

Project	IEEE 802.16 Broadband Wireless Access Working Group < http://ieee802.org/16 >	
Title	Proposed Addition of Section 8.3.3.1.7 [“Channel Quality Measurements at the Subscriber Station”] to Document 80216ab_01/01r2	
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Re:	This is text describing channel quality measurements at the Subscriber Station, which we propose be added to document 80216ab_01/01r2 as a new section, section 8.3.3.1.7.	
Abstract	This proposal provides procedures by which the Subscriber Station PHY may collect channel quality measurements (RSSI, CINR, uncoded BER), compute mean and standard deviation statistics from these measurements, and then report these statistics to the MAC.	
Purpose	To have supplied text incorporated into document 80216ab_01/01r2 as section 8.3.3.1.7	
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Proposed Addition of Section 8.3.3.1.7 [“Channel Quality Measurements at the Subscriber Station”] to Document 80216ab_01/01r2

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Comments

This proposal is intended as only a starting point for discussions on what specifications for channel quality measurements should be. Inputs from other 802.16ab meeting participants to both improve our approach and establish better parameter specifications (such as measurement ranges and accuracies) are especially encouraged. For some of the parameter specifications, we did our best (in a limited amount of time) to propose figures that seemed reasonable. Nevertheless, we view these figures as placeholders, which should be subject to scrutiny and modification.

In our proposed text, we provide definitions for the mean and standard deviation of Received Signal Strength Indication (RSSI), Carrier-to-Interference-and-Noise-Ratio (CINR), and the mean of uncoded BER. We recognize that only a subset of these statistics may be needed, or that additional statistics may also be required.

Proposed Text

8.3.3.1.7 Channel Quality Measurements at the Subscriber Station

8.3.3.1.7.1 Introduction

A Base Station (BS) is responsible for making assignments and/or re-assignments based on both upstream and downstream channel quality assessments. It can directly determine channel quality on upstream channels from the messages that it receives from Subscriber Stations (SS). However, to determine the channel quality of its downstream channels, a Base Station requires channel quality reports from Subscriber Stations.

A Base Station may use channel quality reports from Subscriber Stations to aid its decision-making on issues such as the ‘best’ Base Station to communicate with a particular Subscriber Station. The Base Station might also decide on the adaptive modulation type and FEC to be used when communicating with a Subscriber Station, and/or the necessity of a channel change when channel conditions, such as shadowing or interference levels, worsen. In addition, the Subscriber Station may itself use the information channel quality measurements to select a candidate Base Station (or Base Stations) during registration, or if perhaps, if the Subscriber Station should solicit a channel (or Base Station) reassignment when downstream channel conditions worsen.

Several types of channel quality measurements and associated statistics are defined to address the aforesaid needs. One measurement is a Received Signal Strength Indication (RSSI); another is a Carrier-to-Interference-and-Noise-Ratio (CINR) estimate. A third is the uncoded Bit Error Rate (BER).

The process by which RSSI measurements are taken does not necessarily require receiver demodulation lock; for this reason, RSSI measurements offer reasonably reliable channel strength assessments even at low signal levels. On the other hand, although CINR measurements require receiver lock, they provide information on the actual operating condition of the receiver, including interference and noise levels, and signal strength. CINR measurements also tend to have much more resolution than BER measurements in assessing channel quality, especially at high CINRs. Like CINR measurements, uncoded BER measurements also require receiver demodulation lock, and they also provide information on the reception quality experienced by the receiver. Due to their quantization and finite sample sizes, however, uncoded BER measurements may not be very accurate at low BERs, unless extremely long averaging intervals are chosen. Nevertheless, they do directly measure the demodulated (but not FEC decoded) quality of the channel symbols being processed by the receiver.

Since Non-Line-Of-Sight (NLOS) subscriber locations may experience Rayleigh or Ricean fading, signal quality (and signal quality measures) may vary with time. For this reason, both mean and standard deviation statistics are defined for the RSSI and CINR measurements. Only a mean statistic is defined for the uncoded BER measurement.

The mean statistics are intended to convey the average signal quality level for a channel, whereas the standard deviation statistics are intended to convey the variation in that average value. These variations can be useful when determining whether a given channel is dominantly line-of-sight, Ricean faded, or Rayleigh-faded. Such information may be useful in Base Station selection: for example, a nearby Base Station may be propagating through tree leaves and is Rayleigh-faded, whereas a more distant Base Station is not confronted with the tree-fading. Variance statistics also capture the added capability of a Subscriber Station when it possesses receive diversity.

To reduce complications due to power control and adaptive modulation on the downstream, signal quality statistics shall only be computed using data collected during broadcast messages---since these messages have a fixed and constant modulation and power control level.

The estimators shall also be responsive to reset commands delivered from the Subscriber Station MAC. Reset commands may reset individual signal quality measures, or all measures. During a reset, old estimate(s) and the state variable(s) associated with a signal quality measure are discarded, the time index for that measure and its associated variables reverts to 0, and the estimator(s) and state variable(s) are re-initialized using a fresh set of measurements.

8.3.3.1.7.2 RSSI Mean and Standard Deviation

When the collection of RSSI measurements is mandated in a system installation, a Subscriber Station shall obtain a RSSI measurement from the data associated with every broadcast message (such as the MAC header). From a succession of these measurements, the subscriber unit shall derive and update estimates of the mean and (if mandated) the standard deviation of the RSSI. The subscriber unit shall then be capable of reporting these mean and standard deviation estimates to the Base Station via various MAC messages.

The mean and standard deviation statistics shall be reported to higher layers (i.e., the Subscriber Station's MAC), or to the Base Station in units of dBm. These statistics shall be quantized and reported in 1 dB increments, ranging from a maximum of -60 dBm (encoded 111111 binary) to a minimum of -123 dBm (encoded 000000 binary). Values that extend beyond the extreme minimum or maximum of the reporting scale shall be assigned the closest extreme value within the scale.

The method used to estimate the RSSI of a single broadcast message is left to the implementer, as long as the resulting estimate meets minimum requirements. The relative accuracy of a single signal strength measurement, taken from a single broadcast packet, shall be +/- 2 dB, with an absolute accuracy of +/- 4 dB. This shall be the case over the entire range of input RSSIs. In addition, the range over which these single-packet measurements are measured should extend 3 dB on each side beyond the -60 dBm to 123 dBm limits for the final averaged statistics which are reported. Note that the mean statistic may have higher resolution (at least for static channels), since it is averaged over a number of message intervals.

The (linear) mean RSSI statistic shall be updated using the formula

$$\hat{\mu}_{RSSI_k} = \begin{cases} R_0^{mW} & k = 0 \\ (1 - \alpha)\hat{\mu}_{RSSI_{k-1}} + \alpha R_k^{mW} & k > 0 \end{cases},$$

where k is the time index for the broadcast message (with the initial message being indexed by k=0, the next message by k=1, etc.), R_k^{mW} is the RSSI measurement in mW during broadcast message k, and α is an averaging parameter specified by the Base Station. The mean estimate in dBm shall then be derived from

$$\hat{\mu}_{RSSI_k}^{dBm} = 10 \log_{10}(\hat{\mu}_{RSSI_k}).$$

To solve for the standard deviation, one shall first update the expectation-squared statistic

$$\hat{x}_{RSSI_k}^2 = \begin{cases} (R_0^{mW})^2 & k = 0 \\ (1 - \alpha)\hat{x}_{RSSI_{k-1}}^2 + \alpha(R_k^{mW})^2 & k > 0 \end{cases}$$

and then applies this result to

$$\hat{\sigma}_{RSSI_k}^{dB} = 5 \log_{10} \left(\hat{x}_{RSSI_k}^2 - \left(\hat{\mu}_{RSSI_k} \right)^2 \right),$$

which an expression for the standard deviation of the RSSI in dB. In all reports (to the Base Station, for example) the mean and standard deviation statistic shall be quantized to the specified 1 dB resolution, and coded using the 6-bit binary code previously described

8.3.3.1.7.3 CINR Mean and Standard Deviation

When Carrier-to-Interference-and-Noise-Ratio (CINR) measurements are mandated in a system installation, a Subscriber Station shall obtain a CINR measurement from the data associated with every broadcast message (such as the MAC header). From a succession of these measurements, the subscriber unit shall derive and update estimates of the mean and (if mandated) the standard deviation of the CINR. The subscriber unit shall then be capable of reporting these CINR mean and standard deviation estimates to the Base Station via various MAC messages.

The mean and standard deviation statistics shall be reported to higher layers (e.g., to the Subscriber Station's MAC), or to the Base Station in units of dB. These statistics shall be quantized and reported in 1 dB increments, ranging from a minimum of -10 dB (encoded 000000 binary) to a maximum of 53 dB (encoded 111111 binary). Values that extend beyond the extreme minimum or maximum of the reporting scale shall be assigned the closest extreme value within the scale.

The method used to estimate the CINR of a single broadcast message is left to the implementer, as long as it meets minimum requirements. One method to estimate the CINR of a single message is to normalize the mean-squared residual error of the detected data symbols by the average signal power:

$$CINR_k = \frac{A}{\sum_{n=0}^{N-1} |r_{k,n} - \hat{s}_{k,n}|^2},$$

where $CINR_k$ is the (linear) CINR of broadcast message k , $r_{k,n}$ is a received symbol n within broadcast message k , $\hat{s}_{k,n}$ the detected symbol (with channel state weighting) corresponding to received symbol n , and

$$A = \sum_{n=0}^{N-1} (\hat{s}_{k,n})^2$$

is the average signal power, which is normally kept constant, by action of AGC.

The relative and absolute accuracy of a CINR measurement derived from a single broadcast packet shall be +/-1 dB and +/-2 dB, respectively, for all input CINRs above 0 dB. In addition, the range over which these single-packet measurements are measured should extend 3 dB on each side beyond the -10 dB to 53 dB limits for the final reported, averaged statistics.

Note that the mean statistic may have higher resolution (at least for static channels), since it is averaged over a number of message intervals. The (linear) mean CINR statistic shall be derived from

$$\hat{\mu}_{CINR_k}^{dB} = 10 \log_{10}(\hat{\mu}_{CINR_k})$$

where

$$\hat{\mu}_{CINR_k} = \begin{cases} CINR_0 & k = 0 \\ (1 - \alpha)\hat{\mu}_{CINR_{k-1}} + \alpha CINR_k & k > 0, \end{cases}$$

k is the time index for the broadcast message (with the initial message indexed by $k=0$, the next message by $k=1$, etc.), $CINR_k$ is a linear measurement of CINR (derived by some mechanism which delivers the prescribed accuracy) for broadcast message k , and α is an averaging parameter specified by the Base Station.

To solve for the standard deviation, one first updates the expectation-squared statistic

$$\hat{x}_{CINR_k}^2 = \begin{cases} (CINR_0)^2 & k = 0 \\ (1 - \alpha)\hat{x}_{CINR_{k-1}}^2 + \alpha(CINR_k)^2 & k > 0, \end{cases}$$

and then applies this result to

$$\hat{\sigma}_{CINR_k}^{dB} = 5 \log_{10} \left(\left| \hat{x}_{CINR_k}^2 - \left(\hat{\mu}_{CINR_k} \right)^2 \right| \right),$$

which is an expression for the standard deviation of the CINR in dB.

In reports to supplied to the Subscriber Station MAC or Base Station, the mean and standard deviation statistics are quantized to the specified 1 dB resolution and the quantized results mapped to the 6-bit binary code for CINR which has been previously described.

8.3.3.1.7.3 Uncoded Mean BER

When uncoded BER measurements are mandated in a system installation, a Subscriber Station shall obtain an uncoded BER measurement from the data associated with every broadcast message (such as the MAC header). From a succession of these measurements, the subscriber unit shall derive and update estimates of the mean of the uncoded BER. The subscriber unit shall then be capable of reporting this mean BER statistic to the Base Station via various MAC messages.

The mean statistic shall be reported to higher layers, or to the Base Station, in $10\log_{10}(\text{BER})$ units. The uncoded BER range shall span from -3 (BER=5e-1 in linear terms) to -66 (BER=2.5e-7 in linear terms). The reported statistic shall be rounded to the nearest integer, and encoded into 6-bit unsigned binary word such that 000000 represents -63 and 111111 represents -3 . Values that exceed the extremes of -3 and -63 shall be encoded using the codes for the extreme values.

The method used to estimate the uncoded BER of a single broadcast message requires that the incoming symbol stream from the broadcast message be sliced to form an uncoded bit decision stream, and that bit decisions derived from the inner (convolutional coded) FEC are also sliced then convolutionally encoded to form a reference bit stream. The reference and bit decision stream are XORed, and the number of dissimilar bit locations, e.g. the number of 'bit errors', as well of the length of the bit stream, are recorded. Note that the length of the bit stream is essential, since broadcast messages may not always be of the same length. The BER is then calculated from the ratio of the number of bit errors to the total number of bits in the broadcast message to form the BER measurement, BER_k , for broadcast message k.

The mean BER statistic shall then be updated using

$$\hat{\mu}_{BER_k} = \begin{cases} BER_0 & k = 0 \\ (1 - \alpha)\hat{\mu}_{BER_{k-1}} + \alpha BER_k & k > 0, \end{cases}$$

where k is the time for broadcast message k (with the initial message indexed by k=0, the next message by k=1, etc.), and α is an averaging parameter supplied by the Base Station as a system parameter.

To report this statistic, one computes

$$\hat{\mu}_{BER_k}^{10\log_{10}} = 10\log_{10}(\hat{\mu}_{BER_k}),$$

rounds the result to the nearest integer, and then maps the integer result to the unsigned binary code for uncoded BER which has been previously described.