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Source(s)	Mariana Goldhamer Alvarion Tel Aviv, 21 HaBarzel Street Israel Voice: +972 3 6456241 Fax: +972 3 645 6204 mailto:marianna.goldhammer@alvarion.com
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Purpose	
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BS IP address transmission using Cognitive Signaling and general editorials

Mariana Goldhamer, Alvarion

Introduction

This paper has the changes underlined, versus the basic document. The last paragraph explains hoe the cognitive signaling, in association with the Coexistence Time slot, can allow the transmission of the Base Station IP identifier. This mode will be useful in case that there is no Coexistence Identification Server.

Text with changes

1 Interference detection and prevention – general architecture 2.1 Operational Principles and Policies

1.1.1 General Principles

A possibility of 802.16h usage is in close relation with a database, including both deployment information and an IP identifier for allowing the operation of a technology-independent coexistence approach. It is assumed that:

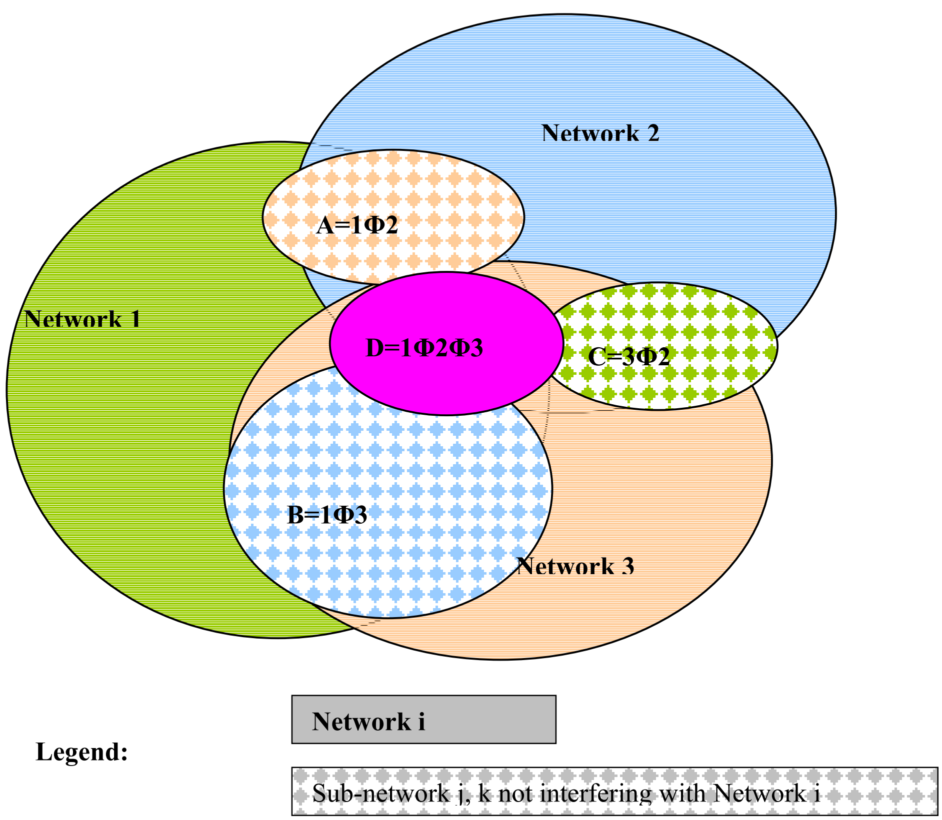
- There is country/region data base, which includes, for every Base Station:
    - *Operator ID*
    - *Base Station ID*
    - *Base Station GPS coordinates*
    - *IP identifier*
- The local Radio Administration may use, for light licensing procedure, its own database, generally notincluding the Base Station ID and IP identifier information.
- There is a Server that manage the write/reading of this Data Base, using the 802.16h standardized procedures including secure access procedures; the Server and the country/region data base can be hostedby one of the operators or a trusted entity, like the local Radio Administration.
- 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, located in a Base Station (see Figure12);
- 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.
- Every network will have a guaranteed minimum access time for the interference free use of the radio resource, being able to receive with minimum interference and to transmit at the needed powers for allowing communication between its Base Station and the remote subscribers.
- ***Neighbor BSs****: The base stations that could create interference to each other or have valid SSs in the common coverage area are called neighbor BSs, and shall form a neighborhood.*
  There are 2 basic conditions to form a neighborhood:
  1) Common coverage area: base stations need to be close enough in geography;
  2) Valid SSs exist in the common coverage area: When SS transfer data with one BS at a time, it shall consider other BSs as an interference source at the same time.

Neighbor Networks*: Neighbor BSs & their SSs are called Neighbor Network, and shall form a network neighbor hood.*

The figures below explain possible ways of implementing the guaranteed radio resource principle, using a example of three overlapping radio networks.

The overlapping radio networks create different interference zones, based on spatial distance between transmitters and receivers. ~~For~~ As example of BS to SS interference, the radio receivers in Zone A, in the figure below, suffer from the interference (noted with Φ) between Network 1 and Network 2. Interference Zone B includes also the Base Station of the Network B.



- $T_{Tx\_sub\text{-}frame} = T_{TxMAC} / (N+1)$
- $T_{Tx\_sub\text{-}frame} = (T_{TxMAC} - T_{Txsh}) / N$

Coexistence Time Slot

CTS (Coexistence Time Slot): a predefined time slot for the coexistence protocol signaling purpose, especially for the initializing BS to contact its neighbor operating BS through one or more ~~the~~ neighbor SSs in the common coverage area.

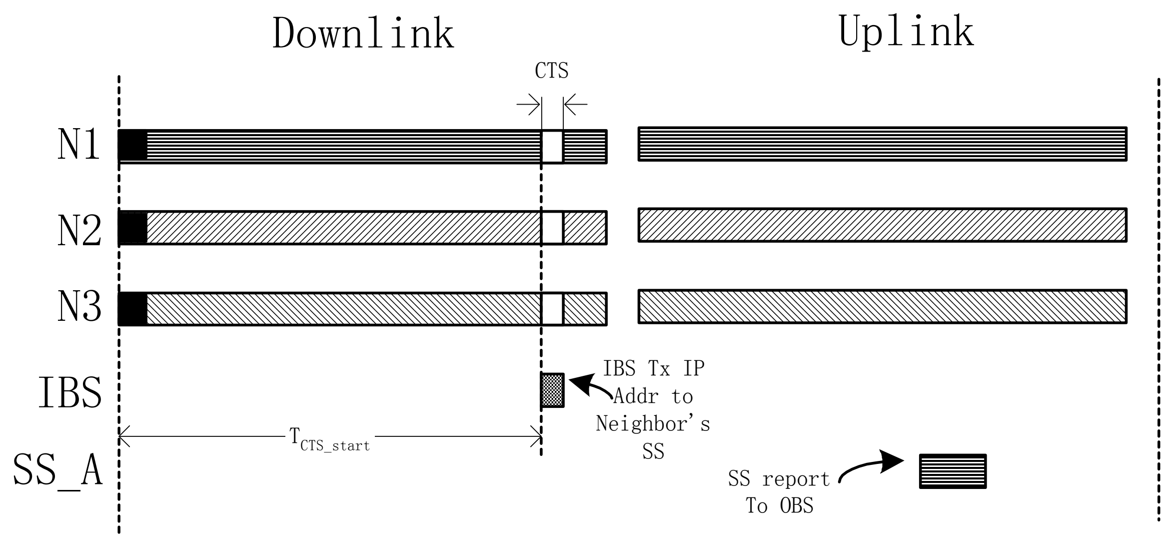


Figure 1. Timing of Coexistence Time Slot

CTS must not be used for other purpose by all the BSs, so that it will be an interference free slot for the neighbor discovery purpose. Initializing BS (IBS) shall use this slot to broadcast its IP identifier, by sending a message and/or by cognitive radio signaling (t.b.d.), so that the neighbor operating BS (OBS) could find the new neighbor in IP network after the SS report the message. Then the IBS and OBS begin further negotiation for coexistence protocol.

The broadcasting procedure is unidirectional, only from the IBS to the SSs in ~~IBS's~~ OBS's coverage, and the SSs shall report all the useful information to their OBSs they registered to. If the message will be forward correctly to the OBSs, the OBSs will then find the IBS in the IP network, and go further signaling using IP network.

The CTS parameters need to be unified in a particular region, and to be well known by the BSs. So that each BS ~~IBS~~ could know the exact time to transmit the broadcasting message in its initialization. The parameters include:

TCTSstart： CTS starting time from the beginning of the frame (ms)
TCTSdurat： CTS duration time (ms)
NCTSstart： CTS starting frame number（ frames）
NCTSintv： CTS interval frames （frames）

Figure 2. CTS parameters

1.1.2 Interference Control

- Interferer identification using the radio signature
  - A receiver will listen to the media during the radio signature slot 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*

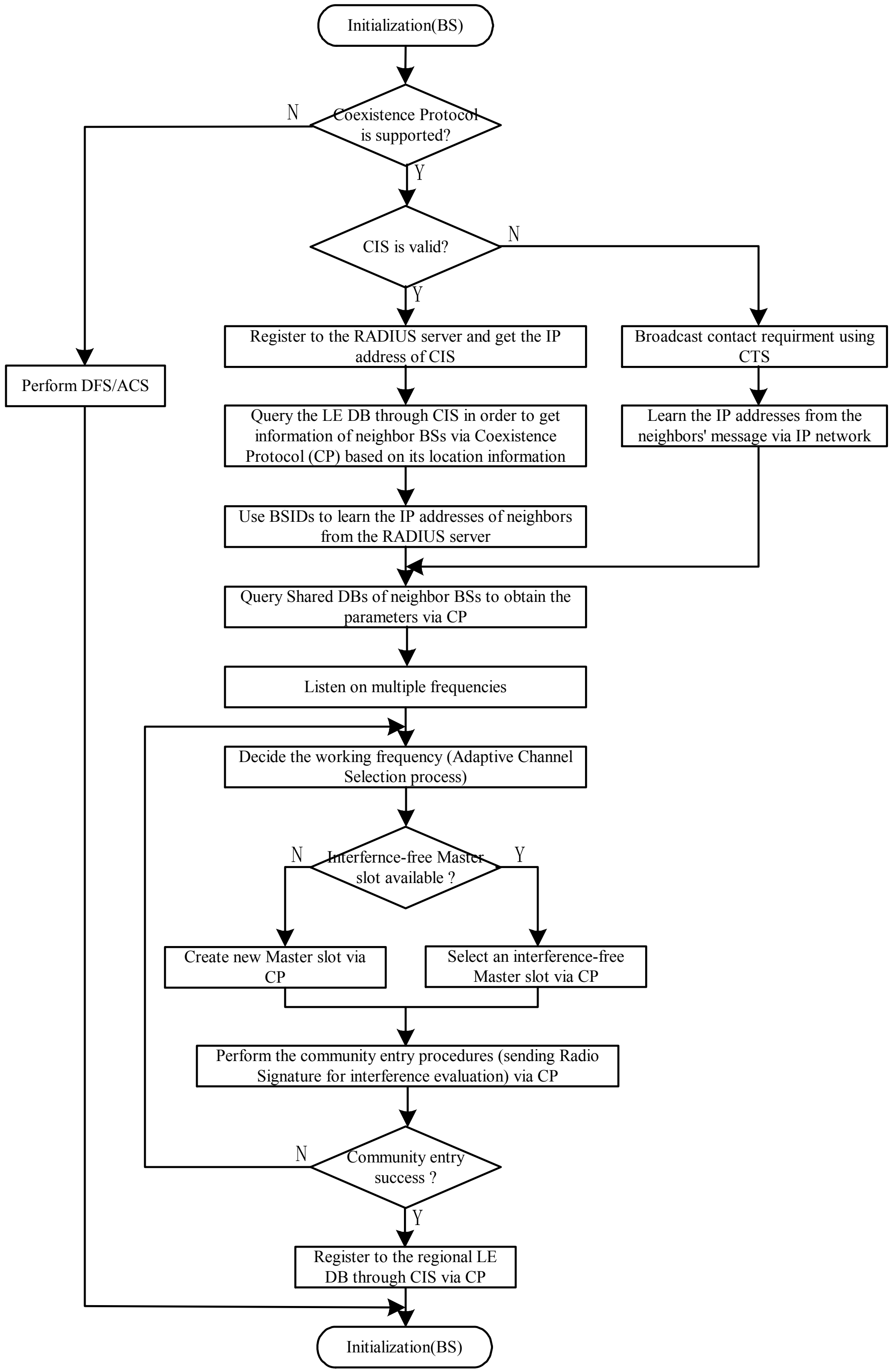


Figure 3. Initialization procedures — BS

- *The first phase of the Community Entry is to judge the validity of country/region data base. If the country/region database is valid (t.b.c: what means valid?), the process further 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;

  Otherwise:
    - *New BS uses the interference free slot to broadcast the message containing the contact request and/or the cognitive radio signal transmitting the IP address*
    - *The SS in the common coverage will forward the information to its operating base station.*
    - *The operating neighbor BS send feedback information to the IBS, using the IP network*
    - *The IBS learn the IP identifier of the neighbor BS By from the message message sent from by the neighbor BS via IP network*
- 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 sub-frame; if not, use the procedure for creating new Master 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.

1.1.2.1 Mixed-PHY Profile communication

In the case of different PHY Profiles the communication will be done at IP Level. Every Base Station should know the IP address of the DRRM of the Base Stations around, by provisioning or/and by using a regional data base approach or/and by using cognitive radio signaling.

2 Pro-active cognitive approach

2.1 Signaling to other systems

[*Note: the cognitive signalling may have effect on the power amplifier and on the PAPR. Call for contribution to investigate if there are any such effects.*]

2.1.1 Ad-hoc systems - operating principles using Cognitive Radio signaling

In order to reduce the interference situations, in deployments in which may exist a combination of 802.16 systems using a Coexistence Protocol and 802.16 ad-hoc systems, the 802.16 ad-hoc systems will apply the Adaptive Channel Selection procedures and use cognitive radio signaling procedures to interact with systems ~~wising~~ using a Coexistence Protocol. The ad-hoc systems obtain a temporary Community registration status, that has to be renewed from time to time.

- during a DL sub-frame, the NAK will be sent by one or more SSs, while to a registration signal sent during UL sub-frame, the NACK signal will be sent by a Base Station. The radio units using the Master sub-frame will send their response in random mode.
- The NACK signal indicates that the requesting ad-hoc device cannot use the specific sub-frame, while using the requesting radio signature
  - Same device may try again, if using a different radio signature (for example, lower power).
- Lack of response, for $T_{cr\_reg\_ack}$ seconds, indicates that the registration is accepted for transmission during the specific sub-frame.

2.1.2 Selection of suitable reception sub-frames

An ad-hoc unit will find his suitable reception sub-frames, by using the ACS and Registration process in a repetitive way, searching for a suitable operation frequency. The practical interference situations, with synchronized MAC Frames are BS-SS and SS-BS interference. Assuming similar transmit powers, the above mentioned process will have as result finding Master sub-frames in which the path attenuation between interfering units is maximal.

2.1.3 Signaling procedures for Cognitive Radio applications

~~For~~ The signaling and message exchange between an ad-hoc system and systems using a Coexistence Protocol~~, it is:~~ is done as detailed below:

- Split the narrowest channel to be used (as defined in 802.16 Profiles) into 32 energy bins, as follows:
  - For 256FFT, to 8 sub-carriers/bin
  - For 512 FFT, to 16 sub-carriers/bin
  - For 1024FFT, to 32 sub-carriers/bin
  - For 2048FFT, to 64 sub-carriers/bin.

- Send an 802.16h MAC message, at a suitable rate, such that the MAC header will use 1 symbol and the MAC PDU will use another symbol; the MAC header and the data field will be built in such a way that the power distribution for different bins will be with at least 5dB higher for a bin marked in Table 1 with "H" than for bin marked with "L".

The data field for both transmit and receive operations, taking into account possible FFT sizes, channel widths and the defined PHY modes, is defined in chap. t.b.d.

The following figures show the desired spectral density for cognitive signaling and the possible outcome of the MAC PDU approach, introducing some distortions in time or frequency domain, but still detectable by non-802.16 systems.

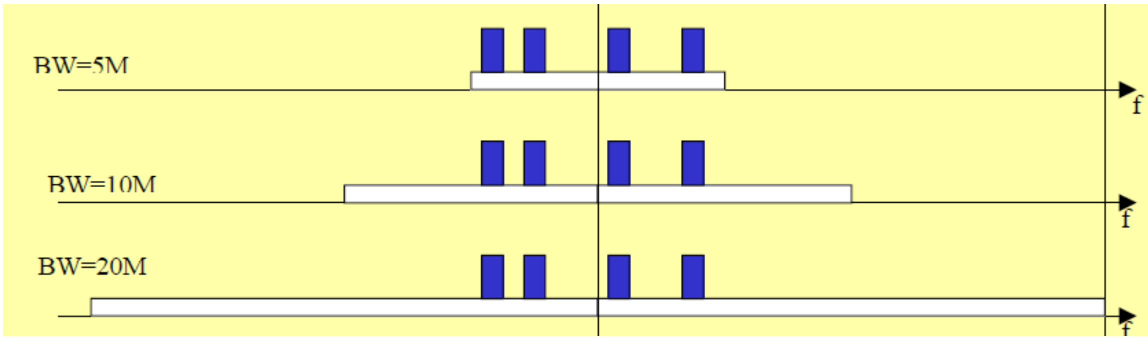


Figure 4. Desired spectral densities for different channel BWs

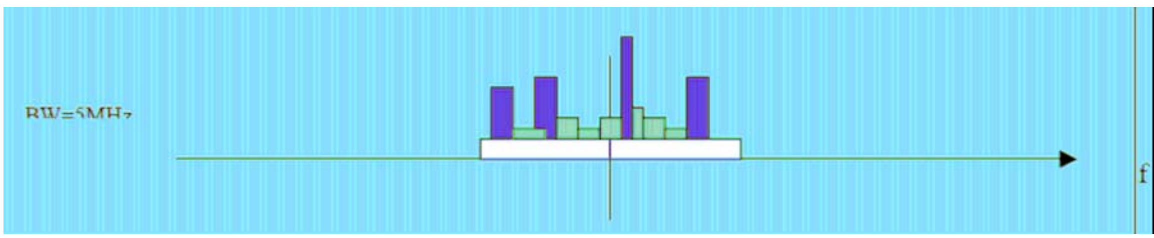


Figure 5. Obtainable spectral densities with MAC PDU approach

Due to the FFT guard sub-carriers, not all the bins are usable; we will use in continuation, from the bins numbered 0…31, where the bin#0 corresponds to the lowest frequency, only the bins 6…26.

The MAC PDUs, having the spectral characteristics defined in the Table 1, are defined in Chap. t.b.d for each of the 3 802.16 PHY modes.

In Table1 were defined a number of cognitive signals, having low inter-correlation properties. The energy on the not-used bins can take any value, but not more than the energy on a bin marked with "H". This tolerance will allow finding adequate data mapping for each PHY mode. Obviously, if the energy on not-used bins will be minimal, the detection process will be easier.

Table 1. Cognitive signal definition

Bin number /Signal number	**6**	**8**	**10**	**12**	**14**	**18**	**20**	**22**	**24**	**26**
1 (802.16h Cognitive MAC Header)	**H**	L	L	**H**	**H**	L	L	L	**H**	L
2 (Tx_start)	L	**H**	L	L	**H**	**H**	L	L	L	**H**
3 (Rx_start or Rx_slot)	**H**	L	**H**	L	L	**H**	**H**	L	L	L
4 (Tx_end)	L	**H**	L	**H**	L	L	**H**	**H**	L	L
5 (Rx_end)	L	L	**H**	L	**H**	L	L	**H**	**H**	L
6 (NACK)	L	L	L	**H**	L	**H**	L	L	**H**	**H**

7 (CTS_Start)	**H**	L	L	L	**H**	L	**H**	L	L	**H**	
8 (CTS_Continuation)	L	**H**	**H**	L	L	**H**	L	**H**	L	L	
9	L	L	**H**	**H**	L	L	**H**	L	**H**	L	

2.1.4 Using the coexistence slot for transmitting the BS IP identifier

The cognitive radio signaling described above may be also used for the transmission of the BS IP identifier, when there is no installed Base Station Identification Server.

The transmission is done in consecutive coexistence time slots, every N_{Iptx} MAC frames. The first CTS in the series starts with CTS start signal, the last CTS contains the Tx_end signal, the continuation in sequential MAC frames starts with the CTS_Continuation, as defined in Table 1. Between these signals is transmitted the IP identifier of the BS and a 8bit CRC, the L.S.B (least significant bit) for each field being transmitted first. The transmission of the above information uses only the bins 6,8,10,12,14,18,20,22,24,26 (10bits / symbol), the L.S.B. corresponding to the lowest frequency.

The transmission of a IPV4 address will request 1+ (32+8)/10 + 1 = 6 symbols and the transmission of a IPv6 address will request 1+ceil((128+8)/10) +1 = 16 symbols.

2.2 Recognition of other systems