ISITEP
D4.3.2 - TETRA-TETRAPOL GATEWAY INTERFACES DESIGN

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REVISION TABLE

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Publishable extended abstract

This document is a technical description of the interface that will be used to connect a TETRAPOL and a TETRA network in ISITEP. It is based on the technical requirements of D4.3.1 deduced from operational requirements gathered in WP2. It is also based on the preliminary definition of TETRA ISI over IP of WP41. As the definition is not complete when this deliverable is released, it has to make some assumptions and keeps as a back-up solution the usage of the E1 interface to connect TETRA network and ensure the demonstrations within the ISITEP project.

CONTENTS

1. INTRODUCTION

1.1 ISITEP at a glance

ISITEP (Inter System Interfaces for TETRA-TETRAPOL Networks) project will achieve operational

interoperability among European first responders addressing the regulative, organizational, operational and technical level. ISITEP (Inter System Interfaces for TETRA-TETRAPOL Networks) project will achieve operational interoperability among European first responders addressing the regulative, organizational, operational and technical level.

The project will define public specifications of technical and procedural innovations, as well as novel processes for safety applications.

Figure 1: ISITEP framework

The general objective is obtained jointly addressing four components that are coherently defined, developed and integrated through a novel Framework which is constituted by:

A Mission-oriented Framework containing a standardized model of operational procedures and associated functional radio model

A European Inter System Interface (ISI) cloud network integrating the PPDR national infrastructures to allow roaming capability services within a secure framework.

Enhanced User Terminals: integrating TETRA/TETRAPOL technology into a novel terminal architecture based on programmable devices (Tablet, Smartphones).

Interoperability enabling tools including tools for infrastructures dimensioning, training, business model assessment and services for safety operations.

1.2. WP43 and status of this deliverable in WP43

In this work package, a hardware and software solution for ISITEP will be developed so that interoperability between TETRA and TETRAPOL networks meets user requirements dealing with security (key exchanges algorithms, quality of service), performance (low latency) and connectivity (easy to deploy and configure).

This solution will connect to TETRAPOL and TETRA network, providing seamless access to the common services offered by both networks (voice, messaging using SDS and status, ...). As part of

the standard ISI over IP protocol, this gateway solution will implement authentication like a TETRA network.

Specific objectives include:

• Verification of Isitep requirements for TETRA-TETRAPOL interoperability.

• Interface design.

• Hardware and software development.

• Unitary testing

This deliverable D43.2 constitutes the interface design for the gateway to connect both to TETRAPOL and TETRA networks. This deliverable takes into account TETRA ISI over IP preliminary specification from WP41.

Please note that TETRAPOL ISI is not defined in TETRAPOL specifications and no implementation of such an interface is deployed on existing TETRAPOL networks.

2. DESCRIPTION OF LEGACY NETWORKS INTERFACES

2.1. On-air interfaces

Mobiles of different networks use different Air interface protocol. As a consequence, TETRA mobiles cannot communicate under a TETRAPOL infrastructure and TETRAPOL mobiles cannot communicate under a TETRA infrastructure. The study of an enhanced terminal able to roam from TETRA to TETRAPOL is the focus point of ISITEP WP5.

2.2. INI – Inter Network Interface

TETRAPOL ISI is not defined in TETRAPOL specifications and no implementation of such an interface is deployed on existing TETRAPOL networks.
TETRA ISI represents a set of basic services necessary to support communication between home and visited network. ISI is an ETSI standard, which is supported by some TETRA manufacturers. Currently, a new ISI is developped : TETRA ISI over IP. Preliminary specifications have been provided from ISITEP WP41.

2.3. CONTROL ROOM INTERFACE

2.3.1. TETRA Control Room Interface

This interface is not standardized and is specific to any vendor (TCS for Cassidian, ACAPI for Rohde & Schwarz and CAPI for Motorola…). So a media and signalling gateway is necessary to interconnect different networks together. The Control Room interface can include provisioning features and so all use cases are in theory possible.

2.3.2. TETRAPOL Control Room Interface

The TETRAPOL Control Room Interface is the only interface available on TETRAPOL to have access to basic services on the TETRAPOL network.

The TETRAPOL Control Room interface is specified in the TETRAPOL specifications and is called CC-API. This interface is not directly accessible on some networks such as Polycom in Switzerland, where an additional layer has been added over the CC-API and the interface is called S-PRO connector.

This interface can be complement with the CC-IS interface to allow provision and setup additional mobiles on the visiting network.

2.4. Access security

Each radio terminal of the TETRA or TETRAPOL network shall be registred into the network and is reconnized by its ID.
Therefore, at the gateway level, it shall be possible to authorize or not each radio terminal.to perform one facility or another.

2.5. Status on legacy PMR networks external interfaces : TETRAPOL network

2.5.1. TETRAPOL network

2.5.1.1. System overview

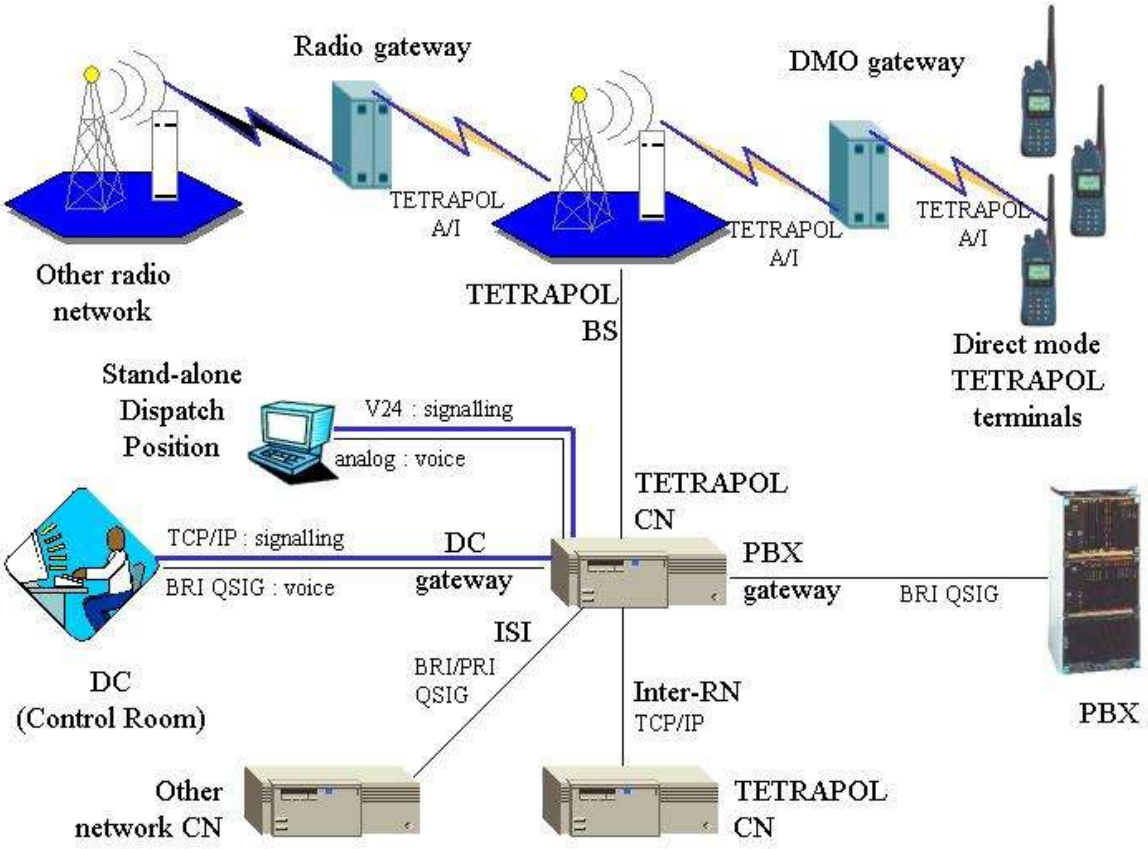


Figure 2 : TETRAPOL network elements (and interfaces)

Interfaces are classified as:

- **Terminal interface**: They are based on a device that has the same functions as a radio or wired TETRAPOL terminal. In particular, they support communications from between an Access Gate (AG) and external interface point, with voice in clear, analog or G711 coded.
- **Network interface**: They are connected on the Control Node (CN) and are considered as infrastructure links. They support CN to CN service with voice coded and encrypted.

2.5.1.2. TETRAPOL Terminal based interfaces

2.5.1.2.1. TETRAPOL Stand-alone dispatch position (SADP) interface

This interface provides voice and signalling interfaces from a TETRAPOL CN to a dispatch position.

Services:

- All voice services
- Status
- SMS services
- Network state information
- End to end encryption is supported from TETRAPOL users up to the gateway.

Interface:

- The component, so named access gate (AG), is embedded in the dispatch position.
- The signalling interface uses a V24 link that carries control signalling, status and system state signalling.
- The AG converts coded and ciphered voice into analog clear.
- The voice interface contains one analog with 4-wire voice line + 2-wire signalling for PTT management.
- The SADP contains a single AG that supports a single communication.

Availability:

- Existing equipment.

2.5.1.2.2. TETRAPOL Control room gateway

This gateway provides voice and signalling interfaces from a TETRAPOL CN (Control Node) to a control room.

Services:

- All voice services

- Status
- SMS services
- Network state information
- End to end encryption is supported from TETRAPOL terminals up to the gateway.

Interface:

- Components, so named access gates (AG), are wire-connected and embedded in the CN, or connected by TETRAPOL radio.
- The AG converts voice coding into G711 or analog and translates ciphered flows in clear.
- The CORBA-based signalling interface uses a TCP/IP link common to all access gates. It supports call control signalling, status and system state signalling.
- The voice interface presents one link for each AG that can be analog or digital :
  - Analog : uses 4-wires voice line + 2-wires signalling for PTT management
  - Digital: uses an ISDN BRI with a single permanent voice channel in B-channel and PTT management in QSIG FACILITY messages.
- An AG supports a single communication. A digital control room interface is generally made of several AG. The number of BRI at DC side shall be equal to the number of AG (only one B-channel is used).

Availability:

- Existing equipment.

2.5.1.2.3. TETRAPOL PBX gateway

This gateway connects a TETRAPOL RSW to a PBX via an ISDN BRI line with QSIG signalling.

Services:

- Individual call
- End to end encryption is supported from TETRAPOL terminals up to the gateway.

Interface:

- Components, so named access gates (AG), are embedded in the CN. Using several access gates provides the possibility to manage several simultaneous calls.
- The AG converts voice coding into G711 and translates ciphered flows in clear.
- Each AG presents a single ISDN BRI interface using standard QSIG-BC signalling. This interface does not manage end-to-end PTT. Half duplex is managed by the AG using VAD.
- An AG supports a single communication. A PBX interface is generally made of several AG's. The number of BRI at PBX side shall be equal to the number of AG (only one B-channel is used).

Availability:

- Existing equipment

2.5.1.2.4. TETRAPOL Gateway to external radio network

This gateway provides an interface between TETRAPOL and another network via the air interface.

Services:

- Group communication.
- End to end encryption is supported from TETRAPOL users up to the gateway. The same for the other network.

Interface:

- The gateway is made of a TETRAPOL device that behaves like a radio terminal and of a similar device of the opposite network. In particular, they have to register in their respective network.
- The TETRAPOL side converts TETRAPOL coded and ciphered flows into analog and clear. The same is done at other network side.
- They are connected by a line that transmits voice and PTT signalling at the other side without any processing.
- A gateway supports a single communication.

Availability:

- Existing equipment.

2.5.1.5. TETRAPOL DMO gateway

This gateway ensures the continuity between a TETRAPOL group communication and a group of TETRAPOL terminals in direct mode.

Services:

- Group communication.
- Network end-to-end encryption is supported from TETRAPOL users up to the gateway. Direct mode encryption is supported from users in direct mode up to the gateway.

Interface:

- The conception of the DMO gateway is close from above external radio network gateway. Users can select the TETRAPOL group communication and the direct mode channel they want to connect together. This is done by gateway MMI.
- A gateway supports a single communication.

Availability:

- Existing equipment.

2.5.1.16. TETRAPOL Network interfaces

- TETRAPOL Inter RN link

Inter-RN links connect TETRAPOL CN and provide complete interoperability of terminals of the RN relative to the connected CN.

Services:

- All voice and data end to end services
- Supplementary services
- Mobility
- Continuity of TETRAPOL interfaces.

Interface:

- TCP/IP link with proprietary signalling and RTP for voice packets.
- On this interface, voice is coded and ciphered.

Availability:

- This is not a standard TETRAPOL interface (proprietary).

- TETRAPOL Inter-System Interface (ISI)

No ISI product exists at this time.

Availability:

- Not implemented.

2.5.2. TETRA network

2.5.2.1. System overview

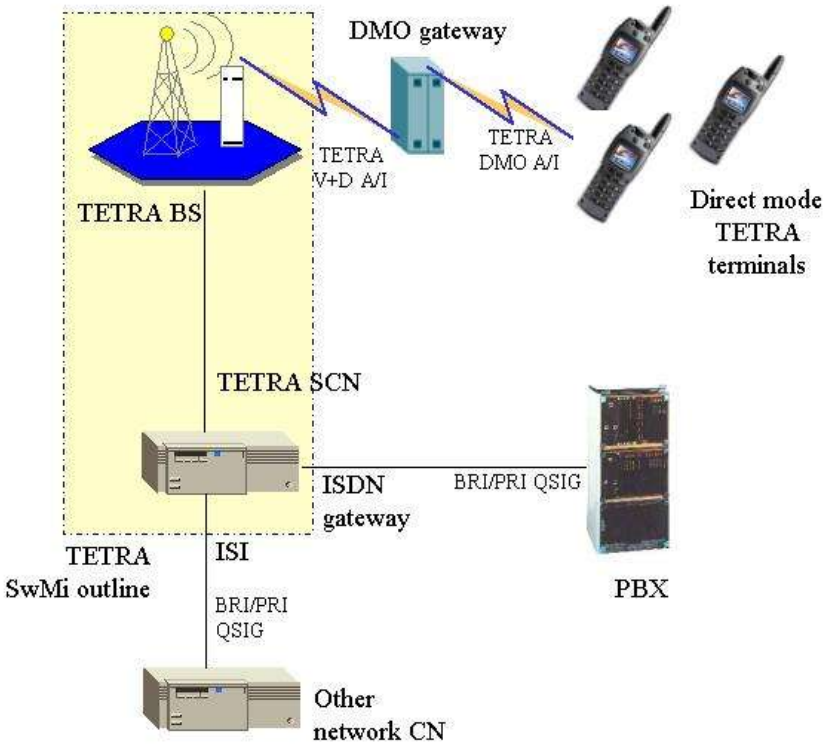


Figure 3: TETRA network elements (and interfaces)

2.5.2.2. TETRA Terminal based interfaces

2.5.2.2.1. TETRA DMO gateway

The gateway connects the TETRA SwMI via the air interface.

Services:

- Group communication.
- Status messaging
- Individual calls are supported only from direct mode terminals to network mode terminals (to be confirmed).

Interface:

- Note that TETRA supports 2 different air interfaces, one at SwMI side (TETRA V+D A/I) and another one at direct mode side (TETRA DMO A/I).

Availability:

- Implemented by several vendors including ESNFI

2.5.2.3. TETRA Network interfaces

2.5.2.3.1. TETRA Inter-System Interface (ISI)

The ISI is for connecting two or more TETRA networks and ensures full interworking between these networks: voice and data communications, mobility…

The ISI can also be used between non-TETRA networks at least for ensuring interworking communications.

The gateway connects SCN (Switching Control Nodes) on a BRI/PRI QSIG (PSS1) line for individual or call, mobility and supplementary services.

Services:

- capability for subscribers to migrate to another network
- mobility management, i.e. location updates to home network HLR
- individual TETRA direct calls across the ISI
- PSTN telephone calls when migrated
- short data messages to individual TETRA addresses
- status messages to individual TETRA addresses
- calling party ID delivery
- joint voice groups to enable group communication between two networks
- control room workstations to communicate with users in both networks: telephone, direct calls, short messages, data as well as connecting to joint voice groups

Interface:

- The ISI uses a link between control nodes. It carries coded and encrypted voice and uses QSIG signalling.
- The connection is achieved via a TETRA SAP (Service Access Point) of the Control Node that converts ciphering and coding of the foreign network into those of TETRAPOL.

Availability:

- Implemented by vendors including ESNFI in TETRA rel 5

2.5.2.3.2. TETRA ISDN gateway

This gateway interfaces TETRA SCN (Switching Control Nodes) to an external telephone network.

It makes it possible for an external telephone subscriber to be involved into a TETRA individual or group call.

The gateway connects SCN on BRI/PRI QSIG (PSS1) line for basic call and supplementary services.

Services:

- Group communication and individual communications.
- Supplementary services
- Mobility
- Homogeneous addressing plan using PSTN addresses conversion.

Interface:

- ISDN BRI or PRI with ISDN or QSIG signalling.
- The standard foresees also a variant on analog line so-named “PSTN interface”.

Availability:

- Existing equipment.

2.5.2.3.3. TETRA Control room gateway

Such gateway is not included in the TETRA standard. However, TETRA control room gateways, based on proprietary API are implemented basically by all TETRA vendors.

3. GENERAL INTERFACE DESIGN

3.1. General overview and configuration

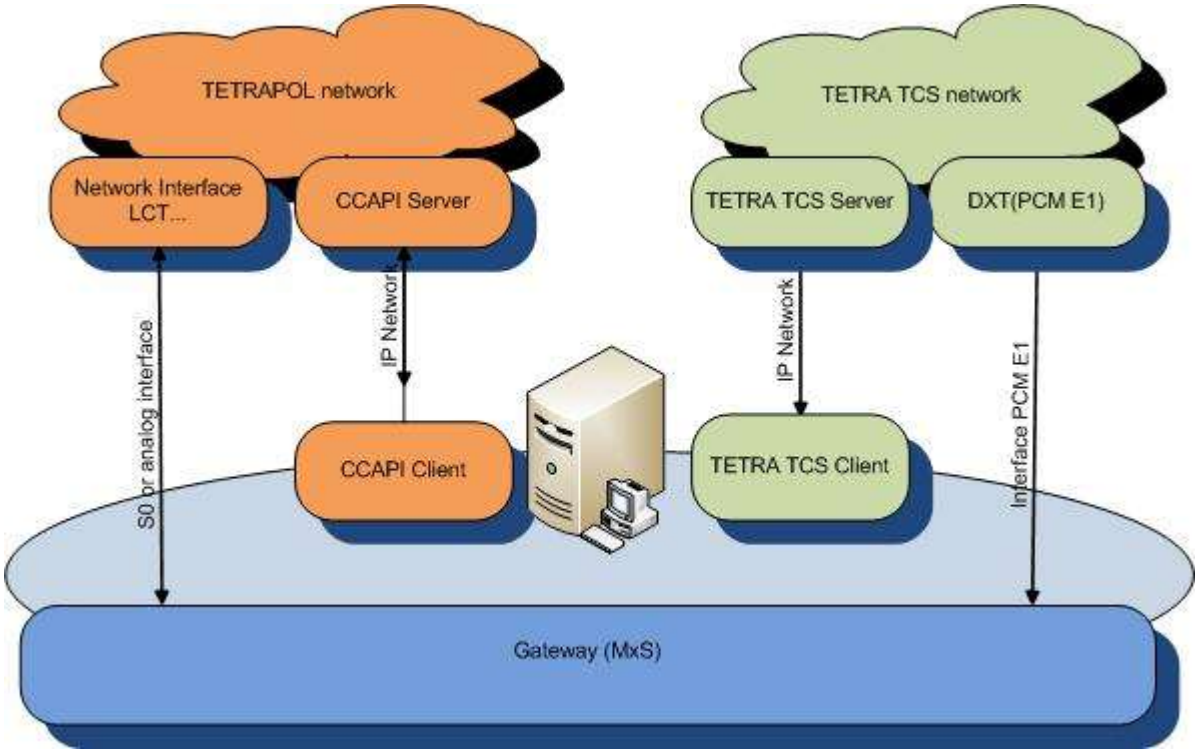
The TETRA and TETRAPOL networks must be interconnected through a gateway. On TETRA side, we have the choice of 3 possible interfaces (Control Room Interface, ISI and ISI over IP), but for TETRAPOL, only the Control Room Interface is available. In order to facilitate the proof of concept of the interconnection, it is preferred to use at both ends the Control Room interface and to use only one gateway. At the time this deliverable is written, we have only some preliminary specifications of ISI over IP from WP41 and the work of standardisation in ETSI may take a long time. That's why the general considered solution leans upon TETRA control room interface in order to derisk the PoC. Nonetheless, in the ISITEP context, the TETRA ISI over IP will be commented upon in this document.

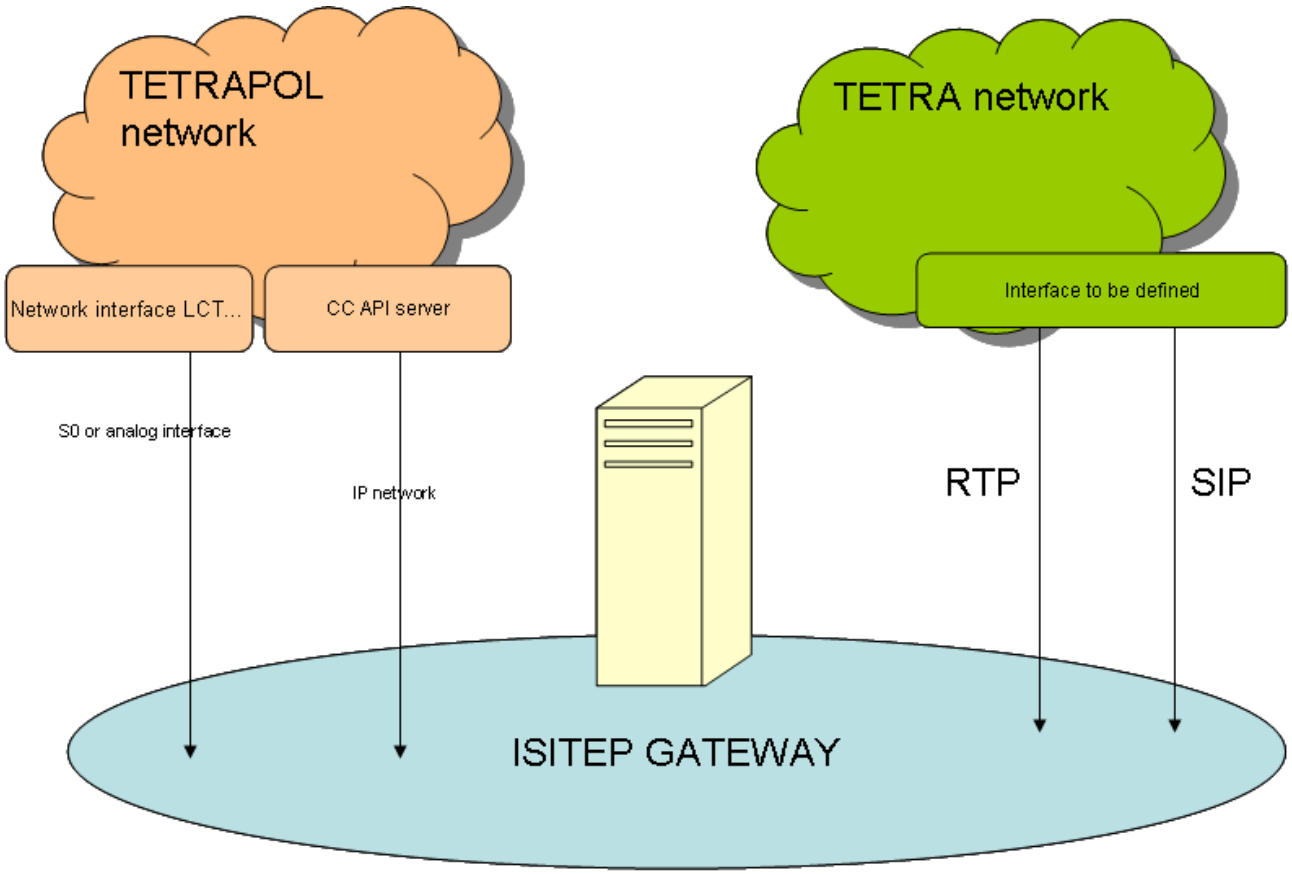
The gateway is connected to the two different networks through a Control Room Interface composed of

- TETRA :
  - E1 for voice (G711 A law)
  - TCS interface for signalling.
- TETRAPOL :
  - Analogue Acces Gates (4w+Ti-Ack+RD+PTT loops) for voice
  - CC-API interface for signaling.

Alternately, in the case of using the TETRA ISI over IP, the gateway is connected to the two different networks through a Control Room and IP to be defined Interface composed of :

- TETRA :
  - RTP Tetra for voice (ACELP)
  - SIP for signalling.
- TETRAPOL :
  - Analogue Acces Gates (4w+Ti-Ack+RD+PTT loops) for voice
  - CC-API interface for signaling.





Available targeted Features:

- Group call : TalkGroup, MOCH (Multi-Site Open Channel) TETRAPOL and group call TETRA
- Private call : private call TETRAPOL and individual call TETRA
- Emergency private call : private call TETRAPOL and individual call TETRA
- Emergency group call : CRISIS or ESOCH (Emergency Single Open Channel) TETRAPOL and group call TETRA
- Status : SMS status TETRAPOL and Status TETRA
- SMS : SMS text TETRAPOL and SDSTLTransfer

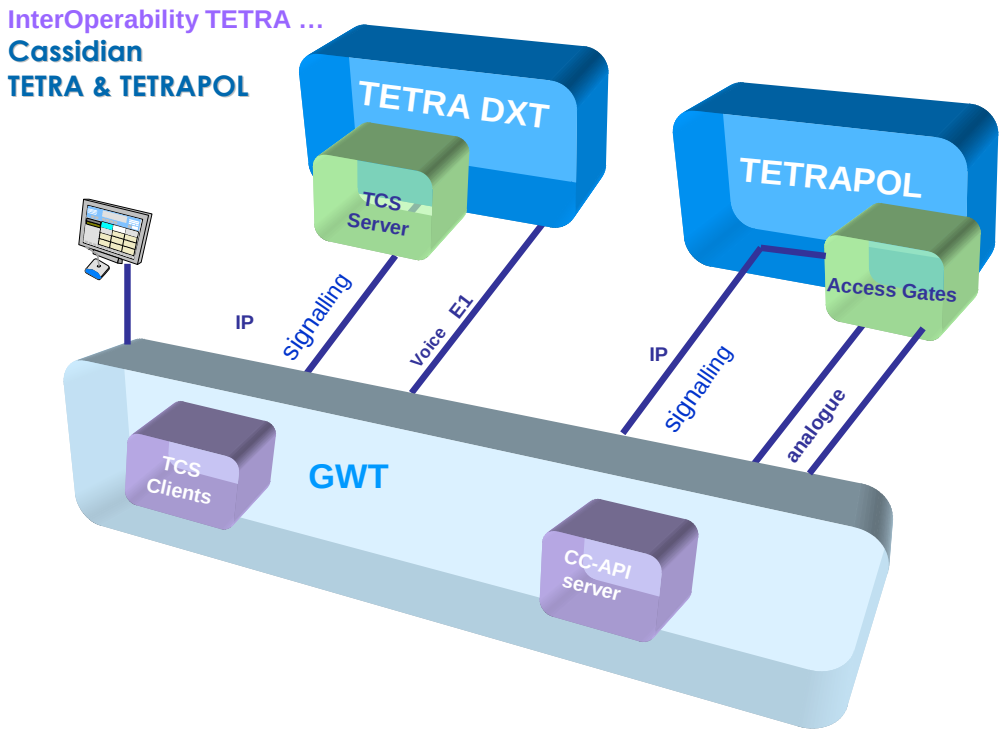
Not available Features:

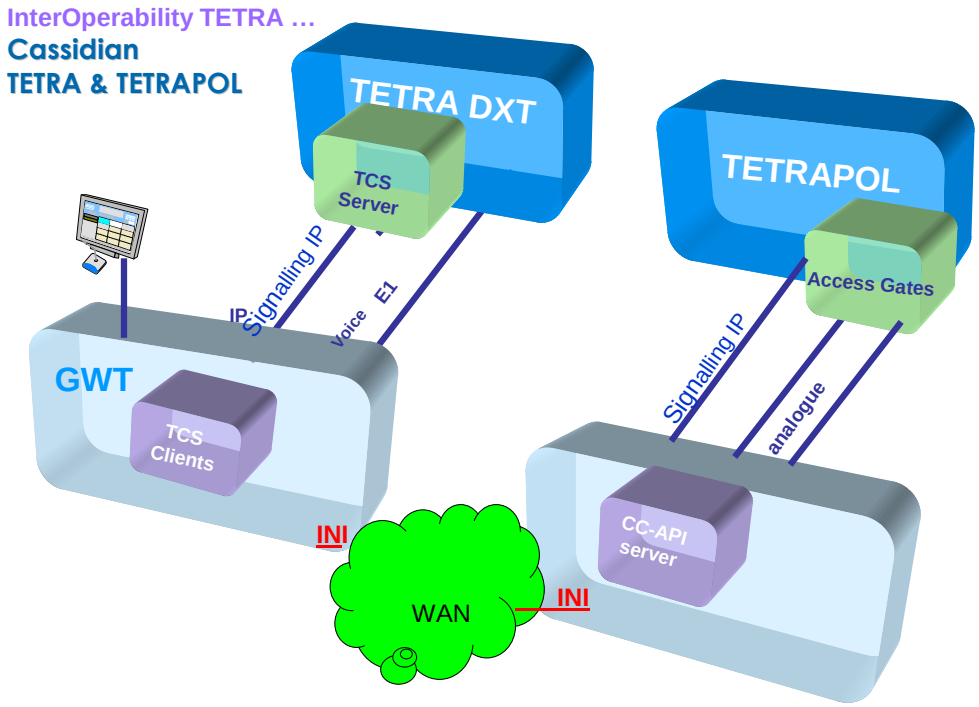
- Emergency group call : ESOCH (Emergency Single Open Channel) TETRAPOL,
- Notification of an emergency private call,
- Notification of an emergency group call (CRISIS or ESOCH).

The gateway can be interconnected to at least two networks. Each network has its own network code. This may vary according to users.

- TETRAPOL (network code : RN) : The network code is defined by 3 digits from the RN number. The user identification called RFSI under TETRAPOL uses 9 digits.
- TETRA : The user identification called ISSI for a subscriber and GSSI for a group under TETRA uses 1 to 9 digits. In the following example, only five digits are managed.

The easiest way from a gateway point of view is to have only one gateway connected to the two networks. However, it is more probable that TETRAPOL switches and TETRA switches of two different networks will not be located in the same place. In such a case an interface between the gateways must be defined. In the following document and synoptic, this interface is named INI.





3.2. Configuration

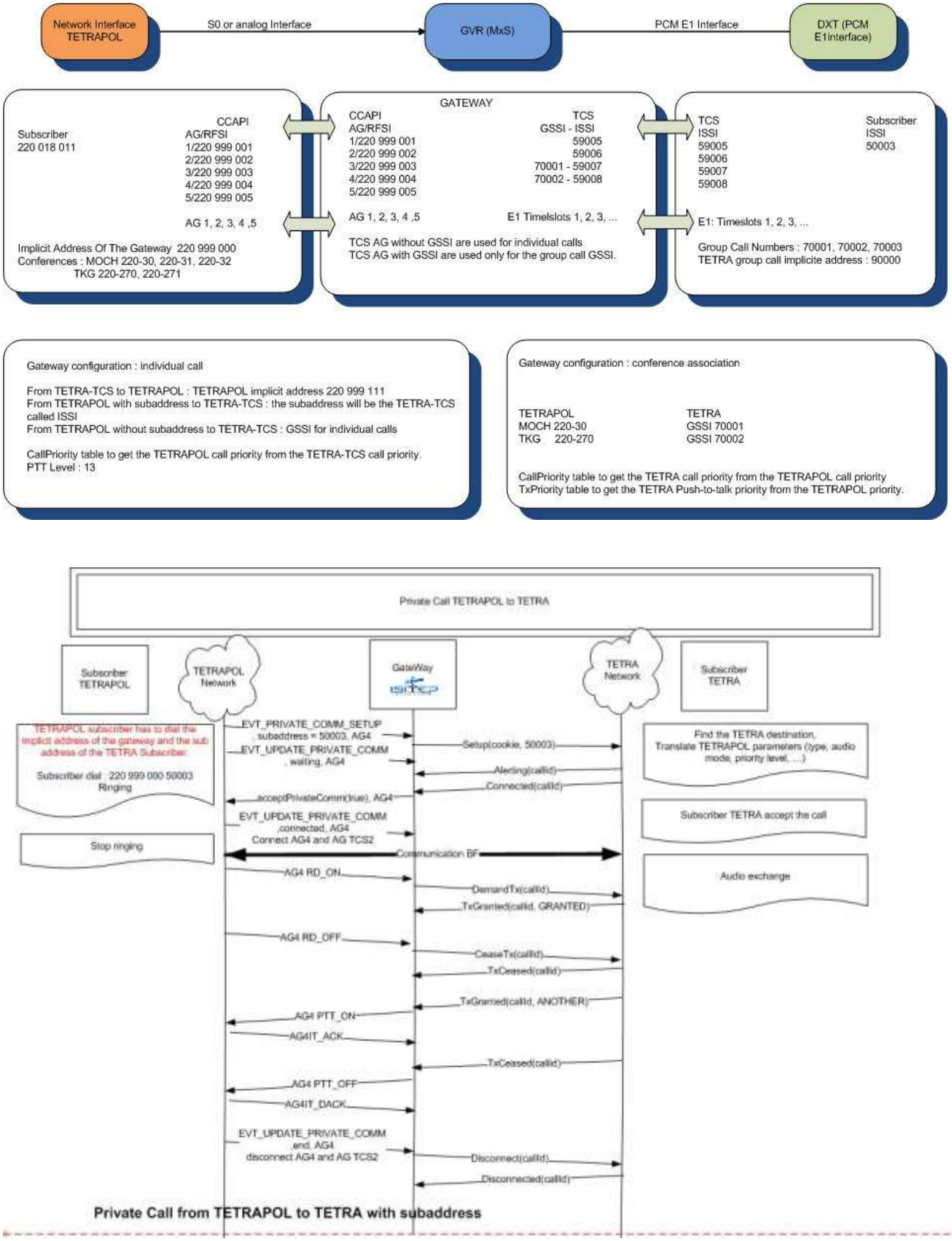


Figure 4: Example: private call TETRAPOL to TETRA with subaddress

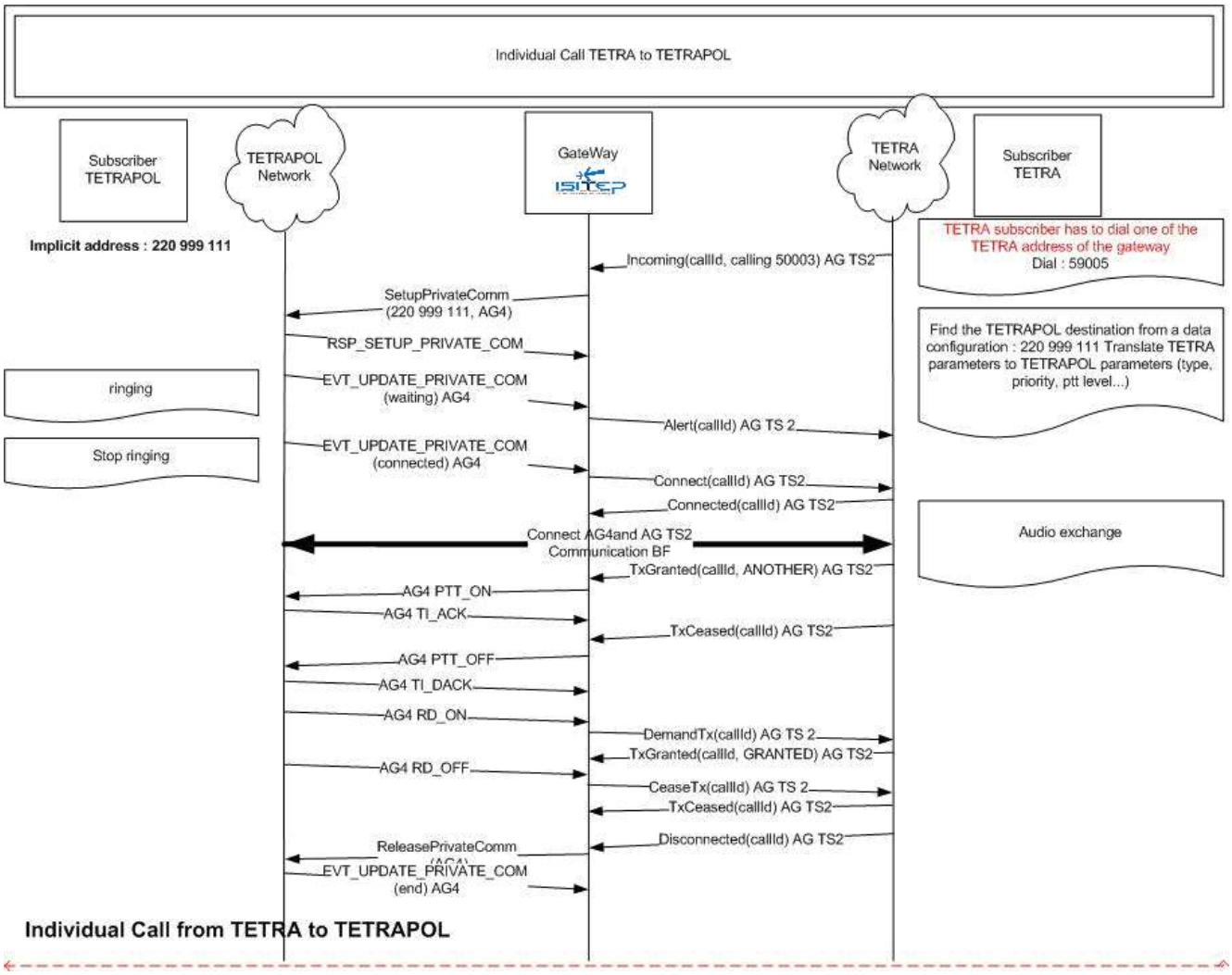


Figure 5: Individual Call from TETRA to TETRAPOL

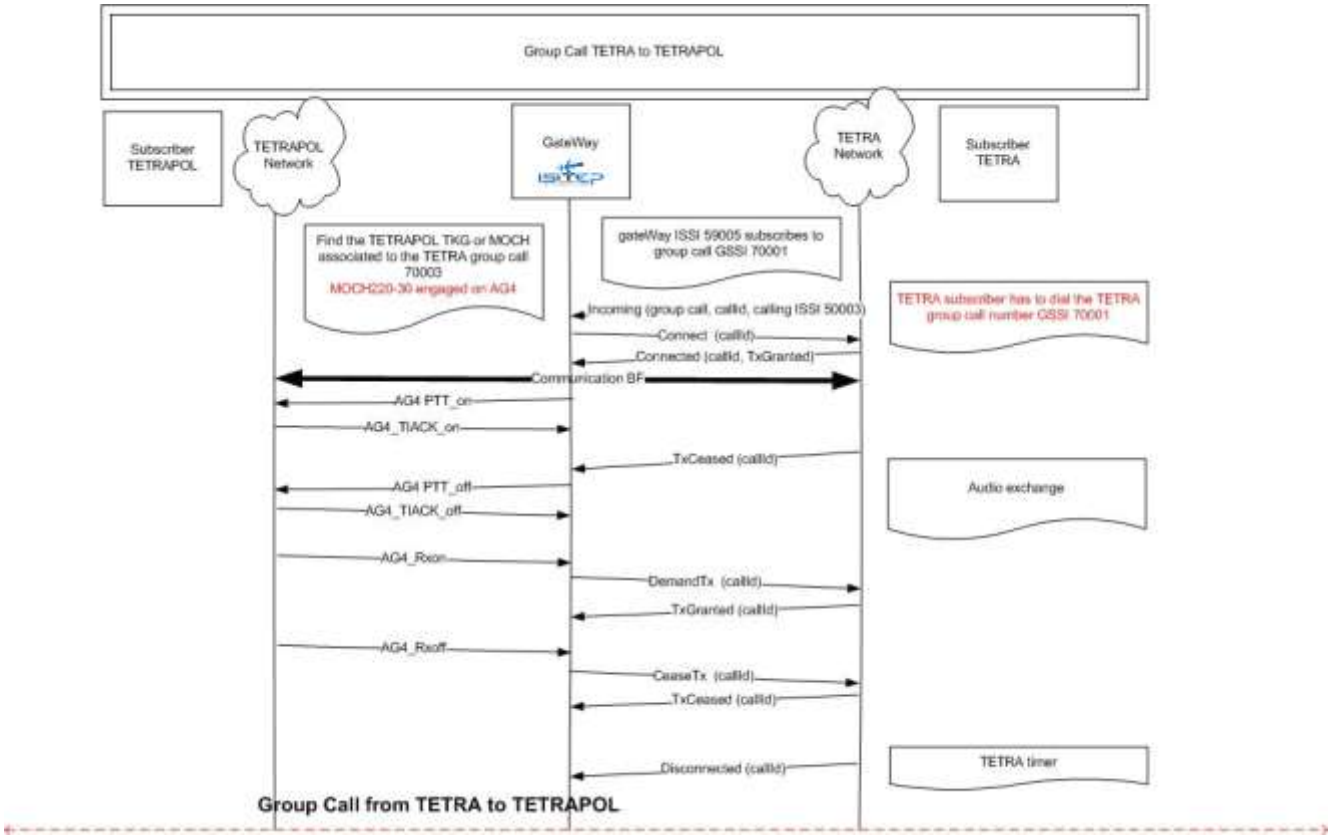


Figure 6: Group Call from TETRA to TETRAPOL

Features not supported:

- Configuration of TETRAPOL group on a TETRA network
  - A subscriber of the TETRAPOL network cannot configure a group in the TETRA network.
  - A subscriber of the TETRA network cannot configure and open a MOCH in the TETRAPOL network.
- Notification of accessible conference from TETRAPOL to TETRA
  - This indication is not sent to the TETRA network.
- Notification of merging from TETRAPOL to TETRA
  - This indication is not sent to the TETRA network.

3.2. Single GATEWAY implementation

3.2.1. Hardware implementation

The single gateway makes possible TETRA & TETRAPOL interconnections. Once again the two subcases must be differenciated. Starting for a TETRA E1 interface : this gateway is made up of:

- An Embedded computer which manages the signalling between the networks,
- A rack to host the gateway interfaces:
  - E1 for TETRA access,
  - Analog 8 wire access for TETRAPOL,
- An Ethernet switch to manage the IP connectivity for configuration and signalling.

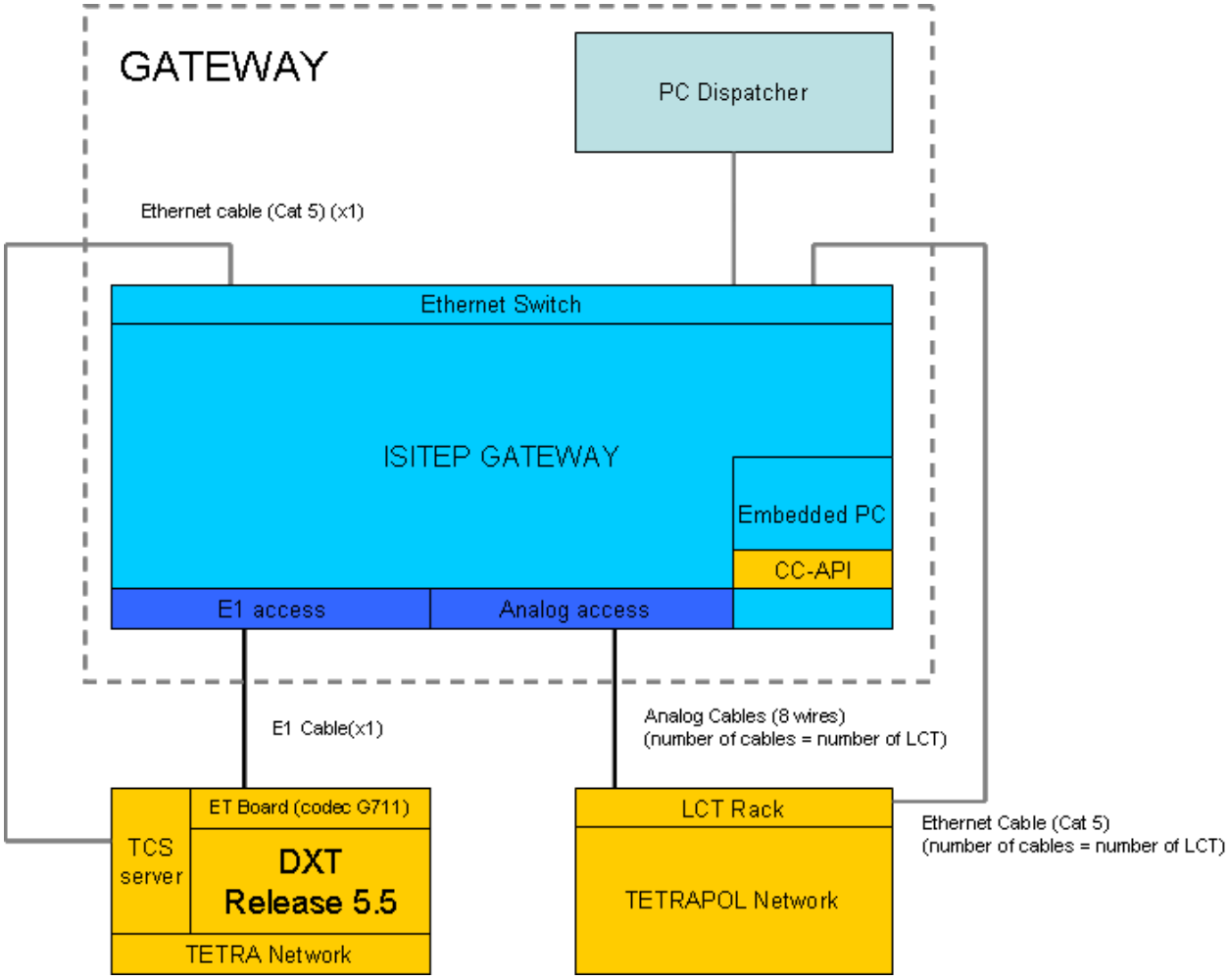


Figure 7 Single Gateway TETRA E1

In case TETRA interface is TETRA ISI over IP, this gateway is made up of :

- An Embedded computer which manages the signalling between the networks,
- A rack to host the gateway interfaces:
  - IP for TETRA access,
  - Analog 8 wire access for TETRAPOL,
- An Ethernet switch to manage the IP connectivity for configuration and signalling.

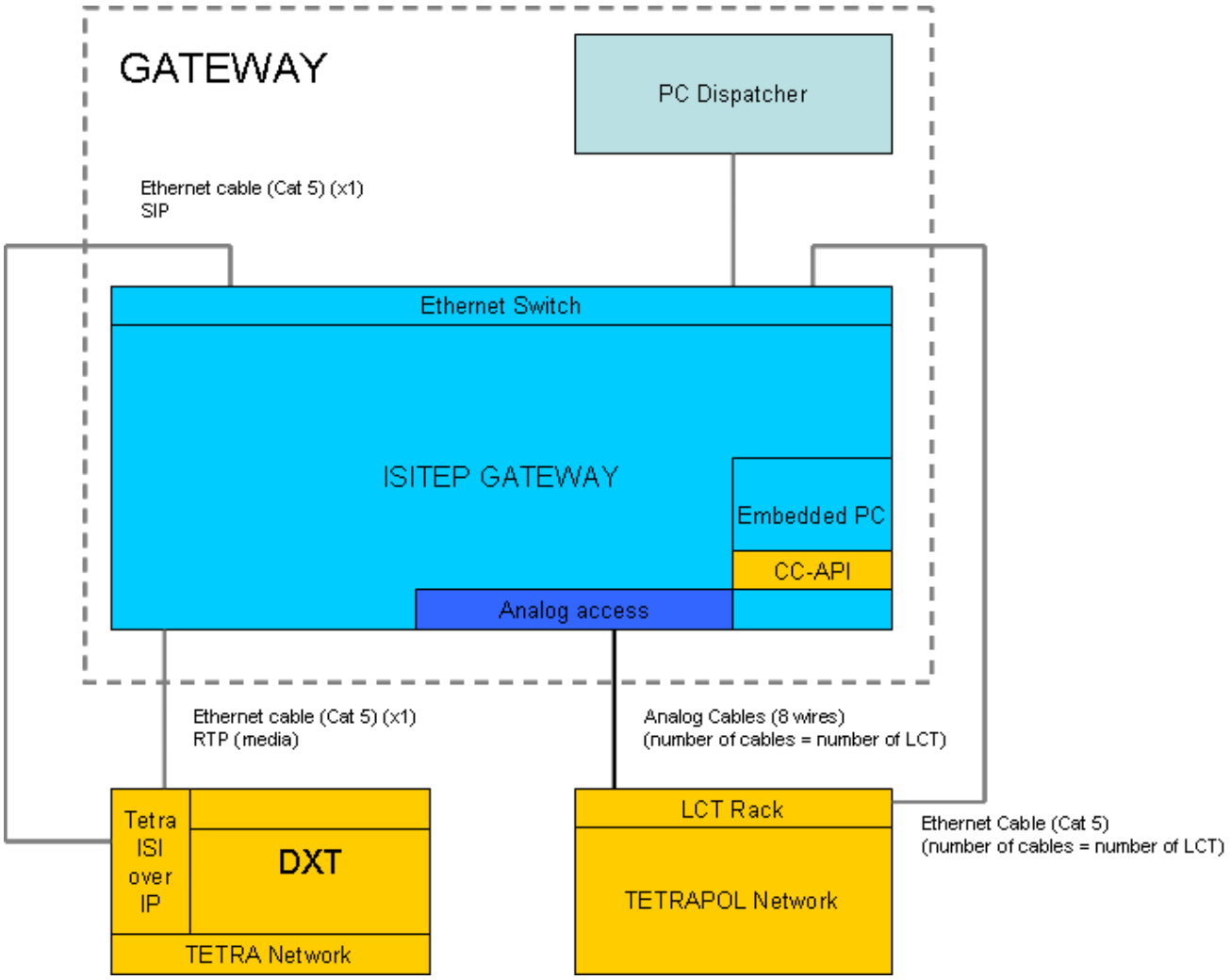
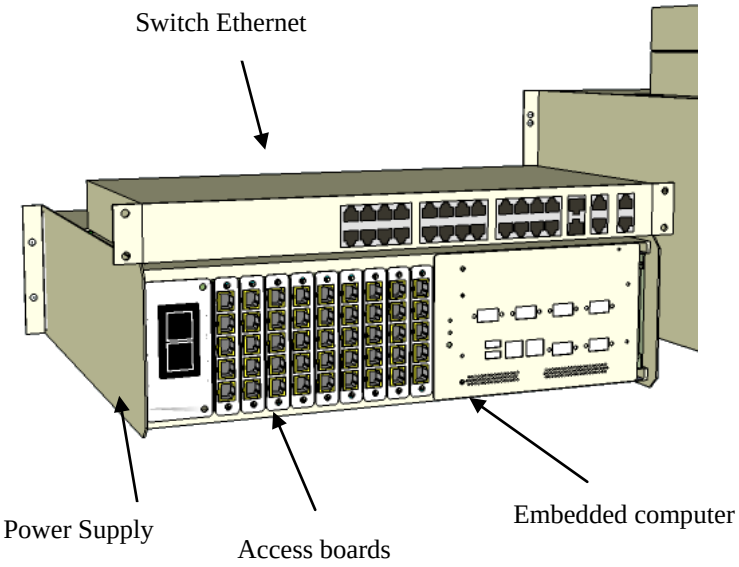


Figure 8 Single gateway : TETRA ISI over IP

The physical implementation of the gateway should look like the next figure :



3.2.2. Software implementation

The Central Management Unit (CMU) will be hosted on the embedded computer and is one of the key organs of the Gateway and performs many essential operations:

Supervision of the Gateway access and modules,
Signalling interface with digital networks (TETRA, TETRAPOL…),
Administration, equipment configuration and setup (network access, operator access, profiles, resource partitioning, priority levels, operation plans ...)
Interface for remote maintenance,
Event Log (events, alarms, communications…).

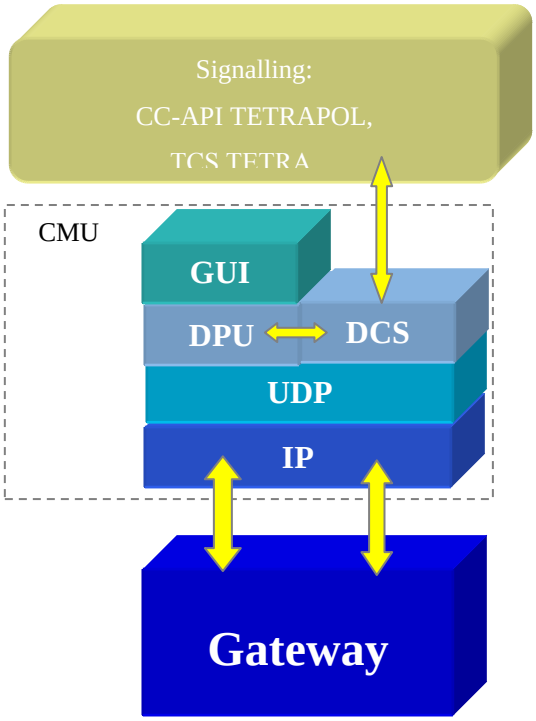
The Gateway Setup function and the processing of Gateway data are provided by the Data Processing Unit (DTU). The DPU deals:

- The access status,
- Conferences, Group calls, connections,
- Backup and recovery of configuration data stored on the CMU.

The real time call processing function is ensured by the Dispatch Control Server (DCS). The DCS has an essential role in the exchange of signalling with digital radio networks connected on the Gateway (example: data exchange with the TETRAPOL CC-API, or the TCS of EADS TETRA networks or the TETRA ISI over IP). The DCS is also used when multiple Gateway are interconnected.

Finally, the display function is provided by the Graphical Interface Unit (GIU). This GIU is a client process that can be installed on multiple machines, allowing multiple users to work simultaneously. In practice, a GIU may be present on each operator's computer.

Software layers for the signalling.

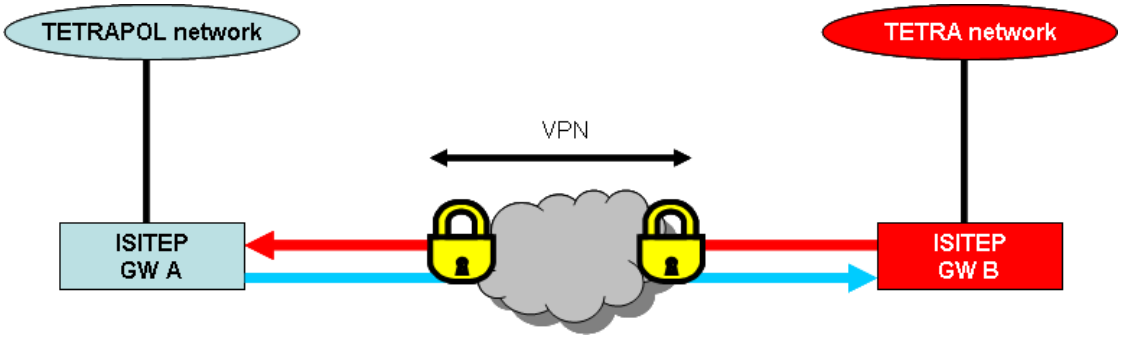


Real time media are directly managed by access board that will handle coding, transcoding, mixing, and interface adaptation through DSP associated with Access boards.

3.3. Dual gateway implementation

For this project another implementation has been proposed in order to take into account operational constraints. In fact, every national public safety radio network has their own procedure to authorize connection and interconnection on their network to ensure and maintain a high degree of security and confidentiality. Every administration wants to manage by themselves the authorization to allow the interoperability with another network on their network. It means that each operator can manage the settings on its own network.

For this reason, we can propose a dual gateway implementation defining an INI (Inter-Network-Interface) between the interoperability gateways.



The physical implementation of the dual gateway is similar to the single one except that each gateway will connect only one type of network and will have a secured IP connection with the other gateway.

The media flow can be encrypted between the two sites and above, an encrypted VPN can be set between the two remote sites.

Each gateway manages the configuration of its network (TETRAPOL or TETRA). It means that each operator can authorize or not the access of the user of the other network.

For the TETRAPOL network, the gateway is made up of:

An Embedded computer which manages the signalling between the networks,
A rack to host the gateway interfaces:
Analog 8 wires access for TETRAPOL,
IP access for the interconnection with the remote gateway,
An Ethernet switch to manage the IP connectivity for configuration and signalling.

For the TETRA network, the gateway is made up of:

An Embedded computer which manages the signalling between the networks,
A rack to host the gateway interfaces:
E1 access for TETRA TCS or IP access for TETRA ISI over IP,
IP access for the interconnection with the remote gateway,
An Ethernet switch to manage the IP connectivity for configuration and signalling.

To facilitate the operations, it is possible to have an application that will display the available talkgroup where an interconnection is possible. This type of interface is much more suitable for operational rather than technical people. In fact, the solution should be put in place easily once installed and not require a technical staff anytime an interconnection is necessary.

4. TETRAPOL – TETRA ISI OVER IP

At this step WP41 is not finished and we have only a partial view on what will be TETRA ISI over IP. Nonetheless, we would like to analyse the first outcomes of WP41 and envisage a global solution for this type of gateway.

4.1. Architecture Overview

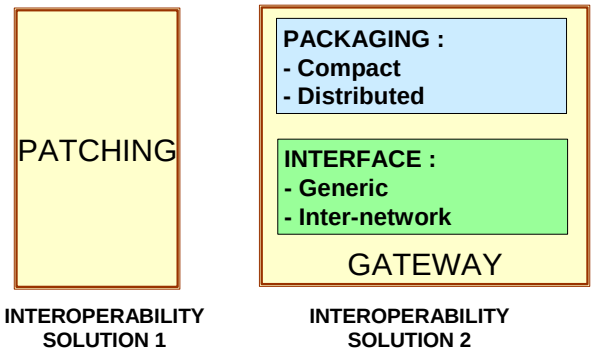


Figure 9: Gateway design for interoperability

There are 2 major types of interoperability:

Patching via an external switching unit (for example in the Control Room)

Patching provides an external connection of calls managed independently of others in different networks.

Using a specific device named a "**gateway**" that is built according to 2 characteristics:

- The packaging that can be:
  - Compact in a single box
  - Distributed in several boxes
- The system interface that can be :
  - A generic interface that is independent of network internal mechanisms
  - An inter-network interface that exports system features into another network.

In opposition with the previous patching, the gateway provides end-to-end service between connected networks.

The next figure presents the architecture in order to interconnect a TETRA network and a TETRAPOL network.

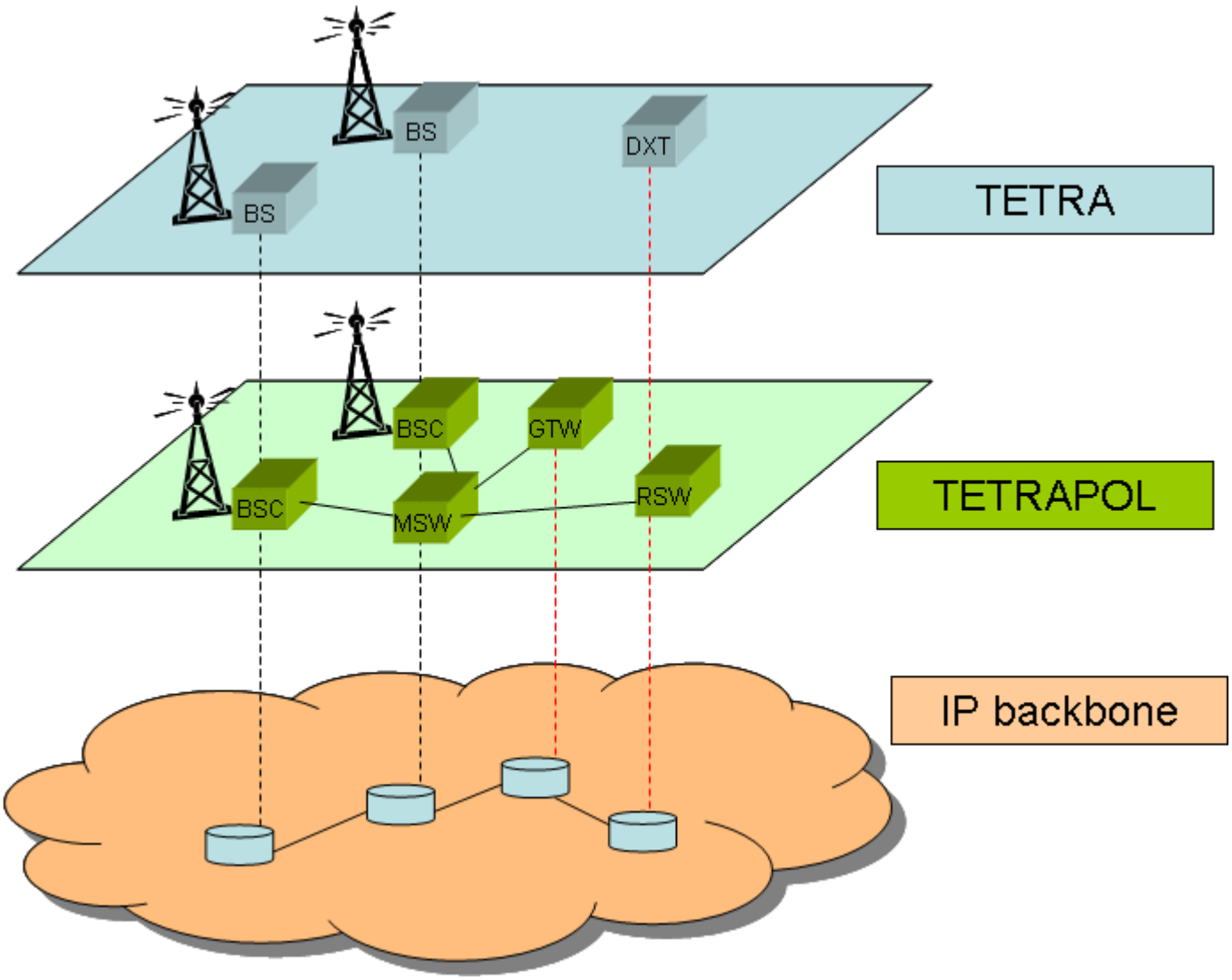


Figure 10 : Zoom on ISI over IP solution

The interoperability between the two networks consists on adding in the TETRAPOL network a new subsystem acting as a gateway with the TETRA network. This gateway acts as a TETRAPOL application server, and communicates over the ISI over IP on appropriate TETRAPOL application.

4.2. Interfaces:

The interface between the TETRA and the gateway is based on:

- SIP protocol for the signalisation protocol
- The group attach / detach by TETRA terminals or network is processed through the SIP register / deregister messages

- The group call set-up by TETRA terminals or network is processed through the SIP invite messages
- RTP / RTCP protocols for the voice transport protocol

The group call services rely on the IP multicast routing. Each attendee of the group call, when the PTT token has been acquired, through a TETRA application signalling mechanism out of the scope of this documents, sends its RTP stream in unicast to the TETRAPOL switch, which in turn forward the stream in m-cast to all the attendees. Since the speaker seen by each attendee is the TETRAPOL switch, all RTCP packets are sent in unicast to the TETRAPOL switch by the attendees.

The interface between the gateway and the TETRAPOL network is based on the TETRAPOL protocol.

4.3. Routing

The following paragraph describes the way the messages are routed between the TETRAPOL network and the TETRA network. This paragraph takes into account the limitations introduced in the previous paragraphs.

4.3.1. Registration:

For the registration phase, the gateway behaves like a SIP REGISTRAR, a logical entity that handles SIP register messages from the TETRA GTW:

The TETRA GTW sends a SIP register message to the TETRAPOL network

The gateway processes the TETRA network request (the gateway matches between the SIP URI and the IP address of the TETRA GTW) and sends the appropriate TETRAPOL registration message to the TETRAPOL Home switch.

The TETRAPOL Home switch processes the TETRAPOL registration message as it does for messages from TETRAPOL terminals, sending the response to the terminal.

The gateway translates the TETRAPOL response into the appropriate SIP message and sends the SIP response to the TETRA GTW

4.3.2. Deregistration:

To be disconnected from the network:

The TETRA GTW must send a SIP REGISTER message with the Expires header set to zero in order to remove the association between his SIP-URI and his IP address in the Location service.

The gateway responds to the terminal with a 200 OK SIP message.

The terminal stops sending request (register (activity)) to the server so that the gateway does not send the TETRAPOL location activity message.

After the timers, in the gateway for TTI time life, the GTW is removed from the TETRAPOL network.

4.3.3. Affiliation:

In order to participate in a group communication, the user must be affiliated with the group communication.

Affiliation is just done on TETRA side, there is no message sent to the network informing TETRAPOL on which group the user is affiliated:

A SIP register message is sent conveying the list of group communications to which the user wants to be affiliated with.

The gateway responds with a SIP 200 OK message containing the group communications multicast addresses of each group.

In the same time, the gateway sends a TETRAPOL location activity message to maintain the TTI and rearm the timers in TETRAPOL in order to detect an activity of the GTW.

4.3.4. Group call:

If the TETRA GTW is the calling party:

The TETRA GTW initiates the group call by sending a SIP invite message (containing in the *To* header the SIP URI of the selected group call) to the gateway.

Then the gateway sends a TETRAPOL group activation message to the TETRAPOL switch (as a TETRAPOL terminal does).

If the TETRA gateway is allowed to initiate the group call, the TETRAPOL switch sends a group activation response message (including the call parameters) to the gateway.

Then the TETRAPOL gateway sends a *200 OK* SIP message (with all parameters about the group communication session) to the TETRA GTW.

A unicast RTP session is set and the user can send the voice over the UDP in the uplink when he presses the PTT.

If the TETRA GTW is the called party, it receives from the gateway the call in the multicast address received in the affiliation step with the group call. The voice session is set over UDP.