3G Overview

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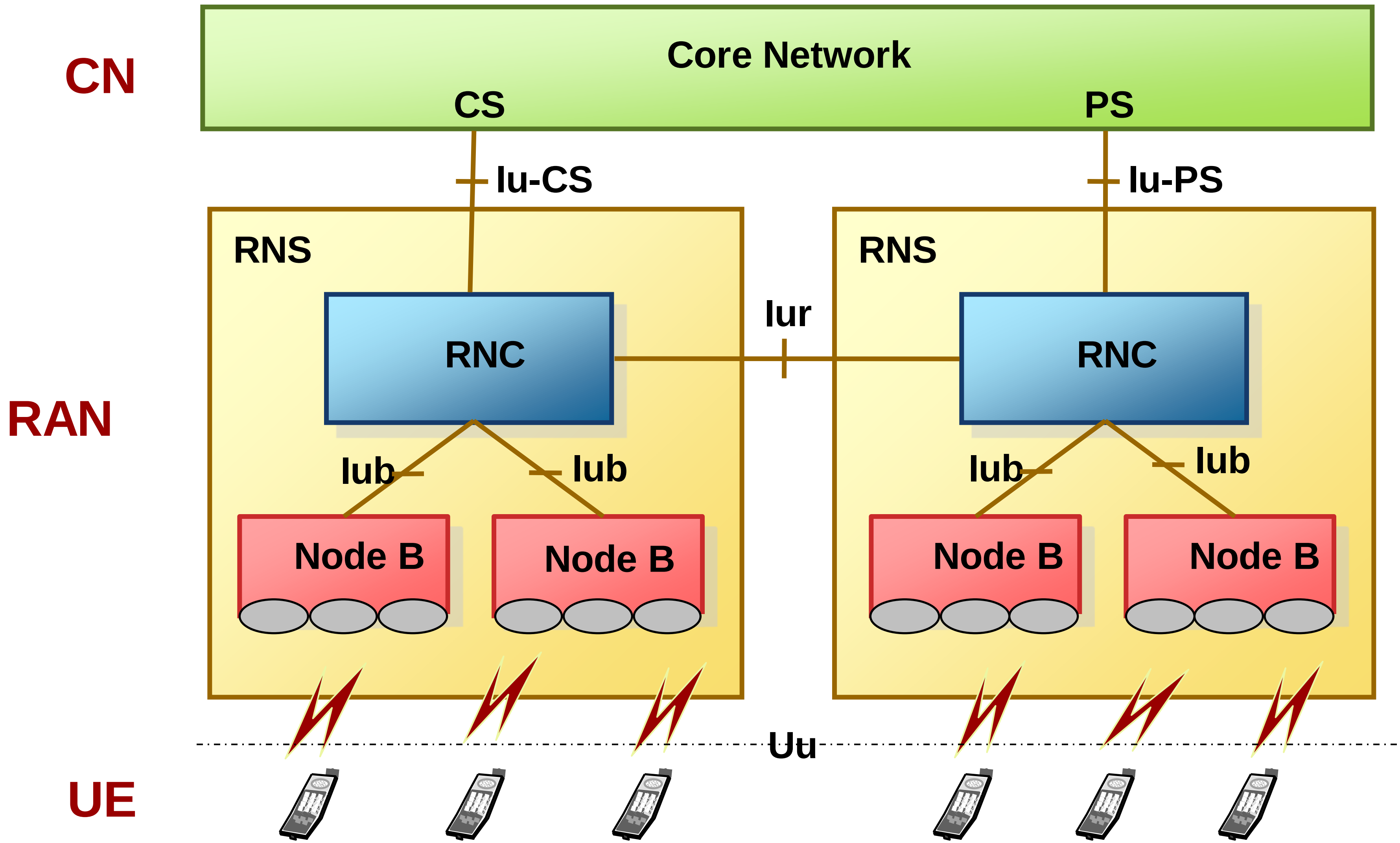
WCDMA System Architecture



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Multiple Access Technology and Duplex Technology

- Multiple access technology
  - Time division multiple access (TDMA)
  - Frequency division multiple access (FDMA)
  - Code division multiple access (CDMA)

WHAT IS DUPLEX TRANSMISSION ?

In mobile telephone full duplex communication systems is used. Full duplex communication implies that simultaneous transmission and reception. Insignificant delays (imperceptible to the subscribers) are acceptable.

- Duplex technology
  - Time division duplex (TDD)
  - Frequency division duplex (FDD)

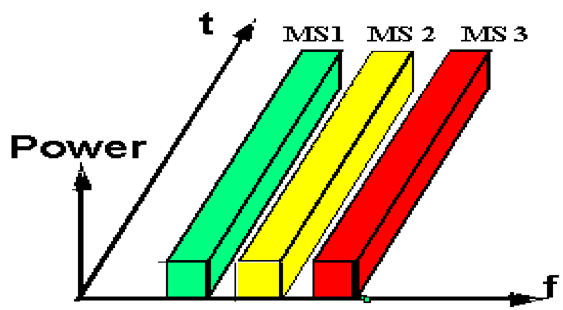
FREQUENCY DIVISION MULTIPLE ACCESS (FDMA)

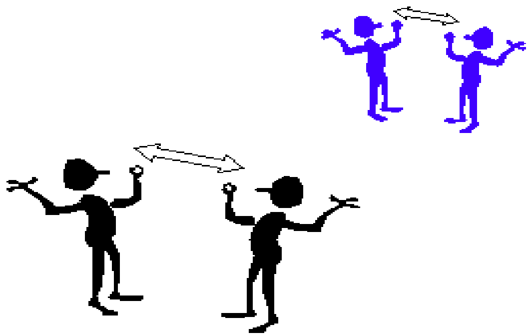
Frequency Division Multiple Access (FDMA) is common in the first generation of mobile communication systems, so called analogue systems. The available spectrum in FDMA is divided into physical channels of equal bandwidth.

One physical channel is allocated per subscriber. In pure FDMA systems, different speech/data/signaling (per subscriber) transmissions may be transmitted at the same time on different frequencies. The physical channel allocated to the subscriber is used during the entire duration of the call and is unavailable for other subscribers during that time. The physical channel is released at the end of the call and is then available for the next subscriber. In summary, in FDMA, narrow bandwidth is used for continuous transmission and reception, there is orthogonality in frequency within the cell, and no synchronization in time is needed.

- Orthogonal in frequency within cell
- Narrow bandwidth per carrier
- Continuous transmission and reception
- No synchronization in time

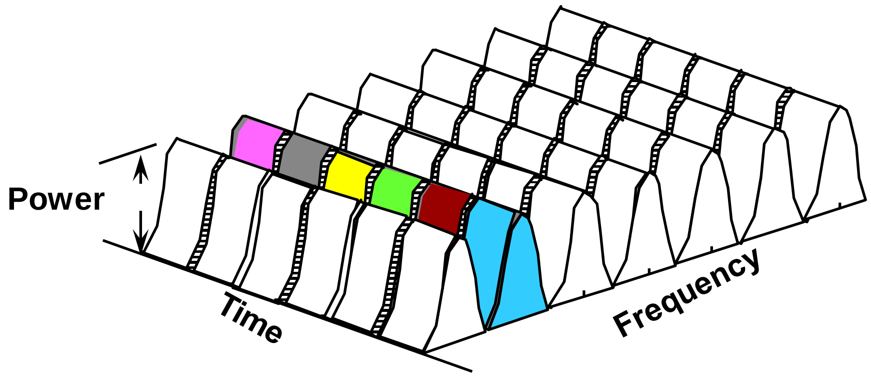
NMT
AMPS
TACS





TIME DIVISION MULTIPLE ACCESS (TDMA)

In TDMA, the available frequency is divided into units, which correspond to units of time, known as time slots. Each subscriber requiring resources is allocated a unit of time (time slot) during which they can transmit or receive data. The TDMA system is used in many Second Generation (2G) systems such as GSM .



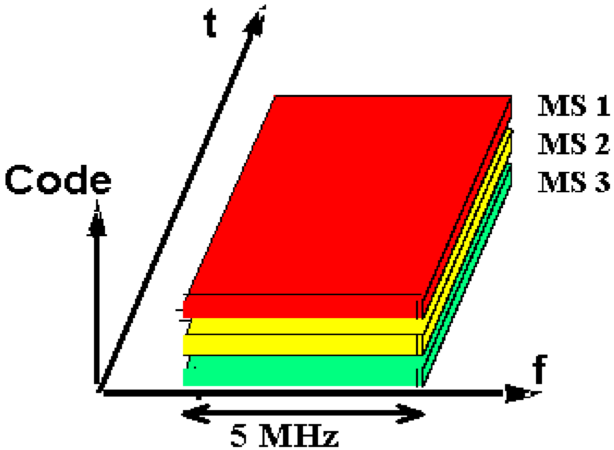
Traffic channels: different time slots are allocated to different users, for example, DAMPS and GSM

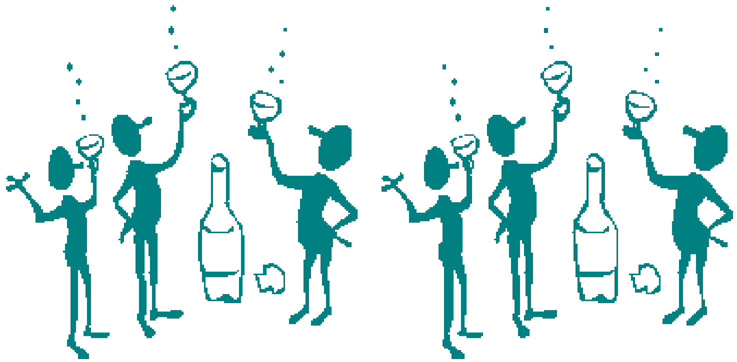
CODE DIVISION MULTIPLE ACCESS (CDMA)

In CDMA, all subscribers share the same frequency at the same time within a cell, so there is a need to distinguish between the different calls or sessions. The information for each user is spread across the spectrum band using a unique code. Spreading
means that the information is multiplied by codes.

- Separate users through different codes
- Large bandwidth
- Continuous transmission and reception

- IS-95 (1.25 MHz)
- CDMA2000 (3.75 MHz)
- WCDMA (5 MHz)





WCDMA Frequency Band

WCDMA was chosen as the technology for UMTS public, wide-area service, on the paired FDD bands:

1920 - 1980 MHz (uplink)
2110 - 2170 MHz (downlink)

TD/CDMA was chosen for private, indoor services in the unpaired TDD band:

1900 - 1920 MHz
2010 - 2025 MHz

(1) The WCDMA technology can also be deployed in existing frequency bands, e.g. 900, 1800 and 1900 MHz
Fit into 2*5 MHz spectrum allocations.

(2) The two modes have harmonized parameters.

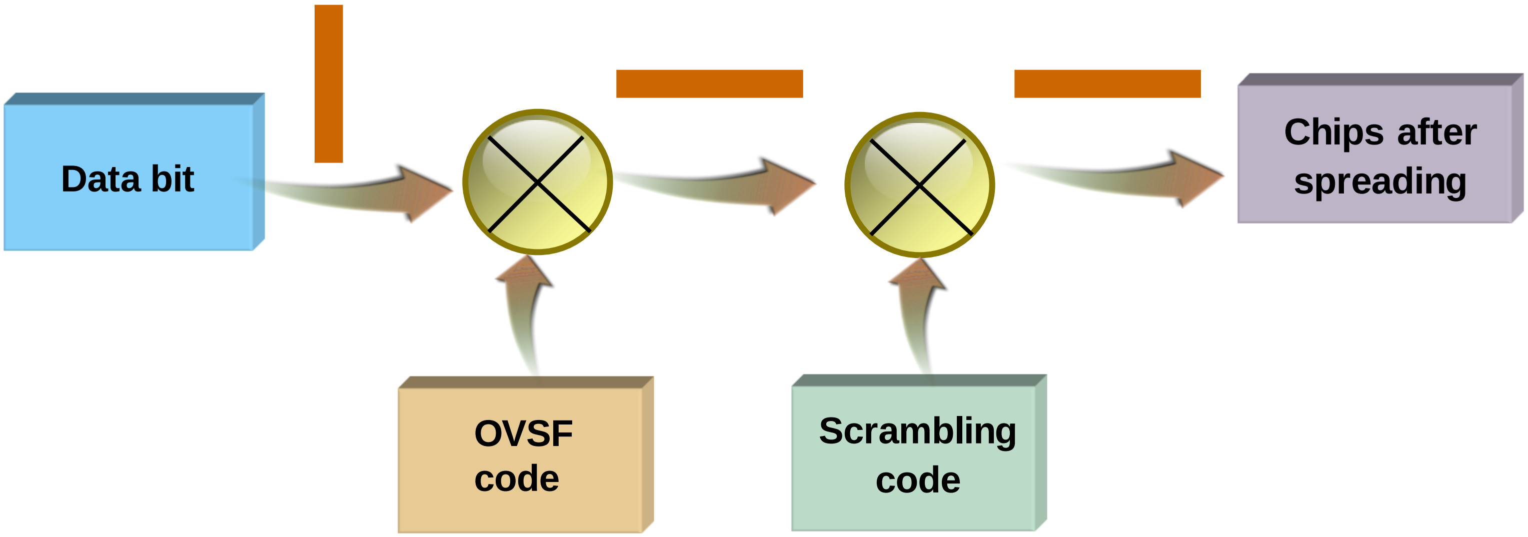
Spreading Technology

SPREADING CODE GROUPS

WCDMA uses different types of codes, which can be divided into two main groups:

- Channelization Codes
- Scrambling Codes (Pseudo Noise Codes)

Coding of the subscriber information is achieved by "multiplying" the transmitted information with Channelization and Scrambling codes.



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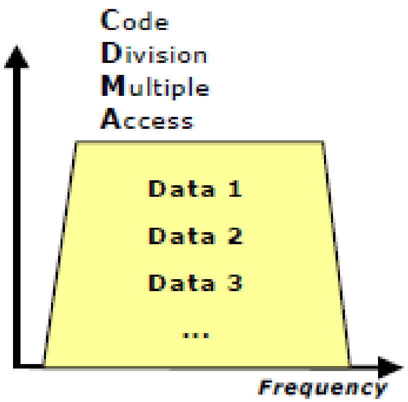
Channelization Code



Each Data Stream has a unique Channelization Code

Many users share the same frequency *and* time

IS-95, cdma2000, WCDMA

- WCDMA allows multiple data streams to be sent on the same RF carrier
  - Perfect isolation between data streams
  - Timing between data streams must be exact
  - Maximum number of data channels = Channelization code length
    - The longer the code, the slower the data rate
- WCDMA advantages are limited in practice
  - Multipath, small timing errors, and motion-related effects diminish the usable code space

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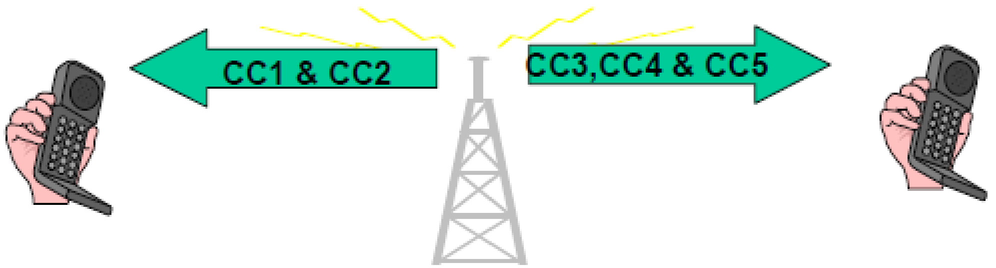
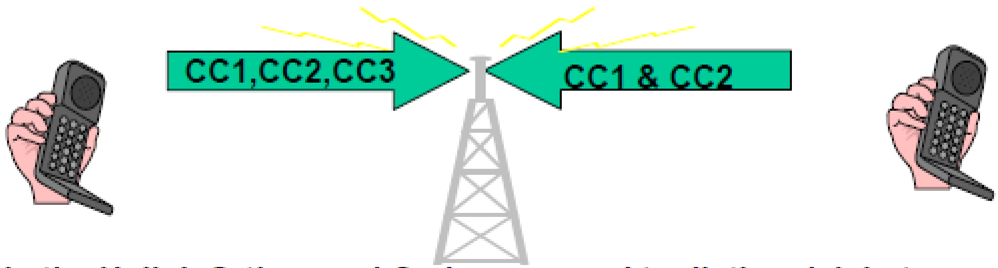
Channelization Code

Channelization codes, often referred to as the Orthogonal Variable Spreading Factor (OVSF) codes are used for channel separation of transmission from one transmitter (UE/BS).



In the Downlink Orthogonal Codes are used to distinguish between data channels from the same Base Station



In the Uplink Orthogonal Codes are used to distinguish between data channels from the same mobile

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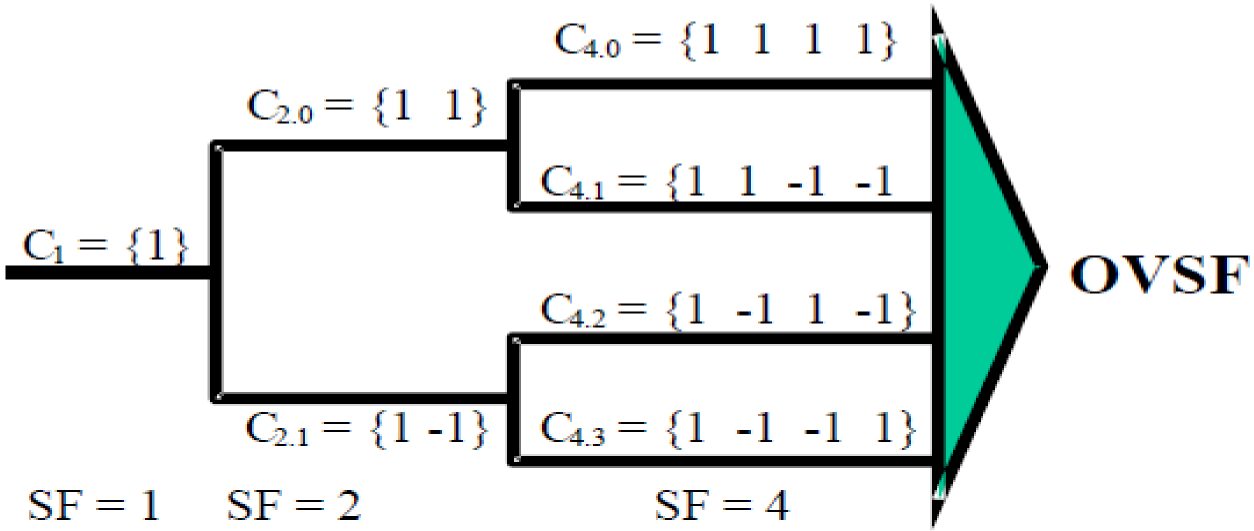
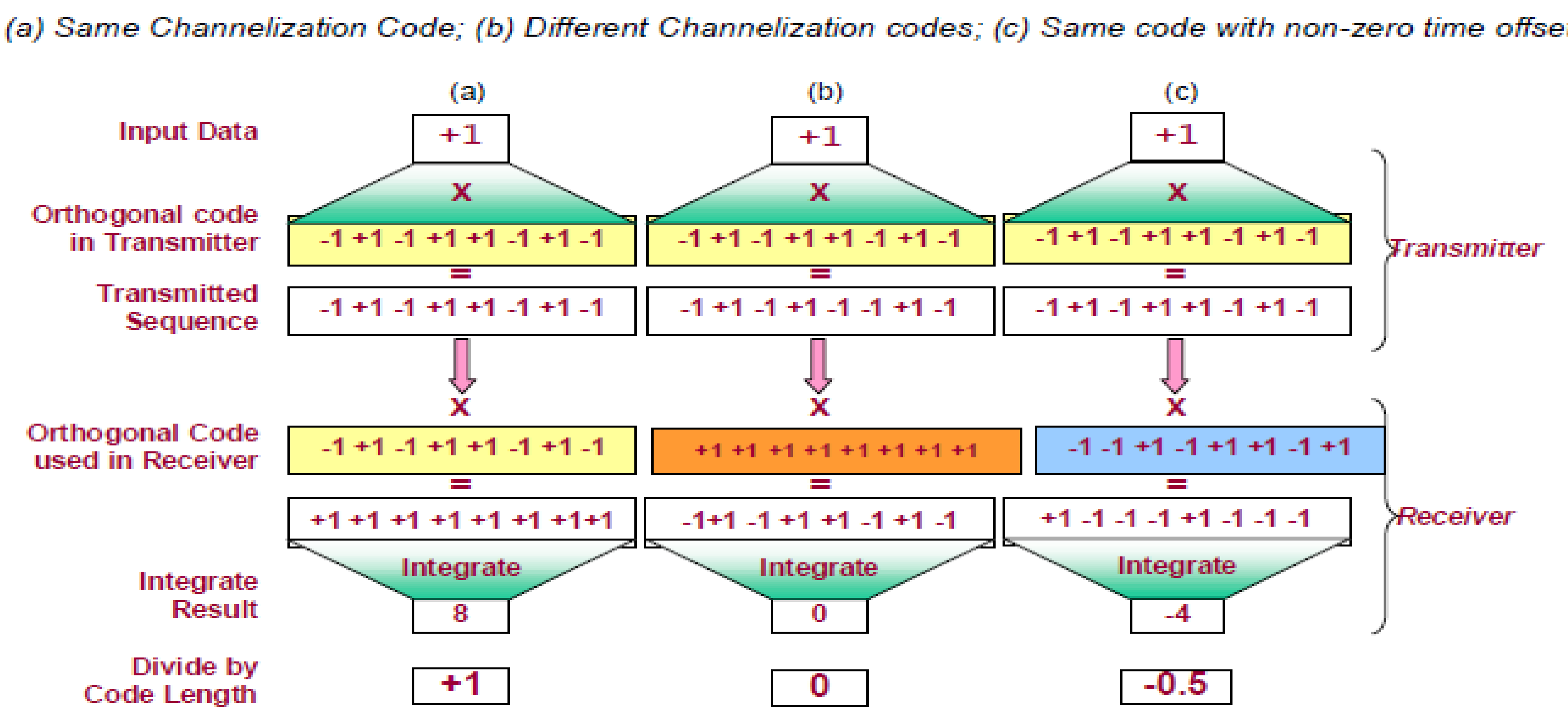
Channelization Code



- Channelization codes of different length, depending of the bit rate
- Ensures orthogonality even with different rates and spreading factors.

Code correlation using Channelization Codes (1/2)



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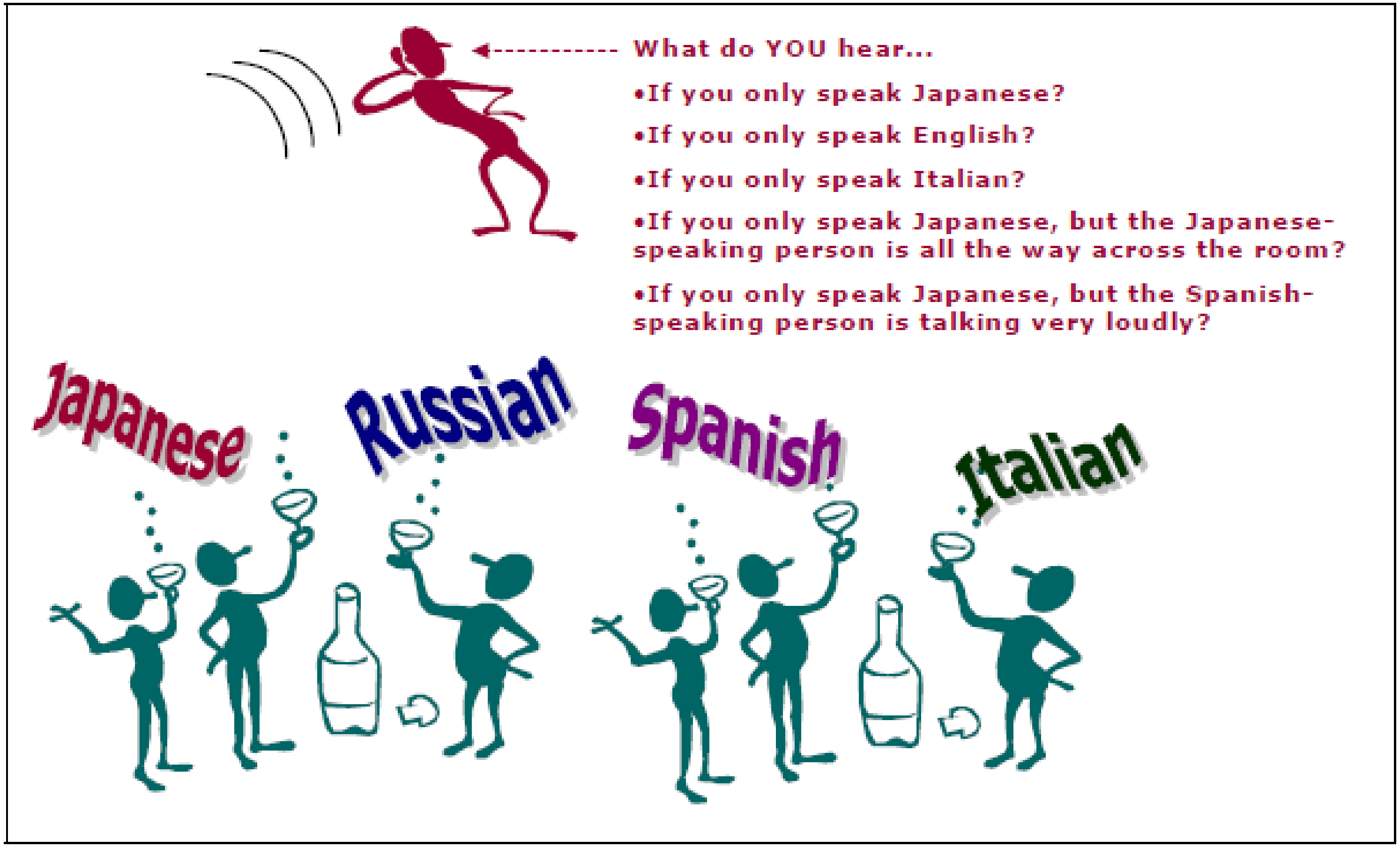
Code correlation using Channelization Codes (2/2)

In the first scenario (a), the same channelization code is used in both the receiver and the transmitter (autocorrelation). This results in a maximum correlation result (100%) and the same information that was sent is received.

In the second scenario (b), different channelization codes are used (cross correlation). Because of the orthogonal properties this results in minimum correlation or zero output.

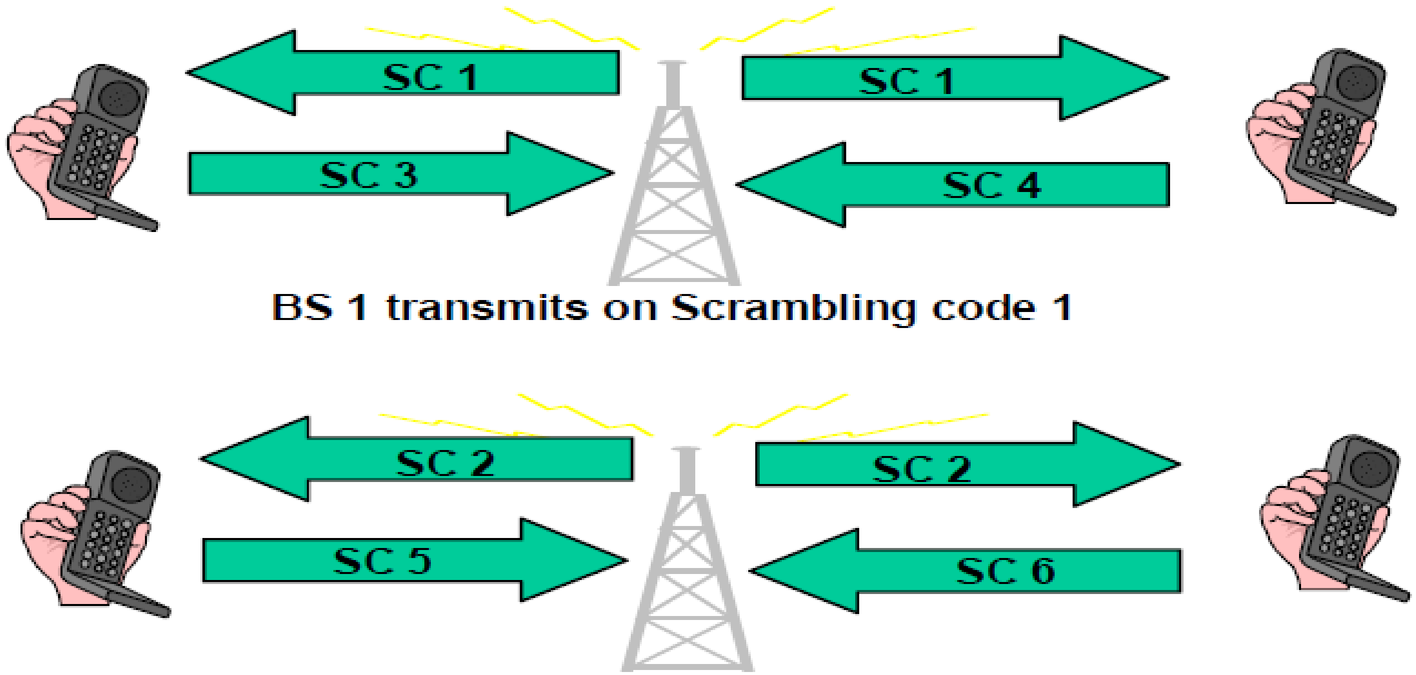
In the third scenario (c), the same channelization code is used, but time shifted. Here it can be seen that these codes are sensitive to time shift and the result is unpredictable. It is therefore necessary to have perfect synchronization of the codes.

Scrambling Code

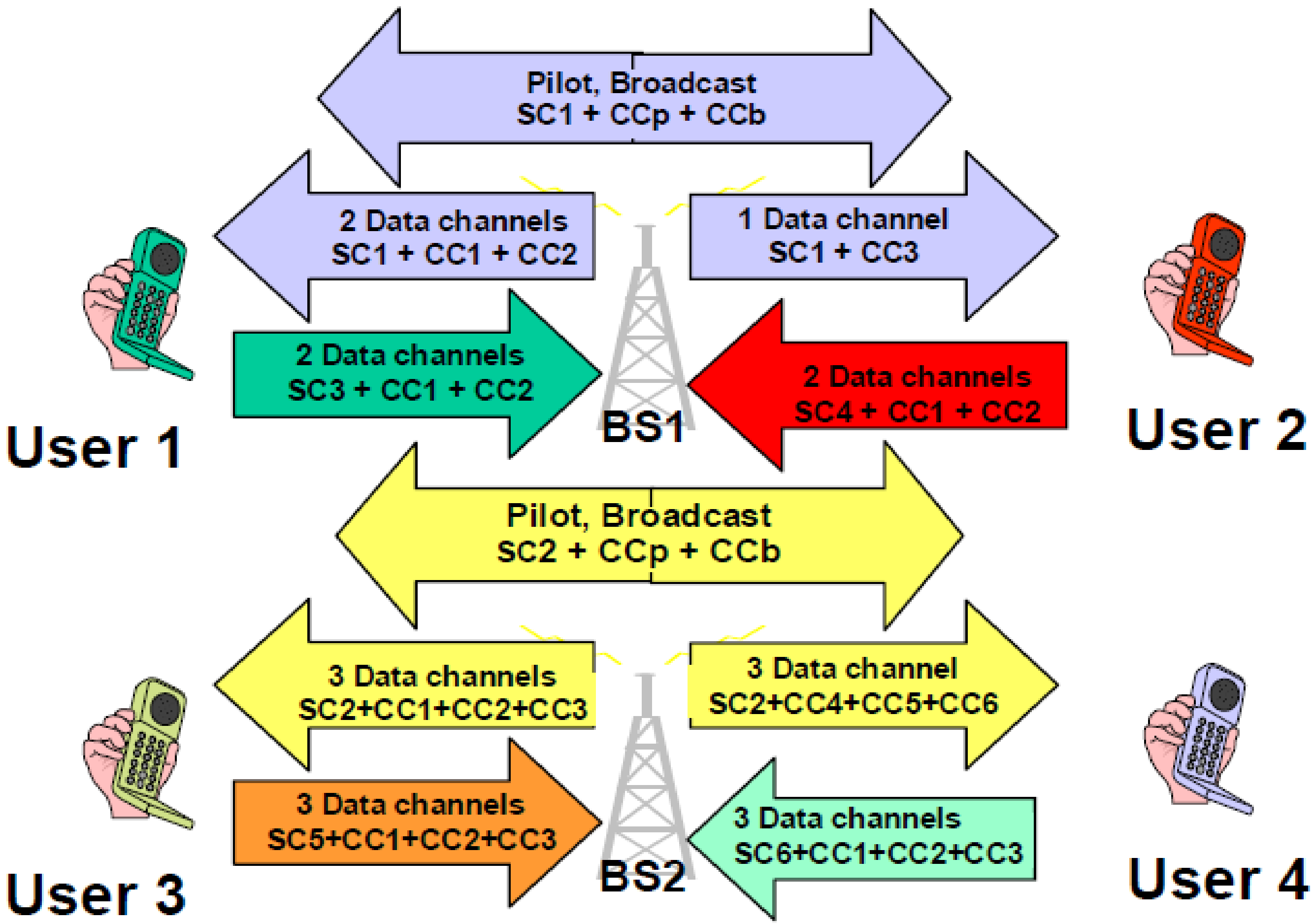


Scrambling Code

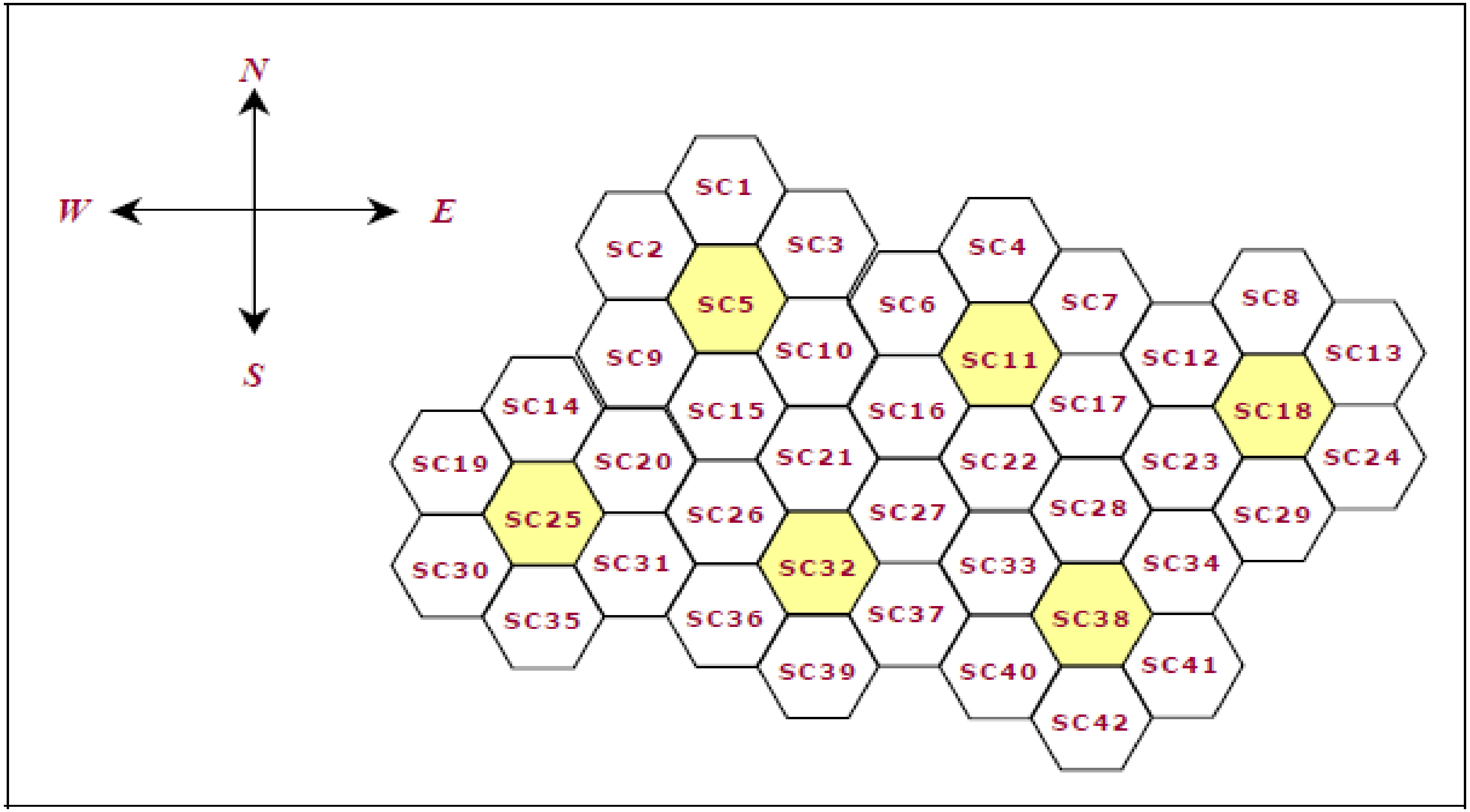
After the channelization codes, the data stream is multiplied by a code from a group of special binary codes, to distinguish between different transmitters. The code gives a unique UE/ BS identity. The process is referred to as 'scrambling' and the codes are usually called 'scrambling codes'. These codes are also called Pseudo Noise (PN) codes due to their properties or sometimes referred to as Gold Codes due to the means of generating them.



Spreading Technology

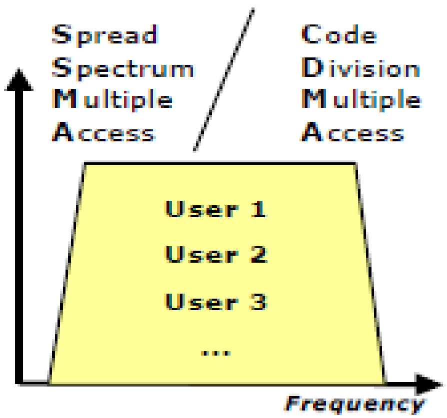


Scrambling Code Planning



The number of codes used in the downlink is restricted to 8192 in total. 512 of these are primary codes (the rest are secondary codes, 15 codes per primary) divided into 64 code groups each group containing 8 different codes.

Channelization Code And Scrambling Code Summary



Scrambling Codes

and

Channelization Codes

are simultaneously utilized

- - Scrambling Codes are used:
  - To distinguish between User Equipments in uplink
  - To distinguish between cells
- Channelization Codes are used:
  - To distinguish between data channels coming from each User Equipment
  - To distinguish between data channels from each cell

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Classification of Handover

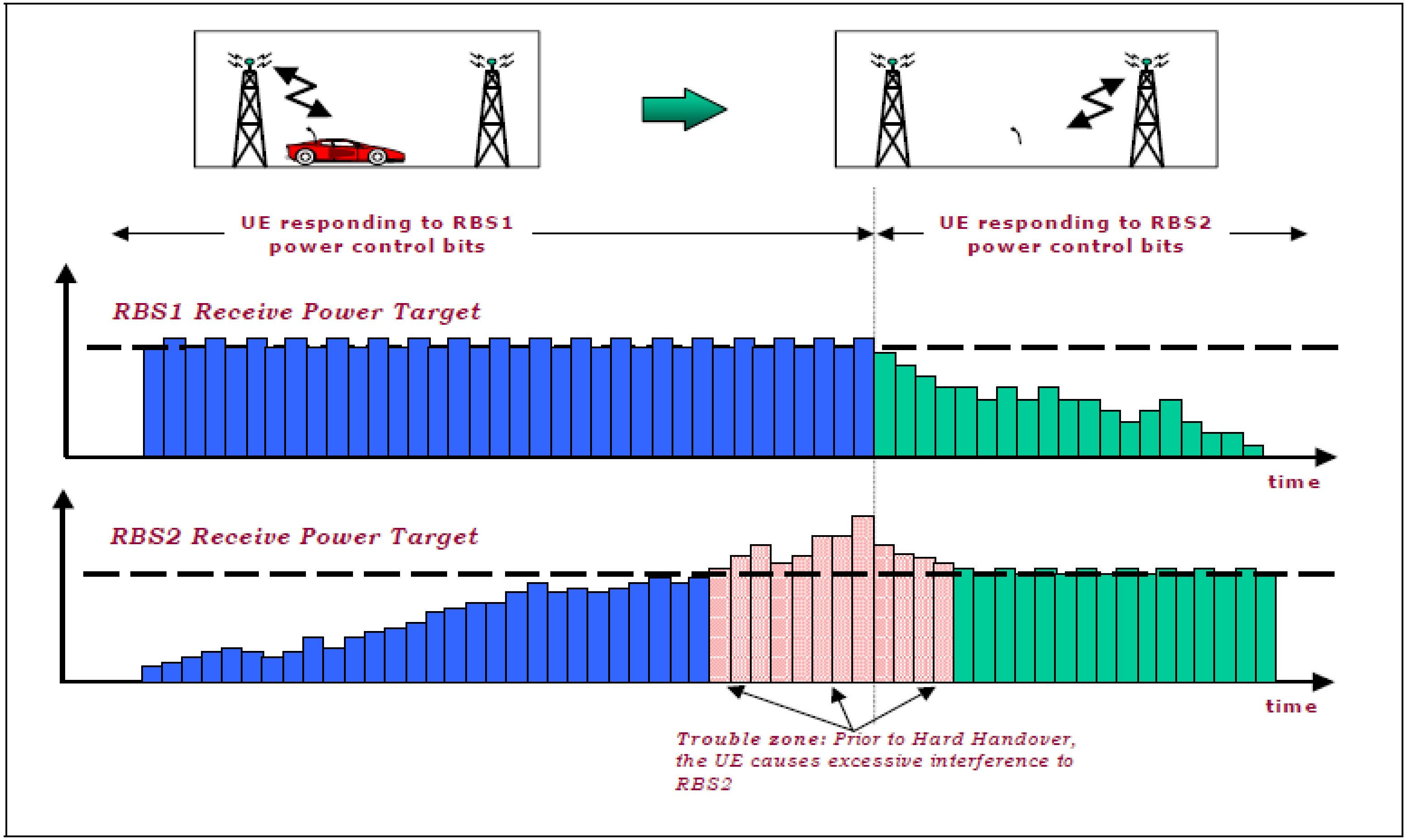
Hard handover

- Intra-frequency hard handover
- Inter-frequency hard handover
- Inter-system handover

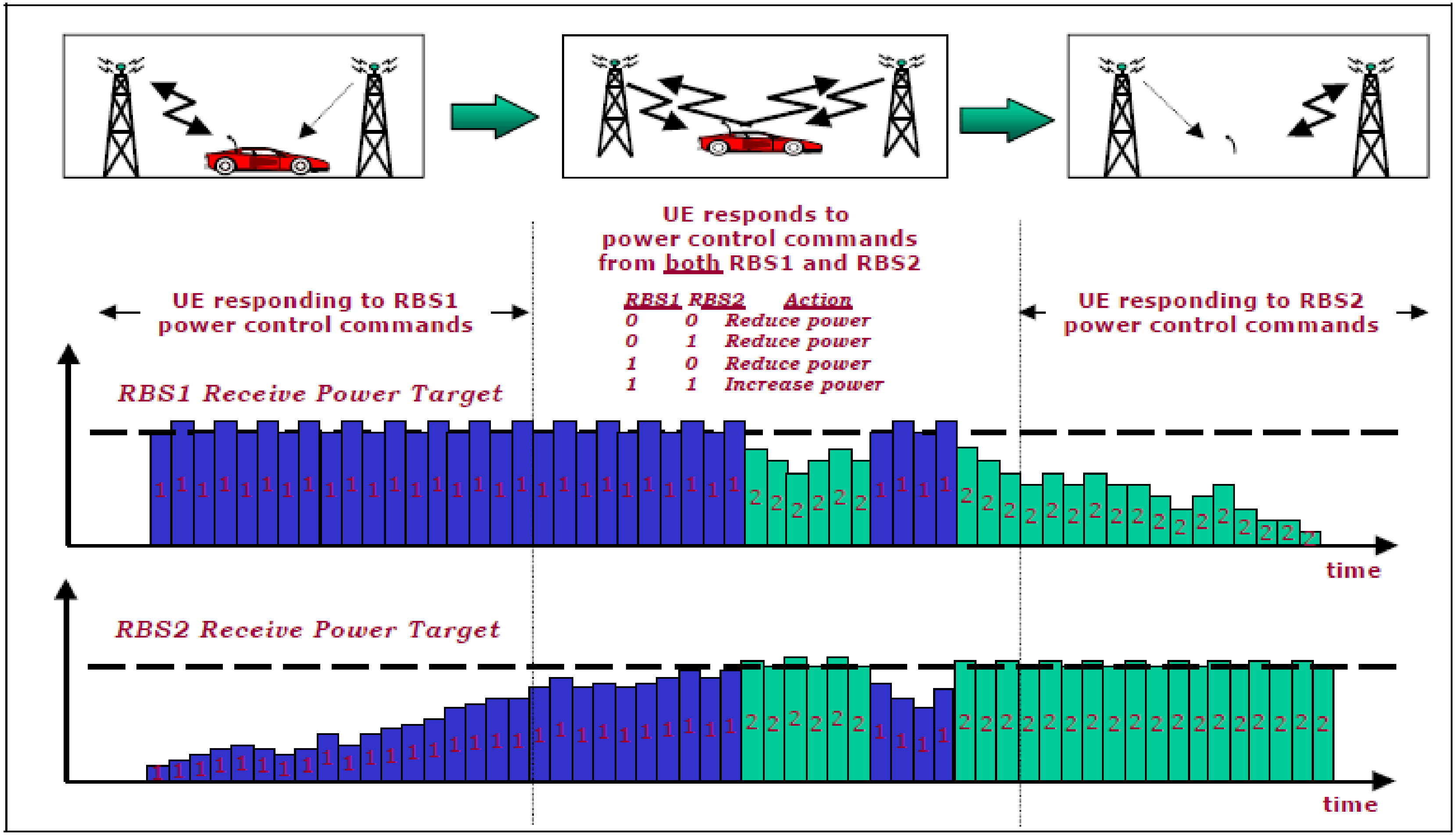
Soft handover

Softer handover

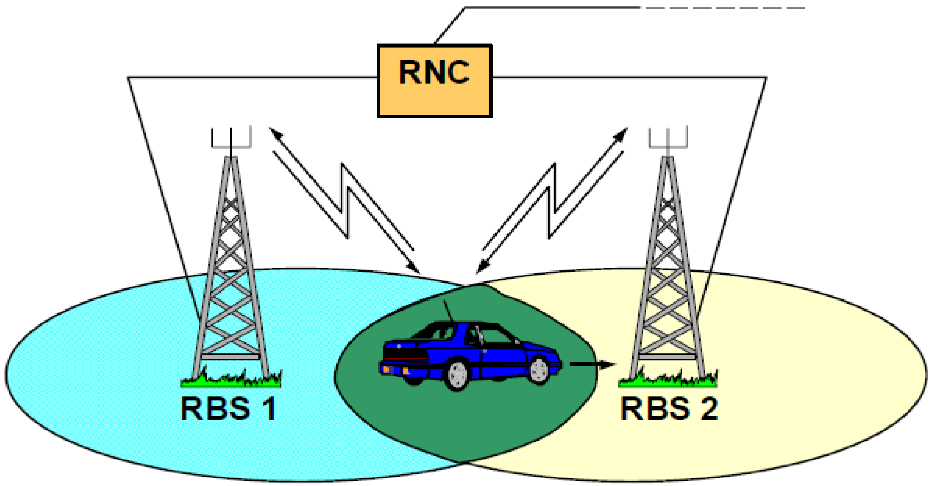
WCDMA without Soft Handover



WCDMA with Soft Handover

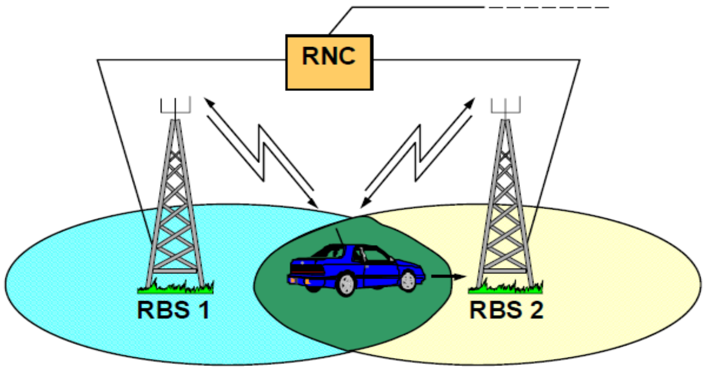


Soft Handover



- Features of soft handover
  - ⇨ Seamless handover with no disconnection of the radio access bearer.
  - ⇨ To enable a sufficient reception level for maintaining communications by combining the received signal at symbol level from multiple cells in case the UE moves to the cell boundary areas.
  - ⇨ The macro diversity gain achieved by combining the received signal in the NODEB (softer handover) or in the RNC (SHO) improves the uplink signal quality and thus decrease the required transmission power of the UE.

Softer Handover

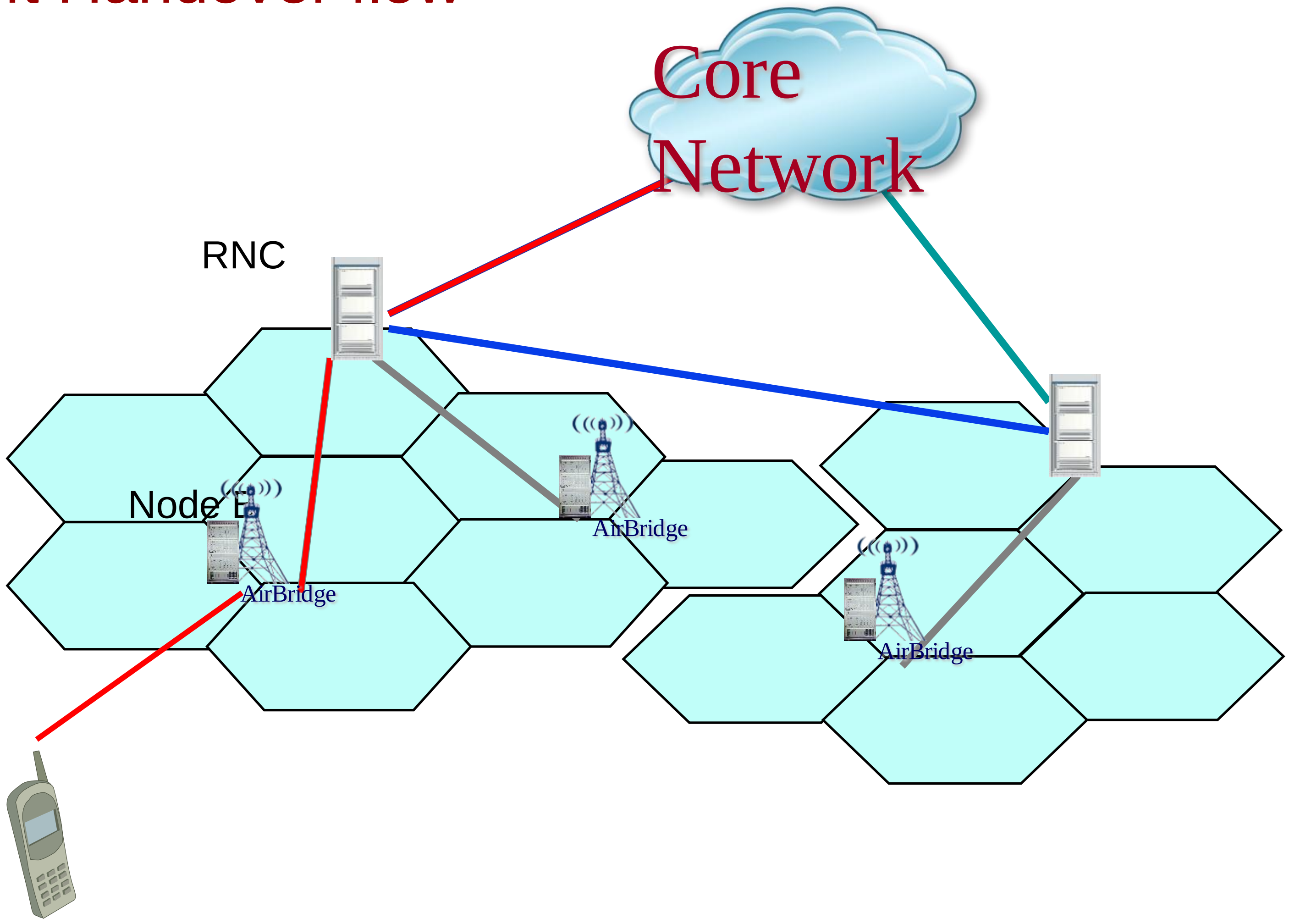


- For soft handover, the combination of multiple RL uses maximum ratio combination (RAKE combination) in downlink and selection combination in uplink.
- When the two cells in soft handover belong to the same NodeB, maximum ratio combination could be used in uplink. In this case the handover is softer handover.
- Softer handover has higher priority in handover schemes because maximum ratio combination has larger gain than selection combination.

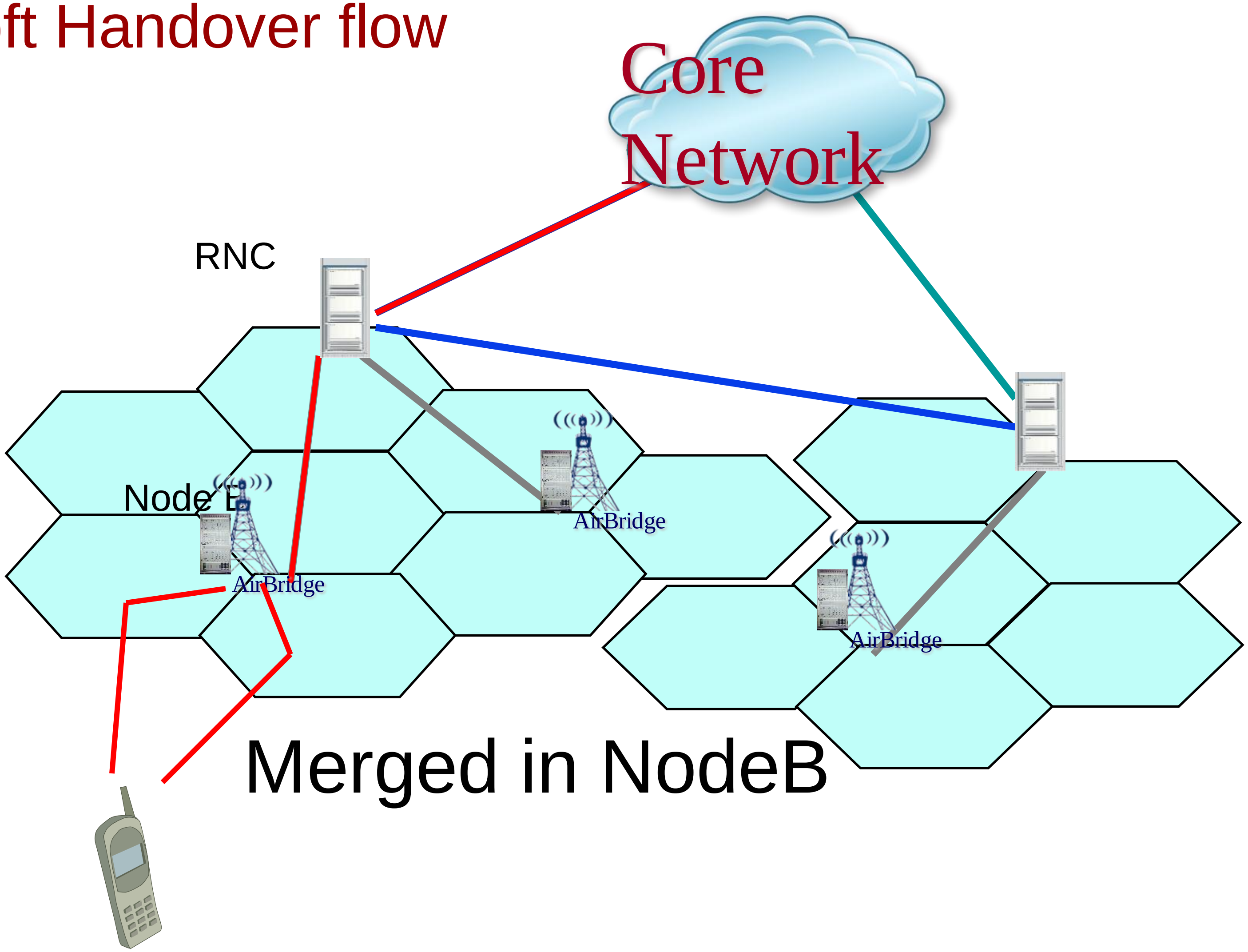
Soft Handover Measurement

- Active set
  - ⇨ Including all cells currently participating in a SHO connection of a terminal.
- Neighbor Set/Monitored Set
  - ⇨ This set includes all cells being continuously monitored/measured by the UE and which are not currently included in the active set.

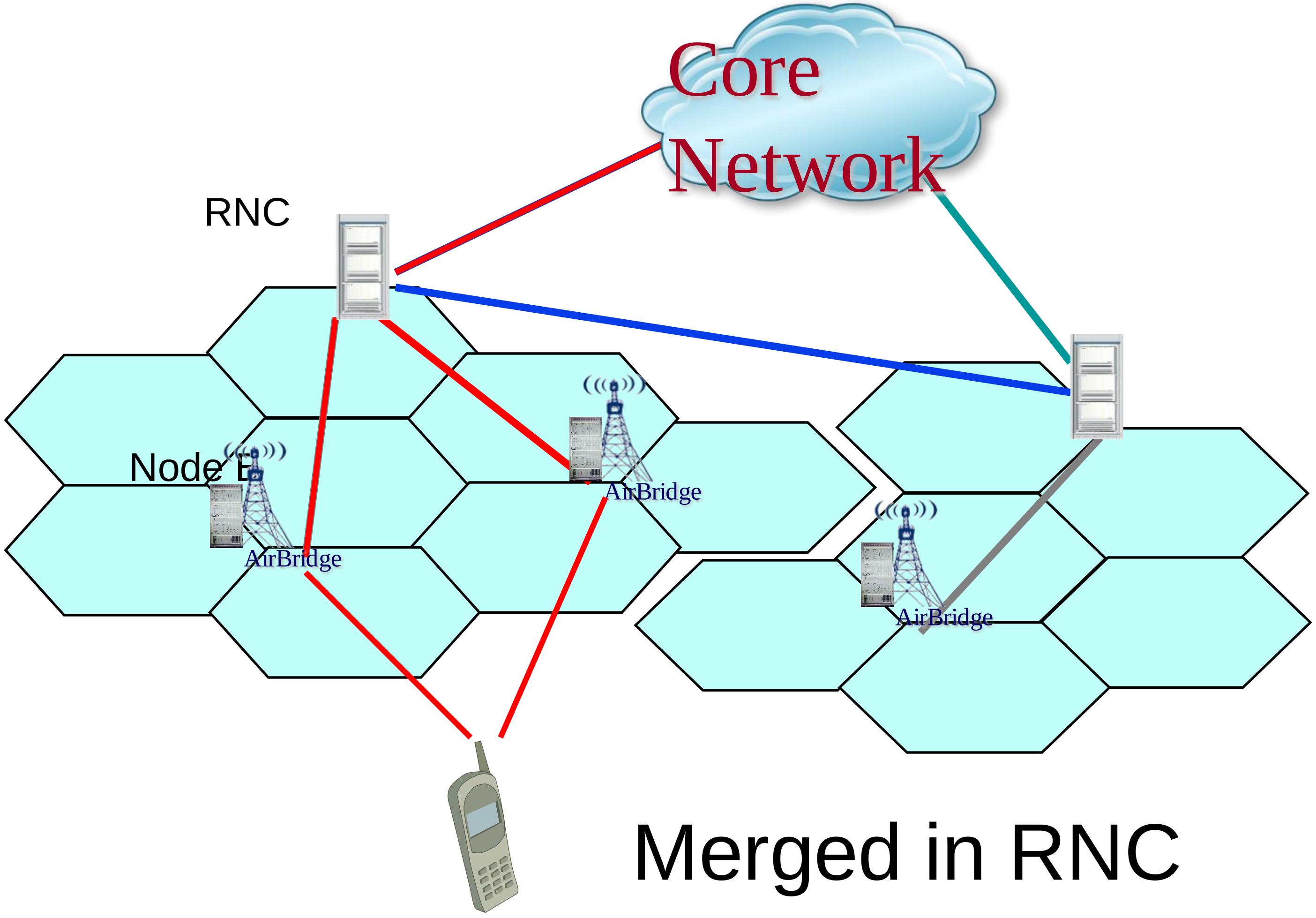
Soft Handover flow



Soft Handover flow

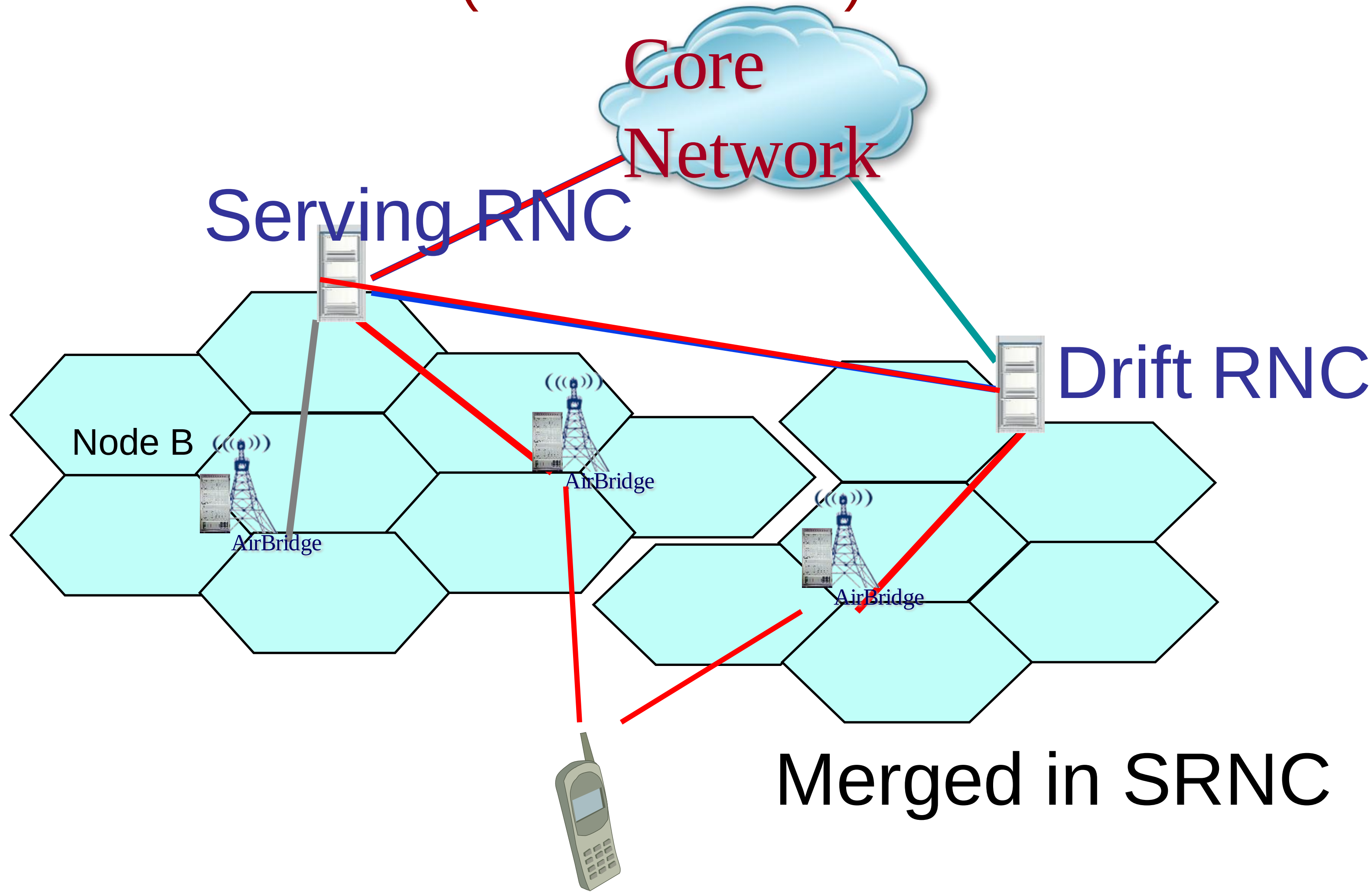


Soft Handover flow

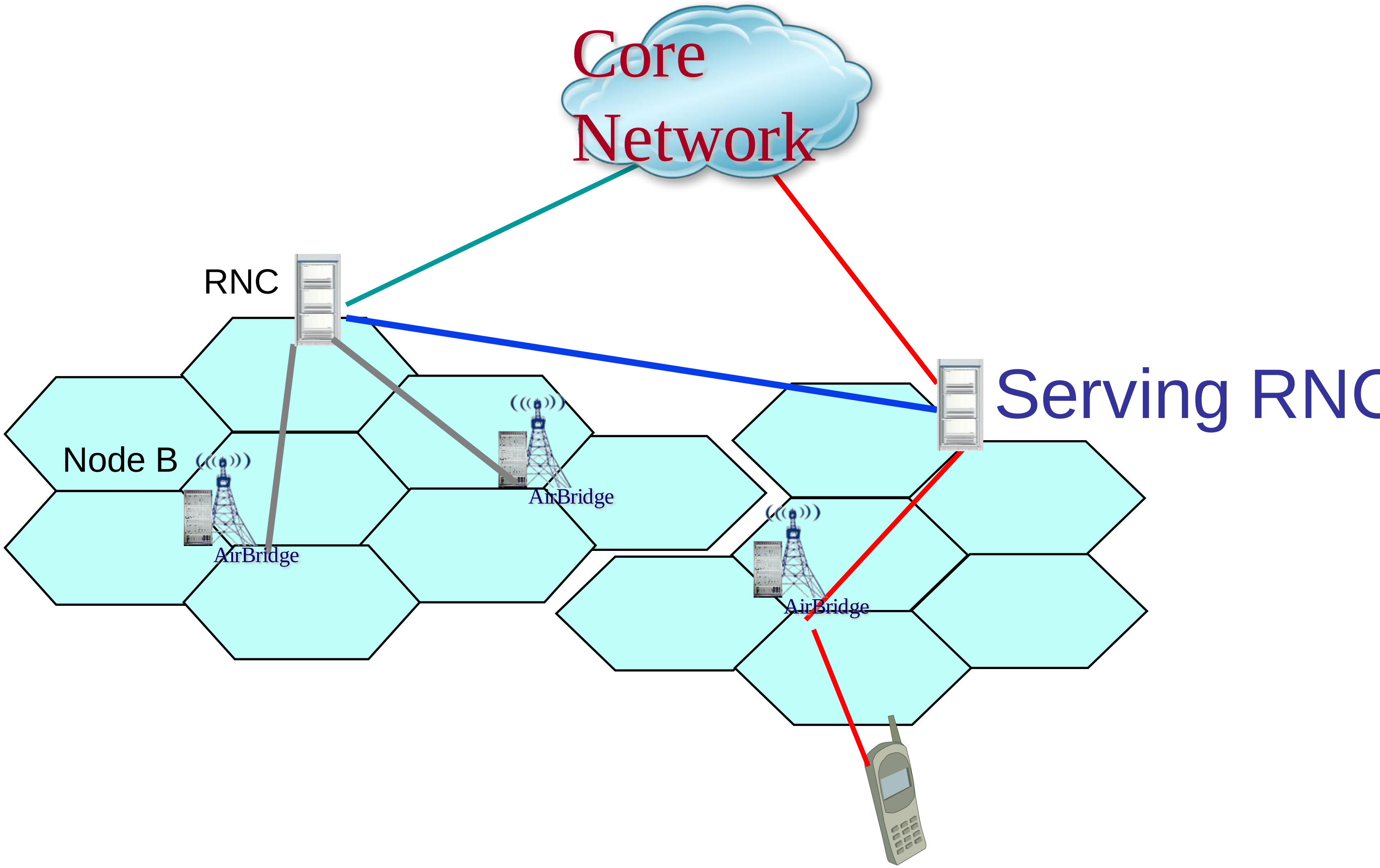


Merged in RNC

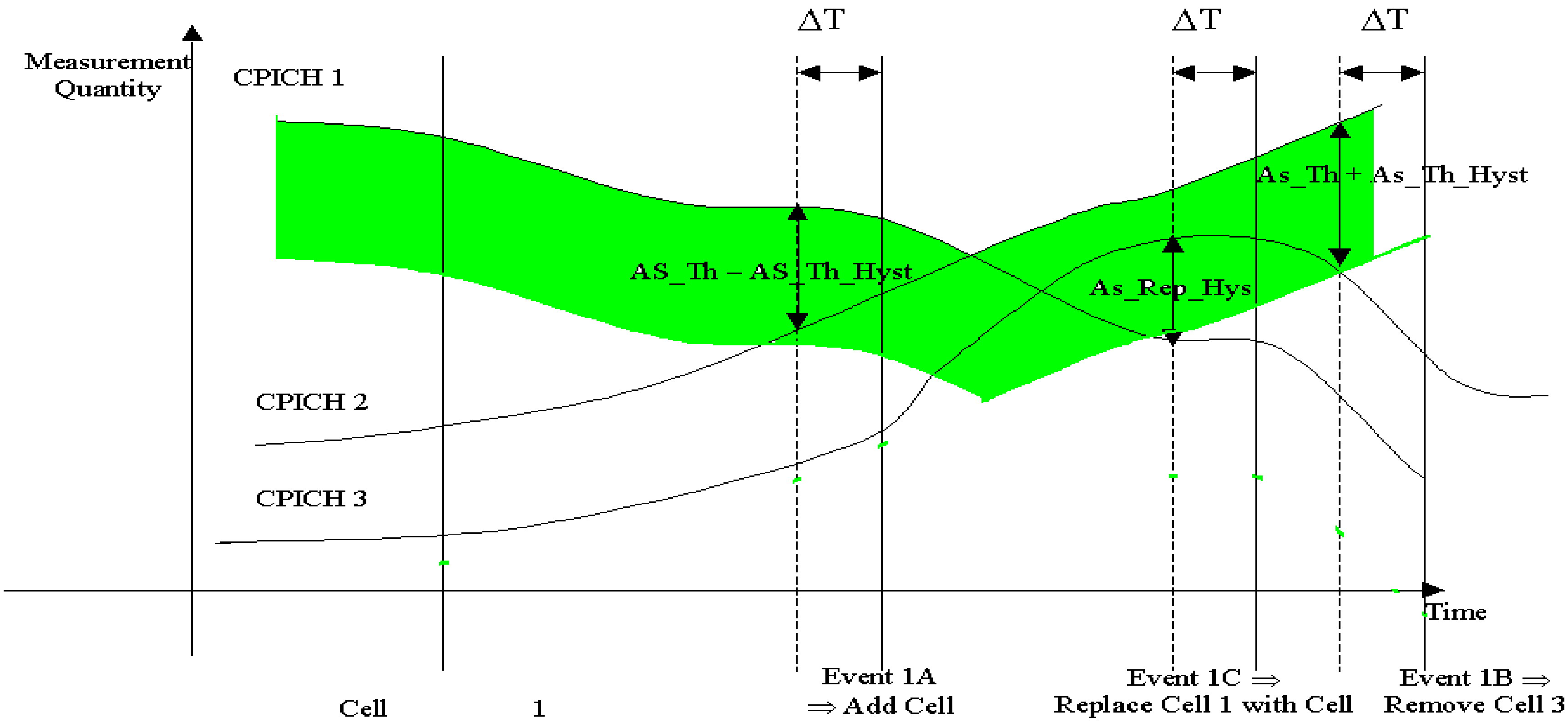
Soft Handover flow (SRNC-DRNC)



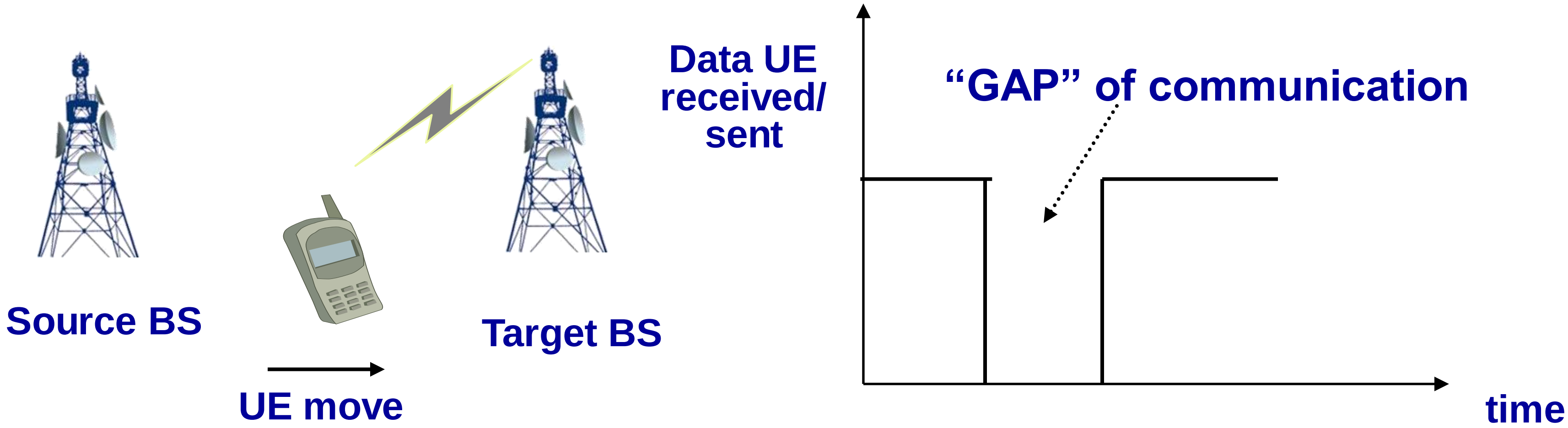
Soft Handover flow (SRN Relocation)



Soft Handover Measurement



Hard Handover

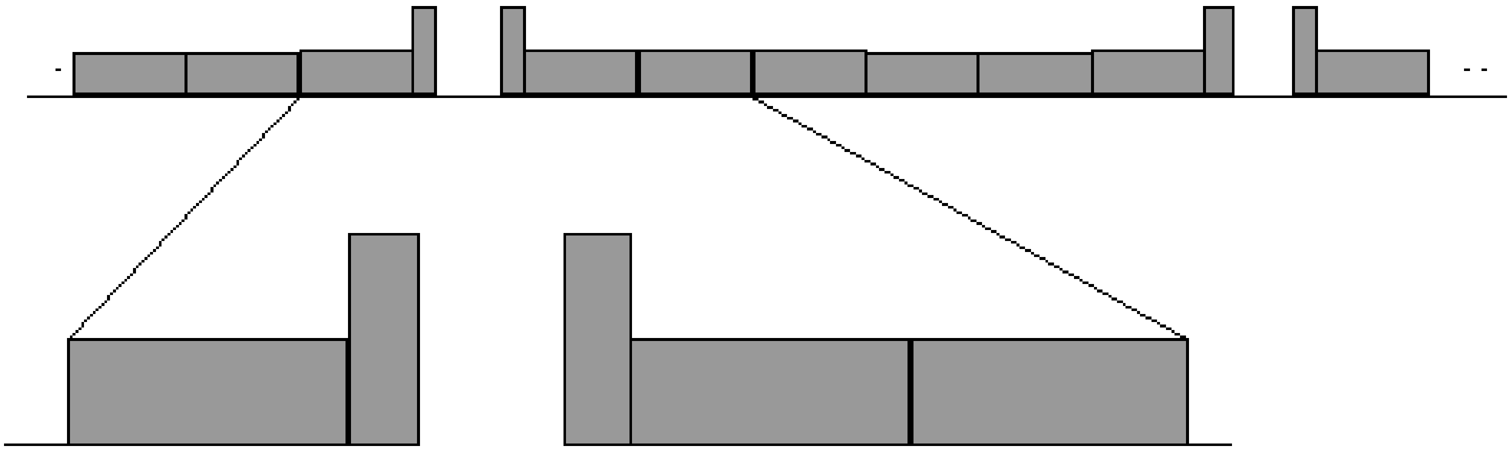


- Features of hard handover:
  - ⇨ HHO causes a temporary disconnection for radio access bearer and is lossless for NRT bearers.
  - ⇨ The UE must either be equipped with a second receiver or support compressed mode to execute inter-system/inter-system measurement.
  - ⇨ CM is to stop the normal transmission and reception for a certain period of time, enable the UE to measure on the other frequency.

Introduction of Compressed Mode

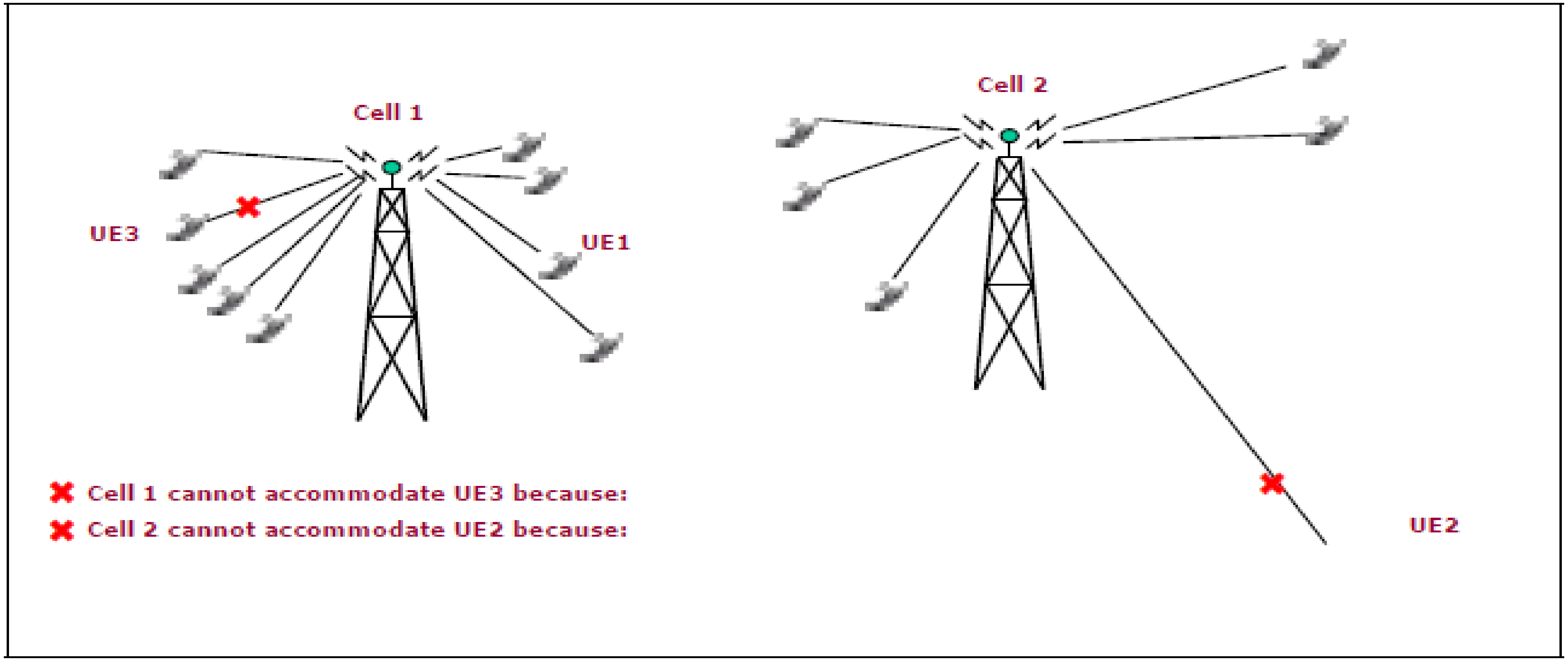
- Compressed Mode
  - ⇨ Intra-frequency neighbors can be measured simultaneously with normal transmission by UE using a RAKE receiver.
  - ⇨ Inter-frequency or inter-system neighbors measurements require the UE measuring on a different frequency, this has either to be done with multiple receivers in the UE or in the compressed mode.
  - ⇨ CM is to stop the normal transmission and reception for a certain period of time, enable the UE to measure on the other frequency.

Compressed Mode



Objective of compressed mode: for UE to realize measurement and synchronization to target cell when inter-frequency handover and inter-system handover is required.

Capacity Limitation (1/2)



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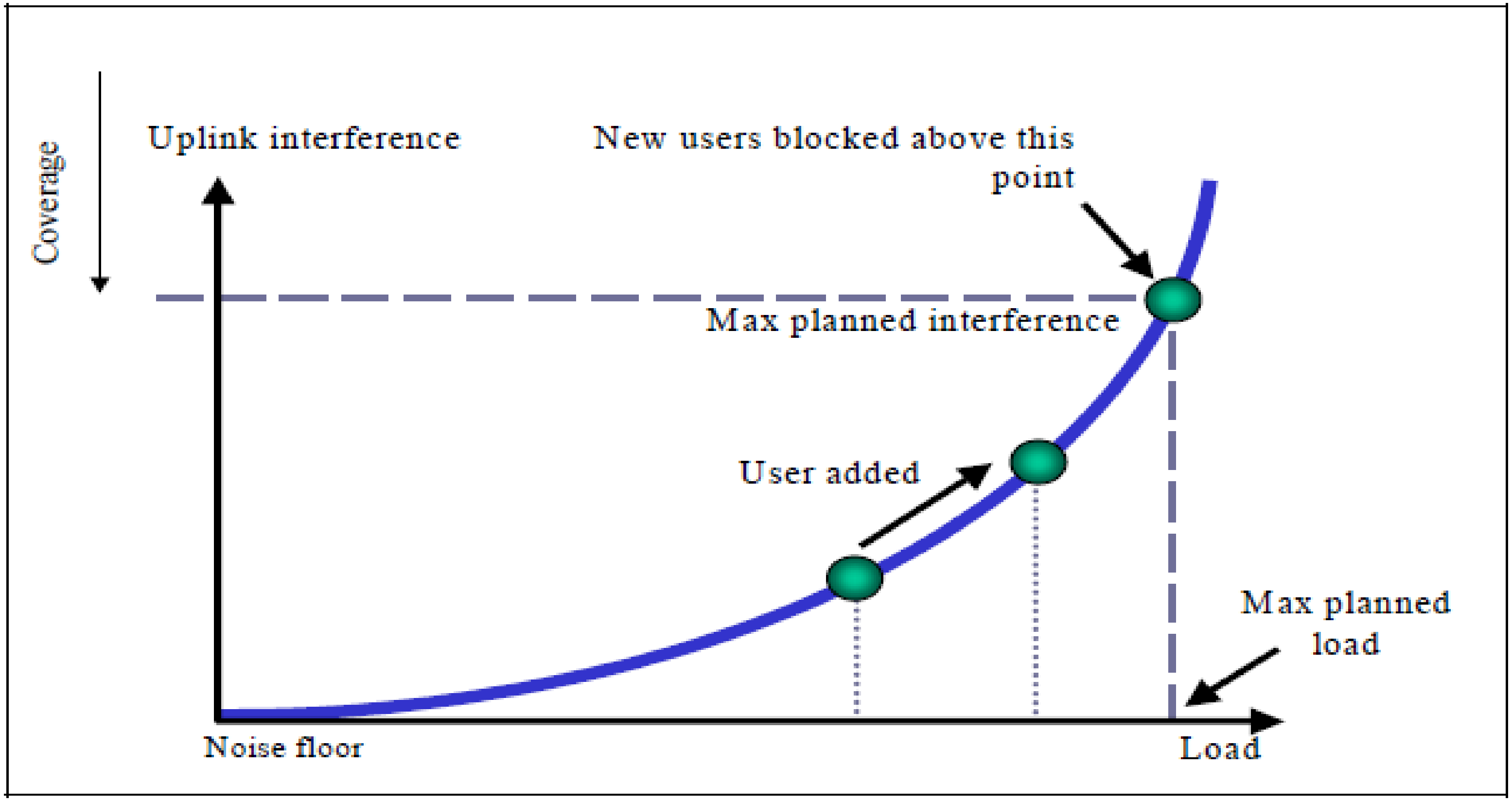
Capacity Limitation (2/2)

In the first scenario, cell 1 cannot accommodate UE3 because the increase in interference in the uplink by adding this connection would be too great and there would be a high risk of dropping a user. In this example the uplink interference has limited the capacity of the cell.

In the second scenario we can see that Cell 2 cannot accommodate UE2 because it is using all its available power resources to maintain the connections to the other UEs. In other words, the base station has not enough power left to achieve the required signal strength (C/I) required by UE2. Another way to understand this is to imagine that the base station has a total power output of 20 W. It allocates 5 W to broadcasting common channels and leaves 15 W available for traffic. In this instance it requires 2 W for each of the 5 ongoing connections and so has no power available to accommodate UE2. In this example the capacity is limited by the downlink.

Admission Control



The purpose of Admission Control is to selectively deny access request in order to limit the load, and so avoids excessive triggering of congestion control.

Admission Control (AC)

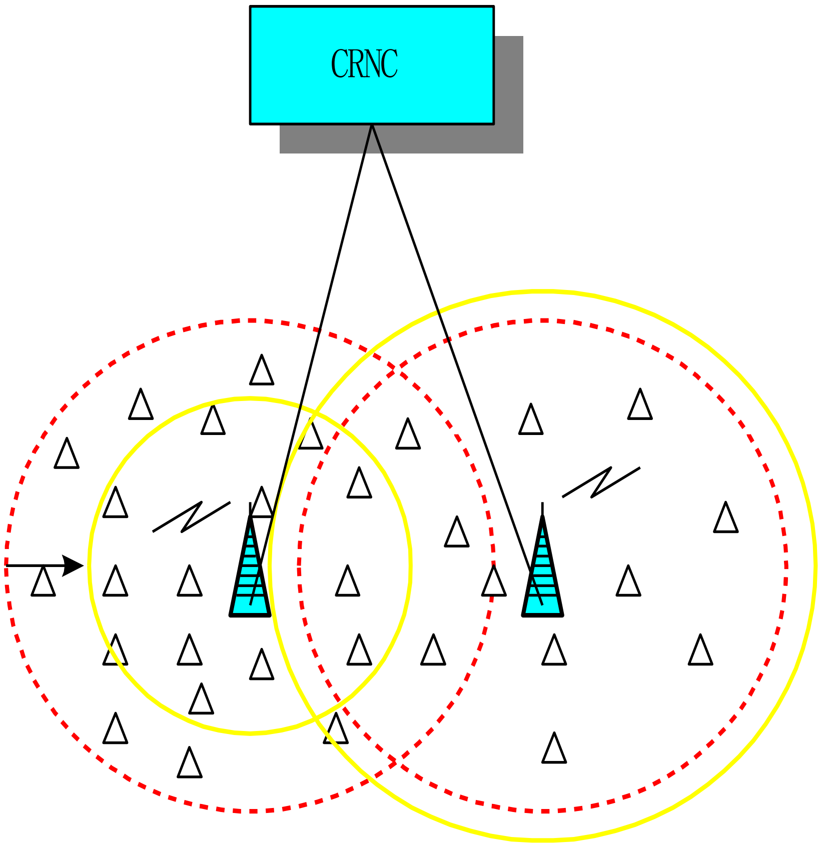
- AC is used to decide whether a new RAB is admitted or a current RAB can be modified.
- Admission control is done in uplink and downlink separately.
- The strategy is that a new bearer is admitted only if the total load after admittance stays below the threshold defined by RNP.

Load Balance

- Load balance between cells
  - ⇨ Load balance between intra-frequency cells
    - − Cell breathing
  - ⇨ Load balance between inter-frequency cells
    - − Inter-frequency load balance

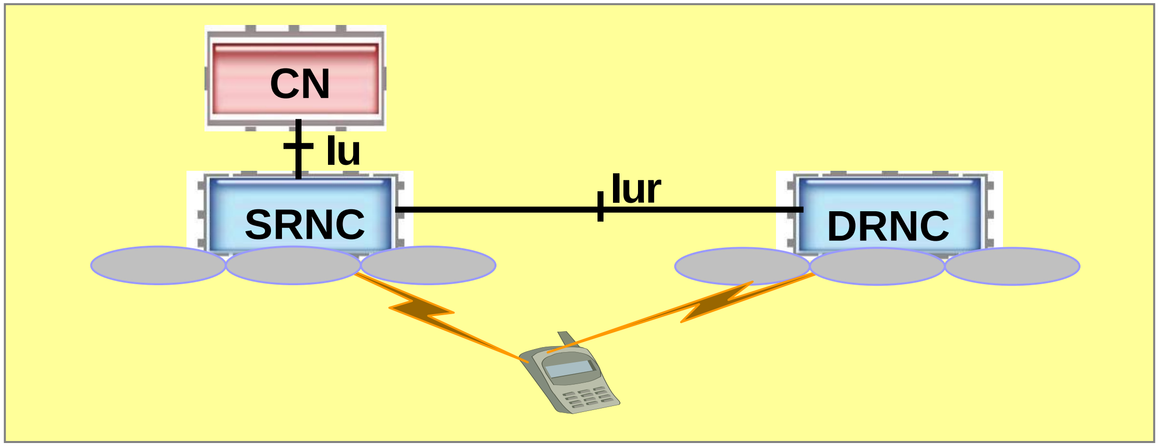
Cell Breathing

The objective of load banlance is to share the load of some "hot" cells in surrounding cells with low load, thus to increase the usage of system capacity.



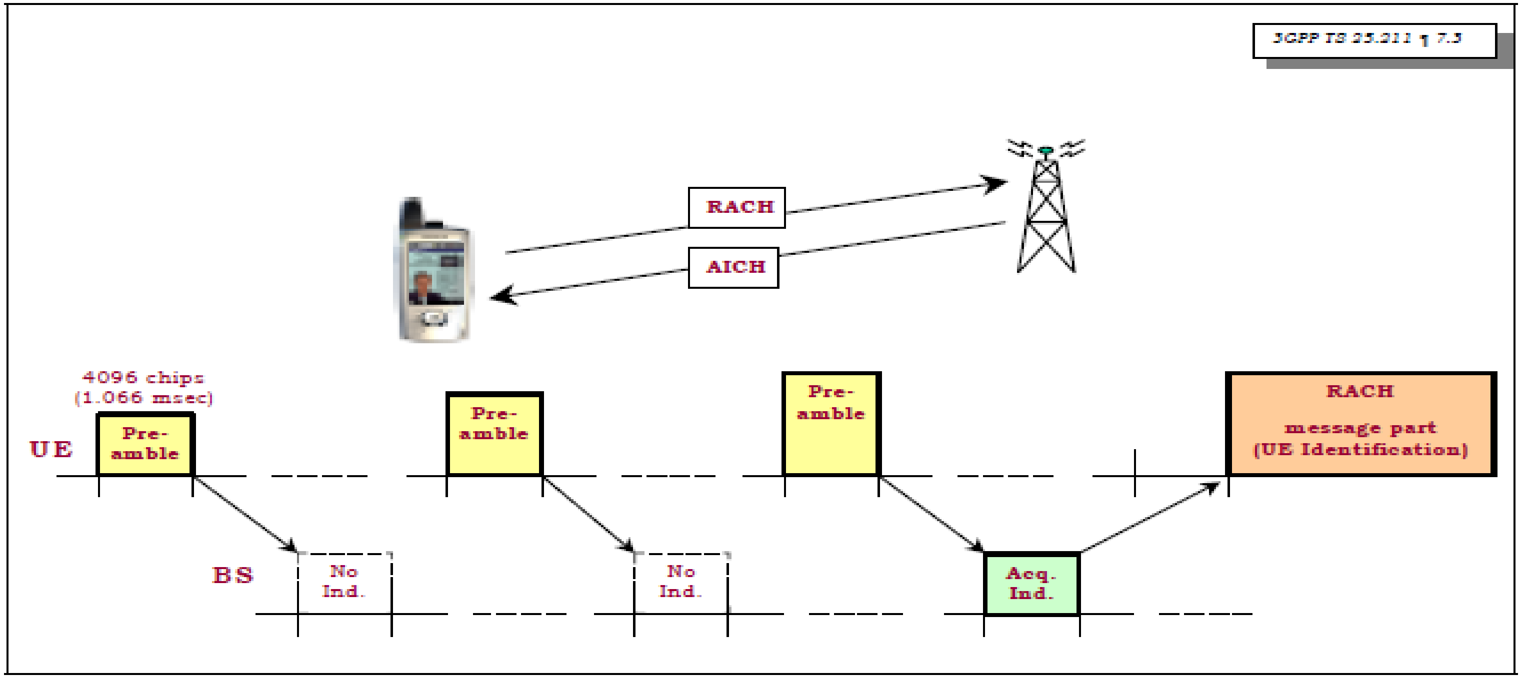
cell breathing

SRNC/DRNC



- SRNC and DRNC are on a per connection basis between a UE and the UTRAN
- The SRNC handles the connection to one UE, and may borrow radio resources of a certain cell from the DRNC
- Drift RNSs support the Serving RNS by providing radio resources
- A UE in connection state has at least one and only one SRNC, but can has 0 or multiple DRNCs

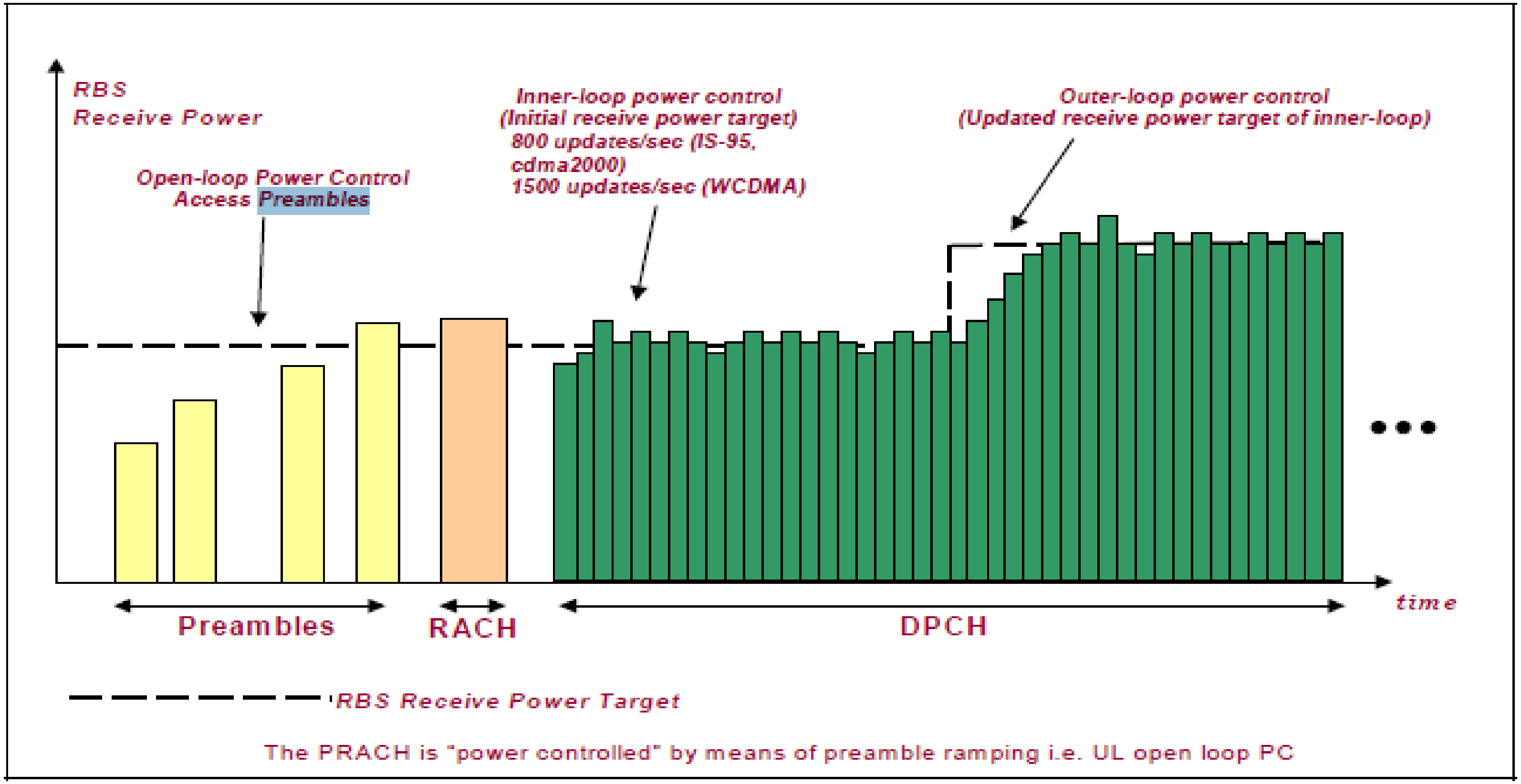
Random Access Procedure



Random access is a process where a UE requests access to the system, and the network answers the request and allocates a dedicated channel to the UE.

It is important to minimize the transmitted power during the random access because excessive power will degrade the WCDMA system capacity.

Power Control



Power control is necessary in any spread spectrum system to ensure that each user transmits and receives just about the right amount of power to maintain the connection quality while at the same time causing as little interference as possible to other users.

The output power of the UE is then adjusted at a rate of 1500 times per second.

Thank you

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