Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Comments on Draft 802.16m Evaluation Methodology Document: Fairness and Lateness Indications**
Date Submitted	**2007-07-15**
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Re:	This is a response to a call for comments on draft 802.16m evaluation methodology document http://ieee802.org/16/tgm/docs/80216m-07_023.pdf.
Abstract	This document provides some comments on the fairness criteria and the lateness performance metrics, and proposes added texts.
Purpose	For discussion and approval by TGm.
Notice	
Release	
Patent Policy	

Comments on Draft 802.16m Evaluation Methodology Document: Fairness and Lateness Indications

1.0 Introduction

This document provides comments on the fairness criteria, which are in Section 13.3 of the draft 802.16m evaluation methodology document, and proposes an added text on short-term fairness. In addition, it is suggested that the definition of lateness be included in the performance metrics for delay sensitive applications, which appear in Section 13.2.2.

2.0 Short-term Fairness Criterion

The fairness criteria in Section 13.3 consider only the long-term fairness, in other words, fairness after an entire simulation run. Since the simulation time depends on the traffic type and mobility considered, and is not specified in the evaluation methodology document, from the long-term fairness results it is not clear whether fairness is maintained in any given short interval. It is suggested that short-term fairness be also considered through specifying a fairness indicator.

2.1 Fairness Indicator

In general, fairness can be measured by comparing the weighted throughputs between users. A weighted throughput of user *i* in time interval $\left[t, t+\tau\right)$ is defined as

$$\hat{T}_i\left(t\right) = \frac{\varphi_i\left(t, t+\tau\right)}{f_i\left(\phi_i, CQI_i\left(t, t+\tau\right)\right)}, \tag{1}$$

where $\varphi_i\left(t, t+\tau\right)$ is the service counted in bits received by the *i*th user in $\left[t, t+\tau\right)$; $f_i\left(\phi_i, CQI_i\left(t, t+\tau\right)\right)$ is the weighting function of the *i*th user dependent of traffic related parameter ϕ_i and the channel quality $CQI_i\left(t, t+\tau\right)$ in $\left[t, t+\tau\right)$. With the weighted throughput, two possible short-term fairness indicators can be defined [6]:

$$F_1\left(t\right) = \frac{\min_{i \in A} \hat{T}_i\left(t\right)}{\max_{i \in A} \hat{T}_i\left(t\right)} \tag{2}$$

$$F_2\left(t\right) = \frac{\left|\sum_{i \in A} \hat{T}_i\left(t\right)\right|^2}{\left|A\right| \sum_{i \in A} \hat{T}_i^2\left(t\right)} \tag{3}$$

where A is the set of users with nonzero buffers in $\left[t, t+\tau\right)$, and $\left|A\right|$ is the cardinality of A. These indicators assume their values between 0 and 1, the higher they are, the fairer the scheduling. During simulation, if either of these indicators is computed every τ time units and recorded, the lowest indicator value of all times can serve as a short-term fairness indication. Thus, it is suggested that, in addition to the fairness criteria given in Section 13.3, a short-term fairness indicator should also be obtained for the purpose of comparison between scheduling algorithms.

Using the Jain fairness index $F_2(t)$ [6] as an example, and without considering the weighting function, it is proposed to add the following text.

13.3.2 Short-term Fairness Indication

During the simulation, the following short-term fairness indicator should be computed and recorded every τ ms (τ is suggested to be 20 or 40):

$$F(t) = \frac{\left|\sum_{i \in A} \hat{T}_i(t)\right|^2}{|A| \sum_{i \in A} \hat{T}_i^2(t)}$$

where $\hat{T}_i(t)$ is the amount of service received by the *i*th user in time interval $[t, t+\tau)$, A is the set of users with nonzero buffers in $[t, t+\tau)$, and $|A|$ is the cardinality of A. The minimum of $F(t)$ during the simulation time, defined as $F_{\min} = \min_{t \in \{0, \tau, 2\tau, \ldots, T_{sim}\}} F(t)$, can serve as an indication of how much fairness is maintained all the time.

3.0 Lateness for Delay Sensitive Applications

In Section 13.2.2, performance metrics for delay sensitive applications are specified. However, these metrics do not explicitly indicate whether the quality of service (QoS) is met. It is suggested that, in addition to delay metrics, lateness metrics should also be provided for delay sensitive applications.

Assuming that the deadline of the *j*th packet of the *i*th packet call destined for user *u* in downlink (uplink) channel is $D_{j,i,u}^{DL(UL)}$ and successfully delivered to the MS (BS) MAC-SAP at time $T_{j,i,u}^{dep,DL(UL)}$, then the packet lateness of the *j*th packet of the *i*th packet call destined for user *u* is defined as

$$lateness_{j,i,u}^{DL(UL)} = [T_{j,i,u}^{dep,DL(UL)} - D_{j,i,u}^{DL(UL)}]^+ \quad (4)$$

Lateness is a measure to see if the received packet is out of time or not, and such a measure is one of the very fundamental QoS parameters. *Thus, it is proposed that the above lateness definition be added to Section 13.2.2, and the deadlines for different traffics be explicitly specified.*

Following are some lateness metrics. According to the assumption in Section 10.7 that each user generates only one type of traffic, these lateness metrics can be derived from the CDF of packet delay per user specified in Section 13.2.2.2. Otherwise, these metrics have to be explicitly computed during the simulation.

3.1 User Average Lateness

The average packet lateness for use *u* in downlink (uplink) channel is defined as

$$lateness_u^{avg,DL(UL)} = \frac{\sum_{i=1}^{p_u^{DL(UL)}} \sum_{j=1}^{q_{i,u}^{DL(UL)}} [T_{j,i,u}^{dep,DL(UL)} - D_{j,i,u}^{DL(UL)}]^+}{\sum_{i=1}^{p_u^{DL(UL)}} q_{i,u}^{DL(UL)}} \quad (5)$$

where $p_u^{DL(UL)}$ is the number of packet calls for user *u*, and $q_{i,u}^{DL(UL)}$ is the number of packets of the *i*th packet call for user *u* in downlink (uplink) channel.

3.2 X% Miss Deadline Packet Per User

The X% miss deadline packet simply means that there is X% of packets for user *u* with lateness greater than zero, and is defined as follows.

$$X_u^{DL(UL)} = \frac{\sum_{i=1}^{p_u^{DL(UL)}} \sum_{j=1}^{q_{i,u}^{DL(UL)}} \gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)})}{\sum_{i=1}^{p_u^{DL(UL)}} q_{i,u}^{DL(UL)}} \tag{6}$$

where $\gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)})$ defined as

$$\gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)}) = \begin{cases} 1, & if \;\; T_{j,i,u}^{dep,DL(UL)} - D_{j,i,u}^{DL(UL)} > 0 \\ 0, & otherwise \end{cases} \tag{7}$$

is the packet lateness indication function of the *j*th packet of the *i*th packet call for user u . (7) means that if the lateness of the *j*th packet of the *i*th packet call for user *u* is greater than zero, then the packet lateness indication function of the *j*th packet of the *i*th packet call for user *u* (that is, $\gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)})$) equals to 1; otherwise, it equals to zero. Therefore, the numerator of (6) can be considered as the total number of packets which miss the deadline for user *u* in the sector, and (6) is the percentage of packets that miss their deadline for user *u*.

3.3 System Average Lateness

The average packet lateness of the system in downlink (uplink) channel is defined as

$$lateness_{sys}^{avg,DL(UL)} = \frac{\sum_{u=1}^{N} \sum_{i=1}^{p_u^{DL(UL)}} \sum_{j=1}^{q_{i,u}^{DL(UL)}} [T_{j,i,u}^{dep,DL(UL)} - D_{j,i,u}^{DL(UL)}]^+}{\sum_{u=1}^{N} \sum_{i=1}^{p_u^{DL(UL)}} q_{i,u}^{DL(UL)}} \tag{8}$$

where N is the number of users in the system. (8) can also be used to represent the average lateness of each sector by using if N is replaced by N_{sub} (which is the number of users in a sector) .

3.4 X% Miss Deadline Packets of the System

$$X_{sys}^{DL(UL)} = \frac{\sum_{u=1}^{N} \sum_{i=1}^{p_u^{DL(UL)}} \sum_{j=1}^{q_{i,u}^{DL(UL)}} \gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)})}{\sum_{u=1}^{N} \sum_{i=1}^{p_u^{DL(UL)}} q_{i,u}^{DL(UL)}} \tag{9}$$

where $\gamma_{j,i,u}^{DL(UL)}(T_{j,i,u}^{dep,DL(UL)}, D_{j,i,u}^{DL(UL)})$ is defined the same as in (7). (9) can also be used to represent the X% miss deadline packets of each sector if N is replaced by N_{sub}.

3.5 Hard QoS Applications Packet Loss Ratio

For hard QoS constraint applications, the packet which misses the deadline should be considered as a loss packet, even though the packet is successfully received. The packet loss ratio per user with hard QoS applications is defined as

$$packet\ loss\ ratio_{(hard\ QoS)} = 1 - \frac{Total\ number\ of\ successfully\ received\ and\ not\ miss\ deadline\ packets}{Total\ number\ of\ successfully\ transmitted\ packets} \quad (10)$$

4.0 References

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