Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Scheduling Issues of 802.16m Relays**
Date Submitted	**2009-03-02**
Source(s)	Eldad Zeira eldad.zeira@interdigital.com Ron Murias All authors are affiliated with InterDigital Communications LLC
Re:	Comment on SDD
Abstract	This contribution discusses the implications of the current relay scheduling modes definition and proposes new definitions
Purpose	To be discussed and agreed by TGm
Notice	*This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups*. It represents only the views of the participants listed in the "Source(s)" field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: <http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and <http://standards.ieee.org/guides/opman/sect6.html#6.3>. Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and <http://standards.ieee.org/board/pat>.

Scheduling Issues of 802.16m Relays

Eldad Zeira, Ron Murias

InterDigital Communications LLC

Introduction

This contribution addresses the current SDD scheduling options, showing their impact on latency and cell edge behavior between the ARS and the ABS. It concludes that the current definitions are overly restrictive and that, if adopted, would result in the penalizing of some users due to requirements of others. New definitions are proposed.

In section 2 we show that according to current definitions, an operator may have to choose between short latency and ABS-ARS cooperation or coordination, but not both. Cooperation techniques have been agreed for ABS-ABS cell edge performance in 802.16m (and, by the way, also in LTE-advanced) and for 802.16m relays.

Considerations for 802.16m Relay Scheduling

The current SDD definition for relay scheduling is provided below:

An ARS operates in distributed or centralized scheduling.

When an ABS is configured to operate in centralized scheduling, each ARS attached to the ABS is configured as a non-scheduling ARS. A non-scheduling ARS is an ARS that does not schedule any radio resource. The ABS schedules all radio resources in its cell and ARSs do not schedule any radio resource.

When an ABS is configured to operate in distributed scheduling, each ARS attached to the ABS is configured as a scheduling ARS, where a scheduling ARS is an ARS that is configured to schedule the radio resources of its subordinate links, each station (ABS or ARS) schedules the radio resources on its subordinate link.

The CS definition seems straightforward in that all resources are explicitly scheduled by the BS. Accordingly, a non-transparent relay would simply relay the necessary control channels to / from the BS.

Centralized scheduling imposes penalty in the form of much increased latency. Latency is doubled for the ABS – AMS link even if we exclude retransmissions (and becomes much worse if we don't). See further relay latency analysis in [2]. Some services (e.g. best effort) would tolerate the additional latency. Others (like gaming) may not. Per our current definition the choice of CS is cell wide (which practically means region wide) therefore choosing it for the BE services would impose too much latency on others. A purely centralized scheduling is therefore not appropriate for general deployment with varied services.

The DS definition is somewhat unclear. Apparently, as it is written, it seems that each RS makes completely independent decisions. If this is the case then ARS and ABS would interfere with each other in the downlink in the region between them. Likewise ARS and AMS would interfere in uplink.

Not stated in the definition but also not prohibited by it, alternatively the ABS plays a role in that it allocates different resource blocks to different relays and leaves the relay to allocate individual AMS. This interpretation would allow the use of frequency reuse techniques.

That leaves us with the question of whether FFR is sufficient. A case in point is inter-BS interference handling for cell edge in LTE. In Release-8, LTE has FFR (called ICIC), implemented by (optional) semi-static coordination between base stations, involving preemptive (DL) and corrective (UL) statistical signaling between BS's. Current agreements for LTE-adv (likely to be implemented in release 10) consists of more dynamic techniques of coordination (example: PMI avoidance) and cooperation (several BSs transmit data). Thus we see that LTE is in the process of migrating from Fractional Frequency Reuse (FFR) in Release-8 to more dynamic handling in LTE-advanced.

Similar decisions have been taken by 802.16m (see [1] SDD, 11.8.4.1) for multi-BS operation:

– *Multi-BS MIMO techniques are supported for improving sector throughput and cell-edge throughput through multi-BS collaborative precoding, network coordinated beamforming, or inter-cell interference nulling.*
– *Both open-loop and closed-loop multi-BS MIMO techniques can be considered. For closed-loop multi-BS MIMO, CSI feedback via codebook based feedback or sounding channel will be used.*
– *The feedback information may be shared by neighboring base stations via network interface. Mode adaptation between single-BS MIMO and multi-BS MIMO is utilized.*

And for ARS cooperation ([1] SDD, sect. 15)

– *Cooperative relaying is a technique whereby either the ABS and one or more ARSs, or multiple ARSs cooperatively transmit or receive data to/from one subordinate station or multiple subordinate stations. Cooperative relaying may also enable multiple transmitting/receiving stations to partner in sharing their antennas to create a virtual antenna array, allowing the extraction of multiple-input multiple-output (MIMO)system benefits such as transmit/receive diversity, spatial multiplexing and beamforming gains (i.e., power efficiency) from the wireless channel in a distributed fashion. ARS may transmit data to the super-ordinate and sub-ordinate station(s) using the same LRU (e.g., MIMO, network coding, etc)*

Finally, relay / BS cooperation has been implemented in 802.16j

We believe that as reflected in the SDD, ABS-ARS operation should support similar cell edge techniques to those supported for ABS-ABS operation. This is the result of the fact that introducing relays creates additional cell edge areas between the relays and base stations. In the case of urban deployment with relays deployed to improve indoor performance these areas tend to be densely populated.

All the above techniques (with the exception of FFR) require tight coupling of ABS / ARS and cannot therefore be implemented with pure DS. The obvious choice is then to use CS, but then we have to use a pure-CS deployment which, as shown above, cannot support all types of services.

From the above we conclude that according to current definitions, Low rate but latency sensitive links will be penalized for "best effort" high data rate links which need the cooperation.

So it seems that according to current definitions, ABS's can cooperate / coordinate but ARS cannot cooperate with ABS without latency penalty. Introducing ARS increase cell edge areas between ARS / ABS. As a result, large areas between ARSs or ARS and ABS will suffer cell edge degradation. It is clear therefore that tighter operation is required in DS mode. Details (timescale, granularity, etc.) are FFS.

Therefore we conclude that the current relay scheduling definition in the SDD doesn't support the relay cooperation techniques in the SDD.

We propose to leave the definition of CS as is but relax that of DS. The new DS definition should have two elements:

- ABS assigns some resources to ARS. Not specified in the definition this could take the form of "regions" of resources in which ARS schedules its links.

- ABS may exercise additional control over some links. Again unspecified this could mean that some specific links could be allocated by ABS for e.g. BS-RS cooperation or coordination.

References

[1] 80216m-08_003r7 SDD
[2] C80216m-08/1104r1 “Feedback and Scheduling Strategies in 802.16m Relays”

Text Proposal

[Change section 15.2 as indicated:]

An ARS operates in distributed or centralized scheduling.
When an ABS is configured to operate in centralized scheduling, each ARS attached to the ABS is configured as a non-scheduling ARS. A non-scheduling ARS is an ARS that does not schedule any radio resource. The ABS schedules all radio resources in its cell and ARSs do not schedule any radio resource.

When an ABS is configured to operate in distributed scheduling, each ARS attached to the ABS is configured as a scheduling ARS. For a given configuration assigned by the ABS, an ARS that is in distributed scheduling mode schedules the resources assigned to it by the ABS for use on its subordinate links. Scheduling involves the allocation of resources and their signaling to AMS or subordinate ARS. The ABS may also exercise additional control over the scheduling actions of ARSs operating in distributed scheduling mode. ~~where a scheduling ARS is an ARS that is configured to schedule the radio resources of its subordinate links, each station (ABS or ARS) schedules the radio resources on its subordinate link.~~