Railway Wireless Communication Network in the Czech Republic

David Žák

Faculty of Electrical Engineering and Informatics
University of Pardubice
Content

- Aims
- Architecture
- Application Current Position of the railway vehicle
- Intelligent functions – Dynamic DNS
- RCN Manager
- Present use
- Near future
- Conclusion
History – before 2008

- The growing needs for data communication with the railway vehicles
- Existence of the 3 independent application with individual solutions for data communication
- Concepts of the new applications
  - Electronic train timetables
  - Active parking of electric units 471 series
  - Passenger information systems
  - Diagnostic systems of rail vehicles
RWCN

- RWCN (Railway Wireless Communication Network, originally Železniční bezdrátová přenosová síť) is the name of the network used for a data communication among mobile objects and infrastructure systems in the railway environment, especially for train to ground communication.

- RWCN consists of
  - transmission networks
  - mobile communication devices (terminals)
  - ground (central) communication gateway
  - interfaces, protocols and rules for wireless communication among users, devices and ground systems
Aims

• Perspective long-term solutions for the railway environment in the Czech Republic
• Usability for all subjects/companies in the railway environment
• Upgradeable for new applications, communication terminals and devices and for new upcoming standards
• Expandable to other types of transmission networks (e.g. CDMA, 3G, LTE, WiMAX)
Basic technical requirements

• Transparent IP communication
• Intelligent addressing of devices based on device names, UIC car codes, order or a function of a engine on the train and the train number
• Possibility of using encryption algorithms
• Definition of security rules
• Definition of quality parameters (QoS)
• Automatic selection of a suitable transmission network without manual operator intervention (based on the network availability or demand for a bandwidth)
• Possibility of integration up to thousands devices of different types
• Minimizing redundant data transfers
RWCN Architecture

RCN – Railway Communication Network
Transparent TCP/IP network

Data service network

CG – Communication Gateway
Application servers
Dispatching site

Application

Router
DNS Database
Firewall

MSC
GSM-R
(CSD and GPRS)

GPRS
gsm-p

BTS
COS GPRS

BTS
GPRS

BWA

BWA

public operator

Dispatching site

GSM-R Device

PDA train crews, stations personal with possibility connection to more networks integrated in RCN

MCU – Mobile Communication Unit

Rail car equipped with communication terminal able to work in one or more transmission networks and terminal devices allowing data transmissions
Transmission Networks

- Public GSM networks (one or more operators), GPRS, EDGE
- Public broadband mobile networks (e.g. CDMA, 3G, WiMAX, LTE)
- GPRS technology in GSM-R network
- or broadband transmission network established for needs of railways (e.g. LTE, WiMAX)

Combination of more mobile technologies is the way for delivery of required services
Gateway

RWCN Gateway provides intelligent services:
• Dynamic DNS provides translation of hostnames to IP addresses
• Termination of tunnels for ensuring transparent IP communication with terminals through var
• RADIUS server for IP address assigning, authentication, authorization and accounting
• Transferring of data obtained from messages of the railway vehicle’s location to all applications that require this kind of information
Gateway – logical schema

Czech Railways BACK OFFICE servers

Railway Undertaker N BACK OFFICE servers

Interconnect, IPSec tunneling
Local TCP/IP Network

Servis status control

Data Storage and processing

Radius, AAA, Registration servers
Application servers
DB Servers
Client configuration and version management
Data provisioning
CG Management WWW interface
DNS Servers

Local firewall
Local firewall
Local firewall
Local firewall
Local firewall
Local firewall
Local firewall

IP communications – routing, policing, tunnel termination, mobile IP Home Agent, IPv4 and IPv6 stack

CG_Router
HA
CG_Router

Railway Communication Network – access layer (GPRS, CDMA, WiFi, etc.), Mobile Operator APN Termination, etc.

GPS satellite

Mobile Communication Unit (MCU)

PDA

Mobile Communication Unit (MCU)

PDA
Terminals

Communication terminals ensure:
• communications of end devices located on the railway vehicle through RWCN
• automatic selection of the transmission network based on predefined algorithms (such as network availability, type of network) – not used yet
• Network Address Translation between LAN and RWCN
• establishing IP tunnels
• safety and compliance with QoS

Communication terminals can be standalone devices, optional modules, vehicle radios or other equipment components (smartphones …).
Application Current Position of the railway vehicle

- The application is installed in the communication terminals of railway vehicles.
- Position data are sent in fixed time intervals or immediately after change of the vehicle status (like stopping or starting) to stationary information systems.
- To transmit these reports, the UDP protocol was chosen because of its minimal data transmission bandwidth.
- Frequency and rules of sending messages can be remotely configured.
Application Current Position of the railway vehicle

- Current Position message contains
  - message number (cyclically from 0 to 255),
  - number of vehicle in UIC number format,
  - current status of the vehicle,
  - current date and time recorded from a GPS receiver (in UTC format),
  - latitude and longitude,
  - speed,
  - azimuth,
  - network used by cab radio (150 MHz TRS, TRS 450 MHz, GSM-R, GSM-P),
  - train number,
  - engine function on train.

- Central gateway uses the received data about the vehicle location for ensuring some intelligent functions of RWCN, mainly for DDNS hostnames to IP translation and provides this location data to other applications.
Dynamic DNS

- For a proper function of a translation hostnames of devices to IP addresses is necessary to ensure the dynamic behavior of the DNS server. DNS server is part of the RWCN gateway and is based on the Oracle database server.

- Changes in assignment of railway vehicles to specific trains and their functions at these trains are saved into database. These information are extracted from messages about the Current Position of the railway vehicle.

- In addition, the database stores information about all devices installed on railway vehicles and their IP addresses.
Hostnames in RWCN

Structure of DNS hostname:

```
[device].[vehicle].[consist].[train].[operator].rcn
```

- [device] – device name,
- [vehicle] – UIC car code or possition of the car on the train,
- [consist] – only for compatibility reasons,
- [train] – number or name of the train,
- [operator] – constant „czechrailways“,
- rcn – constant „rcn“.
Examples of addressing at RWCN

- DNS name of the communication terminal of the railway vehicle with UIC car code:
  
  mcu.UIC515439410488.nuCst.nuTrain.czechrailways.rcn

- After logging engine on the train No. 210 (with UIC car code):
  
  mcu.UIC515439410488.nuCst.tr210.czechrailways.rcn

- Leading engine of the train number 210:
  
  mcu.engine01.nuCst.tr210.czechrailways.rcn

- Other devices located in the same vehicle e.g.:
  
  mat.engine01.nuCst.tr210.czechrailways.rcn
tachograph.UIC515439410488.nuCst.tr210.czechrailways.rcn
Railway vehicle devices addressing

- IP address of a specific network interface of the communication terminal is usually quasistationary assigned by the RADIUS server.

- To the communication terminal can be assigned (for terminals that allow this) network with mask /28, in which is 14 usable IP addresses for addressing of specific devices.

- For simple communication terminals are expected to use only a single transmission network (e.g. GSM-P) and a single IP address (the address of the network interface).
IP tunnels

- IP tunnels are used to ensure the routing of IP subnets assigned to the communication terminals over different transmission networks.

- GRE tunnels (Generic Routing Encapsulation) are used in cases where it is possible to assign a static IP address for network interface of communication terminal.
IP communication with devices on trains

1. DNS request for IP address for tachograph.UIC94541471011.nuCst.tr210.czechrailways.ren

2. DNS response IP address 172.16.107.30

Communication Gateway

Firewall

DNS

Database
AAA - Radius
MSG conversion

Communication between 172.30.10.10 and 172.16.107.30

BWA Network

Network Selection functionality
mcu 10.0.0.1

GPRS APN

Mobile Communication Unit
NAT for end equipment's IP address translation

UIC Car 94541471011

tachograph 10.0.0.6
LAN
MAT 10.0.0.47
RCN Manager – software for management of RWCN

- Supervision of gateway services
- Management of SIM cards, mobile users, user groups
- Management of terminals, IP addresses, subnets
- DDNS configuration
- Logs from the RADIUS server - Authentication, Authorization, and Accounting
- Configuration of Application Current Position of the railway vehicle
- Map view with vehicle location
RCN Manager – Map view

Electric units 471 series on map of Prague and satellite map of train depot station Praha-jih
RCN Manager – Map view with details
Present use

• Integration of the public GSM network (O2) – data services 3G, EDGE, GPRS
• Functional addressing of terminals and other devices on trains using DDNS
• About 150 vehicles series 471, 560, 123, 150, 151, 162, 163, 363, 810, 242 is equipped by appropriate technology (manufacturers UniControls, RADOM, T-CZ) for data transfer and integrated into the RWCN
• Tested possibility to integrate with GPRS service of GSM-R network
• Tested integration of WiFi access points (train depot station Praha-jih) for mobile users
Near future

• Integration of other public networks into RWCN
• Development of the Network Selector and the Session Manager functionalities on terminals
• Implementation of personal units (1600 pcs.) (e.g. portable personal cash registers) a their name addressing
Conclusion

• Three existing communication solutions has been integrated into a single concept at the beginning of the project RWCN in 2008.

• The main benefit of the RWCN is that applications developers do not need to build up and operate their own communication solution and they can use and share the RWCN concept – it enables to run entire communication solutions at reasonable cost.

• Implemented concept of the national communication solution known as the Railway Wireless Communication Network (RWCN) is based on the basic principles of the ICOM architecture described in the InteGRail project.

• We are waiting for new upcoming standards IEC61375-2-6 from IEC/TC9/WG43WG43_SGT_5 Board-Ground Communication.
Thank you for your attention

David Žák
Department of Information Technology
Faculty of electrical engineering and informatics

University of Pardubice
Studentská 95
532 10 Pardubice
tel +420 466 037 060
fax +420 466 036 241
mobil +420 602 242 985
e-mail david.zak@upce.cz
http://www.upce.cz