Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Correction of RS Preamble Configuration Request (RS_Config-REQ) Message
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Re:	Call for Technical Comments regarding IEEE Project P802.16j (IEEE 802.16j-07/013r2)
Abstract	In this contribution, we propose a correction of RS preamble configuration request to avoid the problem of low power-amplifier (PA) efficiency at a RS
Purpose	To incorporate the proposed change into the P802.16j Baseline Document (IEEE 802.16j-06/026r3)
Notice	
Release	
Patent Policy and Procedures	

Correction of RS Preamble Configuration Request (RS_Config-REQ) Message

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1. Statement of the Problem

In Section 6.3.2.3.69 in [1], RS preamble configuration request (RS_Config-REQ) message is specified for a MR-BS (or parent RS) to send configuration information to its subordinate RSs. The 2-bits parameter N_Preamble indicates the number of preambles assigned to the potential RS, to be transmitted simultaneously. When N_Preamble is equal to 2 or 3, the RS will transmit 2 or 3 sets of preambles with different segment numbers simultaneously.

Sending 2 or 3 sets preamble subcarriers simultaneously will cause serious problems, as described hereby:
1. Preamble related RF transmit power increase.
The average RF transmit-power at the output of the RF PA is increased, during the transmission of the multiple access preambles. Specifically, the average transmit-power for the preamble symbol will get increased by 3 dB and 4.8 dB for N_Preamble of 2 and 3, respectively.

2. PAPR preamble related degradation
The Peak-to-Average-Power-Ratio (PAPR) performance gets degraded, when more than one set of preamble gets transmitted during the same symbol. It could be seen from Table 1, that in a conservative case, the maximum PAPR performance gets degraded by 2.8 dB and 4.3 dB for N_Preamble of 2 and 3, respectively (2k FFT), where the maximum PAPR is obtained by examining the PAPR performance of the various combinations of preambles from 2 or 3 different segments with the assumption of the same preamble transmit power for each used segment.

In other words, for FFT size of 2048, when N_Preamble (number of simultaneous transmissions) is 2 or 3, the average and PAPR RF transmit power will be about 5.8 dB or 9.0 dB higher than a regular single-preamble transmission, respectively. To maintain linearity of transmission, higher back-off factors are required for the RF PA, as presented in Table 1.

This increase in the back-off RF power factor is unacceptable due to lower power amplifier efficiency at the RS and poor relay performance at RSs caused by the lower transmit power available for each segment (assuming amplifier size remains unchanged). Figure 1 depicts the RF coverage shrink effect due to the power backoff for N_Preamble of 2 and 3 when the path loss exponent γ is 4, 3 and 2, respectively. It is seen that the coverage area approximately shrinks by 58% and 75% for N_Preamble of 2 and 3, respectively, at γ of 3 (a typical value for obstructed LOS wireless environment). When γ equals 2 (LOS), the RF coverage approximately shrinks by 63% and 87% for N_Preamble of 2 and 3, respectively.

	Parameter	**FFT Size**		
$\mathbf{N_{preamble}}$		**2048**	**1024**	**512**
1	Max PAPR dB]	4.9113 dB	4.4924 dB	4.4450 dB
2	Max PAPR [dB]	7.7079 dB	7.1161 dB	6.9343 dB
	Power increase [dB]	3.01	3.01	3.01
	Max RF power back-off factor [dB]	10.72	10.13	9.93
	Overall input back-off factor degradation [dB]	**5.81**	**5.63**	**5.50**
3	Max PAPR [dB]	9.1988	8.6532	8.3600
	Power increase [dB]	4.77	4.77	4.77
	Max RF power back-off factor [dB]	13.97	13.42	13.13
	Overall input back-off factor degradation [dB]	**9.06**	**8.93**	**8.69**

Table 1—Overall input back-off factor for the RS RF Power Amplifier when multiple preamble transmissions are used

Considering Fig. 1:

- The outer circle (annotated with 100%) corresponds to the service area covered by a one preamble related transmitting RF power
- The first inner circle (pattern filled) represents the 2 preamble coverage area, referenced to the same initial transmitted (one preamble) RF power
- The inner circle represents the 3 preamble coverage area, referenced to the same initial transmitted (one preamble) RF power
- The 1k FFT case is analyzed, considering the input back off factor degradation presented in Table 1, for 2 and 3 preambles referenced to the one preamble transmission situation

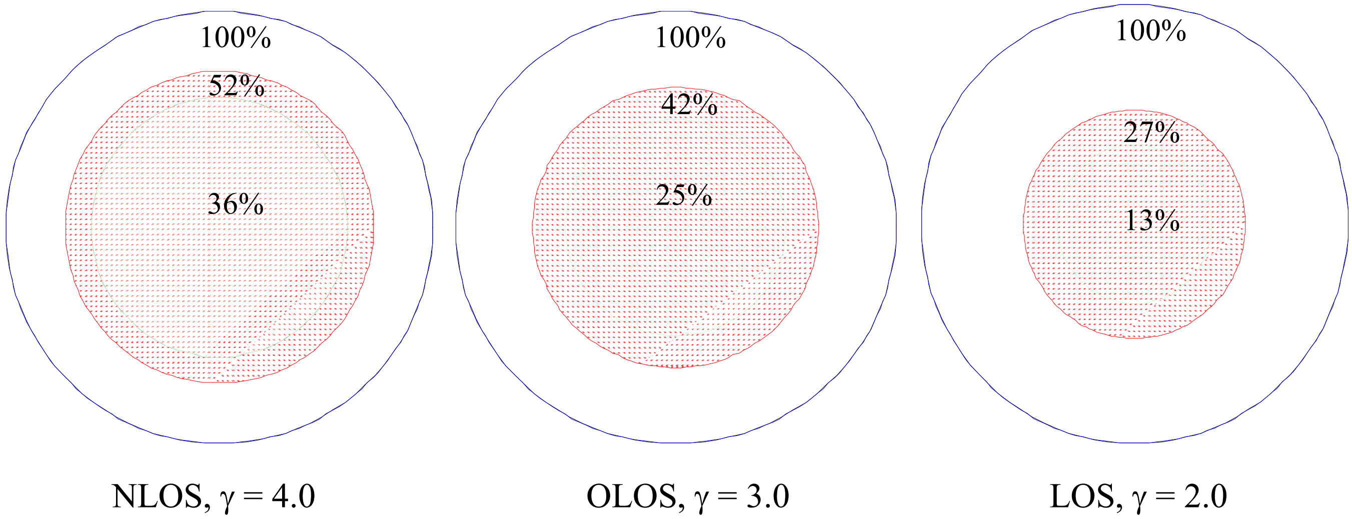

Figure 1 Cell coverage area augmentation due to power amplifier power amplifier input backoff factor

It should be also noted that the resulting service area for the related network synchronization will get decreased under the size of the MAPs coverage area (assuming repetition rate 1) and in the same service area (assuming QPSK1/2 data coverage area), which is a significant functional and performance degradation for a mobile OFDMA network, requesting the increase of the BS density in order to properly provide the network coverage, thus triggering significant cost increases in the network infrastructure.

In other words, we can state that for a regular OFDM amplifier, with an efficiency of 10%, the overall efficiency of the OFDM RF power amplifier will get degraded to 2.5% (when 2 preambles are concurrently transmitted) or 1.25% (when 3 preambles are concurrently transmitted).

It also appears that any HO process developed during a multiple preamble transmission will be severely impacted, due to the reduced cell coverage.

Any cooperative RS operation will be compromised when multiple preambles are transmitted, due to the related cell coverage reduction.

If an RS will equipped with an oversized RF PA, order to accommodate the degraded input back-off factor, the related cost of the respective RS will go up significantly.

3. Receiver AGC-related issues

Assuming that the RS RF PA has enough headroom to accommodate the supplementary back-off factor requested by Table 2, a multiple preamble transmission will no longer be able to be used as a received power reference level, since the regular access preamble power level has been altered. This means that the normalization of the received signal into the PHY (by using Automatic Gain Control) will not be accordingly scaled down, and thus any legacy MS connected to an RS transmitting multiple preambles will not properly execute the de-boosting of the related bursts. This scenario is valid for any MS executing the de-boosting referenced to the preamble level Therefore the related CINR of these decoded bursts will be accordingly impacted.

4. HO scanning related issues

Any mobile RS or MS scanning a neighborhood and executing RSSI scanning measurements on a multiple preamble will report artificially increased values accordingly with the overall back-off factor degradation, presented in Table 2, assuming the RF PA has enough power overhead to accommodate the input back-off factor degradation. Accordingly the roaming RS or MS will detect a strong RSSI signal from the respective RS and it will try to execute a hard HO procedure accordingly attempting to get connected to the RS transmitting multiple preambles, disregarding the other neighboring RSs (assuming the RS transmitting multiple preambles has the strongest RX signal). Therefore the hard HO procedures and scanning neighborhood results will get impacted significantly by any RS transmitting multiple preambles.

Assuming an RS RF PA transmitting multiple preambles, will not have enough overhead to accommodate multiple preamble transmissions, then accordingly with the cell coverage reduction rationale presented in subsection 2, the transmitted RF power will be reduced due to the input back-off factor reduction. Due to the significant cell coverage reduction, no intelligent HO will be possible for any user (either MS or RS) located in the coverage reduction area, therefore the respective MS/RS would need to execute a hard HO.

In either case (no RF headroom provided or enough RF headroom provided) the HO procedure will get impacted.

5. Preamble Coarse Synchronization

An MS or roaming RS relying on the preamble sequence during the synchronization process (implementation specific), generated by a parent RS shifting its preamble sequence from a legacy preamble set to a multiple one (N_Preamble=2 or 3), will be caused preamble detection issues, triggering a possible failure of the synchronization process. It should be noticed, that in this particular case (as opposed to a cell edge case) the receiving RS/MS PHY will detect two preamble sets, received with the same RF power and different PN sequences. Depending on the PHY implementation, possible preamble detection issues could be triggered followed by a subsequent coarse synchronization failure.

6. Spectrum re-growth

In order to simulate the spectral mask impact of a multiple preamble transmissions, the following assumptions have been made concerning typical RF Power Amplifier (PA) with the following characteristics: P1=34 dBm, TOI (IP3)= 45 dBm, Gain = 35.0 dBm, BW=10 MHz. The RF PA has been modulated with an 802.16e frame structure based on a 1k FFT, DL PUSC allocation.

The purpose of the exercise was to simulate the compliance level of the related spectrum against a WIMAX 2.5 GHz spectrum mask (pre-approved WIMAX spectrum mask for 3A profile, for the May 2007 WIMAX TWG FtF meeting).

The following results have been plotted for one, two and three simultaneous transmitted preambles.

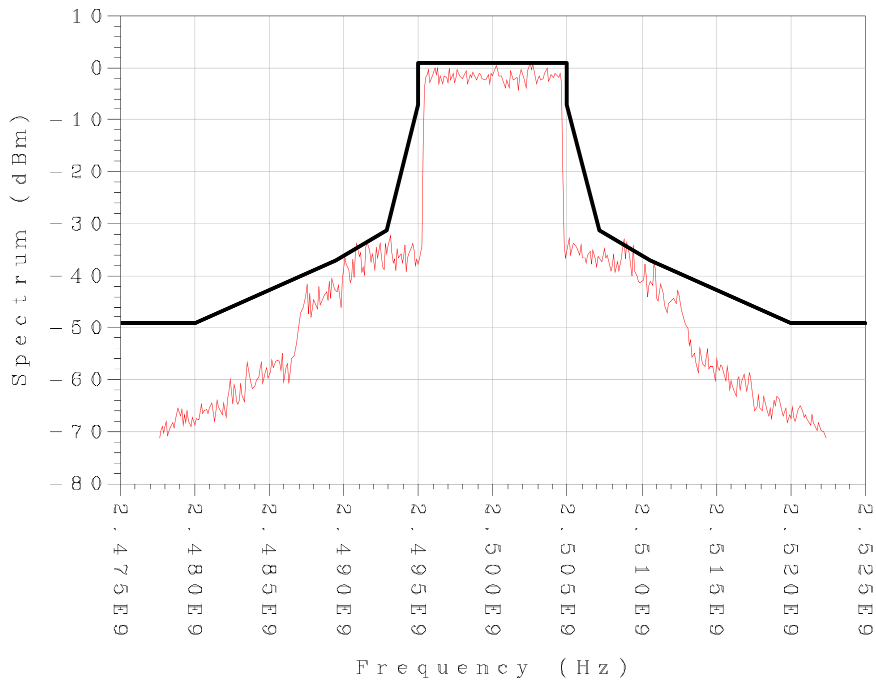

Figure 2 RF spectrum of a RF PA (see assumptions) when a one preamble is transmitted, against a WIMAX 2.5 GHz spectrum mask

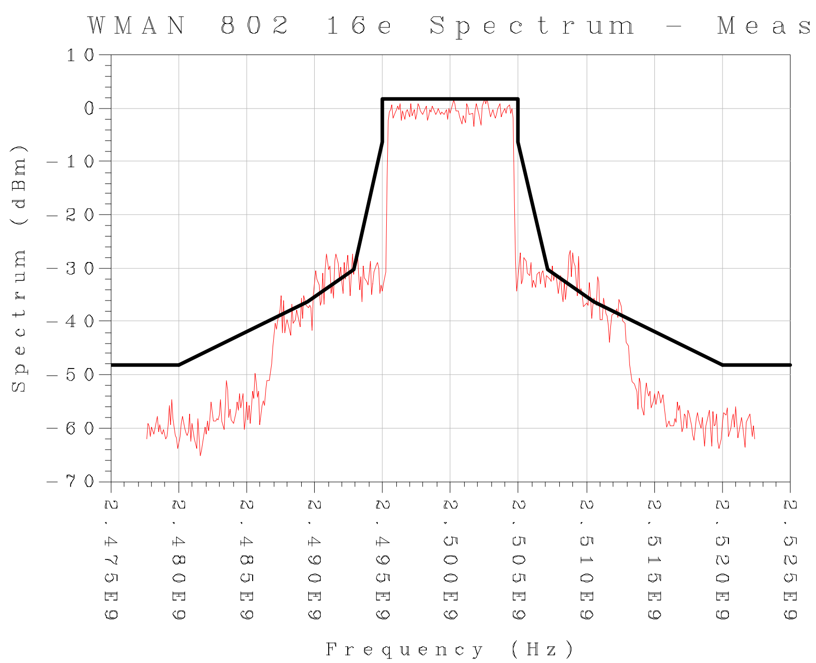

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Figure 3 Two simultaneous preambles transmission impact over the spectrum of a RF PA (see assumptions) against a WIMAX 2.5 GHz spectrum mask

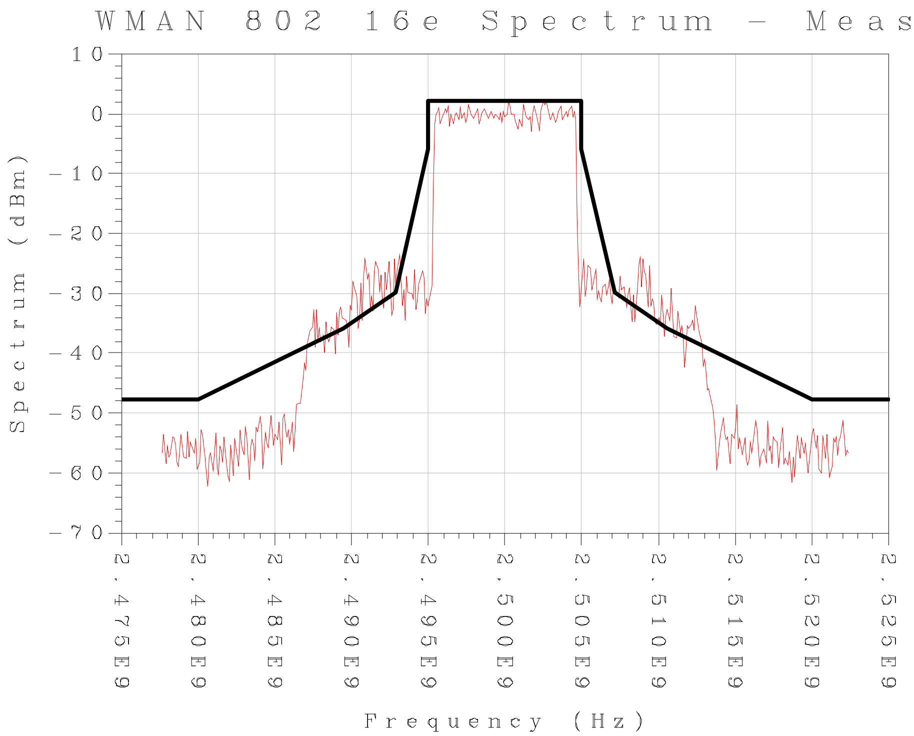

Figure 4 Three simultaneous preamble transmission related impact over the spectrum of a RF PA (see assumptions) plotted against a WIMAX 2.5 GHz spectrum mask

Following the same assumptions, other simulations could be run for different RF profiles.
Concluding the simulations presented in Fig.2, 3 and 4, it appears that a multiple preamble 802.16j frame structure would require a different WIMAX spectrum mask than the actually pre-approved one. Therefore the 802.16j RSs would require a different spectral mask than the (expected to be) certified 802.16e BS spectral mask.

7. Close MS case

When a MS end user operates in the proximity of an RS, which executes a multiple preamble transmissions operation and assuming that the respective RS has enough RF power headroom to accommodate the input back off factor degradation, the related TX RF power could get increased by the input back factors presented in Table 1. Therefore the close MS end users will get received RF powers in excess of the predicted Rx RF power, potentially causing the related close MSs to get received power levels exceeding the prescribed maximal input RF power, causing further non-linear distortions.

8. Multiple MAC instances

Any multiple preamble transmission would require a multiple segment transmission for the same amount of time. Accordingly with [3] #8.4.3.2:

"A Segment is a subdivision of the set of available OFDMA subchannels (that may include all available subchannels). One segment is used for deploying a single instance of the MAC."

Therefore a multiple preamble transmission would require, when implemented, a RS equipped with a processor sized for handling multiple MAC entities. Such an implementation will drive up the related cost of an RS.

Conclusions

Following the technical rationale presented in the items #1 to 7, it appears that an RS transmitting more than one set of preamble subcarriers will trigger significant functional and performance issues for all the child RSs and MSs connected to that RS, causing significant network malfunctions during the concurrent preamble transmissions. The last but not the least, such an RS will have an increased implementation cost.

2. Proposed Remedy

The multiple preamble transmission at a single RS shall not be supported. In other words, N_Preamble shall be 0 (transparent mode) or 1 (non-transparent mode).

3. Proposed text change

+++++++++++++++ Start Text ++

6.3.2.3.69 RS preamble configuration request (RS_Config-REQ) message

Syntax	**Size**	**Notes**
N_Preamble	~~2~~ 1 bit~~s~~	N_Preamble = 0 specifies NULL preamble (e.g., Transparent RS), N_Preamble = 1 assigns one preamble to the RS ~~N_Preamble=2 assigns two preambles on different segments to the RS N_Preamble=3 assigns three preambles on different segments to the RS~~
Reserved	~~6~~ 7 bits	Reserved
for (i=0, i<N_Preamble; i++){		
Preamble index	8 bits	Assign a preamble index value to the potential RS
}		
TLV Encoded Information	Variable	TLV specific

4. References

[1] IEEE P802.16j-06/026r3
[2] IEEE Std 802.16e-2005
[3] IEEE Std 802.16-2004