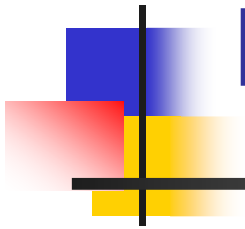

EC 551
Telecommunication System Engineering

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Syllabus

- Tentatively

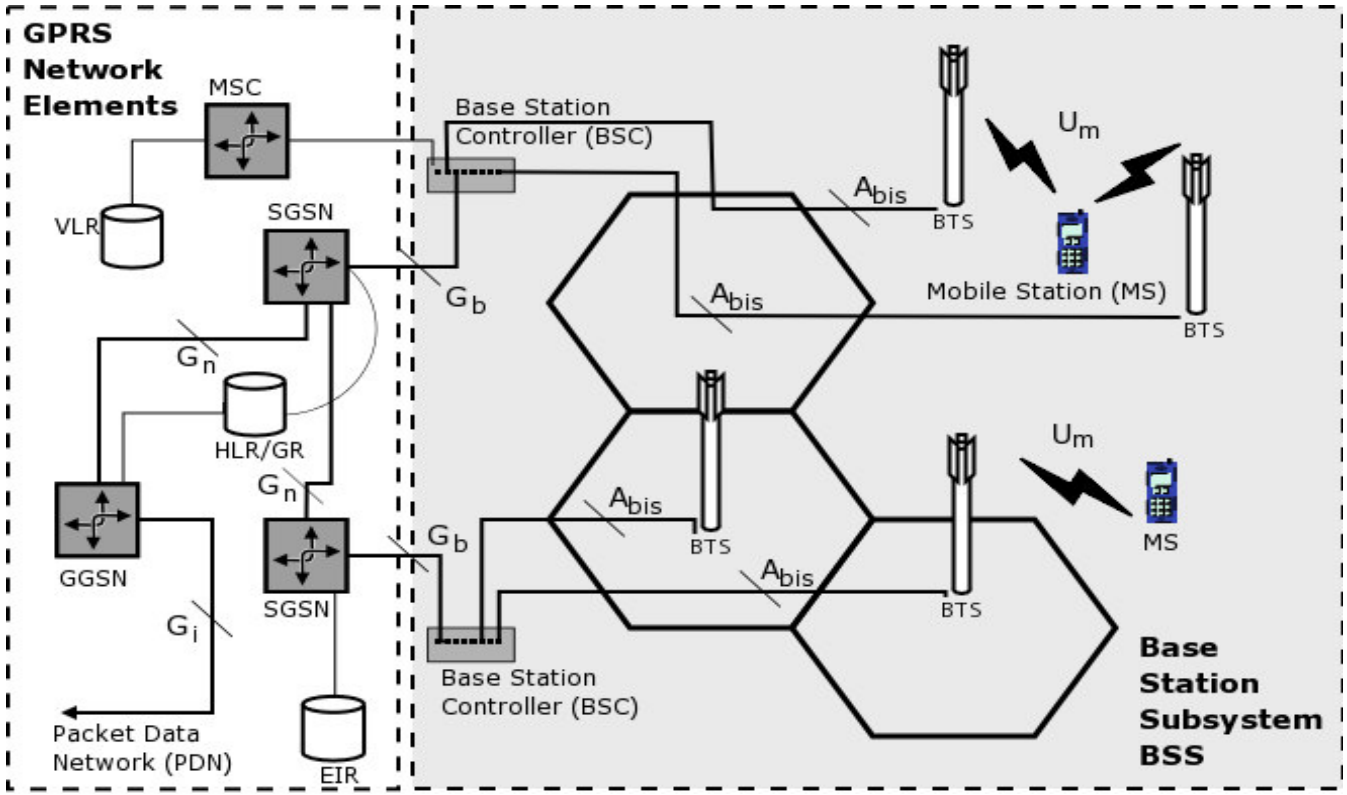
Week 1	Overview
Week 2	**Wireless Channel characteristics**
Week 3	**OFDM and modulation techniques**
Week 4	Coding techniques in wireless systems
Week 5	**WiMax**
Week 6	**WiMax Physical Layer**
Week 7	WLAN Physical Layer
Week 8	WLAN MAC Layer
Week 9	**Cellular Communication Concept**
Week 10	**Cellular Communication Concept**
Week 11	**GSM System**
Week 12	**GPRS System**
Week 13	**UMTS**
Week 14	IP networks
Week 15	VOIP

GPRS General Packet Radio Service

- Standardization of GPRS was important cornerstone for the development of UMTS network
  - GPRS defines an add-on for data services within the GSM networks - packet orientated approach to data switching
  - Allocation of channels request-driven
  - Todays bandwidth of 53,6 kbit/s (4 full rate traffic channels à 13,4 kbit/s), up to 107,2 kbit/s with 8 channels
  - GPRS usually operates asynchronous with more bandwidth for down than for upstream
- GPRS bases on an additional infrastructure: GSN – GPRS Support Nodes as an extension to GSM
  - SGSN (Serving GSN), GGSN (Gateway GSN)

GPRS

- Main GSM components, like MSC, VLR and HLR used for GPRS too, additional infrastructure: GSN – GPRS Support Nodes

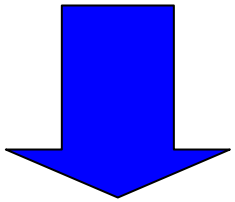


Entities

- The Serving GPRS Support Node (SGSN)
  - Mobility Management
  - Authentication
  - Gathers Charging Information
- Gateway GPRS Support Node (GGSN)
  - Gateway between UMTS Core Network and external networks
  - Address allocation for MS
  - Gathers Charging Information
  - Filtering
- Base Station Subsystem (BSS) / Radio Network Subsystem (RNS)

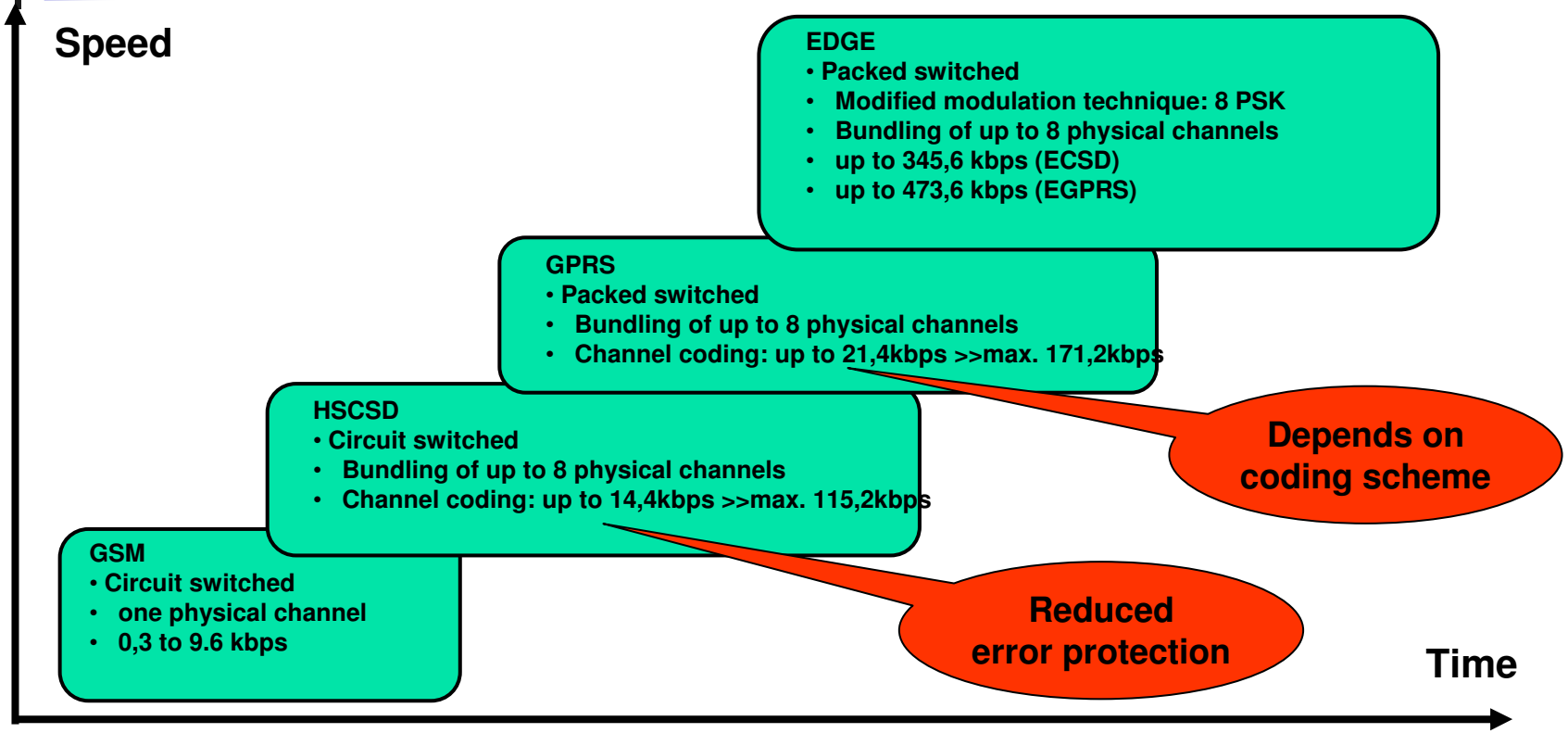
GSM - Data Communication

- **Basic Service**
  - Short Message Services (SMS)
- **Popularity of INTERNET and EMAIL Access**
  - Large amount of data transmission
  - Transmission speed critical
- **Limitation of 9600kbps on GSM**



GPRS - General Packet Radio Service

DATA Rates and Speed



DATA Rates and Speed

GSM

Traffic channel	Information	Error protection	Time slots	Total
>Voice (full rate)	13,0 kbit/	9,8 kbit/s	max. 1	22,8 kbit/s
>Data	2,4 kbit/s 4,8 kbit/s 9,6 kbit/s	20,4 kbit/s 18,0 kbit/s 13,2 kbit/s	max. 1 “ “	

HSCSD

Traffic channel	Information	Error protection	Time slots	Total
>Voice (full rate)	13,0 kbit/	9,8 kbit/s	max. 1	22,8 kbit/s
>Data	14,4 kbit/s	8,4 kbit/s	up to 8 max. Data	 115,2 kbit/s

DATA Rates and Speed

GPRS

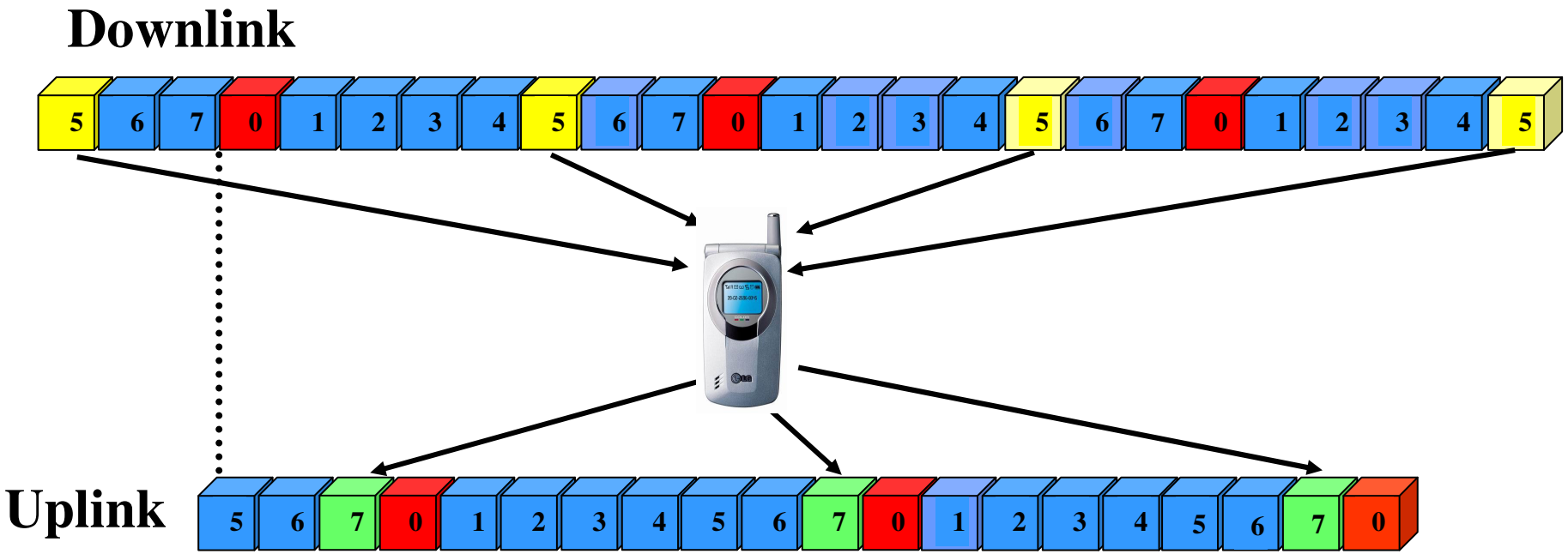
	Time slots 1	Time slots 2	Time slots 8
CS- 1	9,05 kbit/s	18,1 kbit/s	72,4 kbit/s
CS- 2	13,4 kbit/s	26,8 kbit/s	107,2 kbit/s
CS- 3	15,6 kbit/s	31,2 kbit/s	124,8 kbit/s
CS- 4	21,4 kbit/s	42,8 kbit/s	171,2 kbit/s

***EDGE** (8 PSK modulation)*

	Time slots 1	Time slots 2	Time slots 8
ECSD	43,2 kbit/s	86,4 kbit/s	345,6 kbit/s
EGPRS	59,2 kbit/s	118,4 kbit/s	473,6 kbit/s

GPRS – Circuit vs. Packet Switched

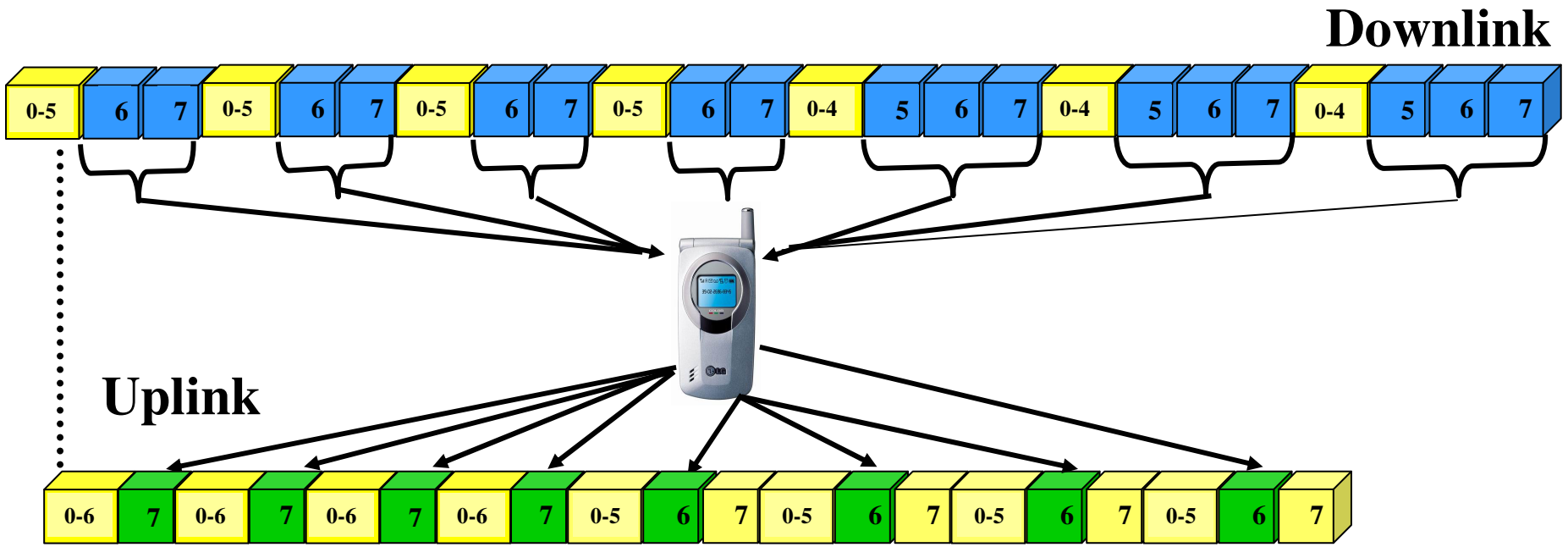
"**Circuit switched Network**"
Fixed allocation from frequency channel and timeslot during connection.



GPRS – Circuit vs. Packet Switched

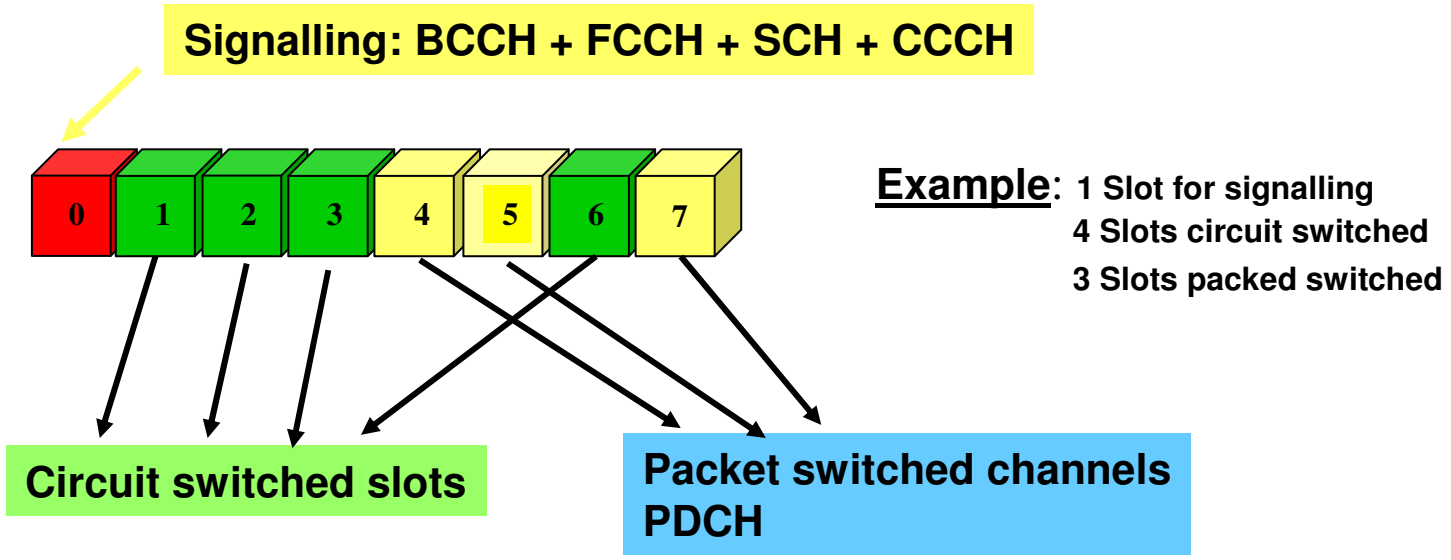
"**Packed switched Network**"

No fixed allocation of frequency channel and timeslots. Only within a "Radio-Block"



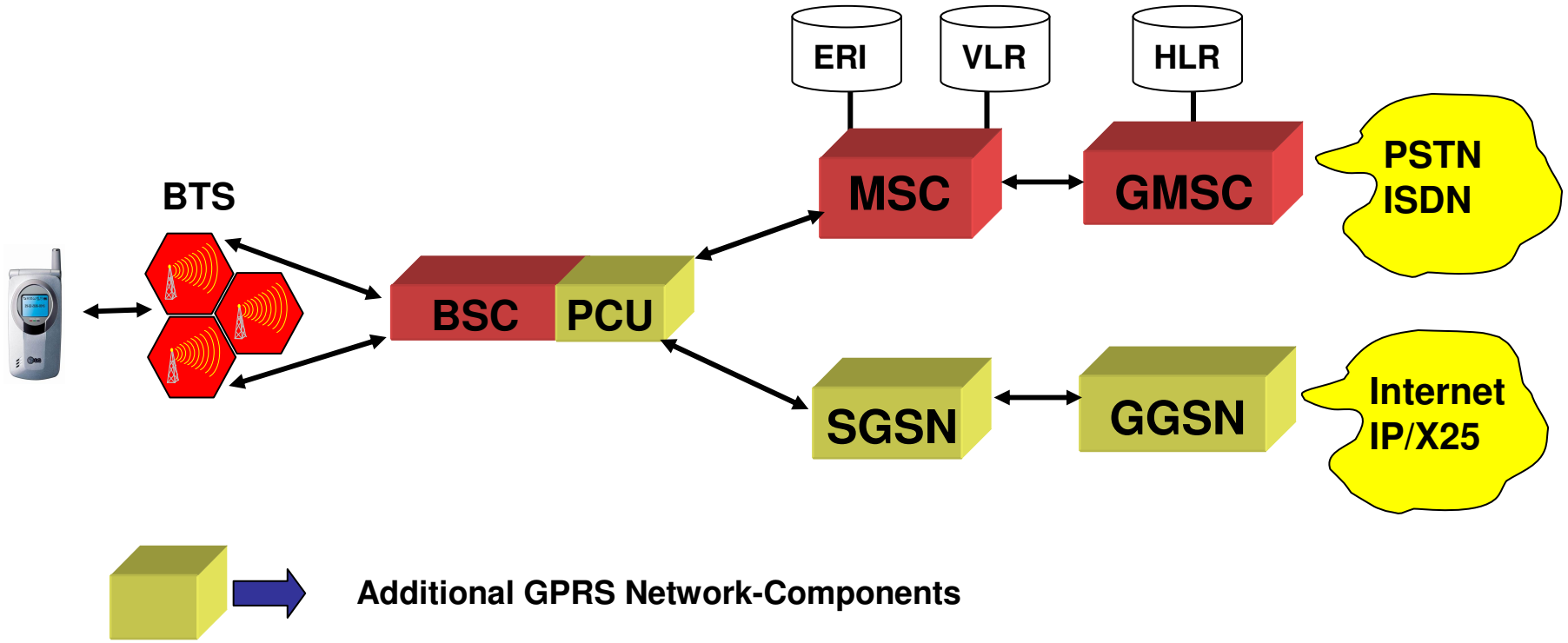
GPRS – Capacities and Parameters

Capacity on demand: Provides Circuit Switched Channels and Packet Switched Channels in a dynamic manner

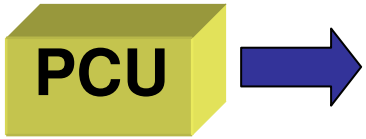


GPRS – How GPRS Phone Works?

Network Architecture and differences



GPRS – How GPRS Phone Works?



Packet **C**ontrol **U**nit

> Channel access control
> Access request management
> Control and management of TCH, PCL
> Structuring of the PDCH

Serving **G**PRS **S**upport **N**ode

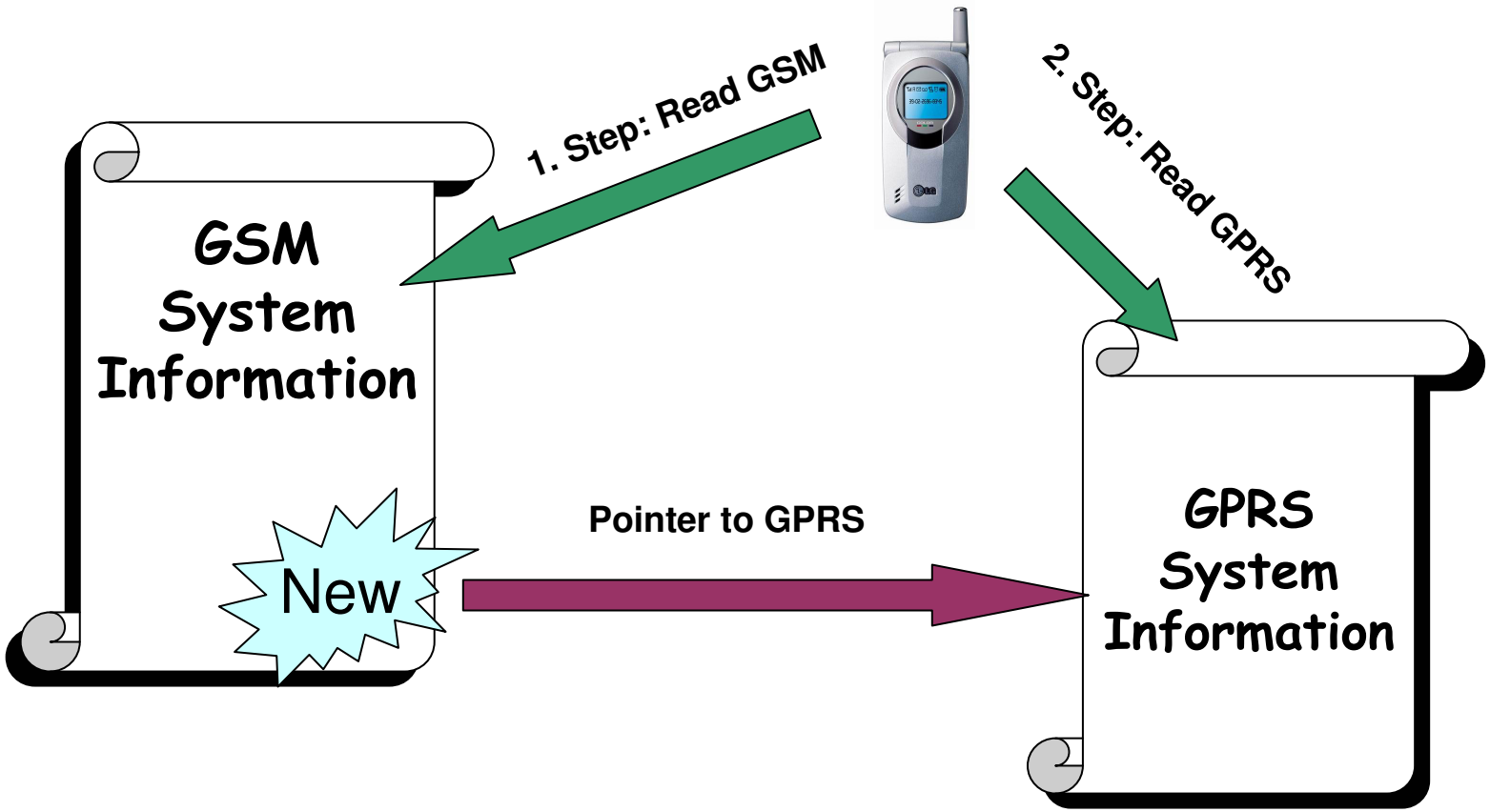
> Control of MS position
> Coding of data and authentication
> Diverting of Data packets
> Mobility management

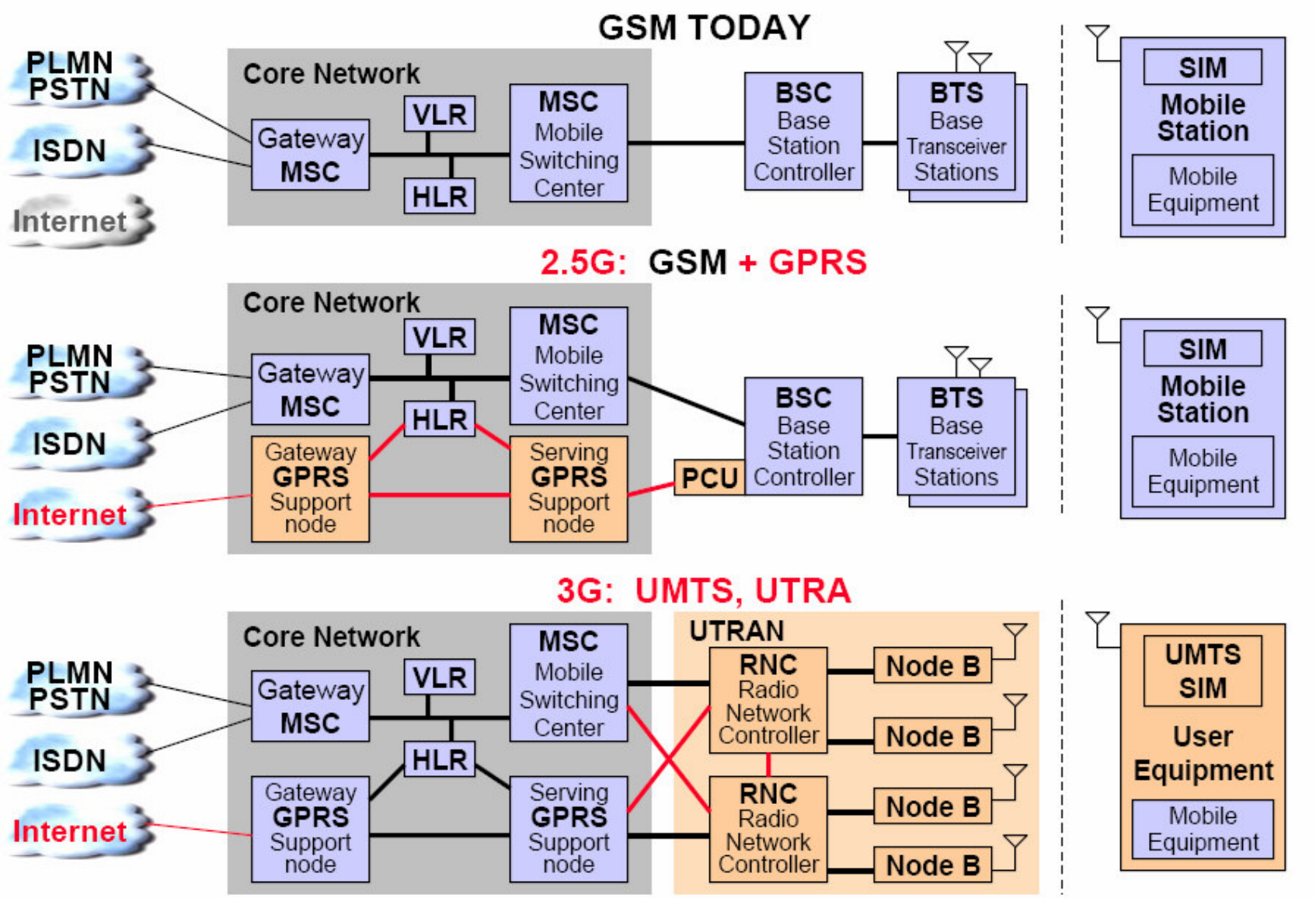
Gateway **G**PRS **S**upport **N**ode

> Interface between PLMN and **P**acket **D**ata **N**etwork (e.g. Internet)
> Providing "Screening Filters" (not wanted information)
> Can act as a firewall
> Data / Packet counting (for charging purpose)

GPRS – How GPRS Phone Works?

Network and Cell Selection




GSM TODAY
PLMN
PSTN
ISDN
Internet
Core Network
Gateway
MSC
VLR
HLR
MSC
Mobile
Switching
Center
BSC
Base
Station
Controller
BTS
Base
Transceiver
Stations
SIM
Mobile
Station
Mobile
Equipment
2.5G: GSM + GPRS
Core Network
Gateway
MSC
VLR
HLR
MSC
Mobile
Switching
Center
Gateway
GPRS
Support
node
Serving
GPRS
Support
node
PCU
BSC
Base
Station
Controller
BTS
Base
Transceiver
Stations
SIM
Mobile
Station
Mobile
Equipment
3G: UMTS, UTRA
Core Network
UTRAN
RNC
Radio
Network
Controller
Node B
UMTS
SIM
User
Equipment
Mobile
Equipment

WCDMA: foreword

New dictionary respect to the GSM

- Bit = one digit of information (data or control) addressed to the other side
- Chip = one digit transmitted on the air interface
- Code = sequence of binary digits
- Spreading = the way to be “broadcasted”
- Scrambling = the way to come out

UTRA Standard ETSI/3GPP

Multiple access mode	DS-CDMA
Duplexing	FDD
Channel Separation	200kHz
Channel Bandwidth	5 MHz
Chip Rate	3.84 Mcps
BS communication mode	Asyncronous
Frame period	15 slot per frame (10 ms)
Spreading Factors	4, 8, 16, 32, 64, 128, 256, 512
Spreading Modulation	QPSK (DL); dual channel QPSK (UL)

Comparison of IS-2000 and W-CDMA

Parameters	3GPP2 (cdma2000)	3GPP (W-CDMA)
Multiple Access Technique and duplexing scheme	Multiple access: DS-CDMA (UL) MC-CDMA(DL) Duplexing: FDD	Multiple Access: DS-CDMA Duplexing: FDD
Chip Rate	N x 1.2288 Mchip/s (N = 1,3,6,9,12)	3.84 Mchips/s
Pilot Structure	Code-divided continuous dedicated pilot (UL) Code-divided continuous common pilot (DL) Code-divided continuous common or dedicated auxiliary pilot (DL)	Dedicated pilots (UL) Common and/or dedicated pilots (DL)
Frame Length	5, 10, 20, 40, 80 ms	10 ms with 15 slots
Modulation and Detection	Data modulation: UL-BPSK DL-QPSK Spreading modulation: UL-HPSK DL-QPSK Detection: pilot-aided coherent detection	Data mod:UL-dual channel QPSK; DL-QPSK Spreading modulation: QPSK Detection: pilot-aided coherent detection
Channelization Code	Walsh Codes (UL) Walsh Codes or quasi-orthogonal codes(DL)	Orthogonal variable spreading factor codes
Scrambling Code	Long code (period 2^{42}-1 chips for N=1) Short PN code (period 2^{15}-1 chips for N=1) N = spreading rate number	UL - short code (256 chips from family of S(2) codes or long code (38,400 chips, Gold-code-based) DL: Gold-code-based
Access Scheme	RsMa - flexible random access scheme Allowing three modes of access: -Basic Access -Power controlled Access -Reserved access Designated access scheme - access scheme initiated by the base station message	Acquisition-indication-based random access mechanism with power ramping on preamble followed by message
Inter-base-station operation	Synchronous	Asynchronous Synchronous (optional)

One of the CDMA Spreading Sequences: Orthogonal Variable Spreading Factor (OVSF)

- 64 "Magic" Sequences, each 64 chips long
- Each OVSF is precisely Orthogonal with respect to all other ovsf Codes
  - it's simple to generate the codes, or
  - they're small enough to use from ROM

Unique Properties:
Mutual Orthogonality

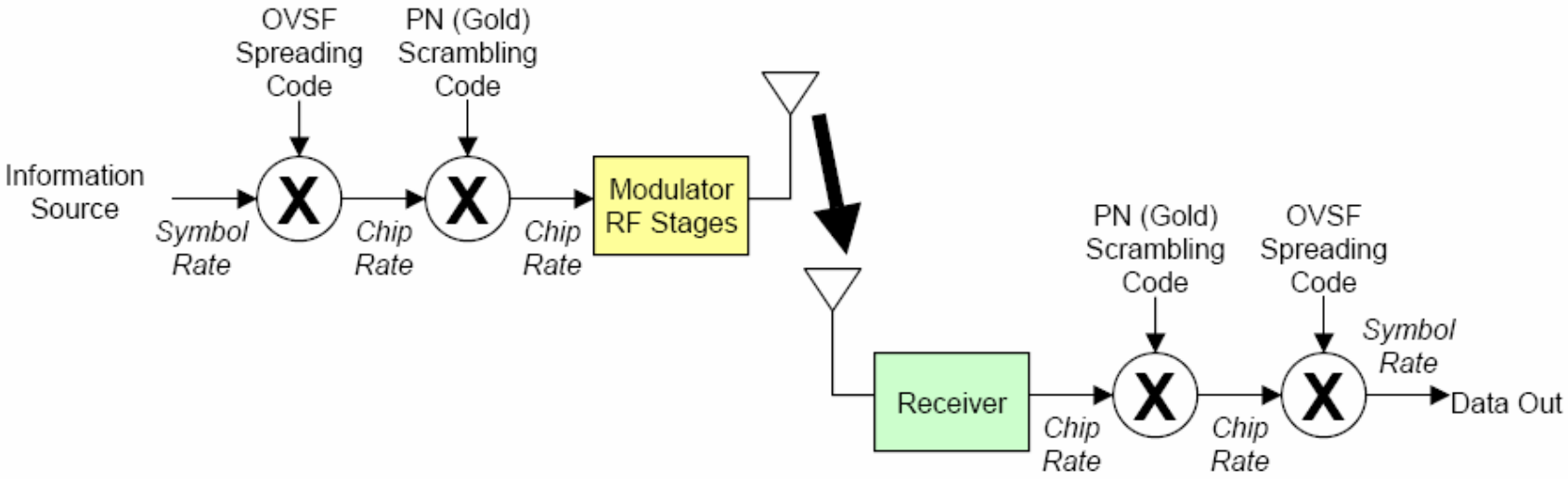
EXAMPLE:

Correlation of OVSF #23 with OVSF #59

```
#23   0110100101101001100101101001011001101001011010011001011010010110
#59   0110011010011001100110011001011001101001100101100110011001101001 1001
Sum   0000111111111000000001111111110000111100000000111111111000000001111
```

Correlation Results: 32 1's, 32 0's: Orthogonal!!

Spread Spectrum Basics
Spreading and Scrambling



- At the transmitter, the information source provides symbols
  - The symbols are applied to a spreading code
  - The resulting chip-rate spread signal is applied to a Scrambling Code
  - The resulting chip-rate spread/scrambled signal modulates the transmitter
- The Receiver recovers the signal and the same scrambling code descrambles it
  - Next the spreading code de-spreads the signal, yielding the original symbol-rate data

Example of DS multiple access waveforms