Handoff in GSM/GPRS Cellular Systems

Avi Freedman

Hexagon System Engineering

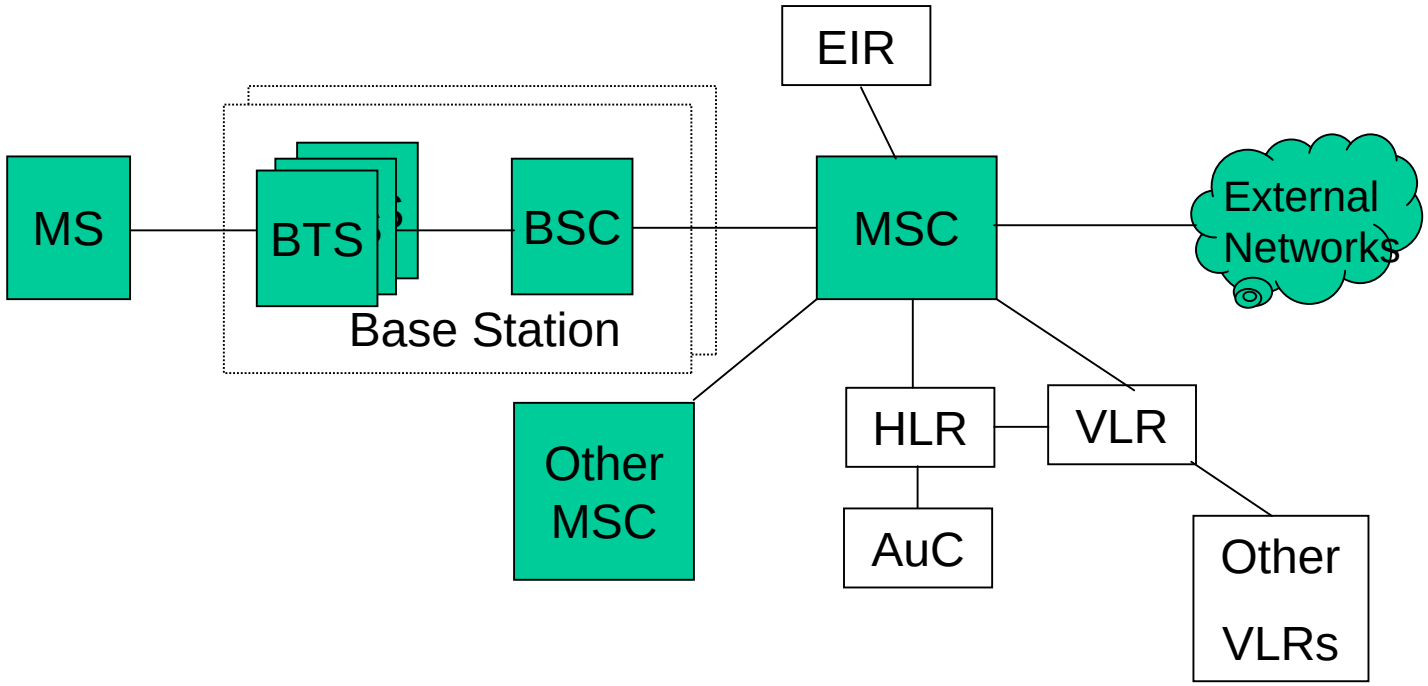
Outline

- GSM and GSM referemce model
- GPRS basics
- Handoffs
  - GSM
  - GPRS
    - Location and Mobility Management
    - Re-selection and routing update
    - QoS

2.5 G – Provide data service

- The GSM family
  - Basic GSM: 9.6 kbps
  - HSCSD: 28.8 kbps / Circuit switched
  - GPRS: 40 kbps
  - EDGE: 384 kbps
- The D-AMPS/ IS-136 Family
  - CDPD: 9.6 kbps / 19.2 kbps
  - EDGE: 384 kbps
- The IS-95 Family
  - IS-95a – 9.6 kbps
  - IS-95b – 115.2 kbps
  - IS-95c / HDR– 2Mbps

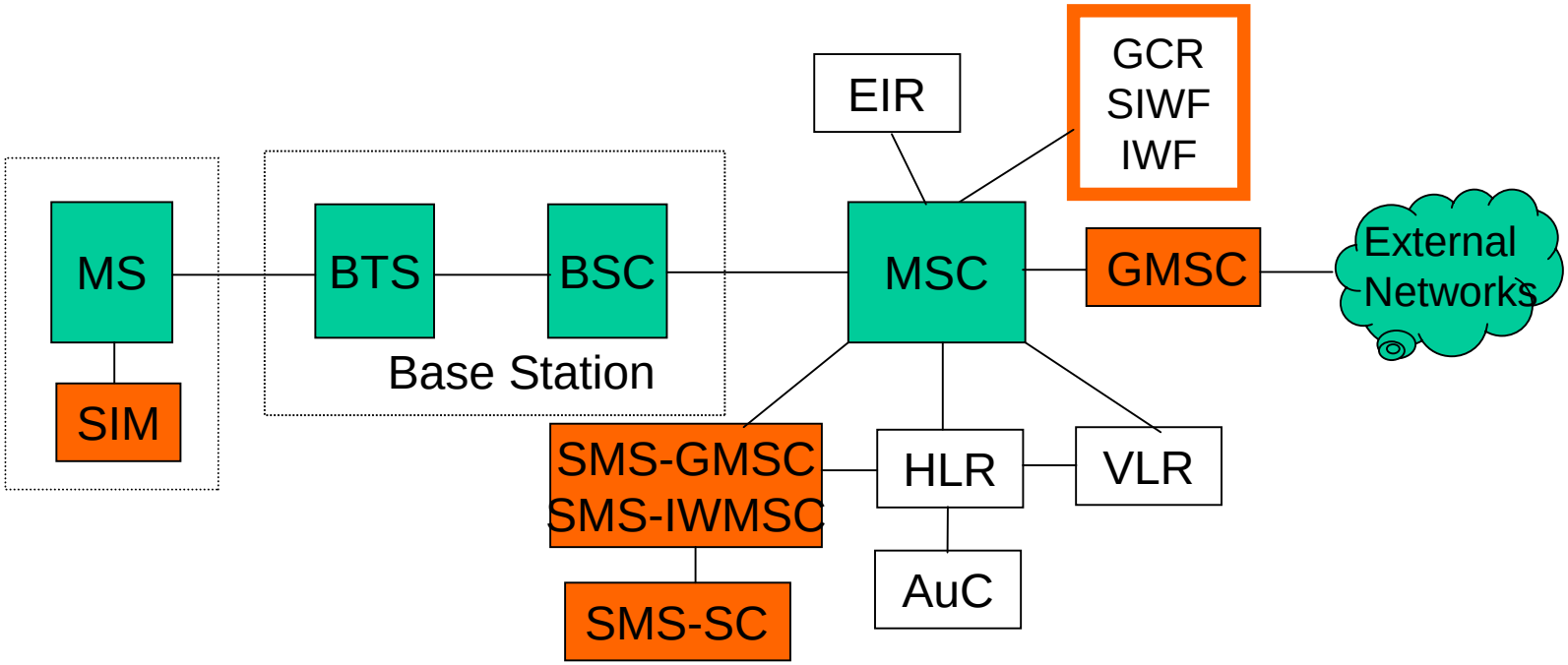
The Cellular Network



- MS – Mobile Station
- BTS – Basestation Transceiver Station
- BSC – Basestation Controller
- MSC – Mobile Switching Center

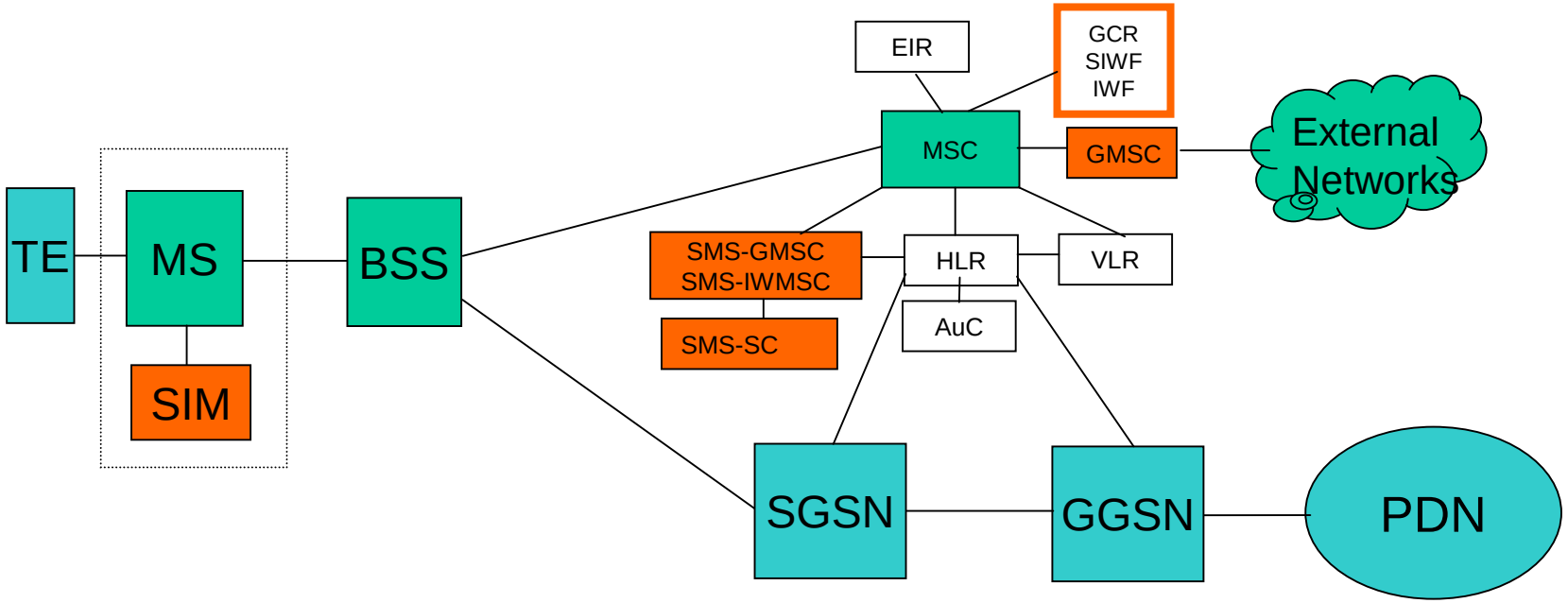
- HLR – Home Location Register
- VLR – Visitor Location Register
- EIR – Equipment Identity Register
- AuC – Authentication Center

Basic GSM reference model



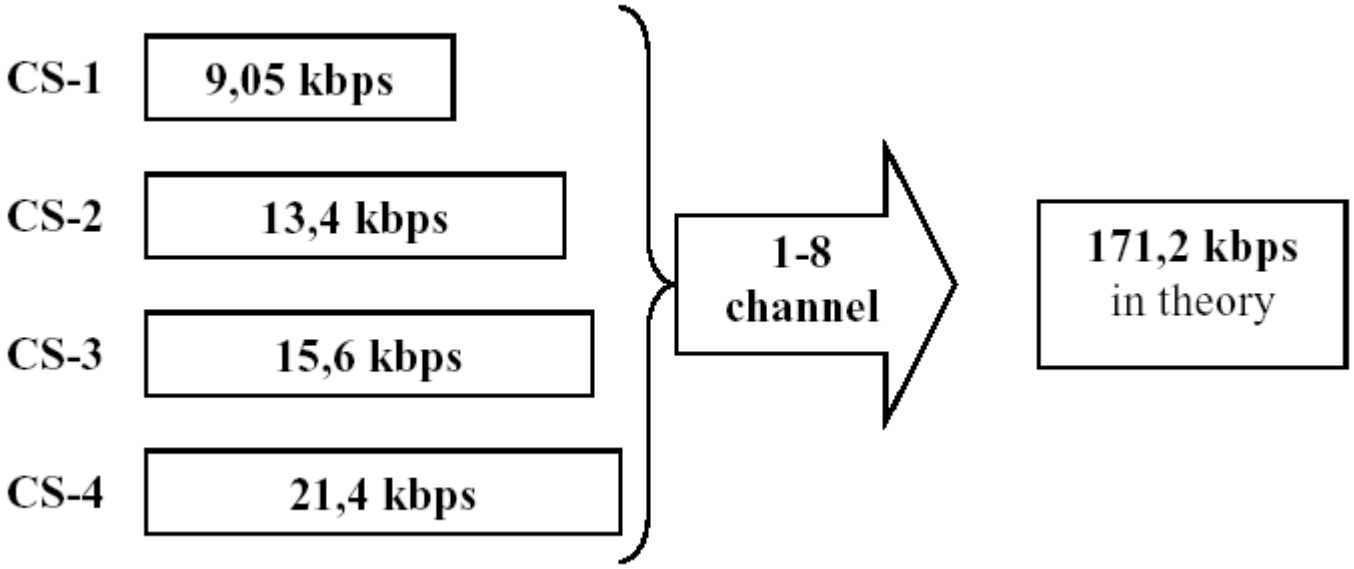
- SIM – Subscriber Identity Module
- GCR- Group Call Register
- IWF – InterWorking Function
- SIWF – Shared IWF
- GMSC- Gateway MSC
- SMS – Short Message Service
- SC – Service Center

GSM/GPRS reference model

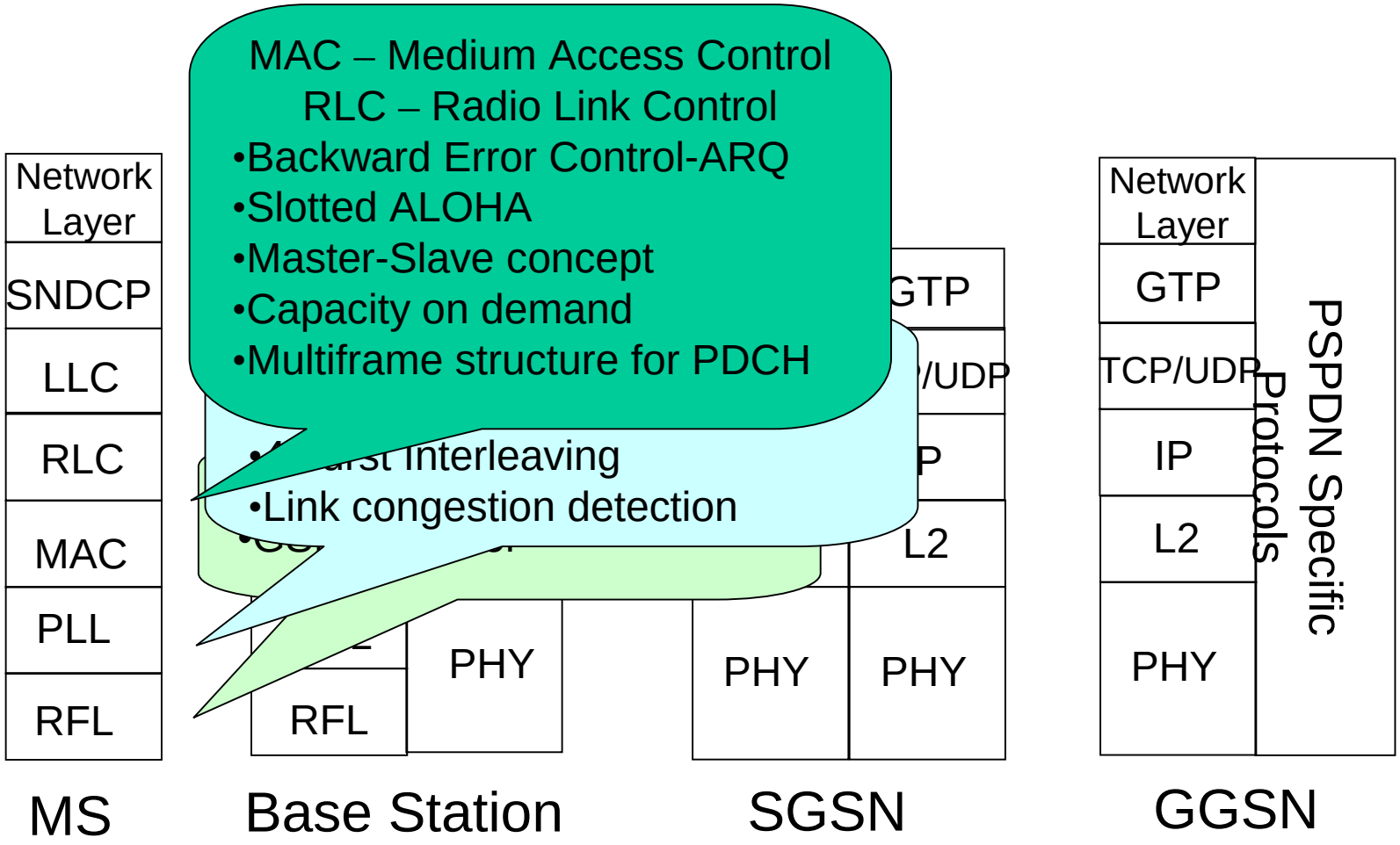


- TE – Terminal Equipment
- PDN – Public Data Network
- SGSN – Serving GPRS Support Node
- GGSN – Gateway GPRS support Node

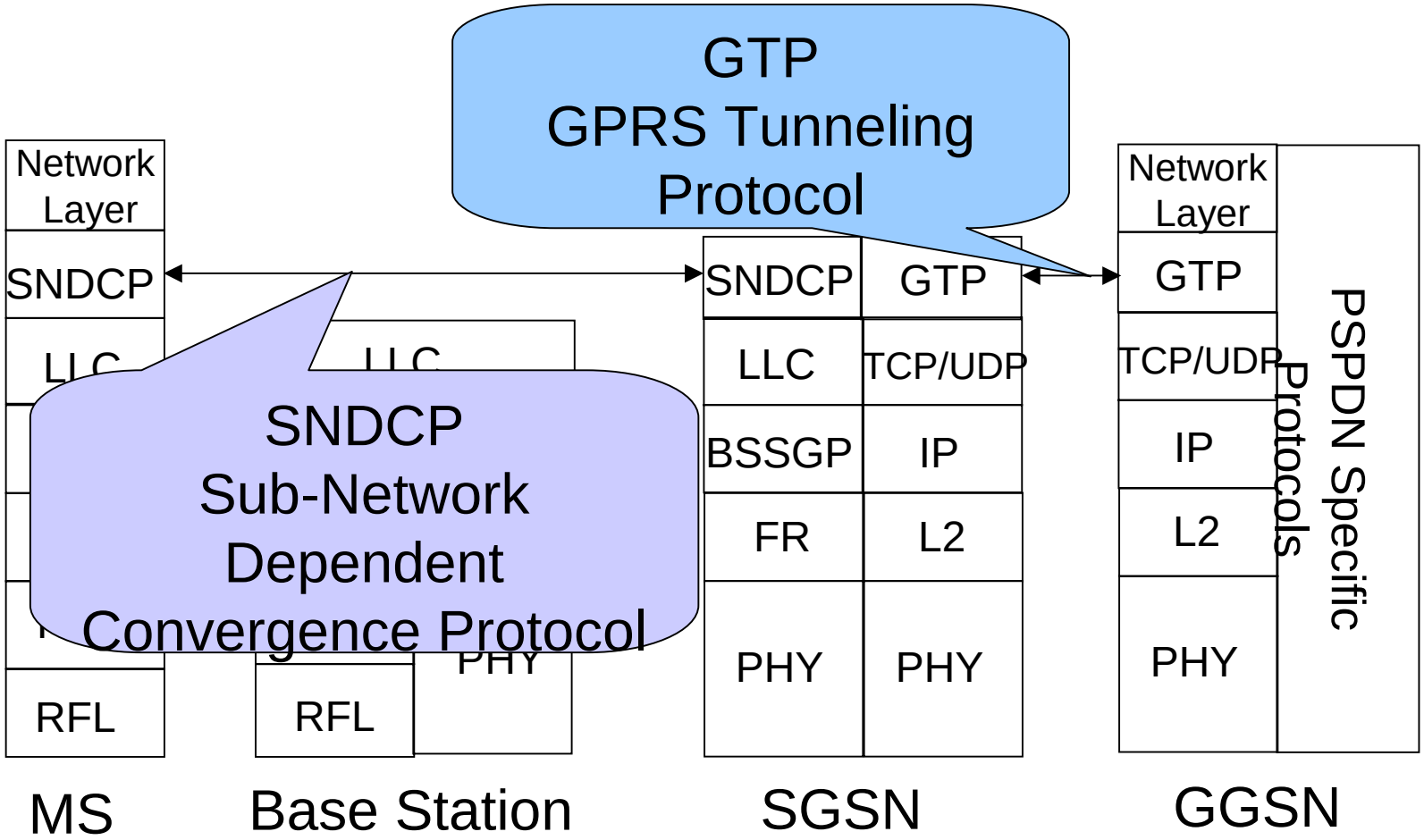
GPRS Data Rate



GPRS Protocol Stack



GPRS Protocol Stack



Handoffs in GSM and GPRS

GSM

- Types (network elements)
  - Intracell HO
  - Inter-Cell HO within the same BSC
  - Intra MSC HO
  - Inter MSC HO
- Types (function location)
  - Mobile initiated
  - Network initiated, mobile assisted

GSM (cont.)

- Measurements of the Broadcast Channel on a free time slot
- Decision according to:
  - Minimum acceptable performance

    power control is preferred over HO
  - Power budget algorithms

    HO is preferred over power control

GSM Handover Initiation

- Initiation by the network providing
  - New channels characteristics
  - Characteristics of a new cell
  - Power level
  - Physical channel establishment procedures
  - *Timing advance*
  - *Cipher mode setting*

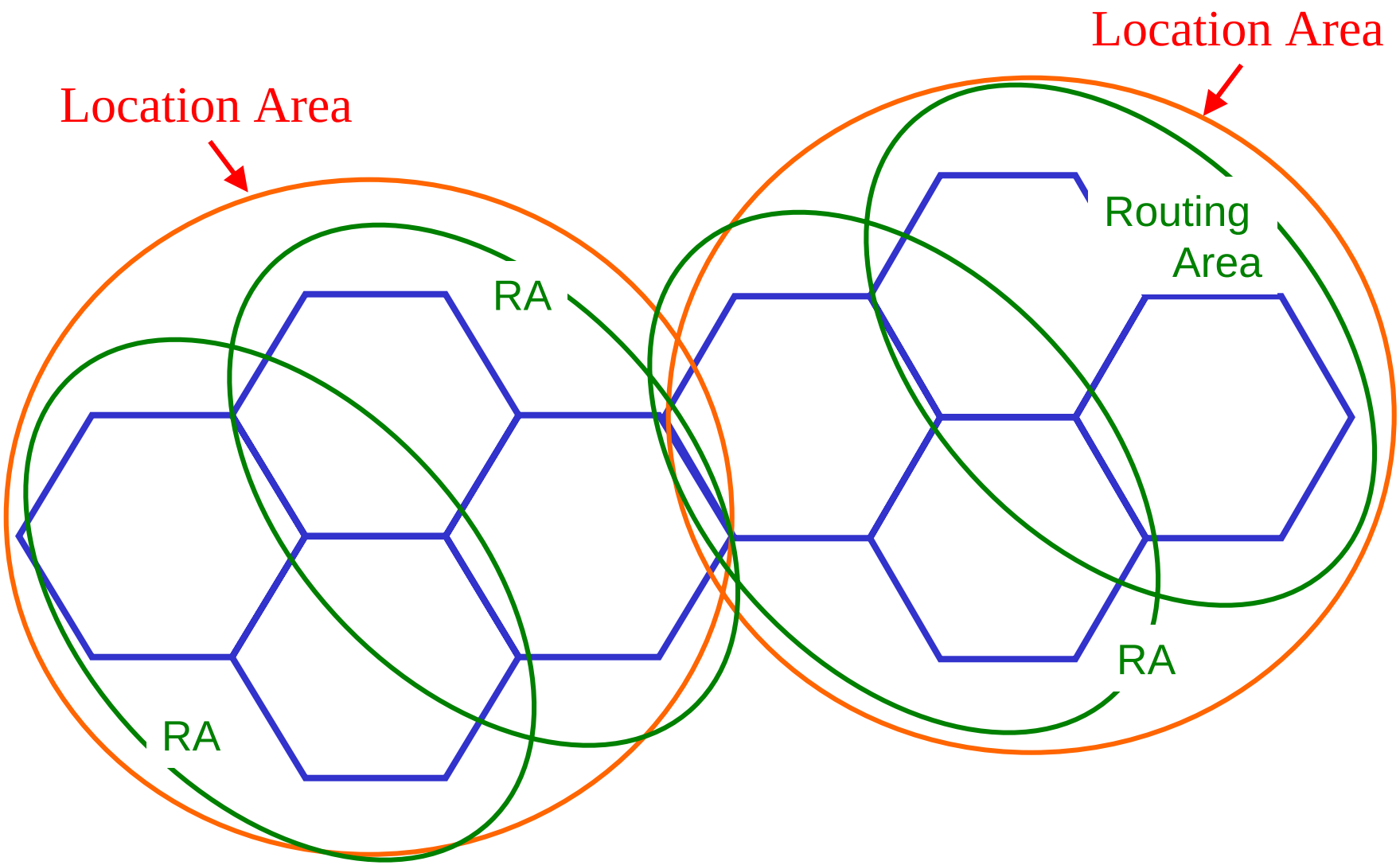
Physical Channel Establishment

- Finely synchronized cells
- Non synchronized cells
- *Pseudo synchronized cells*
- Pre-synchronized cells

GPRS
Mobile Station Modes of Operation

- Class A: The MS is attached to both GSM and GPRS simultaneously
- Class B: The MS is attached to both but can operate in only one at a time
- Class C: The MS is attached to GPRS or other GSM services

Cell Hierarchy



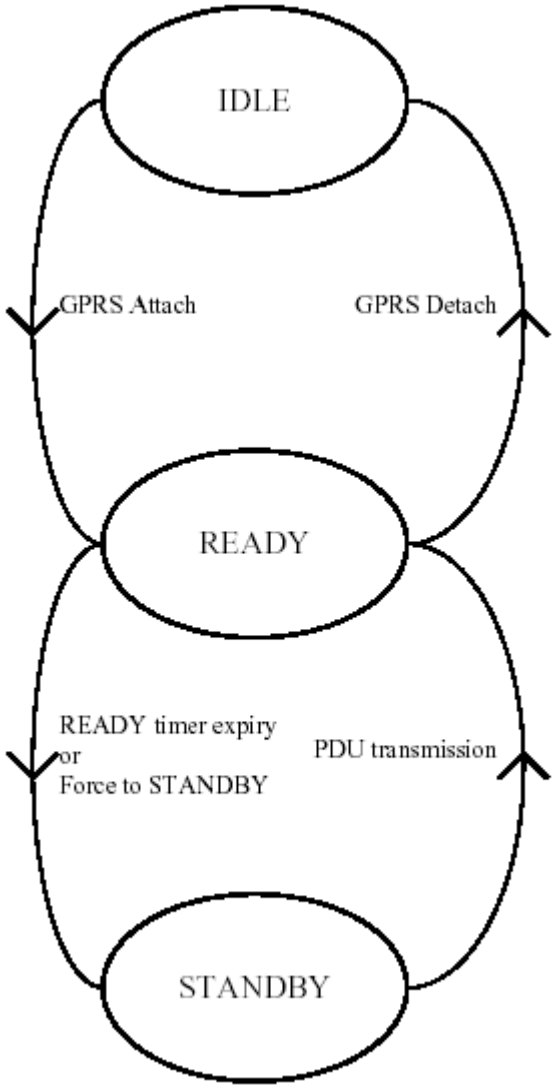
Levels of Location Management

- Cell Update (re-selection procedure)
  - Originated by MS
  - Based on BCCH measurements
  - Other criteria may apply
- Routing Area update
  - Initiated by mobile when crossing RA boundary

Mobility Management States

- Idle
  - MS is not attached to GPRS
- Standby
  - Subscriber is attached to GPRS mobility management
  - MS performs RA and cell selection locally, reports RA changes
  - Data, signaling or page response move the MS to READY
  - Detach procedures moves the state to Idle
- Ready
  - Information on cell selection is reported
  - Cell selection may be done locally or by network control
  - State supervised by a timer

Mobility Management States



GPRS Re-Selection

- GPRS IDLE state and wishes to initiate the GPRS Attach procedure:
  - If the currently camped-on cell supports GPRS then no cell reselection is required.
  - If the currently camped-on cell does not support GPRS, then reselection of a cell supporting GPRS is required before execution of the attach procedure.
- If the MS is in GPRS STANDBY or READY state, cell selection and reselection procedures specific to GPRS shall be used
- The cell reselection procedure used in READY state shall minimise the cell changes.
- If the MS is in dedicated mode, then the changes from one cell to another is performed according to the network-controlled handover procedures.
- There may be co-ordination of the idle and dedicated mode procedures used for circuit-switched services with the READY state procedure for MSs that are both IMSI-attached and GPRS-attached.

Routing Update Procedure

- MS sends RA update request containing the cell identity and the identity of previous routing area, to new SGSN
- New SGSN asks from old SGSN the context (GGSN address and tunneling information) of the MS
- New SGSN updates GGSNs, new SGSN address and tunneling information is delivered to GGSN
- New SGSN updates HLR
- HLR cancels the MS information context in old SGSN
- HLR loads the subscriber data to new SGSN
- New SGSN acknowledges to the MS
- The previous SGSN is requested to transmit the undelivered data to the new SGSN.

www.ece.wpi.edu/~prashant/geo/neth98.pdf

QoS Profiles

- Precedence Class
  - High, Normal, Low
- Delay Classes
- Reliability Classes
- Throughput classes

Delay Classes

Delay Class	Delay (maximum values)			
	SDU size: 128 octets		SDU size: 1024 octets	
	Mean Transfer Delay (sec)	95 percentile Delay (sec)	Mean Transfer Delay (sec)	95 percentile Delay (sec)
1. (Predictive)	< 0.5	< 1.5	< 2	< 7
2. (Predictive)	< 5	< 25	< 15	< 75
3. (Predictive)	< 50	< 250	< 75	< 375
4. (Best Effort)	Unspecified			

Reliability Classes

Reliability class	Lost SDU probability (a)	Duplicate SDU probability	Out of Sequence SDU probability	Corrupt SDU probability (b)	Example of application characteristics.
1	10^{-9}	10^{-9}	10^{-9}	10^{-9}	Error sensitive, no error correction capability, limited error tolerance capability.
2	10^{-4}	10^{-5}	10^{-5}	10^{-6}	Error sensitive, limited error correction capability, good error tolerance capability.
3	10^{-2}	10^{-5}	10^{-5}	10^{-2}	Not error sensitive, error correction capability and/or very good error tolerance capability.

Reliability Classes (cont.)

Reliability Class	GTP Mode	LLC Frame Mode	LLC Data Protection	RLC Block Mode	Traffic Type
1	Acknowledged	Acknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that cannot cope with data loss.
2	Unacknowledged	Acknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that can cope with infrequent data loss.
3	Unacknowledged	Unacknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that can cope with data loss, GMM/SM, and SMS.
4	Unacknowledged	Unacknowledged	Protected	Unacknowledged	Real-time traffic, error-sensitive application that can cope with data loss.
5	Unacknowledged	Unacknowledged	Unprotected	Unacknowledged	Real-time traffic, error non-sensitive application that can cope with data loss.
NOTE: For real-time traffic, the QoS profile also requires appropriate settings for delay and throughput.					

Peak Throughput Class

Peak Throughput Class	Peak Throughput in octets per second
1	Up to 1 000 (8 kbit/s).
2	Up to 2 000 (16 kbit/s).
3	Up to 4 000 (32 kbit/s).
4	Up to 8 000 (64 kbit/s).
5	Up to 16 000 (128 kbit/s).
6	Up to 32 000 (256 kbit/s).
7	Up to 64 000 (512 kbit/s).
8	Up to 128 000 (1 024 kbit/s).
9	Up to 256 000 (2 048 kbit/s).

Mean Throughput Classes

Mean Throughput Class	Mean Throughput in octets per hour
1	100 (~0.22 bit/s).
2	200 (~0.44 bit/s).
3	500 (~1.11 bit/s).
4	1 000 (~2.2 bit/s).
5	2 000 (~4.4 bit/s).
6	5 000 (~11.1 bit/s).
7	10 000 (~22 bit/s).
8	20 000 (~44 bit/s).
9	50 000 (~111 bit/s).
10	100 000 (~0.22 kbit/s).
11	200 000 (~0.44 kbit/s).
12	500 000 (~1.11 kbit/s).
13	1 000 000 (~2.2 kbit/s).
14	2 000 000 (~4.4 kbit/s).
15	5 000 000 (~11.1 kbit/s).
16	10 000 000 (~22 kbit/s).
17	20 000 000 (~44 kbit/s).
18	50 000 000 (~111 kbit/s).
31	Best effort.

Handoff Summary

- No special probe signal is used by BTS (MCHO)
- Several principles are used for handoff decision
- Only passive scanning at MS is employed to detect nearby BTS (like in GSM)
- In network layer MS communicates with SGSN, in physical layer with a BSS.
- Several protocols and channels are employed for indicating the MSs current location

	802.11	GSM/GPRS	CDPD
Beacon	Same physical channel	Separate Physical Channel	Separate Physical Channel
Handoff Decision	Mobile	GSM- BSC GPRS- MS	Mobile
Information to old AP	IAPP	GSM – by BSC GPRS – by SGSN	Message from MHF to MSF of old BS
Channel Monitoring	At the terminal	At the terminal	At the terminal
Access and Monitoring	CSMA Monitored all the time	TDMA Monitored when MS does not transmit or receive	DSMA/CD Monitored all the time

Conclusion

- Wireless data has been considered since early days of cellular technology
- GSM/GPRS supports packet data together with CS traffic, with rates up to 171kbps
- Handover in GPRS is strongly aligned to GSM handover
- QoS is the main issue in handover of GPRS. The standard supports a variety of profiles
- HO principles are similar in various types of systems