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Enhanced Network Control Scheme for the Entry process of IEEE 802.16 Mesh Networks

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Introduction

Broadband Wireless Access (BWA) Networks, based on the standard IEEE 802.16, have gained increased interest during the last few years. This standard has become the best way to fulfill residential, small business and underserved rural-area demand for high speed Internet access, multimedia and voice services. The IEEE 802.16 standard is considered one of the most promising wireless access technologies due to its cost-effective and fast deployment properties.

The IEEE 802.16-2004 standard [1] supports two operating modes of the Medium Access Control (MAC) sublayer: 1) point to multipoint (PMP), where traffic occurs only between the Base Station (BS) and Subscriber Stations (SSs), and 2) mesh topology, where traffic can be routed through other SSs and can occur directly between SSs. The mesh mode is an extension to the PMP mode, with the advantage of having a lower path loss, increased coverage and improved robustness as more subscribers are added. In mesh mode, system throughput can be increased by using multiple-hop paths [2-3]. Thus, wireless mesh networks (WMNs) can be used to extend cell ranges, cover shadowed areas and enhance system throughput.

The IEEE 802.16 mesh protocol has defined two kinds of scheduling mechanisms: distributed and centralized. In the former, a mesh SS (MSS), termed also as node, competes for channel access using a pseudo-random election algorithm based on the scheduling information about its two-hop neighbors, and bandwidth reservation for data transmission is performed using a request-grant-confirm three-way handshaking procedure. In the latter, the mesh Base Station (MBS) works like a head end and receives all bandwidth requests from all MSSs within a certain hop range and grants resources for each node. Because all control and data messages need to pass through the MBS, the scheduling scheme is simple, however, the connection setup delay can be long [4-5]. While in a centralized scheduling, service disruption events, such as large scale power outages, can seriously affect system´s performance. Upon such events, all link connections between the MBS and nodes are terminated.

Most studies found in the literature focus on routing, performance analysis and optimization issues of centralized and distributed schedulers. However, as far as we are concerned, only a few works discuss the performance of the network entry process of IEEE 802.16 mesh networks.

In [6], the authors presented a load-aware network entry mechanism that allows new nodes entering the network to properly sense the load and chose the lower MBS to access. In [7], the authors presented a performance optimization of the network entry and link establishment processes, where they found that about 70% of the network configuration (MSH-NCFG) messages exchanged during the initialization process is successful, but this percentage can be extended to 93% by minimizing the effects of hidden terminals.

Our work, however, is rather different from previous works. In this paper, we study the performance of the initialization process after service disruption in IEEE 802.16 mesh networks, where the successful rate of MSH-NCFG and network entry (MSH-NENT) messages is much lower than the 70% reported in [7], thus new allocation schemes for those messages are needed in order to reduce the recovery time. In this paper we propose a new scheduling control scheme that reduces the recovery time up to 98% compared with the default scheme defined in the standard. In order to study the performance of the MAC protocol of such mesh networks, we have developed a discrete event simulation model based on the OPNET simulation package v14.

This paper is structured as follows. Section 2 presents an overview of the relevant parts of the IEEE 802.16 mesh protocol. Section 3 derives the proposed scheme for the optimization of network control. Section 4 presents the OPNET simulation model used in this paper for the results. In Section 5, we present the performance analysis of the initialization process of the mesh protocol comparing the proposed scheme with the default mechanism defined in IEEE 802.16-2004. We conclude the paper in Section 6.

IEEE 802.16 mesh topology

The centralized and distributed scheduling modes use an entry process that is described in the following section. For a detailed description of the scheduling process in [8], we presented a comparative analysis of wireless broadband mesh and multi-hop networks based on the IEEE 802.16 protocol.

A. Network synchronization

Network configuration (MSH-NCFG) and network entry (MSH-NENT) packets provide the basic level of communication between nodes in different nearby networks, regardless of the equipment vendors or wireless operators. These packets are used to synchronize both centralized and distributed control mesh networks. This communication is used to support basic configuration activities such as: synchronization between nearby networks (i.e., for multiple, co-located MBSs to synchronize their uplink and downlink transmission periods), communication and coordination of channel usage by nearby networks, and network entry of new nodes.

MSH-NCFG, MSH-NENT, and MSH-DSCH (distributed scheduling packets) can assist a node to synchronize frame transmissions. For these messages, the first control subframe, as described in Frame1 of Fig.1, is divided into several transmission opportunities (TxOps) depending on the MSH_CTRL_LEN parameter.

The first TxOp in a network control subframe contains a MSH-NENT message, while the other MSH-CTRL-LEN - 1 TxOps includes MSH-NCFG messages. The MSH-NCFG messages also contain the number of their TxOps, which allow nodes to easily calculate the frame start time. In scheduling control subframes (from frame 2 to frame n in Fig.1), the MSH-DSCH-NUM TxOps assigned for MSH-DSCH messages come last in the control subframe.

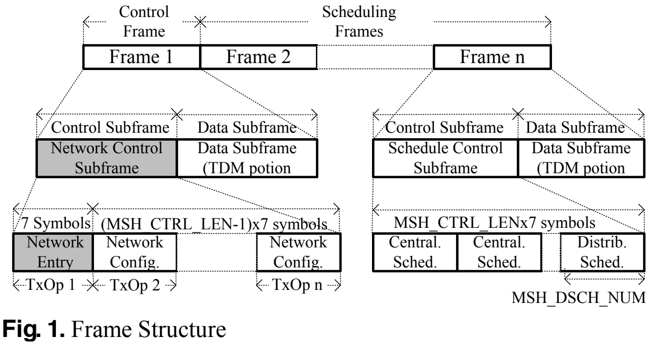


Fig. 1. Frame Structure

B. Initialization process

For the centralized scheduling mechanism of the IEEE 802.16-2004 mesh protocol, upon service disruption, a node must perform the initialization process described as follows.

Node initialization and network entry procedures in mesh mode are in some aspects different from those in PMP mode. A new node entering the mesh network carries on the following steps: 1) Scans for network activity and establishes network synchronization. 2) Obtains network parameters (from MSH-NCFG messages). 3) Opens a Sponsor Channel. 4) Receives node authorization. 5) Performs node registration. 6) Establishes IP connectivity. 7) Establishes time of day. 8) Transfers operational parameters.

On initialization or after signal loss, a node searches broadcast MSH-NCFG messages to acquire synchronization with the mesh network. Upon receiving a MSH-NCFG message, a node acquires the network time from the message´s timestamp field. A node having nonvolatile storage may retain the most recent operational parameters and may first try to re-acquire synchronization with the network using those parameters. If this fails, nodes begin to continuously scan possible channels until a valid network is found. A node completes synchronization after it receives MSH-NCFG messages from the same node twice, and until it has received a MSH-NCFG message with Network Descriptor information with an operator ID matching its own if it has any. In parallel, the new node builds a physical neighbor list from the recently acquired information.

The initialization process is started by a candidate node, which transmits a MSH-NENT: NetEntryRequest message to a potential sponsoring node, which can be the MBS or an intermediate node. Upon reception of the MSH-NENT: NetEntryRequest message with the sponsor node ID equal to the node ID of its own, the sponsoring node assesses the request and either opens the sponsor channel or rejects the request.

The response is given in a MSH-NCFG message with embedded data. If the sponsoring node does not advertise the candidate node’s MAC address in the sponsor’s next MSH-NCFG transmission, then the procedure is repeated MSH_SPONSOR_ATTEMPTS times using a random backoff interval among attempts. If these attempts fail, then a different sponsoring node is selected and the procedure is repeated. If the selected sponsoring node does advertise the candidate node’s MAC address, it continues to advertise this MAC address in all its MSH-NCFG messages until the sponsorship is ended.

Once the candidate node has received a positive response (a NetEntryOpen message) from the sponsoring node in the MSH-NCFG message, it shall acknowledge the response by transmitting a MSH-NENT: NetEntryAck message to the sponsoring node at the following network entry TxOp. Then, the candidate node and the sponsoring node use the schedule indicated in the NetEntryOpen message to perform message exchange. This temporal schedule is called a sponsor channel, where all messages related to node configuration parameters are transmitted (e.g., Node Authorization, Node Registration, Establish IP connectivity, Establish time of the day, Transfer Operational Parameters).

After configuration is completed, the candidate node ends the entry process by sending a MSH-NENT:NetEntryClose message to the sponsoring node in the network entry transmission immediately following a MSH-NCFG transmission from the sponsoring node. Upon receiving this message, the sponsoring node sends an Ack to confirm the end of the initialization process by sending an MSH-NCFG:NetEntryAck message to the candidate node.

In Fig. 2 we show complete message exchange of the centralized and distributed scheduling methods. In the centralized scheme, node X and the MBS node act as the candidate node and the sponsor node, respectively. Once node X is configured, it becomes a forwarding node so that other nodes such as node Y can be configured using the previous initialization process. In this particular case, the MBS still remains as the sponsor node and node Y becomes the new candidate node.

In the distributed scheme, node X and the MBS node act as the candidate node and the sponsor node, respectively. However in the distributed scheme, when node X is configured, it becomes a sponsor node, which can directly configure other nodes such as node Y. In the following sections we focus on the initialization performance of the centralized scheme.

Proposed scheduling control process

In the event of a power outage, a candidate node first needs to synchronize with the mesh network as described in the previous section. Then, whenever the candidate node receives a MSH-NCFG with sponsored MAC address = 0x000000000000, the candidate node should transmit its first message (MSH-NENT: NetEntryRequest) to the sponsoring node or the MBS using contention-based access in the following MSH-NENT TxOp. The other messages (MSH-NENT: NetEntryAck, and MSH-NENT: NetEntryClose) should be transmitted immediately using the following MSH-NENT TxOp, after the candidate node receives its associated MSH-NCFG messages as described above. Therefore, the real problem is that in a power outage, tens of nodes would contend for those MSH-NENT TxOps, resulting in a pour initialization system performance, due to a large number of collisions.

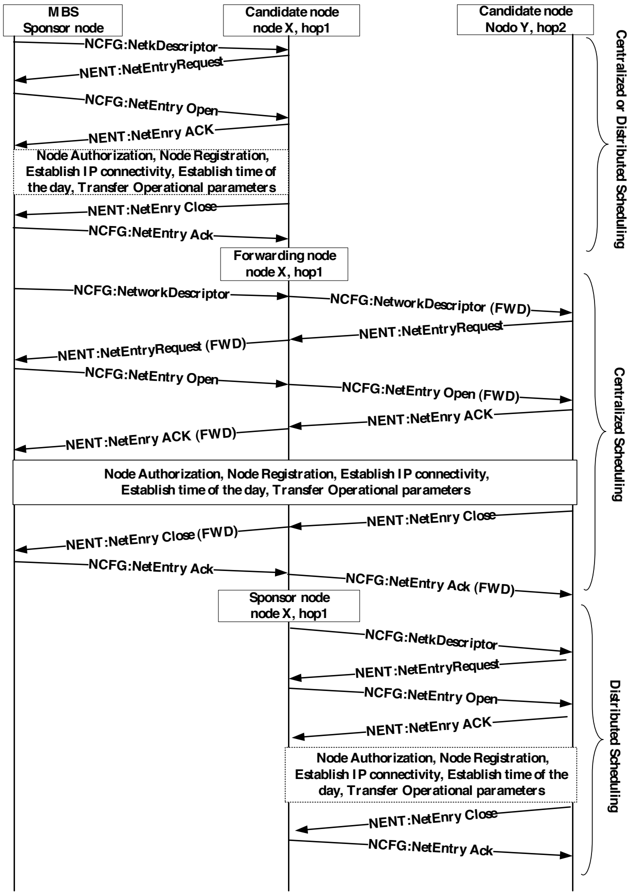
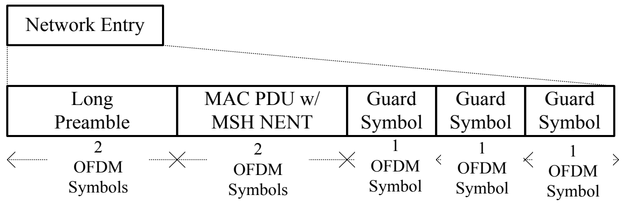


Fig. 2. Signaling of the initialization process

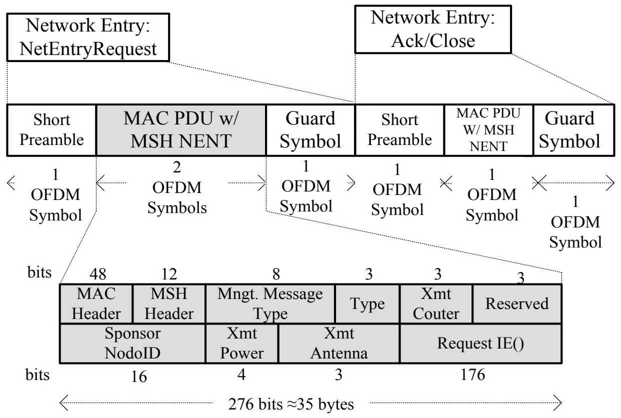
The initialization performance is even worse if the configuration parameters (as described in Table 1) are not optimized for the transmission of MSH- NENT messages.

Table 1. Scheduling control parameters

Parameter	Description
Frame Duration (F_D)	Defines the duration of a frame that contains control and data subframes, as shown in Fig.1[2-20ms]
XmtHoldoffExponent (XHE)	This a configuration parameter used to compute XmtHoldoffTime. [0-7]
XmtHoldoffTime (XHT)	Indicates the number of MSH-NCFG TxOps that a node needs to backoff after the NextXmtTime.
NextXmtMx (NXM)	This is a configuration parameter used to compute NextXmtTime-Interval. [0-31]
NextXmtTimeInterval (NXTI)	Indicates the next interval in which nodes are considered eligible for the transmission of its next MSH-NCFG message.
NextXmtTime (NXT)	Indicates the next MSH-NCFG TxOp.
EarliestSubsequent- XmTime (ESXT)	Defines the earliest TxOp that a node is eligible to transmit a MSH-NCFG message after NextXmtTime
TempXmtTime (TXT)	Defines the next TxOp interval that a node uses to compete with other competing neighbors based on the Mesh Election procedure
Scheduling Frames (S_F)	Indicates how many frames have a schedule control frame between two frames including a network control subframe.
MSH-CTRL-LEN (L)	Indicates the number of TxOp per network control subframe



(a) Default Network Entry frame structure



(b) Proposed Network Entry frame structure

Fig. 3. Network entry frame structures

Since the standard [1] defines only one MSH-NENT TxOp of 7 OFDM symbols every S_f frames, as illustrated in Figure 3a, we propose the following frame structure to optimize this region. In our framing scheme, after a power outage, we propose to use short preambles for the transmission of MSH_NENT messages. This can be done by simply setting the Short Preamble Flag to 1 of the *Nbr Logical IE* Information structure included in the MSH-NCFG message (with sponsored MAC address = 0x000000000000), as indicated in [1], (Section 8.3.3.6).

We also propose to use one Guard Symbol. This is possible because the standard defines that the transition gap for all WirelessMAN-OFDM systems profiles should be ≤ 100 μs (Section 12.3, [1]). In Table 2, for all channel bandwidths supported in the mesh mode, the OFDM symbol duration (T_s) is less than 100μs as computed by the following equations:

$$T_s = \left(\frac{1}{\Delta f}\right)(1+G) = \left(\frac{N_{FFT}}{nBW}\right)(1+G), \tag{1}$$

$$\Delta f = \left(\frac{f_s}{N_{FFT}}\right), \tag{2}$$

$$f_s = nBW, \tag{3}$$

where Δf is the frequency bandwidth of the orthogonal subcarrier, G is a factor that compensates for the cyclic prefix (G=1/8), f_s is the sampling frequency, N_{FFT} is the total number of subcarriers ($i.e.$ N_{FFT}=256), and n is the sampling factor which depends on the channel bandwidth (BW) given in table 3.

We these parameters, the maximum utilization consumed by network entry messages is below 2.5% of the channel capacity for most practical cases, when channel bandwidths are between 7 and 25.6 MHz, as shown in table 2. The channel utilization is denoted by γ for different channel BW configurations, NENT TxOps and scheduling frames (S_F). This parameter is computed by

Table 2. NENT channel utilization

		NENT TxOps	1	2	4	1	2	4	1	2	4
BW [MHz]	T$_s$ [μs]	S$_f$	10	10	10	8	8	8	4	4	4
		No.OFDM symbol/frame]	γ [%]	γ [%]	γ [%]	γ [%]	γ [%]	γ [%]	γ [%]	γ [%]	γ [%]
3	84	119	0.6	1.2	2.4	0.7	1.5	2.9	1.5	2.9	5.9
3.5	72	138	0.5	1.0	2.0	0.6	1.3	2.5	1.3	2.5	5.1
5.5	46	219	0.3	0.6	1.3	0.4	0.8	1.6	0.8	1.6	3.2
7	36	277	0.3	0.5	1.0	0.3	0.6	1.3	0.6	1.3	2.5
10	25	400	0.2	0.4	0.7	0.2	0.4	0.9	0.4	0.9	1.8
25.6	10	1024	0.1	0.1	0.3	0.1	0.2	0.3	0.2	0.3	0.7

Table 3. Sampling Factor per BW

BW (MHz)	Sampling Factor (*n*)
1.75(multiples of)	8/7
1.5(multiples of)	86/75
1.25(multiples of)	144/125
2.75(multiples of)	316/275
2(multiples of)	57/50
25.6	144/125

Table 4. Channel coding per modulation

Modulation	Bits per symbol (m)	Uncoded block size [bytes]	Coded block size [bytes]	Overall coding rate (CR)
QPSK	2	24	48	1/2
QPSK	2	36	48	3/4
16-QAM	4	48	96	1/2
16-QAM	4	72	96	3/4
64-QAM	6	96	144	2/3
64-QAM	6	108	144	3/4

$$\gamma[\%] = \frac{(100)(7)NENT\ TxOps}{(\frac{F_D}{T_S})S_F}, \tag{4}$$

where F_D is the Frame Duration set to 10ms, and S_F are the Scheduling Frames. Only for special cases, when the channel bandwidth is of 3.5MHz or lower, the maximum channel utilization could be up to 5.9% of the channel capacity. In addition, all other frames in the mesh mode (i.e. Centralized Configuration, Centralized Scheduling and Distributed Scheduling) use one Guard Symbol. Therefore, using one symbol for this transition gap is within operational values.

By using short preambles and considering one Guard Symbol we can, in fact, transmit two MSH-NENT messages in one TxOp as illustrated in Fig. 3b. In the first 4 OFDM symbols we can transmit one MSH-NENT message with Type = 0x02: NetEntryRequest. However, in the last 3 OFDM symbols we can only transmit either a MSH-NENT message with Type = 0x01: NetEntryAck or a MSH-NENT message with Type = 0x03: NetEntryClose. Thus, we just need to verify that the MAC PDU w/NENT fits into two OFDM symbols for the NetEntryRequest option and one symbol for the NetEntryAck/NetEntryClose options. In Table 4 we show the channel coding per modulation supported in the Mesh mode. However, the transmission of control subframes (such as MSH-NENT and MSH-NCFG) must be sent using the mandatory coding scheme: QPSK with overall coding rate CR=½, and m=2 bits per symbol. The uncoded frame

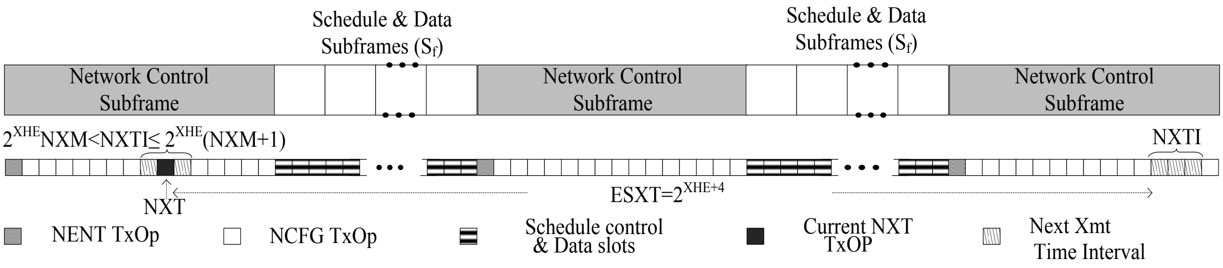


Fig. 4. Network control access

size in bytes that can be transmitted in one OFDM symbol is given by

$$\beta = N_{used} mCR/8, \tag{5}$$

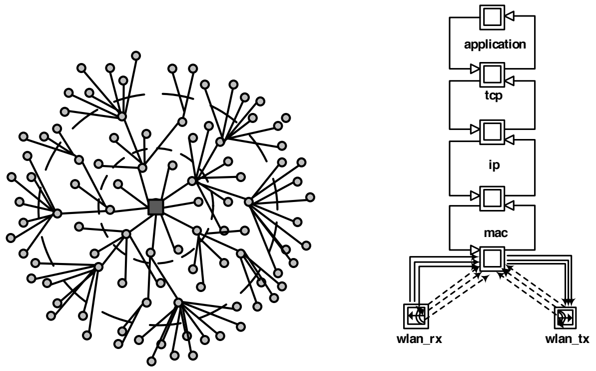
where N_{used} is the number of data subcarriers. Then, the MAC PDU w/MSH NENT:NetEntry Request (Figure 3.b) requires 35 bytes which can be transmitted using two OFDM symbols with the mandatory modulation scheme. The frame structure of the MAC PDU w/MSH NENT:NetEntryAck/NetEntryClose is the same as the MAC PDU w/MSH NENT:NetEntryRequest without the Request IE field. This results in a frame of 13 bytes which can be transmitted using one OFDM symbol with the mandatory modulation scheme.

In addition, we further enhance our proposed framing scheme by using 3 bits of the reserved field in the MSH-NCFG message format. With these 3 bits we propose to add the following parameters:

- ***NetEntry Power Outage Flag, "NetPwrOut",*** (1 bit).
  0: Indicates normal operation, 1: indicates the nodes to entry the network after a power outage.
- ***NetEntry Transmission Opportunities, "NENT"*** (2 bits):
  0: 1 TxOp is required when *NetPwrOut* =0.
  1: 2 TxOp are required when *NetPwrOut* =1
  2: 3 TxOp are required when *NetPwrOut* =1.
  3: 4 TxOp are required when *NetPwrOut* =1.

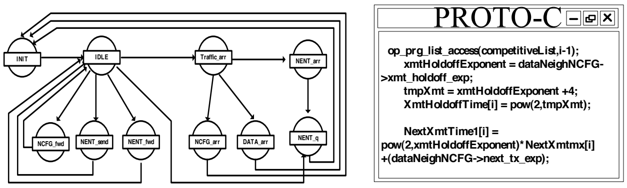
When the NetPwrOut flag is set to 1, it also indicates that our proposed framing structure, as described in Figure 3.b, should be employed in the initialization process after power outage.

By using the proposed framing structure and the new parameters, system performance during the initialization process is considerably improved, as we will demonstrate in the following sections. We just need to explain how the scheduling of the control messages is carried out. In order to transmit the NCFG messages, the standard [1] defines that, after the transmission of a NCFG message at the NXT TxOp (as shown in Fig. 4), node "X" must defer its transmission by a period of ESXT = 2^{XHE+4} TxOps, before contending again. Once the EXST period of a node X has elapsed, such node should content in every TxOp during the interval 2^{XHE}NXM < NXTI≤ 2^{XHE}(NXM+1), using an election procedure.



(a) Network model

(b) Node model



```
op_prg_list_access(competitiveList,i-1);
    xmtHoldoffExponent = dataNeighNCFG-
>xmt_holdoff_exp;
    tmpXmt = xmtHoldoffExponent +4;
    XmtHoldoffTime[i] = pow(2,tmpXmt);

    NextXmtTime1[i] =
pow(2,xmtHoldoffExponent)*NextXmtmx[i]
+(dataNeighNCFG->next_tx_exp);
```

(c) Finite State Machine diagram

(d) Proto-C

Fig. 5. Simulation model

Simulation Model

We implemented a detailed simulation model of the IEEE 802.16 MAC protocol network entry using the OPNET Package v. 14.5. A hierarchical design was used and it is shown in Fig. 5. At the top level of the network topology, the network components, for example the BS and SS, along with their connectivity are shown in Fig 5a. This image shown the tree generated after the simulation. The next level, Fig. 5b, defines the functionality of a SS in terms of components such as traffic sources, MAC interfaces, etc. The operation of each component is defined by a state machine (an example of which is shown in Fig. 5c). The actions of a component at a particular state are defined in Proto-C code (see Fig. 5d). This approach allows modifications to be applied to the operation of the IEEE 802.16 protocol and different optimizations and enhancements can be tested. This simulation carries out the initializations process of candidate nodes (as shown in Fig. 2), using contention access for NENT messages, and using the election algorithm (as defined in [1], p. 345) for NCFG messages. In addition, we employed the transmission timing of control messages as suggested in [9]. To validate the results we also implemented a C++

program where both the NENT and NCFG messages are sent using the election algorithm defined in IEEE 802.16-2004.

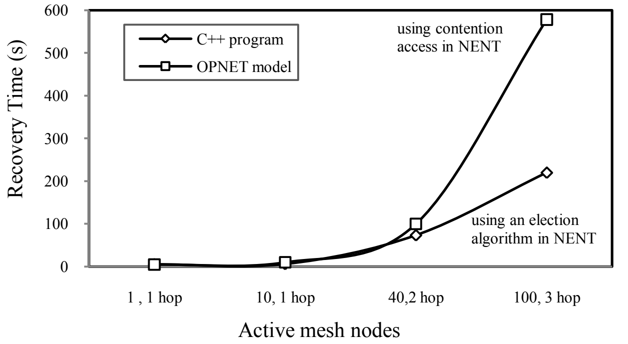
Performance Evaluation

For the performance analysis we employed a mesh network with 100 nodes, where 10 of these nodes (node1 to node10) are 1 hop from the MBS, 30 nodes (node11 to node 40) are 2 hops from the MBS and 60 nodes (node 41 to node 100) are 3 hops from the MBS as depicted in Fig. 5a. The parameters used in the C++ program and in the simulation model are as indicated in Table 4.

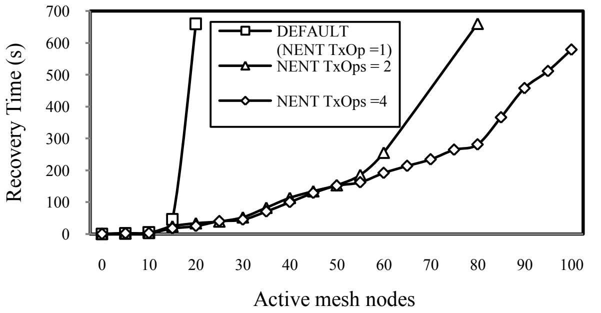
In Fig. 6a, we present the maximum delay that it takes the mesh network to recover after a power outage, using our framing structure with 4 NENT TxOps per Network Control Subframe (*NetPwrOut=1, NENT =0x3).* Both models (simulation and C++ program) present nearly the same recovery delays for nodes that are up to 2 hops from the MBS (node 1 to node 40). This behaviors is to be expected since the number of collisions reported in the simulation model is marginal and does not affect the recovery delay. However, nodes that are 3 hops from the MBS trigger a higher number of collisions since every message sent by nodes from 41 to 100 should be forwarded twice to reach the MBS, provoking an increased number of collisions in the NENT region when the simulation model is used. Compared with the C++ program, the recovery delay given by the simulation model could be reduced from 580 to 220 seconds when an election algorithm is also used for the transmission of NENT messages.

In Fig. 6b we present the recovery delay using only the simulation model. We compare this delay using the default mechanism defined in the standard with our proposed framing structure. The default mechanism presents a very large recovery delay, due to a great number of collisions of NENT messages, since only one NENT TxOp is allocated every (S_f*T_D =) 100 ms. For instance, using a network size of 20 nodes, the recovery delay reported by the simulation model was 660s. By using our proposed framing structure, with 2 and 4 NENT TxOps per Network Control subframe, we can considerably decrease the network recovery time to 33 and 13 seconds, respectively. This results in a maximum recovery time reduction up to 98% (≈[1-13/660]*100).

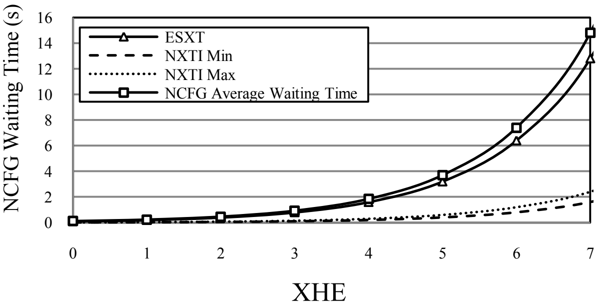
However, having more NENT TxOps in the Network Control subframe increases the signaling overhead. In Table 3 we showed this overhead for different channel bandwidths suggested by the standard for the mesh protocol [1]. For example, for a channel bandwidth of 25.6 MHz as used in the simulation model, the NENT overhead results in approximately 0.3% (≈100*NENT TxOps*7/1024*S_f) of the channel utilization when NENT TxOps =4. This overhead, in the worst case scenario, becomes 5.9% of the channel utilization when S_f = 4, BW = 3MHz and NENT TxOps =4.



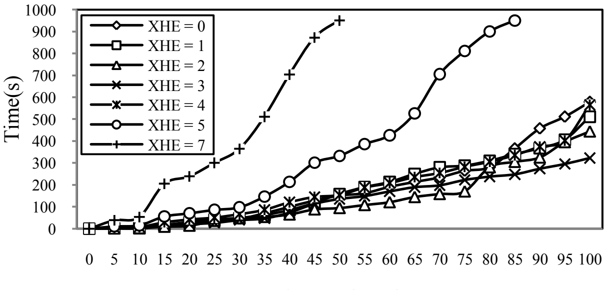
(a) Recovery delay using the C++ Program and the simualtion model, NENT TxOps =4, XHE = 0.



(b) Recovery delay using the simulation model, the default mechanism and the proposed framing structure, XHE = 0.



(c) Average waiting time between NCFG mesages, NENT TxOps = 4, L=10.



(d) Recovery delay using the simulation model, and different XmtHoldoffExponent values, NENT TxOps = 4, L =10.

Fig. 6. Recover delay of the initialization process for different network configurations.

In addition, in order to further reduce the recovery time, it is also necessary to optimize the election period for the transmission of NCFG messages, given by NXTI [2^{XHE}NXM+1, 2^{XHE}(NXM+1)]. From the two configurations parameters: XHE and NXM, the former is the one that can modify the election period. For instance, having XHE = 2, results in an election window size of (2^{XHE} =) 4 NCFG TxOps, compared to 127 NCFG TxOps when XHE = 7. By increasing the election window, however we also considerably increase the Earliest Subsequent Transmission Time (ESTX). Thus, the average waiting time for the transmission of every NCFG message is given by ESTX + ($NXTI_{Min}$+$NXTI_{Max}$)/2, as shown in Fig. 6.c. Hence, for XHE = 2 and 7, the average waiting times for NCFG messages were of 0.5 and 14.8 seconds, respectively, when NENT TxOps = 4 and L = 10.

Finally, in Fig. 6 we show how the recovery time is affected by XHE. We observe that for large networks, the minimum recovery delay is obtained with XHE = 3. The recovery delay is reduced from 580s, obtained with XHE = 0 (see Fig. 6a bad 6b), to 322s when XHE = 3 and there are 100 active nodes in the network. For medium size networks (between 20 and 75 nodes), however, the optimum performance was obtained with XHE = 2. This is to be expected, because the mean waiting time between NCFG messages is reduced by half. For example, with XHE =2, the mean number of contending nodes per election window is between ($2^{XHE}*N/2^{(XHE+4)}$=)1.25 and 4.6. These users share the same election windows=4 NCFG TxOps when network size (N) ranges from 20 to 75 nodes, respectively. On the contrary, when XHE =3, the same number of contending users per election window (1.25-4.6) share 8 NCFG TxOps every 128 TxOps, compared to 64 TxOps when XHE=2.

Conclusions

This paper studied the recovery mechanism of mesh networks based on the IEEE 802.16-2004 standard after a service disruption. Since fast recovery of the mesh network is necessary for the provision o digital services, identifying the parameters controlling it and applying new schemes in order to minimize this disruption is important. Herein we introduced a new scheduling control process that optimized the NENT and NCFG region of the network control subframe. With our proposed scheme, the MAC protocol of such mesh networks is capable of providing a timely recovery after a service disruption event.

In order to validate our scheme, we compared our results with an OPNET simulation model with a C++ program. Both models presented nearly the same recovery delays for nodes that were 1 and 2 hops away the MBS. Finally, by comparing the performance of our proposed scheme with the default mechanism we achieved a recovery time reduction of approximately 98%. Future work will focus on studying the effects of channel errors in our proposed scheme and analyze other configuration parameters.

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The IEEE 802.16-2004 standard defines a media access control (MAC) layer for a mesh network topology. In these networks, wide scale power outages can cause serious disruptions to digital services when a centralized scheduling mode is used. This results in very long service recovery times for all mesh nodes. In this paper we study the performance of the initialization process due to service disruption of IEEE 802.16-2004 mesh networks. We implemented a simulation model of the scheme using the OPNET simulation package v14. Simulation results show that the recovery times obtained with the proposed scheme can be reduced by up to 98% compared with the default scheme defined in the standard.