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Re:	IEEE P802.16e/D5-2004
Abstract	This contribution proposes a new method to enhance the network entry and re-entry procedures in PMP mode.
Purpose	The purpose of this document is to enhance the network entry and re-entry procedures.
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A new method to enhance the network entry and re-entry procedures in PMP mode

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Motivation

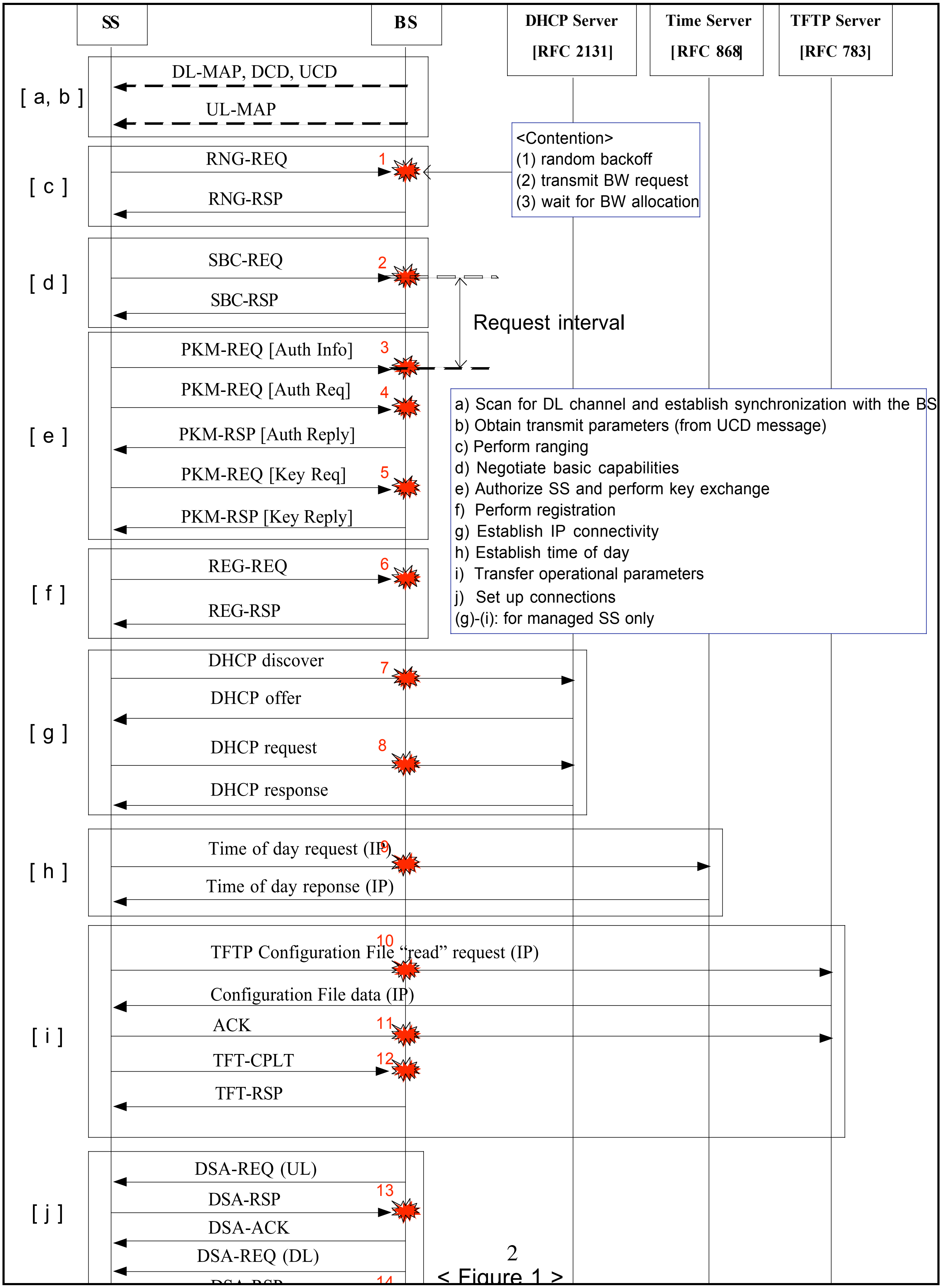
This document proposes a new method to enhance the network entry and re-entry procedures in PMP mode.

Background

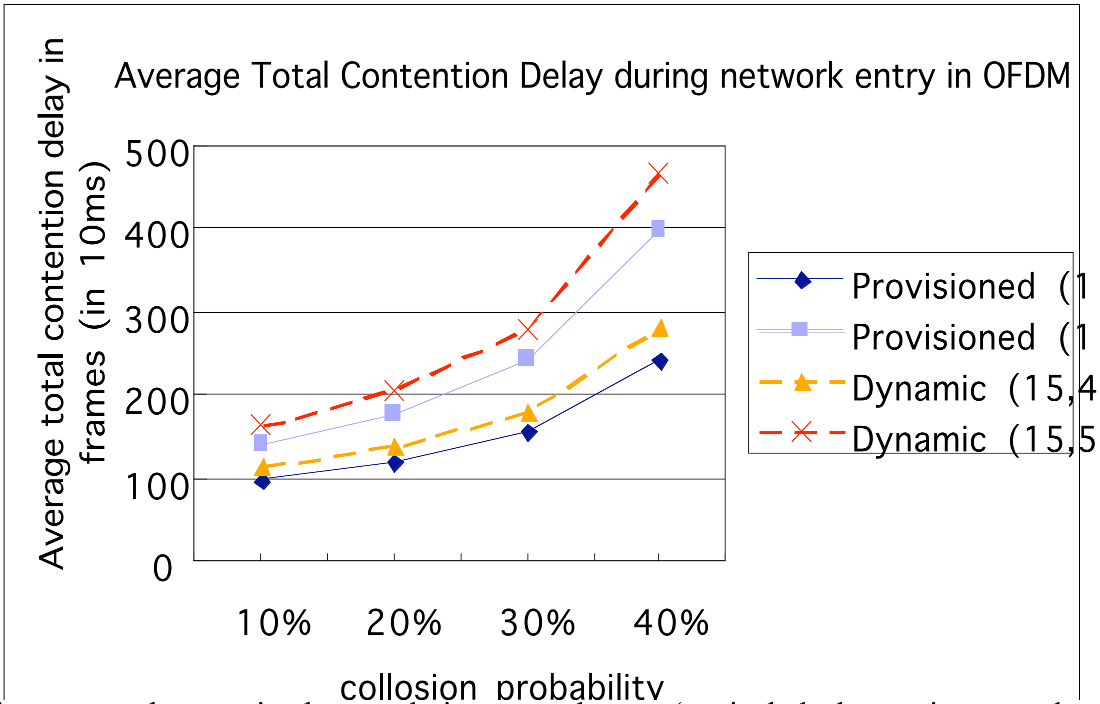
The initial network entry and network re-entry procedures are divided into several phases. Each phase can be treated as an independent signaling procedure and consists of exchange of MAC management messages between the SS and the BS. Due to the BS has no idea when the SS will transmit the requests and how much bandwidth these requests will take up, the BS will passively wait for the requests, e.g. SBC-REQ, from the SS during the network entry procedures. The SS, therefore, will send a bandwidth request in the contention period to make the bandwidth request before transmitting any management message, e.g. SBC-REQ. The SS sends the request after a successful contention, otherwise it retries again if no data grant has been given within T16. This design is simple but not efficient in terms of radio resource usage and power consumption, especially when the network is in a high load condition. When the network load is high, the contention procedures will introduce significant delay and power consumption because of high collision probability prior to transmission of MAC management messages in each phase.

The possible management message handshaking flows of the entire network entry procedures are depicted in Figure 1. The corresponding phases of each group of management message handshaking, which are defined in section 6.3.9, are denoted from [a] to [j]. In this scenario, the SS will produce bandwidth request at least fourteen times (Some messages, e.g. RNG-REQ, may be issued more than once). One DSA-REQ can only create one service flow, and therefore there are two DSA-REQs in procedure [j]. The contention process may take time due to the SS will defer a number of TOs before transmitting the BW request in the mandatory method of the contention resolution. If the initial backoff window is large and the collision probability is high the contention process may introduce significant delay.

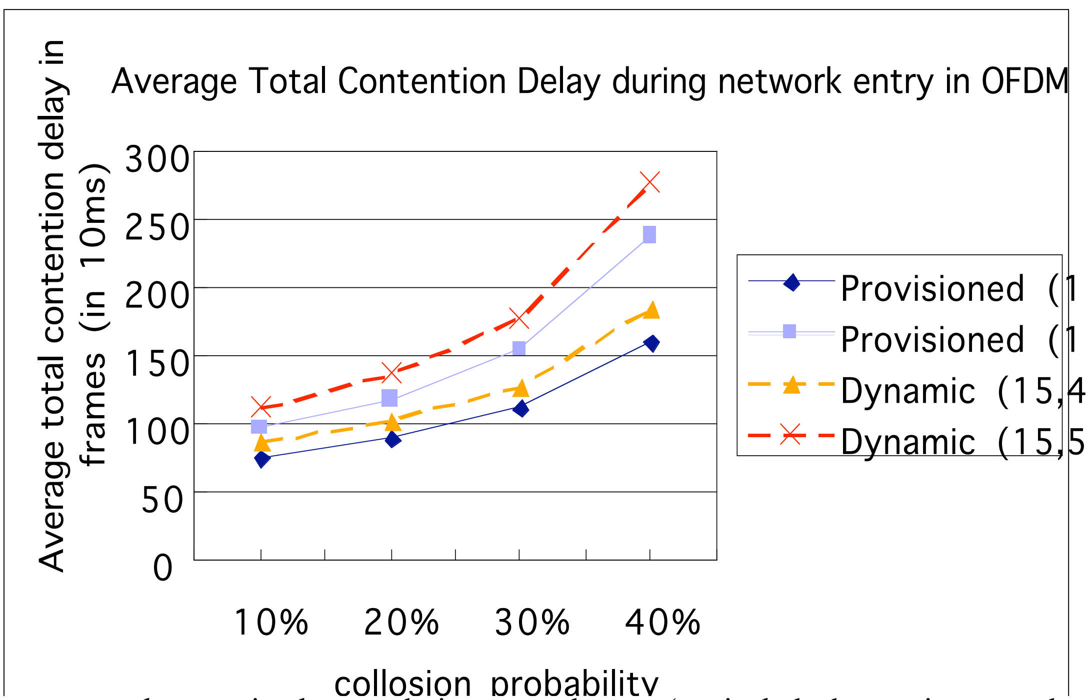
Figure 2 and Figure 3 demonstrate the simulation results of the average total *contention delay* during entire network entry phases under different scenarios in OFDM PHY. The definition of *contention delay* (see Figure 4) is the number of frames used for contention process and transmission of UL data. In Figure 4, the contention backoff procedure is only applied to the non-OFDMA PHY since there is no backoff in OFDMA BW request. Note that the total contention delay during entire network entry only takes into consideration of the time spent on contention process and does not consider those processing time of the each phase, e.g. the processing time of SS's basic capability negotiation procedure. The item "Provisioned (13,4)" in Figure 2 and Figure 3 means the last phase "Set up connections" of network entry is to set up a provisioned service which shall be started by the BS. The number 13 is the total number of request messages shall be sent by the SS and 4 is the value of initial backoff window. Similarly, The item "Dynamic (13,4)" in Figure 2 and Figure 3 means the last phase "Set up connections" of network entry is to set up a dynamic service which shall be started by the SS. Note that we do not count the request number during the ranging procedure in our simulation since it is not a constant value. In other words, we only count the request messages issued by the SS from [d] to [j] in Figure 1. Table 1


SS
BS
DHCP Server [RFC 2131]
Time Server [RFC 868]
TFTP Server [RFC 783]
[a, b]
DL-MAP, DCD, UCD
UL-MAP
[c]
RNG-REQ
1
RNG-RSP
<Contention>
(1) random backoff
(2) transmit BW request
(3) wait for BW allocation
[d]
SBC-REQ
2
SBC-RSP
Request interval
[e]
PKM-REQ [Auth Info]
3
PKM-REQ [Auth Req]
4
PKM-RSP [Auth Reply]
PKM-REQ [Key Req]
5
PKM-RSP [Key Reply]
a) Scan for DL channel and establish synchronization with the BS
b) Obtain transmit parameters (from UCD message)
c) Perform ranging
d) Negotiate basic capabilities
e) Authorize SS and perform key exchange
f) Perform registration
g) Establish IP connectivity
h) Establish time of day
i) Transfer operational parameters
j) Set up connections
(g)-(i): for managed SS only
[f]
REG-REQ
6
REG-RSP
[g]
DHCP discover
7
DHCP offer
DHCP request
8
DHCP response
[h]
Time of day request (IP)
9
Time of day reponse (IP)
[i]
TFTP Configuration File "read" request (IP)
10
Configuration File data (IP)
ACK
11
TFT-CPLT
12
TFT-RSP
[j]
DSA-REQ (UL)
DSA-RSP
13
DSA-ACK
DSA-REQ (DL)
14

< Figure 1 >

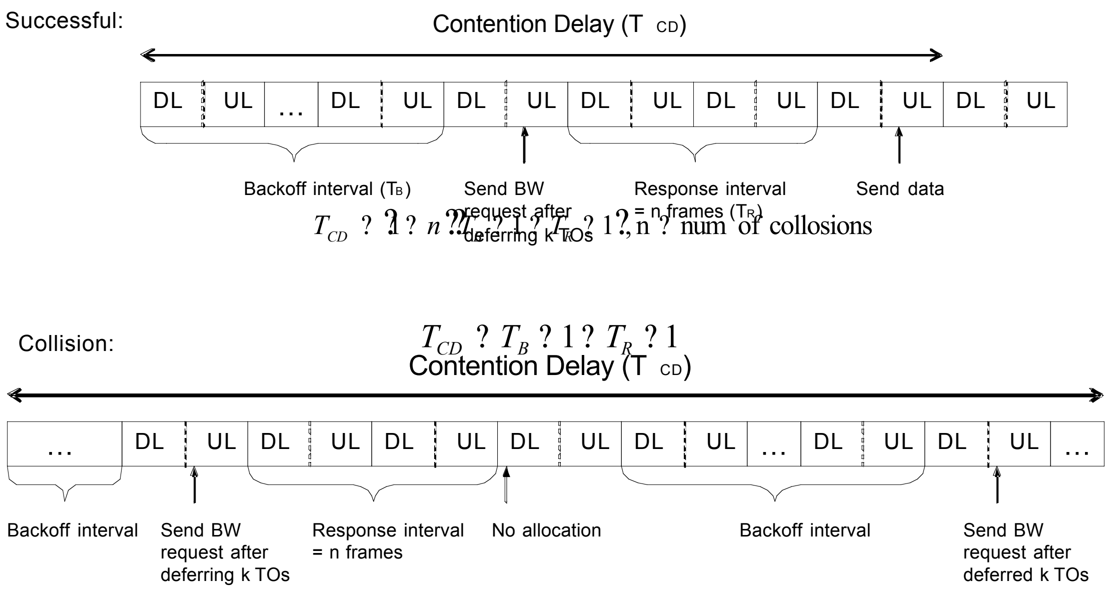


<Figure 2°– Average total contention latency during network entry (not include the ranging procedure) using REQ Region Full with **5%** of UL OFDM symbols for contention, 10ms frame duration>



<Figure 3°– Average total contention latency during network entry (not include the ranging procedure) using REQ Region Full with **10%** of UL OFDM symbols for contention, 10ms frame duration>

summarizes the assumptions of the simulation which is based on [1] and [2]. For the simplicity, we use the fixed collision probability to represent the network load during the contention process. The simulation is mainly to demonstrate the additional delay that is introduced by the contention process during the network entry. As show in Figure 2 and Figure 3, the average total contention delay accumulated in the network entry procedures increases as the collision probability or the initial backoff window increases. The worst case in Figure 1 indicates that the SS may spend more than four seconds on contention process during the network entry procedure. This additional delay may not be acceptable for the user under the mobile operation. Moreover, the simulation does not consider the impact of the contention on the existing traffic.



<Figure 4>

Assumptions	value
UL channel bandwidth	3 MHz
FFT	256-pint FFT
Frame duration	10ms
Response interval	20ms
OFDM symbols per UL subframe	120
Subchannelization	No subchannelization
Contention method	REQ Region-Full
Number of OFDM symbols per contention slot	2

<Table 1°– Simulation assumptions>

In cellular network, the BS provides a power efficient scheme and assigns a dedicated channel to the MS for sending signaling data so that the MS can avoid contention during the network entry. However, the contention scheme in IEEE 802.16 may introduce significant delay and power consumption. Thus, we propose a new method to ease off the problem. For comparison, we will refer to the proposed method as *invited network entry/re-entry*.

Invited network entry/re-entry

In IEEE P802.16e/D5, the Invited Initial Ranging (defined in 6.3.9.5) and the non-contention based MSS Initial Ranging opportunity (defined in 6.3.20.4) are designed for the MSS to use the unsolicited bandwidth allocation to send the RNG-REQ. This mechanism can only apply on the ranging procedures because the size of RNG-REQ can be predicted by the BS during initial ranging. For other management messages such as SBC-REQ are variable-length, the BS cannot predict the actual bandwidth of each management message. Furthermore, the BS cannot predict when the SS are prepared to send the next management message.

Invited Network Entry TLV

To solve the problems described above, we propose a new type of TLV named "*Invited Network Entry TLV*" which is two-byte long and described as follows:

(1) **Invited Network Entry Interval:** The first byte of this TLV is named Invited Network Entry Interval which is in units of frames and indicates the interval in frames between the two successive allocations of unsolicited bandwidth request opportunity.

(2) **Invited BW Request Opportunity Count:** The second byte of this TLV is named Invited BW Request Opportunity Count which is in units of BW request transmission opportunities (TOs) and indicates the expected total number of the unsolicited TOs for bandwidth request during the network entry or re-entry.

This TLV can be included in RNG-REQ/RNG-RSP, SBC-REQ/RSP or REG-REQ/REG-RSP. The SS includes this TLV to indicate the expected interval, which is calculated by the SS, between the two successive unsolicited BW request opportunities. This interval may be the longest interval among the request intervals indicated in Figure 1. During the request interval, the SS may send a management message, receive a response, process the response message and prepare the next management message to be sent. The BS can reject the request from the MSS by setting all bits to zeros, or it can modify the values based on its policy by including this TLV in the response message. In the case of RNG-REQ, this TLV should be included in the RNG-REQ which is transmitted in the invited initial ranging interval since the size of TO for RNG-REQ may be fixed. Invited network entry/re-entry also makes no difference of the procedure between OFDMA PHY and other PHYs. The BS should start to issue the invited BW request opportunities according to the *Invited Network Entry TLV* after the last RNG-RSP. The BS will stop to issue the invited BW request opportunities once the Invited BW request opportunity retries exhaust. Once the invited BW request opportunities are exhausted and the network entry or re-entry is not finished yet, the SS should send BW request in the contention period.

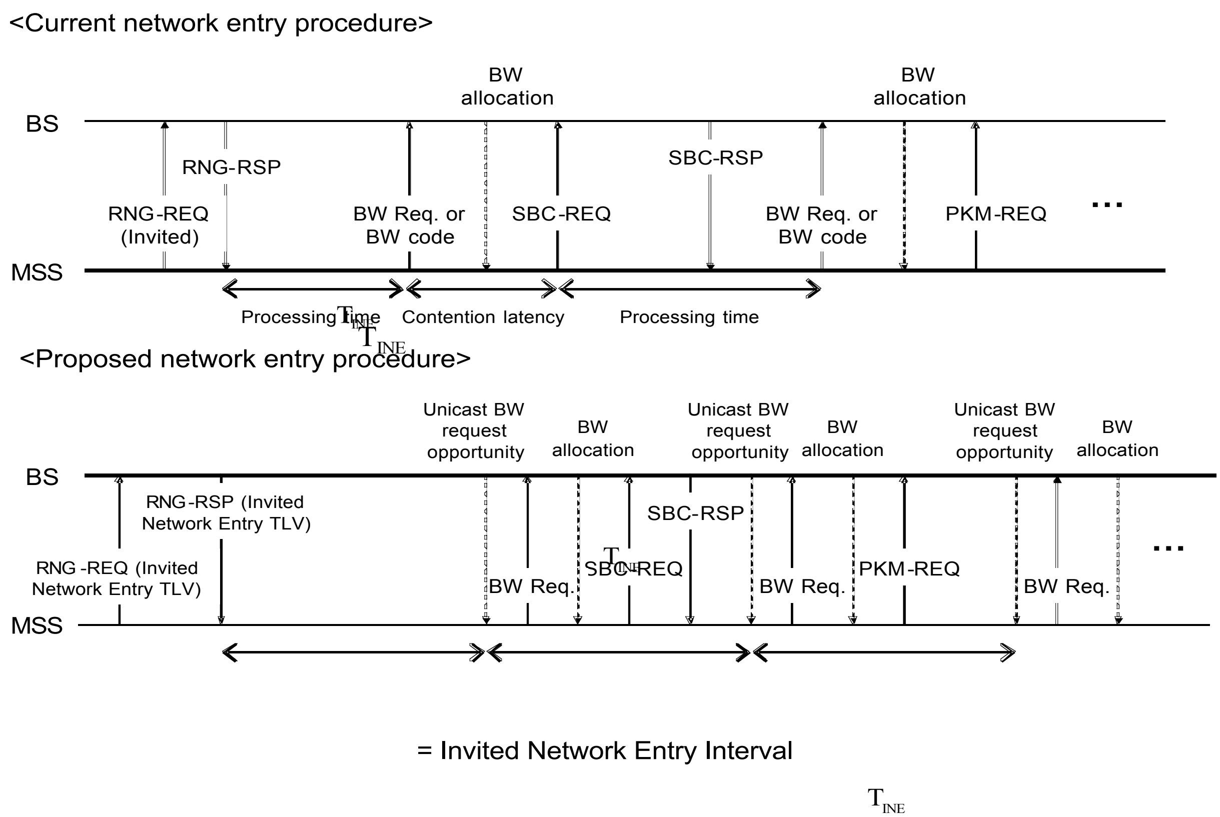
For example, if the SS finds out that the longest request interval is located between the PKM-REQ (5) and REG-REQ (6) (see Figure 1) and its value is 200ms, it will set the *Invited Network Entry Interval* as "0x14" in the case of 10ms frame duration. Additionally, the SS will estimate how many phases it will perform during the network entry or re-entry and, therefore, can obtain the minimum value of invited BW request opportunities to complete the network entry or re-entry. For example, the SS may set the *Invited BW Request Opportunity Count* as "0x10" for the scenario described in Figure 1. The additional two bandwidth opportunities can make up for the lost of the invited BW request opportunities.

New UL_Extended_IE – Invited_Network_Entry_IE() for SCa, OFDM and OFDMA

Due to the Invited BW Request Opportunities which are only for transmitting BW requests, it is not bandwidth efficient if the BS creates a separate UL-MAP_IE for allocating each BW Request Opportunity. Thus, for bandwidth efficiency, we suggest that the BS shall collect those *Invited BW Request Opportunities* scheduled in the same frame together and place those request opportunities in an UL_Extended_IE (UIUC = 15) named *Invited_Network_Entry_IE()* with broadcast CID 0xFFFF.

At last we provide the comparison between the current method and the proposed method. As depicted in Figure 5, the proposed network entry procedure is simple and more energy efficiency. The BS schedules the invited BW request opportunities according to the Invited Network Entry TLVs. And the SS just waits for the invited BW request opportunities from the BS. The impact of the network entry on the existing traffic is also diminished since the MSS will not send the BW request in the contention period. Moreover, the Invited Network Entry Interval makes the entire network entry procedure predictable. It is possible that the proposed *invited network entry* spends less time than the current network process by adjusting the *Invited Network Entry Interval* smaller than the maximum request interval if the maximum request interval is much large than the rest of the request intervals.

We provide a simple estimation of the total network entry processing time. The current network entry procedure after ranging consists of contention latency and processing time (see Figure 5). According to Figure 1, there are 14 times of processing time and 13 times of contention latency. Thus, if we assume that the average processing time is 150ms and the total contention latency is 1.5 seconds (from Figure 2), the total network entry processing time excluding ranging procedure is 3.6 (14*0.15+1.5) seconds. The proposed network entry procedure comprises several *Invited Network Entry Intervals* (see Figure 5). According to Figure 1, there are 13 times of *Invited Network Entry Interval* and if the value of the interval is the maximum value of the interval, say, 300ms, the total network entry processing time excluding ranging procedure is 3.9 (13*0.3) seconds. However, if the SS finds that only two intervals are longer than 200ms and the rest of the intervals are smaller than 200ms, it can choose 200ms as the value of *Invited Network Entry Interval*. Therefore, the result will be 3 (11*0.2+2*0.4) seconds which is even less than the current method.



<Figure 5>

Proposed Text changes

6.3.20.4 Network entry/re-entry

[Add the following text under section 6.3.20.4:]

6.3.20.4.1 Invited network entry/re-entry

Invited network entry/re-entry allows the MSS to issue non-contention BW request for sending management messages, e.g. SBC-REQ, in each phase of the network entry/re-entry by allocating the MSS the invited unicast BW request opportunity periodically. For the MSS that support invited network entry/re-entry may include the Invited Network Entry TLV (see 11.1.8) in the RNG-REQ, SBC-REQ and REG-REQ to ask for the unsolicited BW request opportunities during the network entry/re-entry. In the Invited Network Entry TLV, the MSS needs to specify the Invited Network Entry Interval, in units of frames, and Invited BW Request Opportunity Count, in units of BW request transmission opportunities (TOs) (see 11.1.8). The BS may reject the requested value by setting all this bits to zeros, or it can modify the values based on its policy. For network re-entry, the Target BS may place the Invited Network Entry TLV and HO Process Optimization TLV in the RNG-RSP message, so that the MSS can utilize the invited BW request opportunities to perform the not omitted re-entry procedures.

If the values in Invited Network Entry TLV returned from the BS are not set to zeros, the MSS should wait the invited BW request opportunities and make BW requests for transmitting the management messages during the network entry until the Invited BW Request Opportunity Count is exhausted. The SS should send BW request in the contention period if the invited BW request opportunities are exhausted and the network entry or re-entry is not completed. The BS should start to issue the invited BW request opportunities according to the invited network entry TLV after transmitting the last RNG-RSP with success status or after transmitting other response management message.

For bandwidth efficiency the BS shall collect those invited BW request opportunities scheduled in the same frame together and places those request opportunities in an PHY specific UL_Extended_IE (UIUC = 15) named Invited_Network_Entry_IE() (see 8.2.1.9.3.7, 8.3.6.3.10 and 8.4.5.4.9). The MSS should not issue contention BW requests unless the Invited BW Request Opportunity Count is exhausted. The BS should schedule the invited BW request opportunity on time. The BS may stop to schedule the Invited BW request opportunity if the invited retries count exhausted. (see Figure 130j, Figure 130k and Figure 130l). The ability of invited network entry is optional for the MSS and mandatory for the BS.

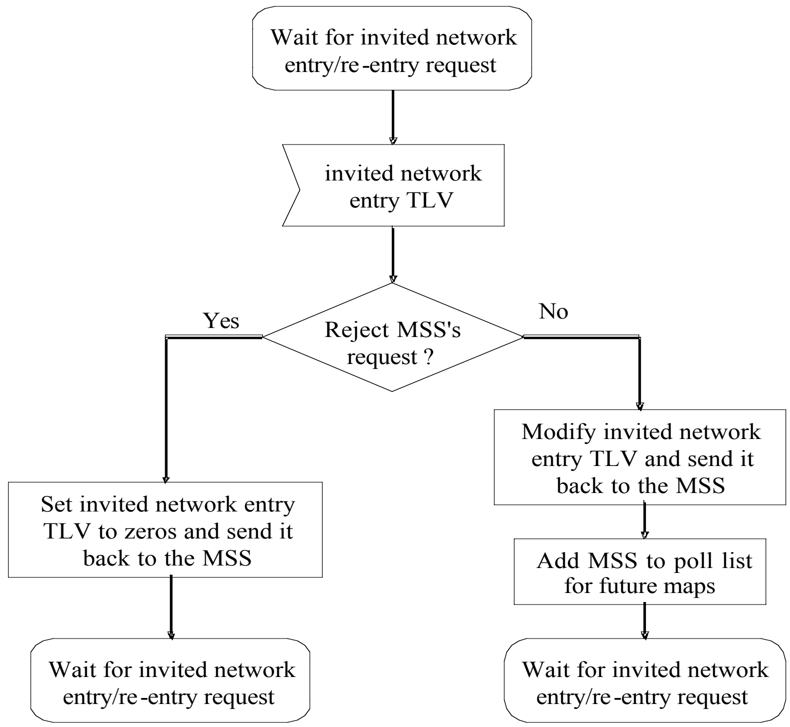


Figure 130j – Invited Network Entry – BS

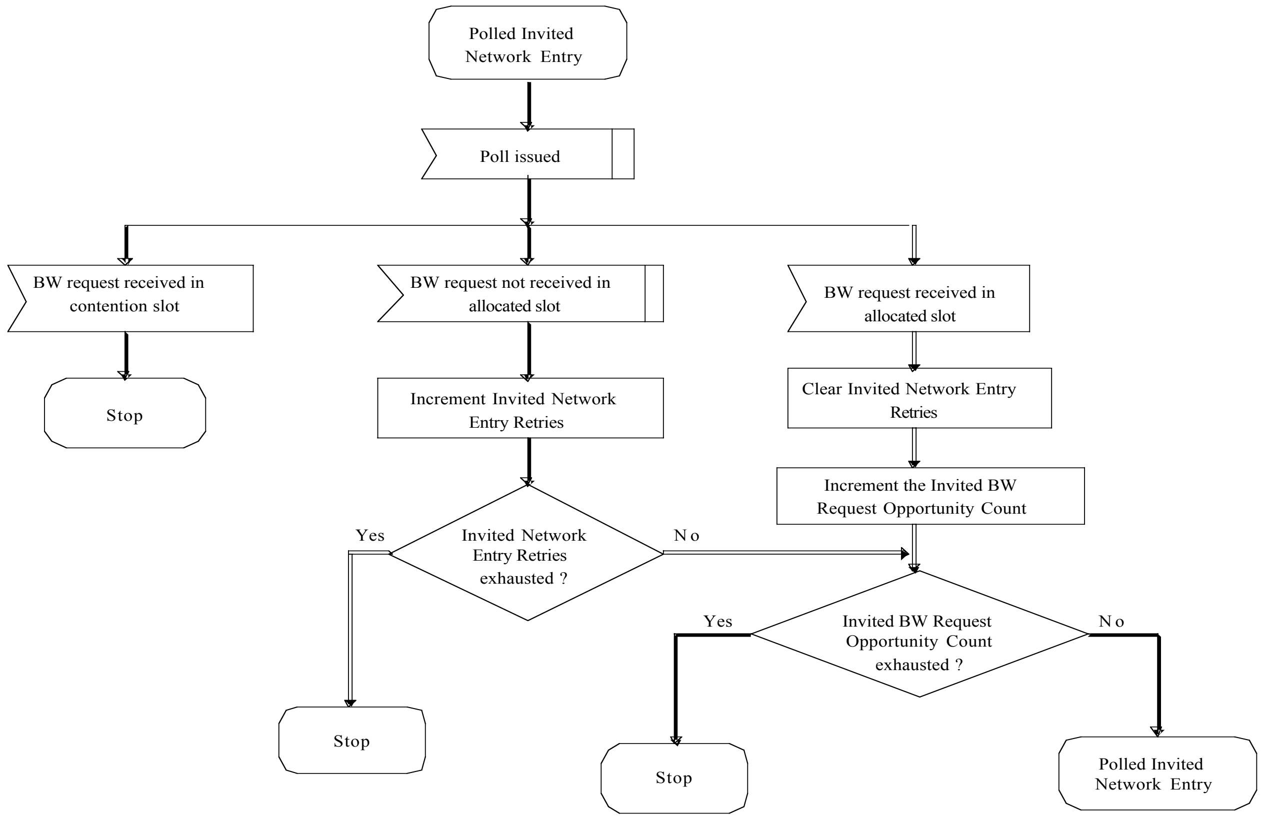


Figure 130k°– Invited Network Entry, Polled Phase°– BS

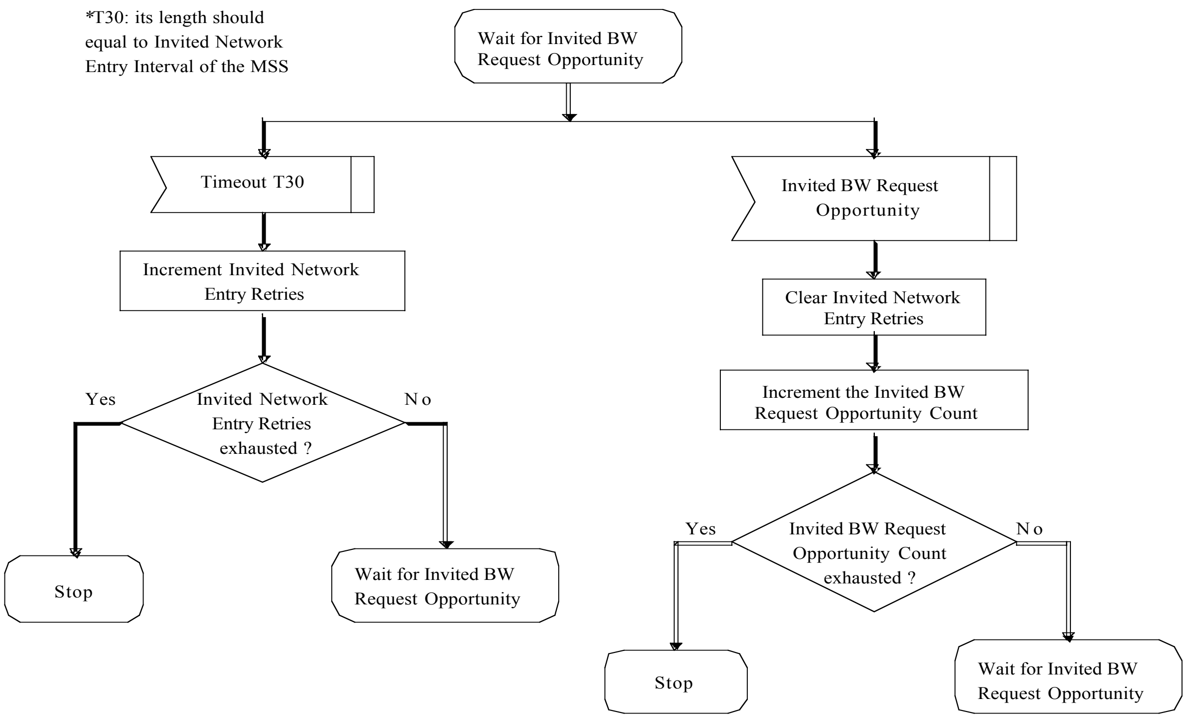


Figure 130l°–Invited Network Entry, Polled Phase°–MSS

8.2.1.9.3 UL-MAP IE formats

[Add the following text under section 8.2.1.9.3:]

8.2.1.9.3.7 Invited network entry Information Element

An invited network entry IE may be place in a UL_MAP message by a BS to provide a group of MSSs with contentionless BW request opportunities. The value of the subcode assigned to this function is 5. The CID value in the UL-MAP_IE() shall be set to 0xFFFF. The CID value in the extended IE should be the Basic CID of the MSS. The format of the extended IE is presented in Table 207a.

Table 207a—invited network entry IE format

Syntax	Size	Notes
Invited_Network_Entry_IE(){		
Subcode	4 bits	Invited_network_entry = 0x05
Length	4 bits	Number of CIDs carried in this extended IE

For(i=0;i<Length;i++){		
CID(i)	16 bits	Basic CID of MSS
}		

8.3.6.3 UL-MAP IE format

[Add the following text under section 8.3.6.3:]

8.3.6.3.10 Invited network entry Information Element

An invited network entry IE may be place in a UL_MAP message by a BS to provide a group of MSSs with contentionless BW request opportunities. The value of the extended UIUC assigned to this function is 4. The CID value in the UL-MAP_IE() shall be set to 0xFFFF. The CID value in the extended IE should be the Basic CID of the MSS. The format of the extended IE is presented in Table 253a.

Table 253a—invited network entry IE format

Syntax	Size	Notes
Invited_Network_Entry_IE(){		
Extended UIUC	4 bits	Invited_network_entry = 0x04
Length	4 bits	Number of CIDs carried in this extended IE
For(i=0;i<Length;i++){		
CID(i)	16 bits	Basic CID of MSS
}		

8.4.5.4 UL-MAP IE format

[Insert the following text under section 8.4.5.4 and modify the numbers of relative sections:]

8.4.5.4.9 Invited network entry Information Element

An invited network entry IE may be place in a UL_MAP message by a BS to provide a group of MSSs with contentionless BW request opportunities. The value of the extended UIUC assigned to this function is 4. The CID value in the UL-MAP_IE() shall be set to 0xFFFF. The CID value in the extended IE should be the Basic CID of the MSS. The format of the extended IE is presented in Table 253a.

Table 295a—invited network entry IE format

Syntax	Size	Notes
Invited_Network_Entry_IE(){		
Extended UIUC	4 bits	Invited_network_entry = 0x04
Length	4 bits	Number of CIDs carried in this extended IE
For(i=0;i<Length;i++){		
CID(i)	16 bits	Basic CID of MSS
}		

11.1 Common encodings

[Change the contents of Table 346 as indicated:]

Table 346—Type values for common TLV encodings

Type	Name
149	HMAC tuple
148	MAC version encoding
147	Current transmit power
146	Downlink service flow
145	Uplink service flow
173	Invited Network Entry
144	Vendor ID encoding
143	Vendor-specific information

[Insert the following section after 11.1.7 MOB-NBR-ADV Message Encodings:]

11.1.8 Invited Network Entry Encodings

This field defines the parameters for the invited network entry or re-entry procedures. This TLV can be included in RNG-REQ/RNG-RSP, SBC-REQ/RSP or REG-REQ/REG-RSP. The SS includes this TLV to indicate the expected interval, which is calculated by the MSS, between the two successive unsolicited BW request opportunities. Additionally, the SS will estimate how many phases it will perform during the network entry or re-entry and, therefore, can obtain the minimum value of invited BW request opportunity count to complete the network entry or re-entry. The BS may reject the request from the MSS by setting all bits to zeros, or it can modify the values based on its policy by including this TLV in the response message. In the case of RNG-REQ, this TLV should be included in the RNG-REQ which is transmitted in the invited initial ranging interval since the size of TO for RNG-REQ is fixed.

Type	Length	Value	Scope
173	2	Bit #0 - #7: Invited Network Entry Interval, in units of frames Bit #8 - #15: Invited BW Request Opportunity Count, in units of BW request transmission opportunities (TOs)	RNG-REQ, RNG-RSP, SBC-REQ, SBC-RSP, REQ-REQ, REG-RSP

References

[1] Jerry Krinock et al., "Contention Schemes For OFDM Mode A_L", IEEE C802.16a-02/12, Jan., 2002.

[2] Jerry Krinock et al., "Supplement to "Contention Schemes For OFDM Mode A_L"", IEEE C802.16a-02/14, Jan., 2002.