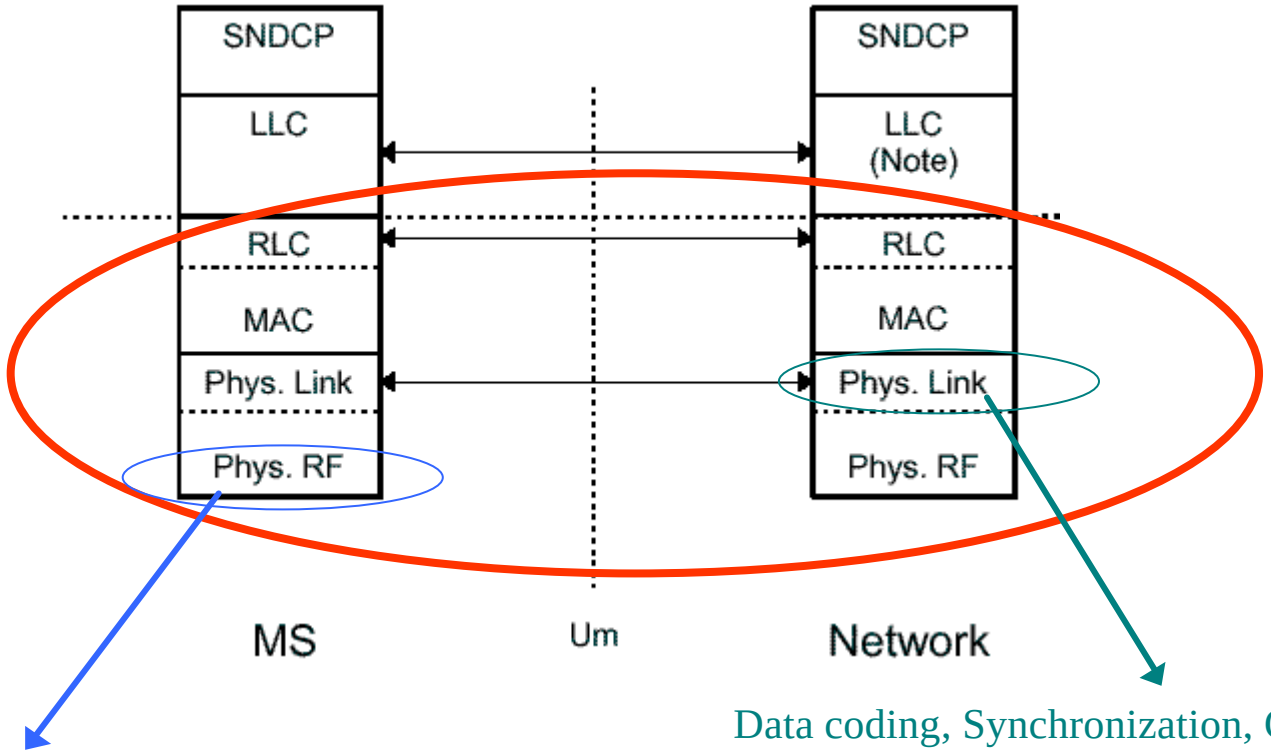
GPRS Dimensioning and Performance Workshop

GPRS Radio Network Configuration

Scope of this Module



Carrier Frequencies, Modulation, TRX properties

Data coding, Synchronization, Cell re-selection, DRX, etc.

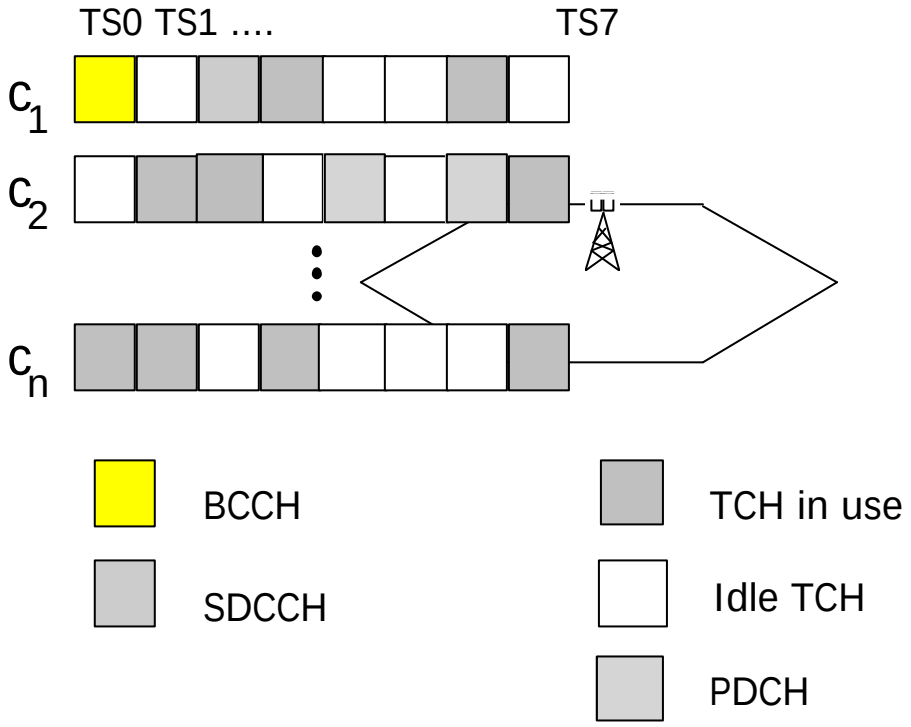
GPRS Radio Network Configuration

- Physical Channel Structure
- Cell Re-Selection
- GPRS Channel Allocation
- Radio Network Features
- Cell planning
- GPRS Cell Parameters and BSC Properties and SGSN Parameters
- EGPRS Radio Network Enhancements in R9.1

GPRS Radio Network Configuration

Part 1: Physical Channel Structure

The packet data radio channels



Packet Data Logical Channels

- PBCCH – broadcast of system information (DL)
- PCCCH –common control signalling
  - PRACH – uplink packet transfer initiation (UL)
  - PAGCH – resource assignemnt (DL)
  - PPCH – paging for either PS or PS&CS (DL)
  - PNCH – PTM – M, Multicast (DL)
- PDCCH
  - PACCH – MS-specific signalization (UL & DL)
  - PTCCH/U – MS-specific timing advance information (UL)
  - PTCCH/D – timing advance information for group of MSs (DL)
- PDTCH – end-user data traffic
  - PDTCH/U – end-user traffic in uplink direction (UL)
  - PDTCH/D – end-user traffic in downlink direction (DL)

Mapping of Logical Packet Data Channels onto the Physical Channels

1 timeslot = 156.25 bit duration (~0,577 ms)

Used by almost all channels

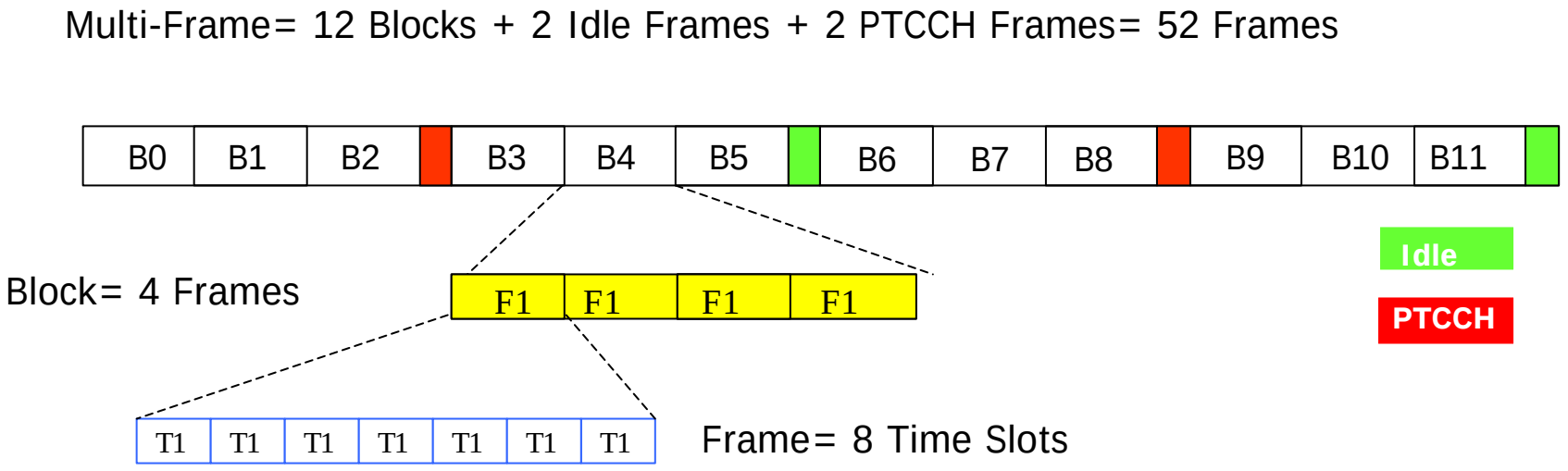
TB 3	Encrypted Bits 57	Flag 1	Training Sequence 26	Flag 1	Encrypted Bits 57	TB 3	GP 8.25

Used by PRACH, PTCCH and PCCH (only in some cases) channels

TB 8	Synchronization Sequence 41	Encrypted Bits 36	TB 3	GP 68.25

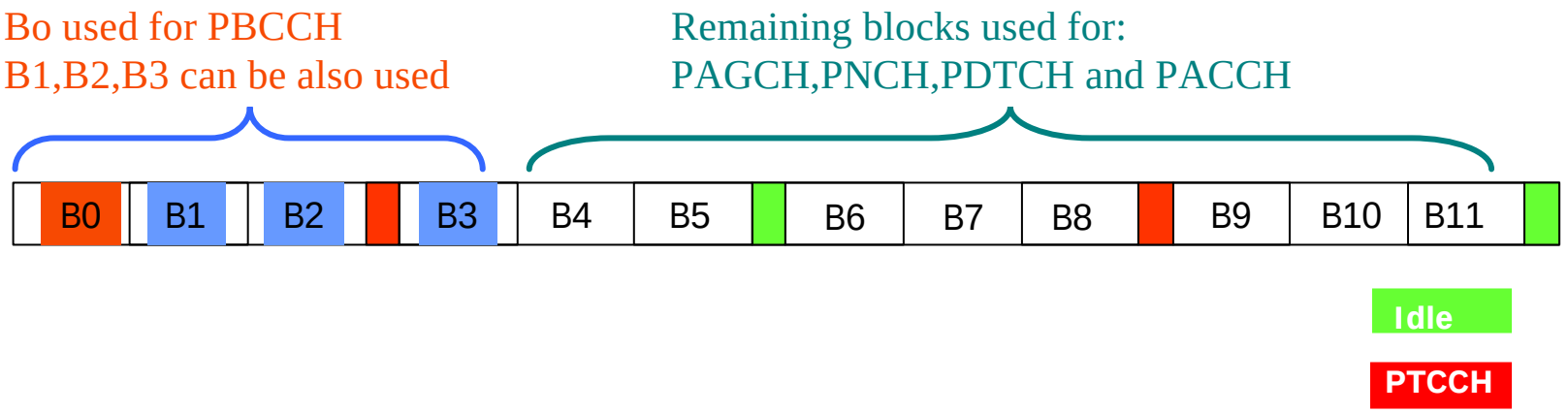
GPRS Multi-Frame Structure

- One TDMA Frame (F) consists of 8 Time Slots (TS)
- 4 Consecutive TDMA Frames (F) are groupped into one TDMA Block (B)
- 12 Blocks + 2 Idle TDMA Frames+ 2 TDMA Frames used for PTCCH consisting 52 Multi-Frame structure



GPRS Multi-Frame Structure (MPDCH)

- PBCCH is indicated on BCCH channel
- Different structure for UL/DL
- Mapping of channels are controlled by PBCCH parameters
- In downlink case first blocks can be reserved for PRACH, other are used for PDTCH and PACCH channels



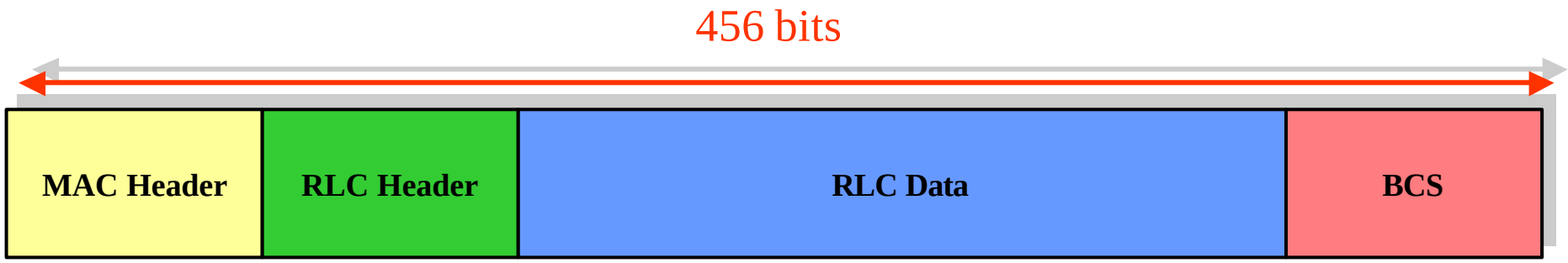
MPDCH mapping – DL example

GPRS Multi-Frame Structure (PDTCH)

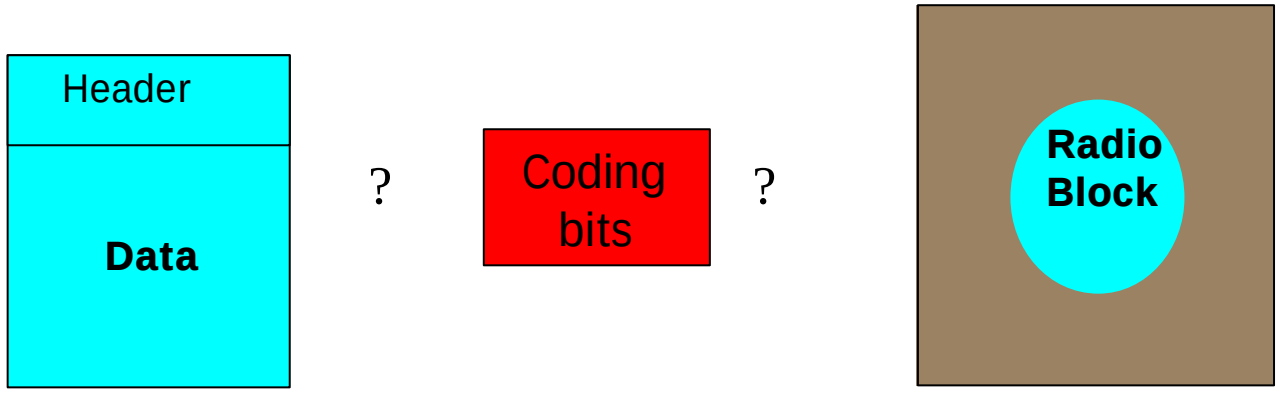
- Very similar in UL and DL
- Almost all Blocks used for PDTCH & PACCH
- Idle and PTCCH can be used for signal measurements and BSIC identification

PDTCH mapping – UL/DL example

Radio Block Structure



Radio Block Structure - Coding



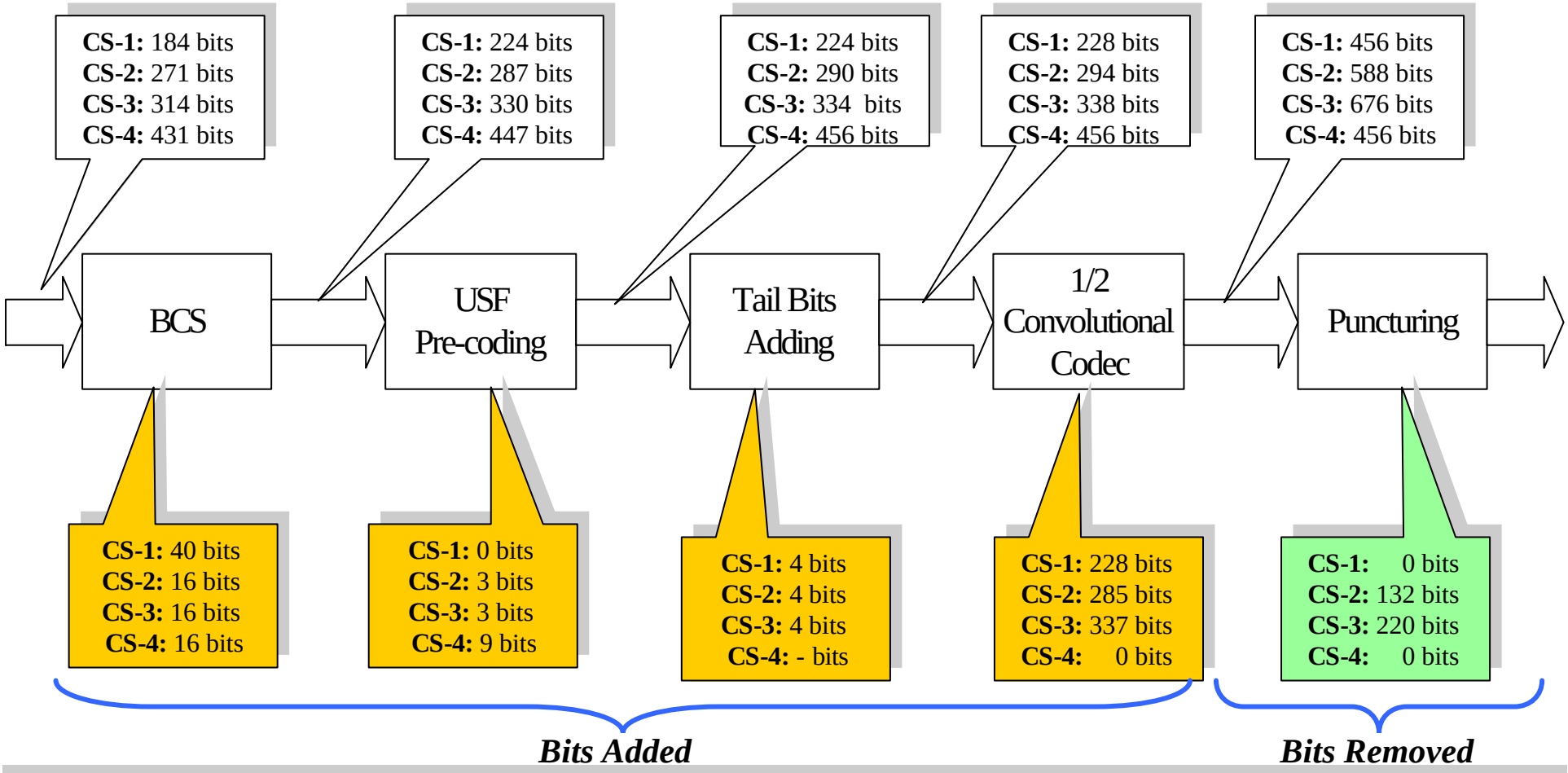
M bits in RLC/MAC block

456-M bits of coding

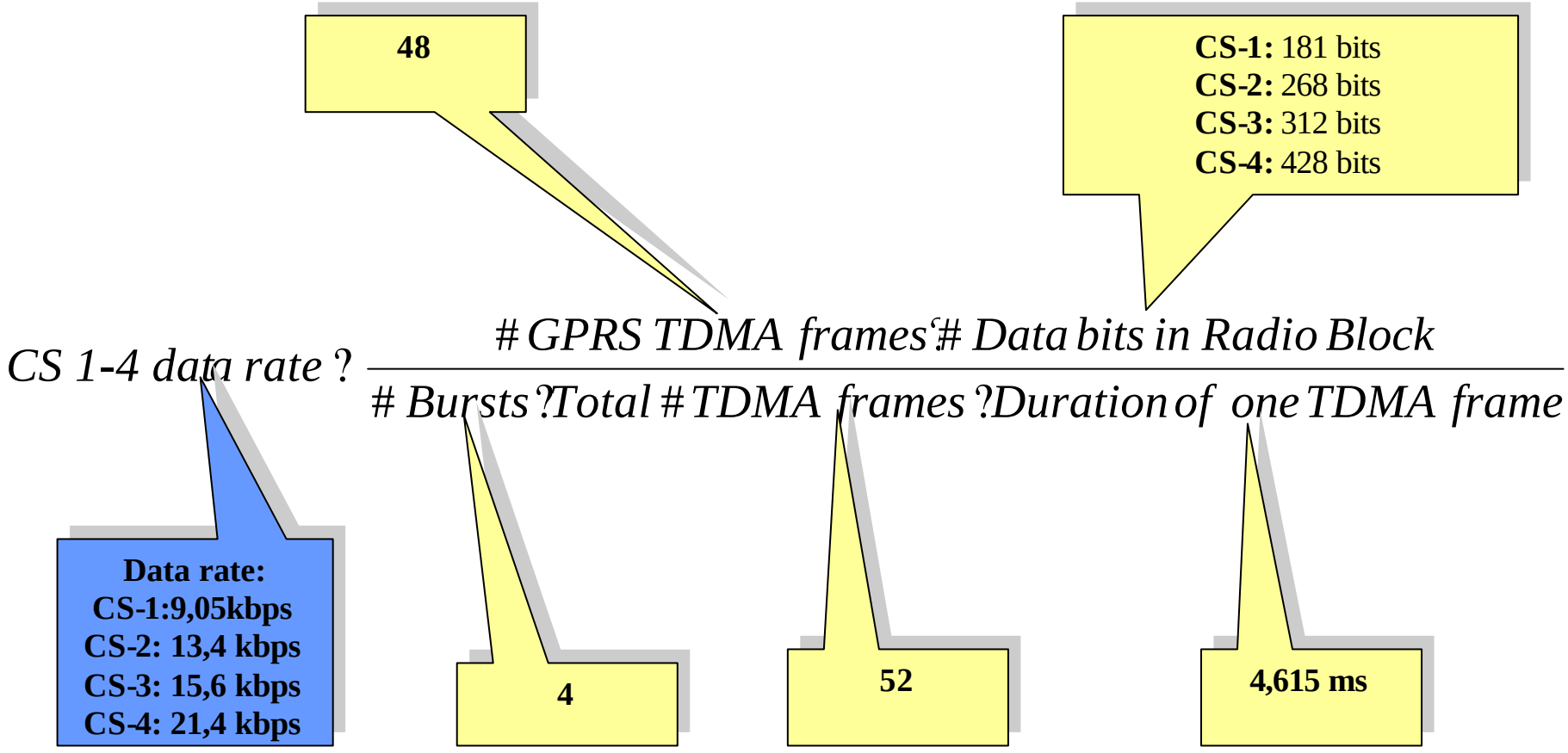
456 bits in each radio block

GPRS Channel Coding

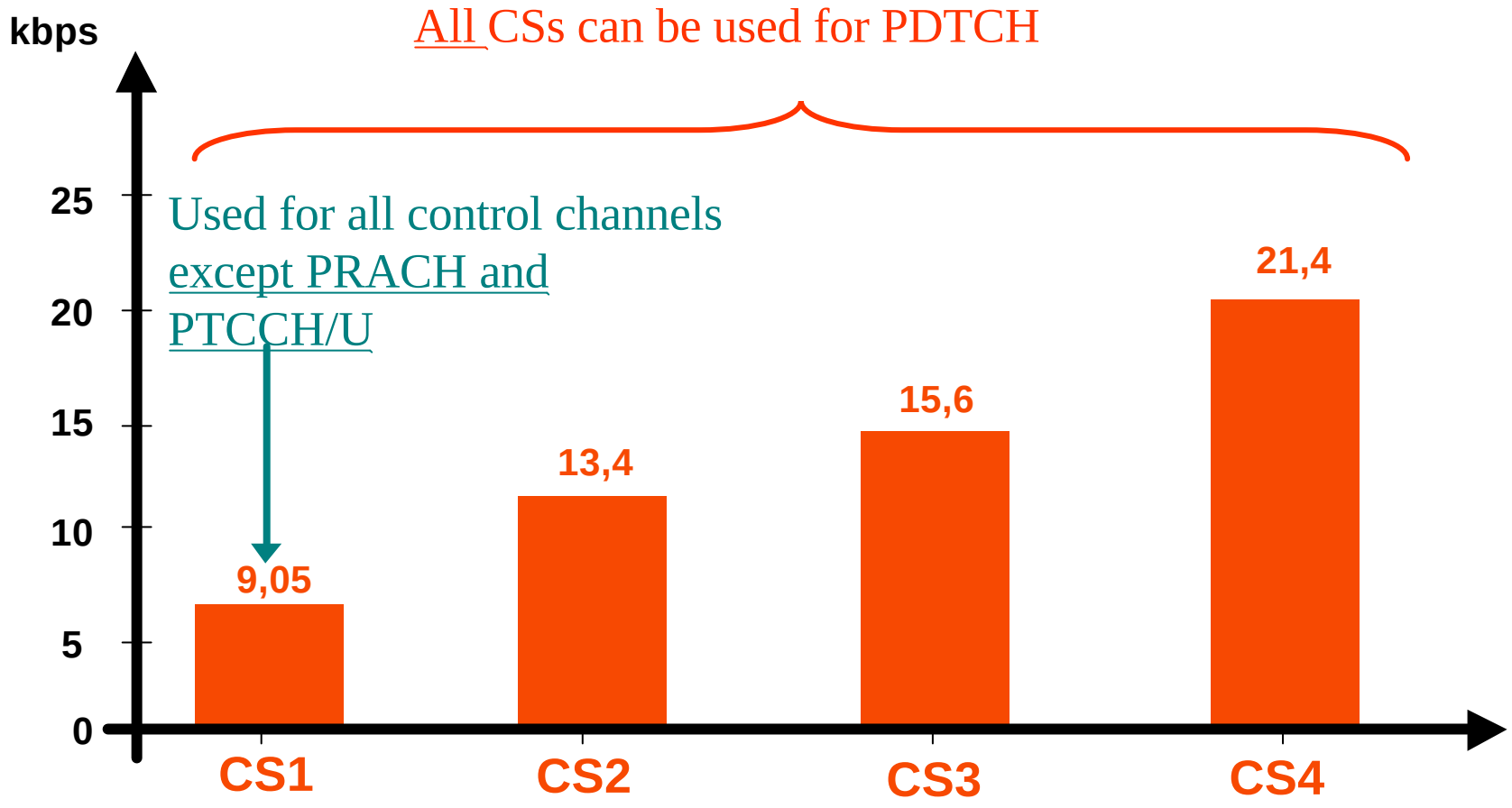
Block Codec output
– 3 USF bits included



Data Rate Calculation (RLC Layer)



GPRS Data Rate on RLC Layer



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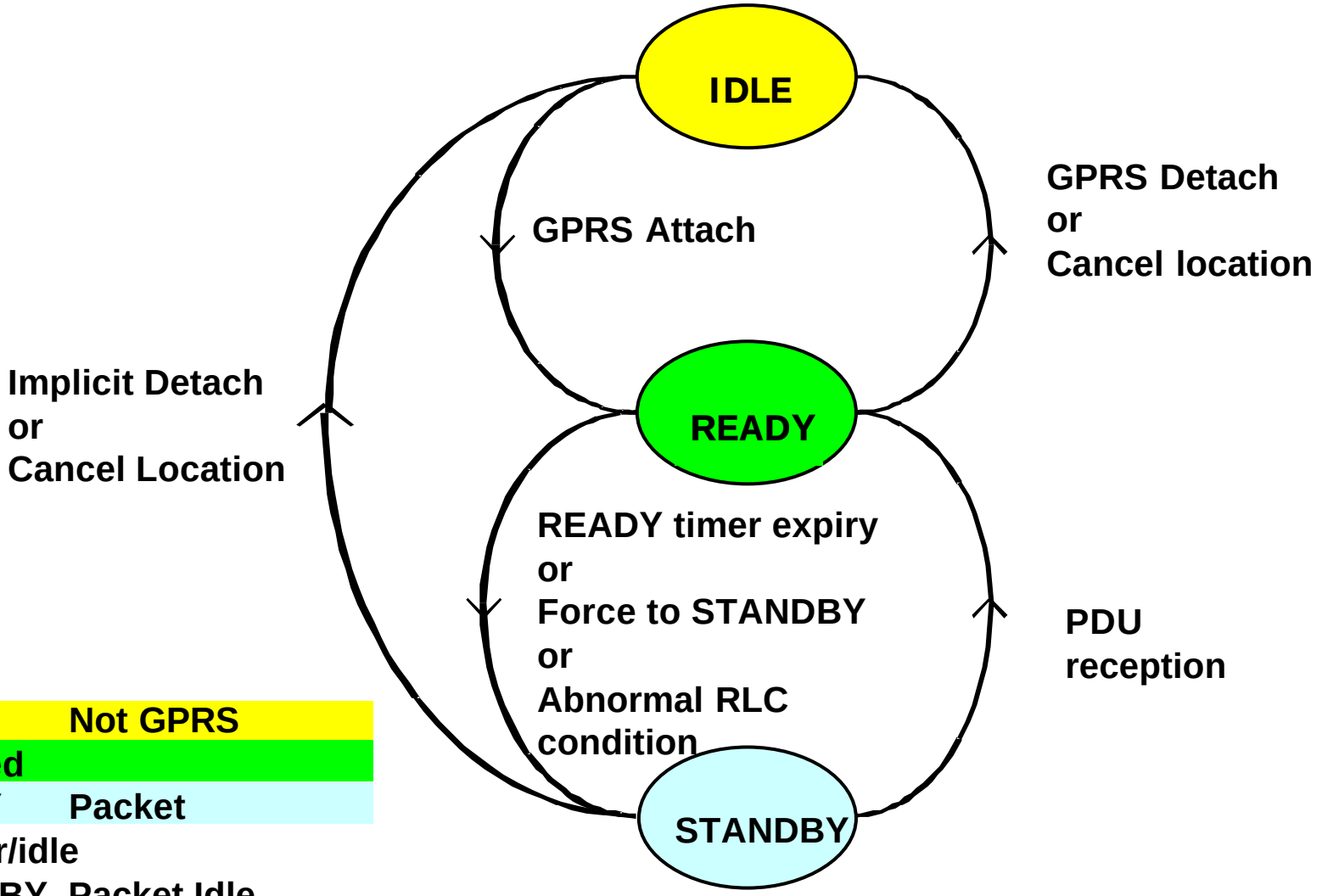
GPRS Radio Network Configuration

Part 2: Cell (Re-)Selection

GPRS Mobility Management

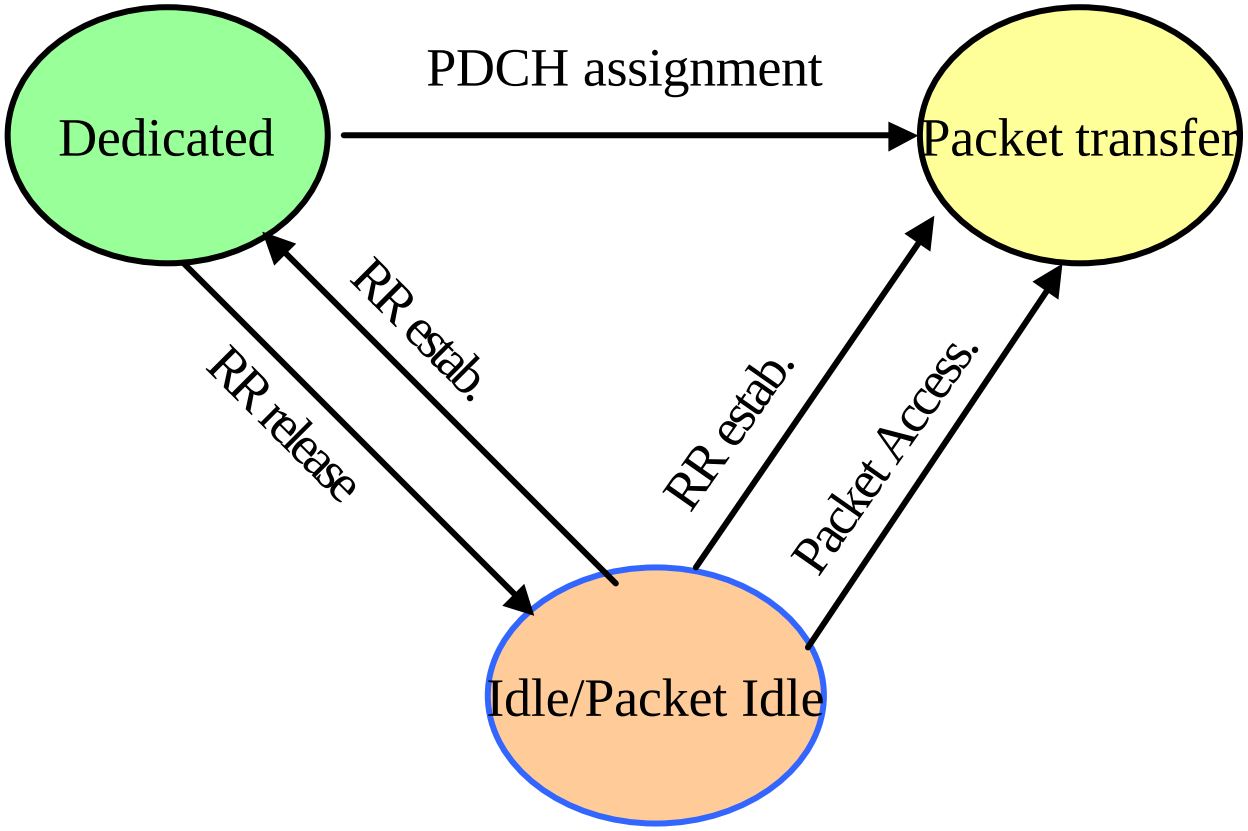


IDLE	Not GPRS attached
READY	Packet transfer/idle
STANDBY	Packet Idle

Radio Resources Operating Modes Definitions (Class B assumed)

- Class B Mobile is able to handle CS and PS Traffic but not at the same time
- Packet Switching Modes
  - Idle (TBF not established)
  - Transfer (TBF exists on one or more radio channels)
- Circuit Switching Modes
  - Idle (no RR connection)
  - Dedicated (RR exists)

Radio Resources Operating Modes & Transitions



RR Operating Modes and MM States

RR BSS	**Packet transfer mode**	**Measurem. reception**	**No State**	**No State**
RR MS	**Packet transfer mode**	**Packet idle mode mode**		**Packet Idle Mode**
MM (MS&SGSN)	**Ready**			**Standby**

Different MS behavior with Packet BCCH

Without allocated PBCCH

The GPRS MS listen to the GSM **BCCH** and **PCH**

- The GPRS MS will use the GSM CS **PCH**, **RACH** and **AGCH**

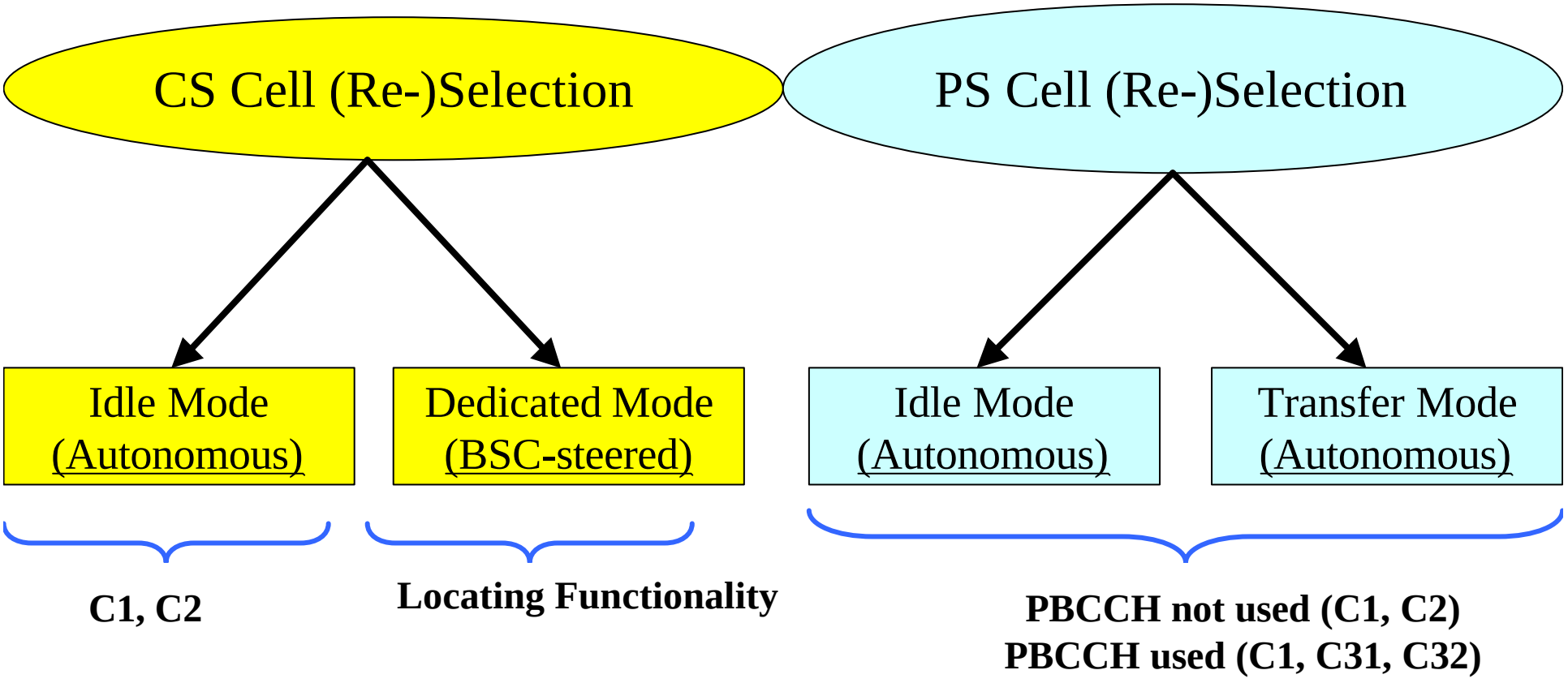
With allocated PBCCH

The GPRS MS reads SI on **BCCH** to find **PBCCH**

- Now the GPRS MS only listens on **PBCCH** and **PPCH**
- GPRS dedicated Packet System Information sent on **PBCCH**
- The **PPCH, PRACH** and **PAGCH** are used

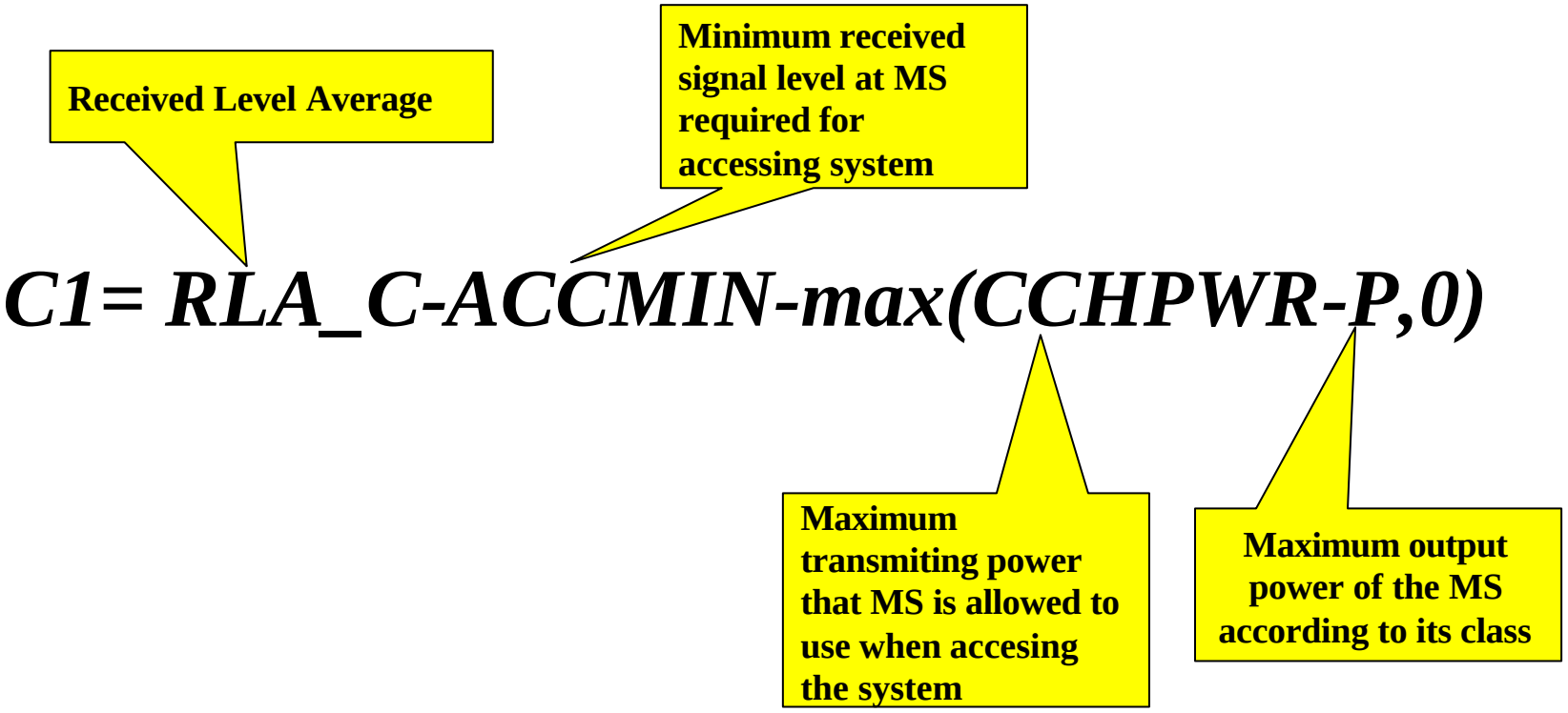
The **PBCCH** timeslot must be a dedicated **PDCH** in R8.

GPRS Cell (Re-)Selection Principles



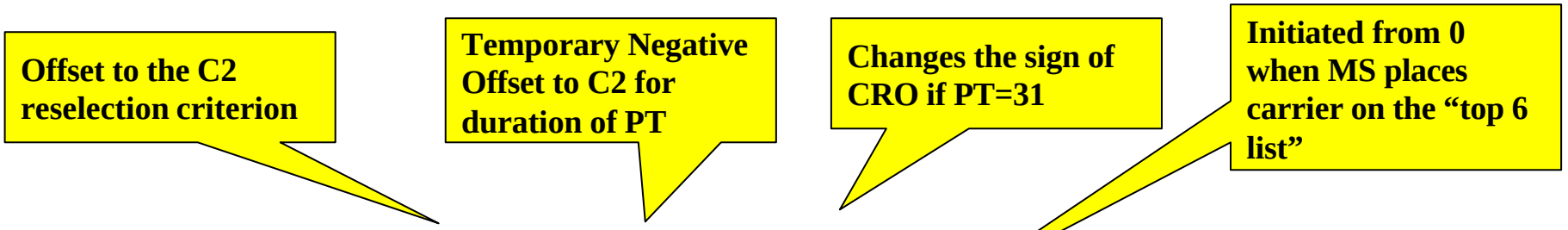
GPRS Cell (Re-) Selection – No PBCCH used (I)

C1 Parameter – Path Loss Criterion



GPRS Cell (Re-) Selection – No PBCCH used (II)

C2 Parameter – Cell (Re-)Selection Criterion



$$C2 = C1 + CRO - TO * H(PT - T) \; ; \; PT <> 31$$

$$C2 = C1 - CRO \; ; \; PT = 31$$

Note: H(x) = 1; X=>0

H(x) = 0; X<0

GPRS Cell (Re-) Selection – No PBCCH used (III)

GPRS MS re-selects a new cell if any of the following criteria is satisfied:

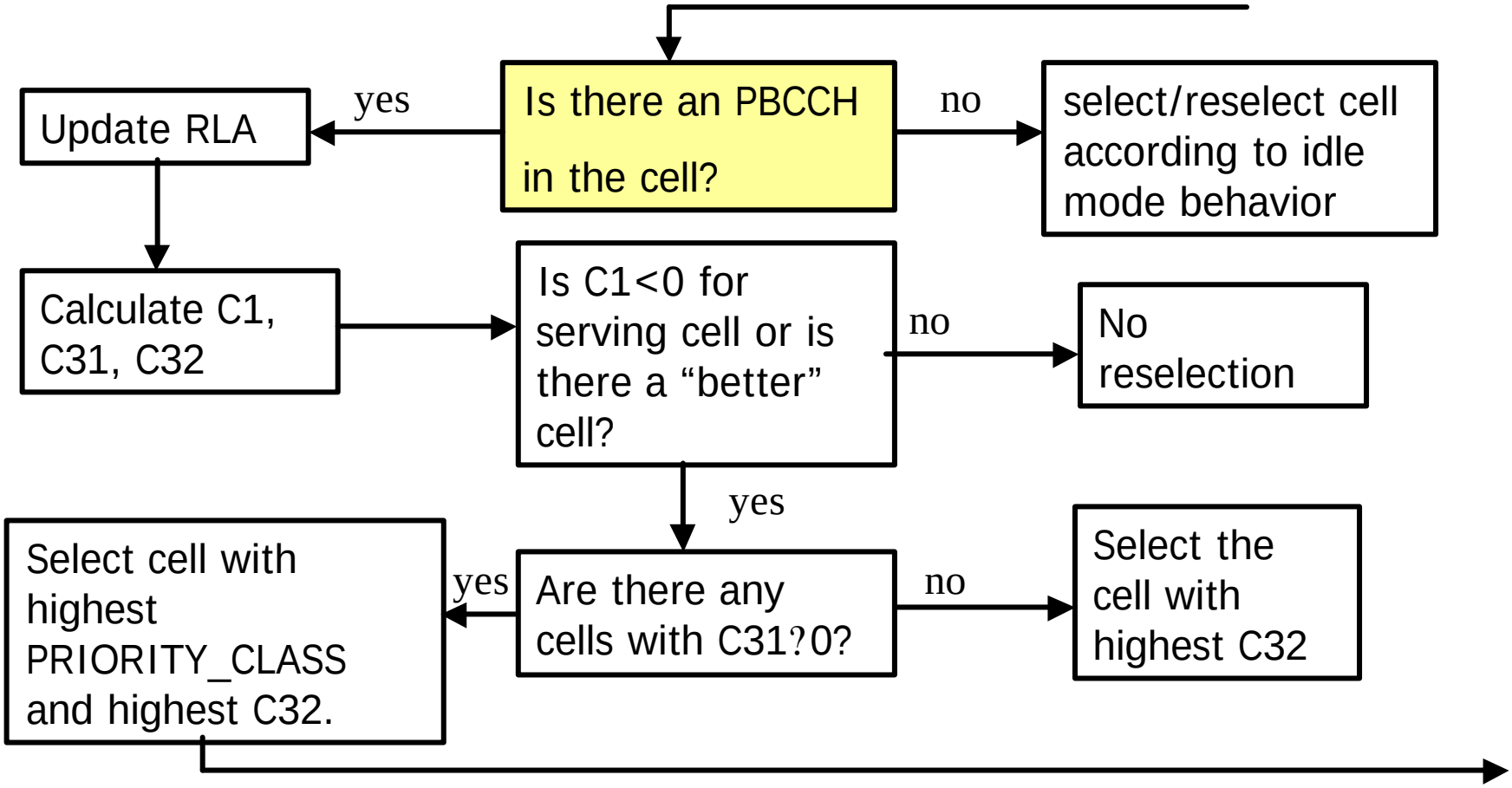
- C1 for the serving cell falls below 0 for a 5 seconds
- C2 of non-serving cell exceeds C2 value of the serving cell for the period of 5 seconds.
- Serving cell becomes barred
- MS has unsuccessfully tried to access network the allowed number of times
- MS dettects a downlink signalling failure

GPRS Cell (Re-) Selection –PBCCH used

GPRS MS re-selects a new cell if any of the following criteria is satisfied:

- C1 for the serving cell falls below 0
- The best non-serving cell does have the highest value of C32 among:
  - All cells with the highest priority fulfilling C31 criterion
  - All cells, if no cells fulfill C31 criterion
- Serving cell becomes barred
- MS has unsuccessfully tried to access network the allowed number of times
- MS dettects a downlink signalling failure

GPRS cell reselection algorithm



GPRS Cell (Re-) Selection – PBCCH used (I)

C1 Parameter – Path Loss Criterion

Received Level Average

Minimum received signal level at MS required for accessing system

$$C1 = RLA\_P - GPRS\_RXLEV\_ACCESS\_MIN - max(GPRS\_MS\_TXPWR\_MAX\_CCH - P, 0)$$

Maximum transmiting power that MS is allowed to use when accesing the system

Maximum output power of the MS according to its class

GPRS Cell (Re-) Selection – PBCCH used (II)
C31 Signal Strength Treshold Criterion for HCS

$$C31(s) = RLA\_P\text{-}HCS\_THR(s)$$

Signal Strenght Treshold for applying HCS re-selection

Temporary offset for duration of GPRS_PENALTY_TIME ...next slide...

$$C31(n) = RLA\_P(n) - HCS\_THR(n) - TO(n) * L(n)$$

L(n)=0 if GPRS_PRIORITY_CLASS(n)= GPRS_PRIORITY_CLASS(s)
L(n)=0 if GPRS_PRIORITY_CLASS(n)<> GPRS_PRIORITY_CLASS(s)

GPRS Cell (Re-) Selection – PBCCH used (III)
C31 Signal Strength Treshold Criterion for HCS

Applied Offset for the GPRS_PENALTY_TIME

$$TO(n) = GPRS\_TEMPORARY\_OFFSET(n) * H(GPRS\_PENALTY\_TIME(n) - T(n))$$

Period while GPRS_TEMPORARY_OFFSET is applied

Initiated from 0 when MS places carrier on the "top 6 list"

GPRS Cell (Re-) Selection – PBCCH used (IV)
C32 Cell Ranking Criterion

$$C32(s)=C1(s)$$

$$C32(n)=C1(n)+GPRS\_RESELECT\_OFFSET(n) - -TO(n)*(1-L(n))$$

Applies offset and hysteresis value to each cell

ERICSSON

oskar

GPRS Radio Network Configuration

Part 3: GPRS Channel Allocation

Dedicated PDCH

- A timeslot, i.e. traffic channel, reserved for packet data traffic.
- A maximum of 8 dedicated PDCH per cell is possible.
- Timeslot 4 to 7 are used

On-demand PDCH

- A timeslot, i.e. traffic channel, temporary allocated for packet data traffic. Circuit switched traffic is prioritised, why pre-emption is possible.
- All but the timeslots used for BCCH and SDCCH can be allocated as on-demand PDCHs.

GPRS Network Modes

- Set per BSC with exchange property GPRSNWMODE.
  - 0 = Network Mode I. No master PDCH allowed.
  - 1 = Network Mode I. First dedicated PDCH in cell configured as master PDCH.
  - 2 = Network Mode II. No master PDCH allowed. Default.
  - 3= Network Mode III. First dedicated PDCH in cell configured as master PDCH.

Recommendation for using Packet BCCH or not (1)

When the GPRS traffic in the GPRS network becomes higher than neglectable - allocate a PBCCH**.**

Advantages

- **Better possibilities to control GPRS MS (C31/C32)**
- **GPRS BA list available**
- **More capacity for PS paging, random access and access grant**

Recommendation for Using Packet BCCH or not (2)

Initially the GPRS MS and network will have problems supporting NW mode 1 and 3. Therefore can no PBCCH be allocated.

BSC Property

GPRSNWMODE=2

When NW mode 1 or 3 are supported and the GPRS traffic becomes higher than neglectable - allocate a PBCCH. (NW mode 1 is preferred.)

Cell Parameter

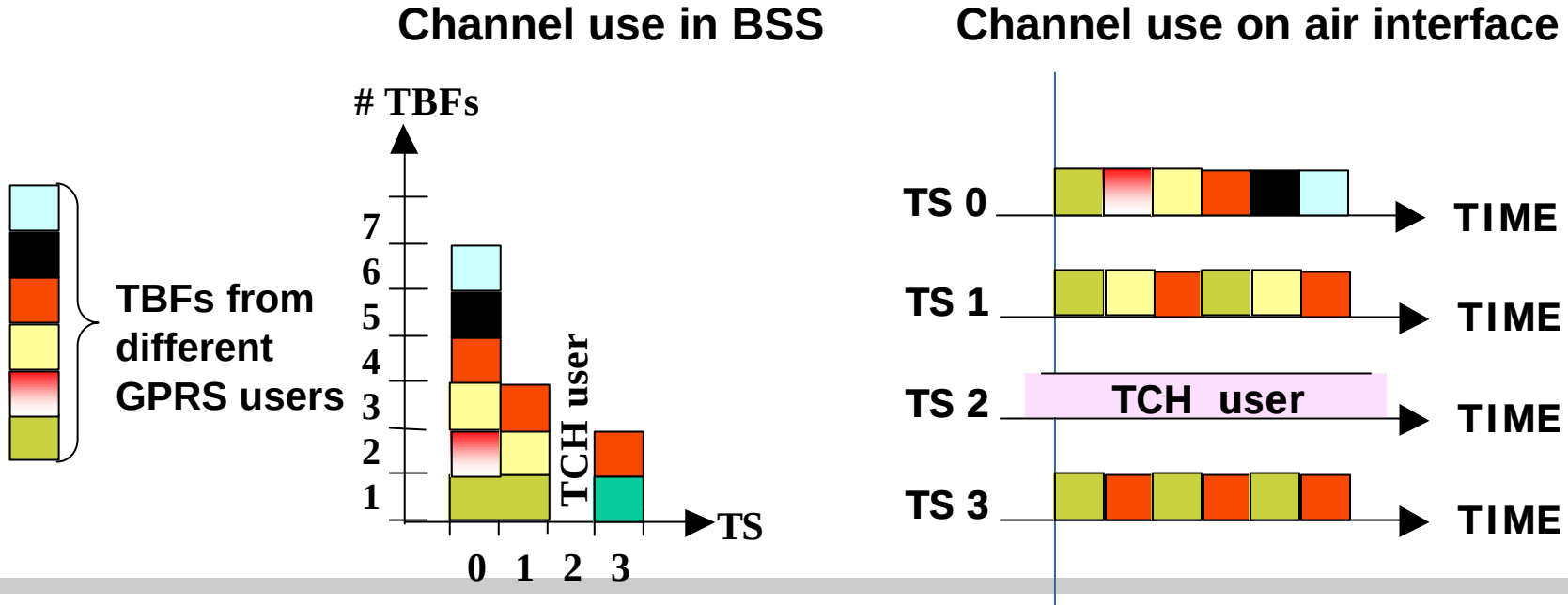
FPDCH ? 1

BSC Property

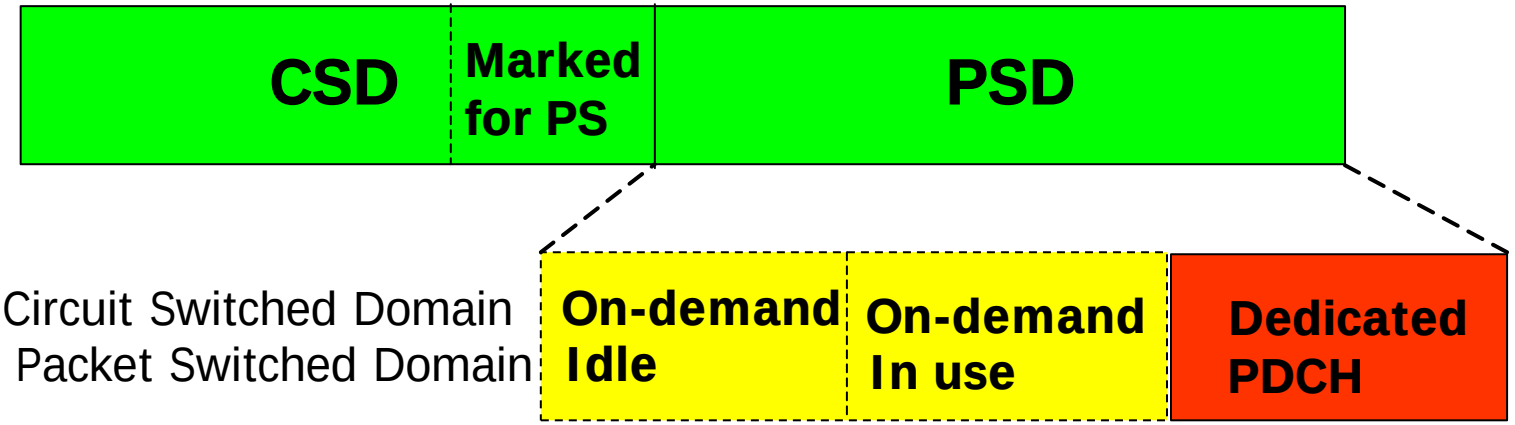
GPRSNWMODE=1 or 3

Reservation of Resources for Data Transfer

- The PDCHs can be shared between many users (8DL/6UL per PDCH))
- A transmission from a user is called TBF - Temporary Block Flow
- The TBFs from users are queued in the PCU before sent.
- Round Robin is used when sending data to more than one user on one timeslot.
- The maximum number of desired simultaneous TBFs on one PDCH is set by the cell parameters: TBFDLLIMIT and TBFULLIMIT.



Request for PS Resources

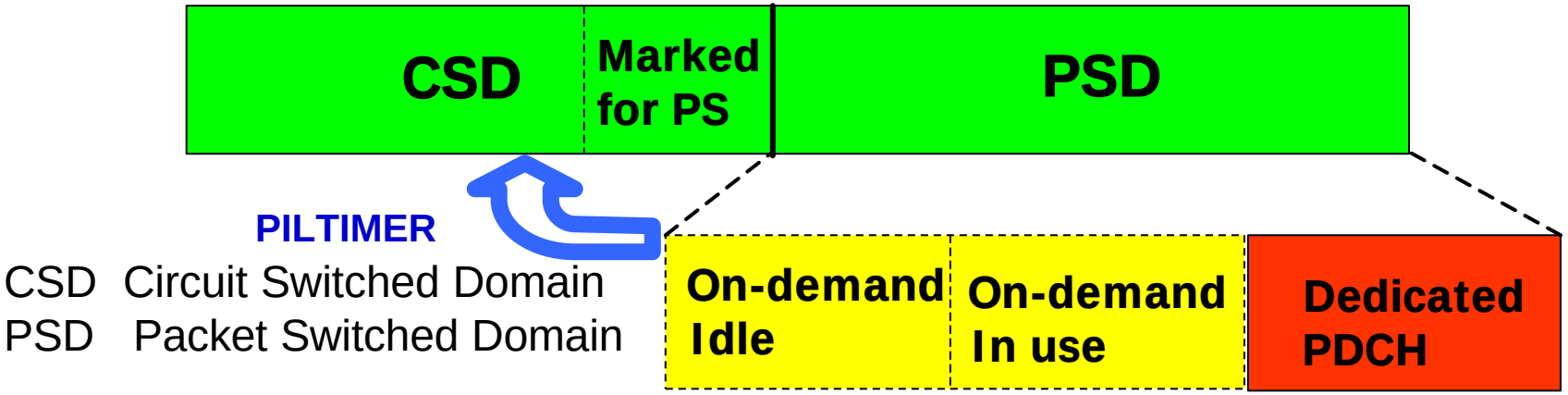


CSD Circuit Switched Domain
PSD Packet Switched Domain

Request for PS Resource

1. **PDCH-reservations on existing PDCH/PSET.**
   (PSET with at least 1 PDCH with less reservations than TBFLIMIT)
2. **PDCH-allocation & reservations of a new PDCH/PSET.**
   (On not complete PSET, an attempt is made to upgrade the PSET to four PDCH)
3. **PDCH-reservation above TBFLIMIT on existing PDCH/PSET.**
   (Maximum PDCH-reservations are DL=8, UL=6 per channel, 32 per PSET.)
4. **PS Congestion.**

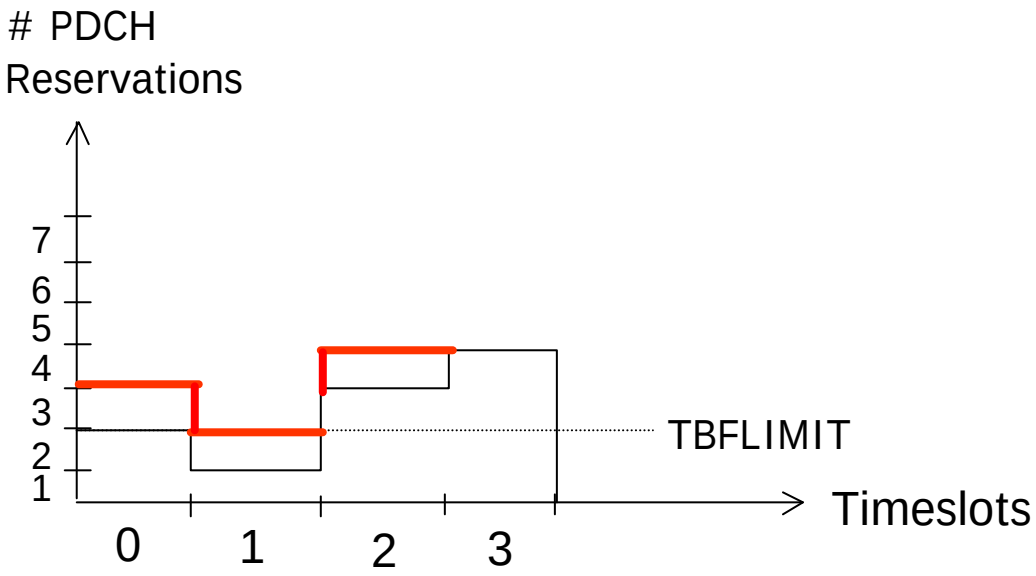
Request for CS Resource



Request for CS Resource

1. Allocate free resource from CSD
2. Allocate free resource from CSD, marked for PS
3. Pre-emption. Allocate resource from PSD, On-demand idle PDCH
4. Pre-emption. Allocate resource from PSD, On-demand in use PDCH
5. CS congestion

PS Resource Request Examples



What happens when a request from a 3-TS GPRS terminal is received in the figure above?

1. PSET is OK since TS1 has TBF<TBFLIMIT
2. Use the least loaded TS. I.e. TS 0->2
3. All TS have TBF>=TBFLIMIT => PDCH-allocation for coming TBFs

NOTE:

A GPRS terminal can be assigned less TS/PDCH than requested.
If no PDCH can be assigned the request is rejected.

Dedicated or on-demand Packet Data CHannels

Using dedicated PDCH's

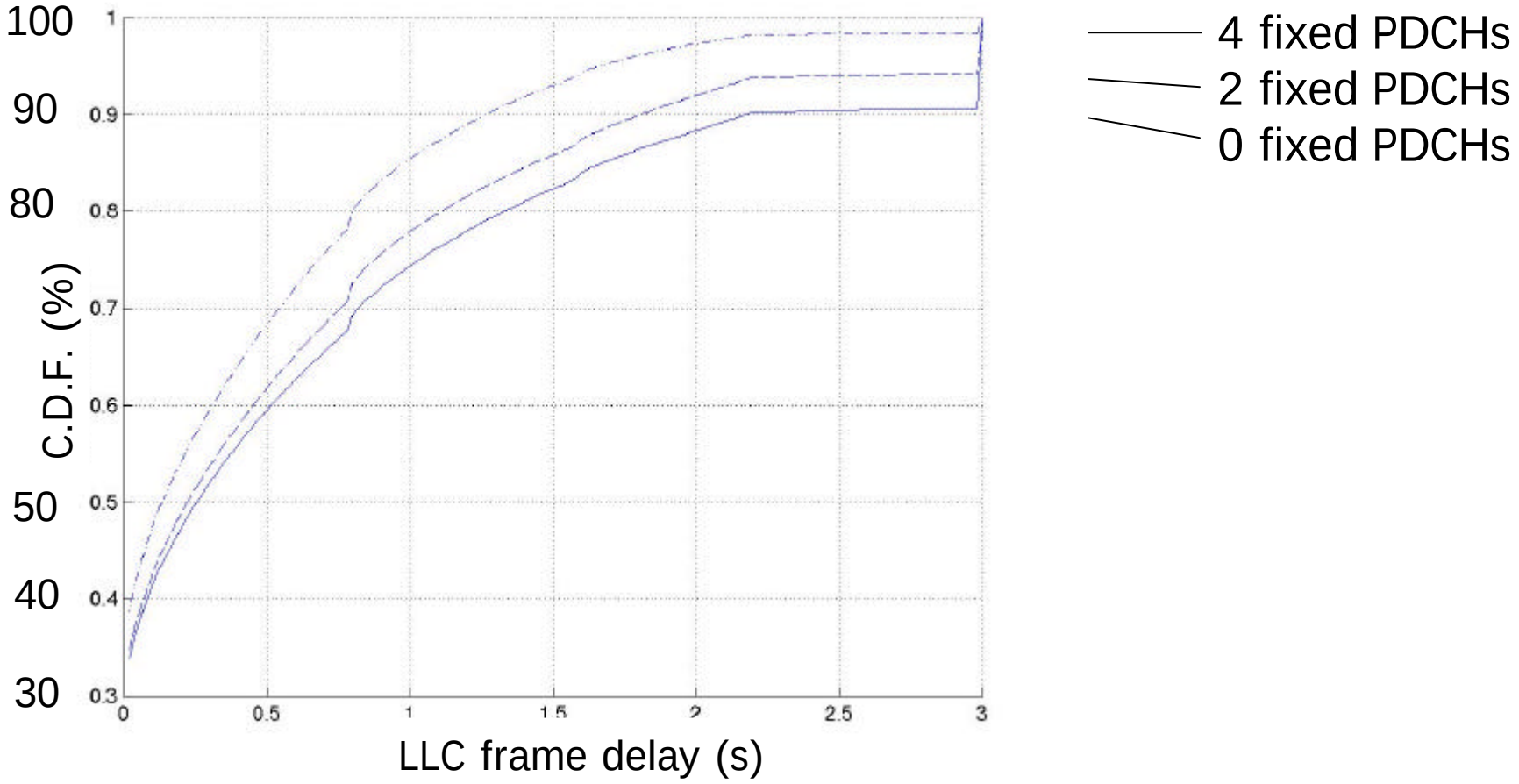
Advantages

- **increase throughput (decrease the user perceived delay)**
- **secure incessant GPRS traffic in each cell**
- **save BSC CPU capacity**
- **allow use of PBCCH**

Disadvantages

- **less capacity for speech traffic**

More dedicated GPRS channels ? Less delay



Recommendation for Dedicated or on-demand PDCH

Secure GPRS capacity in cells with congestion by dedicating PDCHs and hereby avoiding low GPRS performance.

FPDCH: No of dedicated PDCH in the cell

Cell Parameter
FPDCH =0 to 8

GPRS Radio Network Configuration

Part 4: Radio Network Features

Radio Network Features

GPRS support in R8:

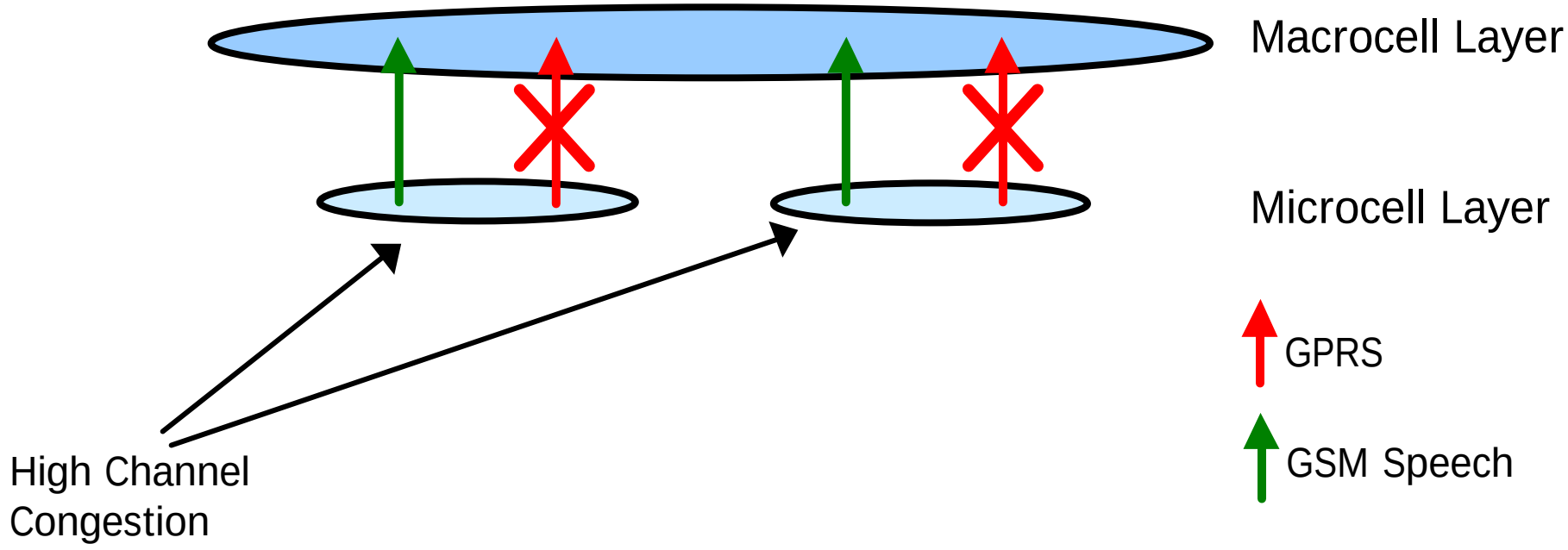
- **Cell Selection/Reselection (automatic parameter mapping)**
- **Frequency Hopping**
- **MS Power Control (GPRS specific)**
- **Idle Channel Measurements (at PSET and PDCH allocation)**
- **Hierarchical Cell Structure**
- **GPRS is supported in underlaid cells**
- **Extended Range SW support single slot GPRS (RBS2000)**
- **Multiband Operation**
- **GPRSPRIO**

Features Improving the GPRS Capacity in the Network

- **Cell Load Sharing**
- **Other circuit switched RN features decreasing the network interference**

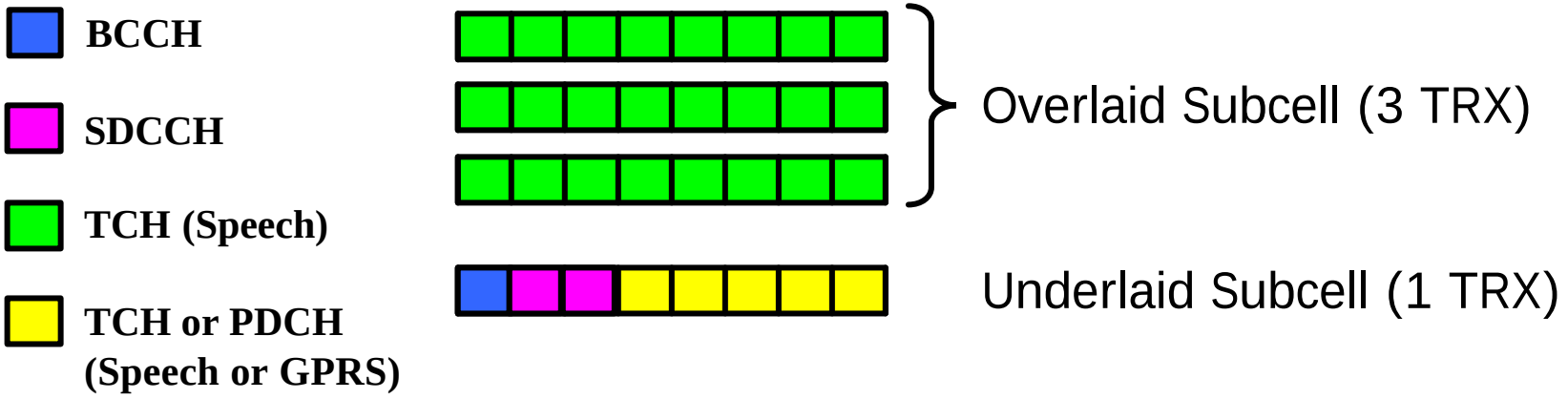
No “Assignment to Worse Cell” for GPRS

The GSM feature “Assignment to Worse Cell” is <u>not</u> supported by GPRS.



GPRS in Overlaid/Underlaid Subcells

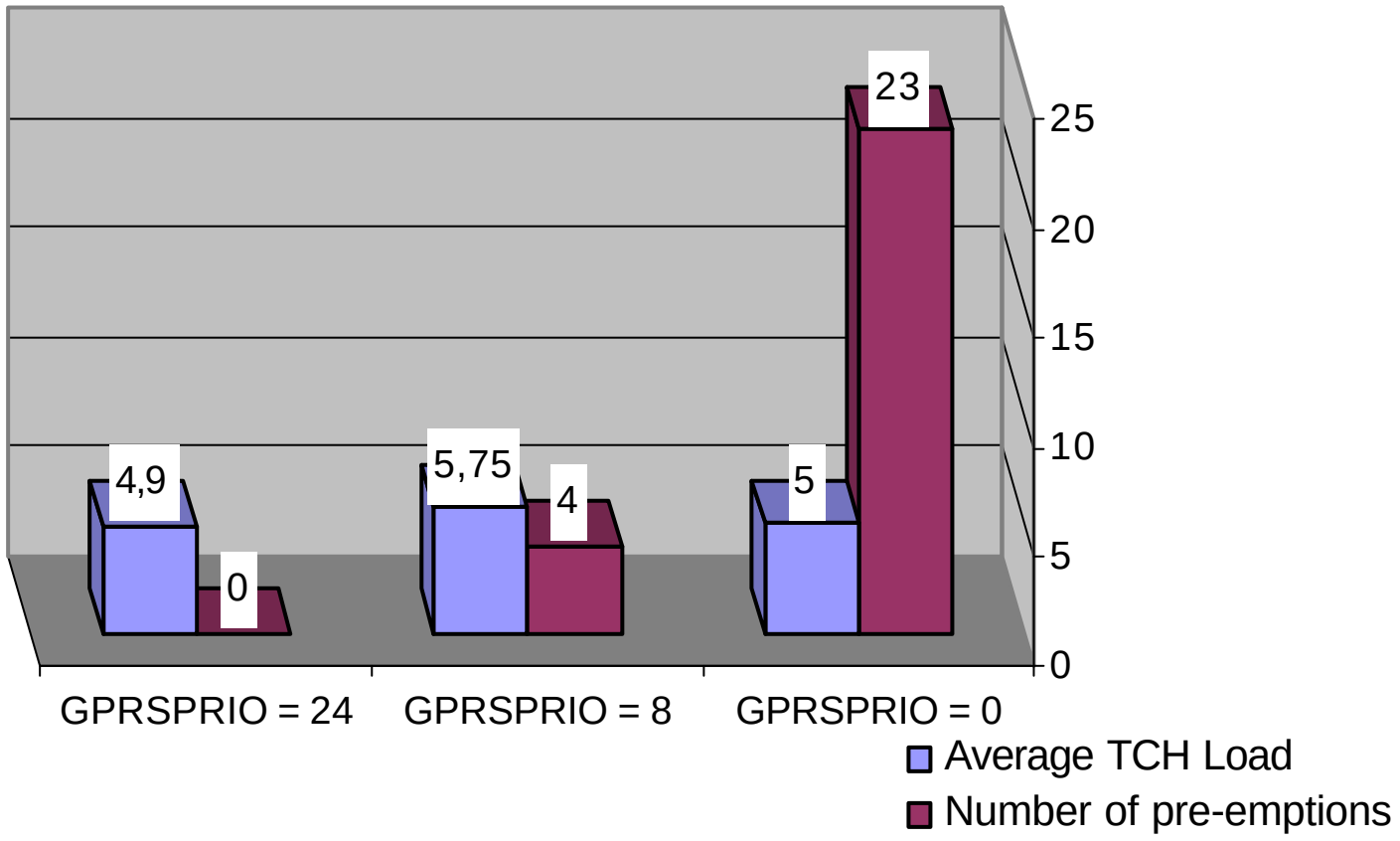
GPRS is only supported in the Underlaid Subcells.



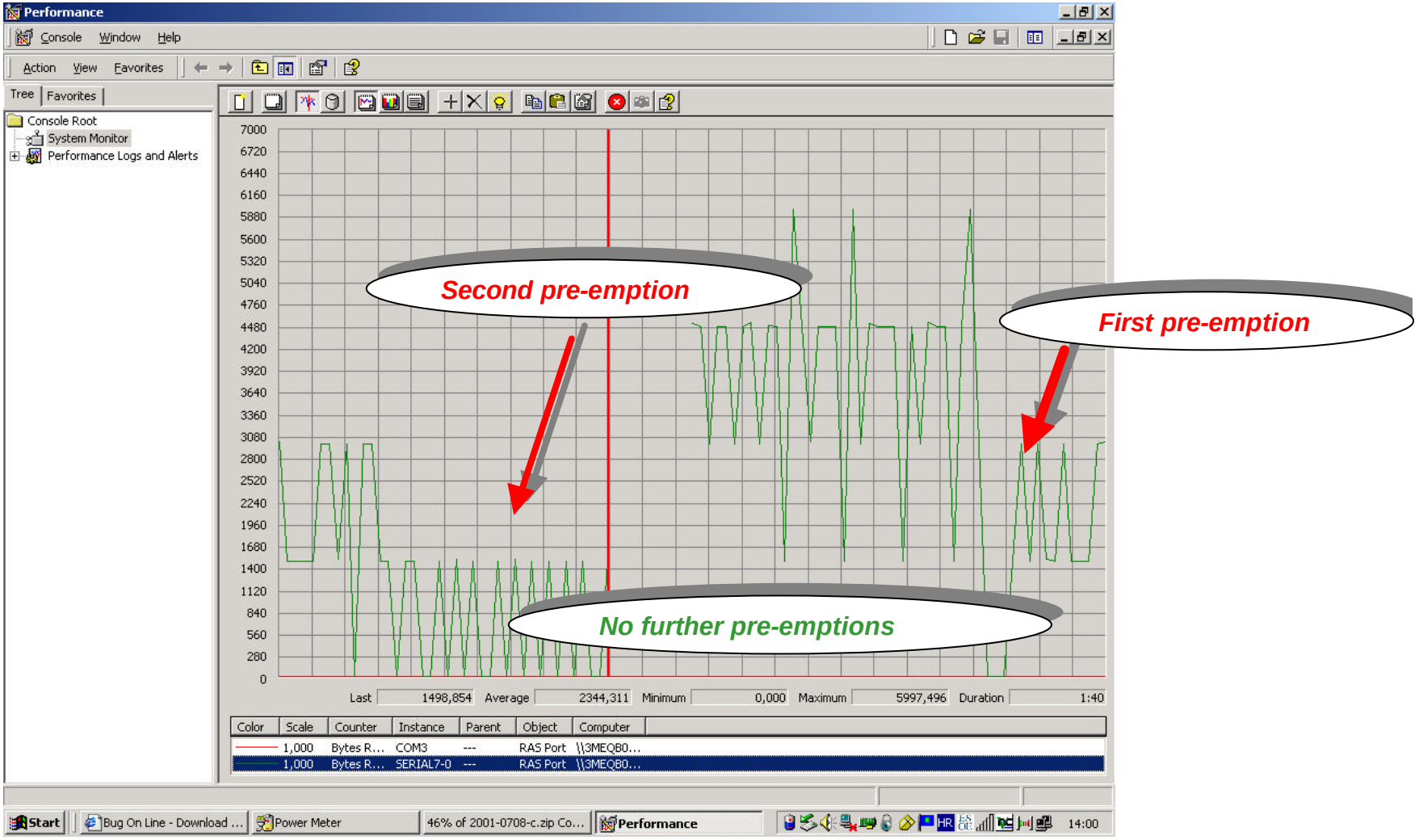
GPRSPRIO Feature – Test Environment

- Real congested cell (2 TRUs)
- Three active GPRS users (FTP via Lap-top & GPRS mobile)
- Three settings of GPRSPRIO parameter:
  - GPRSPRIO=24 – Only idle PDCH can be pre-empted
  - GPRSPRIO=8 – Idle PDCH and non-TAI PDCH can be pre-empted
  - GPRSPRIO=0- Any PDCH can be pre-empted
- Each test GPRSPRIO setting was testing for 30 minutes
- Measurement samples were taken each 15 minutes
  - Average TCH load in Erlangs (TFTTRALACC/TFNSCAN)
  - Number of pre-emptions(PREEMPTPDCH)

Behaviour of GPRSPRIO Feature



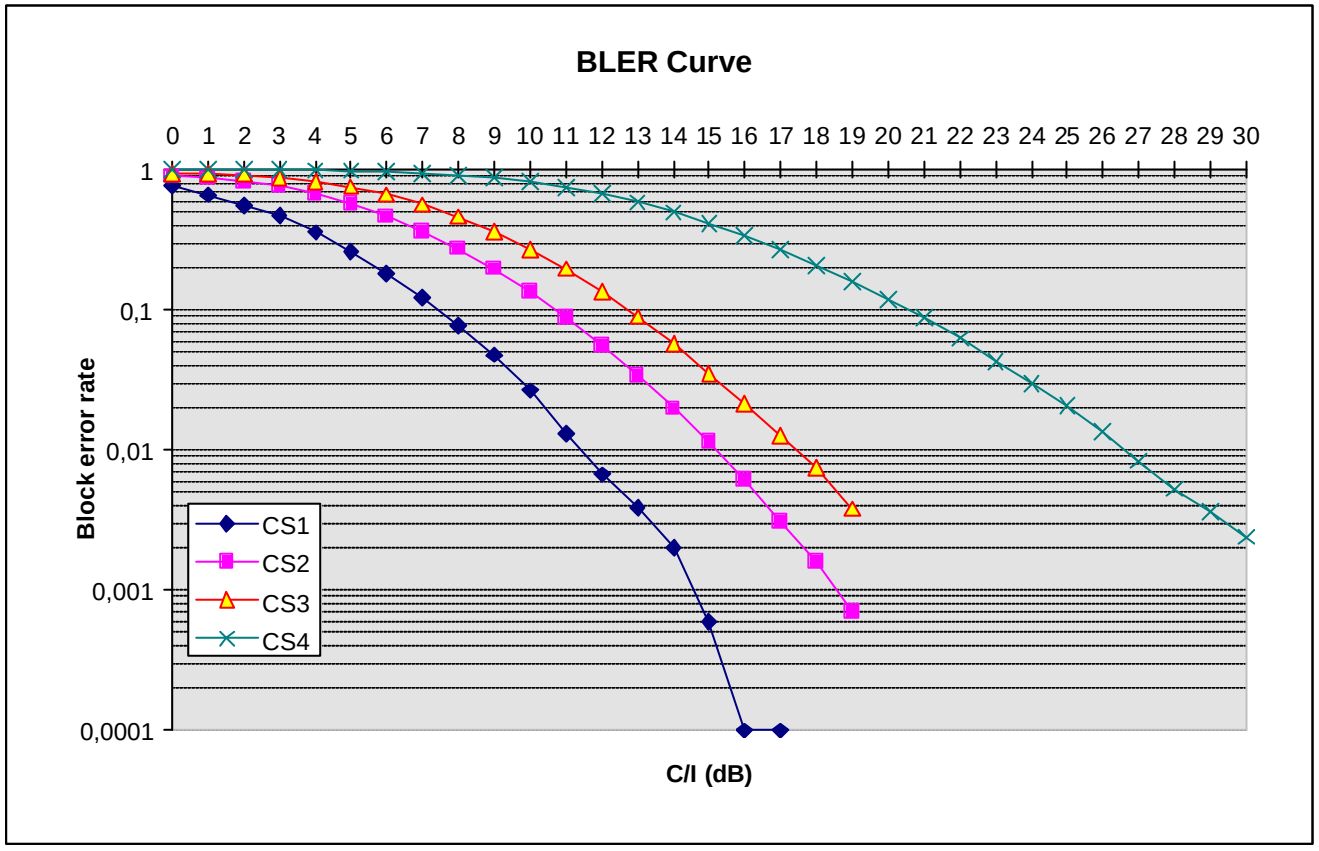
Behaviour of GPRSPRIO Feature – GPRSPRIO=8



GPRS Radio Network Configuration

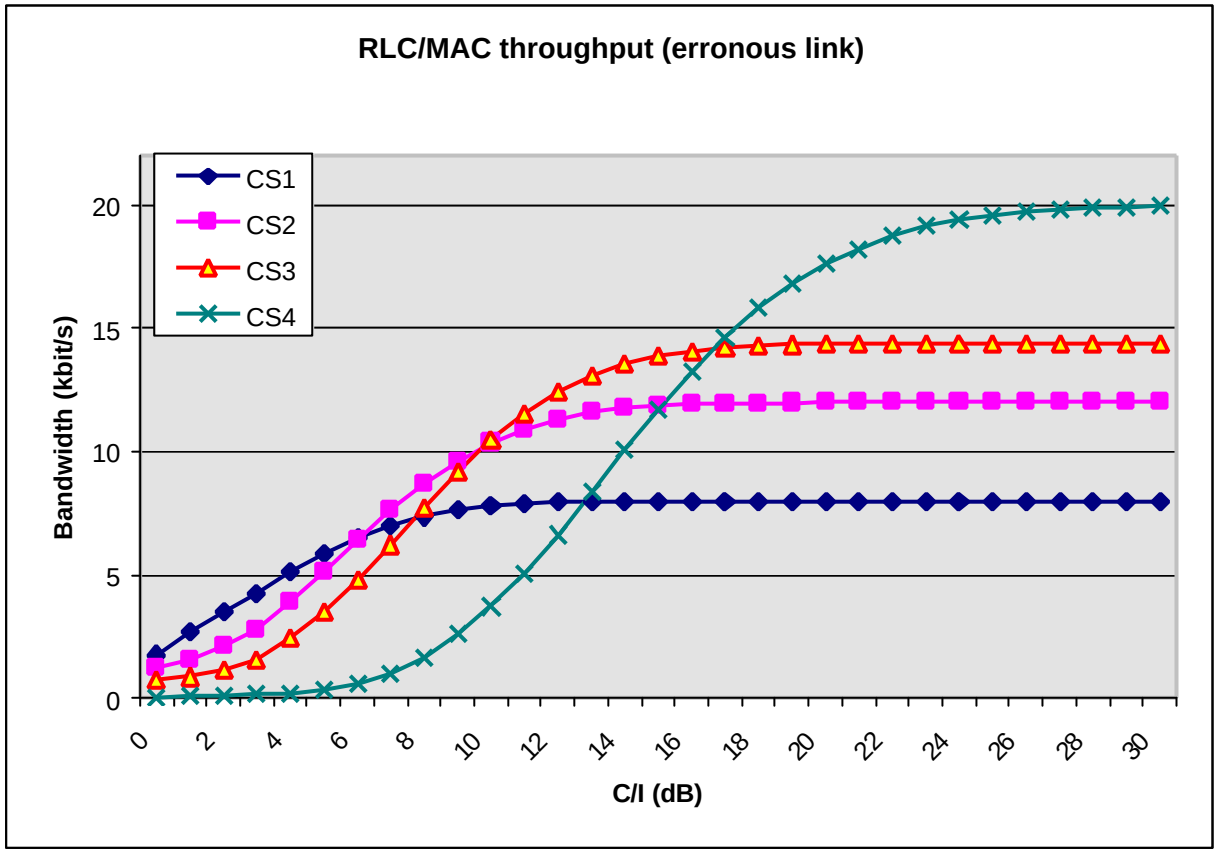
Part 5: Cell Planning

BLER as a function of C/I



C/I ? ? BLER ? ? Throughput ?

Data Throughput as a function of C/I

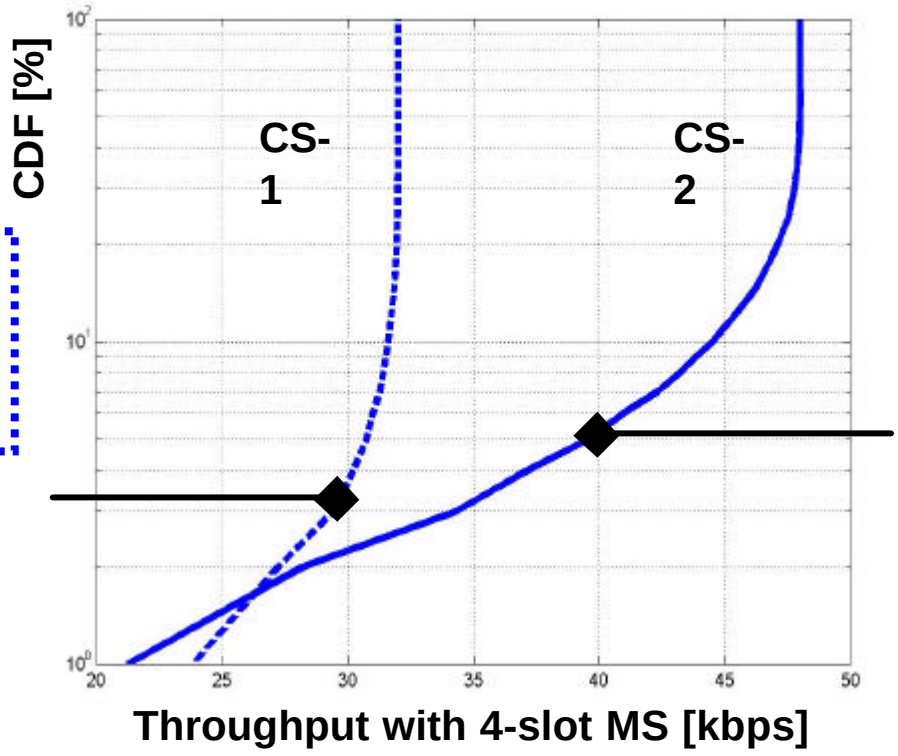


Throughput $_{Erronous\ Link}$ = RLC data X (1-BLER)

GPRS Coverage

Application coverage in a speech network (~9 dB C/I @ 95%)

CS-1: 97% exceed 30 kbps



CS-2: 95% exceed 40 kbps

Cell plan optimized for speech ✍ good GPRS coverage

General radio aspects

	Speech	GPRS	GPRS R8
Coverage	~ 9-12 dB	Set by CS-1 (~ 5-7 dB)	Set by CS-1 (~ 5-7 dB)
Service coverage	~ 9-12 dB	Depends on application (service)	Depends on application (service)
Low C/I (< 10 dB)	Poor quality / dropped call	Low throughput per channel (< 10 kbps)	Low throughput per channel (< 10 kbps)
Medium C/I (10-15 dB)	Good speech quality	High throughput per channel (11-15 kbps)	High throughput per channel (11-12 kbps)
High C/I (> 15 dB)	Good speech quality	Very high throughput per channel (> 15 kbps)	High throughput per channel (11-12 kbps)

Cell planning – an example

ZAGREB

- **GSM system:**

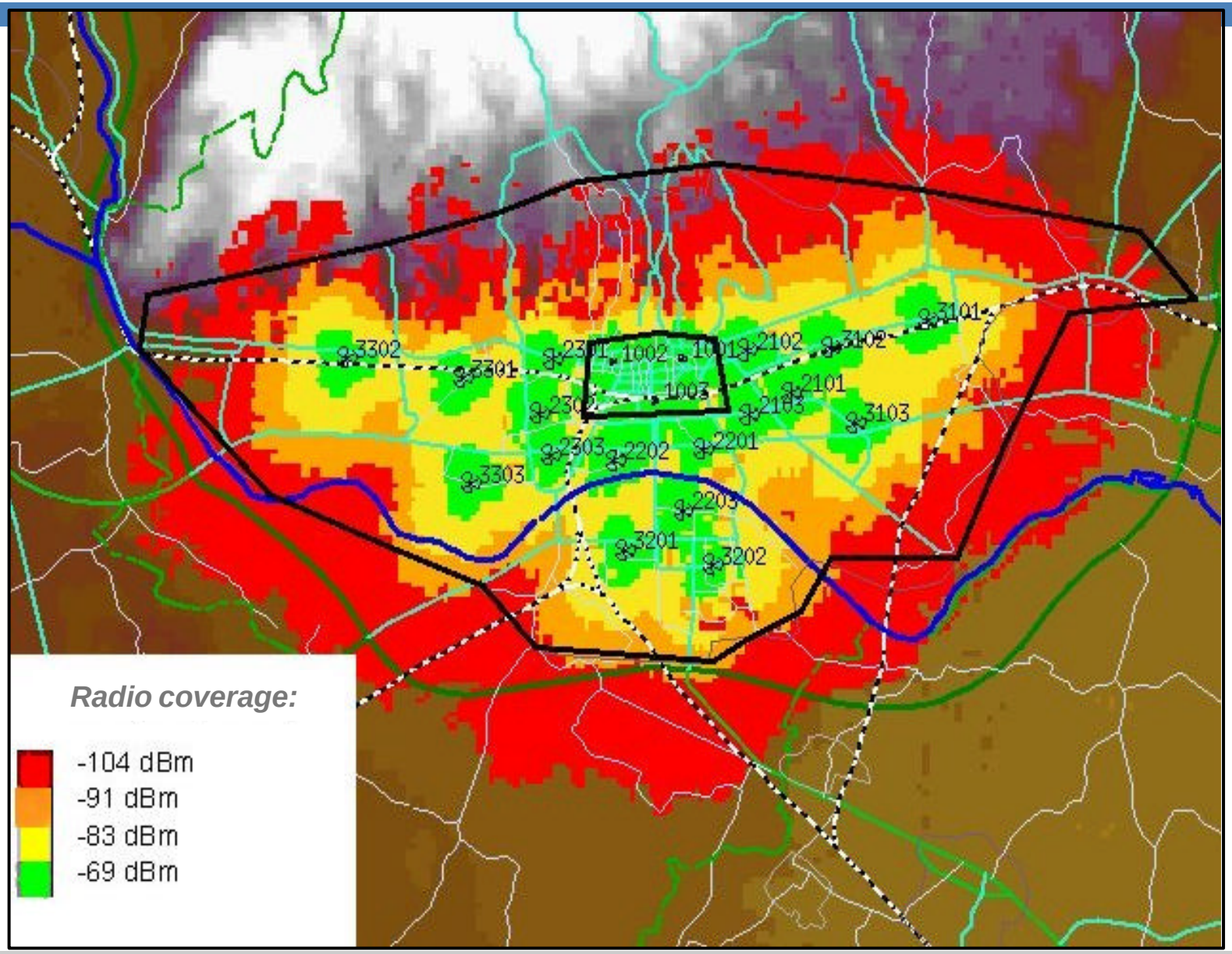
36 carriers GSM-900

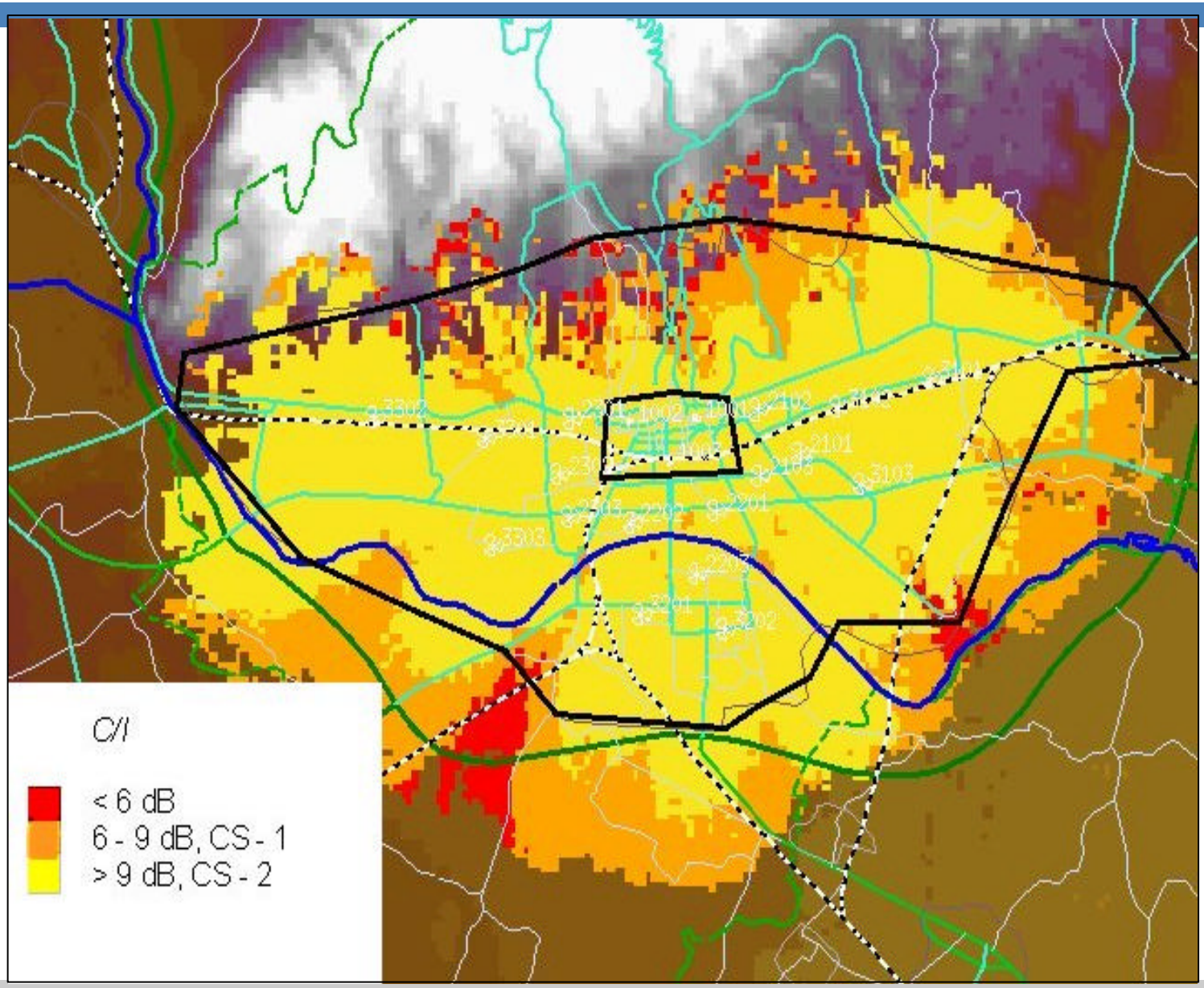
3/9 - reuse pattern - Frequency< hopping is assumed

- **Base stations**

City center: 3 sites; 9 cells; 4 TRU/cells

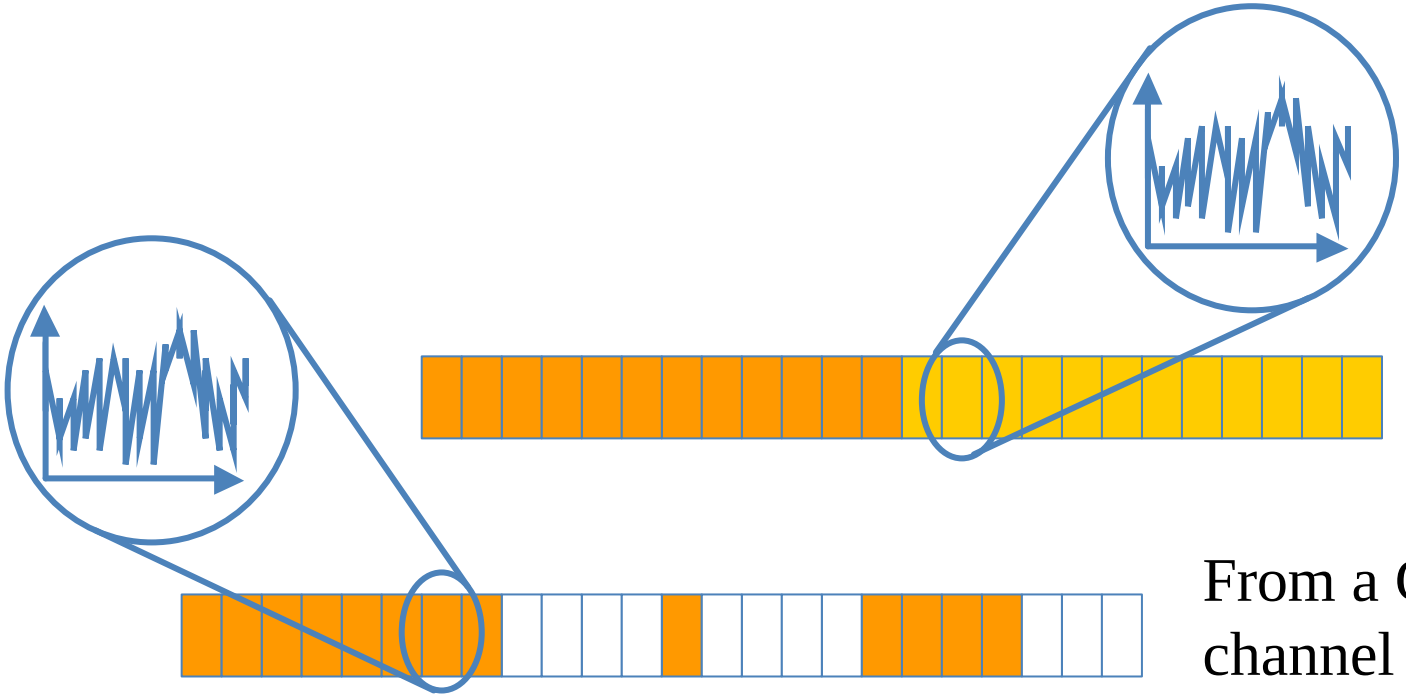
Other city areas: 17 sites; 51 cells; 4 TRU/cells


Radio coverage:
-104 dBm
-91 dBm
-83 dBm
-69 dBm
3302
3301
2301
1002
1001
2102
3102
3101
1003
2101
2103
3103
2302
2303
2202
2201
3303
2203
3201
3202


C/I
< 6 dB
6 - 9 dB, CS - 1
> 9 dB, CS - 2

Frequency Planning (1)

Interference created by GPRS



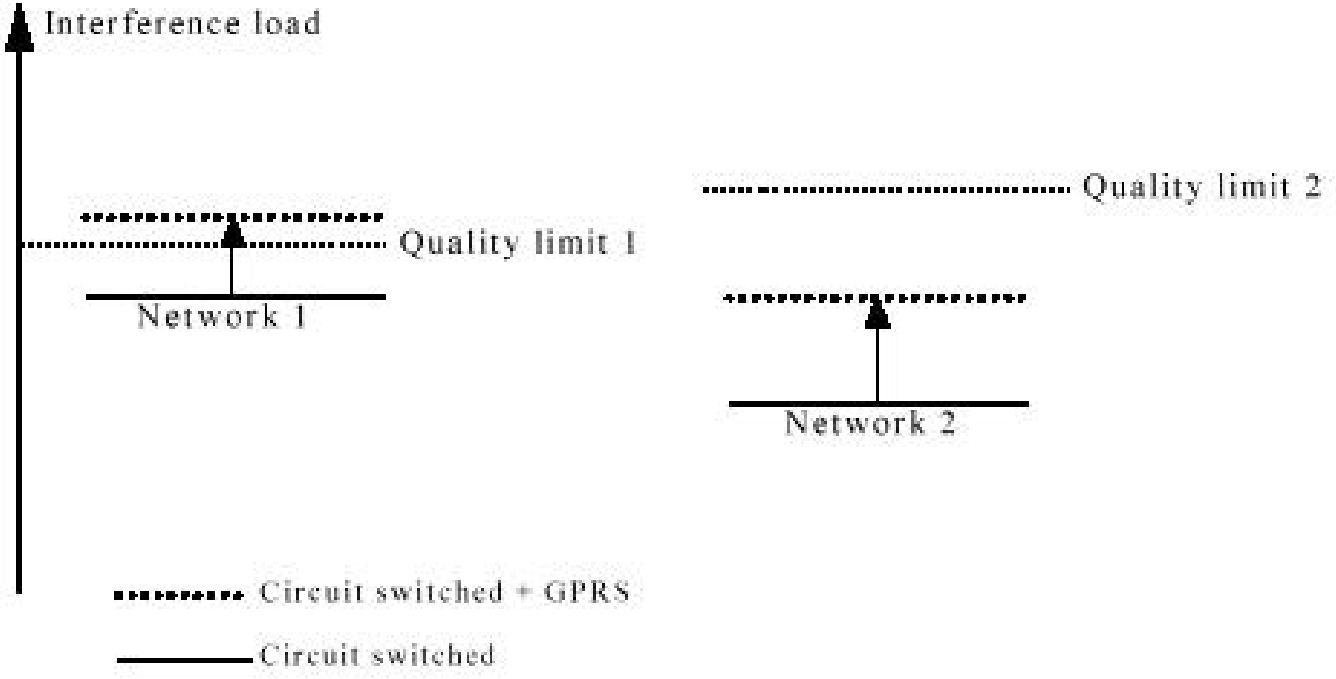
From a speech channel

From a GPRS channel

-No BTS power control (R8)

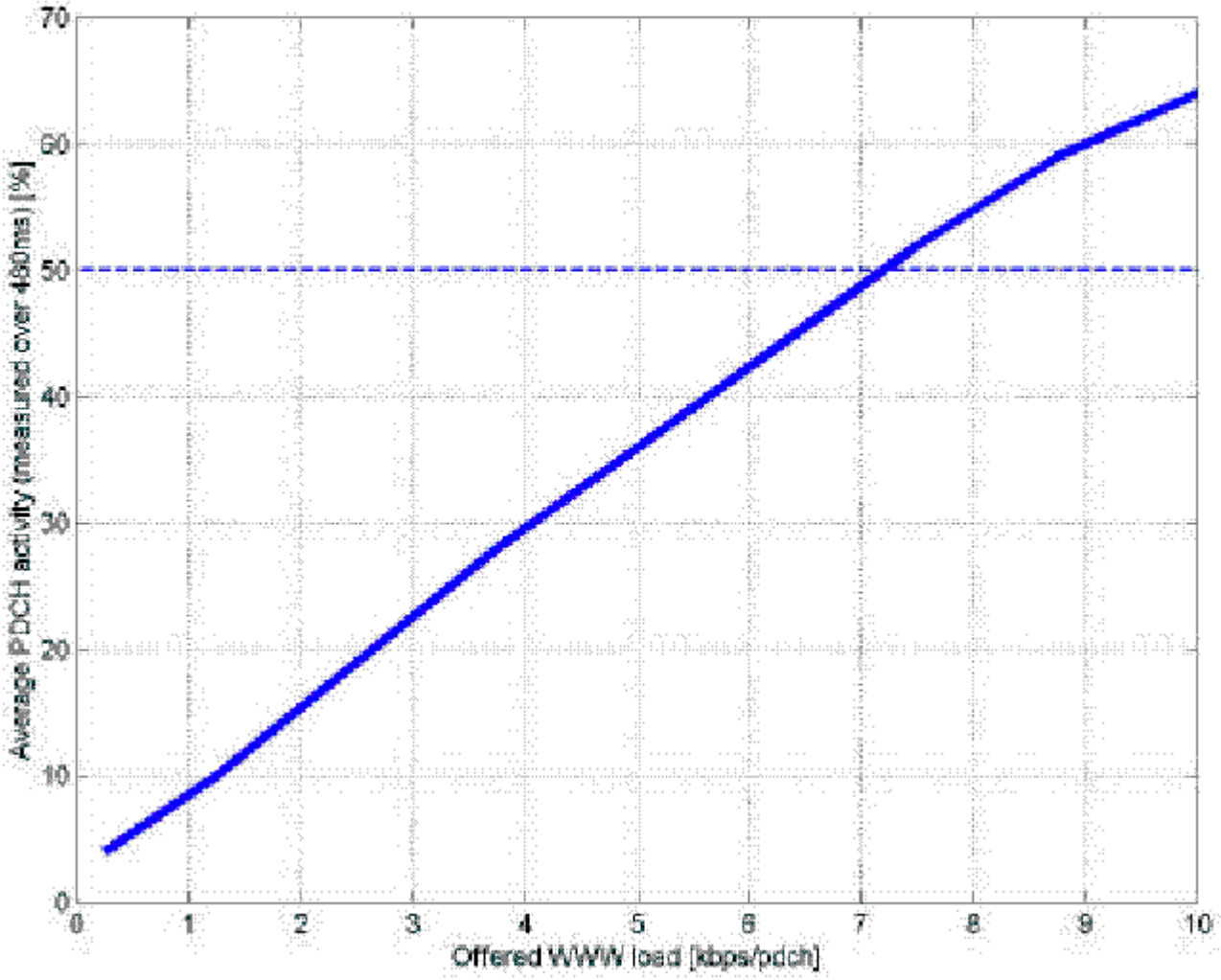
Frequency Planning (2)

Interference load in two different networks when GPRS is implemented.

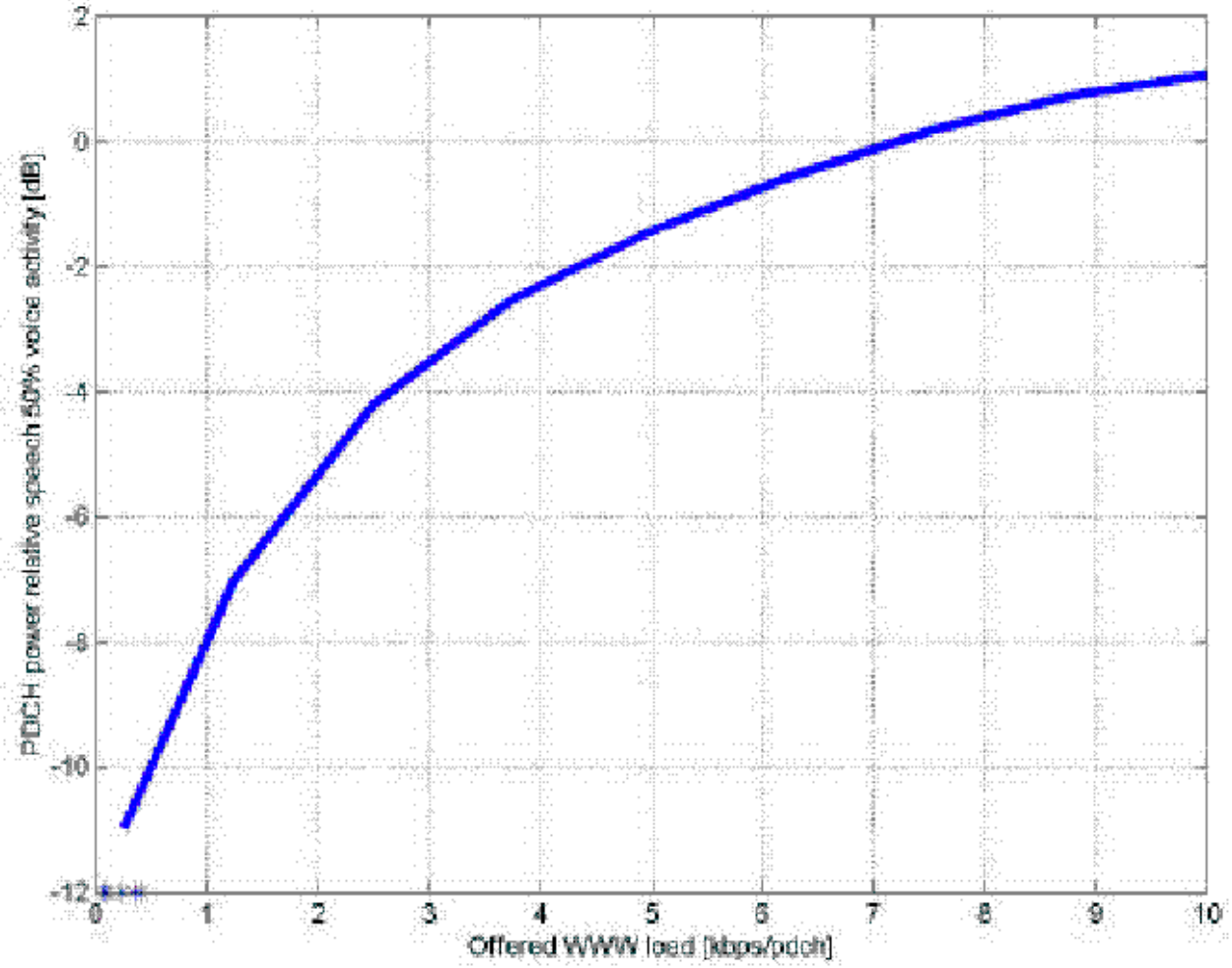


Will the interference exceed your network quality limit?

PDCH Activity for the Given PDCH Data Load



PDCH vs. TCH Interference Increase for the given PDCH Data Load



900 MHz versus 1800 MHz

Dependencies

- **Coverage**
- **Capacity**
- **Number of frequencies**
- **Frequency reuse and C/I**
- **Network strategy**

Method to control the GPRS traffic

Use cell parameter *CRO* to get offset between cells for C1/C2.

NOTE that the idle CS MS are also using C1/C2.

Use the feature *Assignment to other cell* for assigning CS MS to the correct cell.

Allocating non-hopping BCCH frequencies first or last

Dependencies

- **Frequency hopping method used**
- **Reuse and C/I on BCCH frequencies**
- **Reuse and C/I on TCH frequencies**

Cell Parameter

PDCHALLOC = FIRST/LAST/NOPREF

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GPRS Radio Network Configuration

Part 6: GPRS Cell Parameters and BSC Properties and SGSN Parameters (for Radio)

GPRS Cell Parameters and BSC Properties R8

- **An extensive number of GPRS parameters are available.**
- **The major part of the GPRS parameters are mapped from corresponding GSM CS parameters.**
- **The changeable parameters for GPRS R8 are therefore very few, leading to increased implementation speed and fewer mistakes.**

Changeable Cell Parameters and BSC Properties R8

Parameter Name	Recommended	Range	Set per
GPRSSUP	YES	NO, YES	Cell
AGBLK	Network Depend.	0 - 1	Cell
FPDCH	0-4	0 - 8	Cell
PDCHALLOC	Network Depend.	first, last, no pref	Cell
GAMMA	Network Depend.	0 - 62 (even)	Cell
ALPHA	6	0 - 10	BSC
GPRSNWMODE	2 (initially)	0 - 3	BSC
PILTIMER	10 - 20	1 - 3600	BSC
CHCODING	CS-2	CS-1, CS-2	BSC
ONDEMANDGPHDEV	20	1 - 256	BSC
TBFDLLIMIT	1-2	1 - 8	BSC
TBFULLIMIT	1-2	1 - 6	BSC
GPRSPRIO*	-	0-31	BSC

*** With Octoplus package - AC-A05**

GPRS MS Power Control

- The MS output power is regulated so that a desired signal strength is received in the BTS.
- The regulation can be made on each Radio Block
- The output power of the GPRS MS, is calculated for all allocated uplink PDCHs separately.
- The power, P in dBm, is given by the control formula:

$$P = \min(P_{max}, GAMMA_0 - \mathbf{GAMMA} - \mathbf{ALPHA}(\mathbf{C} + 48))$$

$GAMMA_0$ = 39dBm for GSM900 cells

$GAMMA_0$ = 36dBm for GSM1800/1900 cells

GAMMA is a cell parameter for GPRS Dynamic MS Power Control. It is set to give a desired received signal strength at the BTS.

ALPHA is a BSC parameter, decides the level of MS power reduction in relation to the path loss

C is the received SS at the GPRS MS

Parameter Settings - GAMMA

- GAMMA is a cell parameter for GPRS Dynamic MS Power Control. It is set to give a desired received signal strength at the BTS.

$$GAMMA = GAMMA_0 - (1 - ALPHA)\, P_{max} - ALPHA(\, P_{BTS} + SS_{des} + 48)$$

P_{BTS} = BSPWRB

SS_{des} = should be correlated to the setting of SSDESUL for speech

Parameter Settings - ALPHA

- ALPHA is a BSC parameter for GPRS Dynamic MS Power Control. It is set between zero and ten but the setting corresponds to a decimal value (0.0, 0.1 .. 1).

- Decides the level of reduction of the MS output power in relation to the path loss

- Dynamic Aggressive settings: ALPHA should have a high value

- Recommended settings: ALPHA=6

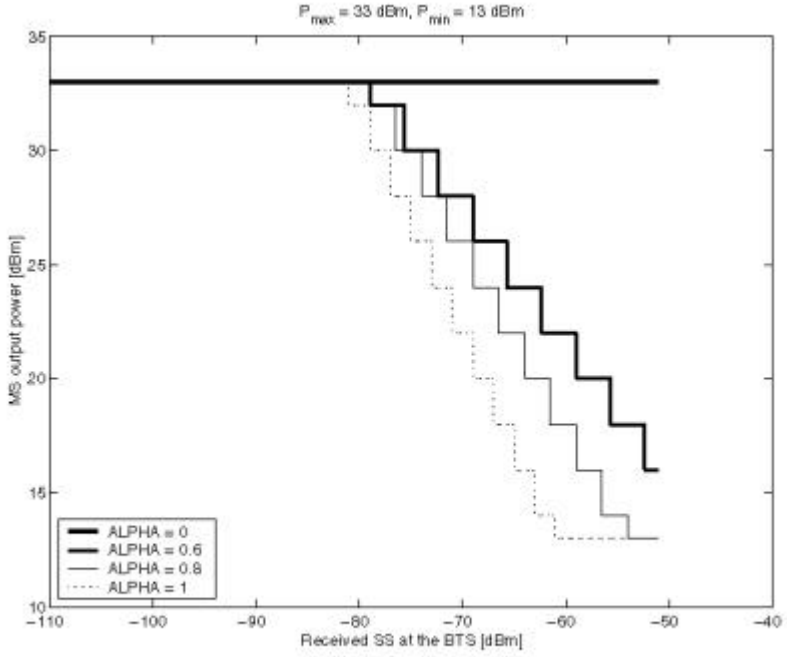

Figure 1 GPRS MS output power with different ALPHA

Parameter settings - GAMMA Exercise

We have the following input values:

GSM 900

P_{max}=	33dBm
P_{BTS}=	43dBm
SS_{DES}=	-80dBm
ALPHA=	6(0.6)

What will be the value of the cell parameter GAMMA?

SGSN Parameters (for Radio)

Parameter Name	Default	Range
T3314 ReadyTimer*	44 s	10-600 s
T3314 ReadyTimerMax	120 s	10-600 s
T3314 ReadyTimerMin	10 s	10-600 s
Mobile Rechable Timer	3840-11040 s (~T3212)	2040 -11040 s
Implicit Detach Timer	0 - 3600 s	0 - 180000 s

***Recommended to be reduced, application depended.**

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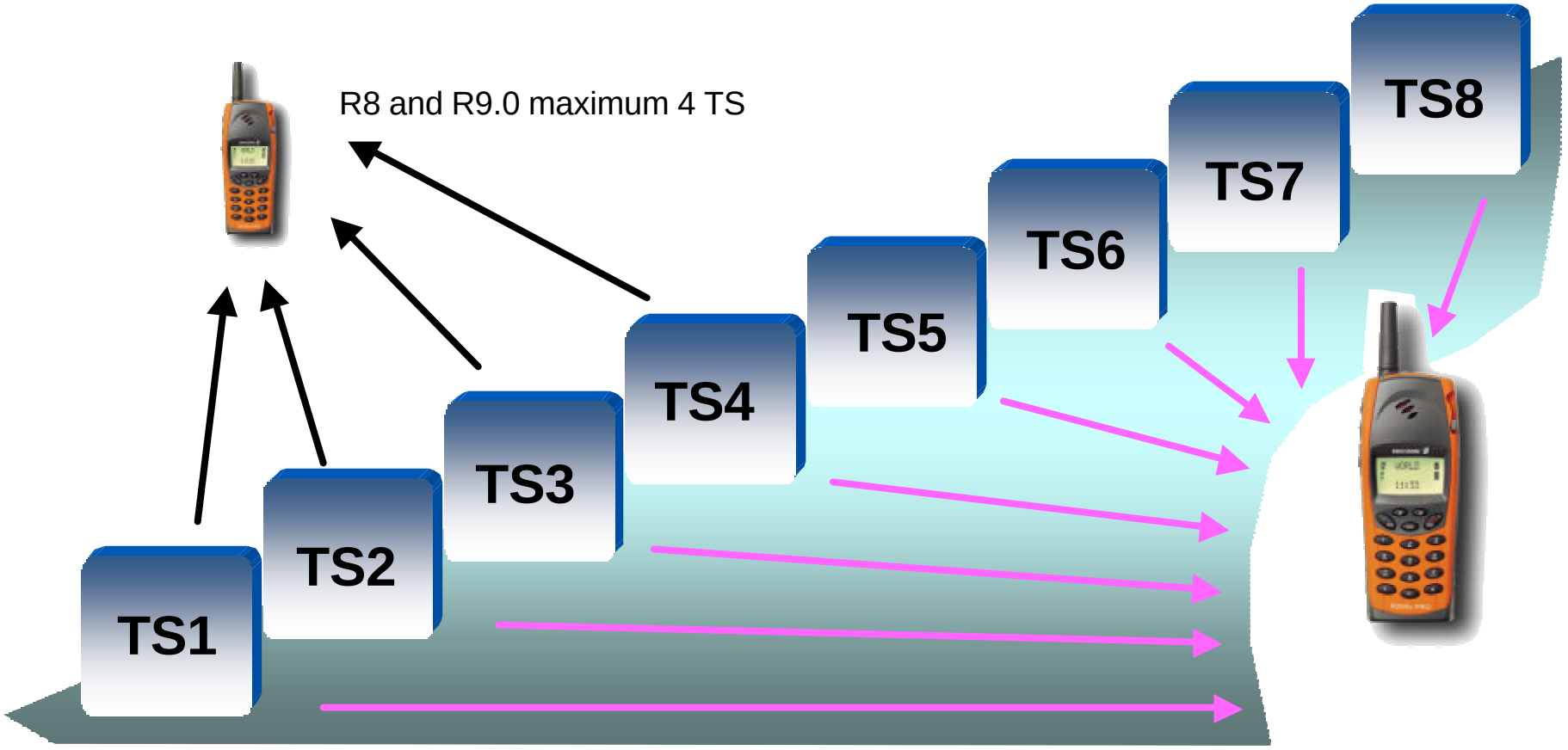
GPRS Radio Network Configuration

Part 6: EGPRS Radio Network Enhancements in R9.1

Main (E)-GPRS-related Improvements

- **Up to 64 RPPs per PCU**
- **Allocation of up to 8 PDTCH within PSET**
- **Support for CS-3 & CS-4 including Link Adaptation Method**
- **EGPRS or EDGE support including two Link Quality Methods**
- **Improved polling mechanism**

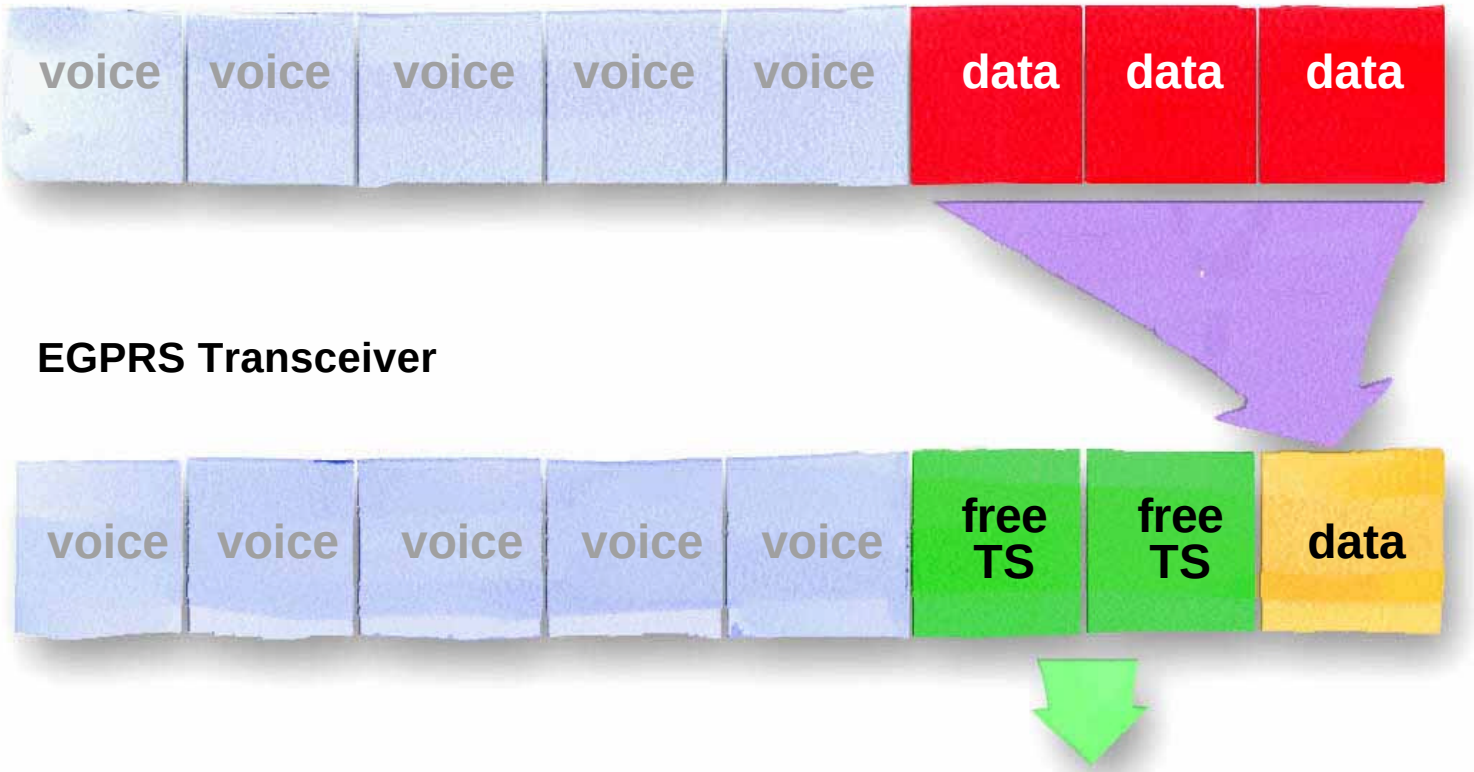
GPRS/EGPRS enhancement to 8 TS



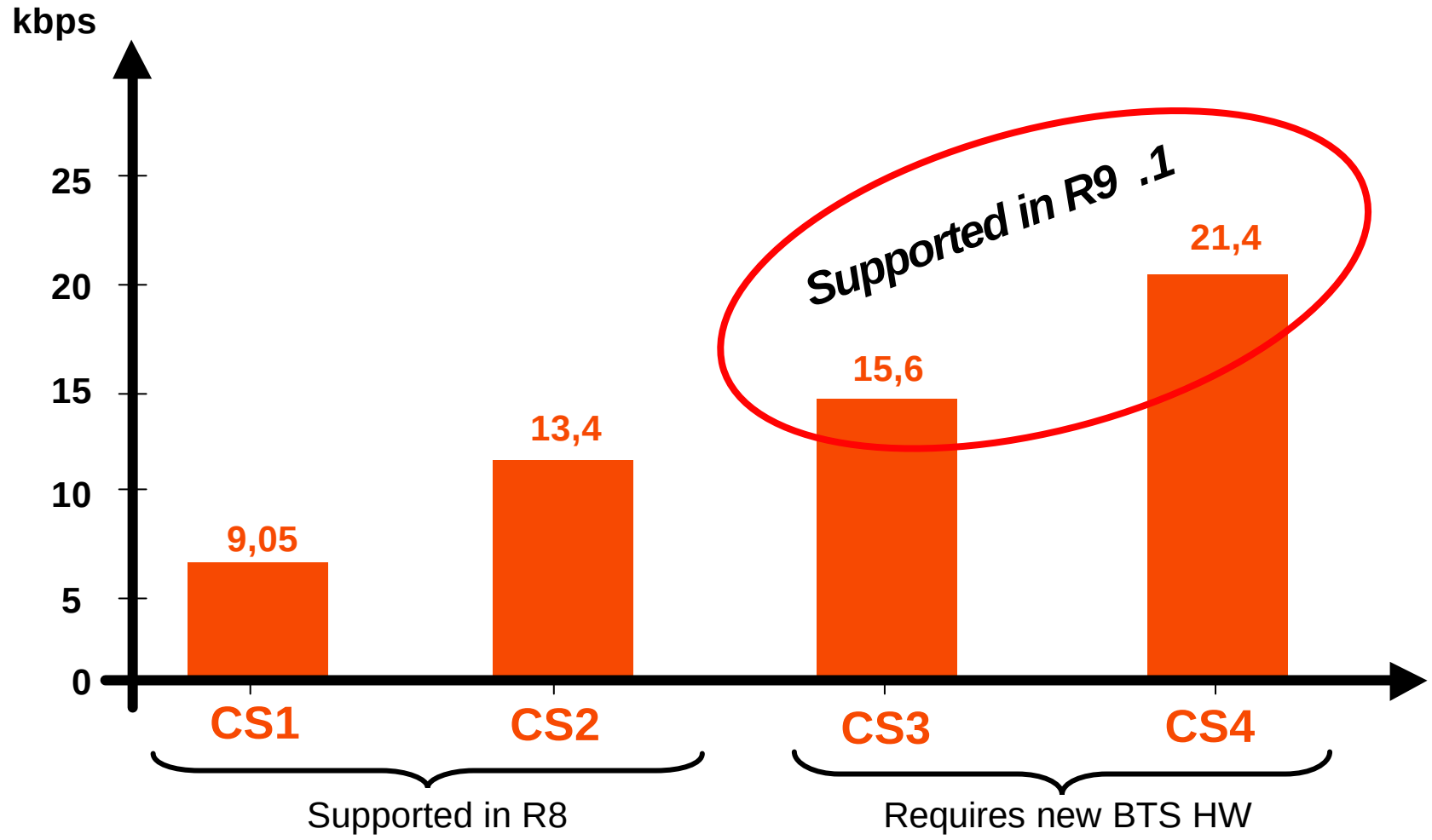
R9.1 offers up to 8 Time Slots per user

EDGE releases voice or data capacity

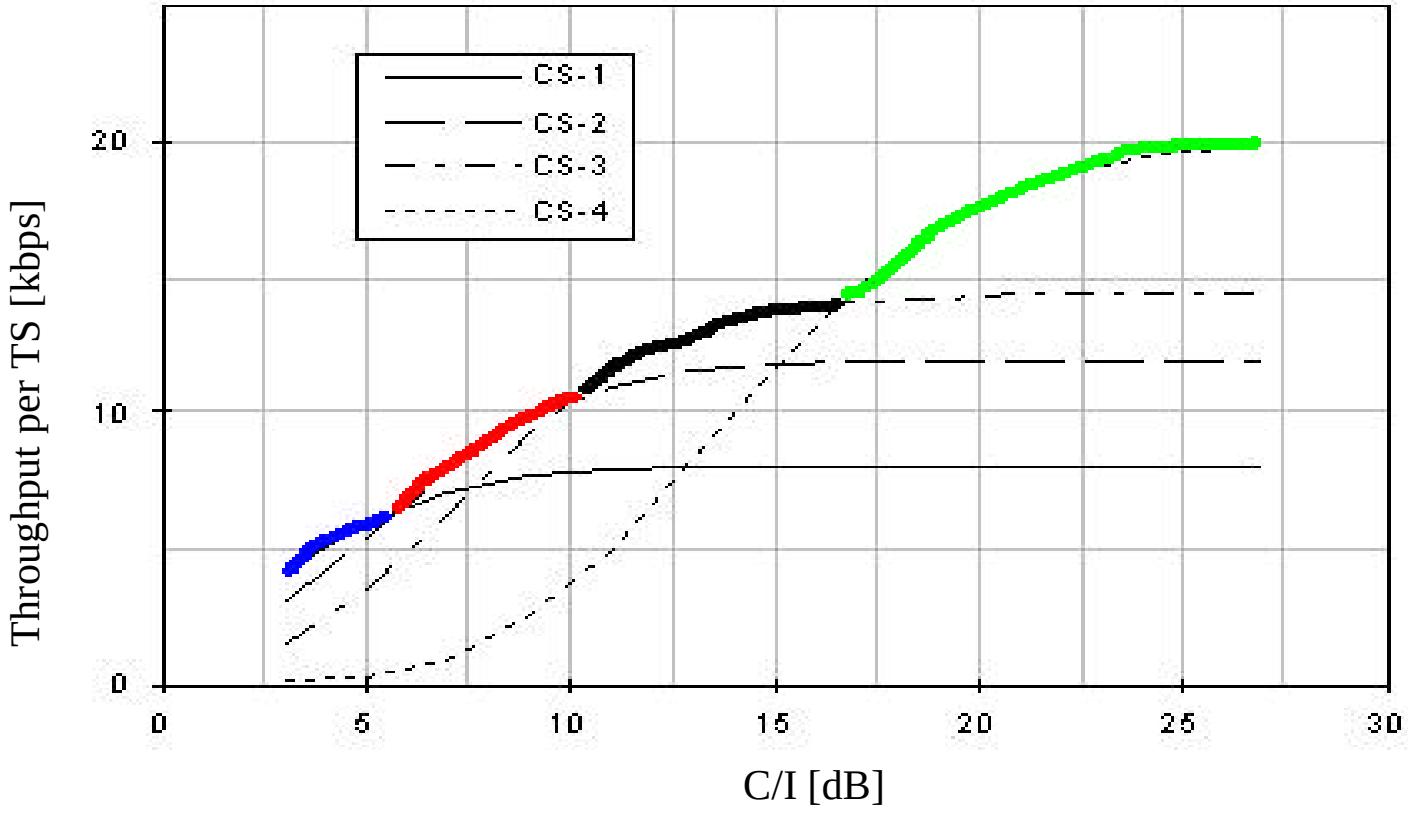
Standard GSM Transceiver



GPRS Coding schemes 3&4



GPRS Link Adaptation



EGPRS Coding Schemes