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Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”	
Abstract	Implementing Relay Stations in the legacy OFDMA networks, using a low frequency re-use factor~~re-using the same frequencies~~ triggers an increase of the network interference amount compared with the legacy 802.16e networks. Detecting and measuring the related interference provides the support for increasing the Quality of Service for the supported links operating on this network topology.	
Purpose	For discussion and approval of inclusion of the proposed text into the P802.16j baseline document.	
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Interference Detection and Measurement in OFDMA Relay Networks

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1. Introduction

OFDMA networks based on the 802.16e standard, operate in high~~h intranet~~ interference environments, due to the very demanding conditions imposed by the aggressive frequency re-use factors (1:1 or 1:3). In order to increase the related intra-cell QoS per link, Relay Station entities, operating on the same sets of subcarriers as the serving BSs, have been defined, in order to combat poor coverage and improve the related spectral efficiency. While the interference in 802.16e networks concerns this contribution, the means proposed to address the interference related issues are specifically related ~~linked~~ to 802.16j networks.

In this contribution we target~~propose~~ the following issues:

- To diverge the To propose a interference a detection/ and measurement scheme that provides useful information related to inter BS/RS interference that can be further employedused by the interference management schemes. The interference management and control algorithmscheme is considered beyond the scope of this contribution.
- To define the related messaging support for different interference detection and measurement techniques.

This contribution envisions maximum flexibility for the network integrator or a service provider with regards to the interference management, therefore specifying only the related messaging support and leaving opento the implementation the management methods open.

2. Interference Detection and Measurements

In order to execute interference measurements, the target intranet interference should be properly detected. The interference measurements shall be normalized in order to be further compared and evaluated and thus allowing the interference detection management algorithm to take the proper steps to combatunter-act the interference.\
Based on the above conditions, an accurate detection and measurement of the intranet interference requires specific known interference patterns to be generated evaluated across a giventhe cluster of cells, user definable, subject to the interference detection and measurementsevaluation. Generating specific additional patterns other than , outside the work frame of the 802.16e specifications, is not the consideredhosen approach considered, providedgiven the fact that the 802.16j specifications shall not un-necessarily un-neccesarily diverge of from the main 802.16e frame work.
Therefore, the following possible symbol structures, defined by 802.16e, could be employedre-used for interference detection and measurements:
1. Access preamble, as defined for the 802.16e Base Stations. This preamblesymbol sequence based method is suggesteduitable for determining the intrinsic 802.16e DL related interference, in TDD/FDD mode of operation.

2. Relay Station UL interference pattern built on the UL sounding structure. This type of interference detection and measurement method is envisioneddedicated for the RS intrinsic interference generated in OFDMA mobile networks. While the definition of such a- pattern is mandated by 802.16e being built based on around the UL Sounding structure, the detailed specifications of such a pattern are left to the implementation. This symbol structure could be used for the specific RS UDL interference measurements in TDD modes of operation, considering the related symmetrical nature of the propagation channel. Thisese interference measurement methods should be seen as complementary to the 802.16e intrinsic interference detection.

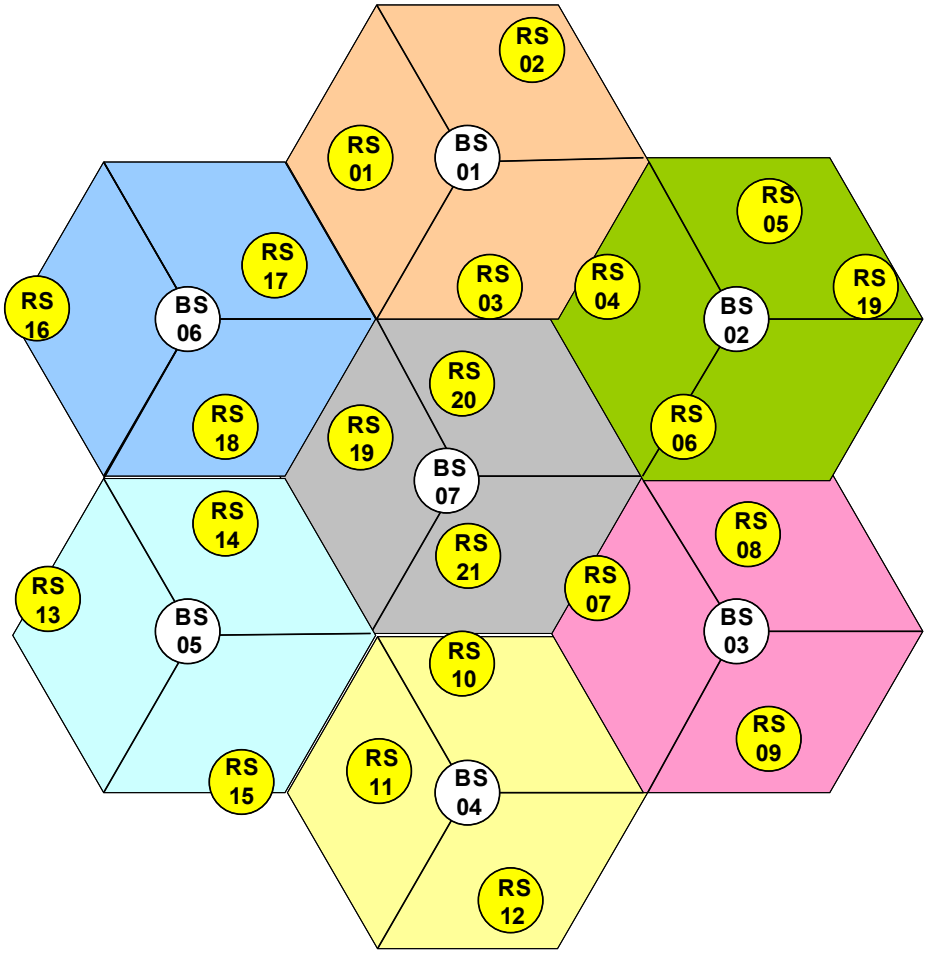

Figure 1 Example of a (1,1,3) network topology.

Based on the example presented in Figure 1 and considering an interference detection algorithm based on the access preamble, as generated by any the 802.16e Base Stations, any RS positioned in inside the cluster of cells subject to the interference measurement and management, will receive and it could detect the related preamble symbol sequence. Further processing will be applied (e.g. RSSI or SINR), subject to the implementation. These processing results shall be reported back to the MR-BS and further to the network management entity, in order to allow further interference management decisions (implementation specific).

Based on the example presented in Figure 1 and considering an interference detection algorithm based on interference pattern built upon the UL sounding structure (implementation specific) , as generated simultaneously by one or more first hop Relay Stations, any BS positioned in inside the cluster of cells subject to the interference measurement and management, will receive and attempt to detect the preamble symbol. Further processing will be applied (e.g. RSSI or SINR), which is implementation specific. These processing results shall be measured by the MR-BS and reported back to the MR-BS and further to the network management entity, in order to allow further interference management decisions (implementation specific).

Provided the symmetrical nature of the propagation channel in the TDD mode of operation, the RS to BS interference is equivalent to the BS to RS interference, assuming equal RF transmission powers. In the case of unequal RF transmission power, the power difference shall be considered when constructing the interference pattern from the channel gain.

3. Summary of modifications

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In summary, new messaging messages, RS specific are proposed:
RS DL REP-REQRS_NBR-MEAS-REQ: request DL type of interference measurement report (preamble based).
RS DL REP-RSPRS_NBR-MEAS-RPT: DL type of interference measurement report (preamble based).

RS UL REP-REQ: request UL type of interference measurement report (UL sounding based).
UL sounding zone allocation IE: change one bit "RS sounding"
RS DL REP-RSP: UL type of interference measurement report (UL sounding based).

4. Specific text changes

Insert new subclause at the end of 6.3.9

During the RS network registration process, the RS acts as a MS/SS and use REG-REQ message to inform the MR-BS that it has relay capability to MR-BS.

Insert new subclause (6.3.2.3.62)

6.3.2.3.62 RS neighborhood measurement request (RS_NBR-MEAS-REQ) message

Syntax	Size	Notes
RS_NBR-MEAS-REQ_Message_Format() {		
Management Message Type = TBD	8 bits	
N_NBR_LIST	8 bits	Number of neighboring RS/BS in the neighbor list
Begin PHY Specific Section {		
For (i=0, i<N_NBR_LIST, i++){		
Preamble Index	8 bits	Scan the preamble index and RSSI

		values in the neighboring list
}		
Report Request TLVs	Variable	TLV specific
}		
}		

The measurement type TLV may include physical CINR orand RSSI to allow more flexibility in interference measurement. It shall be determined based on the capability of the RS and the deployed interference management method. DV Note: The measurement type should not be limited only to RSSI, which is an improper method in heavy interference networks. SINR or CINR should be allowed also, depending on the implementation

N_NBR_LIST
Number of neighboring RS/BS in the neighbor list.

The RS_NBR-MEAS-REQ shall contain the Report Request TLV (define in 11.11 REP-REQ management message encodings). On receiving RS_NBR-MEAS-REQ, a first hop RS shall measure the interference from the neighboring MR-BSss using the specified methods in the Report Request TLVs.

Insert new subclause (6.3.2.3.63)

6.3.2.3.63 RS neighborhood measurement report (RS_NBR-MEAS-RPT) message

Syntax	Size	Notes
RS_NBR-MEAS-RPT_Message_Format()		

{		
Management Message Type = TBD	8 bits	
N_NBR_LIST	8 bits	Number of neighboring RS/BS in the neighbor list
Begin PHY Specific Section {		
For (i=0, i<N_NBR_LIST, i++){		
Preamble Index	8 bits	Record the preamble index and RSSI values from the neighborhood discovery
Report Response TLVs	Variable	TLV specific
}		
}		
}		

DV Note: the report should allow other types of NI measurements (like SINR or CINR) leaving more choices open to the service provider

N_NBR_LIST
Number of neighboring RS/BS in the neighbor list.

The RS_NBR-MEAS-RPT shall contain the Report Response TLV (defined in 11.11 REP-RSP management message encodings).

Insert a new subclause 6.3.27.1:

6.3.27.1 Interferences measurement by RS sounding

In order to predict the interferences between different first hop RSs, the MR-BS needs to collect the interference measurements from the related RSs. The protocol of interference protocol measurement between MR-BS and RSs consists of three steps:

- Firstly, the MR-BS sends a REP-REQ message to all sub-ordinated RSs inside a given cluster of cells, subject to interference analysis. the same MR-cell. Besides, the REP-REQ message indicates the TLV of Channel type request is RS sounding (see 11.11). The number of RSs, RSs' CIDs, and the reporting period are also included in the REP-REQ. When an BRS receives such an REP-REQ, it expects to hear the Sounding zone allocation IE (8.4.5.4.2) in the subsequent frames until the time indicated in the TLV of report period in the REP-REQ message.

- Secondly, the related MR-BSs that service the designated cluster of cells or a part of them, subject to the interference analysis allocates a Sounding zone allocation IE (an exclusive transmission period) for eacha sub-ordinated RS operating within that particular cluster of cells. Depending on the implementation, only, a few or all the the related RSs operating in that cluster of cells could be subject ofperformadopt the interference detection/measurement method. In particular, the last bit in the Sounding zone allocation IE is enabled (see 8.4.5.4.2) to indicate the burst is for athe RS to transmit a sounding signal. This bit also informs the other BRSs, within the same cluster of cells under interference analysis, through the network backboneMR-cell of measuring the sounding signal from the transmitting RS or RSs. Depending on the implementation, one or more BSs could be instructed to listen to the given interference pattern. Therefore the method could be used for RS to/from BS, within a given cluster of cells under interference analysis. In other words, with this bit enabled, the RS Sounding zone allocation IE could instructs not only the all the MR-BSs, operating in the given cluster of cellsMR-BS but it also could be expanded toalso all other RSs within the same cluster of cells (implementation specific), to listen to the transmitting RS interference patternr (implementation specific) based on the sounding signal. The MR-BS uses the same format as UL_Sounding_Command_IE to instruct the designated RSs to build and transmit thecompose RS sounding signals. The entire interference detection/measurement and management procedures should be driven by a network management interference entity or under the control of the MR-BS and thus to be limited to only one cell, if chosen (implementation

selectable)

The scheduling of RS Sounding zone allocation IEs by MR-BS is implementation specific. The scheduling of RS Sounding zone shall consider allowances made by an RS-TTG and RS-RTG in between transmit and receive periods to allow the RS to properly switch between transmit and receive mode. The capabilities RS-TTG and RS-RTG will be provided by the RS during RS network entry.

- Thirdly, after the number of frame whose value is indicated in the report period TLV of the REP-REQ message has been passed, all MR-BSRSs have to send back the measurement results to the network management entity MR-BS. More than one continuous or intermittent round of measurements may be allocated by the network management entityMR-BS. In this case, the average measurement results are reportedAn averaging of all the subsequent measurements may be executed at the MR-BS level or at the network management entity level, being implementation specific. Since the RSs may not communicate directly with each other, whileen performing the related measurements, the measured signal strength can be treated as an approximation or a prediction of the potential interference between different radio links if they reuse the same radio resources. Therefore, the MR network can be configured or reconfigured based on this measurement results, being implementation specific.

8.4.5.4.2 PAPR reduction/Safety zone/Sounding zone allocation IE

Change the second to the last entry of Table 289 as indicated:

Syntax	Size	Notes
Sounding Zone	1 bit	0 = PAPR/Safety Zone

		1 = Sounding Zone Allocation
Reserved RS Sounding zone	1 bit	Shall be set to zero If Sounding_Zone=1 0 = MS UL sounding 1 = RS Sounding

Insert the following text at the end of 8.4.5.4.2:

RS Sounding zone

When Sounding_Zone is set 1 and RS sounding zone is 0, this sounding zone could beis defined for MS UL sounding operations; when Sounding_Zone is set 1 and RS sounding zone is set to 1, this sounding zone isis defined for RS sounding. In the former case, only the BS listens to the sounding signal from an MSS or a sub-ordinatedn RS. In the later case, not only MR-BS but also the designated RSs within the same MR-cell shall listen to the RS sounding signal from the transmitting sub-ordinated RS. In particular, the RSs involved in RS Sounding can be indicated by the CID of UL MAP IE which contains the Sounding zone allocation IE.

11.11 RS REP-REQ management message encodings

Change fourth row of the second table in 11.11 as indicated:

Name	Type	Length	Value
Channel Type request	1.3	1	0b00 = Normal subchannel, 0b01 = Band AMC Channel, 0b10 = Safety Channel, 0b11 = ~~*Reserved*~~Sounding 0b100 = RS Sounding

Insert the following table at the end of 11.11:

Name	Type	Length	Value
RS sounding type request	1.9	variable	Compound
RS Sounding number	1.9.1	1	number of RSs, N_{RS}, participating in RS sounding measurement
RS CID	1.9.2	N_{RS}*2	RS(1) … RS(N_{RS}) basic CID where NRS is the number of RSs participating in the RS Sounding measurements
Report period	1.9.3	1	RS sends REP-RSP after the number of frames since receiving the REP-REQ
RS Sounding Zone-specific CINR request	1.10	1	Bits #0-3: in multiples of 1/16 (range is [1/16,16/16]) Why do we limit this to 1/16 steps? Why shouldn't we specify this in symbols (max 21 symbols for the entire UL subframe)? Bits #4-7: Reserved, shall be set to zero
RS Sounding Zone-specific RSSI request	1.11	1	Bit #0: Type of zone on which RSSI is to be reported 0: RS reports RSSI on all subcarriers 1: RS reports RSSI on the subcarriers allocated in the Sound zone allocation IE Bits #2-5: in multiples of 1/16 (range is [1/16,16/16]) Bits #6-7: Reserved, shall be set to zero

Insert the following text at the end of 11.11:

When the TLV of Channel type request indicates the support of RS sounding, TLV of type 1.9 and 1.10 may be

included in REP-REQ. TLV of RS Sounding number indicates the number of RSs participate in the interference management. TLV of RS CID carries the basic CIDs of all participating RSs. TLV of report period indicates the period of measurement in the unit of frame number. After this period, the designated MR-BRSs shall report to the Network Management EntityMR-BS the related measurement results (implementation specific). TLV of RS Sounding Zone-specific CINR requested is needed only when RSs are requested to report CINR measurements (implementation specific); TLV of RS Sounding Zone-specific RSSI requested is needed only when RSs are requested to report RSSI measurements (implementation specific).

11.12 RS REP-RSP management message encodings

Insert the following rows into the third table of #11.12 [1] as indicated:

REP-REQ Channel Type request (binary)	Name	Type	Length	Value
100	RS Sounding CINR Report	2.6	N_{RS}	CINR for each RS
100	RS Sounding RSSI Report	2.7	N_{RS}	RSSI ranging from –40 dBm (encoded 0x53) to –123 dBm (encoded 0x00)

Insert the following text at the end of 11.12:
When an RS received an REP-REQ with the TLV of Channel type request, it shall respond to the MR-BS with an REP-RSP with TLV of Sound reports (type 2.6 or 2.7) after measuring RS sounding signals from sub-ordinatedother RSs. The reporting time is indicated in REP-REQ. A vector of N_{RS} measurement results of all

participating RSs is reported by each RS. Moreover, an RS reports CINR or RSSI or both information dependent on whether the corresponding TLV (type 1.10 or 1.11) appears in REP-REQ.

5. References (if required)

[1] IEEE802.16e-2005
[2]