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| Purpose | |
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# Proposal for 802.16h general operating principles

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*Alvarion*

## *1. Overview*

This paper presents general operation principles for systems implementing the 802.16h standard. In order to ease the definition of the needed messages, the elements related to messages are in *italics*. The text is intended for inclusion in the standard, under the "Principles" chapter in [1].

The proposal combines the following elements:

- Fair spectrum sharing
- Use of a Regional database
- Use of distributed RRM and Base Station database
- Use of a Coexistence Protocol.

## 2. Operational principles

### *2.1 General principles*

A possibility of 802.16h usage is in close relation with a data base, as has been proposed in [2], including both deployment information and an IP identifier for allowing the operation of a technology-independent coexistence approach. It is assumed that:

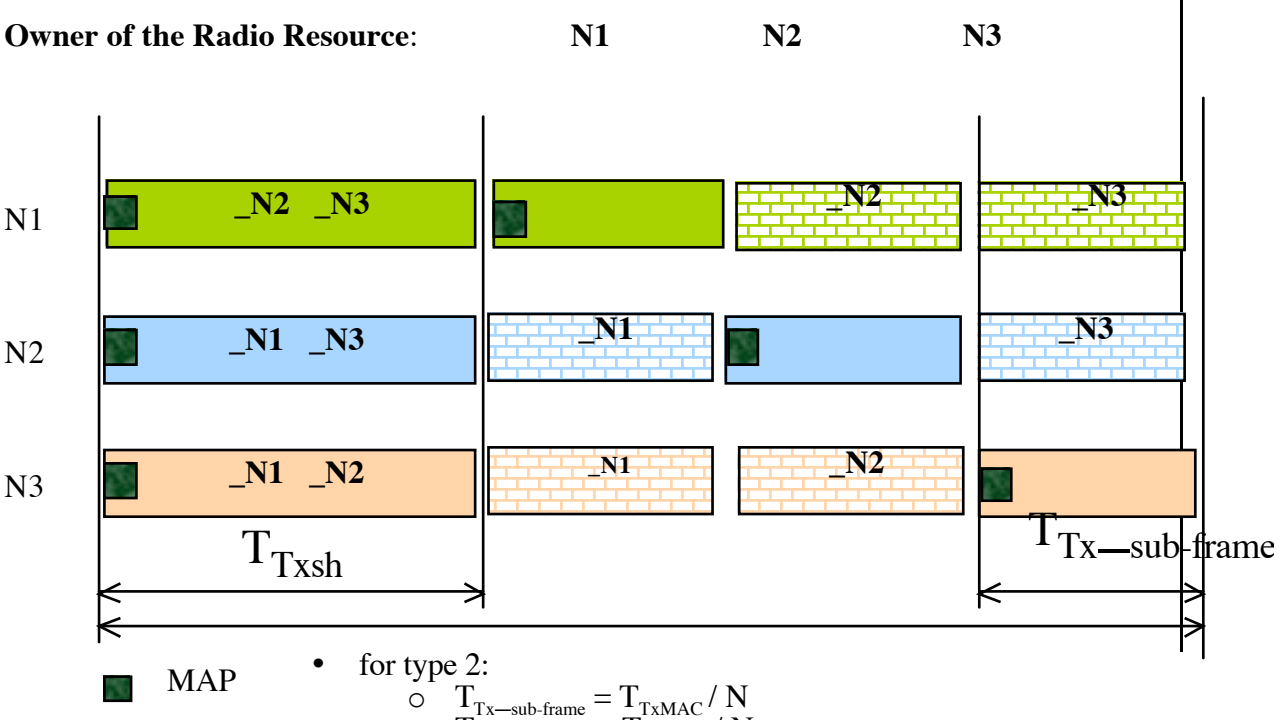
- There is country/region data base, which includes, for every Base Station:
  - *Operator ID*
  - *Base Station ID*
  - *Base Station GPS coordinates*
  - *IP identifier*
- There is a Server that manage the write/reading of this Data Base, using the 802.16h standardized procedures (note: the network model from ITRI contribution applies);
- Every Base Station includes a data base, open for any other Base Station; the BS data-base contains information necessary for spectrum sharing, and includes the information related to the Base station itself and the associated SSs; a Base Station and the associated SSs form a System. Other Base Stations can send queries related to the information in the database to the DRRM entity (note: the network model from ITRI contribution [3] applies);
- The access to Data Bases is secured by authentication and possibly encryption
- 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; 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;
  - It is no need to register the SS location.
- All the Base Stations forming a community will have synchronized MAC frames
- A community will be limited to a reasonable size; the size limitations and interactions between different neighborhoods: t.b.d. in further meetings
- For every community of Base Stations is created a repetitive pattern, based on one of the following possibilities, mentioned in 802.16h Working Document, chapt. 7.2.2.1.3.2:
  - *Type 1 (par.* 7.2.2.1.3.2.1): The MAC frame, for each Tx and Rx part, is split in N+1 sub-frames:
    - One for non-interfering traffic

- Every other one to be used by a single BS or more non-interfering BSs which are assuming the Master role

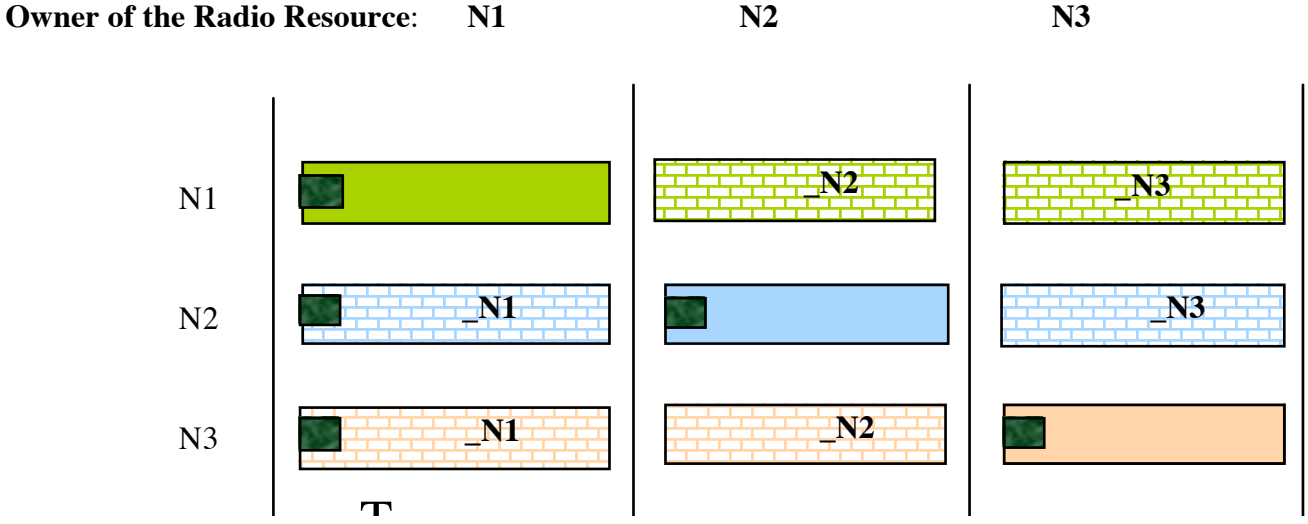
- *Type 2 (par*. 7.2.2.1.3.2.2): The MAC frame, for each Tx and Rx part, is split in N sub-frames, every one to be used by a single BS or more non-interfering BSs which are assuming the Master role during a sub-frame
- *Type 3*: (*par*. 7.2.2.1.3.2.3) The MAC frame is split in two sub-frames: one for non-interfering traffic and one in which a single BS or more non-interfering BSs are assuming the Master role; each Base Station will assume the Master role after M frames

The duration of each sub-frame, in a given ~~is~~community, is calculated (here down are some of possible relations and corresponding MAC frames notation):

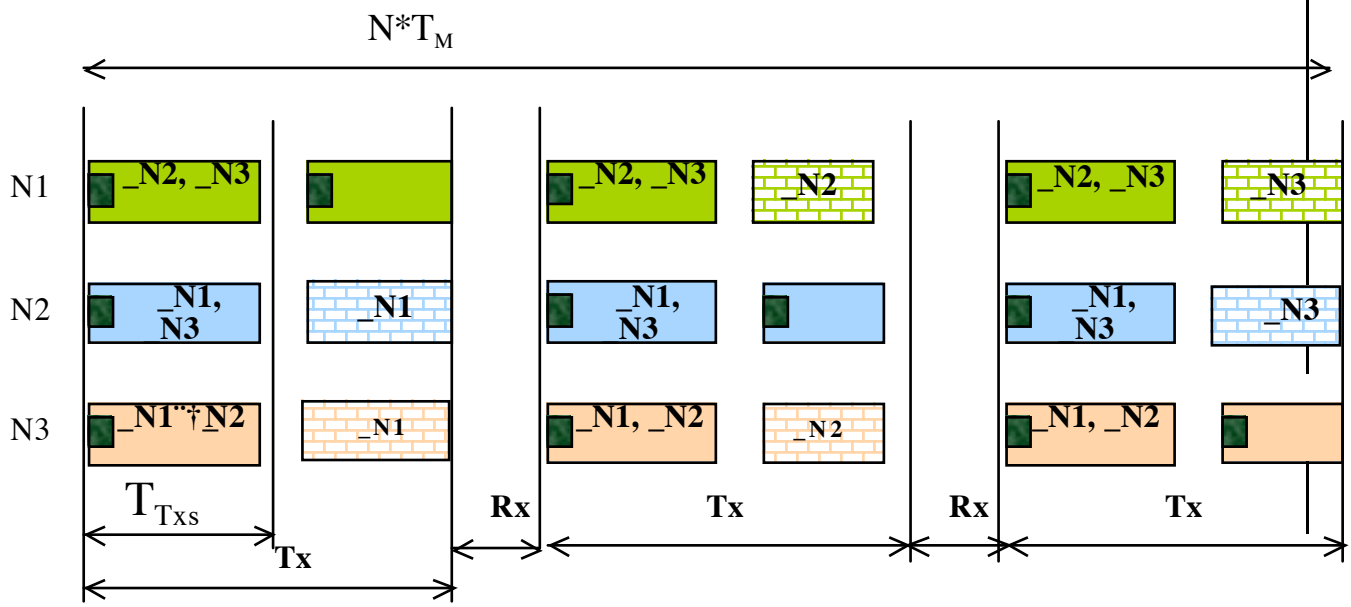
- for type 1:
  - $T_{Tx—sub\text{-}frame} = T_{TxMAC} / (N+1)$
  - $T_{Tx—sub\text{-}frame} = (T_{TxMAC} - T_{Txsh}) / N$
  - $T_{Rx—sub\text{-}frame} = T_{RxMAC} / (N+1)$
  - $T_{Rx—sub\text{-}frame} = (T_{RxMAC} - T_{Rxsh}) / N$




- for type 2:
  - $T_{Tx—sub\text{-}frame} = T_{TxMAC} / N$
  - $T_{Rx—sub\text{-}frame} = T_{RxMAC} / N$



- for type 3:
  - $T_{Tx—sub\text{-}frame} = T_{TxMAC} / 2$
  - $T_{Tx—sub\text{-}frame} = T_{TxMAC} - T_{Txsh}$
  - $T_{Rx—sub\text{-}frame} = T_{RxMAC} / 2$
  - $T_{Rx—sub\text{-}frame} = T_{RxMAC} - T_{Rxsh}$
  - repetition interval = $N*T_{MAC}$,




where $T_{MAC}$, $T_{TxMAC}$, $T_{RxMAC}$, $T_{Txsh}$, $T_{Rxsh}$ are the durations of the respectively the MAC frame, Tx interval and Rx interval of the MAC frame or of the sub-frame used for shared used in the non-interfering sub-frame. In the above relations, the meaning of Tx or Rx is relative to the usage of the MAC Frame by a Base Station.

- During the Master sub-frame the Base Stations assuming Master role may use their maximum power
- During every Master sub-frame, the Base Stations will create a slot, possibly not overlapping with another slot of a neighbor Base Station, during each every transmitter (BS or associated SS) will send a predefined signal; this signal, called "radio signature", will be used to measure the interference created by that transmitter.
  - The "radio signature slot" for a Base Station will be created during its Tx Master sub-frame, every B MAC-frames;
  - The "radio signature slot" for a Subscriber Station will be created during the Rx Master sub-frame;
  - *UL MAP and suitable UIUC for scheduling the "radio signature" shall be defined.*

The figure below shows the possible allocation of the "radio signature" transmission opportunity for a given system, using for example the Type 1 repetitive pattern, with a focus on Network 2.

The Network 2 will transmit its Base Station radio signatures from time to time (every N MAC intervals); different radio signatures will be sent for every used power/sub-channelization/OFDMA sub-channel/ spatial direction combination. During these intervals the other Base Stations will schedule a GAP interval, in order to identify solely one Base Station. Base Stations using the same MAC sub-frame as Master sub-frames shall schedule the transmission of their “radio-signatures” in such a way that will not interfere one with the other.

The transmission of “radio-signatures” used by the active SSs will take place during the Master sub-frame, from time to time (a timer shall be defined). The repetition period and the duration of the signature transmission shall be a parameter in the BS Data Base. The active SSs will provide a signature for every used power/OFDMA/sub-channelization/ direction partition.

The Base Station shall take care to provide enough transmit opportunities for the active SSs. During “radio signature” intervals, all the other BSs and SSs shall use a GAP interval.

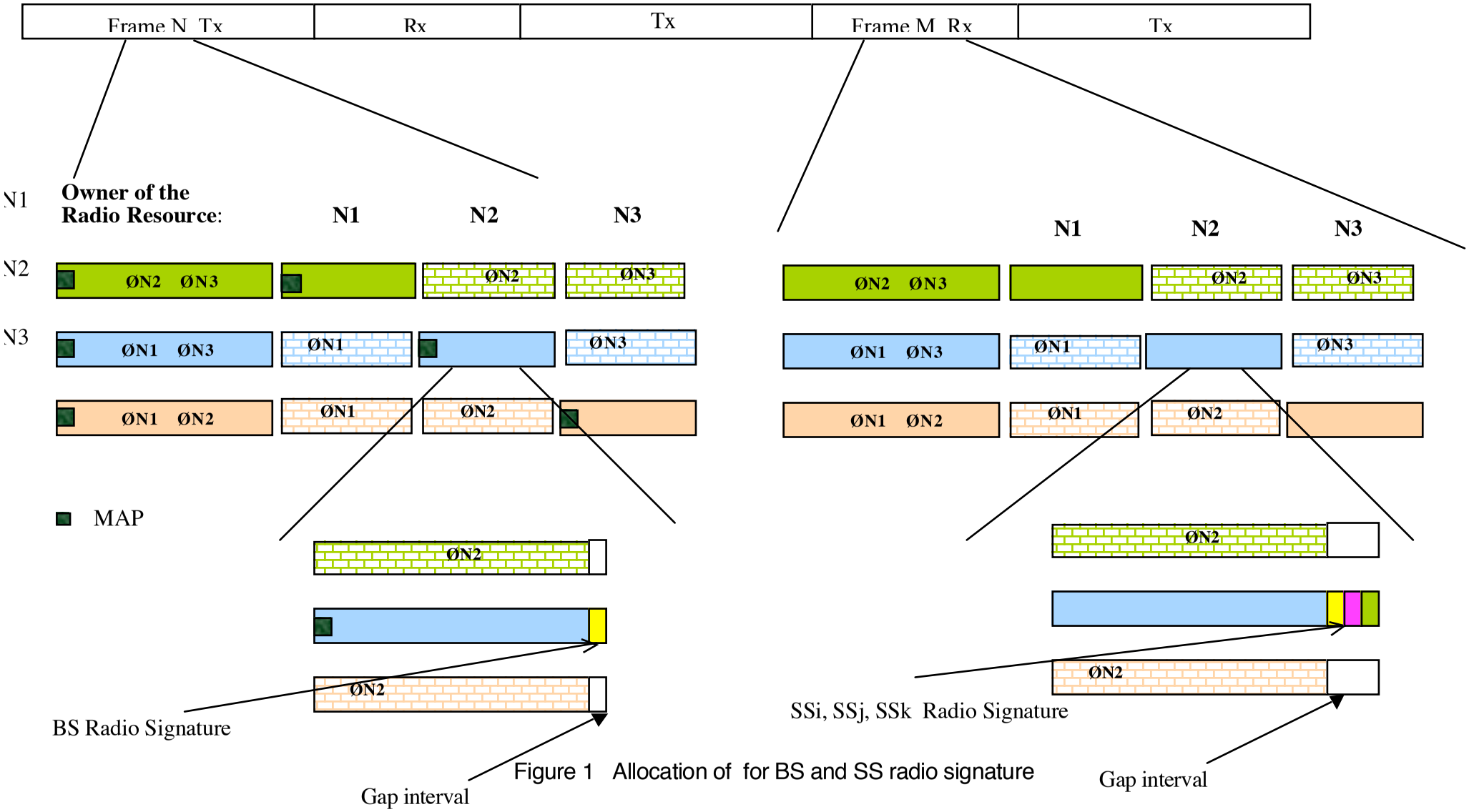



Figure 1 Allocation of for BS and SS radio signature

- The BS data base will include:
  - *Operator ID*
  - *Base Station ID*
  - *MAC Frame duration (same for a community)*
  - *Shared Tx and Rx sub-frame durations (same for a community)*
  - *Type of sub-frame allocation (same for a community)*
  - *MAC Frame number and sub-frame number chosen for the Master sub-frame (same for a community)*
  - *Repetition period for Base Station radio-signature, measured in MAC-frames*
  - *Repetition interval between two Master sub-frames*, measured in MAC-frames
  - *List of other used sub-frames*, in the interval between two Master sub-frames
  - *Time_shift from the Master sub-frame start, duration and the repetition information for the Base Station radio-signature transmission*
  - *Time_shift from the Master sub-frame start, duration and the repetition information for the Subscriber Station radio-signature transmission*
  - *Time_shift from the Master sub-frame start and duration for network entry of a new Base Station*, which is evaluating the possibility of using the same Master slot.

## 2.2 Interference Control

- Interferer identifier
  - A receiver will listen to the media and will find out which are the strongest interferes; by scanning the BS data bases will be possible to identify, due to the knowledge of the frame number, sub-frame number and offset, to which BS is the interferer associated; based on time-shift information, the Base Station will be able to identify the Subscriber Station ID. During the allocated radio-signature transmit opportunity no other radio transmitters will operate.
- Interference reduction
  - A BS has the right to *request an interferer to reduce its power by P dB*, for transmissions during the time in which a Base Station is a Master; if the requested transmitter cannot execute the request, it has to cease the operation during the Master sub-frame of the requesting Base Station; this applies also for systems using the sub-frame as a Master
- Sharing the Master time
  - A Base Station will indicate in the data base *what portion of the sub-frame time, separately for Tx and Rx, is actually used*
  - Other systems, which do not interfere one with each other, may use that time interval
- Target acceptable interference levels during Master sub-frames:
  - For the Base Station and its SS, using the Master sub-frame: min. 14dB above the noise + interference level (16QAM 1/2 (note: we should define the interference criteria; the existing one may be too stringent and not necessary for short links)

## ~~2.2~~2.3 Community Entry of new BS

- The first phase of the Community Entry process uses the country/region ~~(FCC)~~ data base:
  - *Read the Regional/country ~~(FCC)~~ data base;*
  - Identify which Base Stations might create interference, based on the location information;
  - Learn the IP identifier for those Base Stations;
- Build the local image of the relevant information in the community BS's, *by copying the info in those BSs*
- Listen on multiple frequencies
  - Identify the level of interference on each frequency channel;
- Decide the working frequency (ACS – Adaptive Channel Selection process);

- If available, select an interference-free Master ~~slot~~sub-frame; if not, use the procedure for creating new Master ~~slots~~sub-frames;
- Search the Base Station data base for finding the BSs using the selected Master sub-frame;
- *Request those Base Stations, by sending IP unicast messages, to listen during the BS_entry slot* in order to evaluate the interference from the new Base Station;
- Use the allocated slots for transmitting the "radio signature" at maximum power, maximum power density and in all the used directions;
- *Ask for permission of the Base Stations*, using the sub-frame as Masters, *to operate in parallel and use the same sub-frames;*
- If all of them acknowledge, the Base Station acquires a "temporary community entry"status; the final status will be achieved after admission of the SSs;
- If no free Master ~~slot~~ sub-frame is found, use the procedure for creating new Master ~~slots~~sub-frames.

## ~~2.3~~2.4 Network and Community Entry for SS

- Start listening;
- Determine interference intervals;
- Assume that the interference is reciprocal;
- Build database for possible working slots and sub-frames;
- Wait for the Base Station community entry and start of operation;
- At BS request, *send a list of the above identified time intervals;*
- If an old Base Station will perceive interference from the new SSs, it will *ask the new Base Station to find another sub-frame for operation;*
- If the SS will sense interference, will request their Base Station to *find another sub-frame for operation as Master*.

## ~~2.4~~2.5 BS regular operation

- Schedule SS traffic;
- Set Tx power levels, such to use minimum power levels for both BS and SSs;
- Maintain it own database when other BSs join the network.

## ~~2.5~~2.6 Operational dynamic changes

### ~~2.5.1~~2.6.1 Creation of a new sub-frame

If none sub-frame can be used, a *new Base Station may request the addition of another sub-frame*. The effect of such a request will be the reduction of operating time for those Base Stations that interfere with the new Base Station. However, all the others, that do not interfere one with each other and with the new one, may work in parallel and use the same operating time.
A Base Station will request the creation of a new sub-frame by:

- *Sending IP messages to all BS members of the community, and indicating:*
  - *The interfering operator ID and BS ID*
  - *The MAC frame-number in which the addition of a new sub-frame will take place.*
- All the requested *BSs will acknowledge the request*, by
  - *Sending back a message having as parameters:*
    - *Frame-number for the change (must be the same as the requested one*
    - *Master sub-frame number for the new BS (SF = Sfold+1).*
  - If are missing acknowledges, those BS will be asked again, for another M attempts, after that will be considered that they are not working;
  - At the above specified MAC frame number, a new sub-frame partition will take place, by inserting in the sub-frame calculation relation:

    - N=N+1
  - *The BSs will up-date the own SSs about the change*
- Start to use the created Master sub-frame.

### ~~2.5.2~~2.6.2 ~~Reduce~~ Controling interference during master ~~time slot~~sub-frame

#### ~~2.5.2.1~~2.6.2.1 Interferer identification

The interferers will be identified by their radio signature, for example a short preamble for OFDM/OFDMA cases. The radio signature consist of:

- Peak power
- Relative spectral density
- Direction of arrival.

Every transmitter will send the radio signature during an interference-free slot. The *time position of this slot (frame_number, sub-frame, time-shift)* will be used for identification.

#### ~~2.5.2.2~~2.6.2.2 Interference to BS

- Identify the interferers;
- Send messages to interfering BSs, *asking to drop the power of the specified transmitter by P dB;*
- Alternatively, send messages to related BSs, *asking to stop operating during the BS master slot*
  - The requested Base Station has the alternative of looking for another Master slot

#### ~~2.5.2.3~~2.6.2.3 Interference to SS

- *Report to BS about experienced interference*
  - *List of frame_number, sub-frame, offset*
- BS start process for interference reduction with *feedback from the SS.*

## *2.6 Coexistence with non-802.16 wireless access systems*

The above principles are also applicable to non-802.16 systems, like 802.11. During every 802.16 MAC frame, a 802.11 system may find that a sub-frame may be used, due to the low created interference levels. In the case that no operation in parallel is possible, the new system will ask for the creation of a new Master sub-frame. The Coexistence Protocol, working at IP level, will allow the communication between systems using different PHY/MAC standards.
The scheduled use of the MAC frame is possible by using the 802.11 PCF mode.

## References

[1] IEEE 802.16h – 05/010 –Working Document for P802.16h, 2005-03-29
[2] IEEE S802.16h – 05/006 - Proposals for facilitating co-channel and adjacent channel coexistence in 802.16 LE, by Chi-Chen Lee, Tzu-Ming Lin, Fang-Ching Ren, Sheng-Fu Tsai, Keng-Ming Huang, Jhe-Ming Hsu, CCL, ITRI
[3] IEEE 802.16h – 05/011 Storage of identification information and Coexistence Protocol, Chi-Chen Lee, Keng-Ming Huang, Hung-Lin Chou, Han-Chiang Liu, Industrial Technology Research Institute, Computer and Communications Research Labs, Taiwan