Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>	
Title	Interference Detection and Measurement in OFDMA Relay Networks	
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Re:	IEEE 802.16j-07/007r2: "Call for Technical Comments and Contributions regarding IEEE Project 802.16j"	
Abstract	Implementing Relay Stations in the OFDMA networks as specified by 802.16e-2005, using a low frequency re-use factor 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 802.16j links, as a result of	

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	a further network interference control and management which is implementation specific.
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 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, improve the related spectral efficiency and overall increase the aggregate Quality of Service (QoS) for a given link or group of links. While the interference in 802.16e networks concerns this contribution, the means proposed to address the interference related issues are specifically related to 802.16j networks. Due to the smaller coverage area of the RSs and their high deployment density, interference management between these RSs becomes more important to improving the network capacity and the service quality to the users. To facilitate efficient interference management and radio resource reuse among the RSs, it is vital to provide relevant information regarding the interference caused by the RSs and the BS to each other.

In this contribution we target the following issues:
- To propose an interference detection/measurement scheme that provides useful information related to inter BS/RS interference that can be further employed by the interference management schemes. The interference management and control algorithm is considered beyond the scope of this contribution.
- To define the related messaging supports 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 the interference management methods as being implementation specific.

2. Interference Detection and Measurements

In order to execute interference measurements, the interference source should be known and the target interference within a specific target area should be properly detected. The target area to be mapped by the interference measuring scheme can be a MR-BS cell or a sector of a MR-BS cell, or can be a cluster of adjacent cells. The interference measurements ~~shall~~ may be normalized in order to be further compared and evaluated and thus allowing the interference management algorithm (implementation specific) to take the proper steps to combat the interference.

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Based on the above conditions, an accurate detection and measurement of the intranet interference requires specific interference patterns to be evaluated across a given cluster of cells subject to the interference detection and measurements. Generating additional patterns outside the 802.16e specifications is not the considered approach, provided the fact that the 802.16j specifications shall not un-necessarily diverge from the main 802.16e frame work.

Therefore, the following possible symbol structures, defined by 802.16e, could be employed for interference detection and measurements:

1. Access preamble, as defined for the 802.16e Base Stations. This preamble sequence based method is suggested for determining the intrinsic 802.16e DL related interference, in TDD mode of operation.

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2. Relay Station UL interference pattern built on the UL sounding structure. 802.16e_2005 has defined UL sounding as an option for a BS to estimate the channel quality from its MSs in a TDD system. While the definition of such a pattern is mandated by 802.16e being built based on the UL Sounding structure, the detailed specifications of such a pattern are left to the implementation. This type of interference detection and measurement method can also be envisioned for the measuring the intrinsic interference generated by an RS to a BS or another RS. This interference measurement method should be seen as complementary to the 802.16e intrinsic interference detection. In the case of transparent RS which does not transmit preamble, UL sounding scheme can be used for interference estimation.

The interference measurement schemes based on the preamble and based on UL sounding signals are complementary and their usages shall be determined by the vendors. This contribution is focused on the interference measurement scheme based on using the UL sounding signal.

An example of the UL sounding procedure by the RSs and the required messages are provided as follows.

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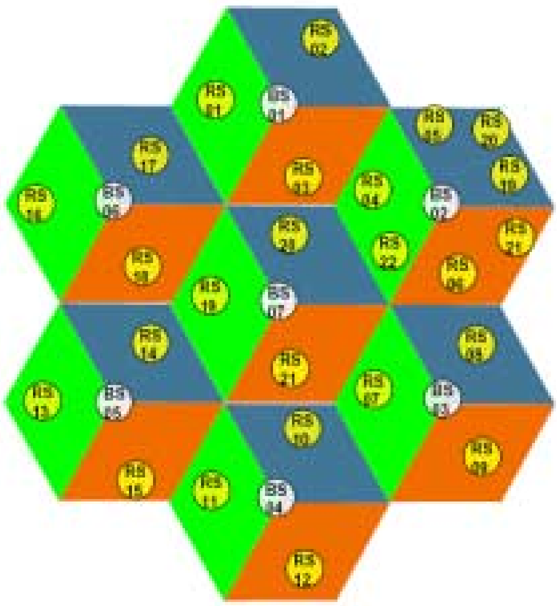

Figure 1 Example of a (1,3,3) network topology.

Figure 1 shows an example of a network topology with (1,3,3) frequency reuse plan with the different colors representing 3 sectors of a MR-BS and the frequency segment used in each sector. In BS02 cell, three sets of RSs are deployed in its 3 sectors, with RS 04, 22 in sector 1 (green), RS 06, 21 in sector 2 (orange) and RS 05, 19, 20 in sector 3 (blue). Considering a generic interference management scheme that requires estimation of the interferences caused by a RS to the MR-BS and the other RSs in the same sector. The BS needs to coordinate the transmission of the UL sounding signal by the RSs and the measurement of the UL sounding signals by the other RSs in order to estimate the interference among the RSs located in the same sector. The transmission of the UL sounding signals by the RSs covered by BS02 can be scheduled as follows:

In Figure 2, BS02 schedules the RSs to transmit the UL sounding signal in their respective segments. For the RSs using the same segment, in sector 1 for example, RS04 and RS22 are instructed by BS02 to send their UL sounding signal in 1 symbol period utilizing part of the UL sounding bands in separate symbols with an idle symbol in between. This allows RS04 and RS22 to measure the sounding symbol signal strength sent by each other and switch between TX and RX mode, if required. Their UL sounding signals are also measured by BS02. The transmission and measuring of the sounding signals by different RSs are coordinated by BS02 through UL_Sounding_Command_IE() and REP_REQ messages sent to the RSs. Further processing will be applied pre request from the BS (e.g. RSSI or SINR), which is implementation specific. These processing results shall be

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measured by the RSs and reported to MR-BS, and optionally further to the network management entity, in order to allow further interference management decisions (implementation specific).

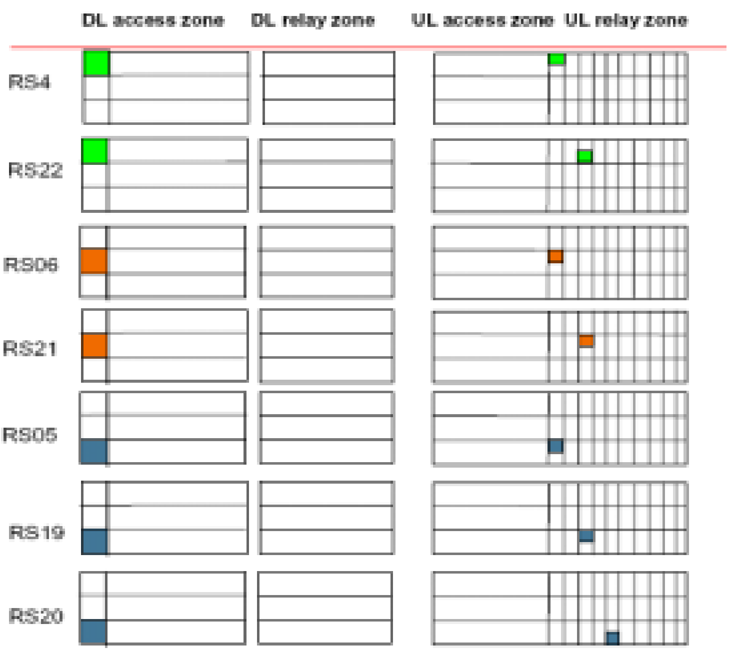

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Figure 2. Example of the UL sounding signal transmitted by the RSs covered by BS02. Different colors represent different segments.

Provided the symmetrical nature of the propagation channel in the TDD duplexing mode, the interference from an RS to an MR-BS (or another RS) is equivalent to the MR-BS (or RS) 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.

The capacity of the UL sounding scheme can be estimated by calculating the number of UL sounding band allowed in a UL relay zone and the length of a UL sounding transmission. Given a sounding band is consisted of 18 consecutive subcarriers and can last as short as a symbol, a sounding slot can be defined as a sounding band which occupy two consecutive symbols. An RS can transmit its sounding waveform in the first symbol, while the second symbol is left idle to allow R-RTG and R-TTG for the RSs. Assuming a UL subframe where the relay zone is 12 symbols long, the number of sounding slots that can be used is given in Table 1. A large number of RSs can transmit their UL sounding signals in a UL relay zone and we envision it is possible to complete the interference mapping in a BS cell within a frame.

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	512 FFT		1024 FFT		2048 FFT	
	# RS sounding symbol per 2 symbols	Max # of UL sounding per relay zone (12 symbols)	# RS sounding symbol per 2 symbols	Max # of UL sounding per relay zone (12 symbols)	# RS sounding symbol per 2 symbols	Max # of UL sounding per relay zone (12 symbols)
PUSC	7	42	15	90	32	192

Table 1. Number of sounding slots allowed per sector in a UL relay zone of 12 symbols.

In the extreme case when the channel gain between every pair of RS/RS or RS/BS need to be evaluated, the efficiency of the UL sounding scheme has to be evaluated with the number of sounding slots together with how these sounding slots are used. To have the RSs send their sounding signal one at a time is clearly under-utilizing the large number of sounding slots. While how to select the RSs to transmit UL sounding signals can be vendor-specific, Figure 3 shows the number of UL frames required to map a large of number of RSs that can be achieved when the RS sounding process is carefully scheduled.

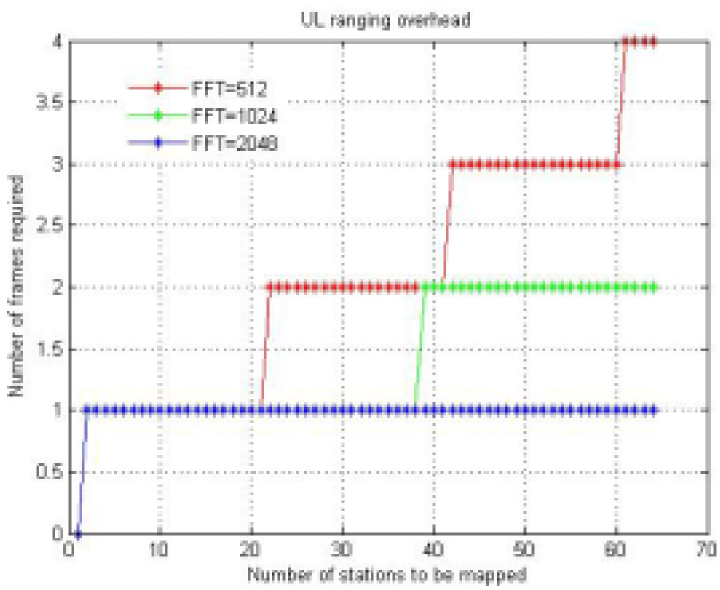

Fig 3. The number UL frames required to completely map the channel between every pair of RSs when the RS sounding process is properly scheduled.

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In a deployed MR network where the RSs are all fixed, the channel gains between the RSs and MR-BSs do not vary with time significantly. This allows a maintenance mode to be defined where the above sounding procedure is conducted periodically without causing significant interruption to the regular data transmissions.

As an option and an extension of the previous intra-BS cell interference mapping procedure, the interference pattern between the RSs and the MR-BSs can be carried across multiple BS cells. This requires the involved MR-BSs to coordinate the RS sounding signal generation and sounding signal measurement with each other (possibly with the help of a network management entity such as a base station controller (BSC)). The BSs can achieve coordination with each other through network backbone and the definition of such messages is beyond the scope of the 802.16j standard. This also requires network-wide time and frequency synchronization, and may require an additional silent symbol to be inserted after the UL sounding symbol as extra guard to counter the prolonged propagation time between a RS and RSs/BSs in another cell (dependant on the max RS related EIRP). The detailed RS sounding pattern across multiple cells and the multi-cell coordination is implementation specific. Figure 4 shows a mapping procedure in multiple cells in a tier-1 and tier-2 cluster of cells, where the cells colored yellow are involved in interference mapping in a UL frame. Assuming a 5-ms frame length, it takes 7*5=35ms to complete the interference measurement in a 19-cell cluster.

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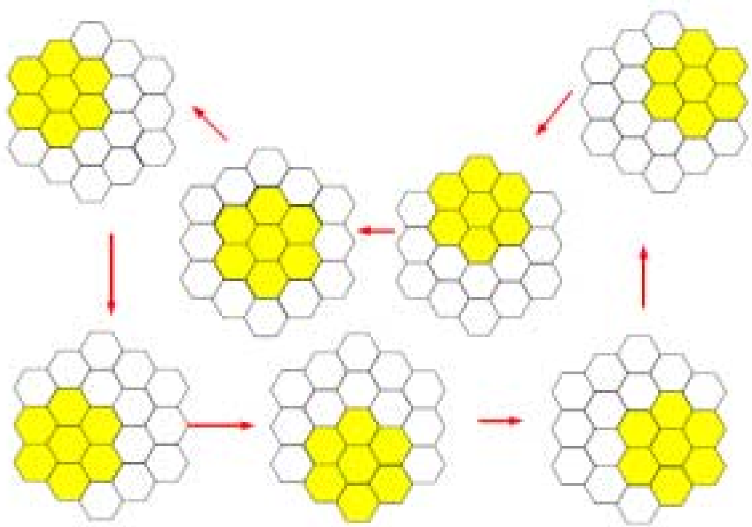

Fig. 4: Interference mapping procedure for tier 1 and 2 cluster of cells

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2.1 Overhead Calculation for UL sounding MAP IE

There are two types of UL MAP IEs needed to support UL sounding mapping. The first is reduction/Safety zone/Sounding zone allocation IE (Table 289 in 802.16e-2005) and the second one is UL_Sounding_Command_IE (Table 315d in802.16e-2005). Reduction/Safety zone/Sounding zone allocation IE is used to define the region where sounding zone locates. UL_Sounding_Command_IE including the list of stations' CIDs in every sounding symbol is used to instruct the stations to send UL sounding signal. Reduction/Safety zone/Sounding zone allocation IE is allocated in every frame where a sounding zone appears. Each reduction/Safety zone/Sounding zone allocation IE occupies 32 bytes. UL_Sounding_Command_IE needs to appear as well in every frame where a non-periodic sounding zone appears (in which the Periodicity bits are set to '000'). In the case of periodic sounding allocation, while reduction /Safety zone/Sounding zone allocation IE is still needed in every frame where sounding zone is allocated, UL_Sounding_Command_IE is needed only in the first and the last frame where sounding zones are allocated. Therefore, the overhead of periodic sounding allocation is much less than non-periodic sounding. In the following example, we will consider the case of non-periodic sounding (with heavier overhead) allocation and type-A sounding signal. Each UL_Sounding_Command_IE occupies 28 + SYMBOL# * (12 + CID# * 44) bits where the SYMBOL # is the number of symbols included in the sounding zone and is restricted to be equal or less than 8, CID# is the number of stations are instructed to send sounding signal in a symbol. Suppose we consider 5MH bandwidth (512 FFT) and 5 ms frame. As shown in Table 1, there are at most 7 CIDs per segments (total 21 CIDs) can be used when the sounding zone use all the subcarriers. If the sounding zone is one symbol and all subcarriers (equivalent to instruct 21 stations to send sounding signals), then the length of UL_Sounding_Command_IE is 28 + 1 * (12 + 44 * 21) = 964 bits. Since sounding measurement is not carried often, the overhead is still within acceptable range.

For estimating the over head incurred by the UL sounding scheme, with the assumption that one frame is used for UL sounding measurement in every second, we obtain the following based on the efficiency measurements in Table 1.

1. Conservative case 512 FFT (optimized for UL): BW=5 MHz, DL symbols =26, UL symbols=21, TDD, assumed, CC QPSK 1/2
2. 512 FFT (optimized for DL): BW=5 MHz, DL=35 symbol, UL=12 symbols, CC QPSK ½
For both cases the net PHY output is considered, assuming a control information allocation of 3 symbols (1 preamble + 2 symbols for MAPs)

	Net PHY Output DL data traffic [Mbps]	UL Sounding IE Overhead [bps]	Net PHY Out Data Throughput Degradation [%]
512 FFT (UL optimized, QPSK ½ CC)	1.396	965	0.066
512 FFT (DL optimized, QPSK ½ CC)	1.942	964	0.047

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Table 2: DL Data Throughput degradation (conservative case) for an intra-cell interference mapping procedure concerning 21 RS sources of interference per cell, under conservative conditions (512 FFT, QPSK ½) when a 2 symbols UL Sounding pattern is used. The evaluation applies to one frame only (the measurement frame)

The same calculations could be carried out if 12 UL Relay symbols are used, employing 6 UL sounding patterns, for interference measurements and the related number of bits required in this case is 5672 bits. We assume one UL sounding measurement per second

	Net PHY Output DL data traffic [Mbps]	UL Sounding IE Overhead [bps]	Net PHY Out Data Throughput Degradation [%]
512 FFT (UL optimized, QPSK ½ CC)	1.396	5672	0.39
512 FFT (DL optimized, QPSK ½ CC)	1.942	5672	0.28

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Table 3: DL Data Throughput degradation (conservative case) for inter-cell interference mapping procedure concerning 21 RS sources of interference per cell, under conservative conditions (512 FFT, QPSK ½) when a 12 symbols UL Sounding pattern is used. The evaluation applies to one frame only (the measurement frame).

As it could be seen from Tables 2 and 3, the net data throughput degradation (PHY output) measured for intra-cell or inter-cell measurements, is negligible. The values are measured under conservative usage. The degradation to the UL throughput is 5% percent for all these cases. For fixed RS, the path loss between RS/BSs do not change much and the above overhead calculation is probably too conservative. How often UL sounding should be invoked shall be decided by the vendor-specific BS algorithm and based on the operation environment.

2.2 Upper Bound of Overheads in RS Interference Mappings

In this section we calculate the upper bound for the overheads required in interference mappings. Suppose we consider M stations in the system and we intend to measure the channel response between each pair of M stations. Further we represent the number of sounding bands can be carried in one symbol is N. Then the total number of symbols required for sounding zone is bounded by S equal to $\left\lceil \frac{M}{2N} \right\rceil \cdot \lceil \log_2(2N) \rceil$. The main advantage of sounding-based measurement against amble-based measurement is the number of N. N is equal to 3 in amble-based measurement, but N is much larger in the sounding-based measurement. For example, Table 1 shows that in the case of 512 FFT, the number of N is equal to 21. Therefore, sounding-based measurement is more efficient and scalable compared to amble-based measurement.

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3. Conclusions

The proposed approach has the following advantages:

A. High flexibility. The method could be easily applied for mapping interference to (1) intra-cells or to (2) clusters of adjacent cells. In both cases, the algorithm could be scheduled to execute interference mapping among the same order RSs or different hops RSs.
B. Efficiency. The method could map as presented in Table 1 a large number of RSs within one frame. Further more, the presented algorithm could be scheduled to execute complex interference mapping for large clusters of adjacent cells in sequential or non-sequential frames
C. Required traffic drop-out. The method is flexible enough to be scheduled on a reduced number of Sounding zones without knocking down entirely the UL traffic, which could be an important feature during the high congestion network traffic periods. If necessary, it could be scheduled to run during the low congestion periods of time, using an increased number of UL sounding zones.
D. Re-using 802.16e specifications. The presented method does not introduce new measurement patterns, re-using previously defined UL sounding patterns. The only new specifications are the related messages to support the proposed measurements.
E. The method could be applied to MSs in any access zone, for intra-cell or inter-cell interference detection measurements, under the control of the MR-BS
F. The method is not dependant on a specific amble structure (either access or relay).

5. Specific text changes

Insert a new subclause 6.3.27.1:

6.3.27.1 Optional interference detection and measurement by RS sounding

As an option, the path loss and interference between multiple RSs and the MR-BS can be estimated using the UL sounding mechanism (8.4.6.2.7). In order to predict the interferences between different RS cells, the MR-BS needs to collect the interference measurements from the related RSs and possibly from their associated MSs. The interference can be estimated by having one or multiple RSs or MSs transmit UL sounding signals at specific sounding zones and having the other related RSs and BSs measure the related CINR or RSSI of the received sounding signals. An MR-BS may construct a multicast group within its MR-cell which uses a multicast CID to represent the group of the RSs that participate in the interference measurement. Alternatively multiple unicast messages can be sent. This group is called RS_interference_measurement group and shall be setup before any measurement of UL sounding signals by the group. The interference measurement procedure is controlled by the MR-BS for intra-MR-cell interference measurement. For interference measurement performed across clusters of MR-cells, a network control entity is required to coordinate the measurement activities across the MR-cells.

The interference measurement operation within an MR cell is as follows: the MR-BS sends an REP-REQ message to its RS_interference_measurement group. The REP-REQ carries the reporting period, start frame number and the type of measurement reports (either CINR or RSSI). MR-BS sends UL_Sounding_Command_IE to RS_interference_measurement_group as a multicast burst. The MR-BS shall also transmit

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PAPR_Safety_and_Sounding_Zone_Allocation_IE. When an RS receives such an REP-REQ, it expects to hear the Sounding zone allocation IE (8.4.5.4.2) starting from the start frame number until the time indicated in the TLV of report period in the REP-REQ message. If an RS specified by the multicast CID in PAPR_Safety_and_Sounding_Zone_Allocation_IE, and indicated by CID in the UL_Sounding_Command_IE, the RS shall transmit the sounding signal at the specified symbol and subcarriers as instructed by the MR-BS. Otherwise, the RSs belonging to the RS_interference_measurement_group shall measure the sounding signals if they are not scheduled to transmit sounding signals in the same symbol. The scheduling of RS Sounding zone allocation IEs by MR-BS is implementation specific.

The sounding signal sent from different RSs and different MSs can be multiplexed in the same sounding zone. This can be done when the MR-BS or RS serving the MS sends to the MS a separate UL_Sounding_Command_IE with instruction of the sounding signal that may be sent by the MS. The measurement and reporting procedure of the MS UL sounding signal by the RSs in the RS_interference_measurement_group remains the same as the RS sounding procedure. ~~After the number of frame whose value is indicated in the report period TLV of the REP-REQ message has been passed, the RSs in the RS_interference_measurement group send back the measurement results to the MR-BS. More than one round of measurements may be allocated by MR-BS. In this case,~~ The average measurement results are reported. ~~The measured signal strength between RSs can be viewed as an approximation to the potential interference between different RS cells. The measurement between RSs can be enhanced by measurement results collected by the RSs on the UL sounding signal sent by the selected MSs in a RS cell. MR-BS could estimate the potential interferences between RSs by receiving a vector of the measurement report from each RS. In the case of inter-MR-cell interference measurement,~~ after an MR-BS receives the REP-RSP from all the RSs in its RS_interference_measurement_group, it shall forward it to the network control entity.

When interference across different MR-cells needs to be estimated, the above UL sounding procedure shall be conducted with the coordination of a network control entity which controls multiple BSs. In this case the network control entity shall coordinate the multiple BSs to send PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE to their respective RS_interference_measurement_groups and MSs for conducting UL sounding measurement across MR-cells. When the RS sounding signal is to be sent by an RS in one of the MR-cells, the same PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE shall be duplicated and sent in the other MR cells, so the RSs in these other cells will conduct measurement on the UL sounding signal.

11.11 REP-REQ management message encodings

Insert the following table at the end of 11.11:

Name	Type	Length	Value
RS sounding Report	1.9	1	RS sends REP-RSP after the number of frames since receiving the REP-REQ

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period			
Start Frame Number	1.10	1	8 LSB bits of the frame number to synchronize the sounding opportunity
RS Sounding Zone-specific CINR request	1.11	1	Bits #0-3: averaging parameter in multiples of 1/16 (range is [1/16,16/16]). Bits #4-7: Reserved, shall be set to zero
RS Sounding Zone-specific RSSI request	1.12	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: averaging parameter 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:
TLV of report period indicates the period of measurement in the unit of frame number. After this period, the RSs in the RS_interference_measurement group shall report to the MR-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 REP-RSP management message encodings

Insert the following rows into the third table of 11.12 as indicated:

REP-REQ Channel Type request (binary)	Name	Type	Length	Value
11	UL Sounding CINR Report	2.6	N	CINR for each of the N RS or MS UL sounding signal in the sounding zone
11	UL Sounding RSSI Report	2.7	N	RSSI for each of the N RS or MS UL sounding signal in the sounding zone

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 or MS sounding signals. The reporting time is indicated in REP-REQ. A vector of N 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 1.11 or 1.12) appears in REP-REQ. The CINR or RSSI report shall be measured on the UL sounding burst.

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Insert the following text as of 8.4.11.2.1

Deleted: 8.4.11.2.1 Optional Burst-specific RSSI measurement

RSSI can also be measured an indication of received signal strength in one particular burst or several bursts. For example, an MR-BS or RS may need to measure and report the received signal level in a UL sounding burst or in a segment (all the bursts in the segment). Because the measured bursts may share the same symbol with other bursts, the regular RSSI measurement in the time domain does not apply. This requires measurement of RSSI in the frequency domain. One possible method to estimate the RSSI is given by the following equation:

$$RSSI_{burst} = 10^{\frac{G_{rf}}{10}} \frac{6.2835 \times 10^{3}}{(2^{2B})R}$$

,

Where

B is ADC precision, number of bits of the ADC,

R is ADC input resistance [Ohm],

V_c is ADC input clip level [Volts],

G_{rt} is analog gain from antenna connector to ADC input,

$Y_{I\ or\ Q}[k,n]$ is the n-th subcarrier in the burst (I or Q-branch) within k-th symbol of the measurement,

N_{sc} is the number of subcarriers in the burst.

K is the number of symbols in the burst used for the current measurement.

$RSSI_{burst}$ can also be measured from preambles which can be considered as a special burst utilizing 1/3 of the subcarriers. When the $RSSI_{burst}$ is measured from regularly transmitted burst of the same dimension (for example, the preamble of a particular segment), its mean should be used instead of individual measurement results. The mean $RSSI_{burst}$ statistics (in mW) shall be updated using the following equation.

$$\mu_{RSSI_{burst}} = \begin{cases} RSSI_{burst} \\ (1-\alpha_{avg})\mu_{RSSI_{burst}} + \end{cases}$$

mW

Where

l is the measurement index (started from 0),

$RSSI_{burst}[l]$ is the RSSI measurement from the l–th burst.

... [1]

8.4.11.2.1 Optional Burst-specific RSSI measurement

RSSI can also be measured an indication of received signal strength in one particular burst or several bursts. For example, an MR-BS or RS may need to measure and report the received signal level in a UL sounding burst or in a segment (all the bursts in the segment). Because the measured bursts may share the same symbol with other bursts, the regular RSSI measurement in the time domain does not apply. This requires measurement of RSSI in the frequency domain. One possible method to estimate the RSSI is given by the following equation:

$$RSSI_{burst} = 10^{\frac{G_{rf}}{10}} \frac{6.2835\times10^{3}V_c^{2}}{(2^{2B})R} \left(\frac{1}{K}\sum_{k=0}^{K-1}\sum_{n=0}^{N_{sc}-1}\left|Y_I[k,n]\right| + \left|Y_Q[k,n]\right|\right)^{2} mW \, ,$$

Where

B is ADC precision, number of bits of the ADC,

R is ADC input resistance [Ohm],

V_c is ADC input clip level [Volts],

G_{rt} is analog gain from antenna connector to ADC input,

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$RSSI_{burst}$ can also be measured from preambles which can be considered as a special burst utilizing 1/3 of the subcarriers. When the $RSSI_{burst}$ is measured from regularly transmitted burst of the same dimension (for example, the preamble of a particular segment), its mean should be used instead of individual measurement results. The mean $RSSI_{burst}$ statistics (in mW) shall be updated using the following equation.

$$\mu_{RSSI_{burst}} = \begin{cases} RSSI_{burst}[0], l = 0 \\ (1-\alpha_{avg})\mu_{RSSI_{burst}} + RSSI_{burst}[l], l > 0 \end{cases} \text{ mW}$$

Where

l is the measurement index (started from 0),

$RSSI_{burst}[l]$ is the RSSI measurement from the l–th burst.

$RSSI_{burst}$ and $\mu_{RSSI_{burst}}$ shall be reported in the units of dBm.

Other burst RSSI measurement implementations are possible, but the related measurement uncertainty shall be located in the +/-1 dB range referenced to the real value. When being reported, $RSSI_{burst}$ shall be quantized in 1dB increments, ranging from -2dBm (encoded 0x67) to -123 (encoded 0x00). Values outside this ranged shall be assigned to the closed value within the range.