Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	Effective Radio Resource Utilization Index for MMR Performance Metric
Date Submitted	2006-09-19
Source(s)	Kanchei (Ken) Loa, Yung-Ting Lee, Yi-Hsueh Tsai Institute for Information Industry 8F., No. 218, Sec. 2, Dunhua S. Rd., Taipei City, Taiwan Voice: +886-2-2739-9616 Fax: +886-2-2378-2328 loa@nmi.iii.org.tw Peter Wang Nokia US 6000 Connection Dr Irving, TX 75039, USA. peter.wang@nokia.com
Re:	
Abstract	In IEEE 802.16j-06/013, “effective system spectral efficiency” is defined as a system-wise performance parameter. It, however, lacks of the granularity of multi-hop path and cannot be used to evaluate path selection schemes. The purpose of “effective radio resource utilization index” is to facilitate the evaluation of path selection schemes for MMR networks.
Purpose	This contribution proposes to add “effective radio resource utilization index” to Performance Metric in IEEE 802.16j-06/013.
Notice	
Release	
Patent Policy and Procedures	

	<mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Effective Radio Resource Utilization Index for MMR Performance Metric

Kanchei (Ken) Loa, Yung-Ting Lee, Yi-Hsueh Tsai

Institute for Information Industry

Introduction

This contribution proposes to add "effective radio resource utilization index" to Performance Metric in IEEE 802.16j-06/013[1]. In [1], "effective system spectral efficiency" is defined as a system-wise performance parameter. It, however, lacks of the granularity of multi-hop path and cannot be used to evaluate path selection schemes. The purpose of "effective radio resource utilization index" is to facilitate the evaluation of path selection schemes for MMR networks.

Text Proposal

-- Text Start --

4.2.6 Effective radio resource utilization index

Effective radio resource utilization index (ERUI) is defined as the radio resource used to transmit the user data normalized by the radio resource used to transmit the same data using 64-QAM CC ¾ with repetition 1. The radio resource is limited to OFDMA slot. Table 1 describes the calculated ERUI of all possible DL burst profile defined in 802.16e-2005. For example, ERUI = 3 means 3 OFDMA slots are needed to send 27 bytes.

Table 1 ERUI of DL Burst Profiles

Type	Burst Profile			Bytes/slot	ERUI
	Modulation	Coding	Repetition		
00	QPSK	CC/BTC/CTC ½	6	1	27.0000
01			4	1.5	18.0000
02			2	3	9.0000
03			1	6	4.5000
04		CC/BTC/CTC ¾	1	9	3.0000
10	16-QAM	CC/CTC ½	1	12	2.2500
11		BTC ½ *1		16	1.6875
12		CC/CTC ¾ *2		18	1.5000
13		BTC ¾		20	1.3500
20	64-QAM	CC/CTC 2/3	1	24	1.1250
21		BTC ¾		25	1.0800
22		CC/CTC ¾		27	1.0000
23		CTC 5/6		30	0.9000

*1: include 64-QAM BTC 1/3

*2: include 64-QAM CC/CTC ½

Formula for the *i*-th MS ERUI (r_{MS}^{i}) along with a selected path is defined as (the selected path could be UL or DL)

$$r_{MS}^{i} = w_{0}^{n_1} r_{0}^{n_1} + \sum_{j=2}^{h-1} w_{n_{j-1}}^{n_j} r_{n_{j-1}}^{n_j} + w_{n_{h-1}}^{i} r_{n_{h-1}}^{i} \qquad (1)$$

where $r_{n_{j-1}}^{n_j}$ denotes the ERUI of the link between node n_{j-1} and n_j,; h is the number of hop-count for the *i*-th MS; $w_{n_{j-1}}^{n_j}$ is a weighting factor due to the radio resource reuse, multicast/broadcast, or spatial diversity. For instance, $w_{n_{j-1}}^{n_j}$ = 1/*m* if *m* access stations use the same radio resource to transmit/receive the traffic simultaneously; $w_{n_{j-1}}^{n_j}$ = 1/*k* if an access station sends the multicast/broadcast data to *k* successors (MS or RS) simultaneously; $w_{n_{j-1}}^{n_j}$ = 1/*l* if an MS or a RS receives the same data from *l* predecessors (RS) simultaneously (a.k.a. Spatial Diversity). In spatial diversity scenario, the *i*-th MS ERUI (r_{MS}^{i}) are defined as the summation of the ERUI along diversity paths.

Four examples are given in Figure 1 to illustrate the MS ERUI along with a selected path. In Figure 1a, all weighting factors are set as 1. Figure 1b shows radio resource reuse scenario, where T^4 and T^6 denote the goodput of MS4 and MS6 when using the radio resource reuse in a certain time interval, respectively. Figure 1c describes multicast/broadcast scenario. In Figures 1d & 1e, two spatial diversity scenarios are described.

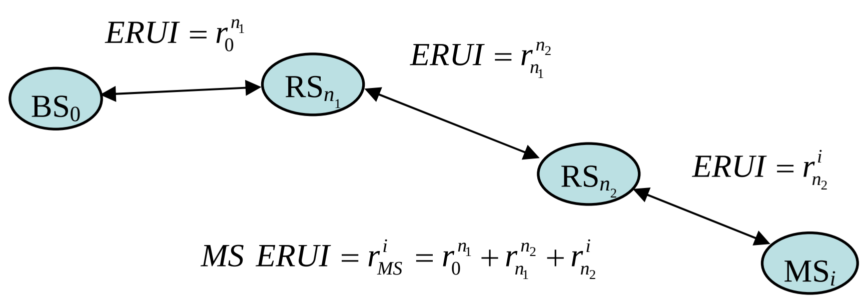


Figure 1a All weighting factors are set as 1

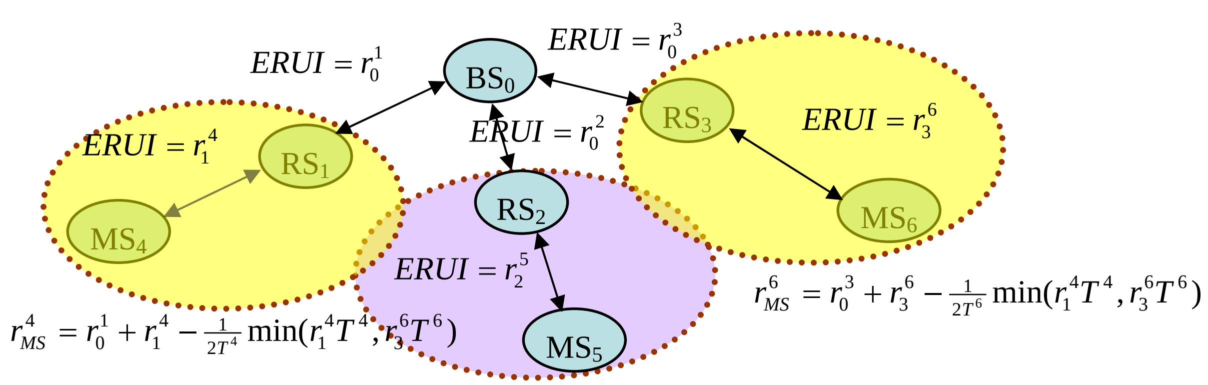
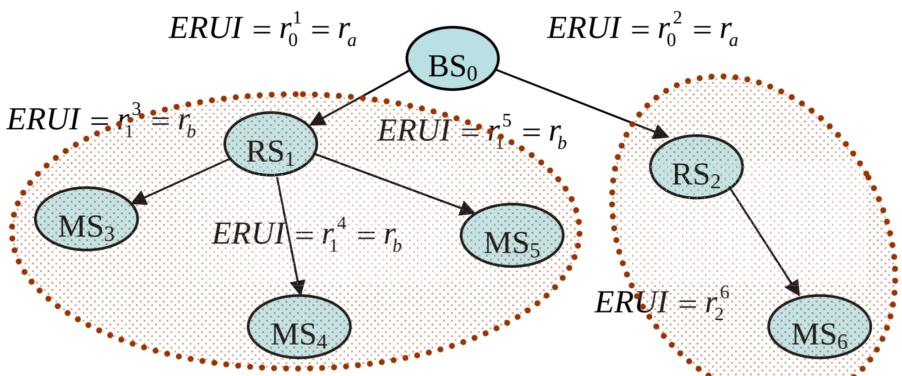
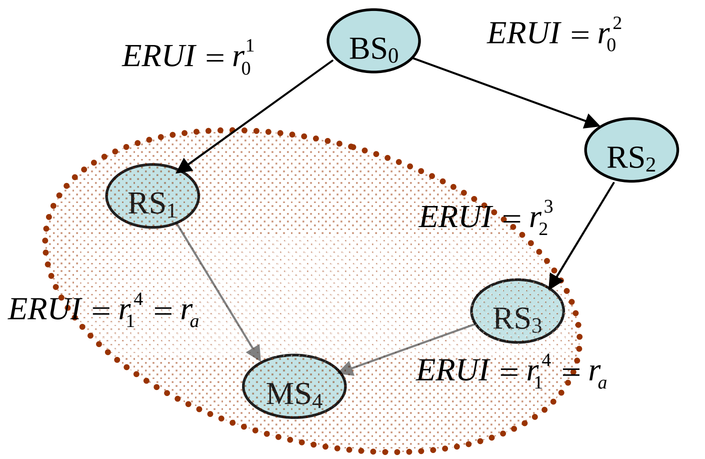


Figure 1b Radio resource reuse scenario



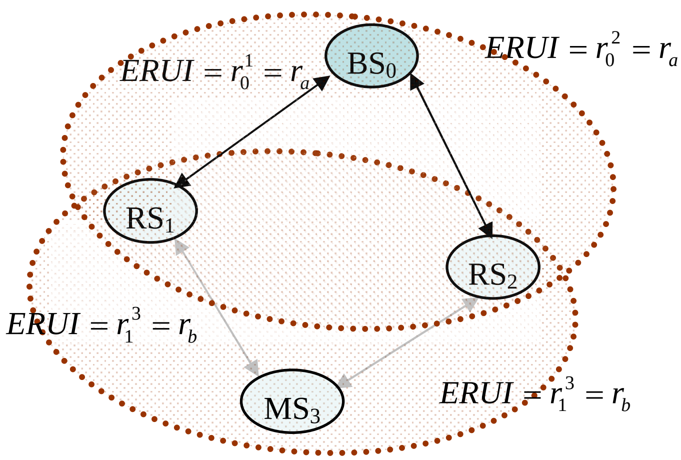
$$r_{MS}^3 = r_{MS}^4 = r_{MS}^5 = \tfrac{1}{2} r_a + \tfrac{1}{3} r_b \qquad r_{MS}^6 = \tfrac{1}{2} r_a + r_2^6$$

Figure 1c Multicast/broadcast scenario



$$r_{MS}^4 = \left(r_0^1 + \tfrac{1}{2} r_1^4\right) + \left(r_0^2 + r_2^3 + \tfrac{1}{2} r_1^4\right) = r_0^1 + r_0^2 + r_2^3 + r_a$$

Figure 1d Spatial diversity scenario I



$$r_{MS}^4 = \left(\tfrac{1}{2} r_0^1 + \tfrac{1}{2} r_1^3\right) + \left(\tfrac{1}{2} r_0^2 + \tfrac{1}{2} r_1^3\right) = r_a + r_b$$

Figure 1e Spatial diversity scenario II

In order to compare the performance of the path selection for the MMR-cell, the effective MMR-cell capacity index ($CI_{MMR-cell}$) is defined as

$$CI_{MMR-cell} = \sum_i \left\{ \left(r_{MS}^i \text{ } in\ downstream \right) \cdot T_{DL}^i \right\} + \sum_i \left\{ \left(r_{MS}^i \text{ } in\ upstream \right) \cdot T_{UL}^i \right\} \quad (2)$$

where T_{DL}^i and T_{UL}^i denote the goodput at *i*-th MS in unit of 64QAM CC ¾ with repetition 1 for DL and UL, respectively. The optimized path selection for all MSs via relay paths in an MMR cell is to maximize the effective MMR-cell capacity index.

-- Text End --

Annex

Examples of Comparison between Direct Path and Indirect Path are given as follows

In the following examples (Figure 2), all weighting factors are set as 1.

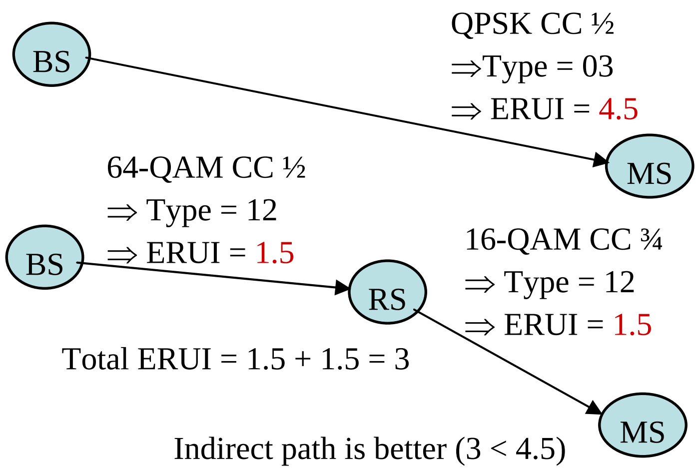


Figure 2a Indirect path is better

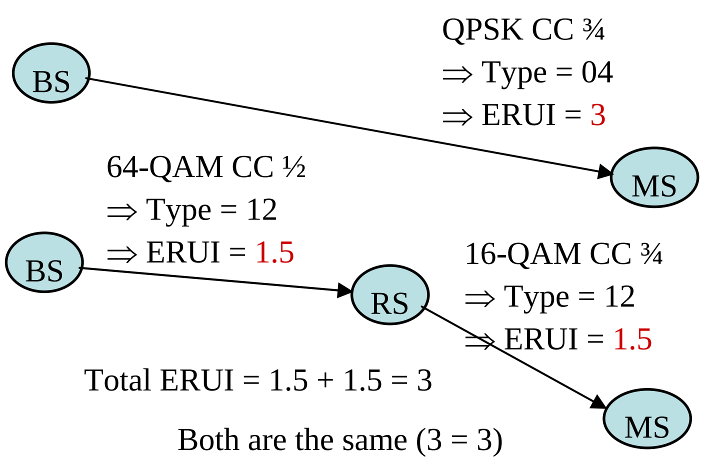


Figure 2b Both are the same

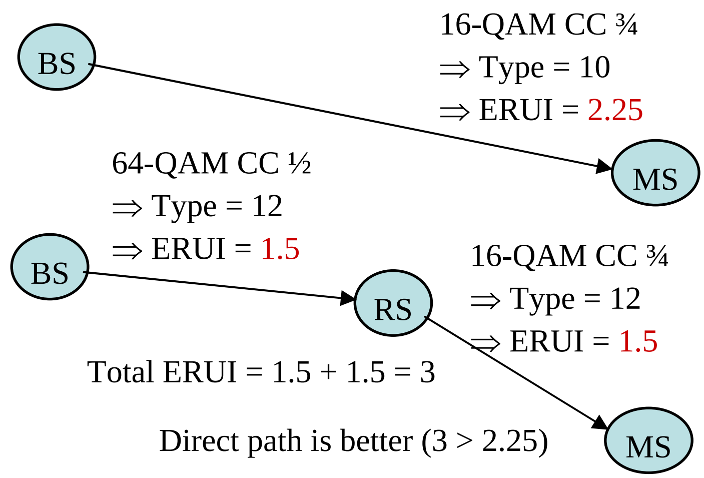


Figure 2c Direct path is better

In the following examples (Figure 3), the weighting factors of RS-MS link are set as 1/3.

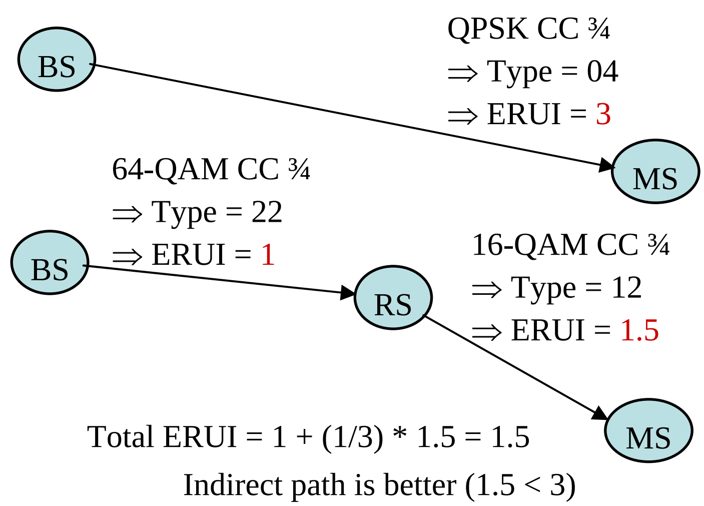


Figure 3a Indirect path is better

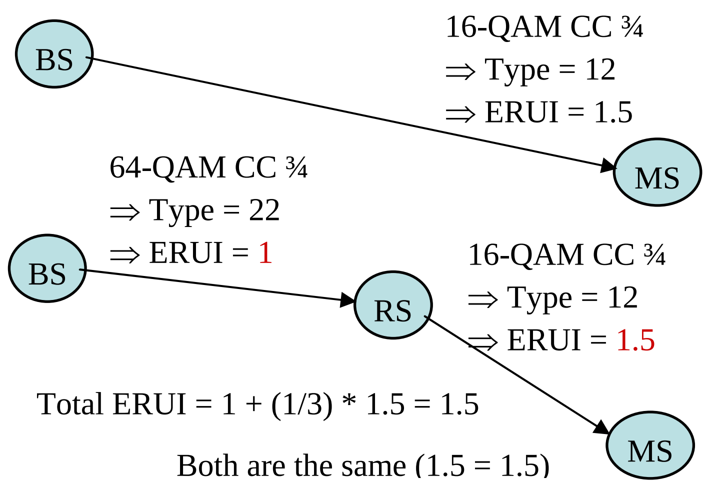


Figure 3b Both are the same

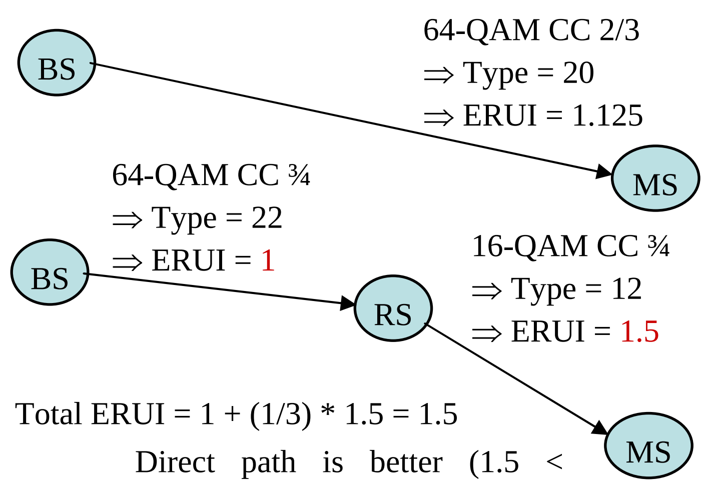


Figure 3c Direct path is better

References

[1] IEEE 802.16j-06/013, "Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)", September 2006.