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Title	**Transparent and Non-transparent Relay structure for diversity gain**
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Re:	TGm SDD: Femtocells; in response to the TGm Call for Contributions and Comments 802.16m-08/052 for Session 59
Abstract	This contribution is a high level proposal for relay structure to obtain diversity gain
Purpose	To discuss and adopt the proposed text in the next revision of the 802.16m SDD.
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Transparent and Non-transparent Relay Structure for diversity gain

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I. Introduction

  Transparent relay in WiMAX system is designed to improve the link budget. The weakest link between Mobile station (MS) and Base station (BS) is not used and the strong link between Mobile station and Relay station (RS) is used for transmission. Also, Non-transparent relay in WiMAX system is designed to increase the cell coverage through allocating relay station at the edge of the cell. This proposal is to achieve diversity gain in given relay structure. In case of transparent relay, Mobile station (or Base station) sends symbols to relay station as well as base station (or Mobile station) even if this link is weak. Therefore, Base station (or Mobile station) receives symbols from relay station as well as mobile station (or Base station) so that diversity gain can be improved using a proposed equation for relay structure. In case of non-transparent relay, Mobile station (or Base station) sends symbols to two relay stations and Base station (or Mobile station) received symbols from two relay stations so that it has two signal paths and can achieve diversity gain like the proposed method for transparent relay.

Proposal

1. Transparent Relay
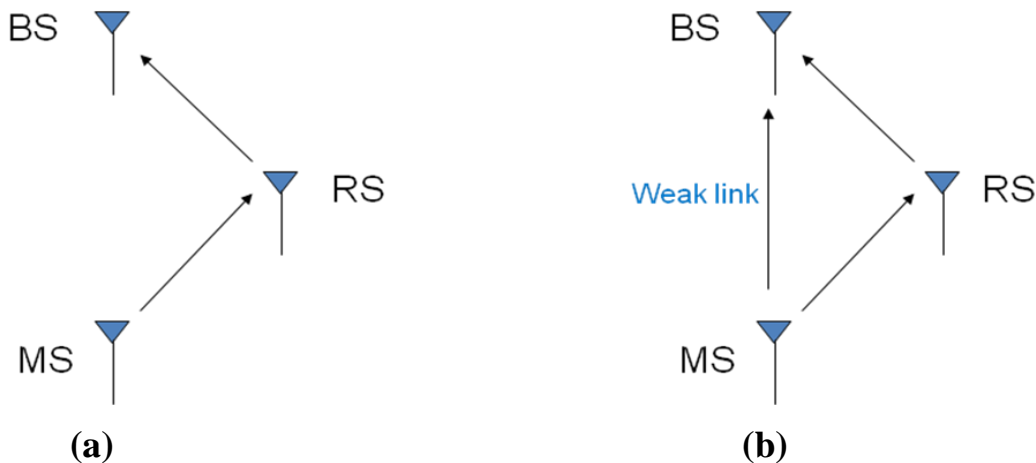

(a)   **(b)**

Fig 1. Transparent Relay (a) and Proposed Transparent Relay (b)

Fig 1(a) represents transparent relay to improve the uplink, which might be the weakest link due to the limited MS Tx power and Number of Antenna. Fig 1(b) represents proposed transparent relay to improve diversity gain. Although the link between BS and BS is weak, the receiver can achieve diversity gain.
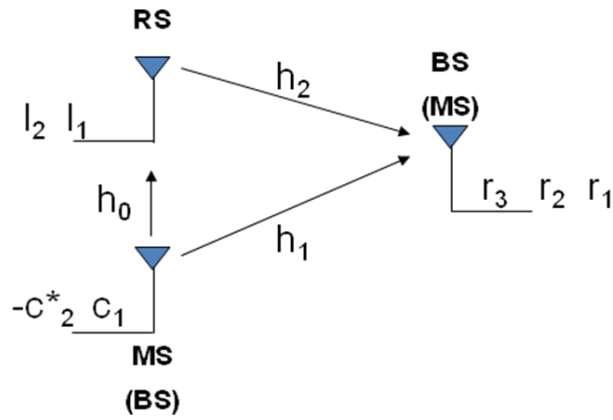
Fig 2. Example of transparent relay for diversity gain

It is shown in Fig 2 that transparent relay as an example can achieve diversity gain. The process is as followings:

1) MS sends C_1 to BS and RS. BS receives r_1 (Eq (1)). RS receives r_{relay1} and changes r_{relay1} to l_1.

2) MS sends $-C^*_2$ to BS and RS. BS receives r_2 (Eq (1))from RS(l_1) and MS($-C^*_2$). RS receives r_{relay2} and changes r_{relay2} to l_2

3) BS receives r_3 (Eq (1)) from RS (l_2)

4) BS combines r_1 and r_3 and then makes a numerical formula like Alamouti scheme (Eq (2) and (3))

$$
\begin{aligned}
r_1 &= h_1 c_1 + n_1 \\
l_1 &= r^*_{relay1} = h_0^* c_1^* + n_2^* \quad , \quad r_{relay1} = h_0 c_1 + n_2 \\
r_2 &= -h_1 c_2^* + h_2 l_1 + n_3 = -h_1 c_2^* + h_2 h_0^* c_1^* + n' \\
l_2 &= -r^*_{relay2} = h_0^* c_2 + n_4 \quad , \quad r_{relay2} = -h_0 c_2^* + n_4 \\
r_3 &= h_2 l_2 + n_5 = h_2 h_0^* c_2 + n''
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
r &= r_1 + r_3 = h_1 c_1 + h_2 h_0^* c_2 + n''' \\
r_2 &= -h_1 c_2^* + h_2 h_0^* c_1^* + n'
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
r_1' &= h_1 c_1 + h_2' c_2 + n''' \\
r_2' &= -h_1 c_2^* + h_2' c_1^* + n'
\end{aligned}
\tag{3}
$$

3

1   Table 1. Timing table for Transparent relay (a) and proposed transparent relay (b)

Symbol \ Time	T1	T2	T3
C1	MS→RS	RS→BS	
C2		MS→RS	RS→BS

2   (a)

Symbol \ Time	T1	T2	T3
C1	MS→RS	RS→BS	
C1	MS→BS		
C2		MS→RS	RS→BS
C2		MS→BS	

3   (b)

4

5   Table 2. Generalized timing table for proposed transparent relay

Symbol \ Time	T_1	T_2	T_3	…	T_{n-1}	T_n
C_1	MS→RS MS→BS	RS →BS				
C_2		MS →RS MS →BS	RS →BS			
C_3			MS →RS MS →BS			
…				…		
C_{n-2}					RS →BS	
C_{n-1}					MS →RS MS →BS	RS →BS
	$r_1=c_1$	$r_2=c_1+c_2$	$r_3=c_2+c_3$		$r_{n-1} = c_{n-2}+c_{n-1}$	$r_n=c_{n-1}$

6

4

1   Table 1 and 2 represent operation for each timing. The proposed transparent relay has 2 diversity gain and both
2   structures have same data rate (n-1/n sym/sec/Hz).
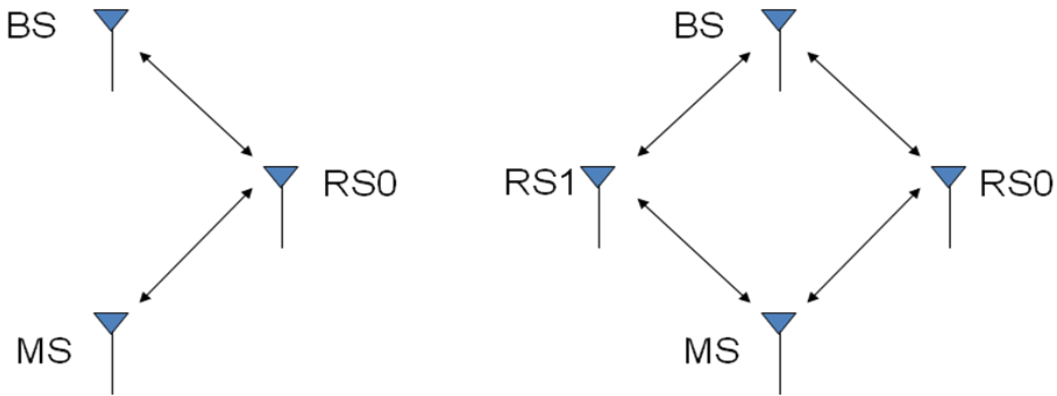
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2. Non-Transparent Relay

5

7   Fig 3. Non-transparent Relay (a) and Proposed Non-transparent Relay (b)

8

9   Fig 3(a) represents Non-transparent Relay to improve the link budget for both DL and UL. Fig 3(b) represent
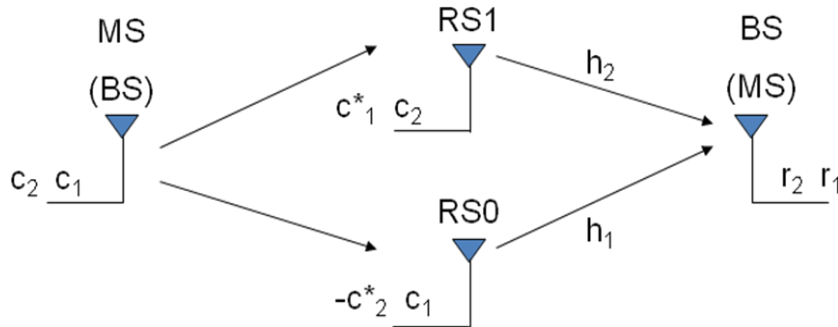10 proposed Non-transparent relay to obtain diversity gain.

11

13   Fig 4. Example of non-transparent relay for diversity gain

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15 It is shown in Fig 4 that non-transparent relay as an example can achieve diversity gain. The process is as
16 followings:

17   1) MS sends C_1 to RS_0 and C_2 to RS_1. BS receives r_1 (Eq (4)) from RS_0 and RS_1.

18   2) MS sends C_2 to RS_0 and C_1 to RS_1. RS_0 changes C_2 to $-C^*_2$ and RS_1 changes C_1 to C^*_1.

19   3) BS receives r_2 (Eq (4))from RS0 ($-C^*_2$) and RS1 (C^*_1)

20   4) The received r_1 and r_2 is same as a numerical formula like Alamouti scheme (Eq (4) and (5))

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$$r_1 = h_1 c_1 + h_2 c_2 + n_1$$
$$r_2 = -h_1 c_2^* + h_2 c_1^* + n_2 \qquad (4)$$

$$\tilde{r}_1 = h_1^* r_1 + h_2 r_2^* = (|h_1|^2 + |h_2|^2)c_1 + h_1^* n_1 + h_2 n_2^* \rightarrow \hat{c}_1$$
$$\tilde{r}_2 = h_2^* r_1 - h_1 r_2^* = (|h_1|^2 + |h_2|^2)c_2 - h_1 n_2^* + h_2^* n_1 \rightarrow \hat{c}_2 \qquad (5)$$

Text Proposal for SDD

--Start of the Text--

15.1.x. Transparent Relay operation for diversity gain

Transparent relay can be used for achieving diversity gain.

BS (or MS) can receive symbols from RS (Relay Station) and MS (or BS) simultaneously.

Synchronization among BS, MS and RS is required.

15.1.y. Non-Transparent Relay operation for diversity gain

Non-transparent relay can be used for achieving diversity gain.

BS (or MS) can receive symbols from two RSs (Relay Station) simultaneously.

Synchronization among BS, MS and RS is required.

---End of the Text---

References

[1]   IEEE C802.16m-08/003r5, "Project 802.16m System Description Document (SDD)".

[2]   IEEE C80216m-08/1498, "Session 58 Relay Rapp Group Report".