A BROADBAND IP-BASED RADIO SYSTEM FOR A WIDE RANGE OF TRAIN APPLICATIONS

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The first commercial maglev line worldwide, the Transrapid system in Shanghai, could be regarded as a high end system of modern railway technology. Its automatic train operation is only possible by the use of a highly reliable radio communication link.

Due to the outstanding requirement of such high end technology the radio system must also provide outstanding features like high availability, jam resistance and high bandwidth for multi-data services like train control data, operational voice communication or online diagnosis data to name but a few.

Meanwhile the situation in the classic railway world has also begun to change. Analogue radio systems and the actual GSM-R technology are focused on operational voice services and train control data (automatic train operation: ATO, automatic train protection: ATP, computer based train control: CBTC).

These services require only a small bandwidth of some Kbit/s to achieve sufficient reliability and effectiveness. The disadvantage, on the other hand, is the lack of upgrade potential for further data applications. Data services like digital online video surveillance (CCTV) from running trains require at some hundreds of Kbit/s. The consequence for the railway market is that there must be a radio technology beyond GSM-R which is able to supply a data interface of some Mbit/s.

Requirements

Actual market demands lead to the requirements which should be met by a broadband radio system. These are:

- IP Data interface: due to the fact that the IP protocol is the most common data protocol worldwide an easy integration of IP-based subsystems must be possible. For the customer reduced cabling efforts and the use of standard network equipment are big benefits compared to proprietary technologies.
- Continuous radio link: The radio link to the trains should be continuous. The user of the communication channel could expect a defined reliability for his application and should not worry about the procedures and algorithms which guarantee the correct routing of data packets over several networks.
- Reliable radio transmission up to 500 kph: Modern high speed trains reach speeds of about 350 kph. Passenger services which like to have internet services on board, require radio transmissions at every speeds. Higher train speeds should not lead to limits of the reliability or data rate of the radio system.
- Multiple data services: Customer needs and economical reasons require that more than one data service should be supported. For example the customer could use voice communication, video surveillance (CCTV) and train control data at once or other combinations of data services with only one radio system. Since some informations (for example CBTC) are more important than others, a quality of service (QoS) handling is absolutely necessary.
- Surrounding: Whether in tunnels or in free field the surrounding should not influence a reliable radio transmission. An example where this requirement is hard to achieve is satellite communication since in tunnels or valleys the line of sight link to the satellite is interrupted.
- Jam resistance: Using licensed frequencies no interference with public frequency bands (ISM) are possible. Compared with ISM frequencies the radio coverage is increased because licensed bands are allowed to use higher output power. Therefore infrastructure efforts along the railway track will be reduced. Typically the radio mast distance for the range form 1 to 10 GHz is some kilometers for line of sight (LoS) conditions. For GSM-R (876-880 MHz and 921-925 MHz) the mast distances are larger and could reach more than 10km because of a very high output power of about 30 W.
- Scalability: Depending on the application and the safety requirements the radio system should be scalable. For operational services like train control data high availability of the communication link is required. The radio system therefore should have redundancy features. An example is a double channel system layout where all the data are transmitted simultaneously with two different radio frequencies. In this case special methods must be implemented to guarantee that the data are not doubled at the subsystem interfaces.

Data services

The broadband IP-based data services could be separated into two groups:

- Operational services
- Train control data: Transmission of signaling data for ATO, CBTC (especially for subways). If required the broadband radio system could also be used as a backup system for GSM-R.
- Online diagnosis: Transmission of the vehicle subsystems status like brakes, air condition to a maintenance and diagnosis center.
- Operational voice communication: The transmission should be done by VoIP technology. An adaptation to analogue, DECT and ISDN devices is possible by using VoIP PABX units.

- CCTV: Modern event driven video surveillance could be used to send video data from the running train to the video command center or to supply the train driver with track sided information like the situation of the next subway station in order to prevent accidents.
- Passenger services
- Internet on board: Passenger notebooks or PDAs are linked by a WLAN interface to the train sided access points (AP) which are part of the train local area network (LAN). Track sided a gateway of the internet service provider must be present. If internet on board is realized together with an operational service safety considerations should be taken into account. An access from the internet to the railway specific network including the radio system must be prevented.
- Online passenger information: Examples are flight schedules for airport links, schedules of connecting trains.
- Online ticketing: Ticketing handhelds which have wireless interface could be used for online ticketing. Like for internet on board a connection through a gateway to the ticketing center is necessary.
- Online advertising: With an existing communication link to a train the railway operator has the opportunity to a return of invest by supplying trains with online advertising.
- Online TV: Similar to the business class of some airlines also the passenger for long railway trips could be entertained by online TV.

Architecture of a Broadband Radio System

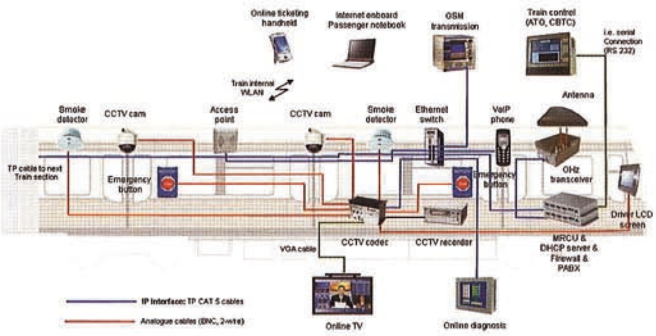
To give an impression about a broadband radio system the TrainComÆ radio system of TELEFUNKEN RACOMS will be introduced. In its previous version it is used for the maglev line in Shanghai. Nowadays it covers the whole classical railway spectrum from light vehicles and subways to high speed trains.

The basic architecture could be seen in the next figures (Figure 1 and Figure 2), where the train and track sided radio systems are shown

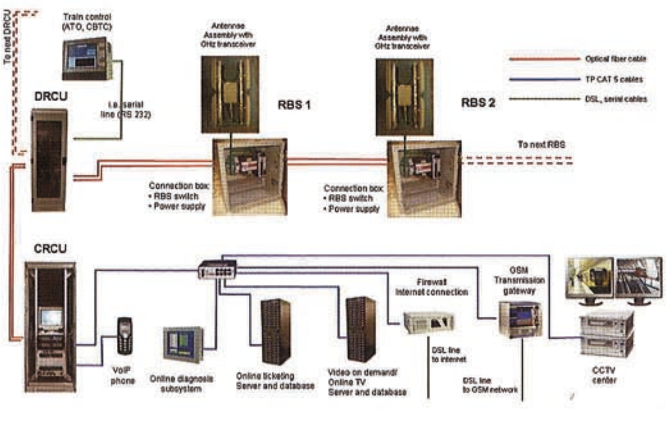
Figure 1above: Trainborne radio system layout

Figure 2below: Track sided radio system

The main components of the radio system are:

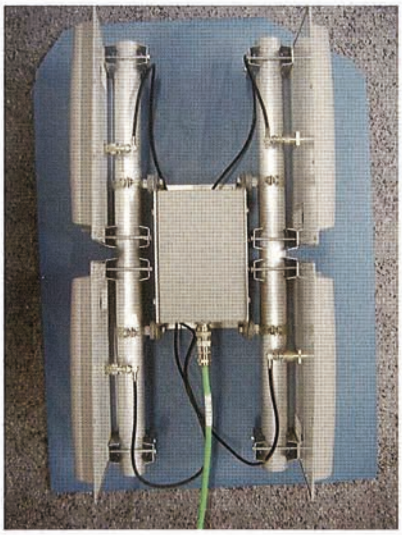


1. CRCU:Centralized Radio Control Unit
Gateway to external network like internet, VoIP PABX



2. DRCU:Decentralized Radio Control Unit
Radio control of radio base stations
3. RBS: Radio Base Station
Track sided radio interface
4. MRS: Mobile Radio Station
Train sided radio interface
5. MRCU: Mobile Radio Control Unit
Mobile radio control and interface to the connected sub-systems

In a sketchy view the radio system represents a modern IP network. Of course this is right because standard network components like switches, firewall, twisted pair cables and optical fibers are main parts of this system. On the other hand IP network technology has to be extended to guarantee stable radio links to the trains. Therefore an "intelligent" combination of network, radio and protocol technologies is the key task to achieve the above mentioned requirements of broadband train communication. A good example of this philosophy is the use of radio diversity. To increase the availability of the radio link not only one antenna is used but four in the case of the radio base station (see Figure 3 above).



The software inside the transceiver unit compares the receive signals of each antenna unit at every time. Even when no antenna receives an optimal signal the transceiver is able to add the partial signals to the original error free data packet.

The same principle is used on the train also where different types of antennae with aerodynamic shape are used to resist the high air pressure at high speeds (see Figure 4).

Figure 4 below: Mobile antenna with aerodynamic shape

Outlook

In the near future it is expected that the railway market will change in the way that modern communication technologies will become more and more important. Internet on board which is already started in Europe and all the other passenger service could attract more and more people for railway journeys. New security requirements and efforts cause railway operators to invest into new technologies.

All these new tendencies and business cases could only become to reality if there are adequate communication solutions suitable for railway market with its special features and requirements. Like for GSM-R with the GSM-world, a new generation of radio systems has started to meet the railway technology.

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