# GPRS
# General Packet Radio Service

## Packet Radio Technology and Applications

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# 1. Why me?

- Hannu H. Kari
  - 1994-1997 in NTC (System architect, GPRS standardization delegate in ETSI)
    - Member of GPRS expert group
    - Member of GPRS standardization groups
      - SMG1 WPD, SMG1 GPRS AdHoc, SMG 2 GPRS AdHoc, SMG3, SMG3 WPA, SMG3 WPB, SMG3 WPC, SMG3 SA, SMG 3 GPRS AdHoc, SMG4, SMG4 GPRS AdHoc, SMG6, SMG6 GPRS AdHoc, SMG10, SMG10 WPA, SMG10 GPRS AdHoc (SMG= Special Mobile Group, ETSI's GSM standardization subgroup)
    - See also, www.cs.hut.fi/~hhk/GPRS/gprs_own.html



# 2. GPRS history

2.1 GSM data services

2.2 Internet over GSM

2.3 GSM data evolution

# 2.1 GPRS history: GSM data services

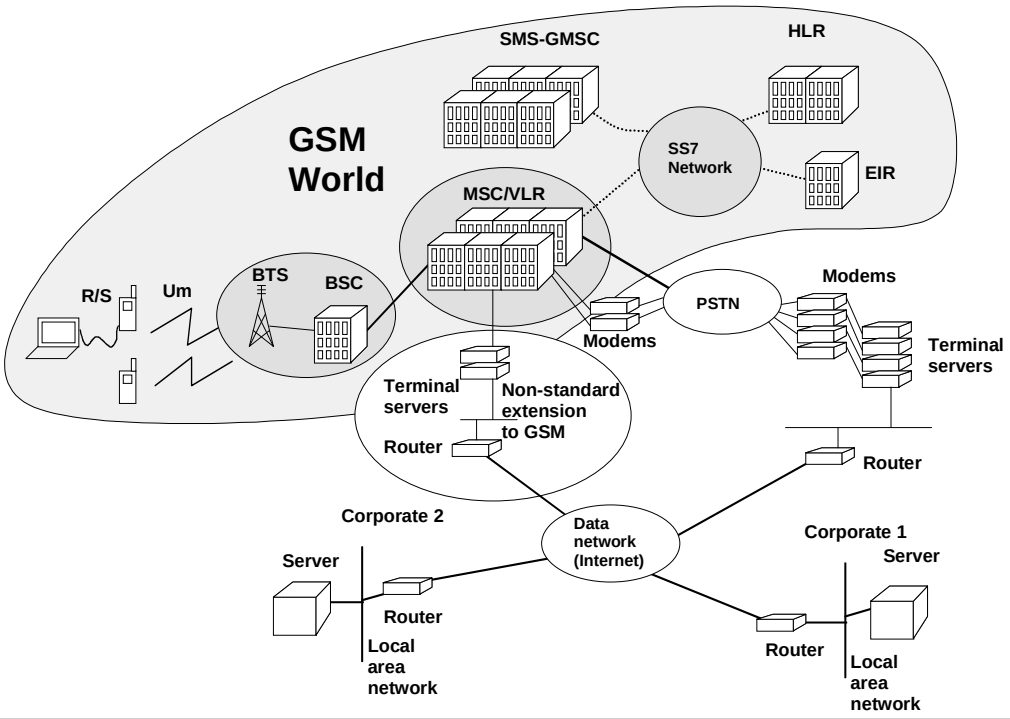
- GSM provides four types of services
  - Voice service
  - SMS service
    - Store and forward messaging
  - Fax service
  - Data service
    - Transparent data (no error correction, constant delay)
    - Non-transparent data (with error correction, variable delay)
    - Max 9600 bps
    - Access to modems in PSTN



# 2.2 GPRS history: Internet over GSM

- Conventional GSM does not provide direct connection to Internet
  - No GSM standard for it!
- Access to Internet requires a call to ISP
- Some proprietary direct Internet access approaches are available
  - In principle similar approach as in any ISP but modems are excluded

# 2.2 GPRS history: Internet over GSM






# 2.3 GPRS history: GSM data evolution

- GSM data limitations
  - Uplink and downlink channels allocated for a user for entire call period
  - User pays based on connection time, not based on volume
    - Bad connections makes more money to operator
  - Connection setup takes 20…25 seconds
  - Limited capacity (9.6 kbps)
  - GSM is designed for speech not data
    - Typically 50% of the radio capacity is wasted
    - Not optimal channel coding for data

# 2.3 GPRS history: GSM data evolution

- ISDN connection
  - Faster setup time
- V42.bis compression
  - "4-to-1 compression ratio" for text but not ciphered data
- Enhanced coding for data
  - Instead of strong error correction send more data (14.4 kbps)
- High speed circuit switched data (HSCSD)
  - Nx9.6 kbps or Nx14.4 kbps
- Enhance channel coding in GSM radio
  - More advanced modulation techniques over the radio



# 3. We are not alone!

- Aloha
  - Early 1970s in Hawaii
- Amateur packet radio
  - AX.25 and NET/ROM
  - http://users.eifelnet.de/wolff/ax25.htm
- CDPD
  - Commercial service in US, max data rate 19,2 kbps
  - http://www.bctm.com/wireless/cdpd.htm
- DECT data
  - Up to 500 kbps
  - http://www.symbionics.co.uk/services/technology/DECT/DECT.htm

# 3. We are not alone!

- IEEE 802.11
  - Wireless LAN standard, 2+ Mbps transfer rate
  - http://www.wlana.com/index.html
- HiperLAN
  - http://www.netplan.dk/netplan/wireless.htm
- Satellite systems
  - E.g. Iridium: 2.4 kbps
  - http://www.apspg.com/whatsnew/iridium/fast.html
- Bluetooth
  - Nokia, Ericsson, Intel, 3Com, …
- Others: TETRA, Mobitex, IrDA, RAM, ...



# 4. Requirements

4.1 Operator requirements

4.2 User requirements

4.3 Manufacturer requirements

# 4.1 Requirements: Operator requirements

- Better utilization of the scarce radio resources
- Simplify the access to data networks
- Get more users
- Divide users to profiles/categories
- Support new government requirements

=> Make more money



# 4.2 Requirements: User requirements

- Lower cost to access data networks (Internet)
- Higher transfer rate
- Short access delay (support for bursty traffic)
- Shorter connection setup time
- Keep the connection open all the time
- Better support for roaming users
- Flexibility and support of access to various data networks
    - Public Internet access, Corporate access, anonymous access

=> Get more for less

# 4.3 Requirements: Manufacturer requirements

- Get into the Internet business
  - Get the share of Internet market
- Sell more
  - Networks
  - Mobiles
  - Services

=> Make more money



# 5. Business model

5.1 Cost of the new system

5.2 Selling arguments

5.3 Sample operator business model

# 5.1 Business model: Cost of the new system

- How much GPRS would cost?
  - A LOT!
  - Existing GSM network elements must be updated
    - In principle, all network elements are impacted
    - MSC, VLR, HLR, BSC, BTS, O&M, …
    - "Don't disturb the money milking cow!"
  - New network elements
    - SGSN, GGSN, IP-routers, firewalls, name servers, ...
    - Internet way of thinking is new to many GSM operators



# 5.2 Business model: Selling arguments

- Higher capacity Internet access
  - Up to 171,2 kbps transfer rate (in theory), 40 kbps in practice
- Quicker access to Internet
  - No set up time, Internet access all the time available
- Lower cost
  - Flat rate or volume based billing
  - No charge for the idle time of the "connection"
- OR NO COST!
  - Via anonymous access (somebody else pays the bill)

# 5.3 Business model: Sample operator business model

- Example business model

| | # subscribers | QoS level | Monthly fee [FIM] | Cost/kB [FIM] | Volume/day [kB] | Monthly cost/subs. [FIM] | Total annual cost [MFIM] | Total data volume [GB] | |
|---|---|---|---|---|---|---|---|---|---|
| Business users | 100000 | High | 50 | 0,02 | 1000 | 650 | 780 | 36500 | |
| "Normal" users | 1000000 | Normal | 25 | 0,01 | 20 | 31 | 372 | 7300 | |
| Web surfers | 1000000 | Best effort | 50 | 0 | 250 | 50 | 600 | 91250 | <= Off-peak |
| Computers | 100000 | High | 50 | 0,1 | 20 | 110 | 132 | 730 | <= Off-peak |
| **Total** | **2200000** | | | | | | **1884** | **135780** | GB/a |

  - 1 USD = 5.4 FIM, 1 GBP = 8.8 FIM, 1 DEM = 3 FIM, 1 ECU = 6 FIM



# 5.3 Business model: Sample operator business model

- Volume calculations

| | | | | | | |
|---|---|---|---|---|---|---|
| Average data volume | | Per day | 372 | GB/d | | |
| | | Per hour | 15,5 | GB/h | | |
| | | Per sec | 4,3 | MB/s | | |
| | | Per sec | 34,4 | Mbps | | |
| | | | | | | |
| Peak hour data volume | | Per year | 43800 | GB/a | | |
| | | Per day | 120 | GB/d | | |
| | | Per hour | 30 | GB/h | All data in 4 busy hours | |
| | | Per sec | 8,3 | MB/s | | |
| | | Per sec | 66,7 | Mbps | | |
| | | | | | | |
| Number of time slots needed | | | 6667 | TSs | Average 10 kbps/TS | |
| | | Carriers | 833 | Carriers | | |

# 6. Constraints

6.1 Mental limitations

6.2 Technical limitations



# 6.1 Constraints: Mental limitations

- What is IP? Is it Intelligent Peripherals, part of Intelligent Network's subsystems?
- This is a telecommunication standard, not Internet standard. We must specify everything!
- Let's spend first 4 years to write the standard, then two years for implementations and then see does it work

# 6.2 Constraints: Technical limitations

- GSM is designed for speech service
  - 1.3 calls per user in a busy hour
  - Circuit based communication
    - Continuous flow of data, not packets
  - All mobile terminating calls go to HLR
  - Radio designed for circuits
    - Channel allocation, channel coding, paging mechanism, power control, timing advance, …

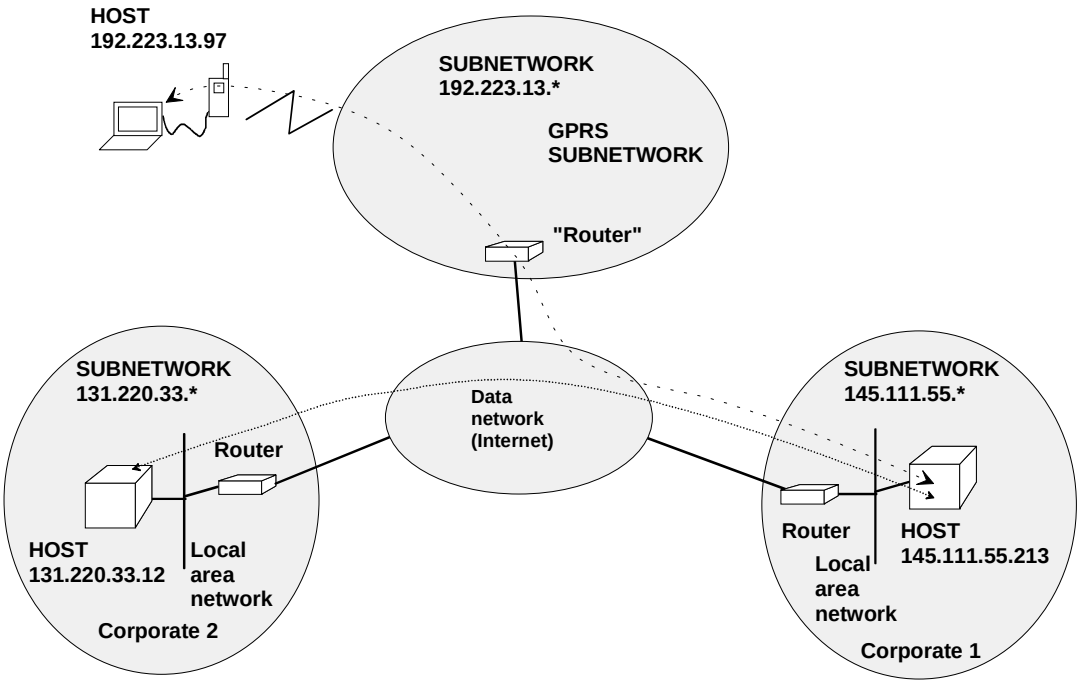
=> GPRS is a 3rd generation service in 2nd generation network



# 7. Architecture

7.1 Outsider's view to GPRS
7.2 Services
7.3 Network elements
7.4 Mobility management
7.5 Session management
7.6 Security
7.7 Data transfer
7.8 Interaction with conventional GSM

# 7.1 Architecture: Outsider's view to GPRS

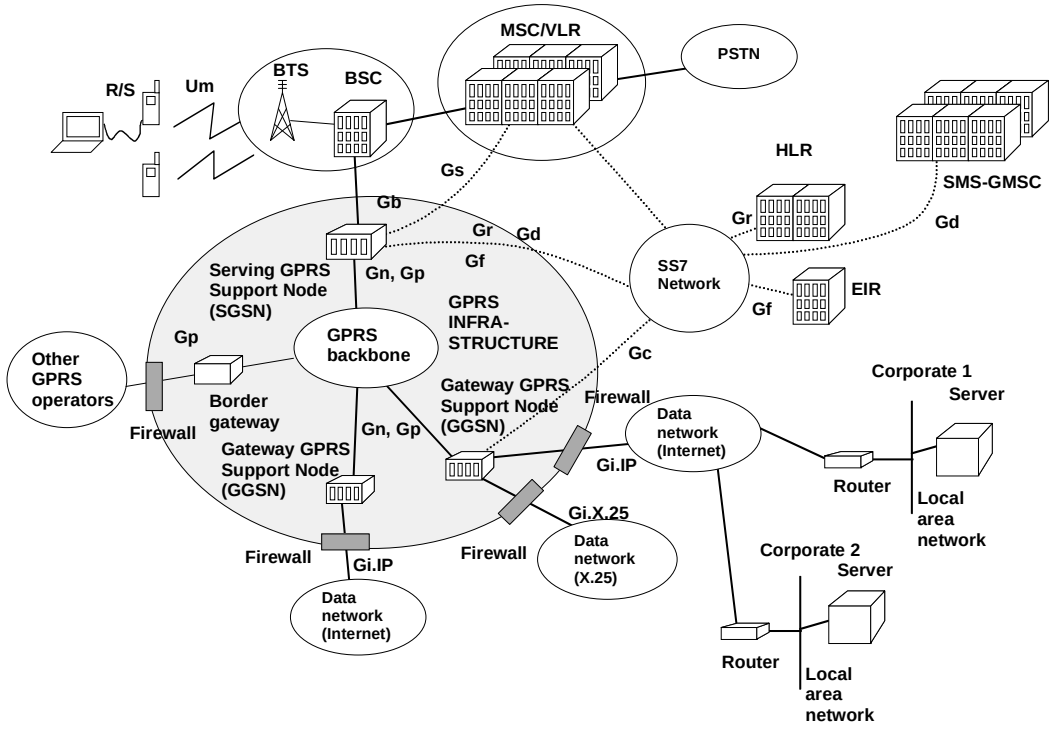





# 7.2 Architecture: Services

- Packet based access to data networks
  - Internet (IPv4/IPv6)
  - X.25
  - Non-anonymous/Anonymous access
  - Private/public networks
- Fast carrier of SMSs
- User QoS categorization
  - Priorities, mean/peak throughput, delay definition, transmission reliability
- Security (operator/user/identity/data protection)
- Mobility management

# 7.3 Architecture: Network elements






# 7.4 Architecture: Mobility management

- Functions
  - To inform the mobile's location to the GPRS network
    - Attach/Detach
      - Subscription of the normal users is stored in HLR and copied to visited operator during the attach
      - When the mobile is attached to the GPRS service, its location is tracked by the network
    - Routing area updates (similar to GSM Location Area updates)
    - Combined updates for GPRS and conventional GSM services

# 7.5 Architecture: Session management

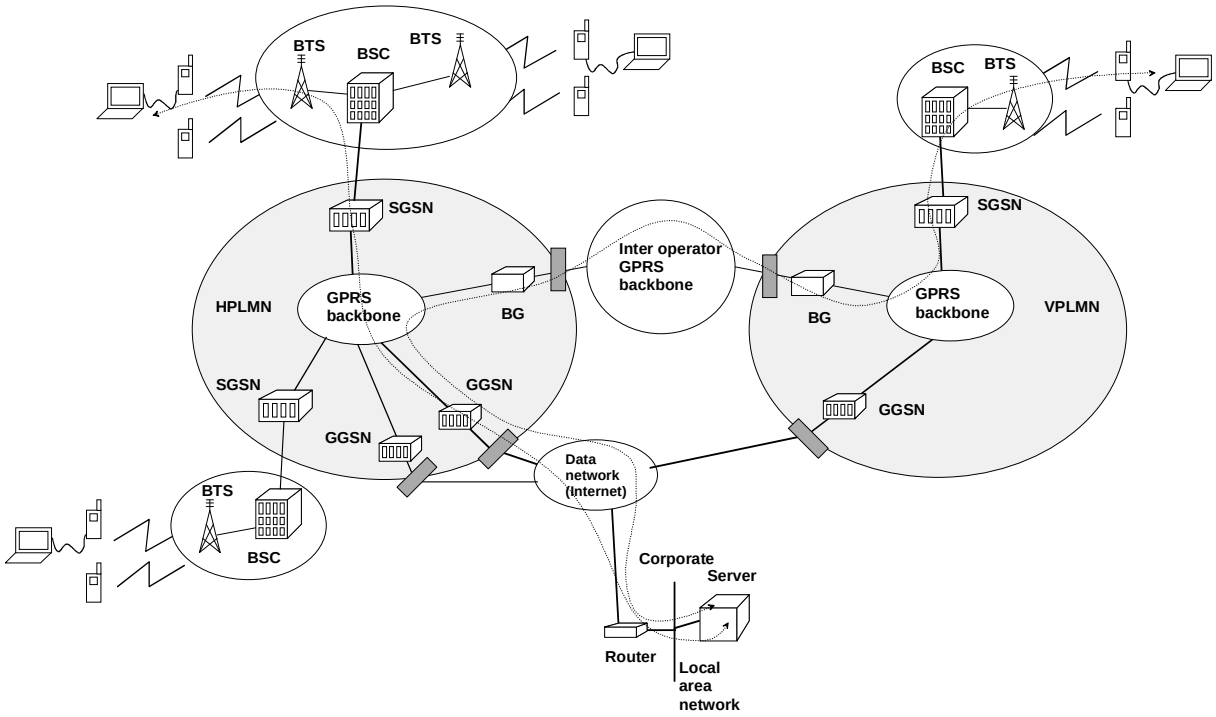
- Functions
  - User may have several subscribed contexts (an access to external data network)
  - Any of the contexts can be activated or deactivated independently
    - When a context is activated, user can send and receive data packets
      - MS->fixed network, fixed network->MS, MS->MS
    - When a context is not activated, the network typically "drops" the packets



# 7.6 Architecture: Security

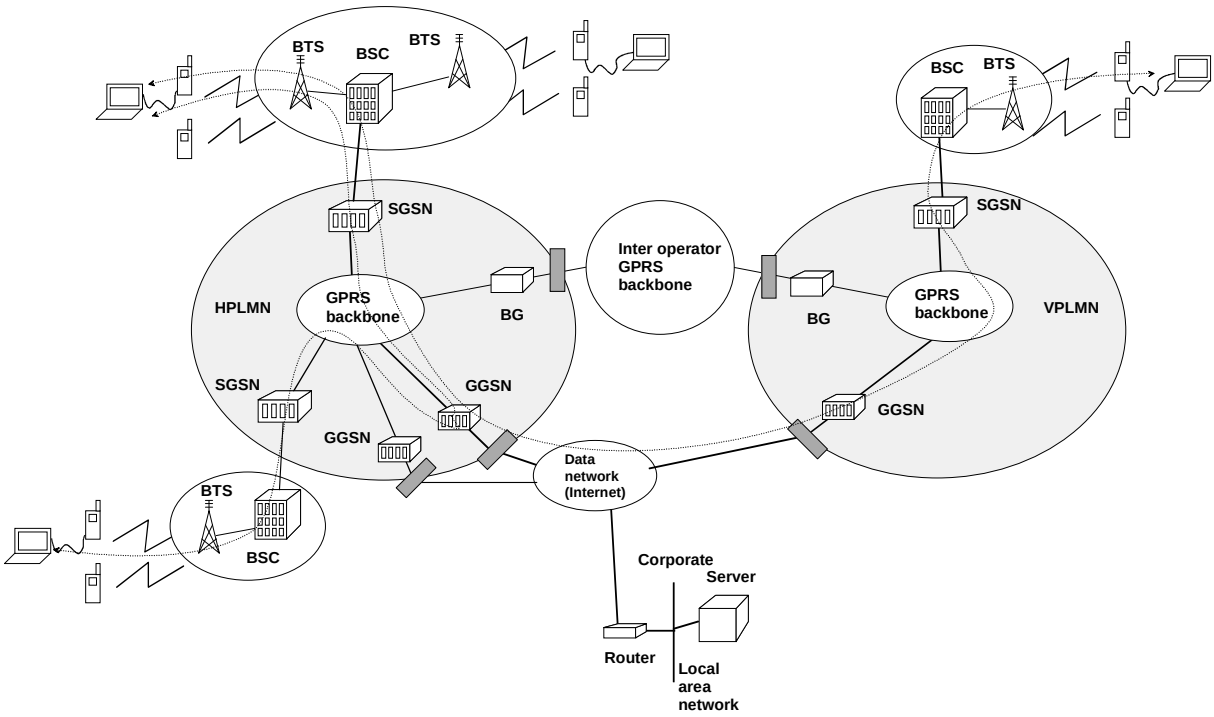
- Users are identified and authenticated
- User identities are protected with temporary identities
- Data transmission is encrypted over the radio
  - To protect user data
  - To identify owners of the packets in the radio
  - But "The Big Brother is watching you"
- Protect against hackers, intruders, eaves dropping, ...

# 7.7 Architecture: Data transfer MS-fixed






# 7.7 Architecture: Data transfer MS-MS



# 7.8 Architecture: Interaction with conventional GSM

- Support of voice calls
  - Paging of mobile terminating calls
- Delivery of short messages (SMSs)
- Supplementary services
- One combined bill to the user for GPRS and conventional GSM services



# 8. Future

8.1 Future of GPRS

8.2 Competitors

8.3 Links with other mobility management approaches

# 8.1 Future: Future of GPRS

- Evolution in the future
  - Easy to add new user protocols
  - Support of UMTS?
    - Guaranteed QoS for a mobile user in GPRS?
      - When GPRS offers for example:
        - 32 kbps mean bit rate, 32 kbps peak bit rate, and reasonable transmission delay for 95% of the packets
      - We can offer speech service over GPRS
      - Similar requirements are needed for multimedia for 2 Mbps!



# 8.2 Future: Competitors

- Need for low cost wireless access for mobile multimedia
  - How much a user would be willing to pay for 5 minutes of multimedia video show?
    - I.e., user transfers 30 Mbits ...4.8 Gbits over the radio
    - 0.05…0.10 FIM maybe, including the content
      - In GSM, it would cost 100 … 8000 FIM!
  - So, if the radio access for wireless multimedia costs very little, how much it would cost to transfer speech over radio?
    - In practice: Nothing!
- Wireless Internet access alternatives
  - WLAN, HiperLAN, IrDA, ...

# 8.3 Future: Links with other mobility management approaches

- Macro/Micro/Nano-mobility
  - Macro-mobility
    - Between organizations
    - Mobile IP, VPN, …
  - Micro-mobility
    - Within an organization
    - GPRS, IP-IP tunneling
  - Nano-mobility
    - Within a subnetwork
    - Adhoc radio networks using protocol such as Manet