Abstract

Long Term Evolution for Railways (LTE-R) is a next-gen communications network dedicated for railway services, enabling high-speed wireless voice and data communications inside trains, from the train to the ground and from train to train. This network supports voice communication among drivers, control center operators, maintenance and other railway staff supporting; push-to-talk group communication, broadcasting, location-dependent addressing and multilevel prioritization; data communication for the train control signaling and other operation and maintenance as well as text messaging during voice communication; multimedia communication for wireless video surveillance, mobile video conference, file sharing, mobile office and passenger infotainment services.

1 LTE-R System Description

To provide improved and more efficient transmission for High-speed railways (HSR) communications, it is vital to consider frequency and spectrum usage for LTE-R. HSRs are important strategic infrastructure. LTE systems work at the bands above 1 GHz, such as 1.8, 2.1, 2.3, and 2.6 GHz, although 700–900-MHz bands are also used in some countries. Large bandwidth is available in the upper bands, giving a higher data rate, whereas lower frequency bands offer longer distance coverage.

Figure 1 Summarizes the frequency bands for LTE-R in China, Europe, and Korea. As a high-frequency band has larger propagation loss and more severe fading, the radius of an LTE-R cell would be >2 km [due to the strict requirement of signal-to-noise ratio (SNR) and BER in HSR], leading to frequent handovers and a requirement of substantial investment for higher BS density. Therefore, the low-frequency bands, such as 450–470 MHz, 800 MHz, and 1.4 GHz, have been widely considered. The 450–470-MHz band is already well adopted by the railway industry; therefore, dedicated bandwidth for professional use can still be allocated from local regulators.

2 LTE-R Services

HSR communications intend to use a well-established/off-the-shelf system, where some specific needs should be defined at the service level. As suggested by the E-Train project, LTE-R should provide a series of services to improve security, QoS, and efficiency. Compared with the traditional services of GSM-R, some features of LTE-R are described.

1. Information transmission of control systems: To enable compatibility with the ETCS-3, LTE-R provides real-time information transmission of control information via wireless communications with a <50-ms delay. While the location information of the train is detected by a track circuit in ETCS-2, ETCS-3 and LTE-R, the location information of the train is detected by RBC and onboard radio equipment. This improves the accuracy of train tracking and the efficiency of train dispatchment.
2. Real-time monitoring: LTE-R provides video monitoring of front-rail track, cabin, and car connector conditions; real-time information monitoring of the rail track conditions (e.g., temperature and flaw detection); video monitoring of railway infrastructures (e.g., bridges and tunnels) to avoid natural disasters; and video monitoring of cross tracks to detect freezing at low temperatures. The monitoring information will be shared with both the control center and the high-speed train in real time, with a $\leq 300$-ms delay. Although some of the aforementioned surveillance can be conducted by wired communications, the wireless-based LTE-R system is more cost effective for deployments and maintenance.

3. Train multimedia dispatching: LTE-R provides full dispatching information (including text, data, voice, images, video, etc.) of drivers and yards to the dispatcher and improves dispatching efficiency. It supports rich functionalities, such as voice trunking, dynamic grouping, temporary group call, short messaging, and multi-
media messaging.

4. Railway emergency communications: When natural disasters, accidents, or other emergencies occur, establishment of immediate communications between accident site and rescue center is required to provide voice, video, data, and image transmissions. Railway emergency communication systems use the railway private network to ensure rapid deployment and faster response (with a \( \leq 100 \text{ ms} \) delay) compared with GSM-R.

5. Railway Internet of Things (IoT): LTE-R provides the railway IoT services, such as real-time query and tracking of trains and goods. It helps to enhance transport efficiency and extend service ranges. Moreover, railway IoT could also improve train safety. Most of today’s trains rely on trackside switches located in remote areas. With the IoT and remote monitoring, it is possible to remake trackside infrastructure from switches to power lines, which could automate many of the routine safety checks and reduce the costs of maintenance.

Figure 3 summarizes the future possible services provided by LTE-R, which is based on the technical reports of the UIC, China Railway, and ERA.

In addition to the features listed previously, some other services of LTE-R should be included, such as dynamic seat reservation, mobile e-ticketing, and wireless interaction of passenger information.

The information/ views expressed in this paper is of the authors and are based on their experience. Comments/ observations may be sent to the author at sambireddy@efftronics.com

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