-point link carrying PDH /SDH traffic have been established by Recommendations ITU-R F.1668 and ITU-R F.1703, in compliance with an ITU-T media independent apportionment criteria, based on the existence of a reference value established for an end-to-end hypothetical connection of 27 500 km length (Recommendation ITU-T G.826).

Due to the evolution of technology and the specific nature of Ethernet, no end to end or objectives has been deemed necessary by ITU-T and no apportionment criteria is available. Nevertheless, Ethernet based radio links continue to be deployed in same geographical and logistic contest used before packet based signals (same regions, towers, propagation, etc.), and there is a need of having objectives to allow proper design of such links.

Error performance and availability objectives for any real point-to-point link carrying Ethernet are given in this Annex, in line with the ITU traditional vision consisting in considering two main kinds of application contests, with two different expected quality levels:

– Links belonging to "high performing" section of connection (transit countries or international section of terminating countries, long haul sections).

– Links belonging to "less performing" sections of the path (national part of terminating countries, short haul and access).

Different allocation rules are used depending on the interested Country belong to international transit section or terminates the path.

2 Time requirement for objective evaluation

Events evaluation: 1 second.

Availability objectives: 1 year

Error performance objectives: 1 month

3 Objective

PEA

PEA objectives applicable to each direction of a fixed wireless link of length, L_{link}, can be derived from the values given in Tables 1 and 2 by means of equations (1):

$$PEA = (1 - \left(B_j \frac{L_{link}}{L_R} + C_j \right))*100 \qquad (1)$$

where:

the value of j is: for international portion:

1	for L_{min}	<	L_{link}	≤	250 km
2	for 250 km	<	L_{link}	≤	2 500 km
3	for 2 500 km	<	L_{link}	≤	7 500 km
4	for		L_{link}	>	7 500 km

for section of national portion:

5 for access network
6 for short haul
7 for long haul

L_R: reference length $L_R = 250$km.

The lower limit of L_{link} used to scale the objectives is $L_{min} = 50$ km.

TABLE 1

Parameters for PEA objectives for links forming part of an international portion of constant bit-rate digital path

Length (km)	**$L_{min} \le L_{link} \le 250$**		**$250 < L_{link} \le 2\,500$**		**$2\,500 < L_{link} \le 7\,500$**		**$L_{link} \ge 7\,500$**	
	B_1	C_1	B_2	C_2	B_3	C_3	B_4	C_4
International portion	1.9×10^{-4}	1.1×10^{-4}	3×10^{-4}	0	3×10^{-4}	0	3×10^{-4}	0

TABLE 2

Parameters for PEA objectives for links forming part of a national portion of constant bit-rate digital path element

Access portion		**Short-haul portion**		**Long-haul portion**	
B_5	C_5	B_6	C_6	B_7	C_7
0	5×10^{-4}	0	4×10^{-4}	3×10^{-4} for 250 km $\le L_{link} <$ 2 500 km 1.9×10^{-4} for $L_{min} \le L_{link} <$ 250 km	0 for 250 km $\le L_{link} <$ 2 500 km 1.1×10^{-4} for $L_{min} \le L_{link} <$ 250 km

FER

No objective is recommended.

FLR

No objective is recommended.

4 Calculation of availability objectives

This section shows some examples of the application of this Recommendation to real links, in order to derive the objectives.

In the following calculations, it is assumed that one year corresponds to 525 960 min.

4.1 International portion

Case 1: length 30 km

The length is shorter than L_{min} = 50 km, so the value of L_{link} = 50 has been used.

$$PEA = (1 - \left(B_1 \frac{L_{link}}{L_R} + C_1 \right))*100 = (1 - \left(1.9 \times 10^{-4} \frac{50}{250} + 1.1 \times 10^{-4} \right))*100 = 99.985$$

These values correspond to an unavailability of 78 min/year.

Case 2: length 80 km

The length is in the range 50-250 km, so:

$$PEA = (1 - \left(B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left(1.9 \times 10^{-4} \frac{80}{250} + 1.1 \times 10^{-4} \right))*100 = 99.983$$

These values correspond to an availability of 99.983% (unavailability of 90 min/year).

4.2 National portion

Case 1: length 30 km in access portion

The length is shorter than L_{min} = 50 km, so the value of L_{link} = 50 km has been used.

$$PEA = (1 - \left(B_5 \frac{L_{link}}{L_R} + C_5 \right) = 1 - \left(0 \frac{50}{250} + 5 \times 10^{-4} \right))*100 = 99.95$$

These values correspond to an availability of 99.95% (unavailability of 263 min/year).

Annex 3

Relation between packet and non packet based parameters

Background

In order to allow a correct planning of the link, the knowledge of fade margin, or the absolute level at which threshold condition is met, are required.

While for PDH/SDH case there is a very consolidated base of measurement, packet based signal thresholds are not so widely referenced.

Tables 3, 4 and 5 show examples of comparative measures between PDH and Ethernet parameters, for different modulations and different Ethernet packet lengths.

In reference system (see Table 3), complete measures are reported; in other modulations, measures without significant deviations are not reported.

– Test was made on modern 18 GHz equipment, using a simulated link in laboratory.
– Equipment allow transmission of a hybrid signal (PDH + Ethernet), where, during each test, modulation was manually fixed in one of possible states.

– Reference stream: (2 150 Mbit/s Ethernet + 2 Mbit/s PDH with 256 QAM) in 56 MHz Channel.

Variation of PRx level is ≤ 0.6 dB for BER range 1.7×10^{-7} to 1.0×10^{-3}.

TABLE 3

PDH / Ethernet parameters - 256 QAM

PDH				Ethernet			
BER	**ESR**	**SES**	**Unav**	**ESR.**	**FLR (=FER[(1)])**	**SES_{ETH}**	**Packet length (Bytes)**
1.7×10^{-7}	20%	0	-	35%	$1.7*10^{-5}$	0	64
2×10^{-7}	23%	0	-	40%	$3*10^{-5}$	0	256
1.7×10^{-7}	14%	0	-	34%	$2.7*10^{-5}$	0	1024
1.7×10^{-7}	17%	0	-	34%	$3.6*10^{-5}$	0	1522
1.0×10^{-6}	80%	0	-	94%	$1.3*10^{-4}$	0	64
1.0×10^{-6}	80%	0	-	94%	$1.6*10^{-4}$	0	256
1.0×10^{-6}	80%	0	-	94%	$2.2*10^{-4}$	0	1024
1.0×10^{-6}	80%	0	-	94%	$2.4*10^{-4}$	0	1522
1.0×10^{-5}	100%	0	-	100%	$1.1*10^{-3}$	0	64
1.0×10^{-5}	100%	0	-	100%	$1.6*10^{-3}$	0	256
1.0×10^{-5}	100%	0	-	100%	$2*10^{-3}$	0	1024
1.0×10^{-5}	100%	0	-	100%	$2.2*10^{-3}$	0	1522
1.0×10^{-4}	100%	≈ 15%	-	100%	$1.2*10^{-2}$	0	64
1.0×10^{-4}	100%	≈ 15%	-	100%	$1.2*10^{-2}$	0	256
1.0×10^{-4}	100%	≈ 15%	-	100%	$2*10^{-2}$	0	1024
1.0×10^{-4}	100%	≈ 15%	-	100%	$2.5*10^{-2}$	0	1522
1.0×10^{-3}	100%	100%	X[(2)]	100%	$1.1*10^{-1}$	0	64
1.0×10^{-3}	100%	100%	X[(2)]	100%	$1.3*10^{-1}$	0	256
1.0×10^{-3}	100%	100%	X[(2)]	100%	$1.7*10^{-1}$	0	1024
1.0×10^{-3}	100%	100%	X[(2)]	100%	$2*10^{-1}$	0	1522

(1) Every error in frame gives rise to cell being discarded.

(2) If the condition persists more than 10 s, reading of ESR and SES becomes meaningless, since system enters in unavailable state.

TABLE 4

PDH / Ethernet parameters – 16 QAM

PDH				Ethernet			
BER	**ESR**	**SES**	**Unav**	**ESR**	**FLR (=FER[(1)])**	**SES_{ETH}**	**Packet length (Bytes)**
2.0×10^{-6}	90%	0	-	98%	$1.4*10^{-4}$	0	64
2.0×10^{-6}	90%	0	-	98%	$2.3*10^{-4}$	0	1522
1.0×10^{-4}	100%	0	-	100%	$9*10^{-3}$	0	64
1.0×10^{-4}	100%	0	-	100%	$2*10^{-2}$	0	1522
4.0×10^{-4}	100%	≈ 15%	-	100%	$1.1*10^{-1}$	0	64
4.0×10^{-4}	100%	≈ 15%	-	100%	$1.6*10^{-1}$	0	1522
1.0×10^{-3}	100%	100%	X[(2)]	100%	$1.1*10^{-1}$	0	64
1.0×10^{-3}	100%	100%	X[(2)]	100%	$2.5*10^{-1}$	0	1522

(1) Every error in frame gives rise to cell being discarded.

(2) If the condition persists more than 10 s, reading of ESR and SES becomes meaningless, since system enters in unavailable state.

TABLE 5

PDH / Ethernet parameters – 1024 QAM

PDH				Ethernet			
BER	**ESR**	**SES**	**Unav**	**ESR**	**FLR (=FER[(1)])**	**SES_{ETH}**	**Packet length (Bytes)**
1.0×10^{-6}	90%	0	-	100%	$2*10^{-4}$	0	64
1.0×10^{-6}	90%	0	-	100%	$4*10^{-4}$	0	1522
1.0×10^{-4}	100%	0	-	100%	$9*10^{-3}$	0	64
1.0×10^{-4}	100%	0	-	100%	$2*10^{-2}$	0	1522
8.0×10^{-4}	100%	15%	-		$1.6*10^{-1}$	0	64
8.0×10^{-4}	100%	15%	-		$3*10^{-1}$	0	1522
1.0×10^{-3}	100%	100%	X[(2)]	100%	$1.1*10^{-1}$	0	64
1.0×10^{-3}	100%	100%	X[(2)]	100%	$2.3*10^{-1}$	0	1522

(1) Every error in frame gives rise to cell being discarded.

(2) If the condition persists more than 10s, reading of ESR and SES becomes meaningless, since system enters in unavailable state.

Conclusion

Measure indicates that, no matter the modulation of the frame length adopted, the SES_{ETH} occurs at a received level slightly lower (fraction of dB) than the level at which the SES is detected in non packet-based case.

Due to the high slope of BER curve in today's equipment, and considering that some equipment declare out loss of alignment before this level (when BER is in the order of 10^{-4} to 10^{-6}), practical differences in case of use of real packet-based threshold and threshold level used for non packet-based appears negligible.