Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Cooperative Relay Approaches in IEEE 802.16j**
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Re:	Call for Technical Contributions, 80216j-02_027
Abstract	The use of cooperative relay allows for spatial diversity or multiplexing in the multi-hop network and benefits the inter relay handoff greatly due to the “virtual cell” concept. Adaptive Distributed Space Time/frequency Coding (ADSTC) is proposed and preferred for cooperative relaying due to its simplicity and its alignment with legacy 802.16.
Purpose	[Description of what the author wants 802.16 to do with the information in the document.]
Notice	
Release	
Patent Policy and Procedures	

Cooperative Relay Approaches in IEEE 802.16j

I. Introduction

Cooperative relaying is principally a distributed multiple-in-multiple-out (MIMO) system in multi-hop environments, as shown in Figure 1. Multiple Relay Stations (RS) work collaboratively as a virtual array to improve signal quality or data rate, owing to spatial diversity or multiplexing respectively. Furthermore, cooperative relaying potentially simplifies handoff between RSs.

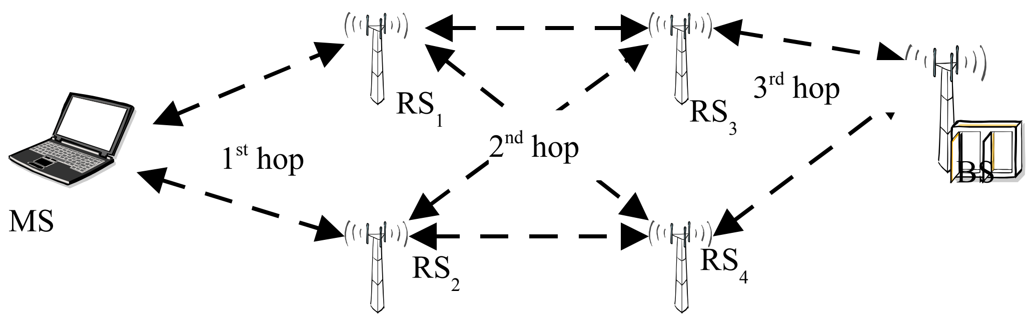


Fig. 1: Cooperative relay in multi-hop wireless networks

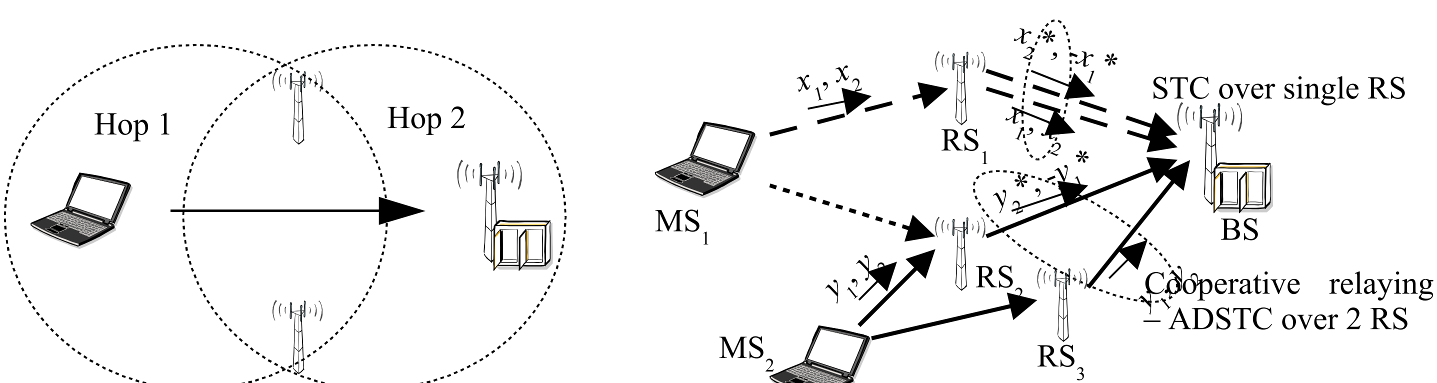
II. System Description

We propose Adaptive Distributed Space Time Coding (ADSTC) method for cooperative relay, which is an adaptive selection of localized Space-Time Coding (STC) and distributed STC. It applies to both uplink and downlink for spatial diversity with minimum additional complexity to the legacy 802.16 Base Station (BS).

In this scheme, neither the need to update the Mobile Stations (MS) nor significant modification of physical layer in the BS is required. RSs work as remote antennas of the BS and the MS. For example, the MS in Figure 2(a) transmits signals to two RSs and consequently these RSs forward signals cooperatively to the BS by using ADSTC techniques in the uplink.

For simplicity, the following description takes the Alamouti code for an example, but the other STC or space-frequency code (SFC) schemes is all supported in both uplink and downlink.

However, the RSs are not co-located which has impacts on the performance of ADSTC. The theoretical and mathematical analysis reveals that no diversity gain is available if received powers of RSs are seriously unbalanced. Furthermore, the symbol-level synchronization between the cooperative RSs is required according to the definition of space-time code.



(a) Virtual remote antenna array (b) A 2-hop uplink example of ADSTC

Fig. 2: ADSTC for cooperative relaying

With the concern of power balance and synchronization, the BS selects localized STC or distributed STC for cooperative relaying as illustrated in Figure 2(b). Criteria, i.e. the maximum SNR criterion, can be used to make the decision of approach selection and power control.

This scheme can be easily extended to the scenario with more hops.

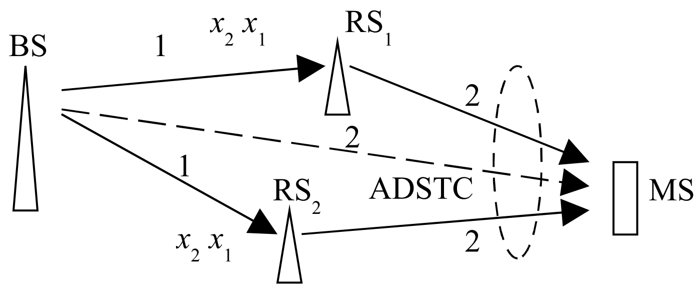


Fig.3: ADSTC method for the last hop in downlink

Figure 3 illustrates a downlink application example of ADSTC for the last hop. In this example, the BS broadcasts signals that are going to be relayed to the MS at Phase .

During Phase , the involved RSs (potentially together with the BS by coherent combining or pre-coding) transmit signals to the MS cooperatively for diversity gain.

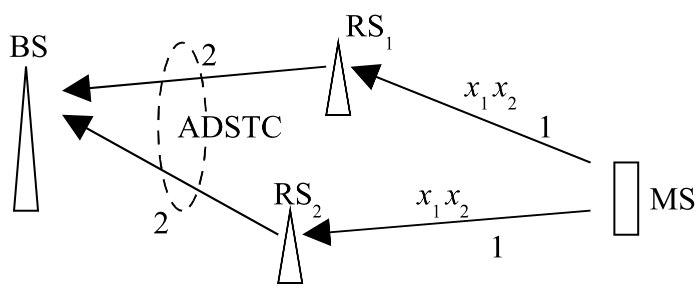


Fig.4: ADSTC method for the last hop in uplink

Figure 4 gives an uplink example corresponding to Figure 3, where the cooperation between the MS and the RSs is optional like that involving the BS.

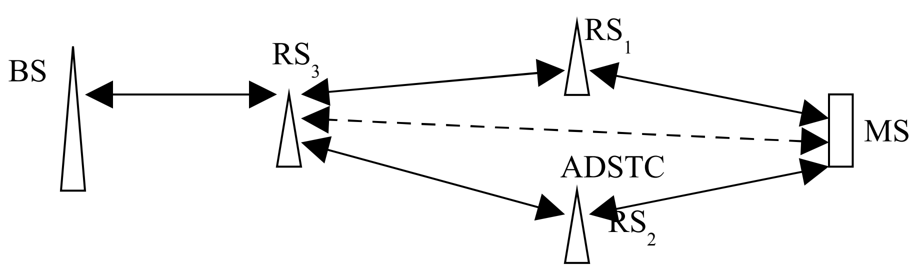


Fig. 5: ADSTC method for networks beyond two hops

Another application scenario is the Multi-Points-to-Point (MP2P) case as indicated in Figure 5 where ADSTC is used not only for the last hop but also for the intermediate hops. Higher spatial diversity is expectable and consequently improves capacity.

III. Summary

A cooperative relay method, ADSTC, is proposed for spatial diversity because of its simplicity and its transparency to the MS. Furthermore, this scheme is fully in alignment with existing IEEE 802.16e and no significant update on the physical layer of the BS is necessary. With this scheme, RSs can work collaboratively for better performance and signal quality.

IV. Proposed Text

+++++++++++++++++++ *Start text proposal* ++++++++++++++++++++++

[Change Table 109z as follows]

Table 109z – RS-CDC message format

Syntax	Size	Notes
RS-CDC_Message_Format( ) {		
Management Message Type = 67 ?	8 bits	
CDC Mode	1 bit	0b0 = Downlink 0b1 = Uplink
Antenna Assignment	4 bits	Bit #0: Antenna #0 Bit #1: Antenna #1 Bit #2: Antenna #2 Bit #3: Antenna #3
RS Encoding Method	1 bit	0b0 = No encoding 0b1 = Encoding
Reserved	2 bits	Shall be set to zero
}		

[Change subclause 8.4.8.10]

8.4.8.10 Cooperative Relaying

Cooperative relaying is principally a distributed MIMO system and can be applied to either access or relay links. ~~Cooperative relaying~~ It can be achieved within an MR-BS cell with BS and RS transmit cooperation, in the same manner as macro diversity with neighboring BS. It is possible to achieve diversity and the pilot collision problem by sending correlated signals across different BS and RS transmit antennas during the transmission of a burst to a particular MS. ~~The three modes of this operation are cooperative source diversity, cooperative transmit diversity, and cooperative hybrid diversity.~~

Cooperative relaying applies to either uplink or downlink between multiple RSs or between the MR-BS and RSs. The three modes of this operation are cooperative source diversity, cooperative transmit diversity, and cooperative hybrid diversity.

The following description describes the various modes~~ in the downlink~~. For cooperative source diversity, the transmitting antennas simultaneously transmit the same signals using the same time-frequency resource. The cooperative transmit diversity mechanism uses STBC-encoded signals across the transmitting antennas using the same time-frequency resources (refer to Section 8.4.8 for a list of valid STBCs). Cooperative hybrid diversity uses a combination of source and transmit diversity. These three mechanisms can also be used in some relay links in both uplink and downlink.

These mechanisms can each be further subdivided into two categories describing the processing required at the RS. If the BS transmits the exact signals for the RS to relay, the RS does not need to encode the data. This is known as the No Encoding mode. Alternatively, the received data at the RS may require some local processing before being relayed. This is known as the Encoding mode, where the RS decodes and re-encodes the data it receives according to the STBC in use as defined by the STC_DL_Zone_IE. In this last category, each RS shall be notified of its assigned antenna number(s).

+++++++++++++++++++ *End of text proposal* ++++++++++++++++++++++