

APPLICATION NOTE

Development of an
audio distribution and
contribution system
based on IP networks
for radio broadcasting
companies



AEQ PHOENIX AUDIOCODECS. APPLICATION NOTE 0-H

Development of an IP-based audio distribution and contribution system for broadcasting networks

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DEVELOPMENT OF AN IP-BASED AUDIO DISTRIBUTION AND CONTRIBUTION SYSTEM FOR BROADCASTING NETWORKS

The system substitutes a satellite-based unidirectional broadcast system, while additionally providing full-duplex audio to more than 125 stations in a flexible way, allowing for national, static regional or occasional local multicast groups.

By Sergio Sanchez, R+D+i engineer at AEQ

1. Introduction

This article is based on the technical description by D. Xavier Cabestany, technical manager of La Xarxa, the organization that uses the system. This description is published on AEQ's website, but it has been extended here to explain the different software applications developed for this Project, as well as other technical details that may be of interest to implement similar systems.

La Xarxa Audiovisual Local (XAL) is a public audiovisual production and broadcast entity, created by the Diputation of Barcelona. It principally generates local informative, sports and entertainment content. XAL counts on its own installations located in Barcelona, but also have numerous affiliate radio stations (more than 125). XAL provides its contents to these stations so that they can broadcast and combine them with their own local productions. The stations, in turn, can also contribute signal to the La Xarxa central office in order to create programs together.

Until this moment, La Xarxa has been distributing the common signal through a satellite-based link, what implies high running and maintenance costs, lack of flexibility (unidirectional and non-selective network) and even the existence of transmission issues when meteorological conditions are adverse. These are mainly motivated by the obsolescence of the satellite receiving equipment.

Back in 2015, it was proposed to undertake the migration/transition of this satellite-based network to another based on terrestrial IP technology. The question was raised in a moment when available networks were mature enough to be able to provide sufficient capacity. At the same time, some audiocodecs on the market could provide very stable, high quality links. These links can offer nearly transparent quality while using moderate binary rates. This combination also provides added-value features, such as higher distribution flexibility or the possibility of creating bidirectional contribution links. All this is achieved at a considerably lower cost. Note that this is the case of both audio and video communications.

This Application Note focus on the description of the solution implemented for the distribution and contribution of AUDIO that XAL contracted from the Spanish Service Provider Telefónica and that was also given the task to provide a private data network (not Internet). Telefónica, in turn, chose AEQ as its provider of audiocodecs.

The solution provided by AEQ consists both in the provision of the required audiocodec devices, necessary for the transmission of the signals (all of them are Phoenix Venus), and the development of a custom-made powerful set of software tools that allow the customer to:

- Control and monitor all audiocodecs deployed in the network from any PC, even remotely connected through the Internet (provided that it has the required security credentials to access the private network).
- Program connection and disconnection events.
- Integrate the system with the existing audio matrix, and execute previously created salvos.
- Dynamically activate local or regional broadcast groups.
- Manage point-to-point contribution connections from the central location.

2. Project requirements and implementation

2.1. Main program broadcasting

The main project's target is the substitution of the current satellite links used to broadcast the "main" program to the local radio stations by a terrestrial IP network using IP Phoenix Venus audiocodecs.

This program is transmitted from Barcelona's central office, by means of a large multicast group that all the local stations are subscribed to. A Venus audiocodec named "MAIN", located in La Xarxa Central office in Barcelona sends the audio stream to a multicast IP address assigned to a server at Telefónica, distributing it to all the remote devices subscribed to that same IP address.

Each local station has a Phoenix VENUS audiocodec installed. Its first channel is always devoted to the reception of multicast flows (by calling to the group's IP address, using standard IGMPv2 – Internet Group Management Protocol -). There are **129 local stations**, and their codecs are named "remotes". Their second channel is used for other kind of point-to-point connections, as explained later on in this document.

Audio quality is almost transparent. A state-of-the-art OPUS algorithm has been selected. This algorithm is included in all latest-generation AEQ Phoenix audiocodecs. In this particular project, audio signal is encoded to 128 or 192 kbps with a 48kHz sampling frequency, allowing for the transmission of a full bandwidth (20-20kHz) and low delay stereo audio channel.

On the other hand, there is a third-party playout automation system generating GPOs (general purpose digital outputs). They were previously sent through the satellite link and received by all local receivers. Now, they are connected to the main multicast Venus codecs GPIs (to both the main and backup units), that notify the control server about any change in these signals. The server broadcasts this information to a previously selected group of subscribed codecs, which in turn reflect the status in their local GPO. These outputs are connected to the already existing audio switches, GPI cards or other pieces of equipment, that were connected to the satellite receivers before. The purpose of these signals is to remotely switch the audio source or provide control for the local station mixing consoles.

Even when the system supports this signaling method to maintain backwards compatibility, the reality is that very few stations associated to La Xarxa are actually using it currently and what's more, the particular implementation varies from one to another.

The continuity of the main signal broadcasting is critical. That's why a redundant backup system using two transmitting audiocodecs (MAIN / BACKUP) has been designed. The control server continuously monitors the status of both devices, and whenever the currently active one fails, the connection to the multicast group is re-established using the other audiocodec. Audio signal from the matrix is distributed to the inputs of both units.

2.2. Regional Multicast Groups

Another requirement that La Xarxa have prescribed, is to be able to schedule different smaller multicast groups, with limited duration and quite regular frequency.

These groups can receive programs produced in Barcelona. A set of 5 VENUS audiocodecs is provided in Barcelona, programmed for MULTICAST transmission, that allow for the broadcasting of up to 10 different programs.

But they may also want to create regional groups, with an even smaller number of receivers, where each transmitter is a local or regional station producing its own program.

In both cases, these groups are controlled by means of a scheduling software that has been designed on purpose. It allows for the creation of groups, defines the time ranges when they will be active, and automatically controls the calls of any of the involved audiocodecs. Note that the first channel of each local Venus is always used for this purpose.

This software is able to know when a local station was connected to the main program group, and if it is temporarily moved to a regional group, when this subscription ends, connection will be automatically re-established in such a way that it will continue receiving the main program.

2.3. Remote contributions

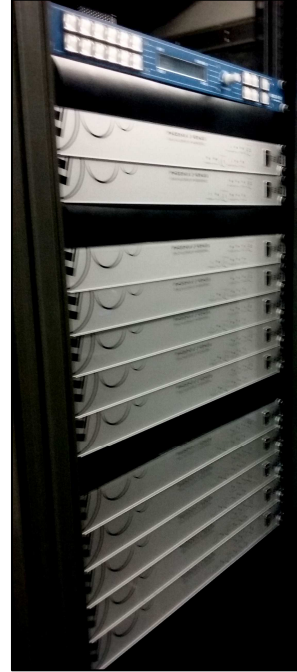
Channel 2 of all local VENUS codecs can also be dedicated to audio contribution to the central office.

In order to do that, there are 5 additional VENUS units dedicated to "CONTRIBUTION" in the central offices. Each one has two channels, allowing La Xarxa to receive up to 10 simultaneous contributions from any associated radio station. These 10 codec channels, that are stereo and bi-directional, are connected to the audio matrix. Using a customized version of a software developed by AEQ, that will be explained later on, connections can be established to the different studios, which can be sent to program or used for coordination while N-1 returns are sent towards each local station. Calls to each station are easily established manually using a pre-defined contact list. Calls are always generated from Barcelona towards the remote stations using AEQ SmartRTP simplified connection protocol.

Second channel of each remote audiocodec is always dedicated to contribution, using SmartRTP so that connections can be established from a single end only (from the CONTRIBUTION codecs, in this case).



Barcelona Central Control Room
Matrix & Codecs



Barcelona Central Control Room
Codecs, close view

2.4. Hardware architecture

Next figure represents the deployed architecture, as well as the connection of the different equipment using the network infrastructure provided and configured by Telefónica.

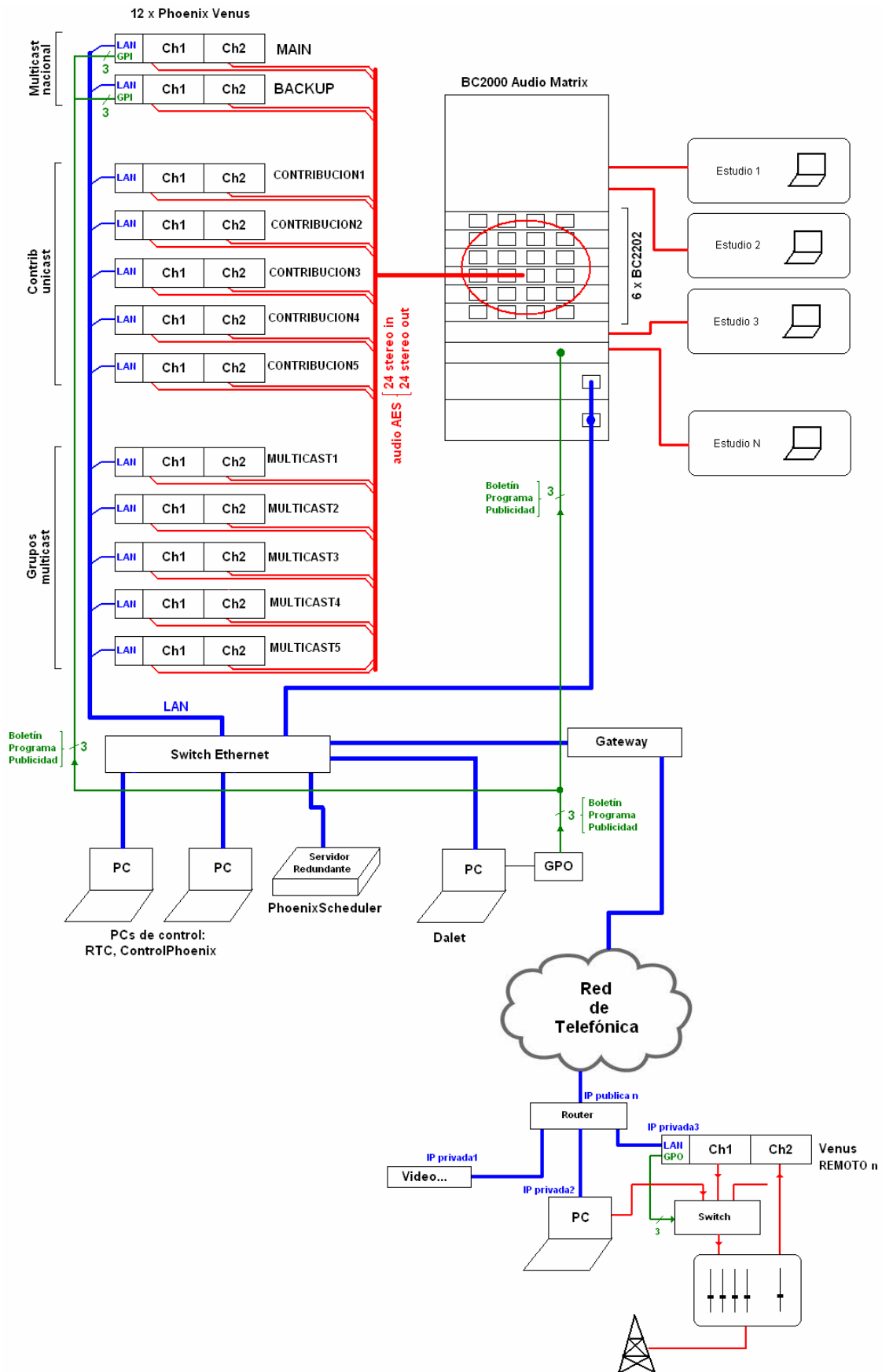


Fig.1: General system architecture

Some explanations about figure 1 (only a single remote station is represented for simplicity):

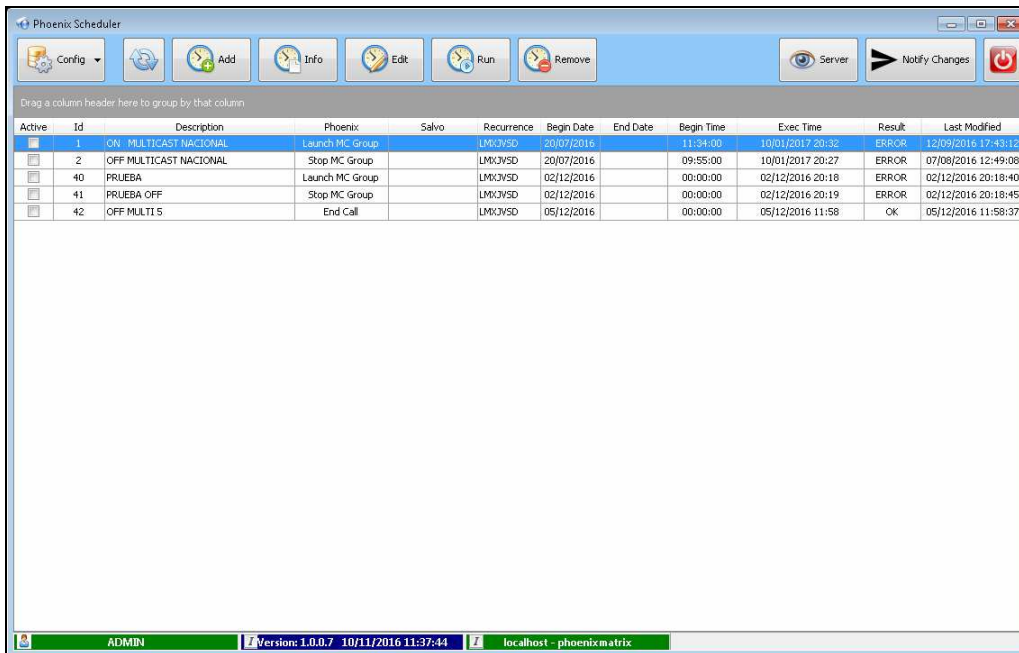
- A set of 12 VENUS audiocodecs is installed in La Xarxa central office. Each one provides two stereo bidirectional channels:
 - MAIN and BACKUP codec broadcast the main multicast program (ch1 used).
 - MULTICAST1..5 allow for the broadcasting of up to 10 alternative multicast programs to smaller groups of remote locations.
 - CONTRIBUTION1..5 allow for the reception of up to 10 point-to-point connections from any remote end in order to elaborate programs from Barcelona. The return unicast channels are used as N-1 feedbacks or for coordination of each contributing local station.
- The network is configured in such a way that all the installed codecs (both the ones located in Barcelona offices and those in the remote venues) are within connected IP networks. These connections are represented in blue. The codec control service can reach every codec in the network and also has IP connectivity to the AEQ BC2000D audio matrix installed in La Xarxa central office in Barcelona, in order to be able to launch salvos on it.
- All audio connections in the central office are digital AES/EBU, and are represented in red color.
- There are several management PCs where the Scheduling and ControlPhoenix applications are installed. The control service is installed on a server, although it may also reliably run ControlPhoenix on a continuous fashion in order to obtain logs. Last, the contribution control software, XAL Control, has been installed in the studio PCs.
- Playout automation system GPOs (contact closures), represented in green, are now connected to the BC2000D matrix through one of the BC2201 cards, and also carried to the MAIN and BACKUP main program codecs' GPIs. There are three different signals: Disconnections, Bulletins, and Programs.

3. Developed software

Two differentiated software suites have been developed in order to cover all the functionality required by the customer:

3.1. Control Service + Scheduler

A new application has been developed that allows the operator to define schedules through a user interface for the creation of codec control commands (such as call, hang-up or multicast group creation), as well as the execution of salvos in the audio matrix.



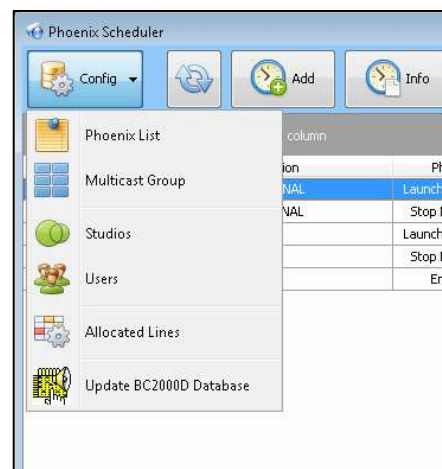
Active	Id	Description	Phoenix	Salvo	Recurrence	Begin Date	End Date	Begin Time	Exec Time	Result	Last Modified
<input type="checkbox"/>	1	ON MULTICAST NACIONAL	Launch MC Group		LMX3VSD	20/07/2016		11:34:00	10/01/2017 20:32	ERROR	12/09/2016 12:43:12
<input type="checkbox"/>	2	OFF MULTICAST NACIONAL	Stop MC Group		LMX3VSD	20/07/2016		09:55:00	10/01/2017 20:27	ERROR	07/08/2016 12:49:08
<input type="checkbox"/>	40	PRUEBA	Launch MC Group		LMX3VSD	02/12/2016		00:00:00	02/12/2016 20:18	ERROR	02/12/2016 20:18:40
<input type="checkbox"/>	41	PRUEBA OFF	Stop MC Group		LMX3VSD	02/12/2016		00:00:00	02/12/2016 20:19	ERROR	02/12/2016 20:18:45
<input type="checkbox"/>	42	OFF MULTIS	End Call		LMX3VSD	05/12/2016		00:00:00	05/12/2016 11:58	OK	05/12/2016 11:58:37

These are different tasks that can be created:

- a) Make a (unicast) call
- b) Hang up a call
- c) Enable or disable ON AIR
- d) Enable or disable the transmission of RTP flow.
- e) Activate multicast group
- f) Stop multicast group
- g) Execute matrix salvos

This same application enables the management of the codec pool (add, delete, modify properties of VENUS audiocodecs), users, studios and matrix synchronization. An SQL database is used for this purpose. Synchronization with the matrix is necessary in order to establish the required cross points, either to send audio from the different studios to the main program (multicast Venus) or for the creation of regional or local programs, in a scheduled way or using the manual control tool described below.

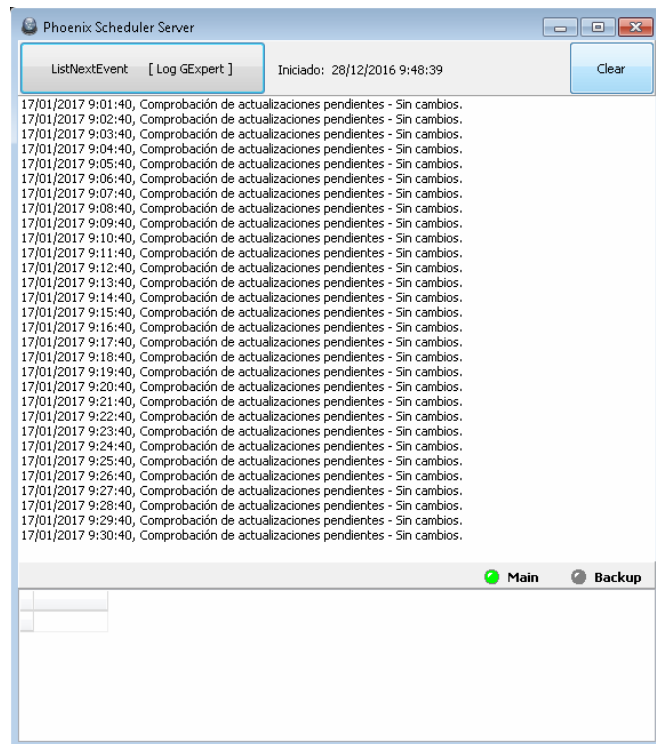
Also, a real time software service implementing the scheduler engine has been designed. It executes each command at the scheduled time and sends the remote XML commands to each involved audiocodec in order to establish connections, hang up, activate salvos in the matrix, etc. This service is running continuously on a powerful server provided and installed by AEQ.



Additionally, this service reads all MAIN and BACKUP codecs' GPI change notifications (these changes are generated from a third-party playout automation system). Whenever there are changes, these are sent to all local stations currently subscribing to the main multicast group and that have been tagged as GPO-enabled during the codec pool definition.

In order to completely adapt the standard Phoenix VENUS audiocodec to all the requirements of this project, some minor firmware modifications have been made, such as:

- Implementing a cyclic GPI reading task that sends notifications to the control service via XML control protocol whenever changes in their state are detected.
- Implementation of remote GPO control using new XML control protocol commands.
- Adaptation of the group management protocol to IGMP v2 as Telefónica's infrastructure doesn't support IGMP v3, implemented as standard in our equipment.
- Forcing Ethernet port speed to 100Mbps, instead of allowing negotiation of 10 or 100Mbps. This proved to work better with the network switches provided by Telefónica.



3.2. "XAL Control" manual control software

La Xarxa also needs to be able to manually assign connections in order to generate programs produced in Barcelona using contributions from remote local stations. So a Manual Control tool was required and AEQ has developed this tool - XAL Control.

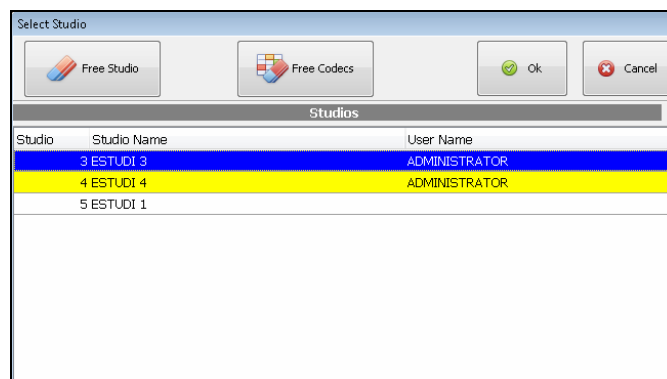
In order to set manual connections from the Barcelona Central office, the customer needs to have a software panel to visualize what codec is available and to select for connection using SmartRTP protocol. For each contribution, they also need to select whether the codec is merely contributing to program or using a coordination circuit.

This tool acts on the dedicated double codecs installed in the central office, that are dedicated to CONTRIBUTION (initially 5 units), sending the necessary control commands, and can be concurrently run on different PCs in different studios. This has required the development of a resource sharing (the contribution channels) and user management system, with two user levels (Administrator and operator). The Administrator has all the permissions. This kind of user can free currently used CONTRIBUTION codecs. The operator users, on the other hand, can only choose codec channels that are not used by others.

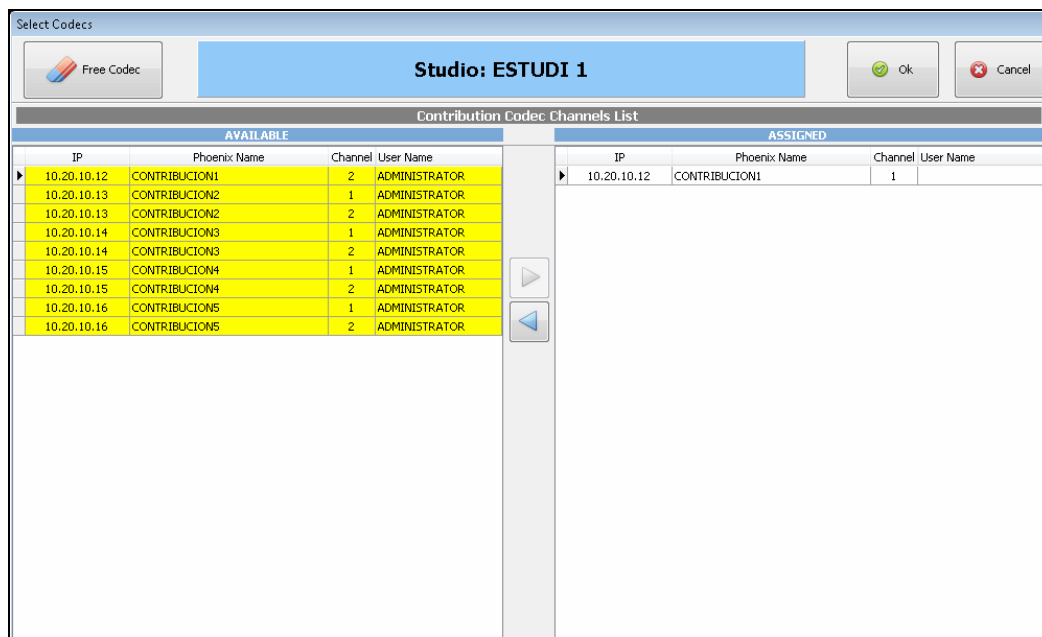
The administrator user can also define other users, studios and matrix audio lines, and assignation to different studios and codecs in the Scheduling application defined in the former section.

This software interacts with the matrix, executing certain crosspoints to connect and disconnect up to 10 codec channels to 4-wire auxiliary and program circuits of the selected studio console, and create the necessary mixes (N-1, coordination). That is, it acts on a small logical sub-matrix within the BC2000D, with maximum size Nx2 (N being the number of contribution channels, 10), where all lines are defined as stereo and bi-directional.

The first thing that an user has to do to run tis application is to log-in and select one of the studios the Administrator has assigned to him.

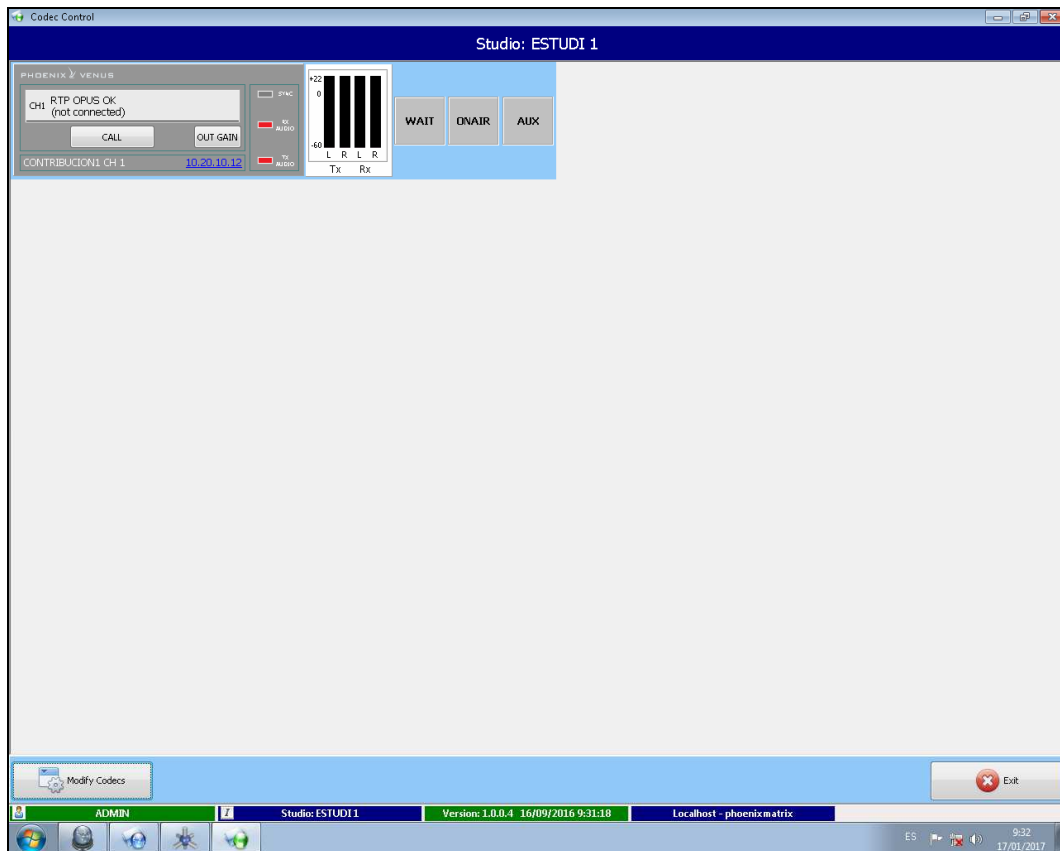


Next, the user has to choose the required contribution audiocodec channels among the 10 available ones (corresponding to 5 CONTRIBUTION VENUS audiocodecs installed in Barcelona). Channels that are currently being used are highlighted in yellow.



When a codec is moved to the right column of this window it becomes “reserved” so this user can make the necessary calls with it (using the provided agenda including all the REMOTE audiocodecs).

The user is responsible to free the calls once finished or when leaving the application, but the Administrator user can also free them if required:



3.3. ControlPhoenix

Besides the two described software tools that were developed on-purpose for this customer, the standard AEQ ControlPhoenix application is used in order to pre-configuration the devices or make occasional manual calls between the system codecs.

This software is provided with all AEQ Phoenix family audiocodecs and can exert total control on up to two devices at a time. However, some unlimited licenses (not limiting the number of connected codecs) have been installed in several control workstations within Barcelona central offices. Control is also possible from any internet connected PC that has credentials to enter the private network.

The list-mode presentation allows for a quick view of the general system status in installations where many codecs are controlled at the same time, such as the one we are presenting:

The screenshot displays the 'AEQ ControlPHOENIX - Registered' application window. The main area shows an 'Installation equipment list' with a table of devices and their connection status. A message box on the left indicates 'Some equipment is not connected.' The table has columns for Description, IP, Device, Status, Channel 1, and Channel 2. Many rows show 'CONNECTED' status with specific IP addresses. Below the table is a 'Registering events' section with a table of event logs, including Date, Time, Desc, Device, and Event. The status bar at the bottom shows 'Total AudioCodec = 84' and the system time '09:29:51' on '17/01/2017'.

Description	IP	Device	Status	Channel 1			Channel 2		
				On	Rx	Tx	Status	On AIR	Rx
BACKUP	10.20.10.6	Phoenix Venus	OK	●	●	●	●	●	●
CONT1	10.20.10.12	Phoenix Venus	OK	●	●	●	●	●	●
CONT2	10.20.10.13	Phoenix Venus	OK	●	●	●	●	●	●
CONT3	10.20.10.14	Phoenix Venus	OK	●	●	●	●	●	●
CONT4	10.20.10.15	Phoenix Venus	OK	●	●	●	●	●	●
CONT5	10.20.10.16	Phoenix Venus	OK	●	●	●	●	●	●
MAIN	10.20.10.5	Phoenix Venus	CONNECTED_NO_DATA 239.20.10.10:5004	●	●	●	●	●	●
MULTI1	10.20.10.7	Phoenix Venus	OK	●	●	●	●	●	●
MULTI2	10.20.10.8	Phoenix Venus	OK	●	●	●	●	●	●
MULTI3	10.20.10.9	Phoenix Venus	OK	●	●	●	●	●	●
MULTI4	10.20.10.10	Phoenix Venus	OK	●	●	●	●	●	●
MULTI5	10.20.10.11	Phoenix Venus	OK	●	●	●	CONNECTED 10.20.174.55:5008	●	●
...

Date	Time	Desc	Device	Event
17/01/2017	9:28:44	...	Phoenix Venus	Configuration Received Channel 2 OK
17/01/2017	9:28:44	...	Phoenix Venus	Configuration Received Channel 2 OK
17/01/2017	9:28:44	...	Phoenix Venus	Channel 1 CONNECTED 239.20.10.10:5004
17/01/2017	9:28:44	...	Phoenix Venus	Channel 2 changed
17/01/2017	9:28:44	...	Phoenix Venus	Channel 2 OK AIR

This tool has also demonstrated to be very useful due to its ability to capture event logs, very handy when debugging problems during the setup phase of the system.

ControlPhoenix allows for the protection of the control of any individual audiocodec by means of a password, in order to prevent unauthorized manipulations.

4. Project development

This project has been developed in coordination with the final customer, La Xarxa, working together with their direct provider, Telefónica, whose responsibility has been to provide a network with enough capacity and quality for audio and video communications, and also to configure their internal infrastructure in order to allow for multicast traffic. On the other hand, AEQ, that some time ago provided the BC 2000 D matrix and broadcast studios in La Xarxa Central office in Barcelona, has now developed the required software tools, provided more than 140 audiocodecs adapted to the required needs and verified and optimized the system.

Software development started after some definition meetings between La Xarxa, AEQ and Telefónica. They allowed for an in-detail definition of all the requirements. Following this, a project proposal document was written, discussed, and finally accepted by all parts involved.

The development was debugged on a test-bench installed in AEQ R&D facilities in Leganés, and once it reached an adequate maturity level, the applications were installed in a high-end server that was sent to La Xarxa.

In parallel, Telefónica deployed and started with the configuration of the network infrastructure. AEQ technicians also traveled to Barcelona and installed the 12 Central Office codecs (MAIN/BACKUP, CONTRIBUTION and MULTICAST), as well as a provisional server used for their pre-configuration. Telefónica provided AEQ a convenient User Remote Access. Using it, AEQ engineers could connect to La Xarxa from Madrid and configure everything, install software in their computers, etc.

Afterwards, engineers from AEQ R&D department traveled to Barcelona for a few days in order to finish local devices configuration, installation of the latest applications versions, and provide an in-situ first demonstration of the operation of the system to La Xarxa technicians, so they could be able to continue testing and validating the solution. In fact, several comments were provided that allowed for a fast improvement of the software functionalities until a fully functional was available.

Once the definitive server was installed in Barcelona, Telefónica started the deployment of the Venus audiocodecs in all remote locations. In order to ease this task, AEQ engineering department elaborated a software installation and operation set of manuals for La Xarxa technical staff as well as a detailed installation and troubleshooting guide for Telefónica installers.

5. Conclusions

As of January 2017, more than 70 radio stations are already connected and the deployment continues at good pace, without remarkable issues, after overcoming the first network configuration issues, etc. that are usual in deployments of this magnitude.

There are considerable savings in running costs as compared to the previous satellite-based infrastructure. At the same time, important advantages have been gained, such as greater flexibility, low delay and the ability to establish bidirectional links.

Due to the large magnitude of the project, involving more than 140 audiocodecs, numerous challenges have been overcome. These challenges relate to traffic distribution (a solution based on multicast traffic has been adopted), network required bandwidth management, centralized device control and design of management tools that make this infrastructure more efficient and productive.

AEQ has also made a great effort adapting the software to La Xarxa specific needs, as well as documenting the installation and deployment of the applications and codecs (carried out by Telefónica) so this could be done in the most efficient way. In this direction, training has been provided in-situ to La Xarxa technical staff on the general system and each tool operation, and to Telefónica installers on the AEQ codec venue installation and basic configuration procedures.

VENUS audiocodecs provide a clean, seamless signal without interruptions and almost transparent quality by taking advantage of OPUS coding algorithm. This algorithm is proving to be an ideal solution for high-quality yet low-delay applications, offering great stability even with two stereo channels being used in the same audiocodec.

The software is being used in a daily basis and, together with the integration with BC 2000D matrix, it grants La Xarxa a great deal of flexibility to produce and broadcast programs together with the associated stations, in a fast and friendly way.

Technical staff from the three involved parts showed a great deal of implication from the very first moment, what allowed for the resolution of all the issues in a very short time.

As can be seen in this application note, this system presents many new features. We believe that they will be used in future audiocodec deployments for audio contribution and distribution over dedicated IP networks for radio station sets.



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