Project	***IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>***
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Source(s)	*Pan Zhong,* *Wu Xuyong,* *Zhao Quanbo* *Huawei* *Huawei Industrial Base, Bantian,* *Longgang, Shenzhen 518129 P.R.C* *Voice: +86-755-28971675* *Fax: +86-755-28972149* *panz@huawei.com* *wuxuyong@huawei.com* *zhaoquanbo@huawei.com*
Re:	*80216h-06_005： Call for Comments and Contributions: IEEE 802.16 License-Exempt Task Group (2006-02-06)*
Abstract	*Base on 3 cases of channel switching allowance, we find the capacity of the channels is quite different, study on the result and continue on, we may discuss on choosing the method of ACS. Allowing channel request in the neighborhood may be a realistic tradeoff between performance and complexity.*
Purpose	*Propose a realizable optimization of channel distribution*
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Optimization of channel distribution

Panzhong, Zhaoquanbo, Wuxuyong
Huawei Technologies Co., Ltd.

Overview

In current working document [2], ACS will be executed in whole community while IBS cannot find a free channel to occupy. ACS means optimization of channel distribution. A smaller scale adjustment will be proposed in this contribution for discussion.

Base on 3 cases of channel switching allowance, we find the capacity of the channels is quite different, study on the result and continue on, we may discuss on choosing the method of ACS. Allowing channel request in the neighborhood may be a realistic tradeoff between performance and complexity.

Abbreviations and acronyms

Reference:

[1] IEEE802.16-2004: IEEE standard for Local and metropolitan area networks Part16: Air Interface for Fixed Broadband Wireless Access Systems 2004-10-01

[2] IEEE P801.16h/D0: Air Interface for Fixed Broadband Wireless Access Systems, Amendment for Improved Coexistence Mechanisms for License-Exempt Operation 2006-01-05

Proposal

We have proposed an optimized channel distribution in whole community in #40 meeting, Vancouver. But, it is not a very good ideal for most cases because channel switches may be required on some BSs far away from IBS. So we will propose a smaller scale optimized channel distribution, it is implemented in neighborhood community, as a great difference from the former.

For a well description, we define two kinds of community. A geography community is the whole community, consists of a group of BSs, in which any two of them form a neighborhood or have a successive neighborhood relationship between each other, that's same to the former definition of community. And a neighborhood community is a part of the whole community, consists of a certain BS and its all of neighbors. For ACS executed during the initialization of IBS, neighborhood community in this proposal indicts IBS and its neighbors.

For optimized channel distribution in neighborhood community, a part of neighbors of IBS should switch to another channel that will not cause new interference to vacate their working channel for IBS.

Comparison on performance is needed between two kind of optimizations. A better distribution will cause more BSs admitted in a given area with certain amount of channels. Obviously, optimized distribution in geography community is better than that in neighborhood community because more BSs may switch their channels, but how many additional BSs can be admitted using optimized distribution in geography community contrasting to that in neighborhood community, how much percent will be lost using optimized distribution in neighborhood community, is it acceptable?

We take the same assumption as in our former proposal, listed below:

1. BSs are added into a rectangle of 8000 * 8000 one by one, with a uniform distribution on their position.

2. Each BS's coverage diameter 2000.

3. Certain amount of channels are available in the rectangle, and intersecting BSs cannot occupy the same channel.

4. The newest add-in BS scan all of the available channels for find a free one. If no free channel can be found, channel distribution should be optimized both in geography community and in neighborhood community. If no channel can be free for the newest BS using channel distribution optimization, no more BS can be added and the mount of BSs that has been admitted is the maximum for current process using this optimization. Until both of two kinds of optimization cannot permit more BSs added in, two maximum for each optimization will be recorded.

5. For more precise, comparison is based on average value of 40 times results for each amount of channels.

6. Increase the number of channels, execute step 1 to 5.

7. Figure out the difference between two kinds of optimization vs. number of channels.

Here is an example of random position of BSs in the given area without any interference while every BS's coverage diameter is 2000, and different color stands for different channel. Left distribution is optimized distribution in geography community admitting 32 BSs for 5 channels, and another is optimized distribution in neighborhood community admitting 26 BSs for 5 channels.

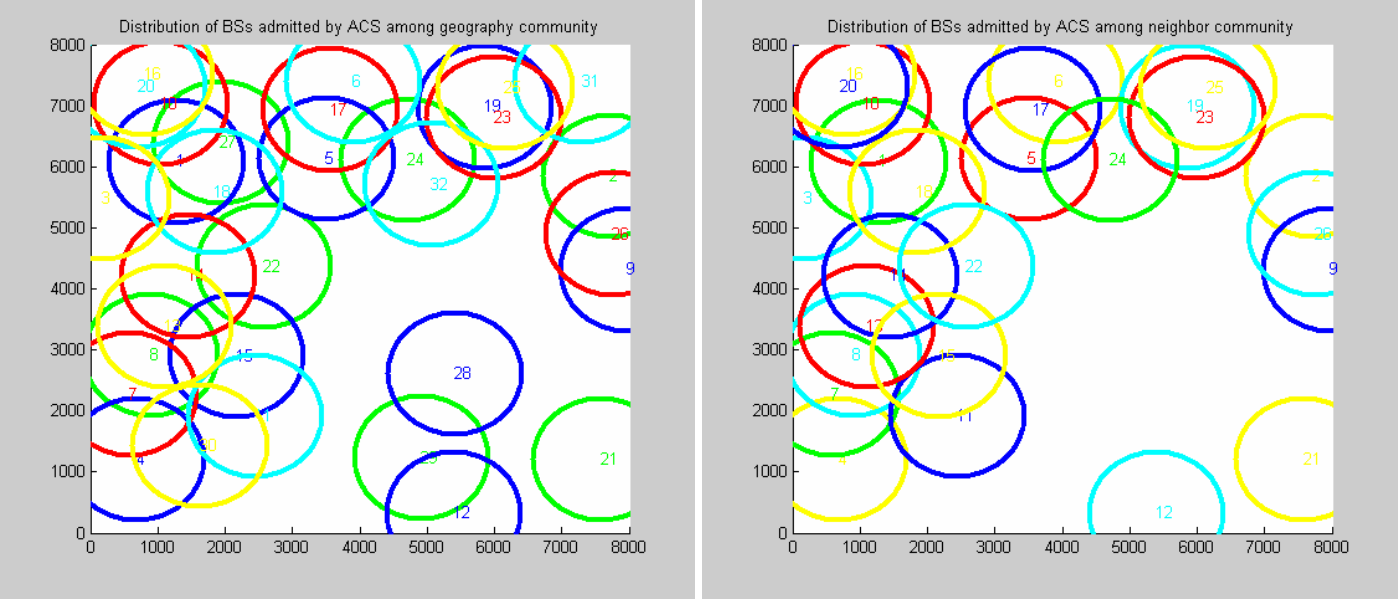

Figure 2 Example of random position of BSs

Simulation results are shown in following table.

Table 1 Simulation result 1 for BS's coverage diameter is 2000

Number of channels	Average number of BSs admitted without any optimization of channel distribution(S)	Average number of BSs admitted with optimization in whole geography community(G)	Average number of BSs admitted with optimization in neighborhood community(N)	Ratio of decrease (R=1-N/G)
4	16.725	20.225	19.65	2.84%

5	23.975	29.325	28.625	2.39%
6	26.8	32.575	32.375	0.61%
7	34.475	43.875	42.325	3.53%
8	41.725	54.075	51.5	4.76%
9	47.85	60.675	58.82	3.05%
10	53.87	71.675	67.475	5.86%
11	61.4	81.375	78.4	3.66%
12	66.5	89.675	86.55	3.48%
13	73.6	101.5	96.525	4.90%
14	81.825	111.1	105.3	5.22%
15	88.05	121.725	112.7	7.41%
16	101.25	133.4	125.475	5.94%
17	104	139.85	132.625	5.17%
18	111.15	511.375	144.55	6.67%
19	119.75	165.9	156.075	5.92%
20	125.825	175.775	162.925	7.31%

Curves about numbers of BSs admitted by two kinds of optimization vs. number of channels are shown in following figure.

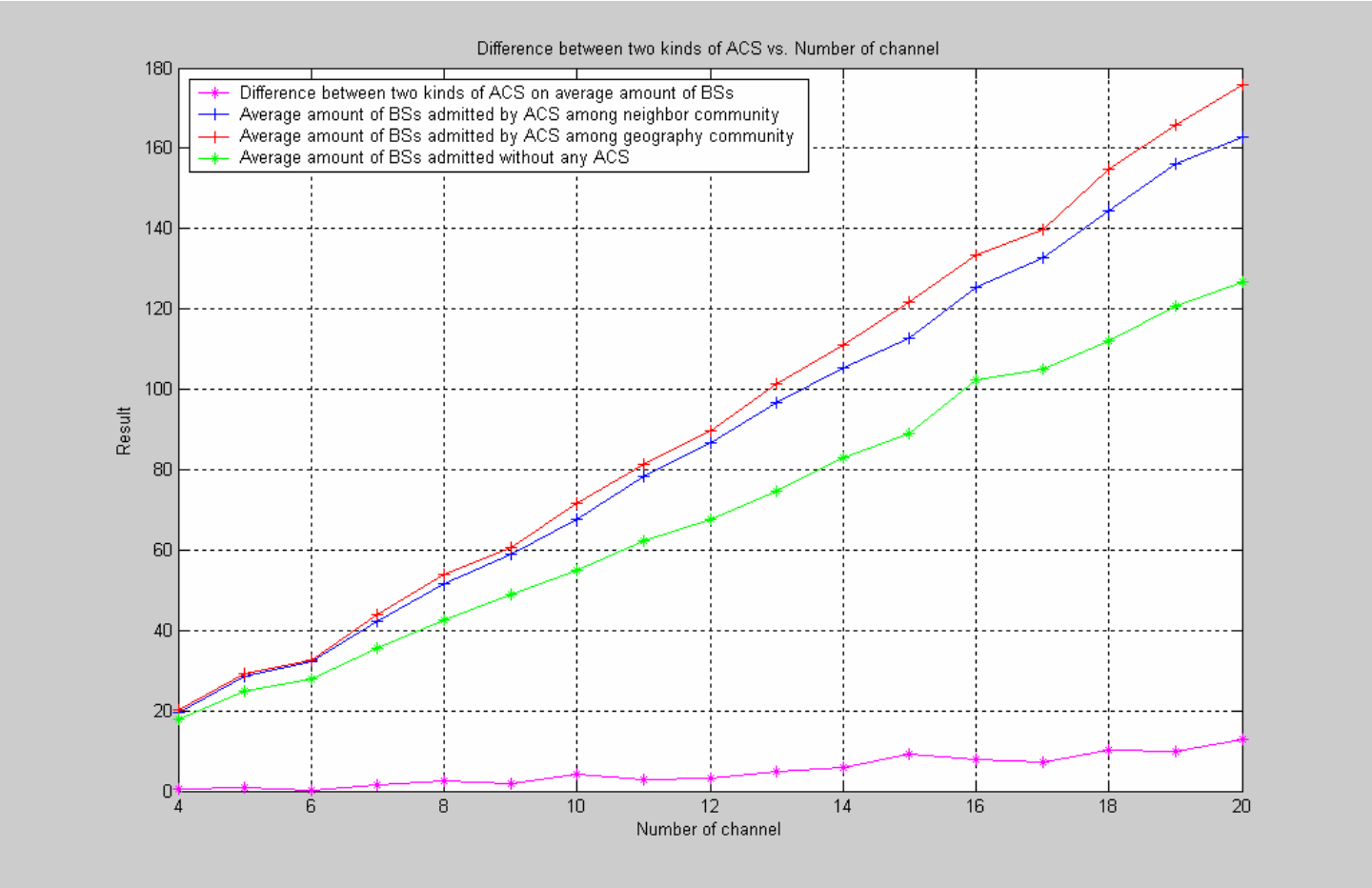

Figure 3 Comparison on number of BSs admitted by two kinds of optimization

If each BS's coverage diameter distributes uniformly on range from 800 to 1300, then results are shown in table 2, and curves are shown in figure 4.

Table 2 Simulation result 2 for BS's coverage diameters range from 800 to 1300

Number of channels	Average number of BSs admitted without any optimization of channel distribution(S)	Average number of BSs admitted with optimization in whole geography community(G)	Average number of BSs admitted with optimization in neighborhood community(N)	Ratio of decrease (R=1-N/G)
4	41.35	50.474	49.075	2.77%
5	58.025	71.025	67.95	4.33%
6	73.9	94.6	92.925	1.77%
7	86.425	119.325	111.65	6.43%
8	109.175	147.275	141.325	4.04%
9	131.175	179.975	170	5.54%
10	149.775	207.875	197.425	5.03%
11	164.9	233.3	222.575	4.60%

12	188.2	258.675	249.975	3.36%
13	202.575	293.6	275.45	6.18%
14	225.2	317.3	308.225	2.86%
15	262.05	360.475	342.125	5.09%
16	275.15	393.4	372.05	5.43%
17	291.525	424.95	403.55	5.04%
18	315.825	457.3	429.3	6.12%
19	351.225	496.325	474.65	4.37%
20	361.025	520.325	507.6	2.45%

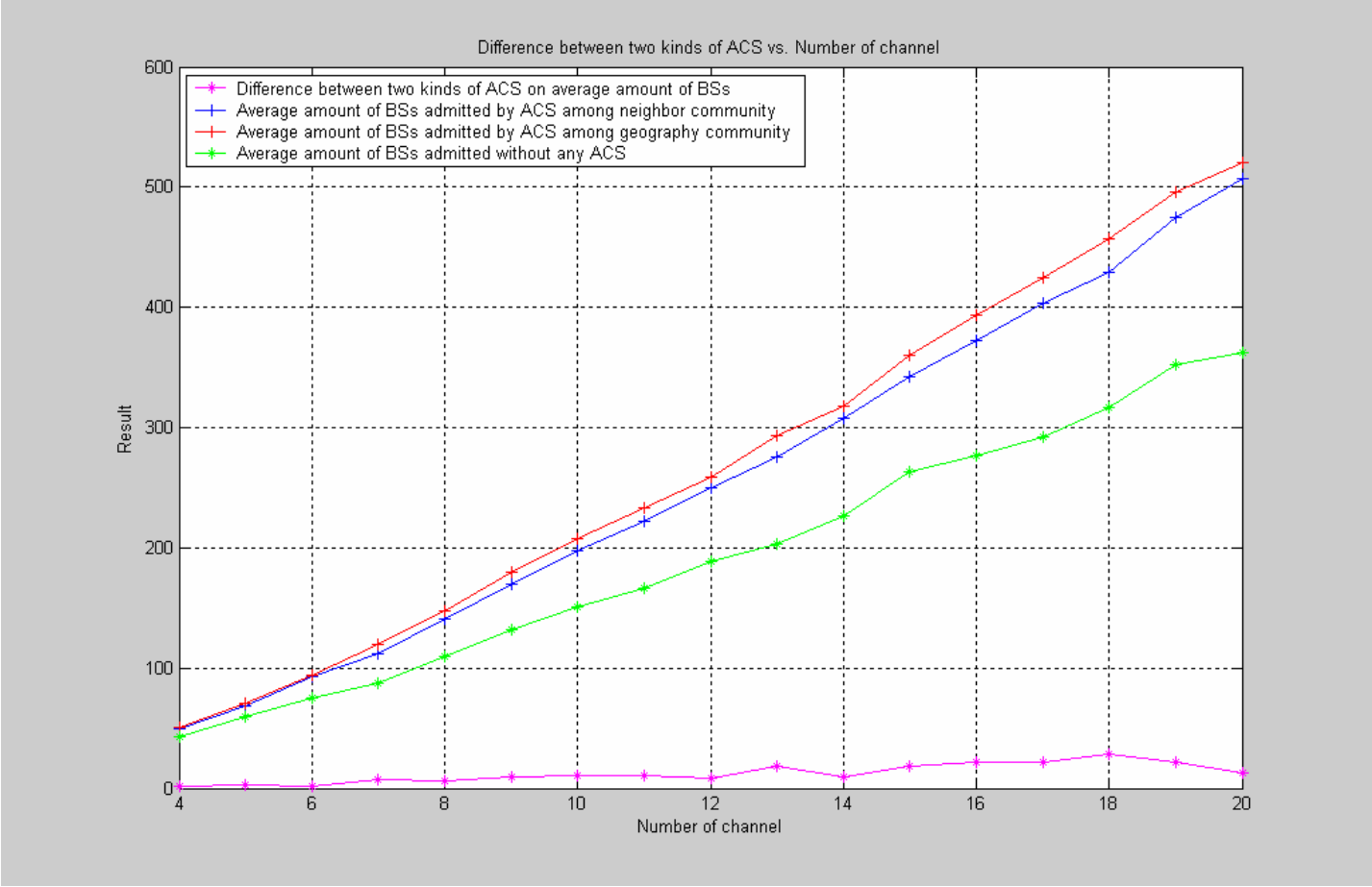

Figure 4 Comparison on number of BSs admitted by two kinds of optimization

We can find that both two kinds of optimization can admit a great more number of additional BSs in the area than distribution without any optimizations. And optimization in neighborhood community doesn't seem a great worse than optimization in geography community. 6%~8% is the greatest difference, that's very small

ratio considering the great increase production. So, we think the performance of optimization in neighborhood community is acceptable.

Here is the process of the smaller scale optimization.

Smaller scale optimization makes channel switches only on neighbors of IBS. IBS figures out the optimized channel distribution according to some assumptions that channel switch on certain neighbor will not bring any interference. In order to calculate the target channel, which IBS will occupy and neighbors working on it will switch to another channel, all neighbors should maintain its own list of escape channels, which are the channels that the BS may work on it without any interference with other BSs.

When IBS cannot find any free channels for itself at the initialization, IBS may query each neighbor for its list of escape channels. If BSs working on same channel have one or more escape channels, the channel that those BSs working on is an potential target channel for IBS. If IBS has several potential target channels, IBS may select the one on which less neighbors are working. The selected channel will be the working channel of IBS, and those BSs working on it should switch to one of their escape channels. At last, each BS should update its list of escape channels according to the working channels of all its neighbors.

Proposed text changes

15.2.2.4 Information table in share database

[Change the following text in 15.2.2.4]

Table h2—This BS information table

Syntax	Size	Notes
Profile(){		
Band		
PHY mode(){		
Modulation		
Working Channel ID	*8bit*	*Identifier of the working channel of this BS.*
Number of escape Channels	*8bit*	*p: The number of escape channels to which this BS can switch without interference.*
For(i = 1; i <= p; i++){		
Escape Channel ID	*16bit*	*Identifier of the escape channel.*
}		
(Tbc).		
}		

Table h3—BS information table

Syntax	Size	Notes
Number of Coexistence neighbors	*8bits*	*m: The number of coexistence neighbors of this BS*
For(i = 1; i <= m; i++){		
BSID		
Working Channel ID	*16bit*	*Identifier of the working channel of this neighbor.*
Escape Channel Flag	*1bit*	*Flag indicts this neighbor has one or more escape channels.*
(Tbc).		
}		

15.7.1.4 Optimization of Channel Distribution

[Insert the following text in 15.7.1.4]

In the initialization phase of an IBS, IBS's neighbors will send their current OCTS allocation and current subframe allocation to it using CP message, as well as flag of having escape channels. IBS may maintain the channel information of neighbors in BS information table.

When IBS cannot find any free channels for itself at the initialization, channel distribution may be optimized to vacate a free channel for IBS by switch some neighbors' working channels to others.

First, IBS picks up all the channel that every neighbor working on it has escape channels, and reorders them according to increasing number of neighbors working on it.

Afterwards, IBS select the channel of minimum usage in the remained channels. The neighbors working on the selected channel are called BS_sc, IBS should check whether every BS_sc has one or more escape channels. If any of them has none escape channel, then IBS cannot working on this channel and continue to check another one. Else, IBS considers this channel as it potential working channel.

Then, IBS should negotiate to every BS_sc. To each BS_sc, IBS should select one channel as the BS_sc's target working channel from it escape channel list, then IBS sends Channel Switch Request message to it containing BSID of the BS_sc, current working channel ID, and the FSN indicts when to switch channel.

Every BS_sc, which is one of IBS's neighbors, should check whether the request is acceptable, such as whether it has escape channels and other information is right. If the channel switch request is acceptable, BS_sc should acknowledge to IBS by sending back Channel Switch Reply message with agreement, and the channel it will switch to, else BS_sc should send back the message with deny.

When IBS received all the acknowledged messages, optimization vacates a channel for IBS. If IBS received some denies, IBS should consider the next channel.

For the case of successful negotiation, list of escape channels of relative BS should be updated because its neighbors or itself will change their working channels. For IBS, it has none escape channel, and it should broadcast to all its neighbor that it will working on the selected channel by sending Channel Occupy Notify message, and all its neighbors should add IBS as its new neighbor in BS information table, and exclude IBS's target working channel in the list of escape channel if the channel exists in the list. For BS_sc, it also should send Channel Occupy Notify message to all its neighbors. Because BS_sc will switch from its current working channel to one of its escape channel, so some neighbors of BS_sc may add BS_sc's current working channel into its escape channel list for case of no other neighbors working on this channel. BSs receving Channel Occupy Notify message should reply with Channel Occupy Acknowledge message.

If all left channels can not be selected as IBS's working channel, optimization is failed, and IBS should share one channel with some of its neighbors.

The process of channel distribution optimization is shown in Figure h26a.

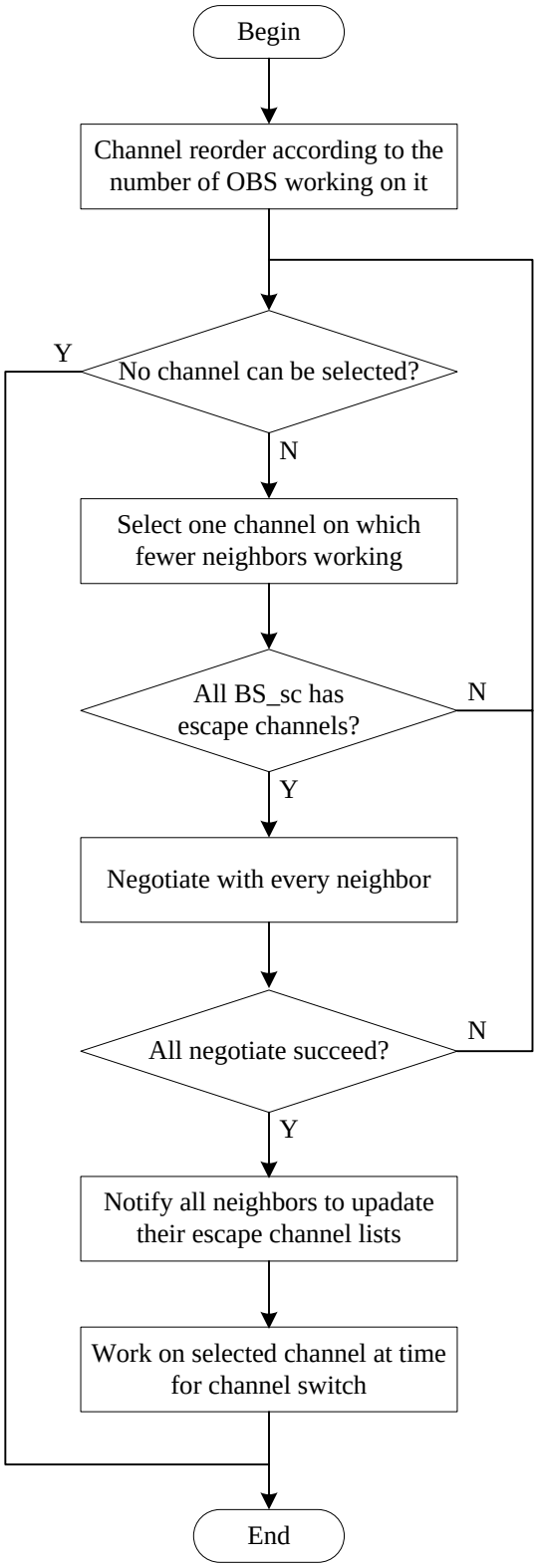

Figure h26a—Process of channel distribution optimization

[Change Table h8 as indicated:]

Table h8. LE_CP message codes

Code	CP Message type	MAC Message Type	Protocol type	Direction
…	…	…	…	…
		-	-	-
37	Channel ~~Switch~~ Negotiation Request	LE_CP-REQ	TCP	BS->BS
38	Channel ~~Switch~~ Negotiation Request	LE_CP-RSP	TCP	BS->BS
~~39~~	~~Channel Switch Request~~	~~LE_CP-REQ~~	~~TCP~~	~~BS->BS~~
~~40~~	~~Channel Switch Reply~~	~~LE_CP-RSP~~	~~TCP~~	~~BS->BS~~
39	*Channel Occupy Notify*	*LE_CP-REQ*	*TCP*	*BS->BS*
40	*Channel Occupy Acknowledge*	*LE_CP-RSP*	*TCP*	*BS->BS*
41~255	*reserved*			

[Change the following text at the paragraph of 15.6.1.37]

15.6.1.37 Channel Switch ~~Negotiation~~ Request message

This message is send by BS to another coexistence BS in the community to negotiate to switch ~~to a certain target~~ channel.

Code: 37

Parameters:

Table h19a—Channel Switch Request message attributes

Operator ID	*The Operator identifier of requesting BS.*
BSID	*The requesting BS identifier*
Requested BSID	*BS identifier of the requested BS*
Working Channel ID	*The current working channel ID of the requested BS*
FSN	*Frame sequence number when to switch channel*

[Change the following text at the paragraph of 15.6.1.38]

15.6.1.38 Channel Switch ~~Negotiation~~ Reply message

A message sent by BS, reply to Channel Switch ~~Negotiation~~ Request message about whether it agree or refuse to switch *channel*.

Code: 38

Parameters:

Table h19b—Channel Switch Reply message attributes

Operator ID	*The Operator identifier of requesting BS.*
BSID	*The requesting BS identifier*
Requested BSID	*BS identifier of the requested BS*
Acknowledge	*Agreement or deny.* *0: refuse to switch channel.* *1: agree to switch channel.*
Target working channel ID	*The channel ID of the requested BS will switch to*

[Delete the following text]

~~**15.6.1.39 Channel Switch Request message**~~

~~This message is send by BS to another coexistence BS in the community to request *negotiate* to switch to a certain target channel.~~

~~Code: 39~~

~~[Change the following text at the paragraph of 15.6.1.40]~~

~~**15.6.1.40 Channel Switch Reply message**~~

~~A message sent by BS, reply to Channel Switch Request message.~~

~~Code: 40~~

[Add the following two sections at the end of 15.6.1]

15.6.1.39 Channel Occupy Notify message

A message sent by BS to notify its neighbors that it will work on certain channel. Every neighbor should update its escape channel list, and add the notifier as a new neighbor if the notifier is an initializing BS.

Code: 41

Parameters:

Table h19c—Channel Occupy Notify message attributes

Operator ID	*The Operator identifier of requesting BS.*
BSID	*BS identifier of the notifier*
BSID	*BS identifier of the receiver*
Current working channel ID	*The current working channel ID of the sender* *0xFFFF indicts an IBS, which has no working channel*
Target working channel ID	*The target working channel ID of the sender*

15.6.1.40 Channel Occupy Acknowledge message

A message sent by BS, to reply to Channel Occupy Notify message.

Code: 40

Parameters:

Table h19d—Channel Occupy Acknowledge message attributes

Operator ID	*The Operator identifier of requesting BS.*
BSID	*BS identifier of the responser*
BSID	*BS identifier of the notifier*