

Source: Doc. 5D/5, 5D/97 and 5D/EVAL-CG

**TECHNOLOGY**

Subject: [Question ITU-R 229-1/8](#)

## **Institute of Electrical and Electronics Engineers (IEEE)**

### **PROPOSED AMENDMENTS TO [IMT.EVAL]**

This contribution was developed by IEEE Project 802®, the Local and Metropolitan Area Network Standards Committee (“IEEE 802”), an international standards development committee organized under the IEEE and the IEEE Standards Association (“IEEE-SA”).

The content herein was prepared by a group of technical experts in IEEE 802 and industry and was approved for submission by the IEEE 802.11™ Working Group on Wireless Local Area Networks, IEEE 802.16™ Working Group on Broadband Wireless Access, the IEEE 802.18 Radio Regulatory Technical Advisory Group, IEEE 802.20™ Working Group on Mobile Broadband Wireless Access, and the IEEE 802 Executive Committee, in accordance with the IEEE 802 policies and procedures, and represents the view of IEEE 802.

This contribution is a follow up to Document 5D/5. Some of the proposals in Doc. 5D/5 were already incorporated into IMT.EVAL at the first meeting of WP 5D; however some important definitions about performance metrics have not yet been included. In this contribution it is proposed that they be added in a separate annex of IMT.EVAL that is referenced in Section 7 of the main body, but there may be other alternatives for its inclusion.

For example, with reference to the chairman’s report (Attachment 6.7 to Doc. 5D/97), the following quote is item 10 in Section 7.1 (Simulation Procedure). With reference to the output of the correspondence group (Doc. 5D/??) this is the bullet item with the same text in Section 7.1 (Simulation for evaluation purpose). The reference to the new annex could be included as follows:

“10) Simulation time is chosen to ensure convergence in user performance metrics ([see Annex 3](#)). For a given drop the simulation is run for this duration, and then the process is repeated with the users dropped at new random locations. A sufficient number of drops are simulated to ensure convergence in the system performance metrics.”

**Attachment 1.** Proposed new Annex 3 for IMT.EVAL on Performance Metrics

Attachment 1

**Proposed new Annex 3 for IMT.EVAL on Performance Metrics**

Annex 3

**Performance metrics**

**1 Definition of performance metrics**

Performance metrics may be classified as single-user performance metrics or multi-user performance metrics.

**1.1 Single user performance metrics**

**1.1.1 Coverage range (Noise limited) – single-cell consideration**

Coverage range is defined as the maximum radial distance to meet a certain percentage of area coverage (x%) with a signal to noise ratio above a certain threshold (target SINR) over y% of time, assuming no interference signals are present.

**1.2 Multi-user performance metrics**

Although a user may be covered for a certain percentage area for a given service, when multiple users are in a coverage area, the resources (time, frequency, power) are to be shared among the users. It can be expected that a user's average data rate may be reduced by at most a factor of N when there are N active users, compared to a single user rate.

**.3 Definitions of performance metrics**

The simulation statistics are collected from sectors belonging to the test cell(s) of the deployment scenario. Collected statistics will be traffic-type (thus traffic mix) dependent.

In this section, we provide a definition for various metrics collected in simulation runs. For a simulation run, we assume:

- 1] Simulation time per drop =  $T_{sim}$
- 2] Number of simulation drops =  $D$
- 3] Total number of users in sector(s) of interest =  $N_{sub}$
- 4] Number of packet calls for user  $u$  =  $p_u$
- 5] Number of packets in  $i^{th}$  packet call =  $q_{i,u}$

**1.3.1 Throughput performance metrics**

For evaluating downlink (uplink) throughput, only packets on the downlink (uplink) are considered in the calculations. Downlink and uplink throughputs are denoted by upper case DL and UL respectively (example:  $R_u^{DL}, R_u^{UL}$ ). The current metrics are given per a single simulation drop.

The throughput shall take into account all layer 1 and layer 2 overheads.

### 3.1.1 Average data throughput for user u

The data throughput of a user is defined as the ratio of the number of information bits that the user successfully received divided by the amount of the total simulation time. If user  $u$  has  $p_u^{DL(UL)}$  downlink (uplink) packet calls, with  $q_{i,u}^{DL(UL)}$  packets for the  $i^{\text{th}}$  downlink (uplink) packet call, and  $b_{j,i,u}$  bits for the  $j^{\text{th}}$  packet; then the average user throughput for user  $u$  is

$$R_u^{DL(UL)} = \frac{\sum_{i=1}^{p_u^{DL(UL)}} \sum_{j=1}^{q_{i,u}^{DL(UL)}} b_{j,i,u}}{T_{Sim}}$$

### 1.3.1.2 Average per-user data throughput

The average per-user data throughput is defined as the sum of the average data throughput of each user in the system as defined in Section 1.3.1.1, divided by the total number of users in the system.

### 1.3.1.3 Sector data throughput

Assuming  $N_{sub}$  users in sector of interest, and  $u^{\text{th}}$  user where  $u \in N_{sub}$  has throughput  $R_u^{DL(UL)}$ , then DL or UL sector data throughput is :

$$R_{sec}^{DL(UL)} = \sum_{u=1}^{N_{sub}} R_u^{DL(UL)}$$

### 1.3.1.4 Cell edge user throughput

The cell edge user throughput is the  $x^{\text{th}}$  percentile point of the CDF of user throughput as defined in IMT.TECH.

## 1.3.2 Performance metrics for delay sensitive applications

For evaluating downlink (uplink) delay, only packets on the downlink (uplink) are considered in the calculations. Downlink and uplink delays are denoted by upper case DL and UL respectively (example:  $D_u^{DL}$ ,  $D_u^{UL}$ ).

### 1 Packet delay

Assuming the  $j^{\text{th}}$  packet of the  $i^{\text{th}}$  packet call destined for user  $u$  arrives at the BS (SS) at time  $T_{j,i,u}^{arr,DL(UL)}$  and is delivered to the MS (BS) MAC-SAP at time  $T_{j,i,u}^{dep,DL(UL)}$ , the packet delay is defined as

$$Delay_{j,i,u}^{DL(UL)} = T_{j,i,u}^{dep,DL(UL)} - T_{j,i,u}^{arr,DL(UL)}$$

Packets that are dropped or erased may or may not be included in the analysis of packet delays depending on the traffic model specifications. For example, in modeling traffic from delay sensitive applications, packets may be dropped if packet transmissions are not completed within a specified delay bound. The impact of such dropped packets can be captured in the packet loss rate.

### **1.3.2.2 The CDF of packet delay per user**

CDF of the packet delay per user provides a basis in which maximum latency, x%-tile, average latency as well as jitter can be derived.

### **1.3.2.3 X%-tile packet delay per user**

The x%-tile packet delay is simply the packet delay value for which x% of packets have delay below this value.

### **1.3.2.4 The CDF of X%-tile packet delays**

The CDF of x%-tiles of packet latencies is used in determining the y%-tile latency of the x%-tile per user packet delays.

### **1.3.2.5 The Y%-tile of X%-tile packet delays**

The y%-tile is the latency number in which y% of per user x%-tile packet latencies are below this number. This latency number can be used as a measure of latency performance for delay sensitive traffic. A possible criteria for VoIP, for example, is that the 95<sup>th</sup>-%-tile of the 97%-tile of packet latencies per user is 50 ms.

### **1.3.2.6 Packet loss ratio**

The packet loss ratio per user is defined as

$$\text{Packet Loss Ratio} = 1 - \frac{\text{Total Number of Successfully Received Packets}}{\text{Total Number of Successfully Transmitted Packets}}$$

## **1.3.3 System level metrics for unicast transmission**

### **1.3.3.1 Spectral efficiency**

Spectral efficiency should represent the system throughput measured at the interface from the MAC layer to the upper layers, thus including both physical layer and MAC protocol overhead.

The average cell/sector spectral efficiency is defined as

$$r = \frac{R}{BW_{eff}}$$

Where  $R$  is the aggregate cell/sector throughput,  $BW_{eff}$  is the effective channel bandwidth. The effective channel bandwidth is defined as

$$BW_{eff} = BW \times TR$$

where  $BW$  is the used channel bandwidth, and  $TR$  is time ratio of the link. For example, for FDD system  $TR$  is 1, and for TDD system with DL:UL=2:1,  $TR$  is 2/3 for DL and 1/3 for UL, respectively.

### **1.3.3.2 Application capacity**

Application capacity ( $C_{app}$ ) is defined as the maximum number of application users that the system can support without exceeding the maximum allowed outage probability.

### **1.3.3.3 System outage**

System outage is defined as when the number of users experiencing outage exceeds x% of the total number of users. The user outage criterion is defined based on the application of interest.

## **1.4 Fairness criteria**

### **1.4.1 Moderately fair solution for full buffer traffic**

It is an objective to have uniform service coverage resulting in a fair service offering for best effort traffic. A measure of fairness under the best effort assumption is important in assessing how well the system solutions perform.

Fairness is evaluated by determining the normalized cumulative distribution function (CDF) of the per user throughput. The CDF is to be tested against a predetermined fairness criterion under several specified traffic conditions.

The CDF of the normalized throughputs with respect to the average user throughput for all users is determined. This CDF shall lie to the right of the curve given by the three points in [Table 3](#).

TABLE 3

### **Moderately fair criterion CDF**

<b>Normalized throughput w.r.t average user throughput</b>	<b>CDF</b>
0.1	0.1
0.2	0.2
0.5	0.5