

televic

WHITE PAPER

Digital fallback solutions for railway audio systems: the good without the bad

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Part One

Summary

For decades now, audio systems have played an important role in informing passengers and facilitating communication between drivers and crew members on board trains.

In recent years, digital Ethernet connections have hugely broadened the functionality of these audio systems. UIC568 (°1996), the international standard for audio communication in railway applications, has not evolved to include Ethernet-based communication.

However, the standard is still used as a fallback option in case of Ethernet failure. This has several limitations. These can be overcome by dual homing, an Ethernet redundancy option with a big cost impact.

In this white paper, we propose an alternative fallback solution. TRACS (TRain Audio Communication System) is Ethernet-based and supports all features that come with it while remaining cost-efficient: the best of both worlds.

The gap between standards and requirements

A couple of decades ago, when only analogue audio and signalling were used for communication purposes, five audio functions were deemed essential:

1. Public address (manual) from the driver or the crew to passengers
2. Intercom between crew and driver
3. Intercom between crew and dispatching on wayside (via radio)
4. Intercom between driver and dispatching on wayside (via radio)
5. Broadcast of music or speech to passengers via tape recorder

Intercom between driver/crew and passengers was not considered because the staff on board needed to address any assistance or emergency requests physically.



This is reflected in the international UIC558 (1996) and UIC568 (1996) standards. Both standards address interoperability to:

- Guarantee the satisfactory operation of the audio system even when large numbers of coaches from different railways are coupled together (e.g. to form an international train)
- Ensure a minimum broadcasting quality
- Since then, digitalisation introduced several additional functions (for further reading, see attachment)
- Intercom with passengers
- Differentiation between a call-for-aid and a passenger alarm
- Different announcements in different zones of the train
- Conferencing between 3 or more crew members
- Self-test capabilities

However, the UIC558 and UIC568 standards did not evolve to include these new functions. While the standards remain active to this day, the Technical Specifications for Interoperability (TSIs) in European Directive 2016/797 were also adopted.

This EU directive defines the essential requirements for interoperability in the European Union. The possibility of two-way communication between passengers and crew is one of them.



Part Three

Ethernet: back to physical compatibility

Since the new requirements were not part of the UIC568 standard, different vendors of railway audio communication systems started implementing proprietary additions to the UIC568.

Often, a data communication was added to meet the additional functional requirements, while the analogue lines were kept for ‘traditional’ audio communication.

This data bus was implemented under different forms, such as RS458 or CAN. This means that systems from different vendors weren’t physically compatible anymore, let alone functionally compatible.

After a while, Ethernet technology was widely adopted in railway. Now, the physical medium for audio and control information between (sub)systems was de facto standardised. Ethernet supports much more data traffic than before and opens up possibilities for innovations like remote control and advanced diagnostics.

Physical compatibility still doesn’t guarantee functional and protocol compatibility. Stable and complete standards like UIC568 no longer provide an answer due to the growing complexity and the rapid evolution of software.

However, agreements about a communication framework with a basic feature set exist, as can be found in the IBIS-VDV301 and ITxPT standards.

Part Four

Using UIC568 as a fallback path: functional drawbacks

The introduction of Ethernet technology has rendered UIC568-based communication functionally obsolete. However, as UIC568 has a proven track record and is well-known, it is still widely used by audio communication vendors as a backup (also known as ‘fallback path’) in case the Ethernet backbone fails. When coupled with older vehicles that are not retrofitted with Ethernet, basic functionality is still supported.

Using UIC568 as a fallback medium has significant drawbacks:

- Due to the limitations in the number of wires, many Ethernet functions are simply impossible (e.g., crew conferencing, the driver wants to contact crew). UIC568 only supports Public address (PA) and crew intercom. Any additional functionality results in a proprietary solution and an interoperability issue between systems of different vendors.
- No audio communication by the passengers is supported by default, and if implemented, queuing or simultaneous activation are often not well supported.
- For PA functionality, a direct connection between the UIC568 fallback lines and the loudspeaker outputs can be supported in hardware. This direct connection is activated in case the microcontroller fails and guarantees the PA functionality in this failure mode. However, this solution needs to be tuned to the acoustical environment for each project separately and cannot take advantage of the audio processing algorithms (noise reduction or anti-Larsen), which can result in practical limitations (such as decreased broadcast level).
- Continuous monitoring of the fallback lines is impossible as this would activate functionality. As such, dormant failures may exist.

An overview of the standard UIC568 functionality can be found in the following tables.

PA: Public address	
Types	2 (Priority & Normal) Normal is used for tape recorder functionality
Priority	Priority type interrupts normal type
Simultaneous	No, 1 PA active only
Exterior / Interior PA	Only interior

Table 1: UIC568 PA functionality

PA: InterCom	
Types	2 CREW -> CAB, CREW -> RADIO
Priority	First come, first served principle
Number of participants	2 (point-to-point)
Simultaneous	No, 1 IC active only

Table 2: UIC568 IC functionality

Using Ethernet as a fallback path: financial drawbacks

Due to its functional limitations, UIC568 is not very suitable as a fallback path. In driverless or driver-only operated trains, where passenger emergency communication is a must, there has to be an alternative.

A possible solution is the use of dual homing techniques found in modern Ethernet networks. Dual homing is a network topology in which a device is connected to the network by way of two independent access points.

One is the primary connection, the other one is activated if the primary connection fails (Figure 1).

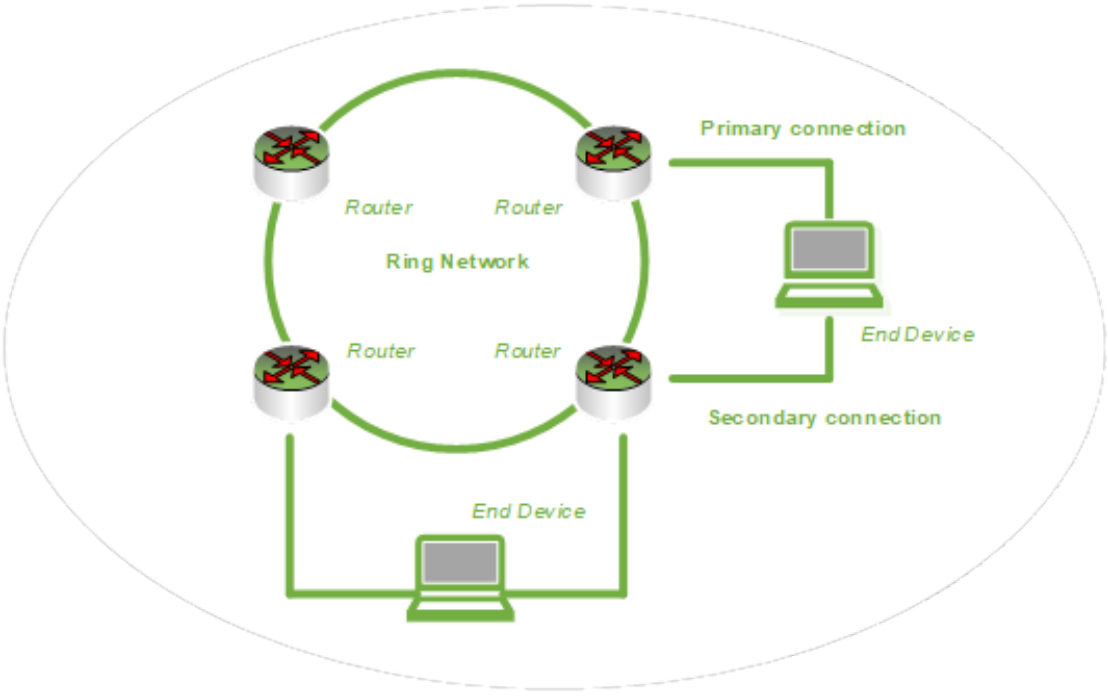

Figure 1: Dual homing with single ring network

This technique maintains the exact same functional behaviour. The problem is solved completely on network level and as such the user retains access to the complete audio functionality. This is a big advantage as fallback modes are only active very sporadically.

In critical situations, when unnecessary stress should be avoided at all cost, a change in functional behavior of the system is certainly not desired. Furthermore, the network can be continuously monitored to avoid any dormant failures.

Unfortunately, the dual homing approach also has disadvantages.

- The Ethernet backbone needs twice as many Ethernet ports, usually with Power over Ethernet (PoE) to power the end devices and double the number of cables to a central switch location. Costs are thus increased.
- The devices are still on the same network. Misconfiguration or other network failures are common and will lead to complete functional failures, unless a complete second redundant network is installed – which again increases costs (see Figure 2).

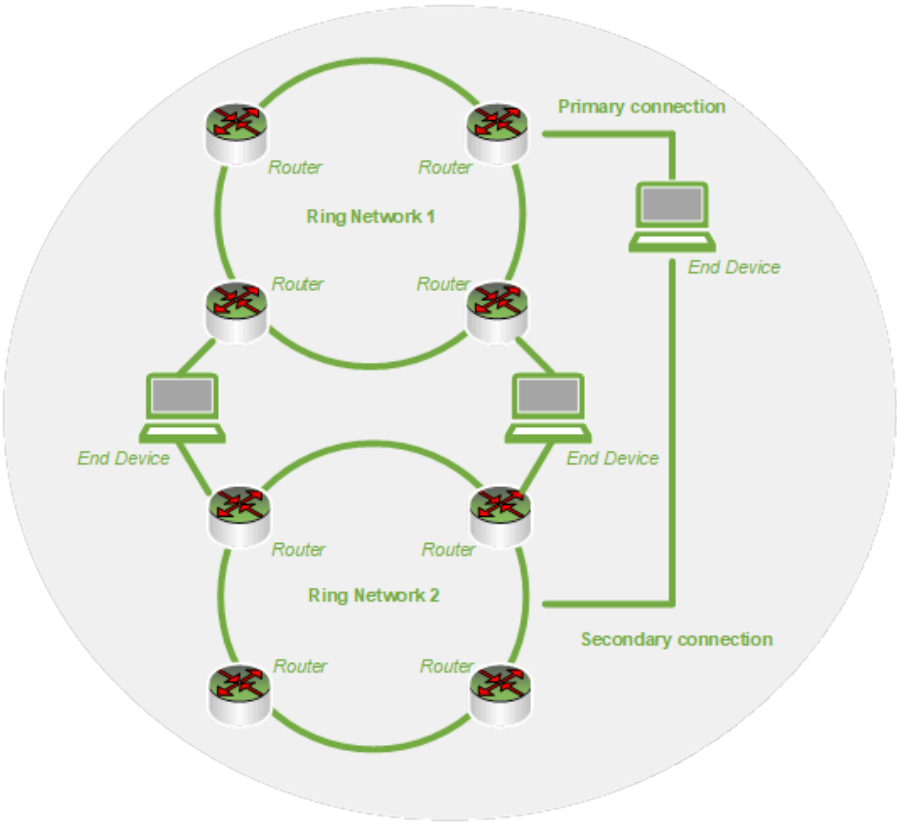

Figure 2: Dual homing with double ring network

TRACS: functional reliability without high cost

Previously, we discussed the UIC568 standard and dual homing as methods to increase functional reliability. We also discussed the drawbacks of each approach. However, they may still be valid options if all project requirements are fulfilled and/or cost isn't an issue.

Televic Rail has investigated other solutions for fallback paths. We concluded that a digital channel is best suited to support the critical functionality of today and tomorrow. This is why we developed TRACS (TRain Audio Communication System) as an alternative to the dual homing approach.

TRACS is a fully integrated communication solution based on standard technology that's already used in railway applications: daisy-chained Ethernet combined with PoE. The fallback is integrated in TRACS by design; no additional components are required.

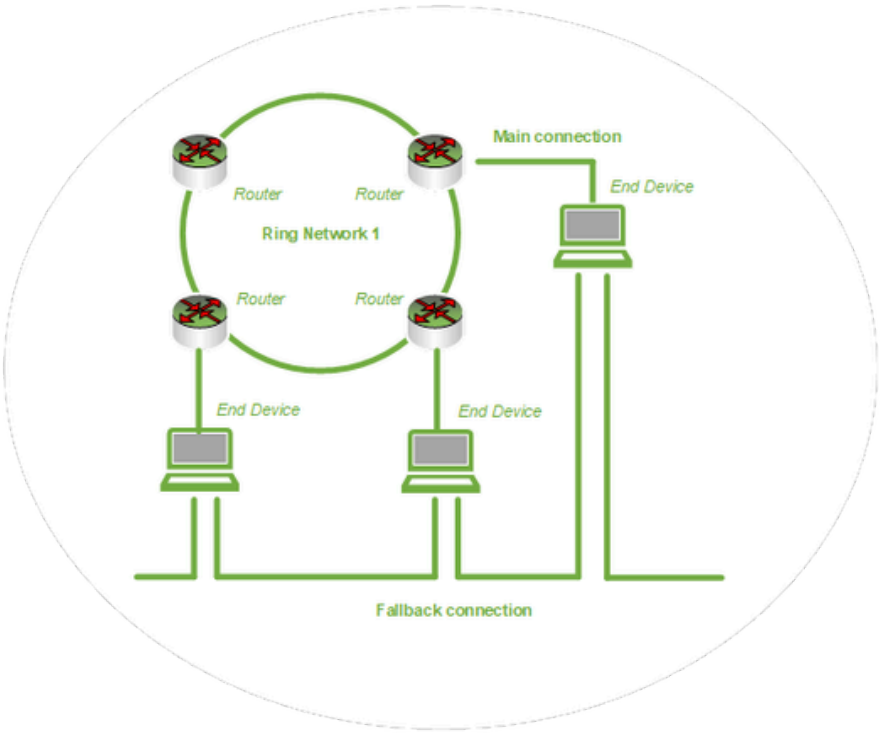

Figure 3: TRACS fallback approach

The advantages of this approach are functional and financial.

- No additional switch ports are required. The Ethernet switch is integrated in the end devices, reducing the additional costs for the customer.
- A completely separated network by daisy chaining the TRACS devices on dedicated ports. This network is able to determine the device location independent of the main Ethernet backbone and works fully independent of the main network.
- A redundant power supply independent of the main Ethernet backbone. TRACS draws its power directly from the train battery supply and delivers it to the individual TRACS devices via PoE.
- As with the dual homing approach, this technique has the advantage of offering transparency for the application. End-users retain access to the complete audio functionality with the same functional behaviour.
- Continuous monitoring of the fallback network is possible. As such, failures can be reported in real-time and repaired before a loss of function occurs.

This digital fallback method has a proven track record in running projects. The additional network ports can also be used to make cost-efficient topologies that only require 1 network port per coach.

This way, we can optimise for cost, functionality or redundancy while using the same basic components. The re-use of standard components and core software largely reduces the risk and time-to-market for new projects.



Conclusion

The introduction of Ethernet was a gamechanger for inter-device communication and added many features to railway audio systems. However, the standards did not evolve to incorporate the added features. The UIC568 standard is still used as an analogue fallback solution, but the limits render it increasingly unfit, even for fallback.

Digital solutions such as dual homing circumvent these drawbacks, but at a relatively high cost. However, TRACS retains full functionality in case of failure of the main Ethernet backbone. Since the digital fallback network is integrated in TRACS, additional external components are unnecessary.

Televic Rail offers systems with UIC568 fallback and digital fallback using the same basic components. By re-using proven design hardware and software building blocks we further increase the reliability of the audio system.

Thanks to these building blocks, we are very flexible in offering an optimised system architecture that suits the project needs, while keeping costs low. If you want to know more about our audio communication solutions, feel free to get in touch.

Contact us today

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Attachment

Specifications of modern audio communication in railway

How should you specify an audio system that complies with today's requirements if you cannot refer to up-to-date standards? Requirements are specific for every project, but basic requirements show a trend towards driver-only and even driverless operation.

Today's requested essential audio functionality:

1. Public Address from on-board crew/driver to the passengers.
2. Public Address from dispatching (off-board crew) to passengers.
3. Automated audio announcements based on location & time.
4. Intercom between on-board crew/driver.
5. Intercom between crew and dispatching (off-board crew).
6. Intercom between on-board crew and passenger.
7. Intercom between dispatching (off-board crew) and passenger.

Intercom functions with dispatching are possible via (analogue) GSM-R radio, but the use of VoIP via LTE(-R) connection is becoming the dominant wireless communication method. This wireless communication path should be made redundant to mitigate single-point-of-failures.

In case of LTE(-R) connections, these can be included in the digital fallback lines. By using a bypass, the LTE(-R) radio could even be connected directly to the audio communication system in case of a failure in the main network.

The audio system's most used feature is broadcasting automated announcements (pre-recorded or via text-to-speech). As with the LTE(-R) connections, making the system redundant will increase the availability of this important function for your passengers.

Today's requested additional audio functions:

1. Zoning: support for different announcements in different zones of the train (first class or second class, vestibule or seating area…).
2. Ambient music broadcast.
3. Handling of call-for-aid and a passenger alarm by different crew members.
4. Audio recording for incident investigation and training purposes.
5. Self-test capabilities to eliminate dormant failures.

Redundancy (a fallback path) is essential in achieving high availability of the audio features. Depending on which functions are considered vital in your specific project, you can choose analogue or digital fallback. Just remember the limitations of analogue fallback.