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Abstract	Clarify the concept of community and proposed a efficient method for coexistence ACS
Purpose	
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ACS procedure in Coexistence Community

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Overview

In current working document [2], IBS will listen on multiple frequencies after network parameters got via CP. If there is no channel free of interference, then it should try to share one channel with its neighbors. However, for each BS in one community, it is always better to have an exclusive channel than share with others.

So we need to try to admit more BS in one community without sharing the channel with other BS.

Radio spectrum is a scarce and limited resource in wireless communication. We need to use spectrum more efficiently. We will discuss what we can do in the community to use the spectrum in an efficient way.

For example, in the figure 1 below, three BSs have interference with each other, so they should work on different frequency. Assuming there are only three interference-free channels, indicated by red, yellow and blue colors respectively, then, a case of channel allocation among the six BSs is shown.

Now, BS7, a new BS, is provided to start its initialization at the center of the area. BS7 can't find any channel available without interference.

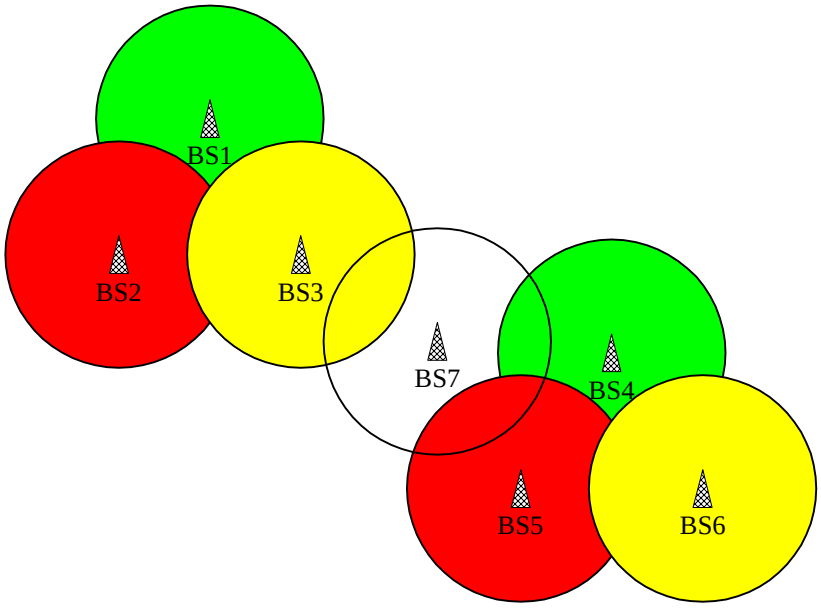

Figure 1

Assuming we can change the channel distribution among the 6 BSs into the order shown below, BS7 can select the red channel as a interference free channel, so all the BSs got the exclusive channel for operation as shown in figure 2.

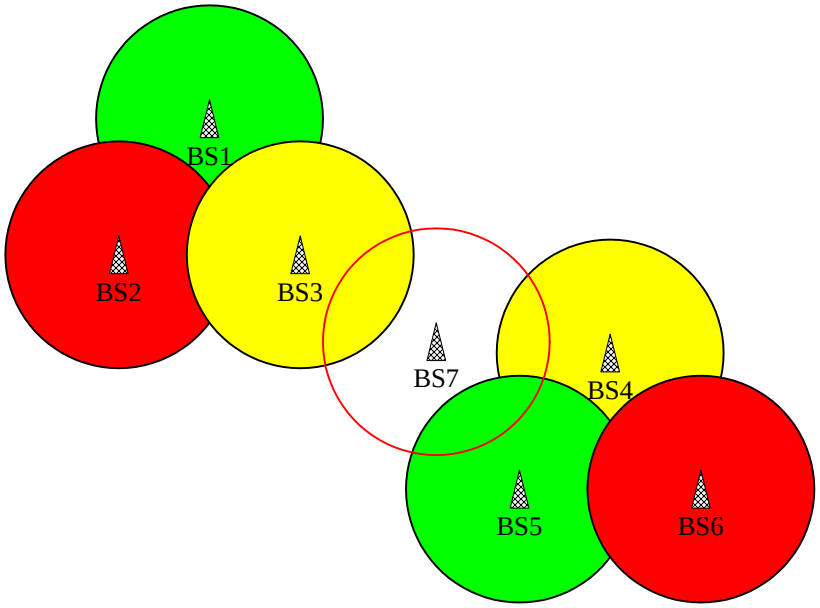

Figure 2

This simple example shows that we can optimize the channel distribution in the community to acquire larger capacity. Here is a simulation for comparison about statistical maximum BSs occupying a exclusive frequency channel between two kind of allocations, one base on the assumption that the IBS only using random free channel selection, while another assumes that the BSs will coordinate with each other to optimize channel distribution to increase the capacity of community.

Following three tables are shown for an example of 8000m*8000m square with different range of BS's coverage. The maximum BSs occupying a exclusive channel that can be admitted in the square are listed for amount of available channels correspondingly. More BSs can be admitted using optimized distribution than using random distribution.

Table 1: Comparison between two allocations with BS's coverage ranges from 300m to 5000m

Number of channels	Maximum BSs using random distribution	Maximum BSs using optimized distribution	Increasing ratio
2	5	6	20.00 %
3	8	10	25.00 %
4	11	14	27.00 %
5	14	18	28.57 %
6	18	24	33.33 %
7	22	29	31.82 %
8	25	34	36.00 %
9	29	40	37.93 %

10	32	45	40.63 %
11	35	49	40.00 %
12	40	56	40.00 %
13	42	61	45.24 %
14	46	67	45.65 %
15	50	73	46.00 %

* All results are averaged values by 500 times simulation.

* Greedy algorithm employed for optimized distribution.

Table 2: Comparison between two allocations with BS's coverage ranges from 800m to 1500m

Number of channels	Maximum BSs using random distribution	Maximum BSs using optimized distribution	Increasing ratio
2	13	15	15.38%
3	23	27	17.39%
4	37	46	24.32%
5	50	64	28.00%
6	63	83	31.75%
7	77	105	36.36%
8	93	127	36.56%
9	108	149	37.96%
10	125	170	36.00 %
11	143	195	36.36%
12	161	225	39.75%
13	175	245	40.00%
14	195	277	42.05%
15	212	302	42.45 %

* All results are averaged values by 150 times simulation.

* Greedy algorithm employed for optimized distribution.

Table 3: Comparison between two allocations with BS's coverage is 1000m

Number of channels	Maximum BSs using random distribution	Maximum BSs using optimized distribution	Increasing ratio
2	18	19	5.56 %
3	30	35	16.67 %
4	46	54	17.39 %
5	61	78	27.87 %
6	79	102	29.11 %
7	104	138	32.69 %
8	121	162	33.88 %
9	145	200	37.93 %
10	156	221	41.67 %
11	186	263	41.40 %
12	206	287	39.32 %
13	235	326	38.72 %
14	255	365	43.14 %
15	278	393	41.37 %

* All results are averaged values by 50 times simulation.

* Greedy algorithm employed for optimized distribution.

Here are curves about the increasing ratio versus the number of channels for three simulations. The ratio of augment will increase while available channel increasing.

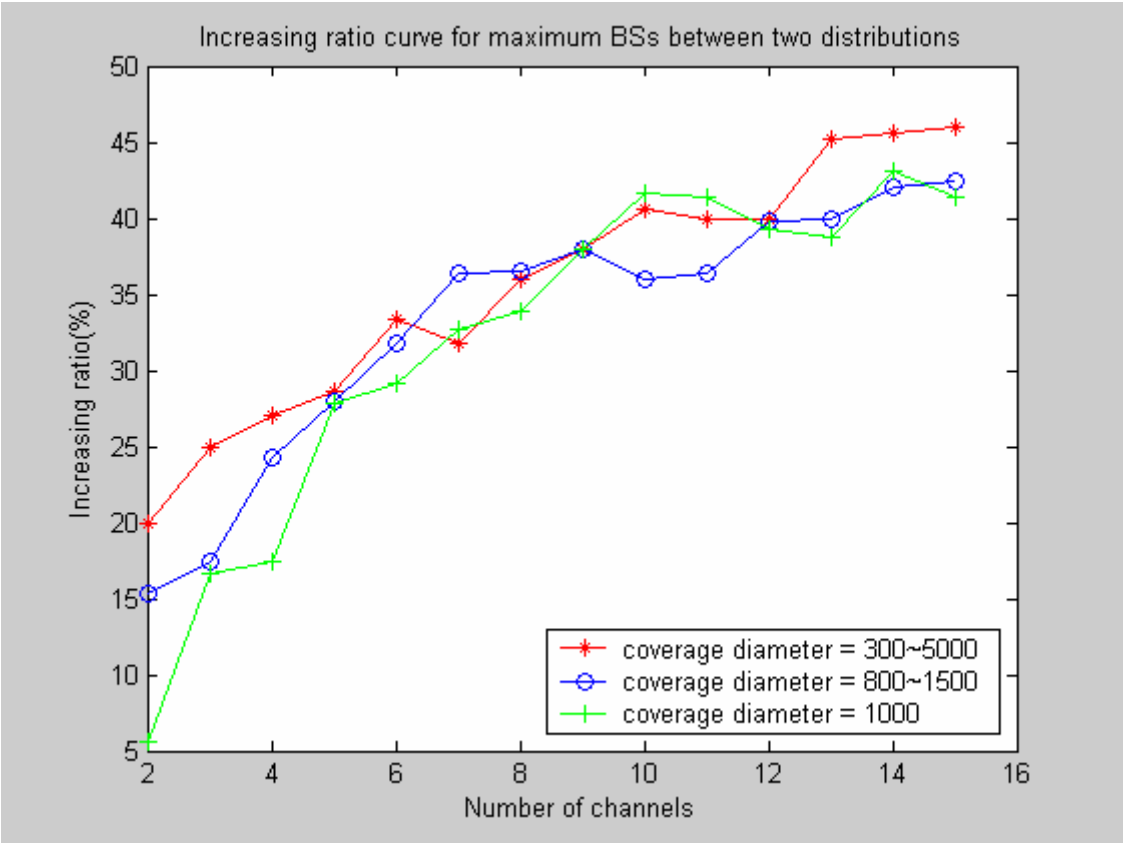

Figure 3

Proposed Text Changes

We proposed some text changing in related section to clarify this feature:

[Change the 15.2.1.1 Generic Principals into the following text in 802.16h]

A community of BSs is formed in an ad-hoc mode; in this community are included Base Stations, ~~if at least two of the Base Stations interfere,~~ if any two of the base stations form a neighborhood or have a successive neighborhood relationship between each other; every Base Station maintains the list of the Base Stations forming the community. Supplementary, when using the IP-based communication approach:

- *An SS will not communicate directly with a foreign BS in IP-based communication;*
- *It is no need to register the SS location.*

We propose an update flow for *15*.2.1.3 Community Entry of new BS.

[change the ninth paragraph in 15.2.1.3 Community Entry of new BS]

(1) *Initialization stage*

In initialization stage the LE BSs may avoid the co-channel or adjacent channel interference by scanning the available frequencies. But this method cannot avoid the hidden LE BS problem, i.e. the BS that cannot be heard directly but may have overlapping service coverage. Thus, with the knowledge of coexistence neighbor topology the LE BSs can detect the hidden LE BSs and can, therefore, avoid the possible interferences from coexisting coexistence neighbors. Alternatively, if the country/region database is not valid in this phase, the initializing BS (IBS) will use the coexistence time slot to broadcast its IP address to its coverage using its maximum power. In this way, the SSs in the reachable zone of the new BS's interference will receive the message and forward the address to its serving BS. And after the neighbor BSs get the address via the SSs' reports, they will contact with their new coming neighbor(IBS) via IP network and updating the database on both side. Thus, in ad-hoc fashion, it will avoid the hidden neighbor BS issue by the SSs in the neighbor network. ~~The procedures are described in Figure12.~~ If the IBS finds that there is no "free" channel, the coexistence neighbor topology in the share database provides the ~~guidelines~~ information of with whom it should negotiate. LE BS may decide whether a "free" frequency can be allocated for itself by channel reallocation within community, If IBS can figure out optimized channel distribution in the community, which made every member in the community could occupy a exclusive channel, IBS should contact the BSs in the community which need to reallocate the channel in the new distribution and negotiate, after admitted by each BS, IBS should send a message to the candidate BS to indicate the switch time and the target channel, all the candidate BS should then follow the indication and switch to the target channel synchronously. Otherwise, if IBS can't get a "free" frequency whatever reallocation executed, that means IBS should have to share a frequency with one or some of its neighbors. The procedures are described in Figure12.

(2) Operating stage

In operating stage the LE BS has SS associated with it, however, even the operating system parameters has decided, the co-channel or adjacent channel interference from LE BSs of different network may still have a chance to happen due to the detection of interference from primary user, channel switching of coexistence neighbor BS or the entry of new coexistence neighbor BS makes the community so crowded that there is no enough channels. If the IBS finds that there is no "free" channel at that moment, synchronous channel switching maybe executed, or the coexistence neighbor topology provides the guidelines of with whom it should negotiate to share the channel. [detailed procedures are to be defined]

Figure12 shows the initialization procedures for the 802.16 LE BSs. Note that the procedures that BS tries to create a Master slot or channel switching are also applicable for operating stage. The detailed negotiation and update procedures are described in section 15.2.2.3 and 15.7.1.4.

[Add following text after the 13th paragraph in page 28]

- *Decide the working frequency (ACS – Adaptive Channel Selection process);*
  - *If no interference detected on some channels, select one randomly as working channel;*
  - *If interference detected by IBS or OBS network on all channels, then IBS should decide whether an optimized channel distribution can allocate an exclusive channel for each BSs including IBS in community.*
  - *If every BS in community can be allocated an exclusive channel without interfering with others, that means default interference-free Master slot is available for this initializing BS.*

[Change Table h9 as indicated:]

Table h9. LE_CP message codes

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

[Insert the following text at the end of 15.6.1]

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: tbc.

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.

Code: 38

Parameters: tbc.

15.6.1.39 Channel Switch Request message

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

Code: 39

Parameters: tbc.

15.6.1.40 Channel Switch reply message

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

Code: 40

Parameters: tbc.

[Insert the following paragraph at the begin of 15.7.1]

15.7.1 How to select a "free" channel (for ACS and DFS)

BS should listen on multiple frequencies during the selection of working frequency. If the interference's level is greater than the detection threshold, which is the required strength level of a received signal within the channel bandwidth, the channel is considered as a interfered channel. If IBS can't find a "free" channel by scanning, it should figure out whether an indirect "free" channel can be found by optimized channel distribution, as described in 15.7.1.4.

Process of ACS is shown in Figure h29. ACS results two kinds of resolution, a "free" channel found with or without channel switching, or no "free" channel found.

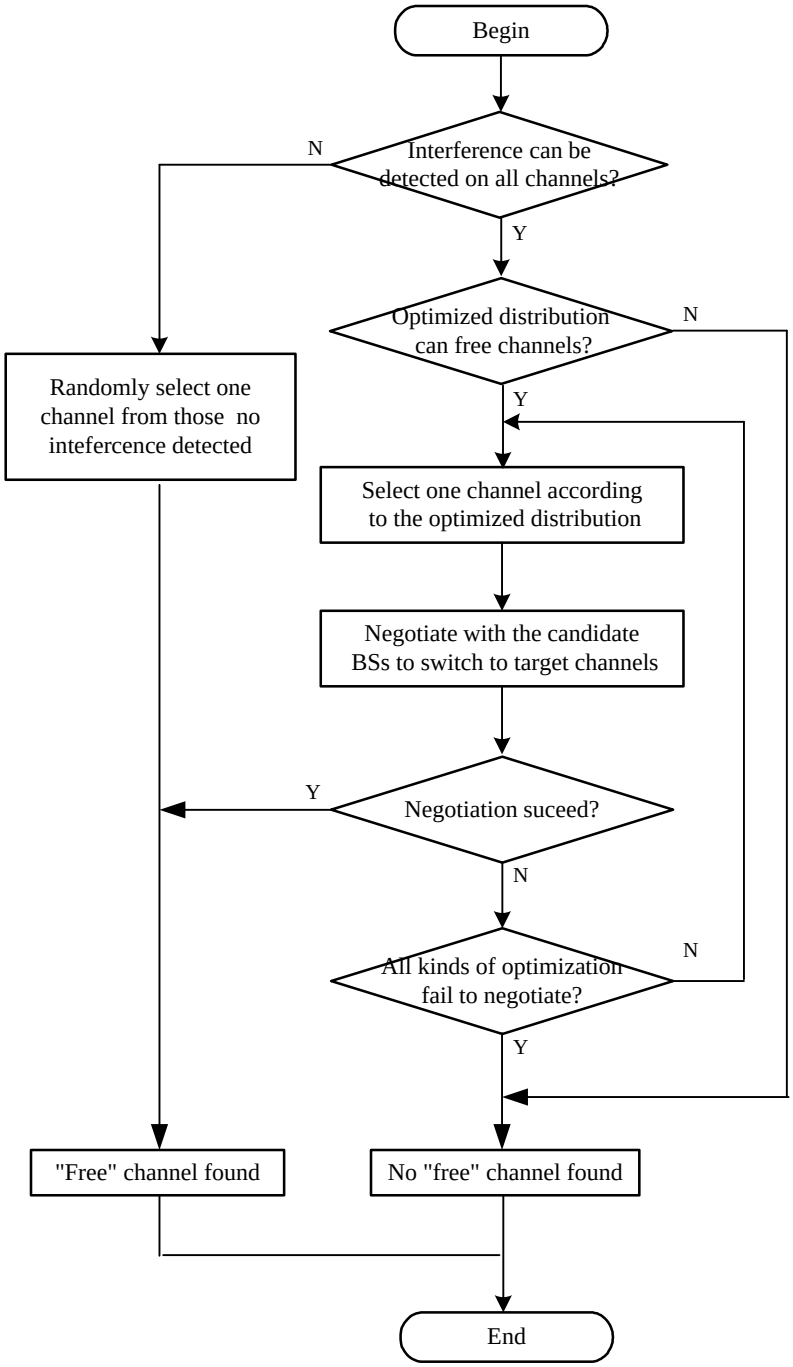

Figure h29 Process of ACS

If a "free" channel found, means default interference-free Master slot is available, otherwise, IBS need to share the channel with coexistence neighbors, as described in 15.2.1.7.

[Insert the following text at the end of 15.7.1]

15.7.1.4 Optimization of Channel Distribution

If interference can be detected on each channel, IBS cannot find a "free" channel directly. But there's still a chance to find a "free" channel for it by channel reallocation in community.

First, because of the appearance of the IBS, new community comes into being. IBS copies information from BSs to build the whole neighborhood of the new community.[t.b.c]

Then, IBS decides optimized channel distribution for all BSs in the community could occupy a exclusive channel, that means every BS, including the IBS, needn't share a frequency with its neighbor BSs, thus each BS can gain maximum throughput. At the same time, IBS should decide which BSs should switch channel and which channel should they switch to, and negotiate with them using channel switch negotiate request messages. If not all candidate BSs can be switch to the target channels, IBS tries to another optimization distribution. Otherwise, negotiation succeeds, and IBS should send channel switch request message to those candidate BSs, each message contains BSID of each BS, target channel and time to switch. All candidate BSs should switch to their target channels synchronously, all BSs can fully work without interference with each other.

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 802.16-05/022: working document Amendment for Improved Coexistence Mechanisms for License-Exempt Operation 2005-09-28*

[3] *ETSI EN 301 893 V1.3.1 (2005-08): Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive ETSI.*

[4] *Models and methods for frequency allocation with cumulative interference constraints;(submitted to the International Transactions in Operational Research, special issue IFORS 20052) Mireille Palpant, Cristian Oliva, Christian Artigues, Philippe Michelon, Mohamed Didi Biha*

[5] *Channel Assignment, Umesh Kumar, State University of New York, Stony Brook*