Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Multihop System Evaluation Methodology – Fairness Criterion {Harmonized}**
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Re:	Response to a call for comments for C80216j-07/040.pdf
Abstract	This document provide fairness criteria to be used by 16j and to be included as a sub-section of the Performance Metric document. This is a modified version of the content of 43 submissions on evaluation methodology.
Purpose	To propose fairness criterion to be used in the evaluation
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Multi-hop System Evaluation Methodology: Performance Metrics

1 Introduction

Due to the near-far effect of a wireless system (i.e. mobile which are located far away from the base and relay receives low signal quality or data rate), the system capacity of a cellular system may be increased by giving priority to high data rate users and therefore, consideration of fairness in serving users is important in cellular systems. The efforts to provide fairness means some users need to be provided with additional resources that may also impact system throughput since shared channel is not used at the peak data rate.

When a user is connected to a BS via multiple hops, those users utilize more resources (two or more links) than the other users even under usual round robin scheduling scheme. The schemes such as proportionate fairness [1] schemes may provide different level of fairness for relay systems (i.e. different distribution of the throughput or delay) compared to the fairness obtained by using that scheme for the cellular system.

Therefore, for relay systems special consideration may be given to incorporate the impact of these when evaluating capacity and fairness.

2 Text Proposal

++++++++++++++++++++++++ *start text proposal* ++++++++++++++++++

Fairness Criteria

Since one of the primary objectives of the introduction of relays is to have uniform service coverage resulting in a fair service offering, a measure of fairness is very important in assessing how well the relaying solutions perform.

The 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 same scheduling algorithm shall be used for all simulation runs. That is, the scheduling algorithm is not to be optimized for runs with different traffic mixes. The owner(s) of any proposal are also to specify the scheduling algorithm.

Let $T_{put}[k]$ be the throughput for user k. The normalized throughput with respect to the average user throughput for user k, $\widetilde{T}_{put}[k]$ is given by

$$\widetilde{T}_{put}[k] \quad \frac{T_{put}[k]}{\underset{i}{avg}\, T_{put}[i]}.$$

Fairness Index

Since CDF does not provide a quantitative measure of fairness it is important to define a metric to measure fairness. Since fairness of a system can be increased by providing more resources to low rate users which result in a reduction of the system capacity, when performance is measured it is important to specify the associated fairness. Then, the performance of two systems can be compared under same fairness conditions. For this

purpose, fairness index of a resulting throughput distribution is defined as,

$$\text{Fairness Index (FI)} = e^{-\sigma} \quad \text{---------} \quad (2)$$

where σ is the standard deviation of the normalized per user throughput distribution.

Note that higher the FI higher is the fairness of a system and FI =1 corresponds to the case where all the users receive same throughput.

Depending on the service type and test case being simulated, different fairness requirements may be specified. Three such fairness criteria are specified in this document for this purpose. The evaluation methodology should specify what fairness criterion has to be met for a given test case.

(1) Equal Throughput Criterion:

(2) To have a reasonably compromise fairness as specified in [1] to meet a CDF requirement.

(3) To meet a specified level of fairness

Equal Throughput or Full Fair Criterion:

To satisfy equal throughput requirement, all the users who are admitted to the system should get equal per user throughout if they have same amount of traffic to send/receive. In a full queue scenario, where traffic is assumed to be always available for transmission, the equal throughput requirement can be achieved by allocating time slots to users, such that the time allocated during a certain period for that user is inversely proportional to the data rate capability of the user.

If the data rate capability of the ith user is *r(i)*, under the equal throughput criterion, time allocated to each user should be proportional to 1 / *r(i)* (assuming equal input traffic).

Comment from David Chen:

{This is per user throughput not total throughput}

Harmonized Resolution: Reject the comment as this is the aggregate throughput.}

The resulting equal aggregate throughput is, $C \quad \frac{1}{\sum_{i=1}^{n} 1/(r(i))}$

Since one of the primary objectives of relays is to provide uniform service offering across users, the total aggregate throughput under equal throughput criterion, is a good metric to compare two systems.

Moderately Fair Solution as Specified in [1]:

In certain cases, the fairness requirement specified in [1] which is appended below, is to be used to provide a moderate fairness across users.

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 1.

Table 1 Criterion CDF

Normalized Throughput w.r.t average user	CDF

throughput	
0.1	0.1
0.2	0.2
0.5	0.5

Fairness Criterion to meet a Specified Fairness Index

{ Comment by David Chen: The word lower should be replaced by Higher}

{Harmonised Resolution: The word is to to be replaced as the original document has an editorial error}

Under this fairness criterion, the fairness index of the normalized per user throughput should be ~~lower~~ higher than a target value. This target value is to be specified under each test case. i.e., the fairness requirement is,

Fairness Index of the resulting distribution > target_fairness_index.------ (3)

++++++++++++++++++*end of text proposal* ++++++++++++++++

References

[1] 3GPP2/TSG-C.R1002, “1xEV-DV Evaluation Methodology (V14)”, June 2003.