

3rd Generation Systems

- Review of Cellular Wireless Networks
- UMTS

Cellular Wireless Network Evolution

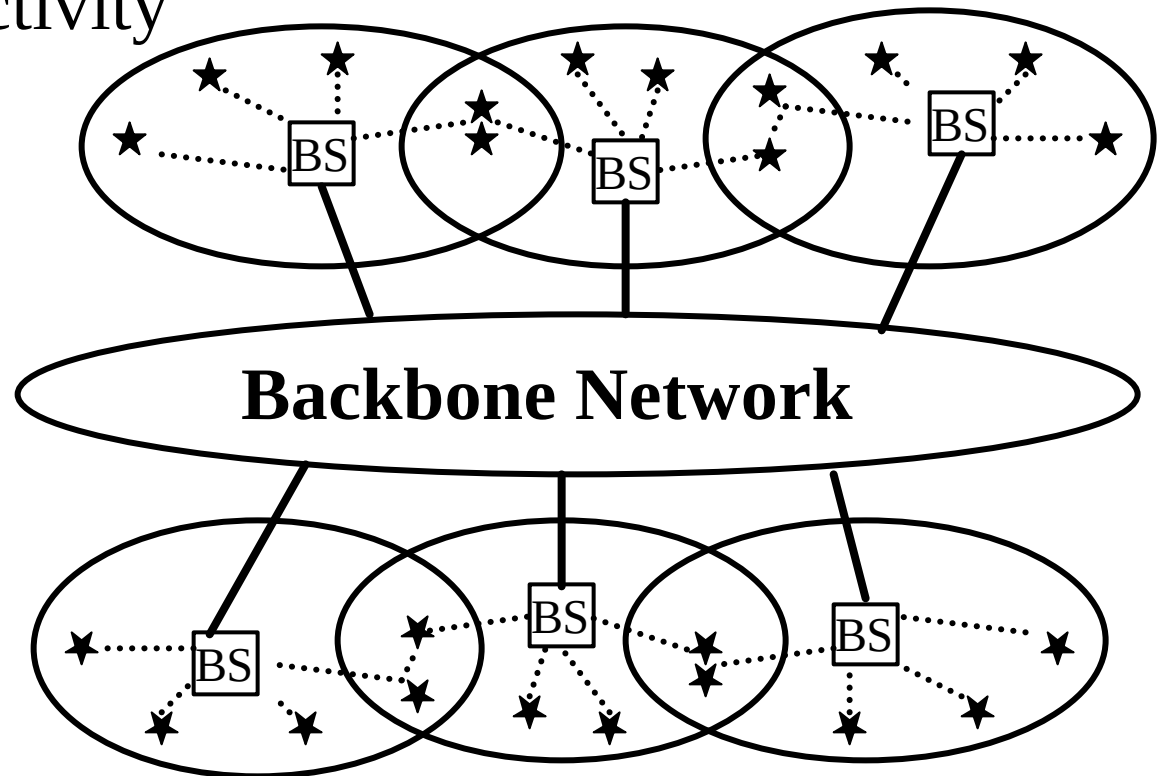
- **First Generation: Analog**
 - AMPS: Advance Mobile Phone Systems
 - Residential cordless phones
- **Second Generation: Digital**
 - IS-54: North American Standard - TDMA
 - IS-95: CDMA (Qualcomm)
 - GSM: Pan-European Digital Cellular
 - DECT: Digital European Cordless Telephone

Cellular Evolution (cont)

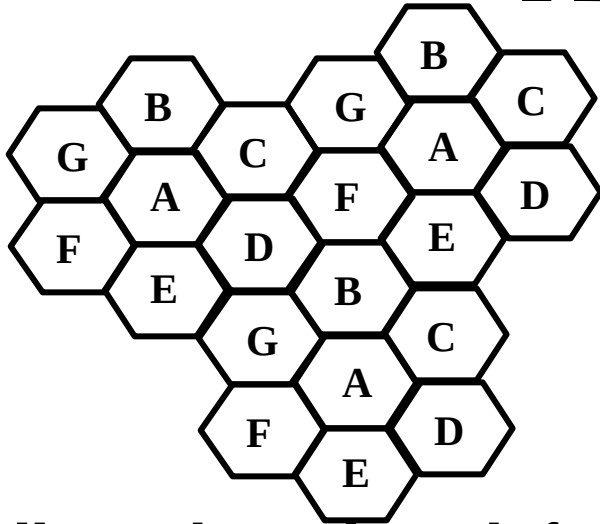
- **Third Generation: T/CDMA**
 - combines the functions of: cellular, cordless, wireless LANs, paging etc.
 - supports multimedia services (data, voice, video, image)
 - a progression of integrated, high performance systems:
 - (a) GPRS
 - (b) EDGE
 - (c) UMTS

Cellular Concept

- Geographical separation
- Capacity (frequency) reuse
- Backbone connectivity



AMPS (Advanced Mobile Phone System): FDMA



Frequencies are not reused in adjacent cells

In each cell, 57 channels each for A-side carrier and B -side carrier
Channels are divided into 4 categories:

1. Control (base to mobile) to manage the system.
2. Paging (base to mobile) to alert mobile users to incoming calls.
3. Access (bidirectional) for call set up and channel assignment.
4. Data (bidirectional) for voice, FAX, or data

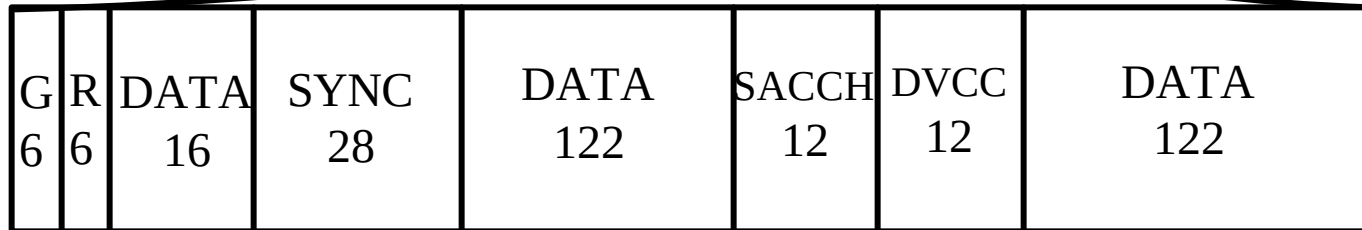
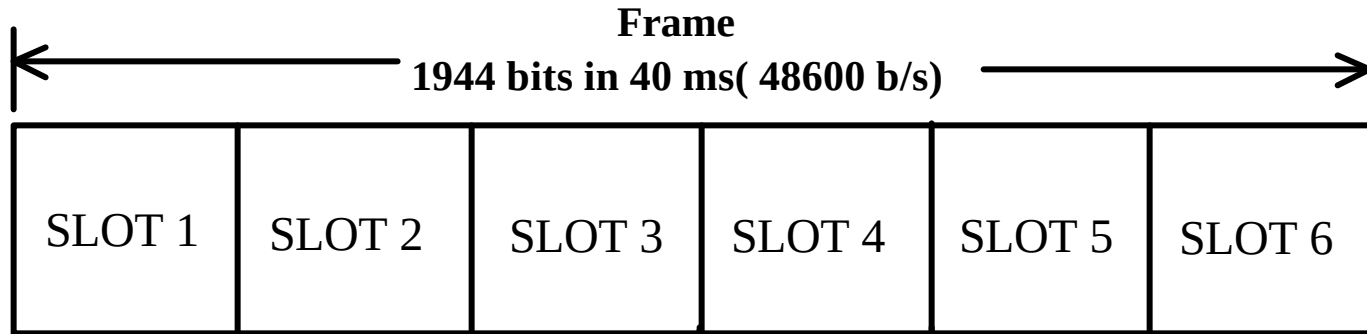
Handoff

- Handoff: Transfer of a mobile from one cell to another
- Each base station constantly monitors the received power from each mobile.
- When power drops below given threshold, base station asks neighbor station (with stronger received power) to pick up the mobile, on a new channel.
- The handoff process takes about 300 msec.

Digital Cellular: IS-54 TDMA System

- Second generation: digital
- Same frequency as AMPS
- Each 30 kHz RF channel is used at a rate of 48.6 kbps
 - 3 TDM slots/RF band
 - 8 kbps voice coding
 - 16.2 kbps TDM digital channel
- 4 cell frequency reuse
- Capacity increase per cell per carrier
 - $3 \times 416 / 4 = 312$ (instead of 57 in AMPS)
 - Additional factor of two with speech activity detection.

IS-54 slot and frame structure

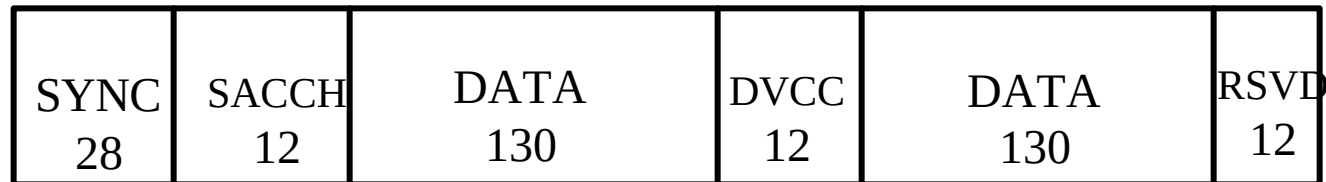


MOBILE TO BASE

G:GUARD TIME R:RAMP TIME

DVCC: DIGITAL VERIFICATION COLOR CODE

RSVD: RESERVE FOR FUTURE USE



BASE TO MOBILE

GSM (Group Special Mobile)

Pan European Cellular Standard

Second Generation: Digital

Frequency Division duplex (890-915 MHz Upstream; 935-960 MHz Downstream)

125 frequency carriers

Carrier spacing: 200 Khz

8 channels per carrier (Narrowband Time Division)

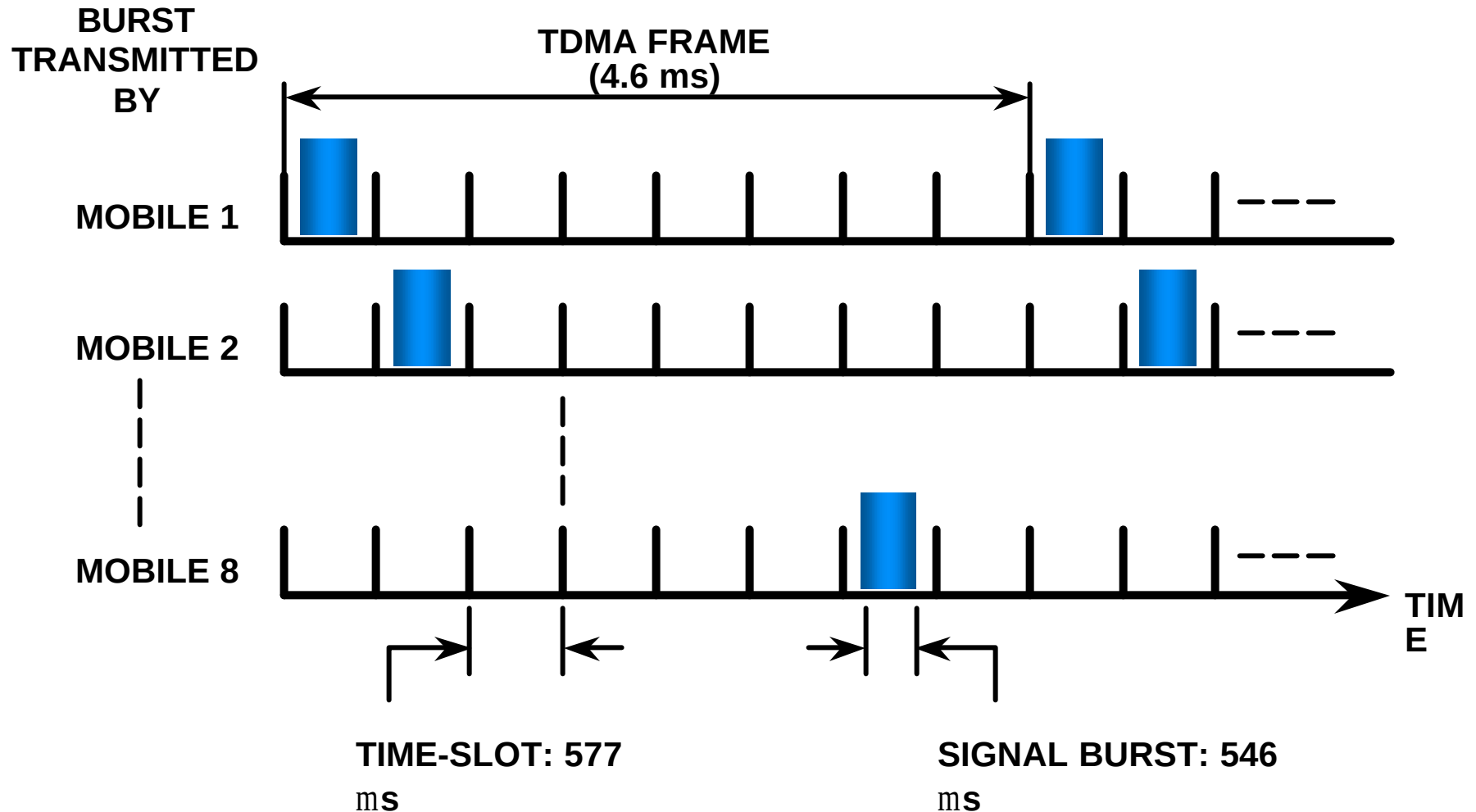
Speech coder: linear predictive coding (Source rate = 13 Kbps)

Modulation: phase shift keying (Gaussian minimum shift keying)

Multilevel, time division frame structure

Slow frequency hopping to overcome multipath fading

GSM functions - TDMA access technique



GSM network architecture and functions

Signalling channels

BCCH: Broadcast Control Channel

- **point-to-multipoint unidirectional control channel**
broadcasting system information to MS

CCCH: Common Control Channel

**up-link: RACH (Random Access
CHannel)**

**down-link: PCH (Paging Channel)
AGCH (Access Grant CHannel)**

DCCH: Dedicated Control CHannel

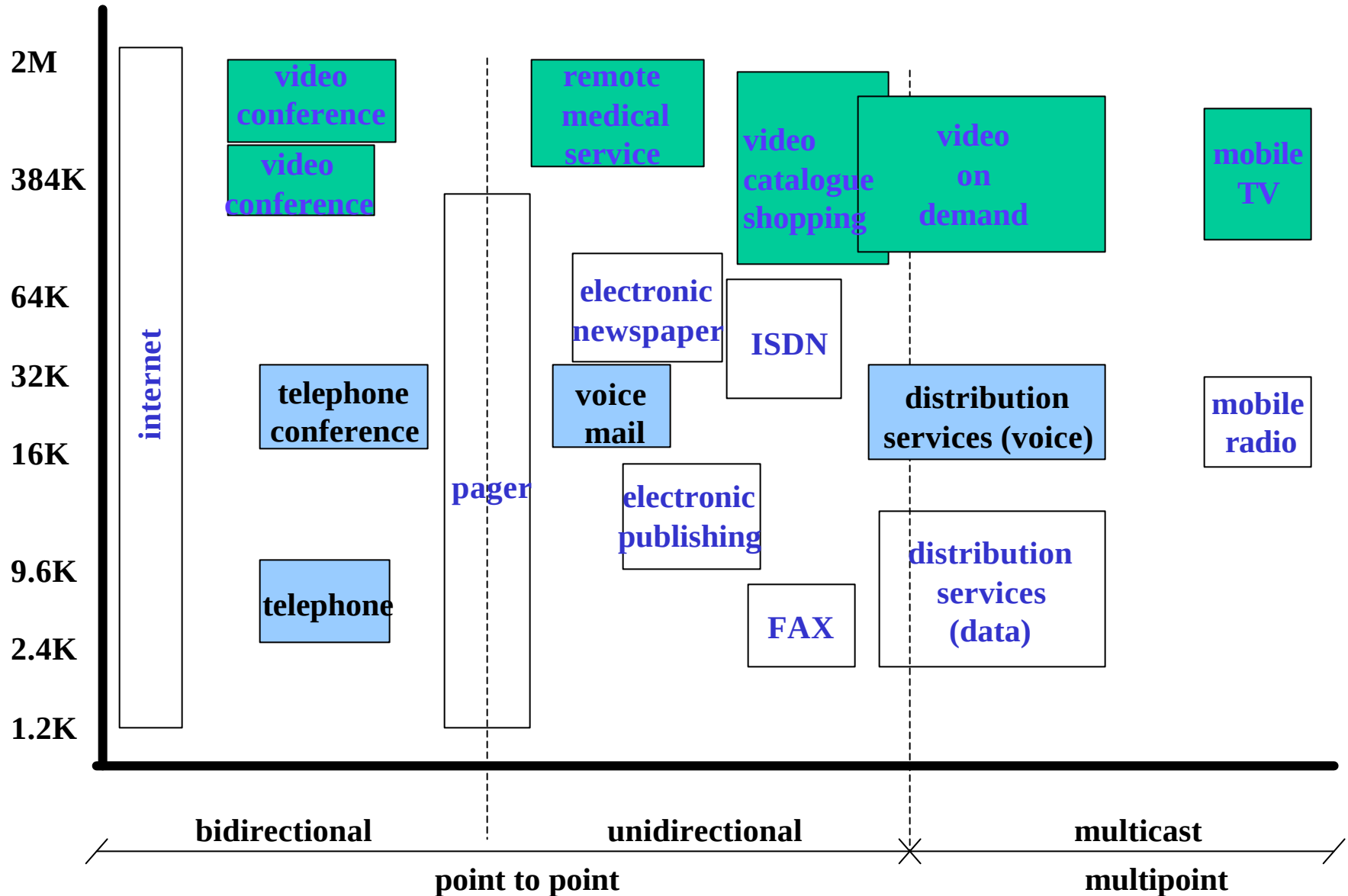
- **point-to-point bidirectional control channel**
- **SACCH (Slow Associated Control CHannel)**
- **FACCH (Fast Associated Control CHannel)**
- **SDCCH (Stand Alone Dedicated Control CHannel)**

UMTS (Universal Mobile Transport Service)

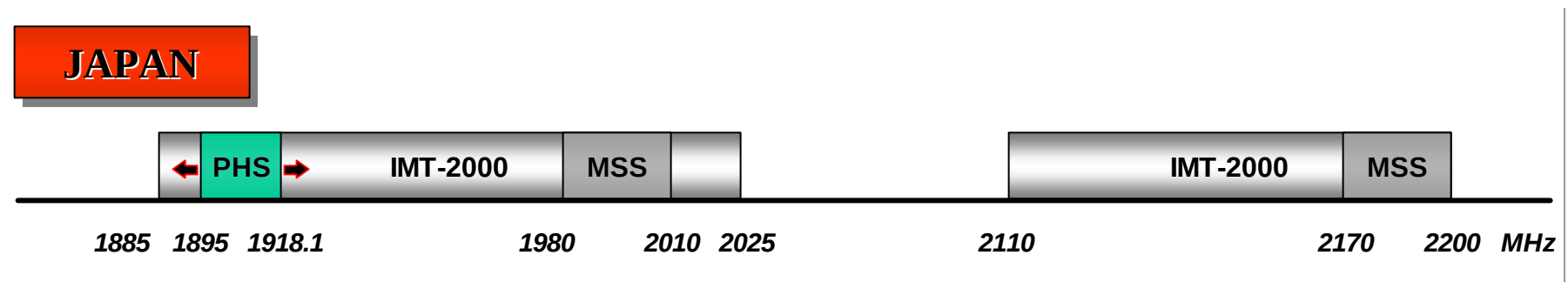
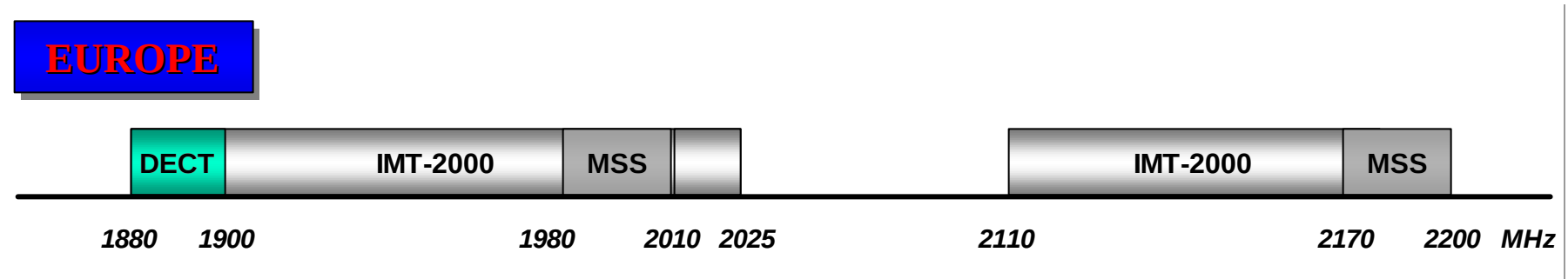
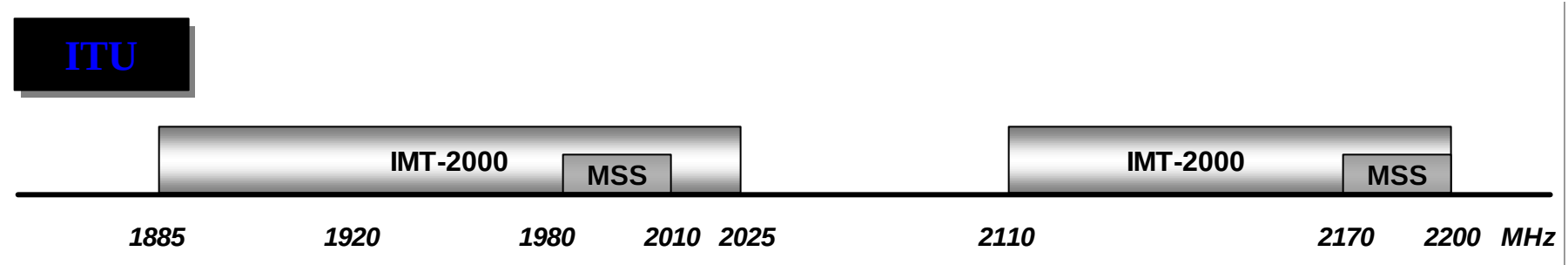
Requirements

- 384 Kbps for full area coverage
- 2 Mbps for local area coverage
- variable bit rate
- packet traffic support
- flexibility (eg, multiple, multimedia streams on a single connection)

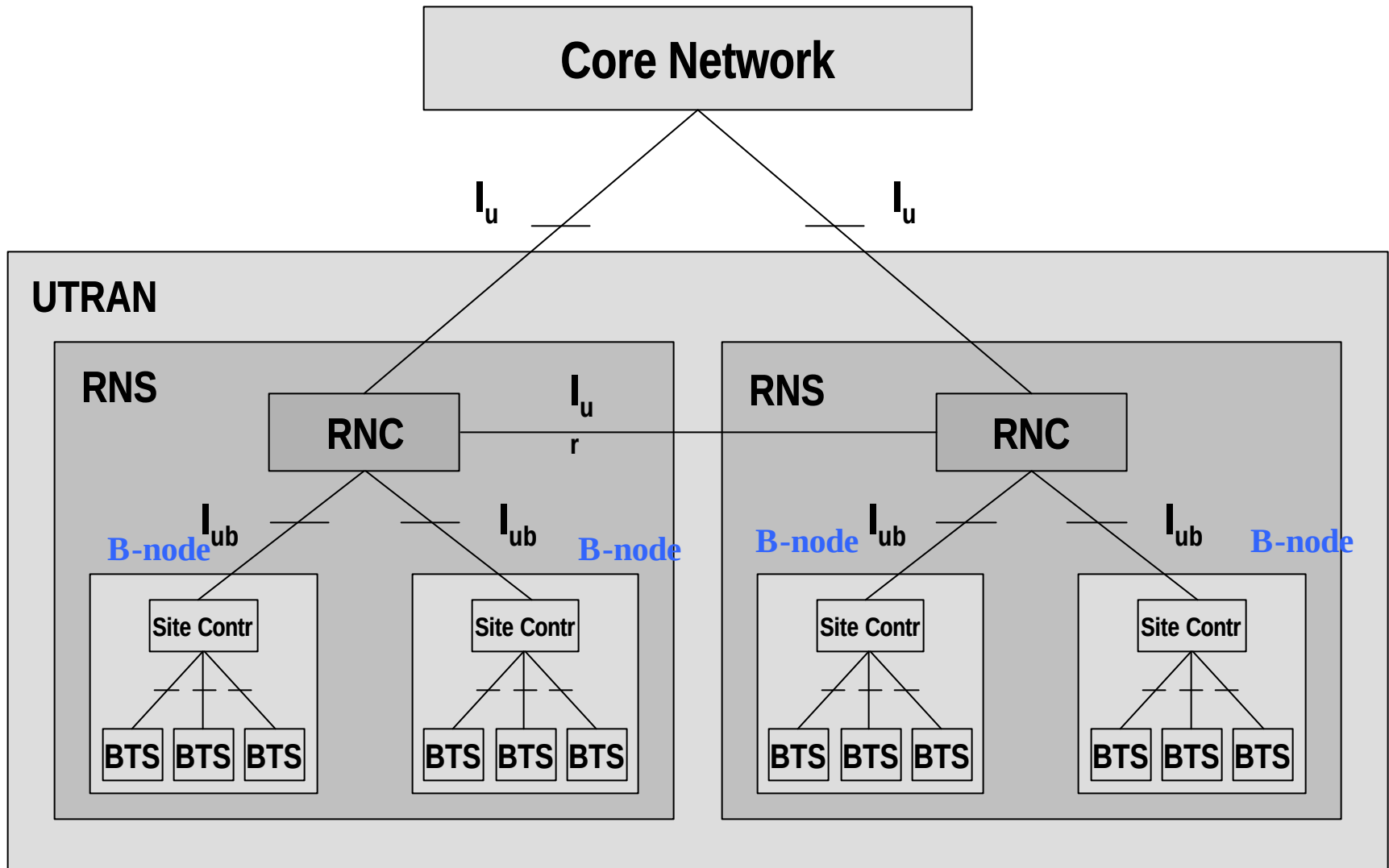
Third generation services



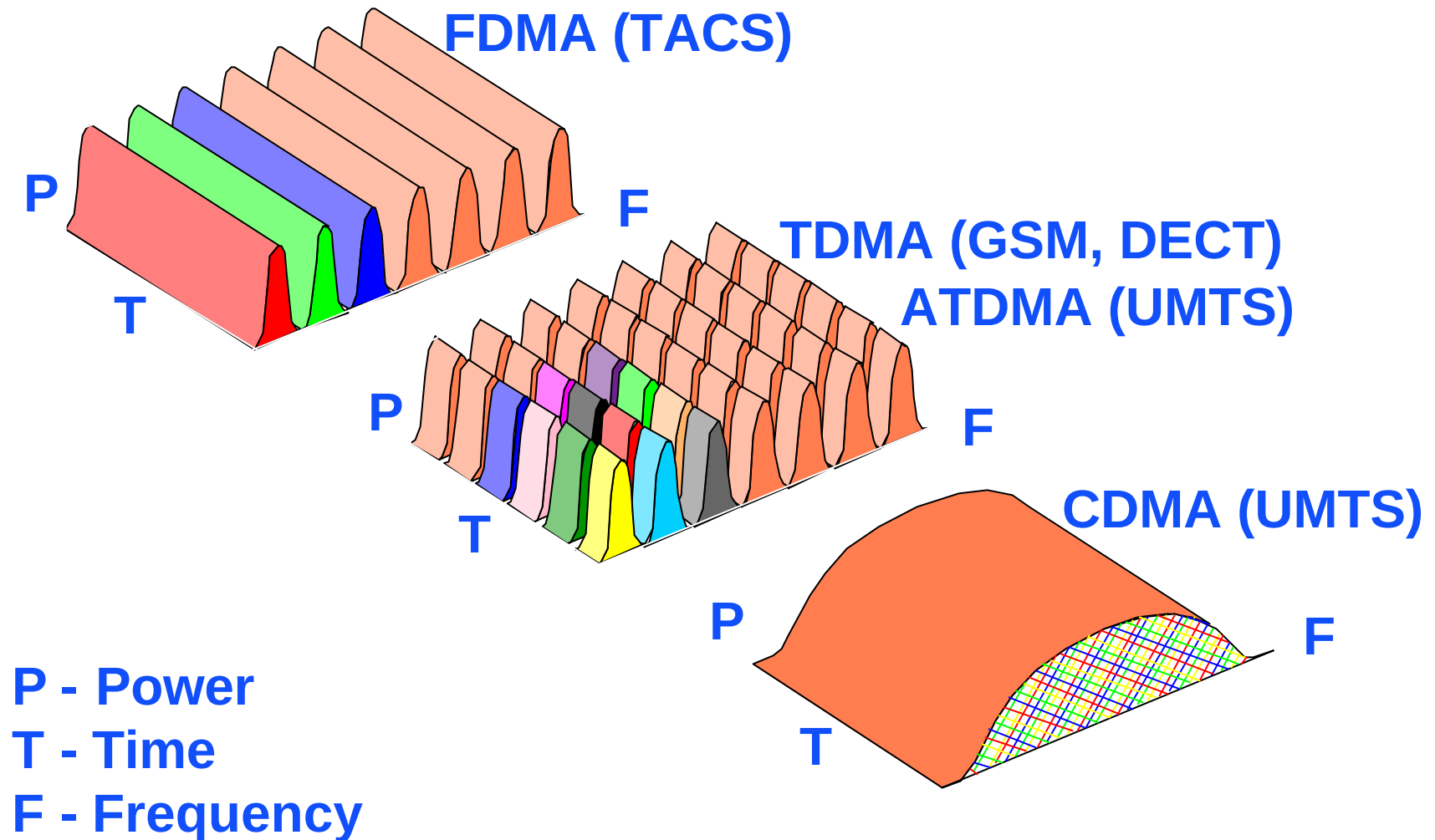
Third generation bandwidth assignment (I)



UTRAN (UMTS Terrestrial Radio Access Net) Architecture



Access techniques for mobile communications

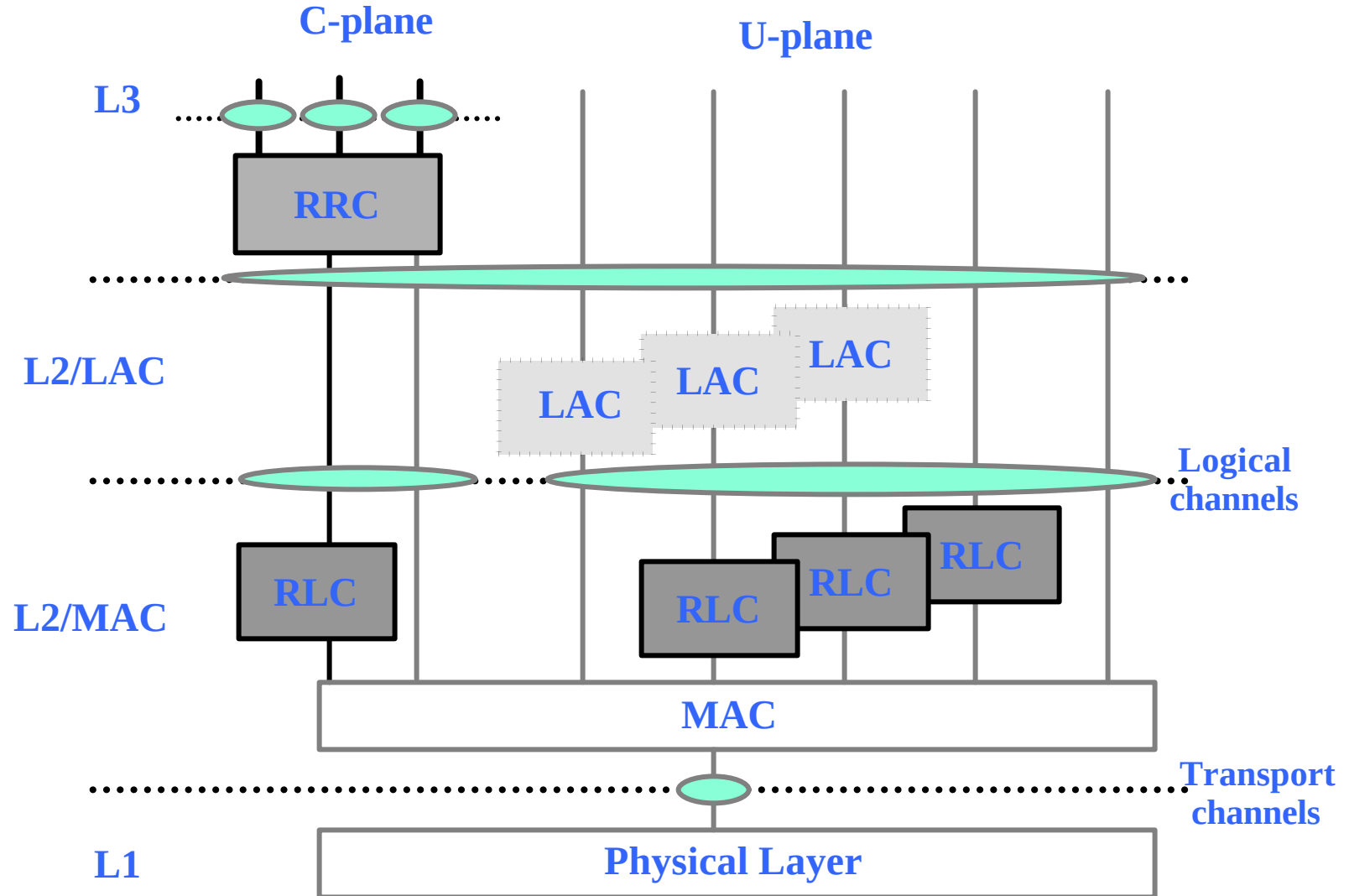


W-CDMA (Wide Band CDMA)

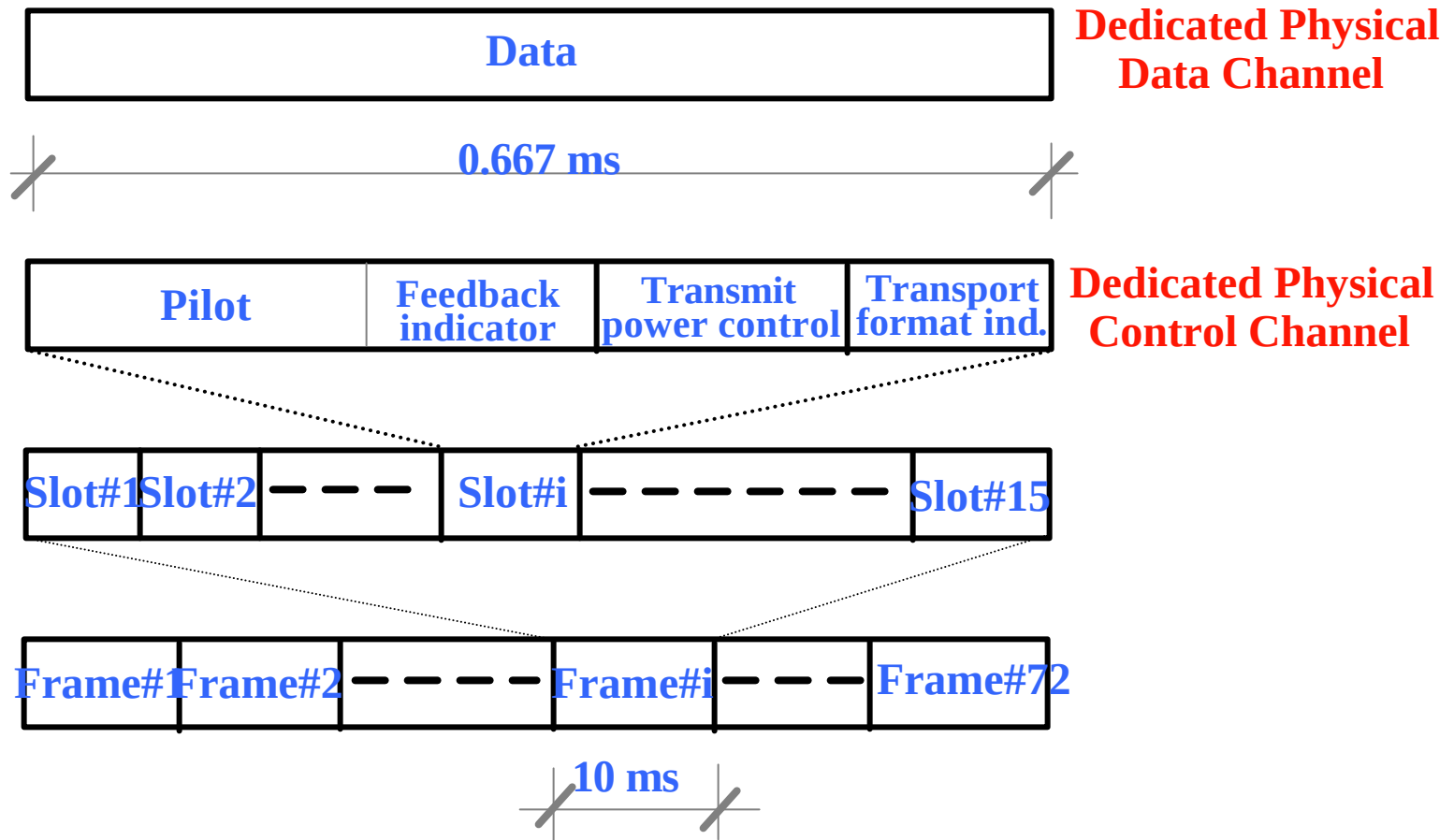
Key features

- Improved **capacity** and coverage (over second generation CDMA); backward compatible
- High degree of **service flexibility**: multiple, parallel services per connection; efficient pkt access
- **Operator flexibility**: asynchronous interstation operation; hierarchical cell structures (HCS); adaptive antenna arrays (enabled by uplink pilot symbols); TDD (Time Division Duplex) mode for asymmetric traffic and uncoordinated environments.

Radio Interface - protocol architecture

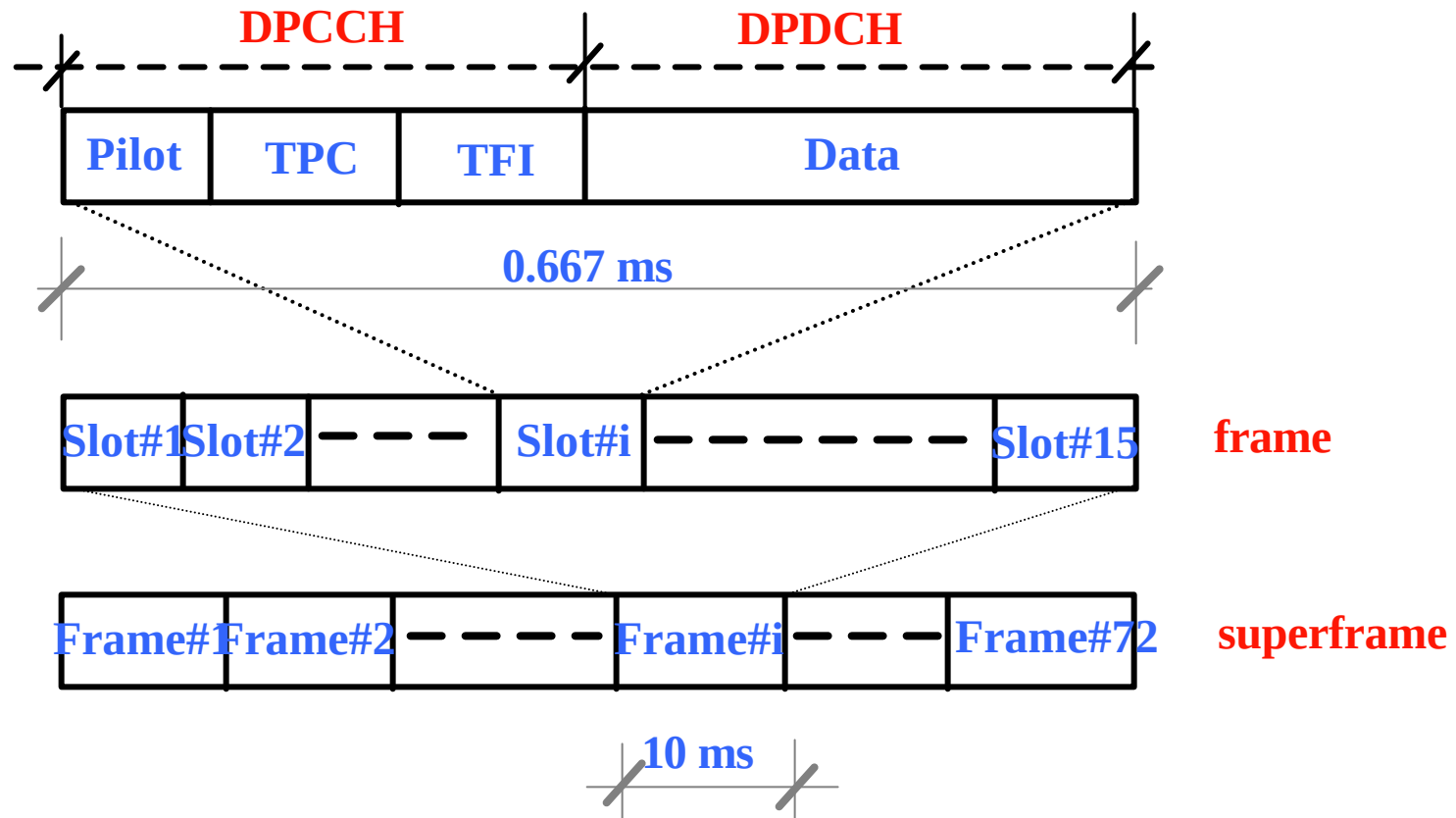


Layer 1 - up link physical channels (W-CDMA)



Layer 1 - down link physical channels

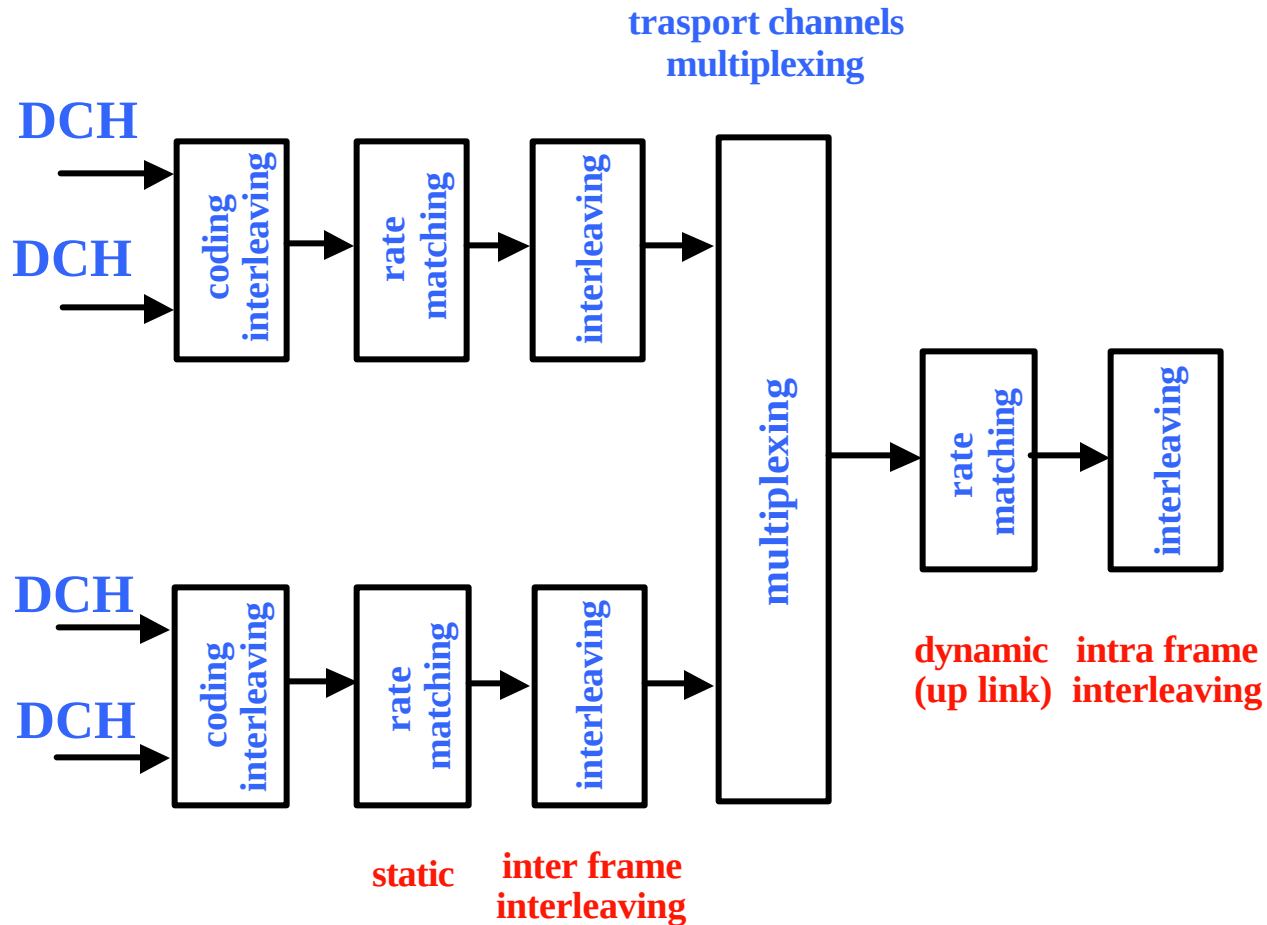
(W-CDMA example)



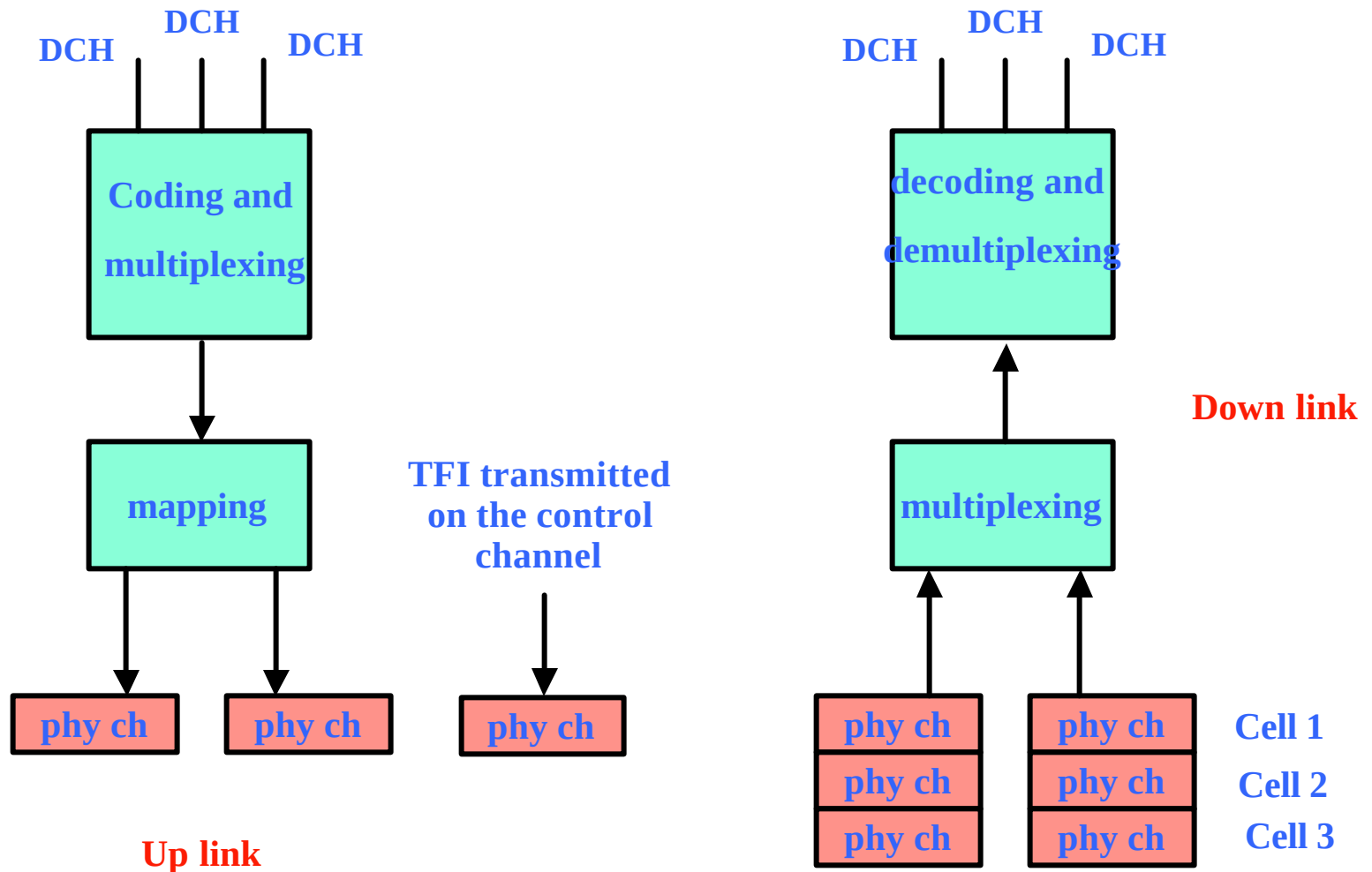
Transport channels (example)

- **Dedicated Channel (DCH):**
 - fast change of bit rate (10ms)
 - fast power control
 - inherent MS addressing
- **Random Access Channel (RACH) - up link:**
 - collision
 - open loop power control
 - explicit MS addressing
- **Broadcast Control Channel (BCH) - down link**
- **Forward Access Channel (FACH) - down link:**
 - slow power control
 - explicit MS addressing
- **Paging Channel (PCH) - down link:** use of sleep modes

Multiplexing transport channels onto physical channels



MS physical layer up-down link example of multiplexing

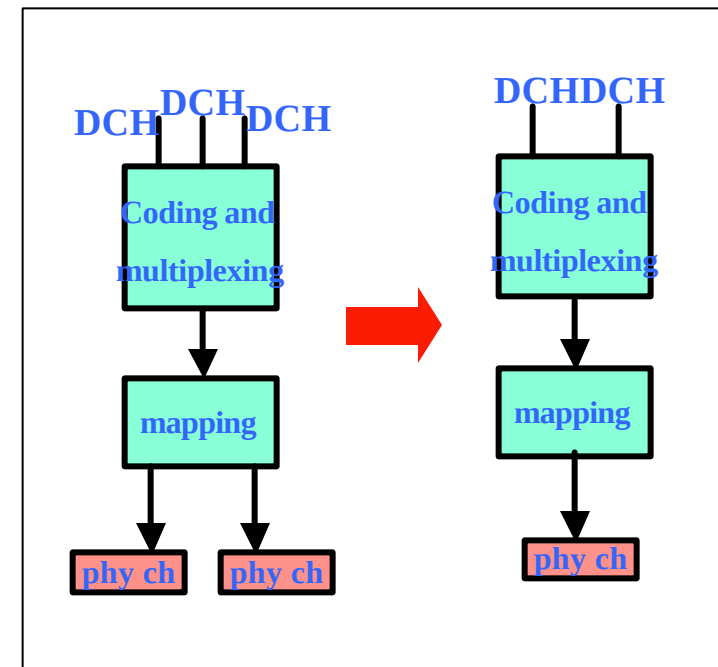


MAC Services and Functions

- set-up, release of logical channels
- data transfer service on logical channels
- allocation/re-allocation of radio resources
- measurement report

Functions ↓

- Selection of the transport format
- Handling of priority within one user/between users
- Scheduling of control messages (broadcast, paging, notification)
- Multiplexing/de-multiplexing of higher layers PDUs on/from common or dedicated transport channels
- Contention control on the random access channel



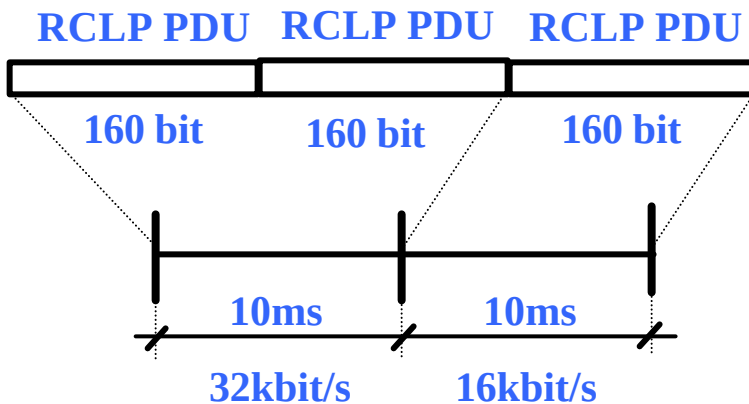
Retransmission Protocol - services and functions

- Layer 2 connection set-up and release
- transparent data transfer
- unacknowledged data transfer
- acknowledged data transfer

Services



Functions

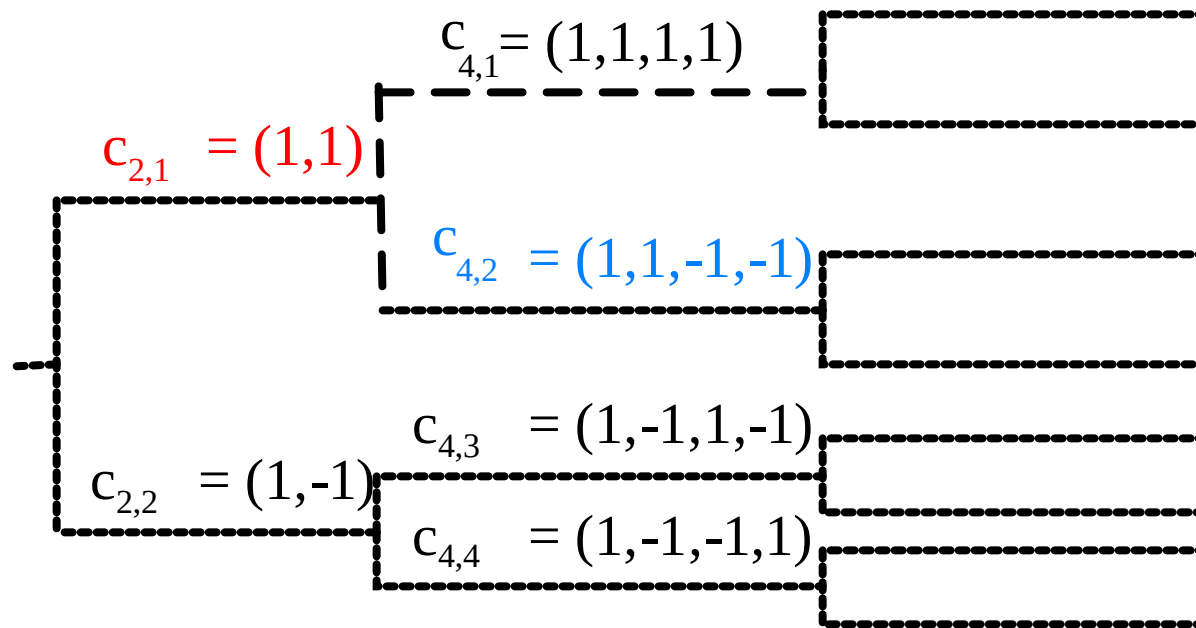


- connection control
- segmentation and re-assembly
- error detection/recovery and in-sequence delivery
- transfer of user data
- flow control
- duplicate detection
- QoS adaptation

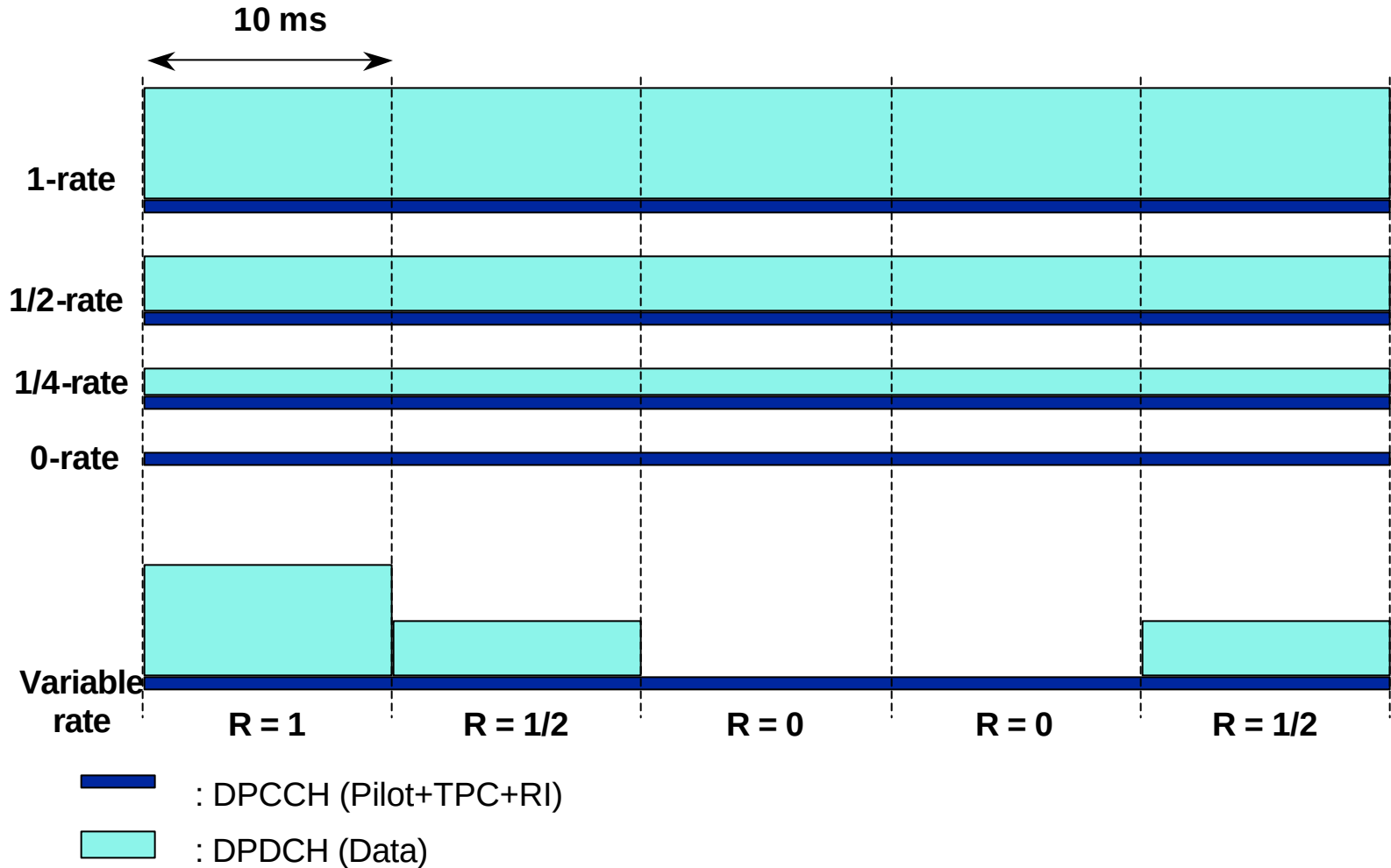
Radio Resource control - functions

- Broadcast of information | provided by the Core Network related to the access segment
- Set-up, maintenance and release of an RRC connection
- Set-up, maintenance and release of radio bearers on the user plane
- Assignment, reconfiguration and release of radio resources for the connection
- Arbitration of radio resource allocation between cells
- RRC connection mobility functions
- Quality of Service control and radio resource allocation among the cells
- Admission and congestion control
- Control of the MS measurement reporting

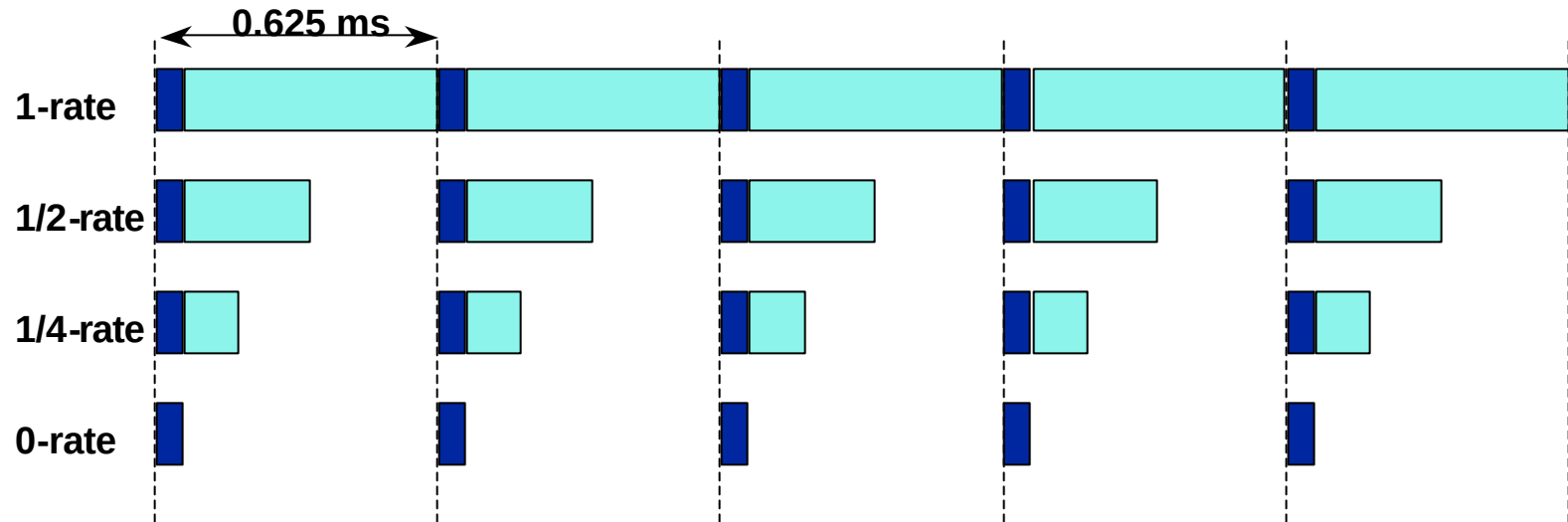
Orthogonal Variable Spreading Factor



Uplink Variable Rate



Downlink Variable Rate (DTX based)



■ : DPCCH-part (Pilot+TPC+RI)

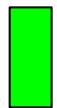
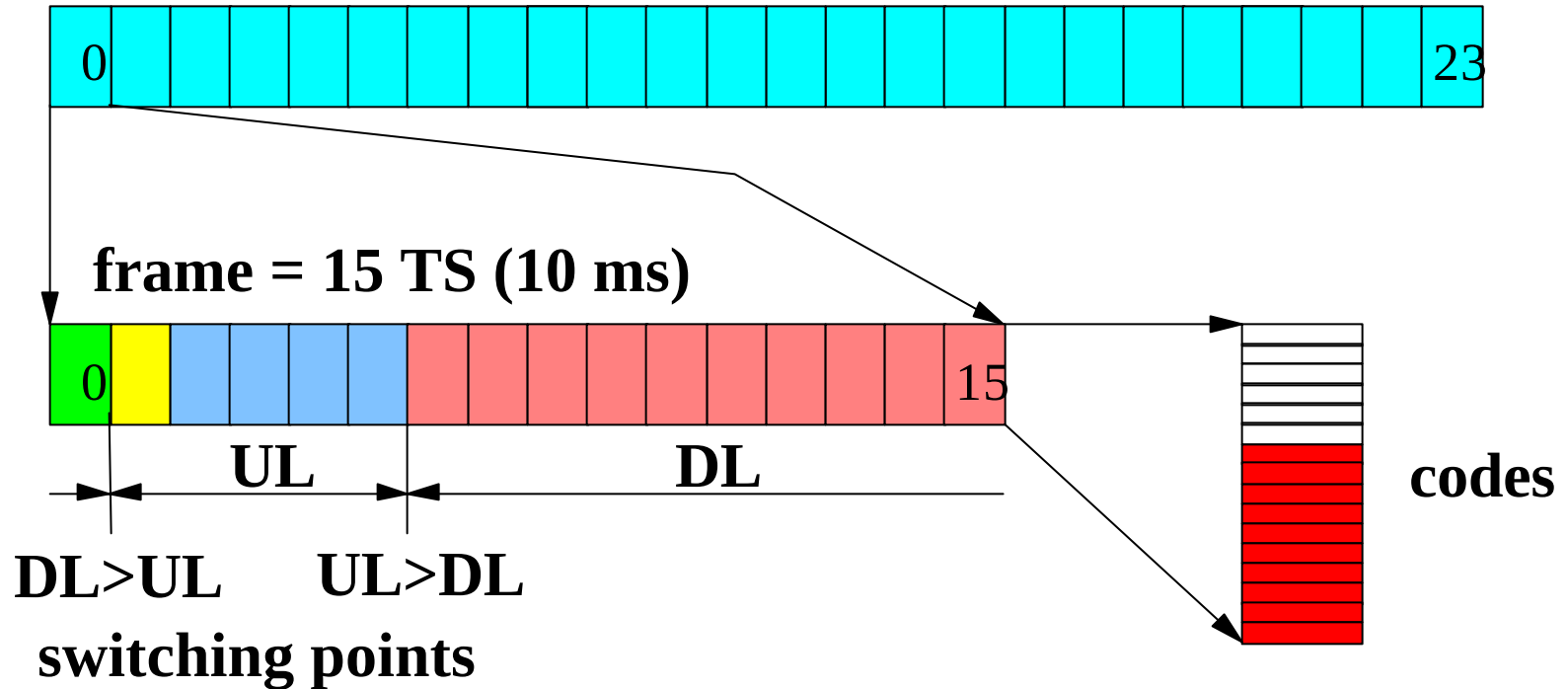
■ : DPDCH-part (Data)

TD-CDMA (Time Division Duplex)

Multiple access scheme	TDMA/CDMA
Channel spacing	5 MHz
Carrier chip rate	3.84 Mchips/s
Spreading factor	1-16
Frame length	10 ms
Multirate concept	multislot /multicode
Modulation	QPSK
Burst Types	burst 1 long delay spread burst 2 short delay spread
Detection	Coherent, based on midamble

TDD - frame structure

multiframe = 24 frames (240 ms)



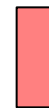
BCCH



RACH



UL TCH



DL TCH

Packet Data Service

In W-CDMA, data packets can be transmitted in 3 ways:

- (a) **RACH** (Random Access Channel): used for small amount of data; no reservations, thus low latency; but, collisions and no power control (on RACH)
- (b) **Request a dedicated channel** (like VC setup): MS sends a Res Req msg (on RACH) with traffic specs; network returns a Req All + Cap All (with transport formats) on FACH, if resources are available; Cap_All may be issued separately (later) if the network load is high; MS transmits after receiving the Cap All.

Packet Data Service (cont)

- (c) use **existing dedicated channel** (before it expires): if a DCH was recently used, go ahead and tx the unscheduled pkt on that channel. If timer expired, the MS can still omit the Res Req and issue just the Cap All

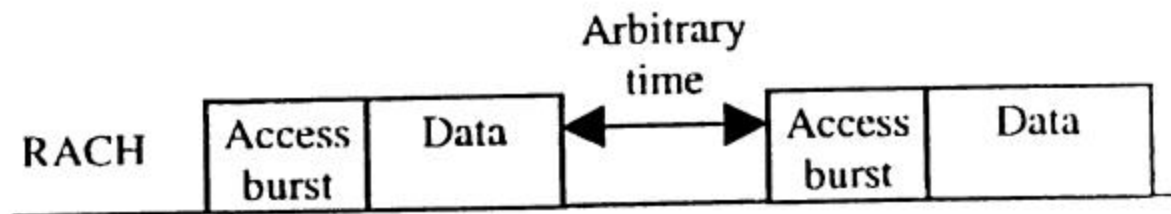


Fig. 16. Packet transmission on the RACH.

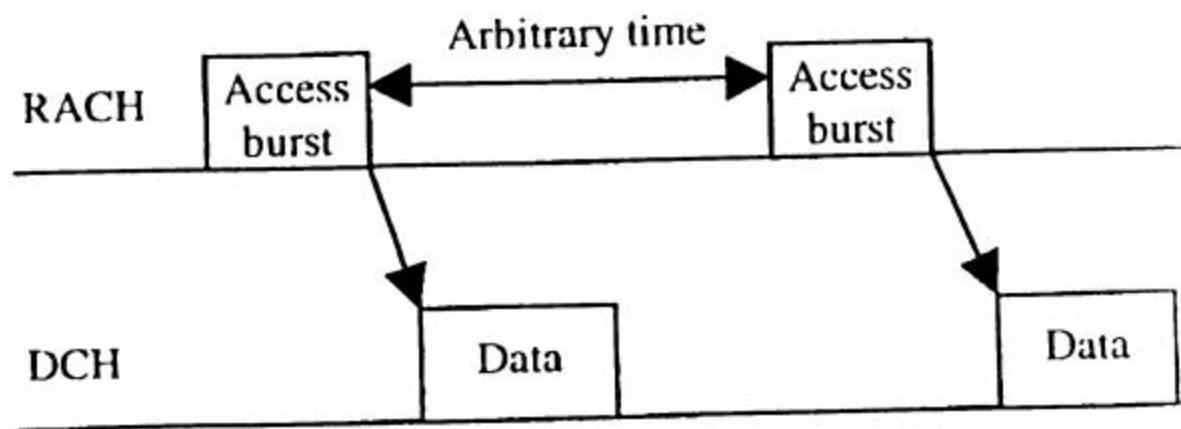


Fig. 17. Packet transmission on a dedicated channel.

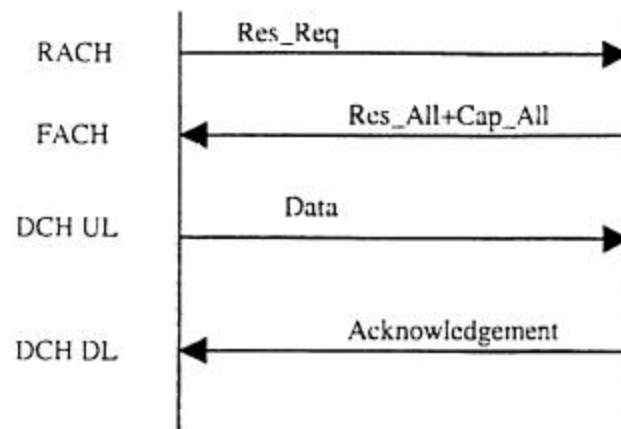


Fig. 18. Resource request and allocation on the RACH and FACH, respectively, followed by transmission of data on the dedicated channel.

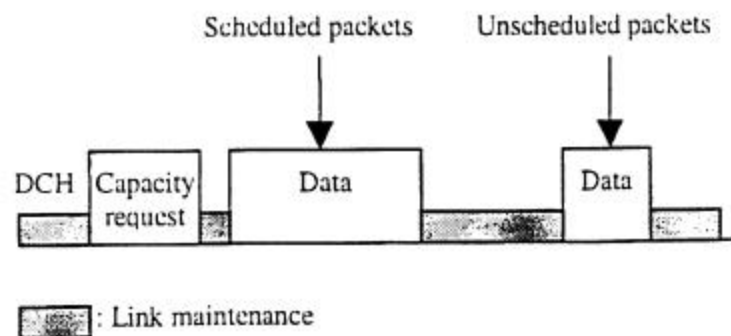


Fig. 19. Packet transmission on the dedicated channel.

Real time services

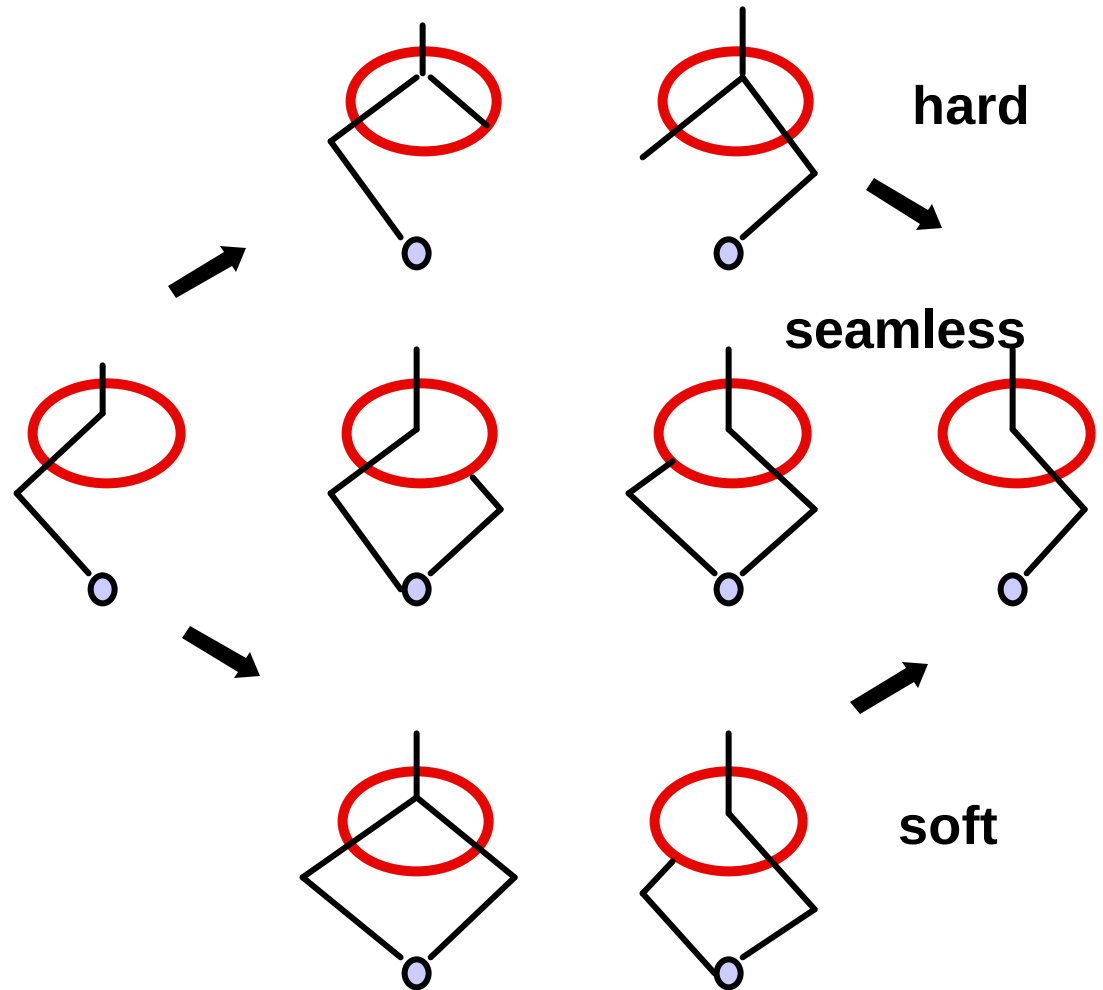
- MS issues Res_Req on RACH (or on DCH if it has one going)
- Network issues Res All (with TF parameters)
- MS starts transmission immediately (no wait for Cap_All)
- Network may later reduce/restore the TF depending on load fluctuations

Congestion Control

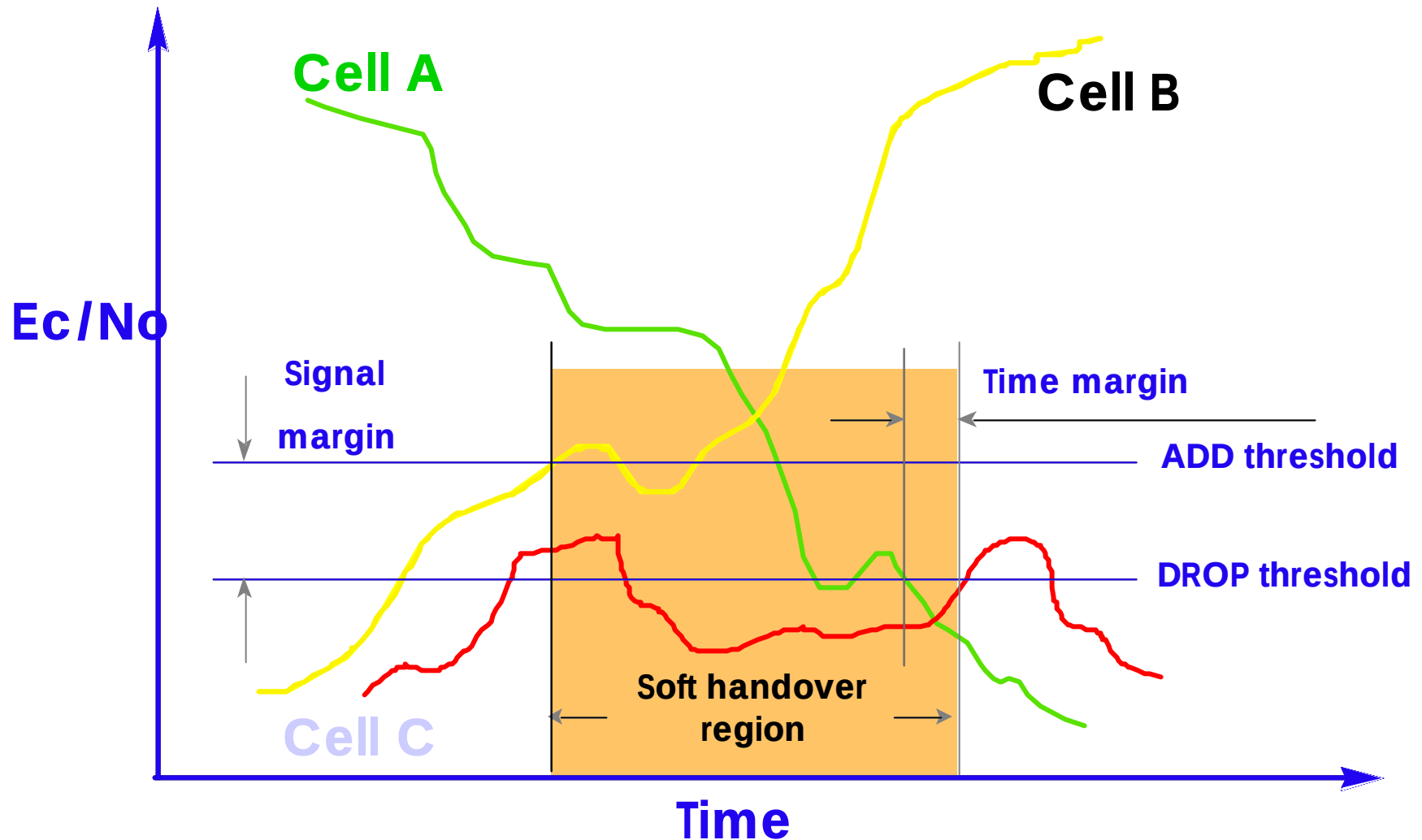
- Congestion may occur even after careful admission control
- without cong. control, mobiles tend to **increase their tx power**, to combat interference, thus aggravating the problem
- solutions:
 - (a) lower bit rate of users insensitive to delay;
 - (b) perform interfrequency handovers
 - (c) remove connection(s)
- congestion control remedies activated by load thresholds

Handover modes

**Handover
Functions
basic feature
for the RAN
architecture**



Macrodiversity - active set



The macrodiversity control

