GPRS in GSM-R
Packet Data Network Elements

Packet Control Unit
> Responsible for the radio related aspects of GPRS
> Logically associated with a BSC

Serving GPRS Support Node
> Keeps track of the location of an individual MS
> Performs security functions and access control.

Gateway GPRS Support Node
> Supports the edge routing function of the GPRS network.
> Performs as IP router to external packet data networks.

APPLICATION
Packet data is optimized for sporadic-, burst-data allowing to leverage periods of low data volumes with other subscribers.
Packet Data Network Elements (SGSN HW Description)

SGSN Cabinet

**Interfaces:**

- **Gb**: Frame Relay over E1
- **Gn**: Ethernet (100,1000)
- **Gr' & Gs'**: Ethernet (100)
Packet Data Network Elements (GGSN Platform Main Characteristics)

GGSN Gateway GPRS Support Node

**Chassis**
- 14 slots
- 2 x Control management cards (CMC)
- 2 x Switch fabric card (SFC)
- 10 remaining slots
- 2 x (up to 6) Subscriber Service Cards (SSC)
- 2 x (up to 10) Line Cards
- DC/AC power Full Hot Swap

**Interfaces:**  
Gn, Gi, Gp

2 x 8 port Fast Ethernet

From the Customer: DNS, Radius

CMC card: 2 port 10/100BaseT Ethernet

- **CMC card:**
  - Slot 13 (backup)
  - Slot 14 (primary)

- **SFC card:**
  - Slot 7, 8

- **SSC and LC cards:**
  - Slots 1 to 6 and 9 to 12

- **Fan Assembly**
SS7 Gateway (IP STG)

HP ProLiant DL380G5 server based

Duplex High Availability configuration

Provides interworking between GPRS nodes in an IP network and GSM nodes in an SS7 network

Supported interface

- Gr : SGSN – HLR
- Gs: SGSN – VLR
- Gd: SGSN – SMSC
PCU Overview (PCUSN-18)

Fig. 8: MSS 7480 shelf used for the Nortel PCUSN

Fig. 12: RAD - Optimum-XLE1/16 (balanced model)
## GPRS versus Circuit Switched Data

<table>
<thead>
<tr>
<th></th>
<th>GPRS</th>
<th>Circuit Switched Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>eMLPP compliant</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>IP flow establishment time</td>
<td>0.5s (in GPRS standby mode)</td>
<td>3-5s</td>
</tr>
<tr>
<td>“Bursty” applications i.e. timetable enquiry</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Radio coverage loss</td>
<td>Data flow suspended</td>
<td>Data flow interruption – new call must be established</td>
</tr>
<tr>
<td>Number of users</td>
<td>Up to 8 per timeslot</td>
<td>1 per timeslot</td>
</tr>
<tr>
<td>C/I and sensitivity</td>
<td>CS-1 slightly better than 9.6</td>
<td>2.4 more robust than voice</td>
</tr>
</tbody>
</table>
4 coding schemes have been defined from 3GPP Rel.97, allowing different trade-offs between throughput and radio protection.

All GPRS MS have to support CS1 to CS4.

Maximum speed may be increased by use of multiple time slots.

Timeslots may also be shared by different MS (spectral efficiency).

### GPRS Data Throughput

<table>
<thead>
<tr>
<th>Multislot class</th>
<th>No of slots</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Rx</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
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<tr>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>
Channel Type Configuration

Possible Configurations:

Channel Type PDTCH
1 2 3 4
Reserved for GPRS

Channel Type TCH
5 6 7 8
Shared for Voice or Data
Dedicated to circuit
Resource Sharing (PDTCH/TCH)

Sharing:
GPRS Mobile (Cab radio suppliers)

Hörmann Funkwerk Kölleda/Kapsch
- GPRS Class B or C
- multislot capability class 10
- Products:
  - 8 Watt Module MT2
  - PortBox ultralite

SAGEM
- GPRS Class B
- Multislot capability class 10
- Products: TiGR155R; TiGR350R
GPRS Mobile or Modules

- GPRS Class B
- Multislot capability class 10
- Products:
  - 2 Watt Module TRM-2; 2a; 2T
  - Mobiles: TR-C81, TR-M81, TR-S68
GPRS Mobile or Modules

- GPRS Class B
- Multislot capability class 8
- Products: RGG100; ROG100

and other supplier

In the future also PDA devices
Customer Data Request
Customer Data Request for Radio (1)

Customer Data Request:

dedicated packet channels?

Kapsch Proposal:

No dedicated packet traffic channels, 4 channels shared
Customer Data Request for Radio (2)

Customer Data Request:

Capacity requirements for GPRS Traffic, additional carrier needed? Existing BTS are configured 1+1 In the future configuration 2 active DRX

Kapsch Proposal:

In the future, use the second DRX to have enough capacity
Customer Data Request for Radio (3)

Customer Data Request:

GPRS Cell planning of Routing Area?

Kapsch Proposal:

Location Area and Routing Area should be the same size.
Customer Data Request:

Which Coding Schema should be used?
e.g. CS-1, CS-2, CS-3, CS-4

Kapsch Proposal:

Use CS-1 and CS-2 to optimize throughput and transmission retry (radio protection)

Open Data

Check radio planning.
Customer Data Request for Radio (5)

Customer Data Request:

Traffic model?
QoS Parameters?
Application requirements?

Open Data

Information from CD necessary (application, data rates requirements)
Back up Sides
GPRS Services

- Operational surveillance
- Remote experts
- Level Crossing
- Platform
- Monitoring/Scheduling
- Coaching/Tracking

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Monitoring inside passenger coaches

Monitoring of coach cabins

Advantages
- Increased passenger security without additional personnel
- Security status in real time

Added business value
- increased passenger security
- improved planning of extent of utilization
Monitoring inside passenger coaches

Information sources are

- Webcam in coaches
  - Triggered by
    - Move detection
    - Time controlled

Information transmitted to

- Train security staff (PDA application)
- Centralized security staff
- Engine driver
- Passenger counting system
Train station monitoring

Station Monitoring

Operational advantages
- Increased security

Added business value
- Enhanced passenger/ railway customer safety
- Security/ staff cost savings
Train station monitoring

Information source

• Monitoring cameras
• Triggered by movement detection

Information transmitted to

• PDA or Video screen for security staff
• Security staff
  • centralized
  • mobile (use of Cell Broadcast)
Platform monitoring and supervision

Platform monitoring through transmission to driver cabin

Operational advantage

• Platform status directly displayed to train driver, no monitoring equipment needed on platform

Added business value

• Improved security and platform supervision
• Saving monitoring equipment
Platform monitoring and supervision

Information source

- Monitoring cameras on platforms
- Triggered by movement detection or remotely controlled through the train/ traction engine

Information transmitted to

- Display in the driver’s cabin
- PDA or display with the relevant dispatchers
- Security staff
  - centralized
  - mobile (use of Cell Broadcast)
Remote supervision of level crossings

Level Crossing monitoring

Operational advantages
• Enhanced security

Added business value
• Improved level crossing operation
Remote supervision of level crossings

Information source

• Monitoring at the level crossing
• Transmission through radio or through fixed lines

Information transmitted to

• Display in the driver’s cabin
• Display with the responsible service manager
Maintenance support

Damage or work proceeding (s) transferred as image
- Defective element to Inventory staff
- Work Proceeding (s) to Maintenance experts

Operational advantages
- Direct expert involvement & support
- Early start of preparatory work
- Reduced remote staff requirement

Added business value
- Reduction of Repair Time
- Direct central specialist support
- Reduced number of remote specialist staff
Maintenance support

Information source

• Remote personnel
• PDA and/or GPRS Mobile with integrated camera

Information transmitted to

• Inventory
• Involve other remote staff (e.g. through conference)
Work Processes

Centralized distribution of job orders for maintenance crews and shunting orders

Operational advantages
• Short term flexible changes
• Reduced number of inquiries

Added business value
• Increased staff efficiency
• Reduced operating cost
**Work Processes**

Information source

- Database
  - Work orders
  - Staff resources

Information transmitted to

- Mobile terminals
  - Reports on “work in progress”
  - New job order distribution
  - Staff notifications
Customer Example Live usage of advanced services

Current projects with a GSM-R GPRS capable PDA (MIO A701) of an European Railway Operator

**Online ticket validation:** When buying tickets via Internet the traveler gets a code (x-digit number). The number has to be verified by the train conductor against the database in the network. As tickets can be bought up to the last minute and reservations can also be changed until shortly before the train leaves, downloading this information to the PDA prior to train departure is not possible.

**Real time update of trains** and delays for passengers with connecting trains. Passengers need to know if they can get their connections. For this purpose the trains send updates of their current position to a central database.

**Ticket sales:** Train staff can sell online tickets via their PDAs.

**Train Position Updates:** Today 3000 trains are equipped with GPS devices that report the position of the train to the network. This is done via SMS for the moment. It is planned that the next generation of these devices use GPRS instead. This data is then used to update a real time data base so train personnel of other trains can check the timeliness and availability of other trains for connections.

**GPS Position of Maintenance Trains:** These trains report their location to a central database so the maintenance department knows the exact position of their trains. In case of problems appearing on the network it's simple to find the closest train.

**Field worker reporting:** Field workers report completion of activities to a central database. They can also check the availability of spare parts in stock via GPRS. Also they report faulty part numbers so the organization can react appropriately and order new spare parts.

**Side Wind Sensors:** For high speed tracks, side wind is a critical thing to be measured. Measurement devices use the GPRS network (public network today) to report the data to a database.

**Temporary Tunnel Video Surveillance:** In some cases it is required to temporarily monitor tunnels. For this purpose devices can be installed on a temporary basis in tunnels. These send back video images via GPRS.

**Supervision of Public GSM coverage:** Monitoring of public GSM coverage in tunnels and if there is a problem the monitoring device reports the issue via GSM-R GPRS back to maintenance departments.

**Train Black Box Data Transfer:** Today, 40 train depots are equipped with Wifi for maintenance. When a train comes in for inspection, measurement data is automatically transferred from the train via Wifi to the depot server.
Conclusion

GPRS offers a multitude of value added services for Rail Operators

• Passenger service
• Maintenance
• Network operation

GPRS offers system enhancements for data services

• Increased data transfer than with circuit switched solutions
• Increase of simultaneous use
• Improved data link recovery over circuit switched solutions
• Improved spectrum efficiency

Nortel GPRS solution is compatible with all ASCI features and functions
PCU Overview (PCUSN-18)

Fig. 8: MSS 7480 shelf used for the Nortel PCUSN

Fig. 12: RAD - Optimux-XLE1/16 (balanced model)
## PCUSN-18 Feature

### PCUSN-18 Features Overview

<table>
<thead>
<tr>
<th>Domain</th>
<th>Model capabilities</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCM Type</td>
<td>E1</td>
<td>✓ 75 or 120 Ohm impedance</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>✓</td>
</tr>
<tr>
<td>Server Processor Type</td>
<td>PCUSP</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>PCuspe2</td>
<td>✓ PCuspe2 required</td>
</tr>
<tr>
<td>Interface Modularity</td>
<td>Agprs</td>
<td>18 Cf Note 2</td>
</tr>
<tr>
<td></td>
<td>Go</td>
<td>8 (4×4), 12 (8×4) or 16 (12×4) From 2 to 4 4PE1/DS1C Gb boards – See Note 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64 (32+32) 2 x 32PE1/DS1 MSA boards</td>
</tr>
<tr>
<td>Maximum number of BSCs supported</td>
<td>BSC3000</td>
<td>9 Cf Note 1</td>
</tr>
<tr>
<td></td>
<td>BSC12000</td>
<td>9 Cf Note 1</td>
</tr>
<tr>
<td>Number of Multiplexers</td>
<td>E3/E1</td>
<td>2 E1 configurations</td>
</tr>
<tr>
<td></td>
<td>T3/T1</td>
<td>1 T1 configurations</td>
</tr>
<tr>
<td>Extension paths available</td>
<td>Go interface</td>
<td>8→12: 12→16: 8→16: By inserting additional 4PE1/DS1C FPs (1 or 2) in PCUSN shelf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8/12/16→64: By replacing existing 4PE1/DS1C FPs with 2 x 32PE1/DS1 MSA boards</td>
</tr>
<tr>
<td></td>
<td>A&lt;sub&gt;on&lt;/sub&gt; interface</td>
<td>10 PCUSN-32 (E1): By inserting 2 additional PCuspe2 in PCUSN shelf (T1 scenario: one additional T1-T3 Mux required)</td>
</tr>
</tbody>
</table>

"✓" → Supported  "✗" → Not Supported
Board Description

CP Board:
The control processor (CP) manages and controls PCUSN applications supporting both system and network functions.

TDM Port (E3C):
TDM termination boards are connected to the BSCs over the Agprs interface, and operate in conjunction with multiplexers. 32-port E1 FP board, also referred to as 2-port E3C board, for countries where E1 PCM transmission is used.

Gb Boards:
One of the roles of the 4-port E1C/DS1C or 32-port E1/DS1 for multi-service access function processor is the provision of communication services (based on Frame Relay) with the SGSN.

PCUSP Boards:
The PCUSP Function Processor is a multi-purpose FP for the data and signaling paths. It has both digital signal processing and general purpose “processing” capabilities.
GPRS Data Throughput

4 coding schemes have been defined from Rel.97, allowing different trade-offs between throughput and radio protection.

All GPRS MS have to support CS1 to CS4.

The link adaptation (LA) algorithm is not standardized. (LA is the system which chooses the coding scheme depending on quality of radio link)

Maximum speed may be increased by use of multiple time slots.

Timeslots may also be shared by different MS (spectral efficiency)

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Parameters:
30 WWW-Users
8 TS for GPRS

Terminals:
1 TS Up / 4 TS Down

CS1: 9.05 kbit/s/TS
CS2: 13.4 kbit/s/TS
CS3: 15.6 kbit/s/TS
CS4: 21.4 kbit/s/TS

Each Coding Scheme has its preferred range
More users may be supported within the same spectrum
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BER 10-4 target (for data)

Impact of speed on CS-1 and 9.6k circuit must be taken into consideration for radio planning (-114dBm being usual target)
Resistance to Interference (C/I) Ratio at speed

BER 10-4 target (for data)

Impact of speed on CS-1 and 9.6k circuit must be taken into consideration for radio planning (9dB C/I being usual target)
GPRS QoS and PDP Contexts

QoS profile associated to each PDP context
QoS profile is negotiated between the MS and the Network
- At PDP context activation
- When PDP context is already active
- Change can be requested by network or MS

Subscriber can have multiple concurrent PDP contexts
- Primaries and secondaries

Requires MS support
GPRS QoS Profile

R97 attributes + new R99 attributes (equivalent to UMTS QoS attributes)

Fine grain QoS attributes designed to support all traffic type

Traffic Class indicates the application type: Conversational, Streaming, Interactive and Background

Precedence Class indicates the relative priority of PDP contexts under abnormal conditions (usually congestion)

As per TS24.008 Release 99
QoS Negotiation Flow DP Context Activation Procedure

(*) Allocation Retention Priority as per TS23.060
(**) Radio Priority as per GSM04.60 RLC/MAC
(***) Aggregate BSS QoS Profile (ABQP) is negotiated between the SGSN and the BSS