Curso Comunicaciones Móviles - 2017

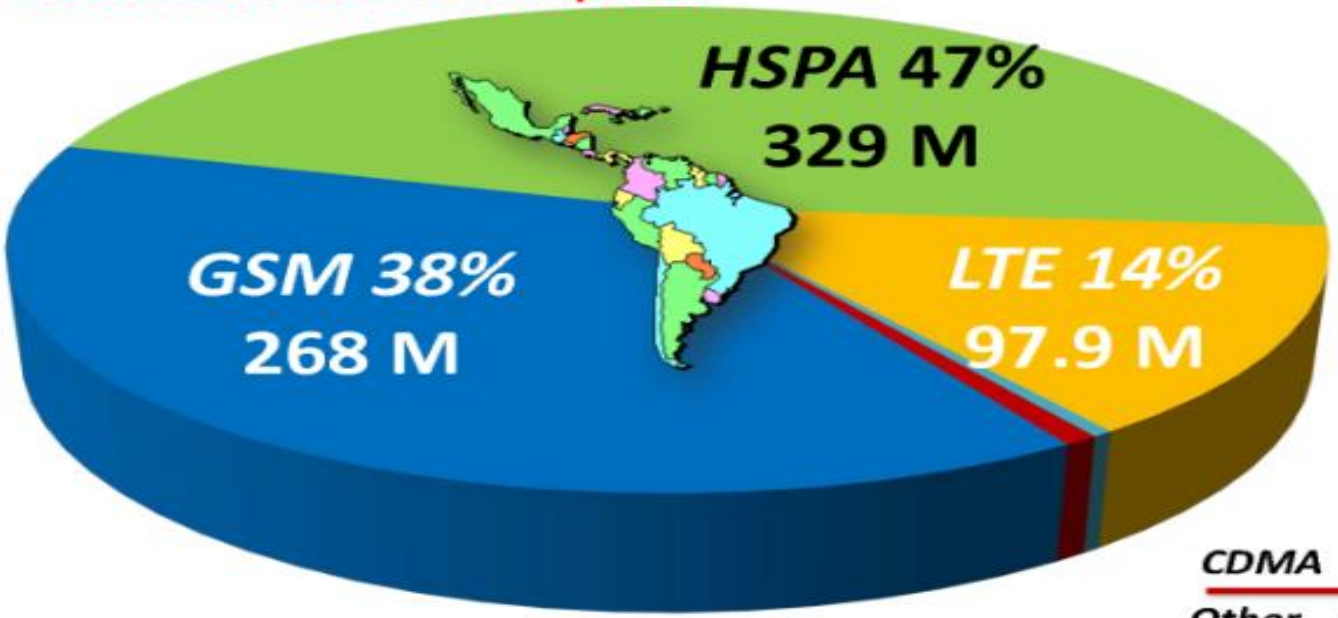
Sistemas de 3era Generación (UMTS/HSPA/HSPA+)

*Mg. David Ramirez de los Reyes_*

Latin America & Caribbean - Mobile Subscribers and Market Share by Technology

703 million total subscriptions

September 2016



CDMA > 1% 5 M

Other >.5% 3 M

Source: OVUM September 2016

5G americas
www.5gamericas.org

Sistemas de 3era Generación

3era. Generación Móvil Celular 2001

Sistemas de 3era Generación

Evolución celular…

- **1G FDMA (NMT, AMPS, TACS)** — 80's
  - Voice (analog traffic :)

- **2G TDMA (GSM, D-AMPS, PDC) and CDMA (IS-95)** — 90's
  - Voice, SMS, CS data transfer ~ 9.6 kbit/s (50 kbit/s HSCSD)

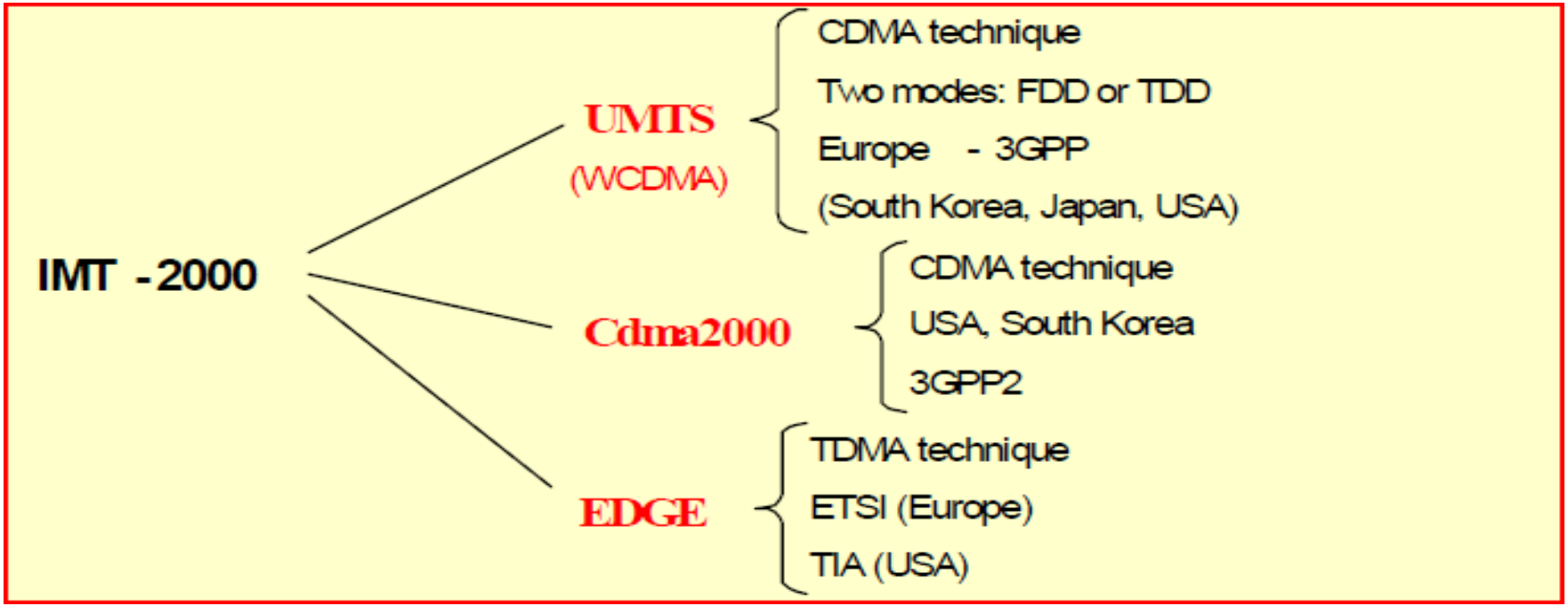
- **2.5G TDMA (GPRS)** — 00's
  - PS data transfer ~ 50 kbit/s

- **2.75G TDMA (GPRS+EDGE)** — 00's
  - PS data ~ 500kbit/s

- **3-3.5G WCDMA (UMTS) and CDMA 2000** — 00's
  - PS & CS data transfer ~ 14-84 Mbit/s (HSPA/HSPA+), Voice, SMS

Sistemas de 3era Generación

Systems around the world



Sistemas de 3era Generación

UMTS Releases

1999	UMTS Release 99	• UMTS CN - N/W evolution • WCDMA – New Air Interface
2001	UMTS Release 4	• Low chip rate TDD mode • UTRA repeater • IP transport of CN protocols
2002	UMTS Release 5	• High Speed Downlink Packet Access (HSDPA) • Wideband AMR • Initial phase of the IP Multimedia Subsystem (IMS) • IP transport in the UTRAN • HARQ/AMC/TTI=2ms/16QAM
2006	UMTS Release 6	• FDD Enhanced Uplink (HSUPA) • IMS Phase 2 • Wireless LAN/UMTS Inter-working • Multimedia Broadcast/Multicast Service (MBMS)
2007	UMTS Release 7	• HSPA+ (MIMO & Higher Order Modulation) • 64 QAM/ 16QAM • Direct Tunnelling
2008	UMTS/LTE Release 8	• HSPA+ Enhancements • LTE + SAE/EPS
2009/10	LTE Release 9	• LTE-A: IMT-Advanced (4G) proposal

Sistemas de 3era Generación

UMTS Releases

2011 → LTE Release 10

- Up to 3Gbit/s downlink and 1.5Gbit/s uplink
- carrier aggregation (CA), allowing the combination of up to five separate carriers to enable bandwidths up to 100MHz
- Higher order MIMO antenna configurations up to 8×8 downlink and 4×4 uplink
- Relay nodes to support Heterogeneous Networks (“HetNets”) containing a wide variety of cell sizes

2013 → LTE Release 11

- enhancements to Carrier Aggregation, MIMO
- introduction of new frequency bands
- coordinated multipoint transmission and reception to enable simultaneous communication with multiple cells

2014 → UMTS Release 12

- enhanced small cells for LTE, introducing a number of features to improve the support of HetNets
- inter-site carrier aggregation, to mix and match the capabilities and backhaul of adjacent cells
- new antenna techniques and advanced receivers to maximise the potential of large cells
- interworking between LTE and WiFi or HSPDA

2016 → UMTS Release 13

- LTE in unlicensed
- LTE enhancements for Machine-Type Communication
- Elevation Beamforming / Full-Dimension MIMO
- Indoor positioning
- LTE-Advanced Pro

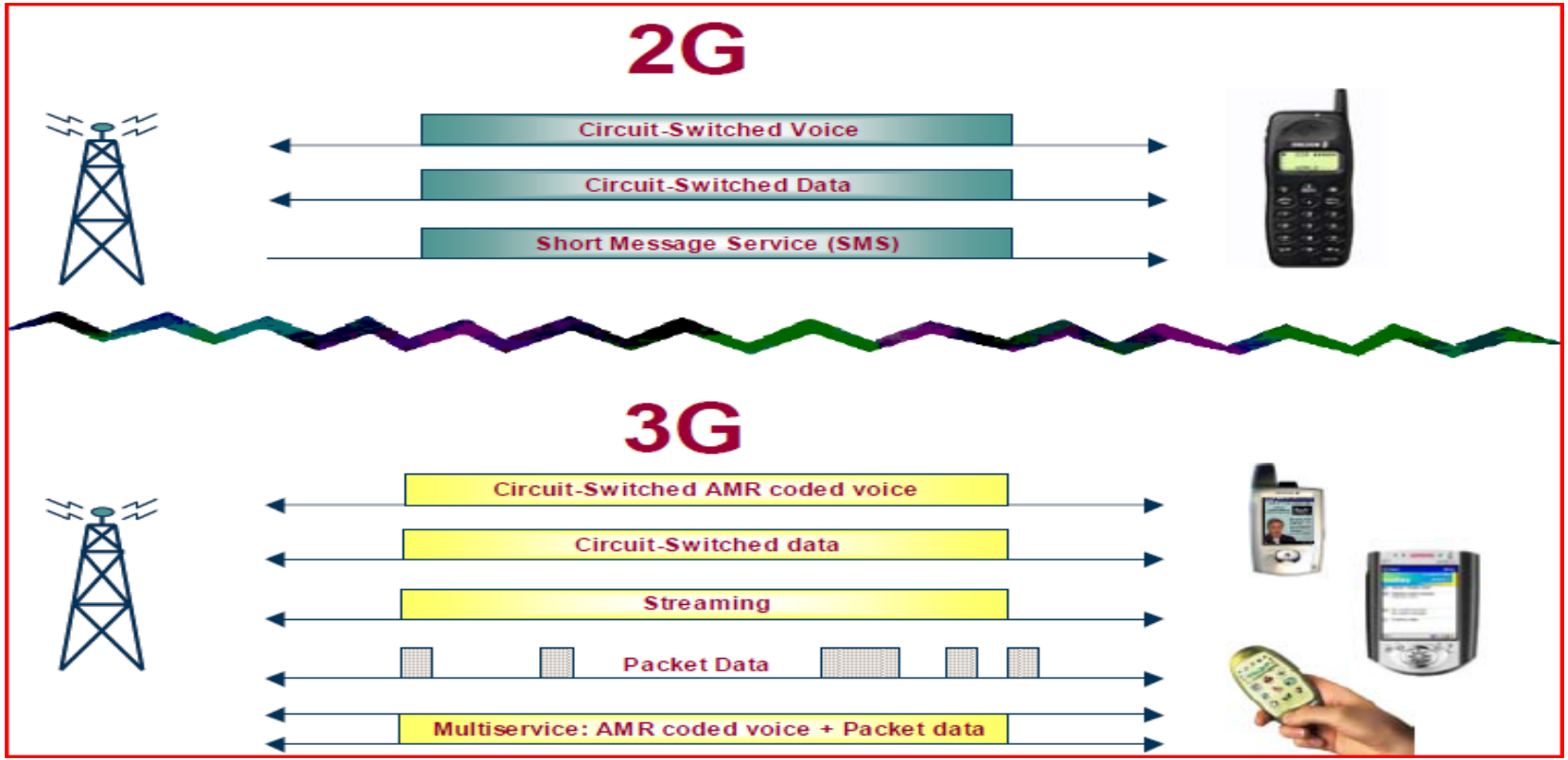
Sistemas de 3era Generación

WCDMA Key Features

- Support of the high-data-rate transmission, 384 kbps wide area coverage, 2 Mbps with local coverage. This can be achieved in a total bandwidth of approximately 5 MHz.
- High service flexibility, that is, support of multiple bearers and variable bit rates on each connection.
- Co-existence of second and third generation systems and inter-system handovers
- Co-existence of FDD and TDD modes.
- Efficient power control. This reduces the interference in the whole network (increases capacity) and at the same time reduces the transmission power (increases battery lifetime of the mobile).

Sistemas de 3era Generación

From 2G to 3G



Sistemas de 3era Generación

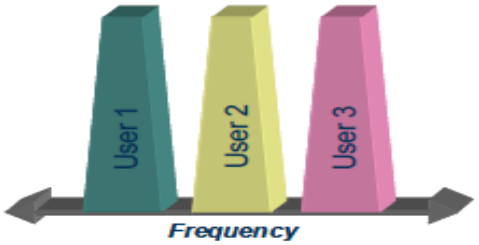
Differences between gsm & wcdma

Property	GSM	WCDMA
Carrier spacing	200 kHz	5 MHz
Radio access scheme	FDMA/TDMA	CDMA
Frequency reuse factor	Multiple reuse	1
Power control frequency	2Hz or lower	1500Hz
Modulation	GMSK	QPSK
Frequency diversity	Frequency hopping	5 MHz bandwidth gives multipath diversity with Rake receiver
Packet data	Not supported in GSM but is in GPRS	Supports CS and PS
Planning	Frequency Planning	Code planning

Sistemas de 3era Generación

Multiple Access

Frequency Division Multiple Access



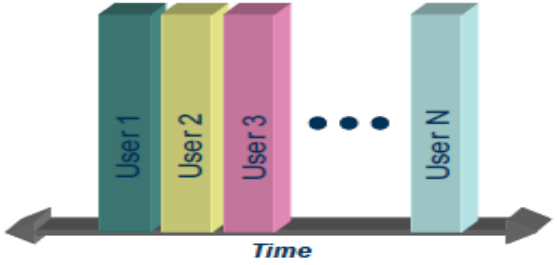
Each User has a unique **frequency**

(1 voice channel per user)

All users transmit at the same time

AMPS, NMT, TACS

Time Division Multiple Access



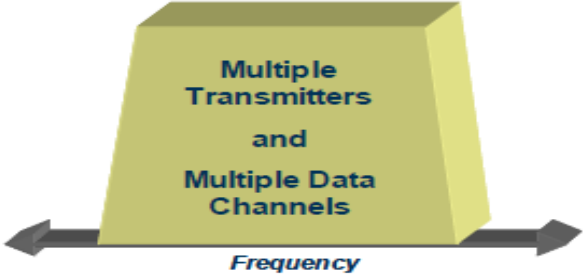
Each User has a unique **time slot**

Each Data Channel has a unique **position within the time slot**

Several users share the same frequency

IS-136, GSM, PDC

Spread Spectrum Multiple Access / **Code Division Multiple Access**



Each Transmitter has a unique **Scrambling Code**

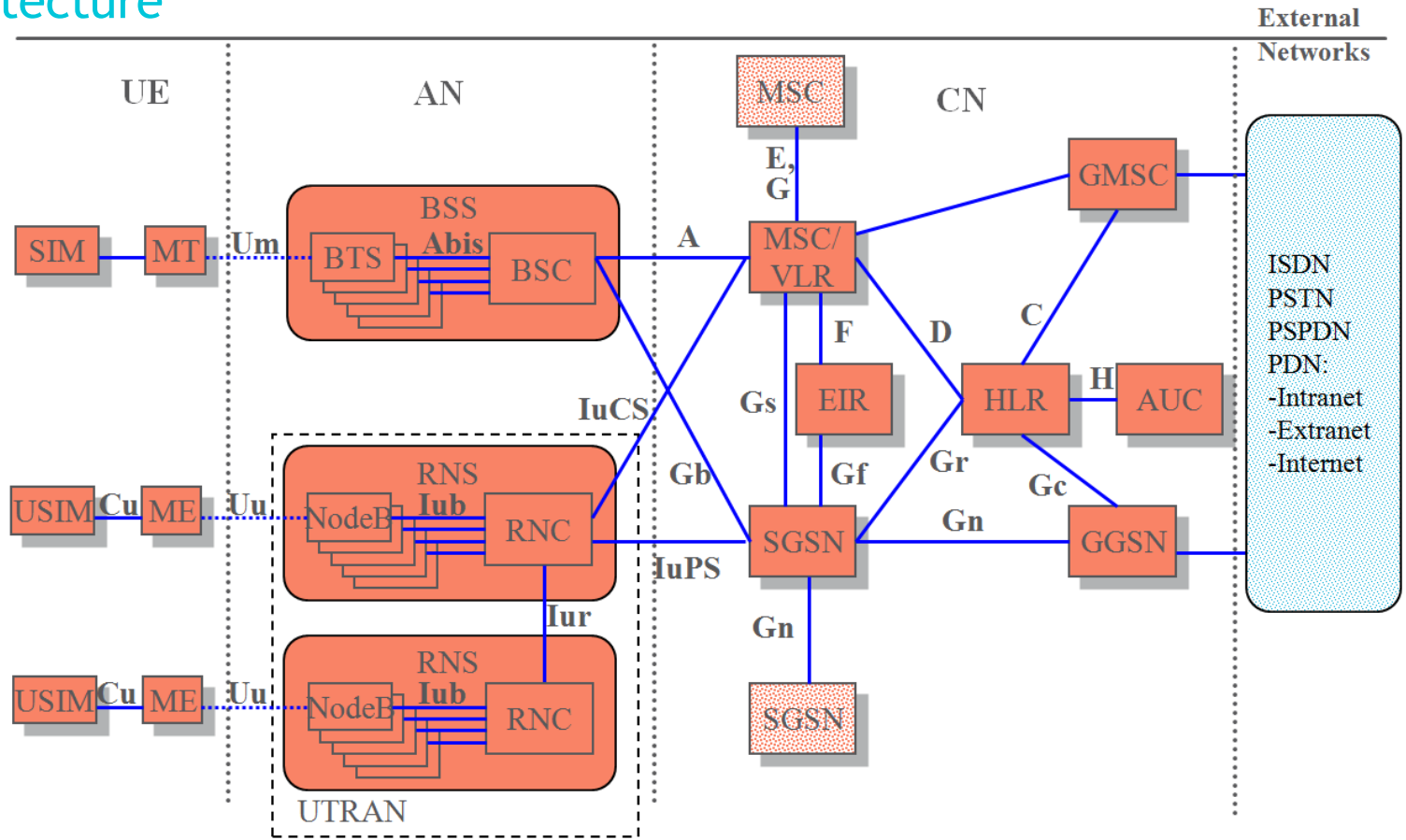
Each Data Channel has a unique **Channelization code**

Many users share the same frequency *and* time

IS-95, cdma2000, WCDMA

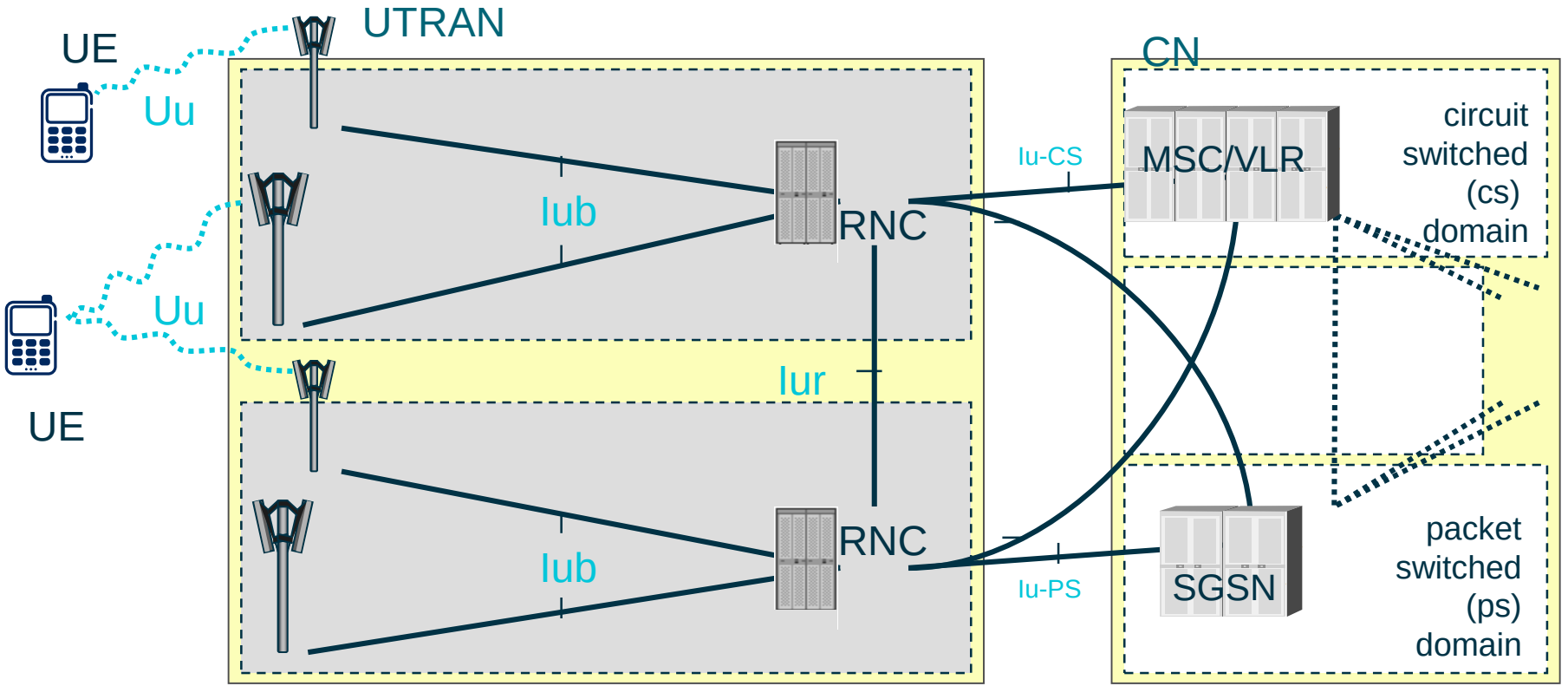
Sistemas de 3era Generación

Architecture



Sistemas de 3era Generación

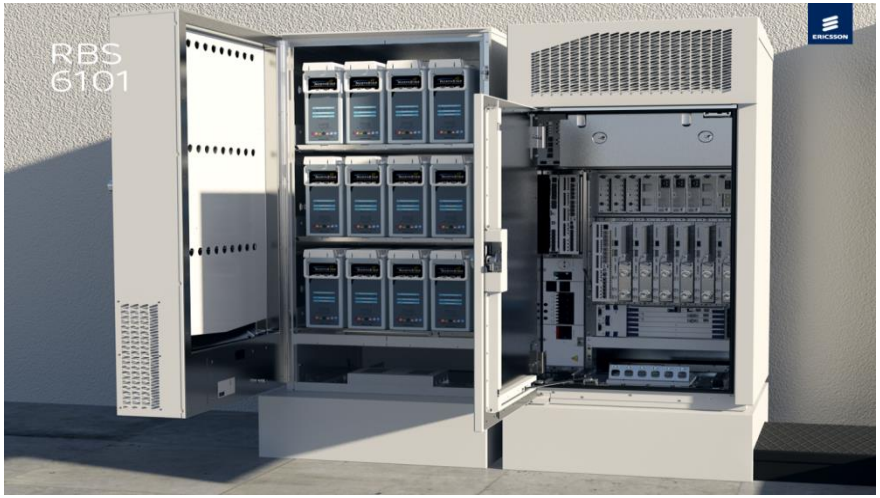
Architecture



Sistemas de 3era Generación

eNodeB

- Channel coding, Interleaving
- Scrambling & Descrambling
- Spreading, Rate adaptation
- Modulation / Demodulation
- RF Amplification & Transmission
- Power control (Inner Loop)
- Channel Mapping to Physical channel
- O&M – alarms etc.



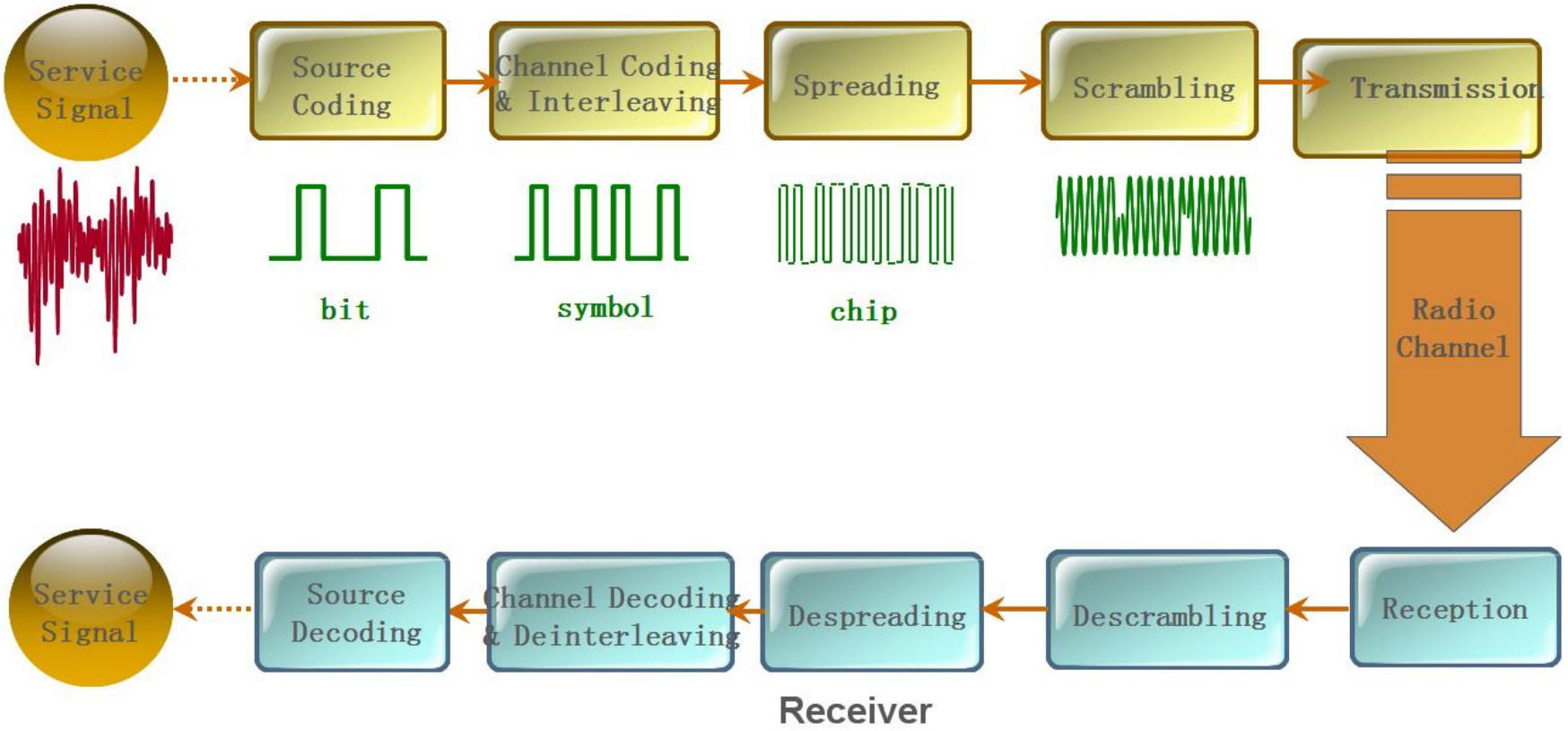
Sistemas de 3era Generación

RNC

- Radio Recourse control
- Admission control
- Congestion Control
- HO decision
- Codes allocation
- Power control (Outer loop)
- Manage connections towards UE's, including connection establishment, radio bearer establishment and release, handover and connection release.

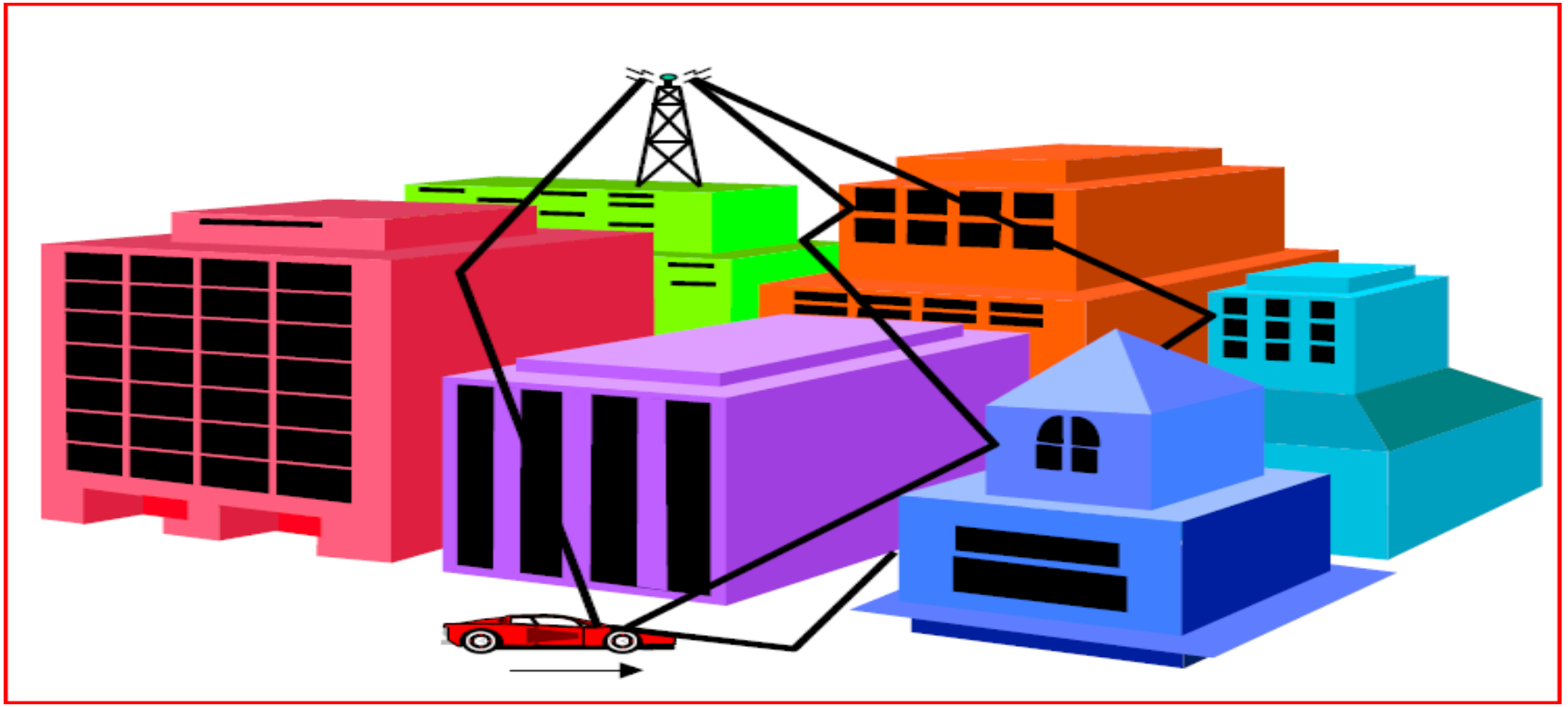
Sistemas de 3era Generación

Processing Procedure of WCDMA System



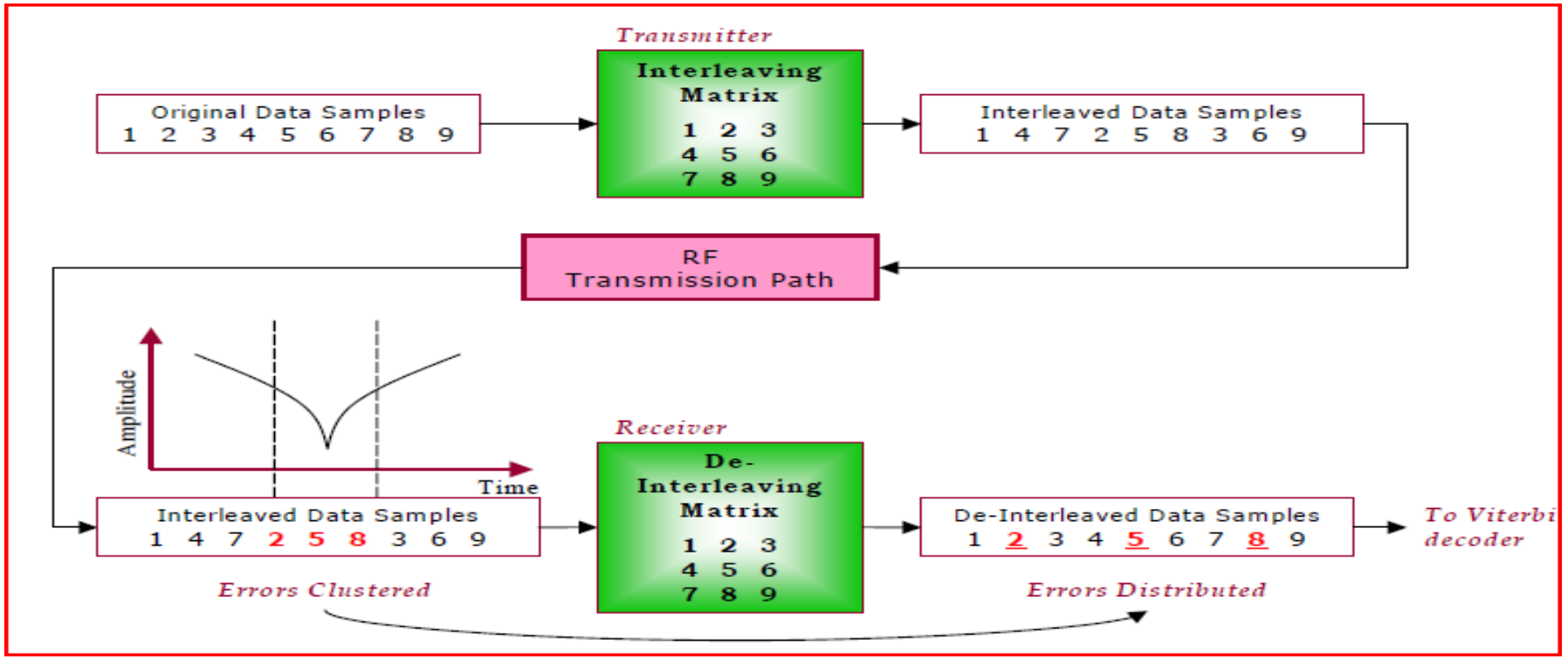
Sistemas de 3era Generación

Interleaving



Sistemas de 3era Generación

Interleaving



Sistemas de 3era Generación

WCDMA Codes

- **Channelization codes** (also sometimes called orthogonal codes, short codes, Walsh codes or Spreading codes)

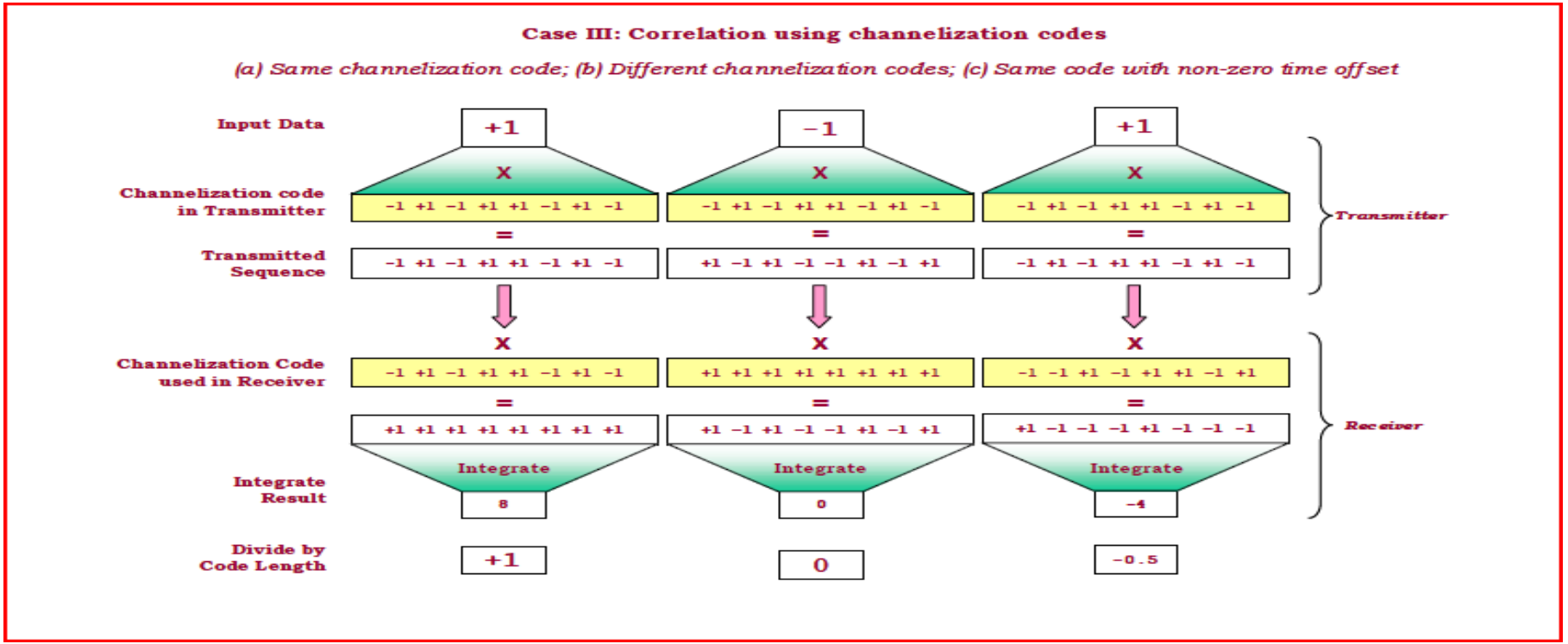
Allows multiple data channels to be sent from each transmitter (cell or UE)

- **Scrambling Codes** (also sometimes called PN codes, Spread Spectrum Multiple Access Codes, Long codes):

Allows multiple WCDMA transmitters to share the same Radio Frequency

Sistemas de 3era Generación

Code Correlation - properties



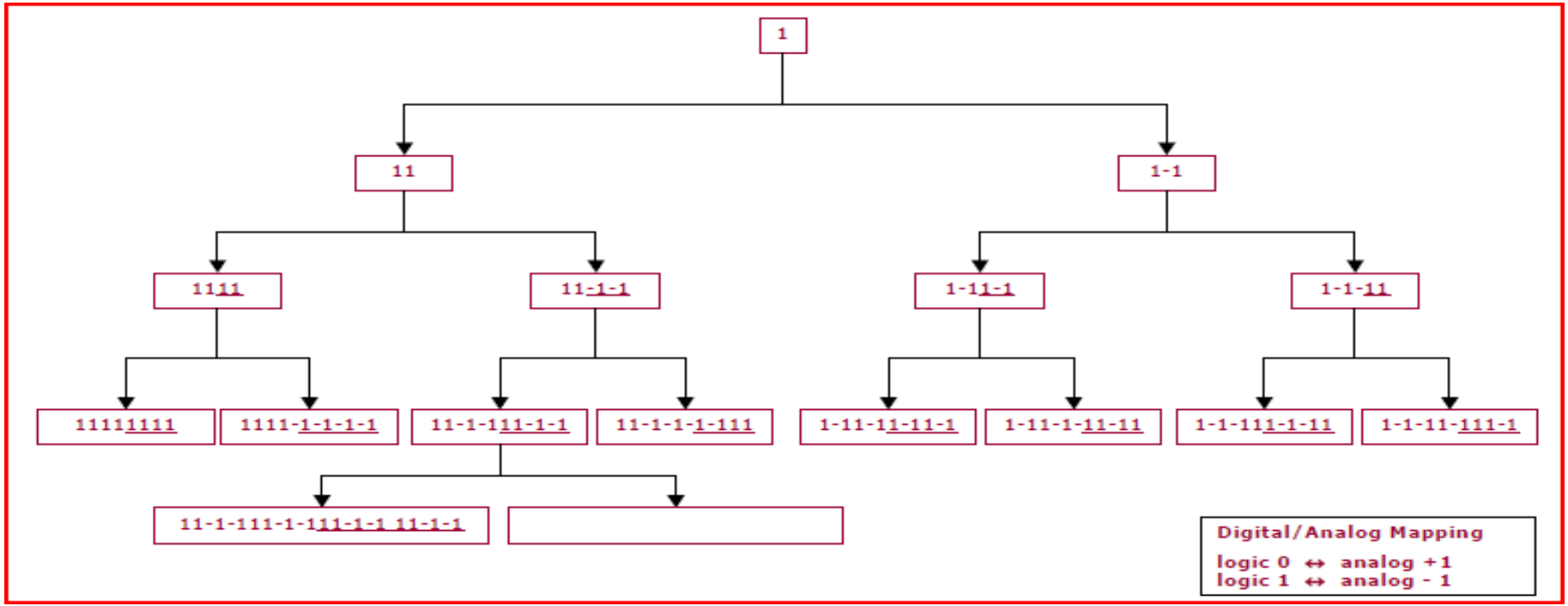
Sistemas de 3era Generación

Code Correlation: Key points

- TX, RX use same codes, at the same time offset
  - Channelization Codes: 100% correlation
- TX, RX use different codes
  - Channelization Codes: 0 % correlation (perfect separation)
- TX, RX use same codes, but at different time offsets
  - Channelization Codes: Unpredictable results (orthogonality is lost)

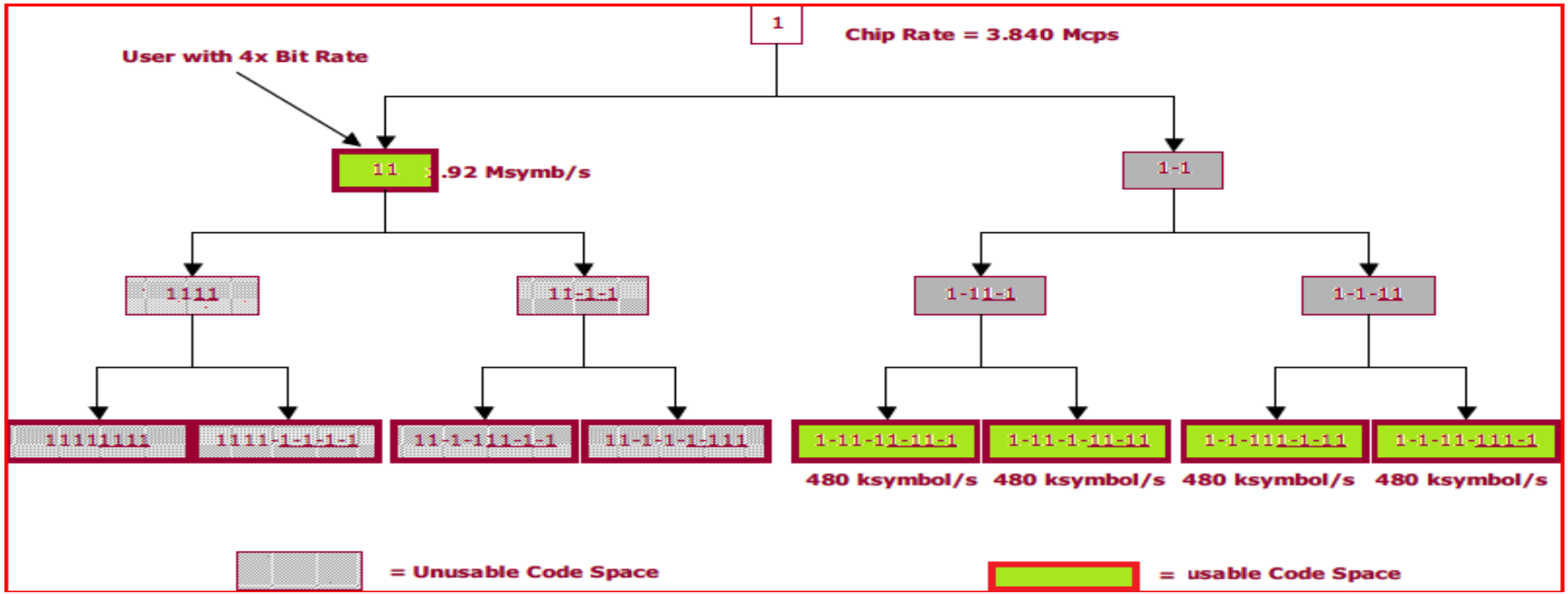
Sistemas de 3era Generación

Channelization Code Generation



Sistemas de 3era Generación

Usage of the channelization code tree



Sistemas de 3era Generación

Physical Layer Bit Rates (DL)

Modulation :
DL : QPSK, 16 QAM.
UL : BPSK

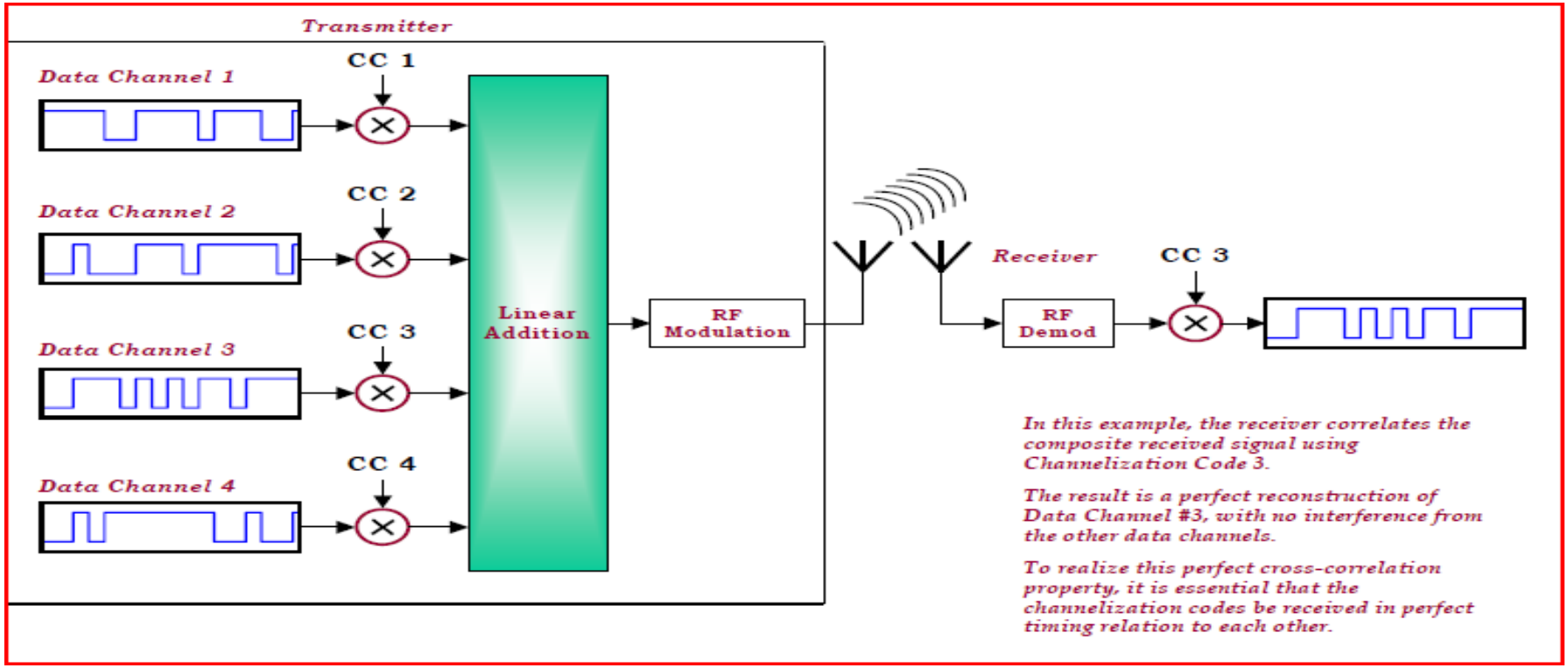
Spreading factor	Channel symbol rate (ksps)	Channel bit rate (kbps)	DPDCH channel bit rate range (kbps)	Maximum user data rate with ½-rate coding (approx.)
512	7.5	15	3–6	1–3 kbps
256	15	30	12–24	6–12 kbps
128	30	60	42–51	20–24 kbps
64	60	120	90	45 kbps
32	120	240	210	105 kbps
16	240	480	432	215 kbps
8	480	960	912	456 kbps
4	960	1920	1872	936 kbps
4, with 3 parallel codes	2880	5760	5616	2.3 Mbps

$$R_{Symbol} = \frac{W}{SF} \qquad R_{b\_phy} = 2 \cdot R_{Symbol}$$

(QPSK modulation)

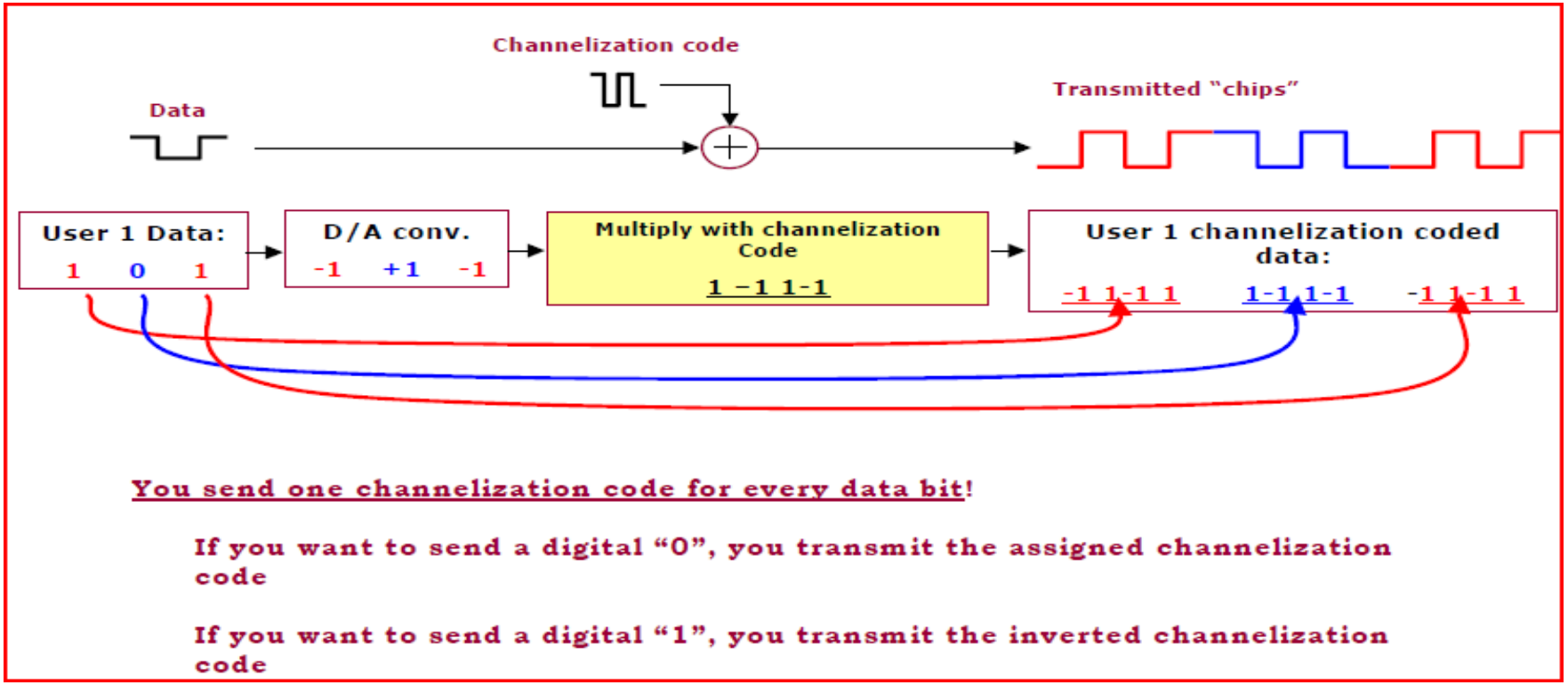
Sistemas de 3era Generación

Channelization Codes



Sistemas de 3era Generación

Channelization coding



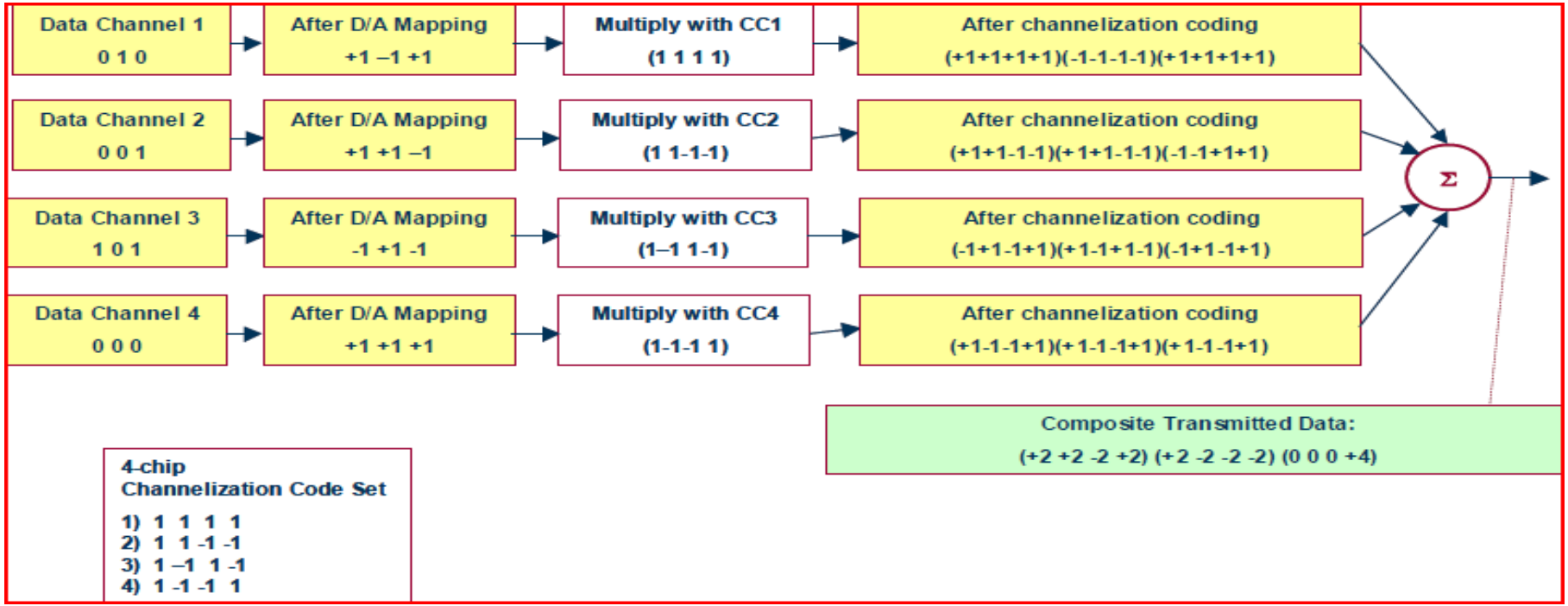
You send one channelization code for every data bit!

If you want to send a digital "0", you transmit the assigned channelization code

If you want to send a digital "1", you transmit the inverted channelization code

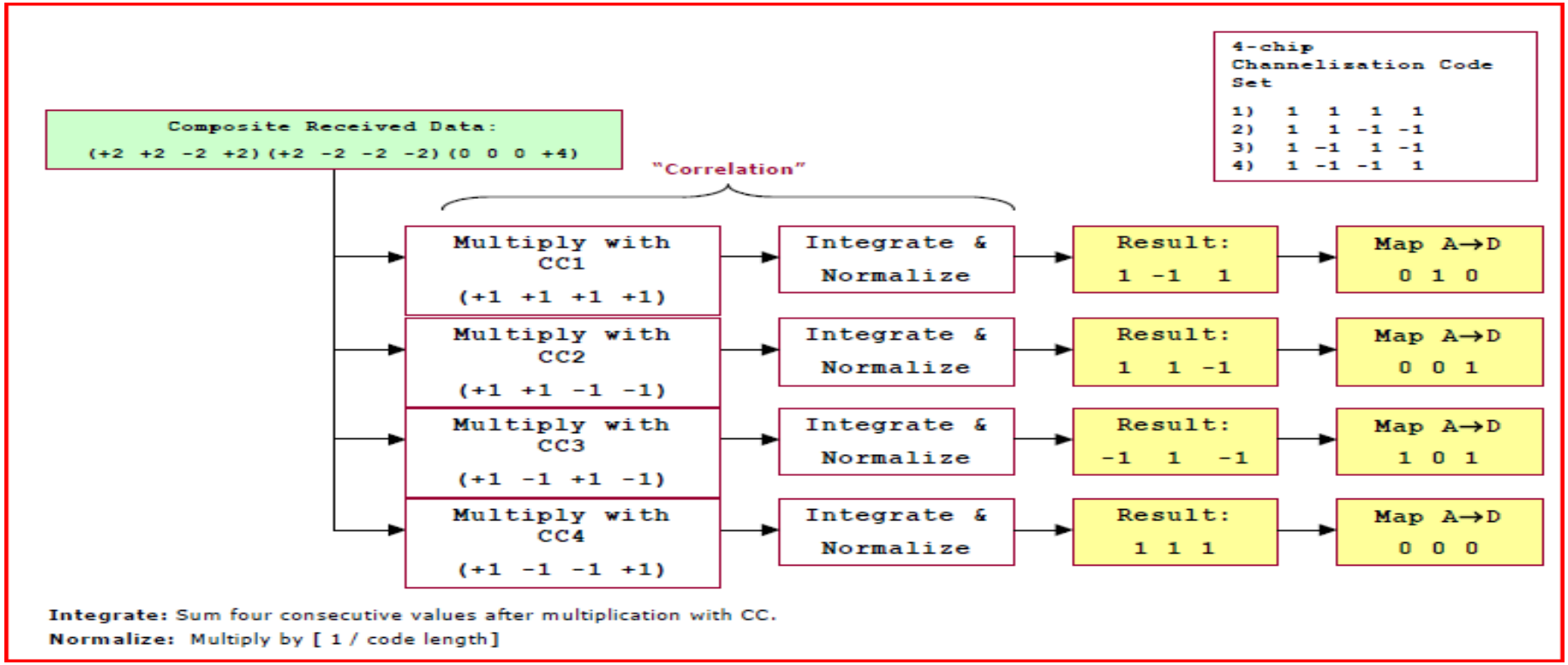
Sistemas de 3era Generación

Channelization Coding example - Transmitter



Sistemas de 3era Generación

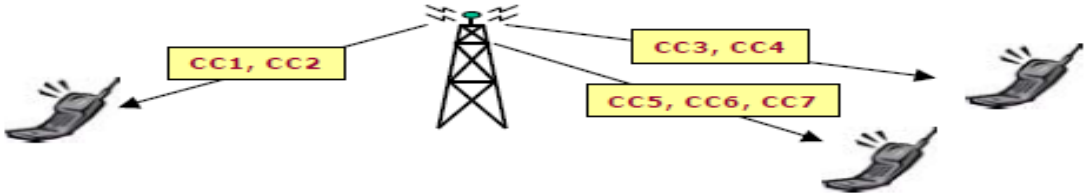
Channelization Coding example - Receiver



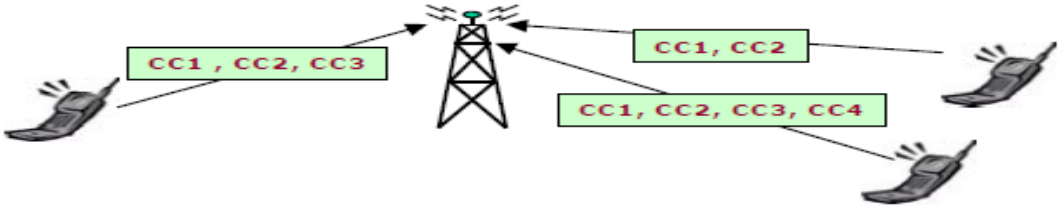
Sistemas de 3era Generación

Uplink and Downlink Channelization Code Usage

Downlink: ***Channelization Codes used to distinguish data channels coming from each cell***



Uplink: ***Channelization Codes used to distinguish data channels coming from each User Equipment, UE***



Sistemas de 3era Generación

UL and DL Channelization Codes

- SF: 4-512 is allowed in the WCDMA DL.
- SF: 4-256 is allowed in the WCDMA UL.

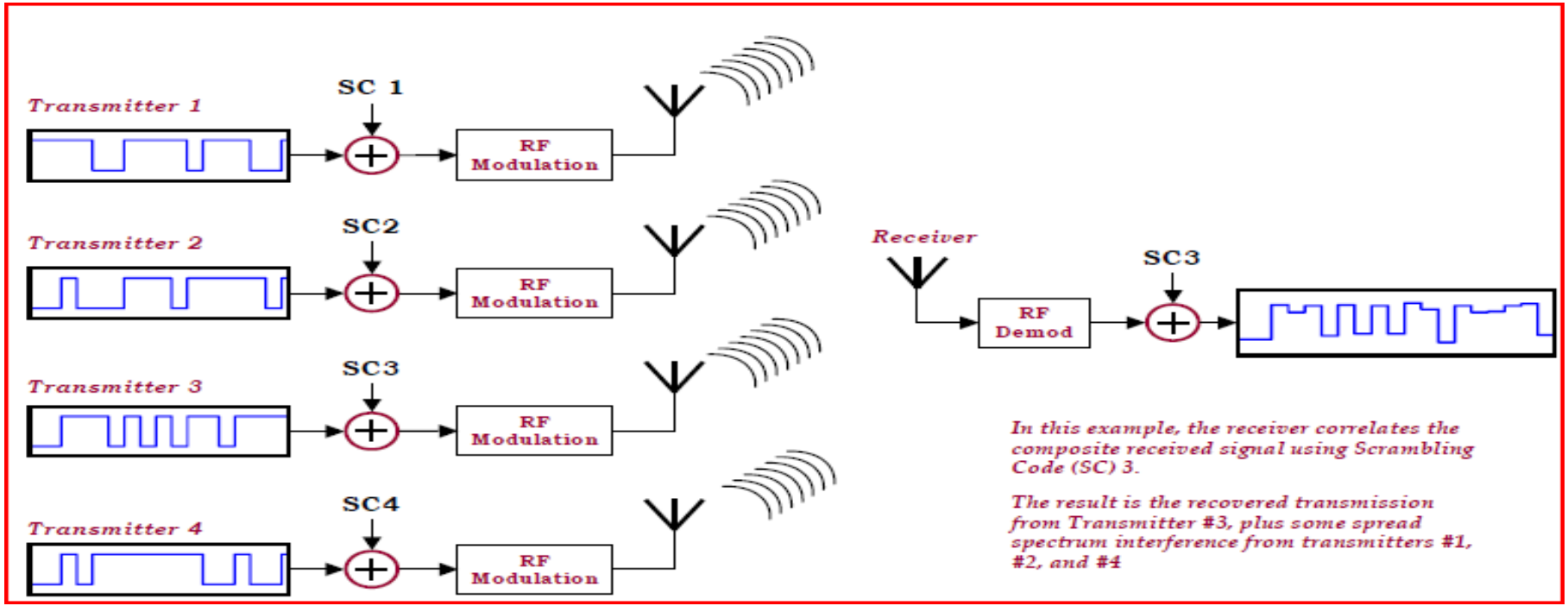
Sistemas de 3era Generación

Scrambling codes

- TX, RX use same codes, at the same time offset
  - Scrambling Codes: 100% correlation
- TX, RX use different codes
  - Scrambling Codes: "Low" (noise-like) correlation at any time offset
    Average correlation level proportional to 1/(code length)
- TX, RX use same codes, but at different time offsets
  - Scrambling Codes: "Low" (noise-like) correlation for any offset > +1 chip

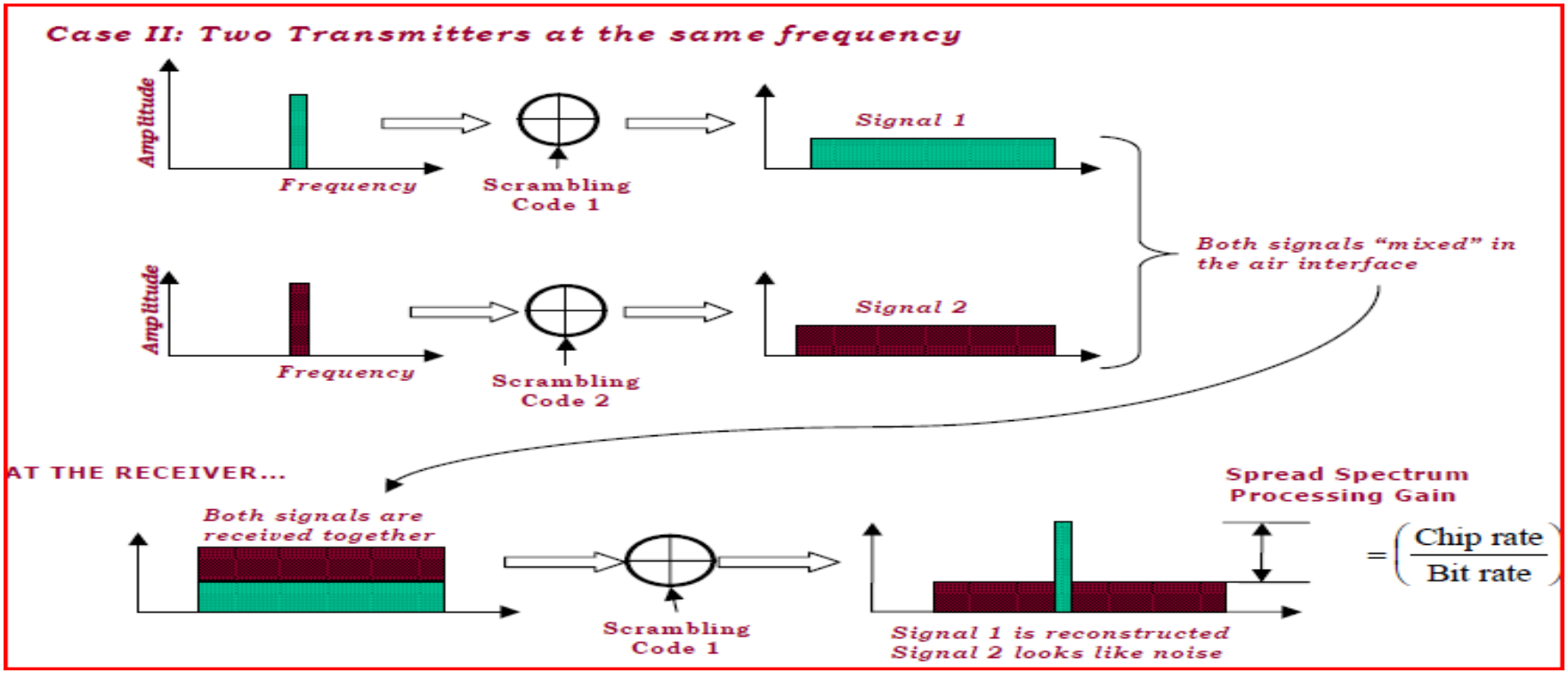
Sistemas de 3era Generación

Scrambling codes



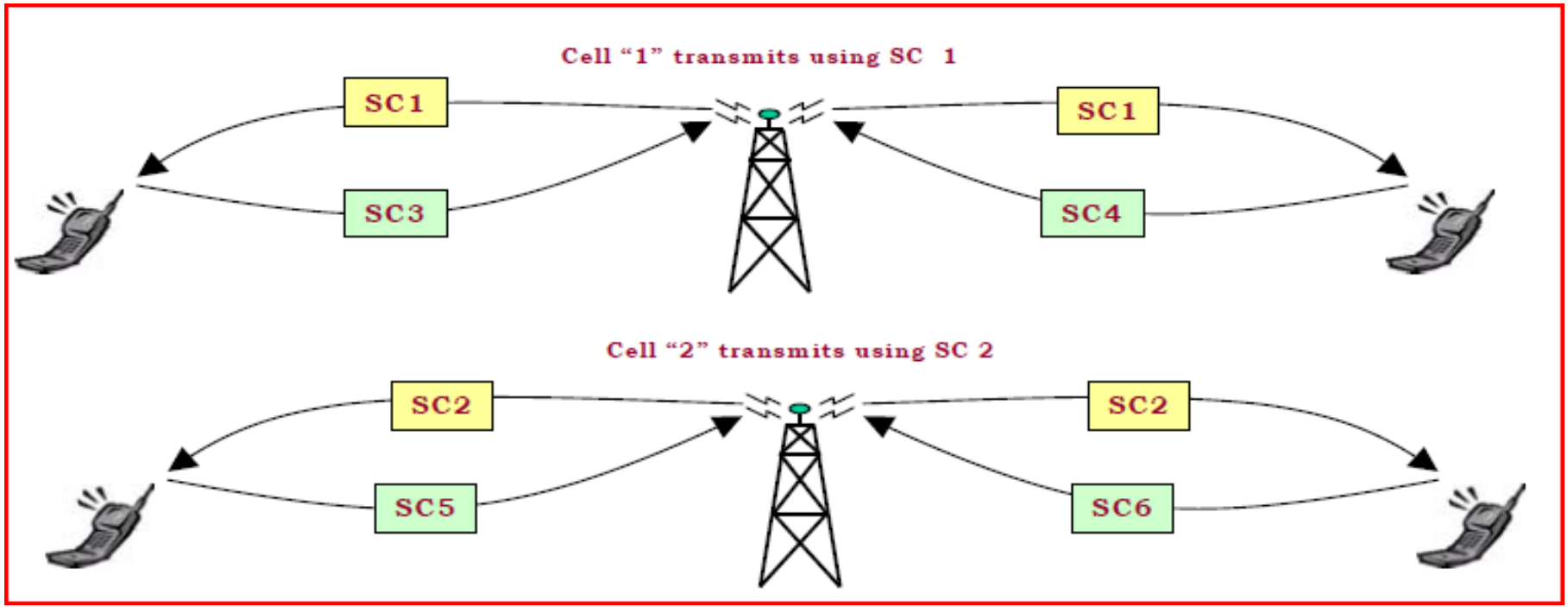
Sistemas de 3era Generación

Scrambling codes



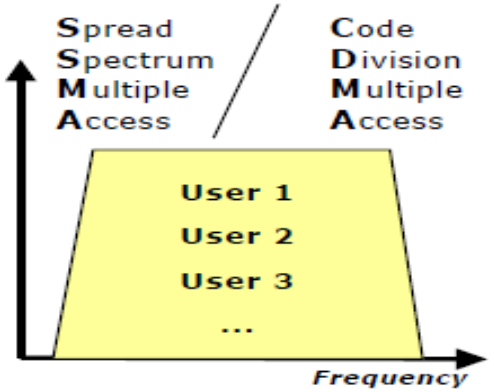
Sistemas de 3era Generación

Scrambling codes planning



Sistemas de 3era Generación

Channelization and scrambling code summary



Scrambling Codes

and

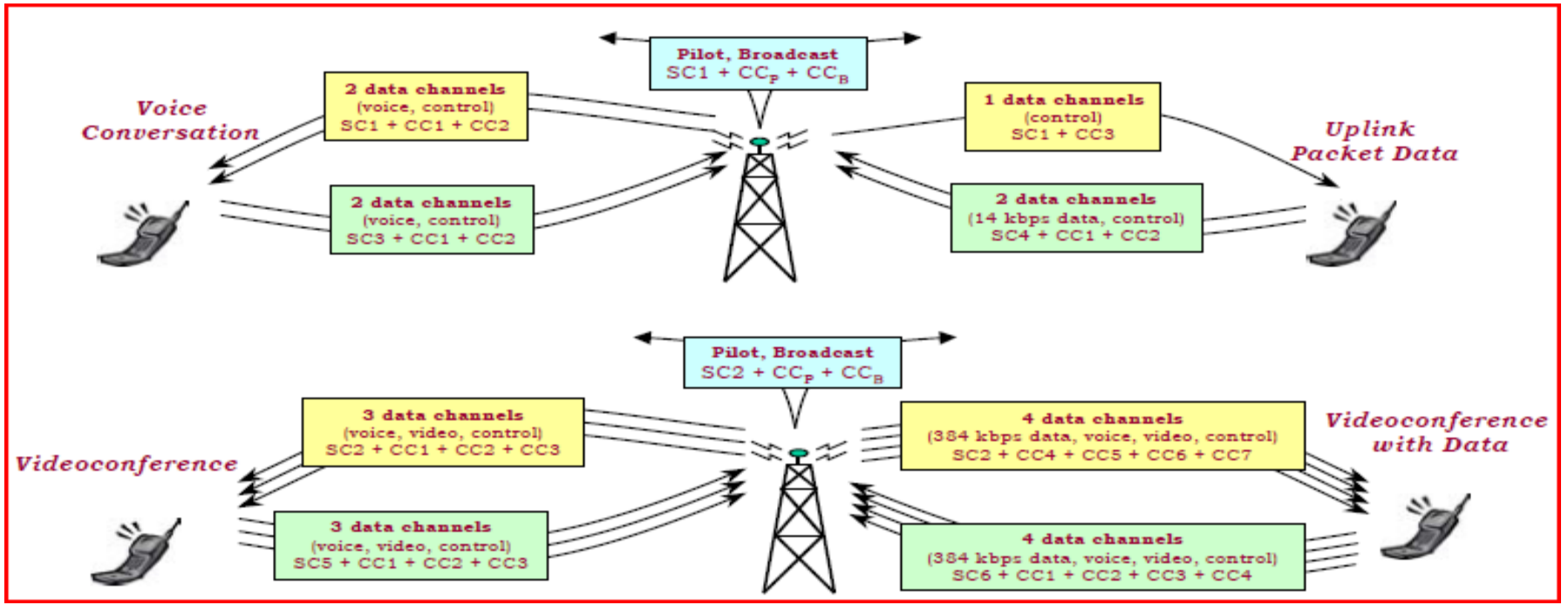
Channelization Codes

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

Sistemas de 3era Generación

Code usage in WCDMA network



Sistemas de 3era Generación

WCDMA POWER CONTROL

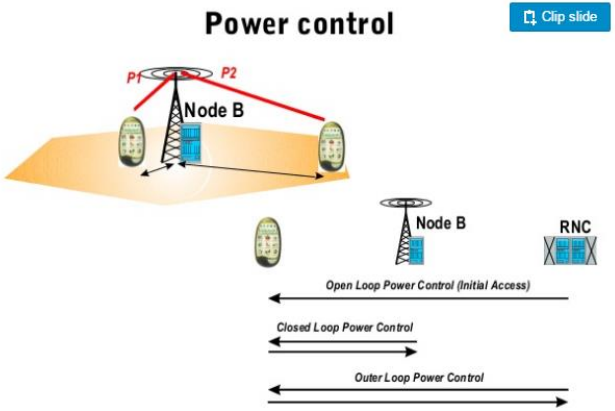
Power control is necessary in any spread spectrum system to ensure that each user transmits and receives just about the right amount of power to maintain the connection quality while at the same time causing as little interference as possible to other users.

Three types:

- Open loop
- Inner loop
- Outer loop

Sistemas de 3era Generación

Power Control Types



1. **Open-Loop Power Control (Initially, No signaling)**
   UE measure pilot,
   read receiving level from BCH, determine PL
   Transmit at calculated power,
   Ramp up power

2. **Outer-Loop Power Control (slow)**
   maintains the required Block Error Rate (BLER) for a service by modifying the SIR target
   Dedicated channels
   If the BLER measured (DL@UE, UL@RNC) is below/ above the minimum acceptable BLER,
   UE/RNC increase/reduce SIR target.
   Use the new SIR target for the Inner-loop PC.

3. **Inner-Loop Power Control (fast)**
   minimizes the power and interference of ongoing connections by maintaining a minimum SIR.
   Dedicated channels
   Performed 1500 times per second,
   Adjust (up or down) the Tx power to reach the SIR target.

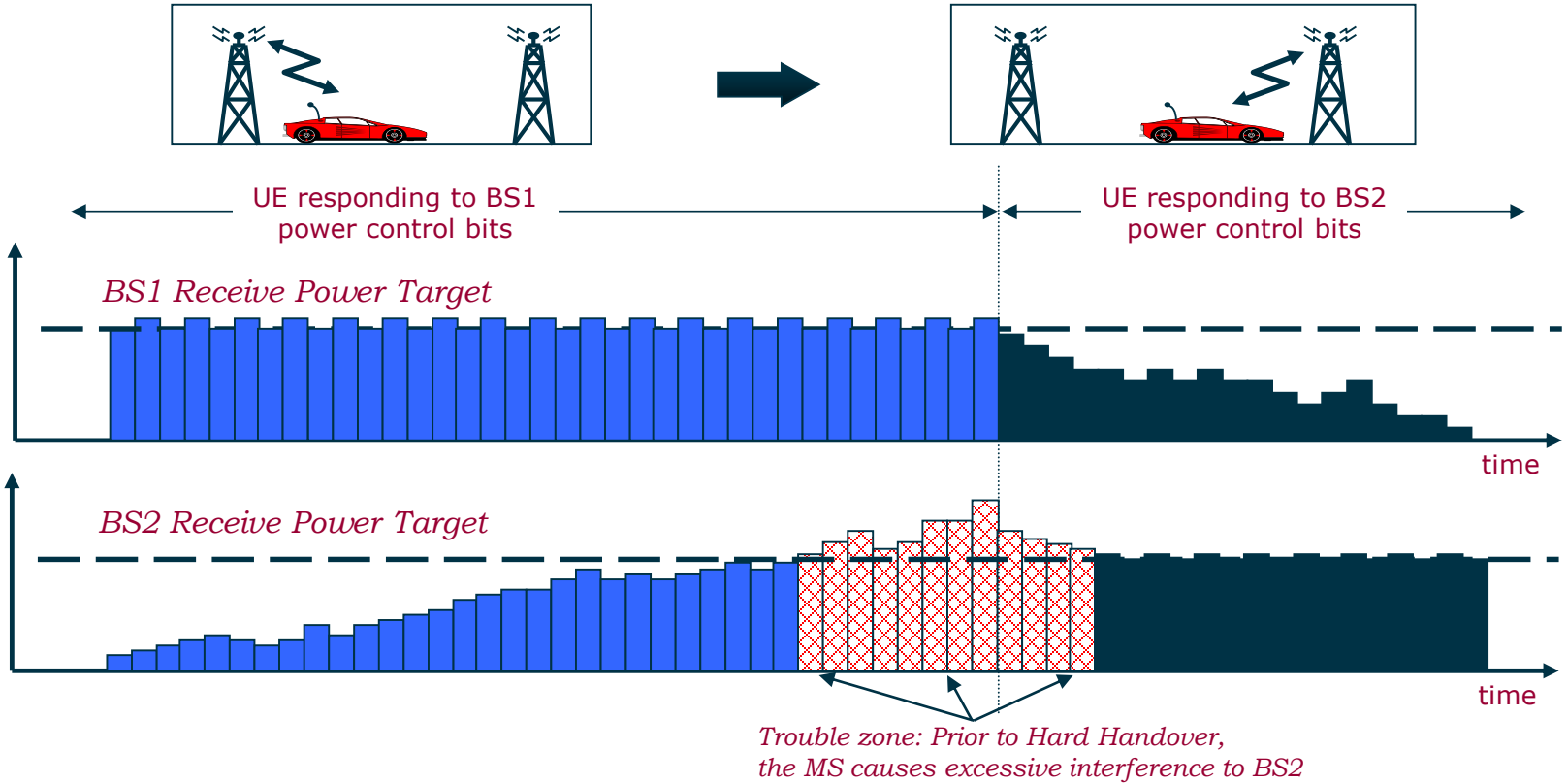
Sistemas de 3era Generación

WCDMA Handover

- Inter-Radio Access Technology (IRAT) Handover
  - Handover from a WCDMA system to GSM/GPRS
  - Traffic and Control Channels are Disconnected and must be Reconnected
- Inter-frequency Handover
  - When the UE must change WCDMA carrier frequency during the Handover
  - Traffic and Control Channels are Disconnected and must be Reconnected
- Soft Handover
  - During Handover, the UE has concurrent traffic connections with two , three or four RBSs.
  - Handover should be less noticeable
- Softer Handover
  - Similar to Soft Handover, but between two cells of the same site
  - Handover is simplified since timing sectors have identical timing

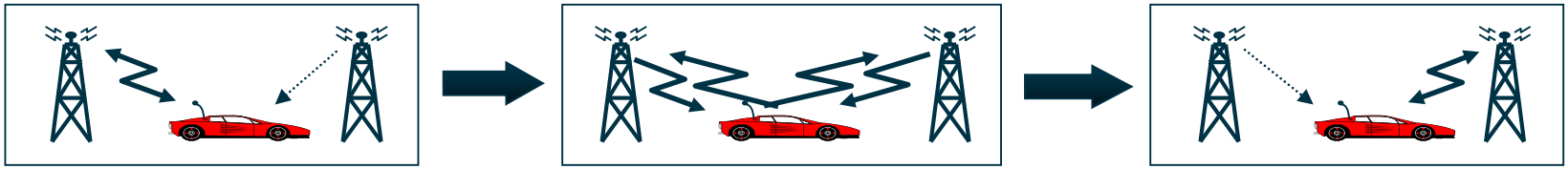
Sistemas de 3era Generación

WCDMA With and Without SHO



Sistemas de 3era Generación

WCDMA Soft Handover Process



One finger of the RAKE receiver is constantly scanning neighboring Pilot Channels.

When a neighboring Pilot Channel reaches the t_add threshold, the new BS is added to the active set

When the original Base Station reaches the t_drop threshold, originating Base Station is dropped from the active set.

Sistemas de 3era Generación

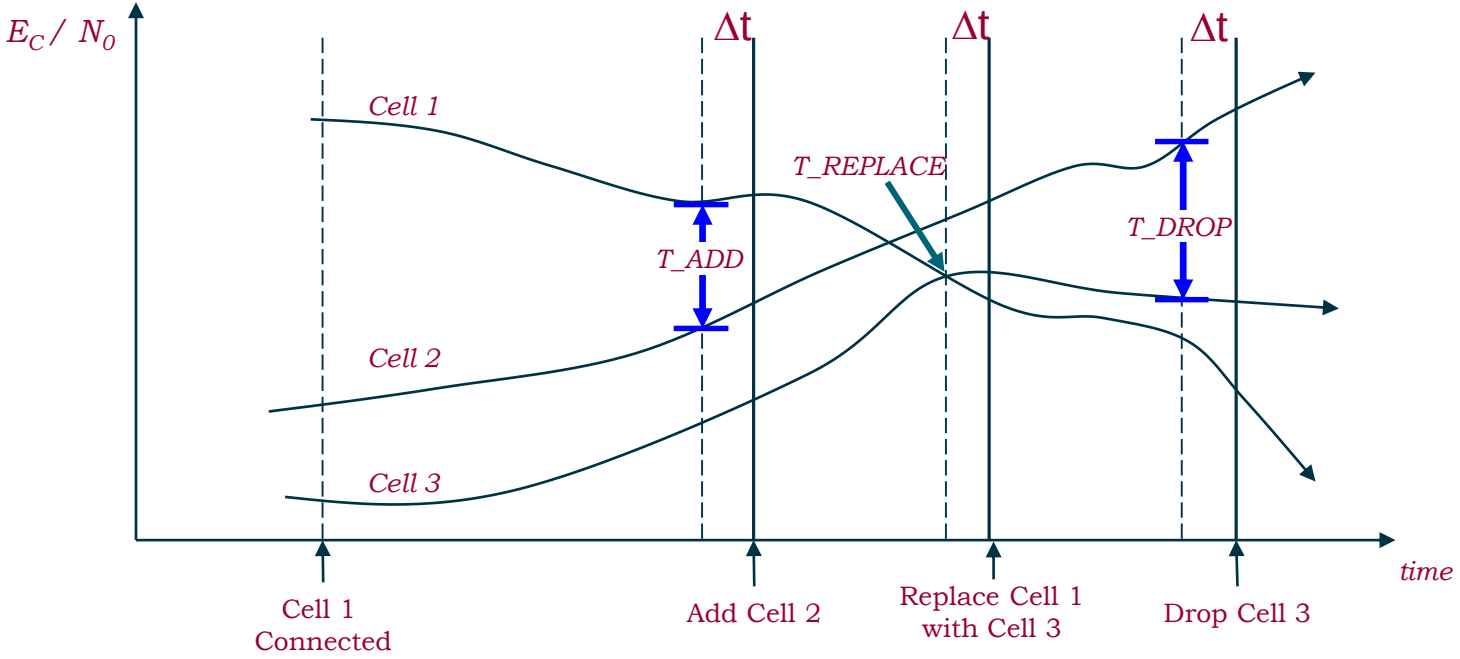
Soft Handover

- The active set refers to the collection of cells retaining radio connection with UE.
- The monitored set refers to the collection of cells retaining no radio connection with UE but requiring measurement by sending the intra-frequency measurement control message to UE.
- The detected set refers to the collection of intra-frequency cells except cells in the active set and monitored set

Sistemas de 3era Generación

Soft Handover Add/Drop/Replace

- Soft Handover Measurement and Decision



Sistemas de 3era Generación

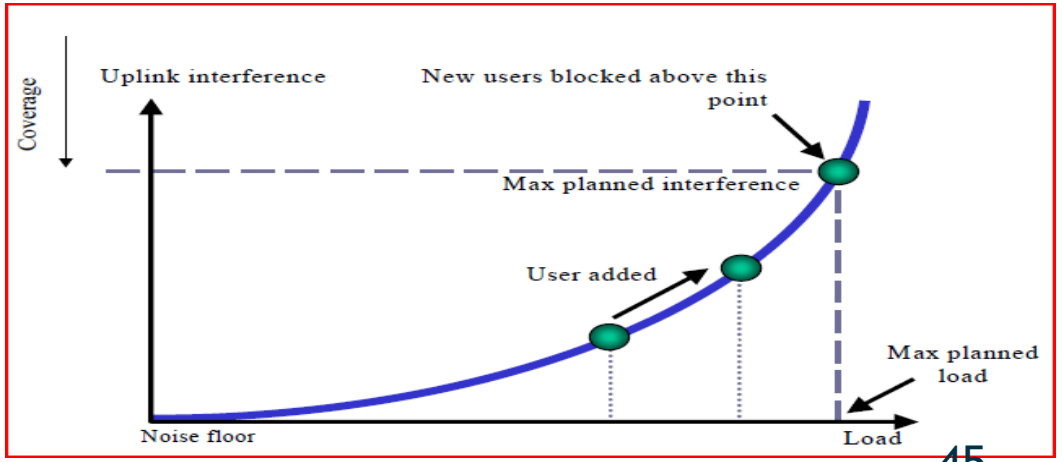
Soft Handover Key Points

- Soft handover provides performance benefits:
  - “Seamless” coverage at cell fringes
  - Handover may be less noticeable to the user
- Soft handover also degrades system capacity:
  - Uses redundant physical layer resources from adjacent or overlapping cells.

Sistemas de 3era Generación

Capacity Management Functions

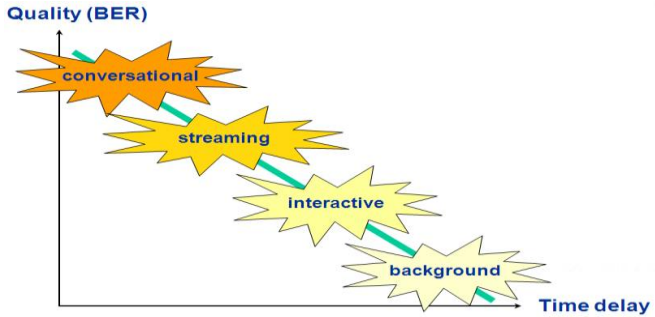
- **Objective**
  - Controls the load in the cells and enables the system to provide the requested QoS and coverage for individual UE connections.
- **Admission Control**
  - Responsible for controlling the utilization of dedicated monitored resources by accepting or refusing requests for usage of these resources
- **Congestion Control**
  - Responsible for detecting and resolving overload situations on certain dedicated monitored resources



Sistemas de 3era Generación

QoS classes

Traffic class	Conversational class conversational RT	Streaming class streaming RT	Interactive class Interactive best effort	Background Background best effort
Fundamental characteristics	• Preserve time relation (variation) between information entities of the stream • Conversational pattern (stringent and low delay)	• Preserve time relation (variation) between information entities of the stream	• Request response pattern • Preserve payload content	• Destination is not expecting the data within a certain time • Preserve payload content
Example of the application	- voice	- streaming video	- Web browsing	- background down-load of emails



Sistemas de 3era Generación

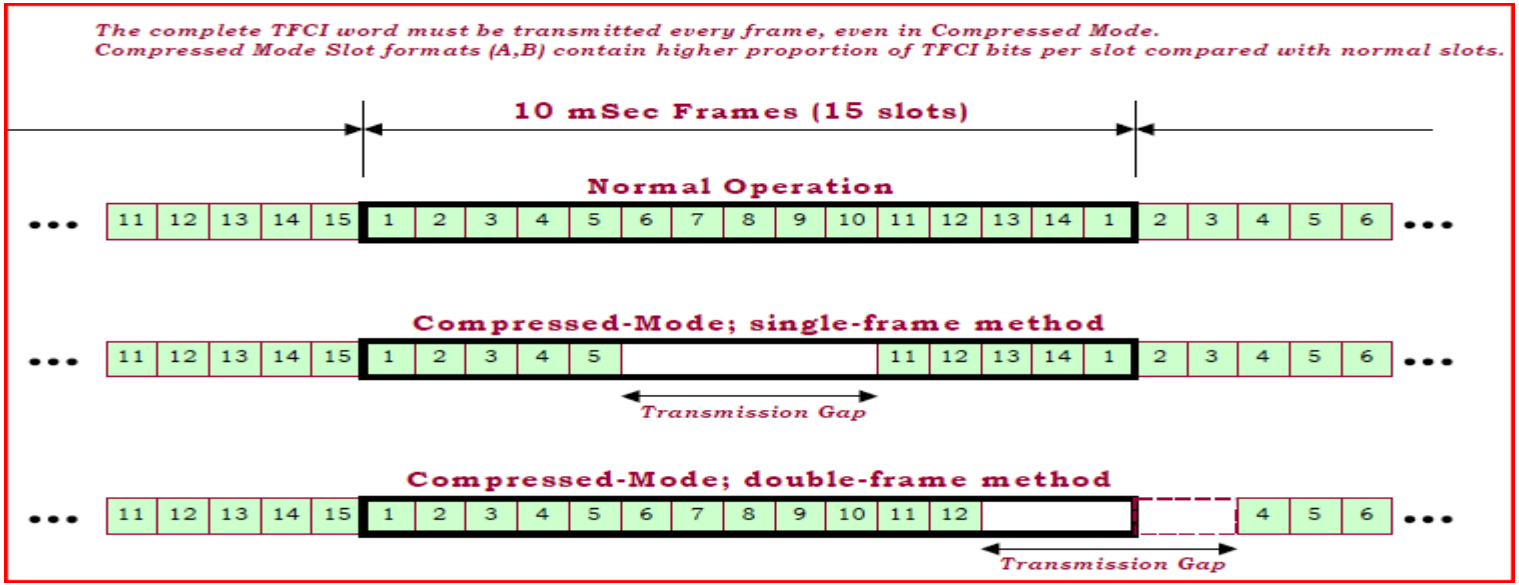
Current R99 RABs – P4

Traffic class	RAB configuration
Conversational	Speech 12.2 kbps RAB
	64 kbps CS RAB
Interactive	64/64 kbps PS RAB
	64/128 kbps PS RAB
	64/384 kbps PS RAB
Streaming	57.6 kbps CS RAB
	16/64 kbps PS RAB + Interactive 8/8 kbps PS RAB
	16/128 kbps PS RAB + Interactive 8/8 kbps PS RAB
Mixed	Conversational 64 kbps CS + Interactive 8/8 kbps PS RAB
	Conversational/Speech 12.2 kbps RAB + Interactive 64/64 kbps PS RAB
	Conversational/Speech 12.2 kbps RAB + Interactive 0/0 kbps PS RAB

Sistemas de 3era Generación

Compressed mode

Slot formats ending with A or B are used for compressed mode operation. As can be seen from the table, only 8 to 14 slots are transmitted in each frame thereby giving time for the UE to measure the signal levels from non-WCDMA networks (GSM) or to make hard handovers to WCDMA carriers on other frequencies.



Sistemas de 3era Generación

Compressed mode

The physical channel is reconfigured to create transmission and reception gaps.

Data compression can be accomplished by:

- Decreasing the Spreading Factor by 2:1
  Increases Data Rate so bits get through twice as fast!
- Puncturing bits
  weakens FEC coding.

UE then tunes to other frequencies (GSM) to conduct measurements.

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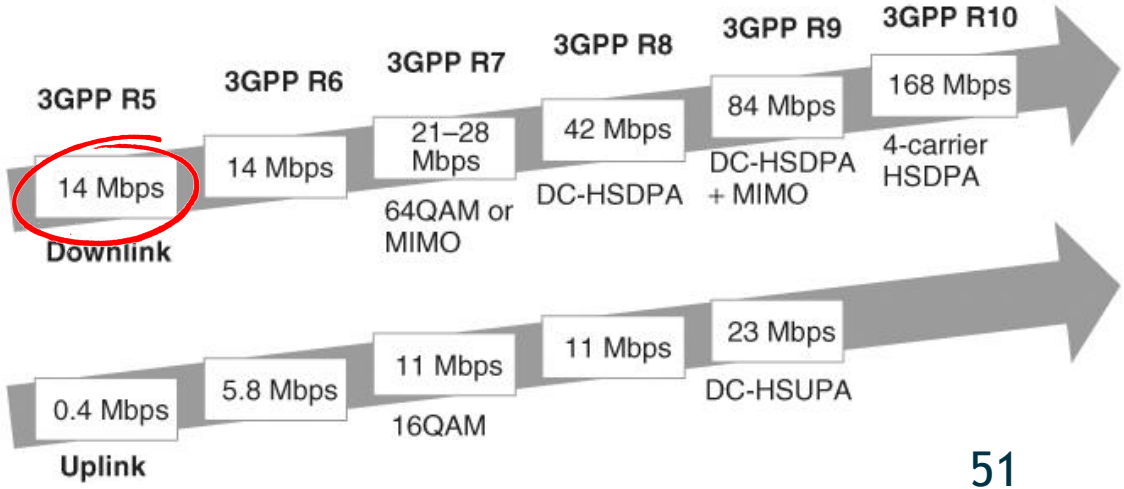
Sistemas de 3era Generación (HSPA)

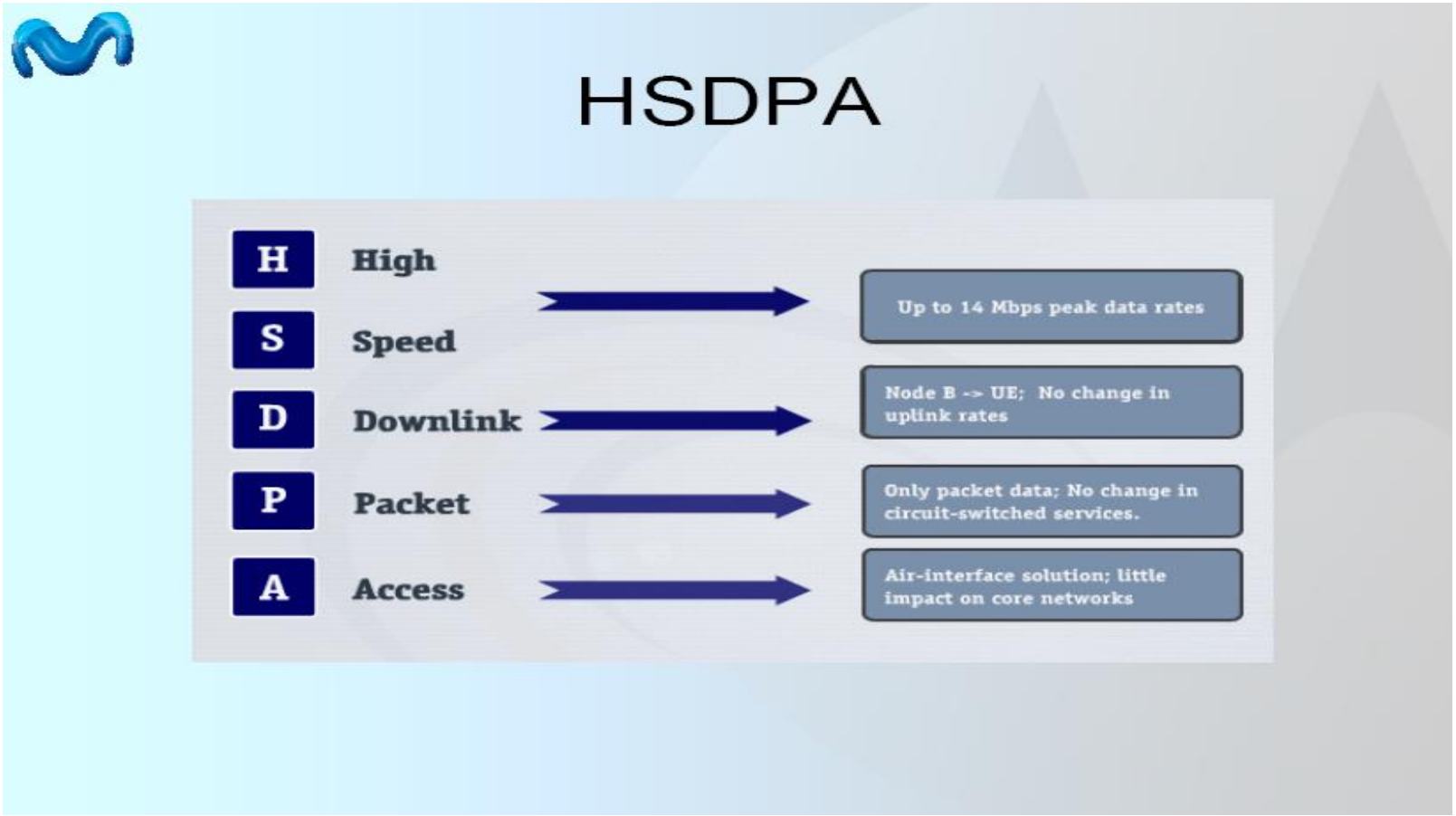
Mg. David Ramirez de los Reyes

HSDPA

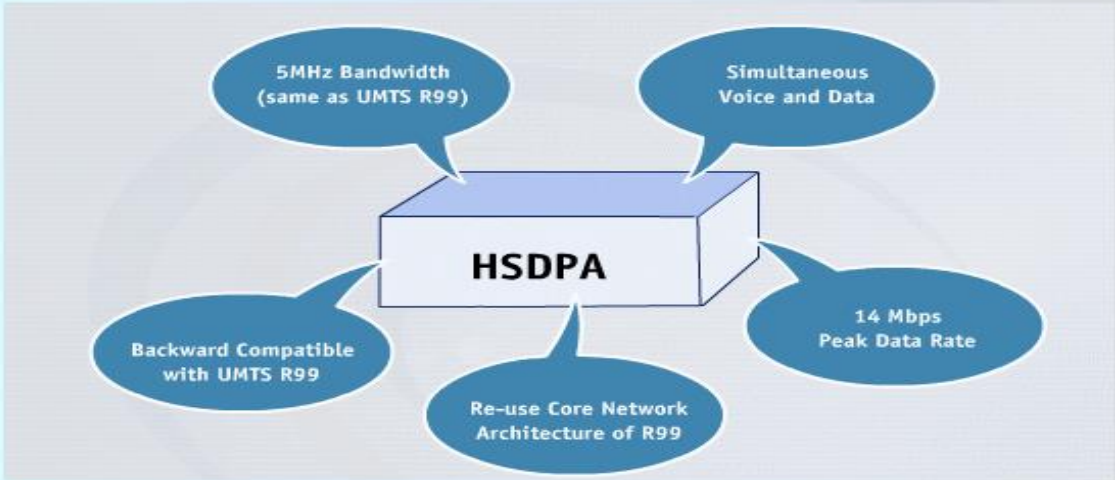
3GPP	R99/1999	R5/2002	R6/2005	R7/2007*	R8/2008**
Peak Data Rate	0.384 Mbps DL 0.064 Mbps UL	14 Mbps DL 0.384 Mbps UL	14 Mbps DL 6 Mbps UL	28/42 Mbps DL* 12 Mbps UL	160 Mbps DL 50 Mbps UL
Commercial Availability	2001	2005	2006	2008	2009



HSDPA


HSDPA
H
High
S
Speed
D
Downlink
P
Packet
A
Access
Up to 14 Mbps peak data rates
Node B -> UE; No change in uplink rates
Only packet data; No change in circuit-switched services.
Air-interface solution; little impact on core networks

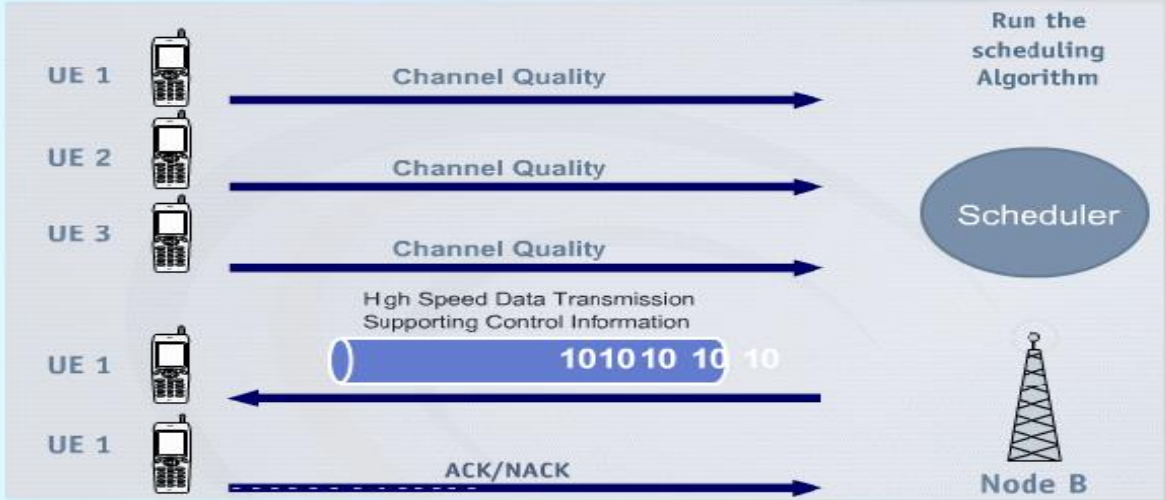
Características de HSDPA



Características de HSDPA

- Utiliza la misma banda de 5MHz de UMTS.
- Soporta Voz y datos simultáneamente.
- Tiene un data rate máximo de 14 Mbps.
- Usa el mismo Core de Release 99
- Es full compatible con UMTS Rel. 99

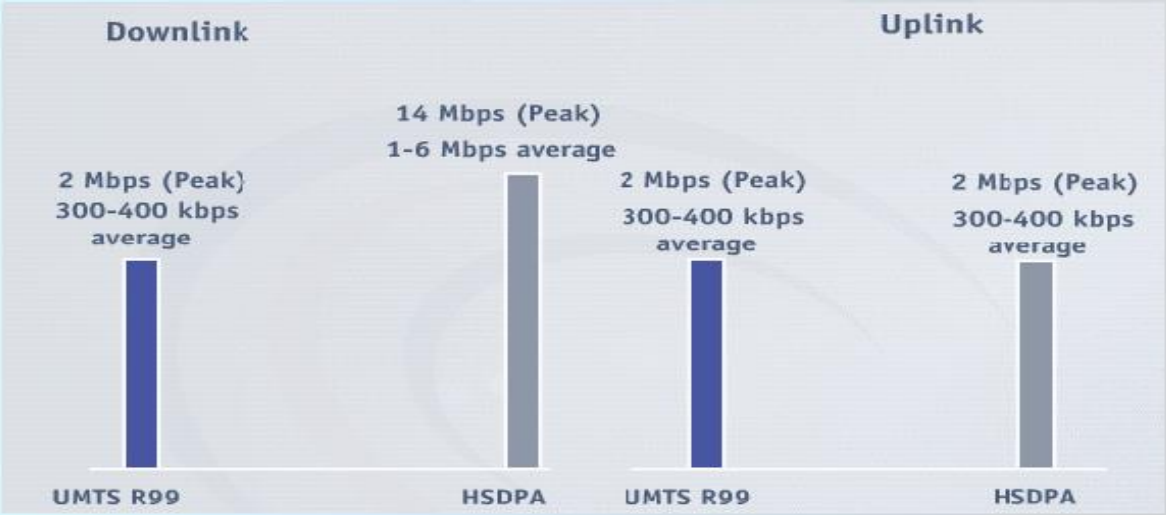
Transmisión de Datos en Downlink



Transmisión de Datos en Downlink

1. Todos los UE envian sus reportes de calidad.
2. El Algoritmo de Scheduling del Nodo B selecciona aquellos usuarios candidatos a usar canales de High Speed basado en sus reportes de Calidad y otros factores.
3. Los datos son transmitidos usando canales de HSDPA a aquellos UE seleccionados.
4. El nodo B transmite un canal separado con información de cómo decodificar ese canal de HSDPA.
5. El Nodo B envia un AKC o un NACK al recibir el paquete.

Comparación de la Velocidades



Transmisión de Datos en Rel. 99

Transmisión de Datos en Rel. 99

1. El SRNC determina un target QoS para el UE.
2. El RNC asigna un Data Rate.
3. El Nodo B trabaja en conjunto con el UE para mantener esa velocidad a través de el control de potencia Inner Loop.

- ¿Cómo podemos cambiar el Data Rate?

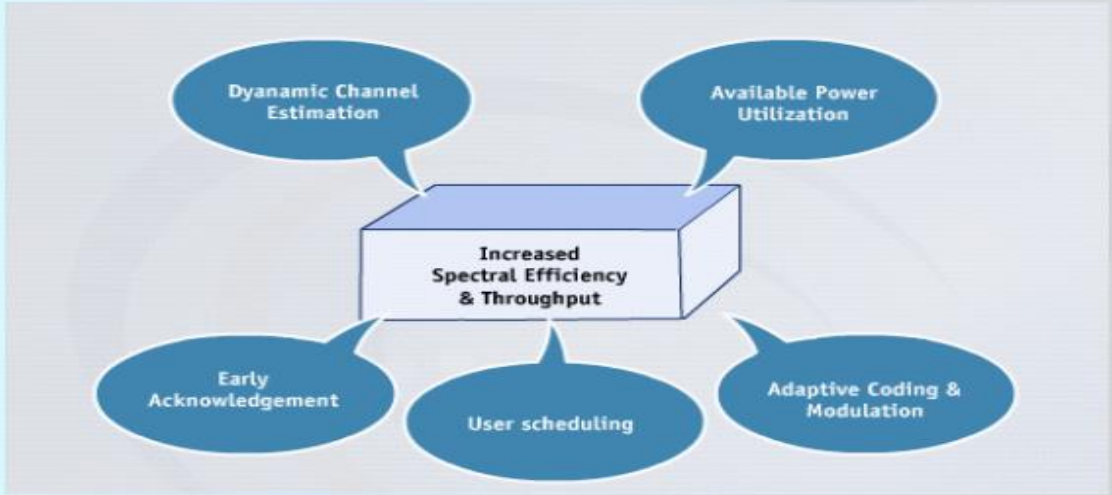
Transmisión de Datos en HSDPA

Transmisión de Datos en HSDPA

1. El SRNC determina un target QoS para el UE.
2. El Nodo B determina el Data Rate basado en los recursos disponibles.
3. El Nodo B mantiene la Calidad de Servicio cambiando la codificación, data rate, esquema de modulación y el tamaño de los paquetes.

- La Potencia se mantiene constante durante el intervalo de la transmisión del paquete.

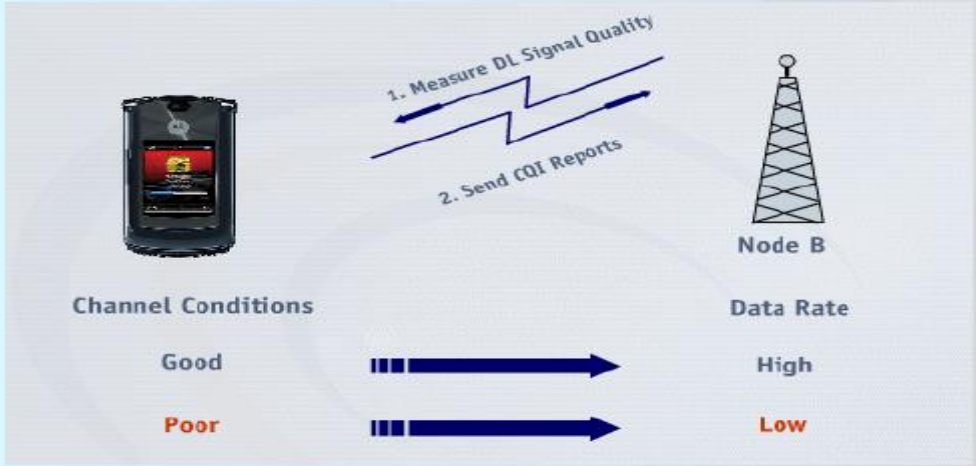
Factores para High Data Rate



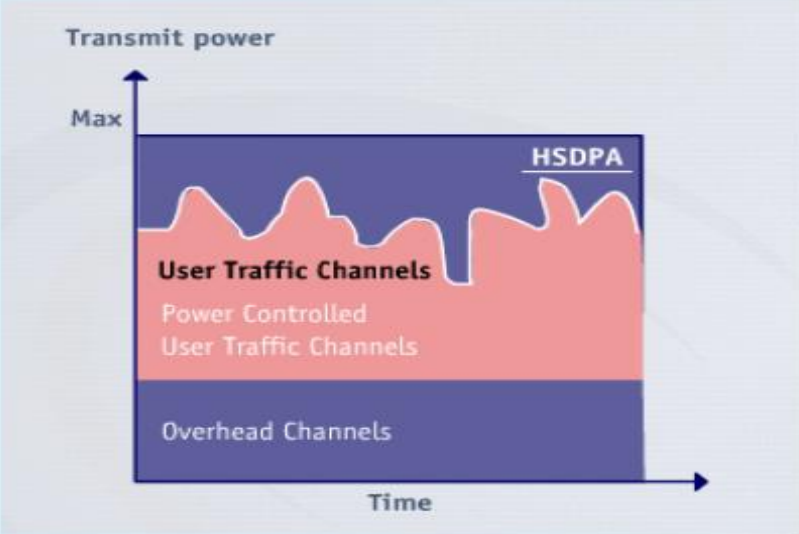
Factores para High Data Rate

- UE estima la calidad del enlace dinámicamente enviando reportes de Calidad.
- HSDPA utiliza toda la potencia disponinble en el Nodo B para transmitir sus canales.
- Utiliza Codificación y Modulación adaptativa para mantener QoS e incrementar el throughout.
- El nodo B agenda los UE basado en sus reportes de Calidad.
- Early Aknowledgement.

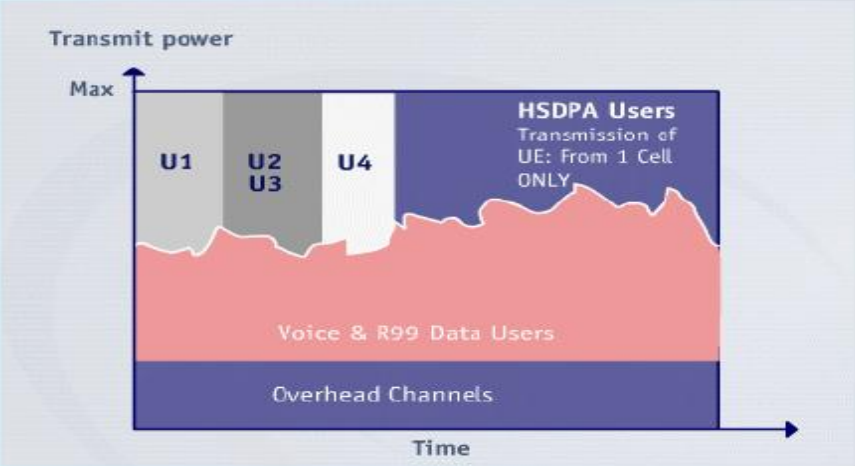
Dynamic Channel Estimation



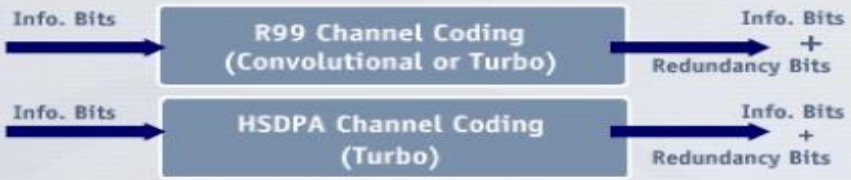
Utilización de Potencia en HSDPA



Asignación de Potencia

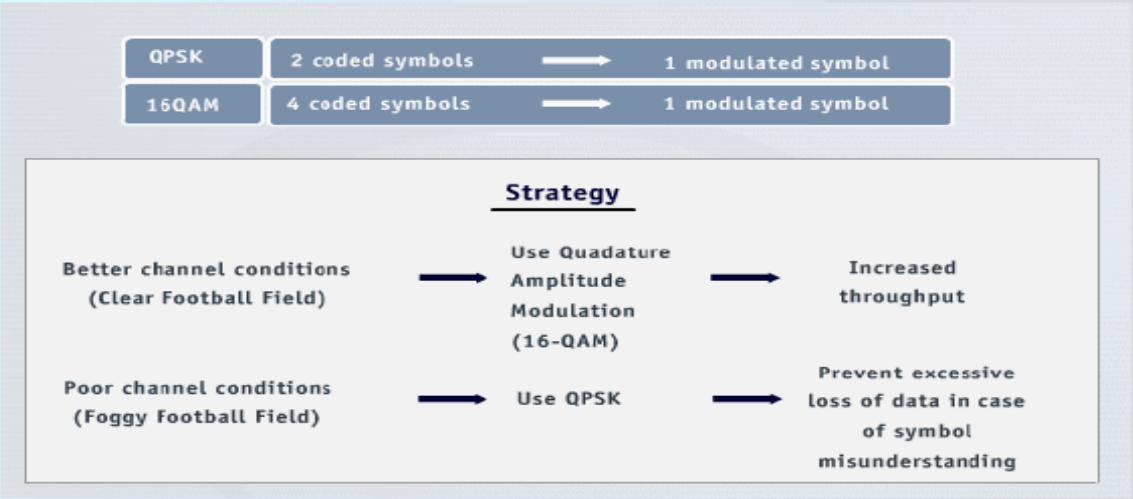


Adaptative Coding

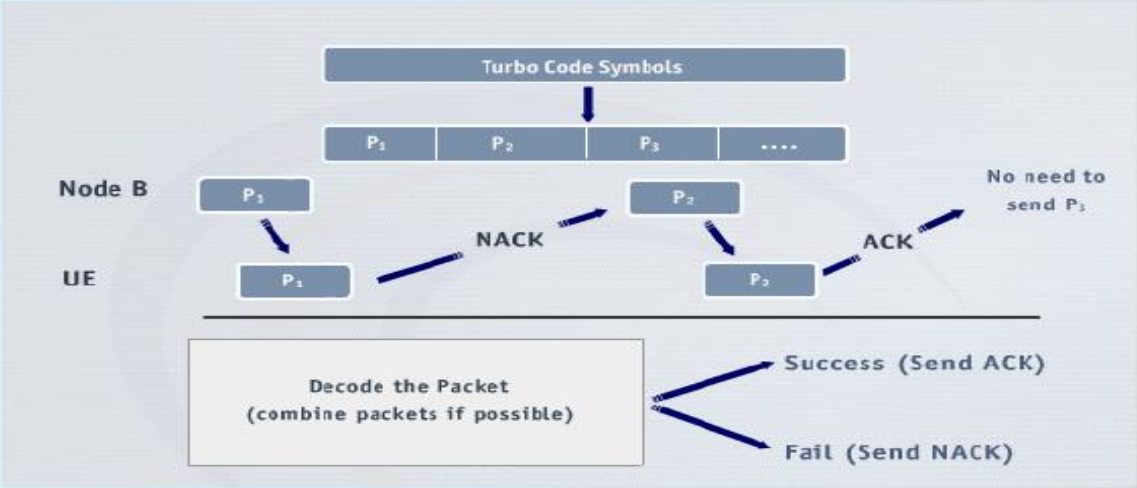


Channel Conditions	R99 over the Air Transmission	R5 over the Air Transmission
Good	(Info+ Redundancy) Bits	Info Bits
Poor	(Info+ Redundancy) Bits	(Info+ Redundancy) Bits
	Fixed Coding	Adaptive Coding

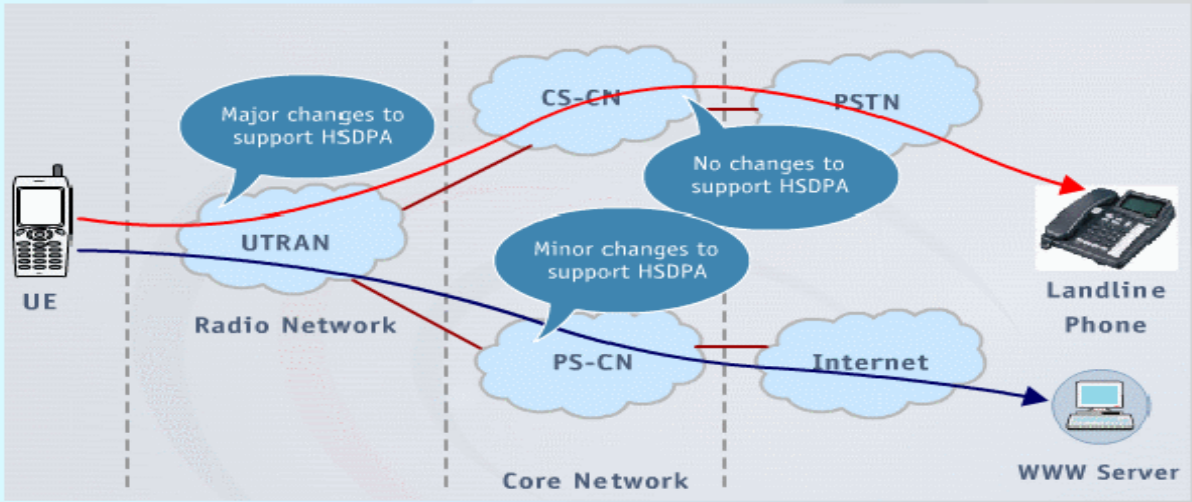
Adaptive Modulation



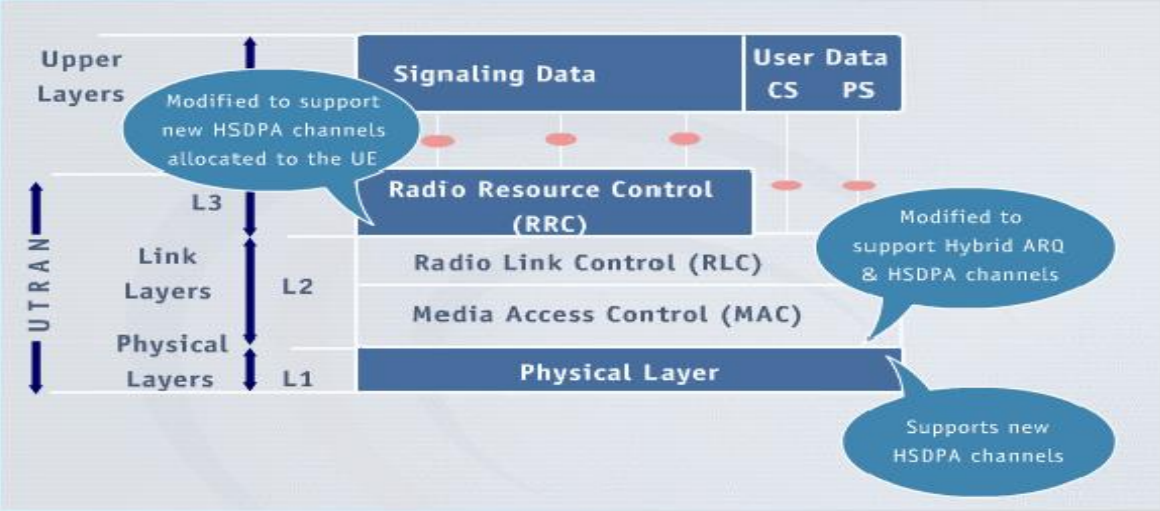
Hybrid ARQ Operation



Cambios en UMTS Rel.99 para HSDPA



Modificaciones para HSDPA



Funciones en el Nodo B

UMTS R99 Node B

Responsibilities

- Physical layer operations
- No dynamic decision making

HSDPA Node B

Responsibilities

- Physical layer operations
- Sophisticated scheduler
  - Channel conditions report processing
  - Buffer management
  - OVSF code management
  - Scheduling
  - Modulation scheme

Categoría de los UE

- Hay 12 categorías, basadas en las capacidades del physical layer.
- Categoría 10 es la mas alta, soporta 14Mbps.
- Categoría 11 es la menor con 0.9 Mbps.
- Categorías 11 y 12 soportan sólo QPSK.
- El resto soporta QPSK y 16-QAM.

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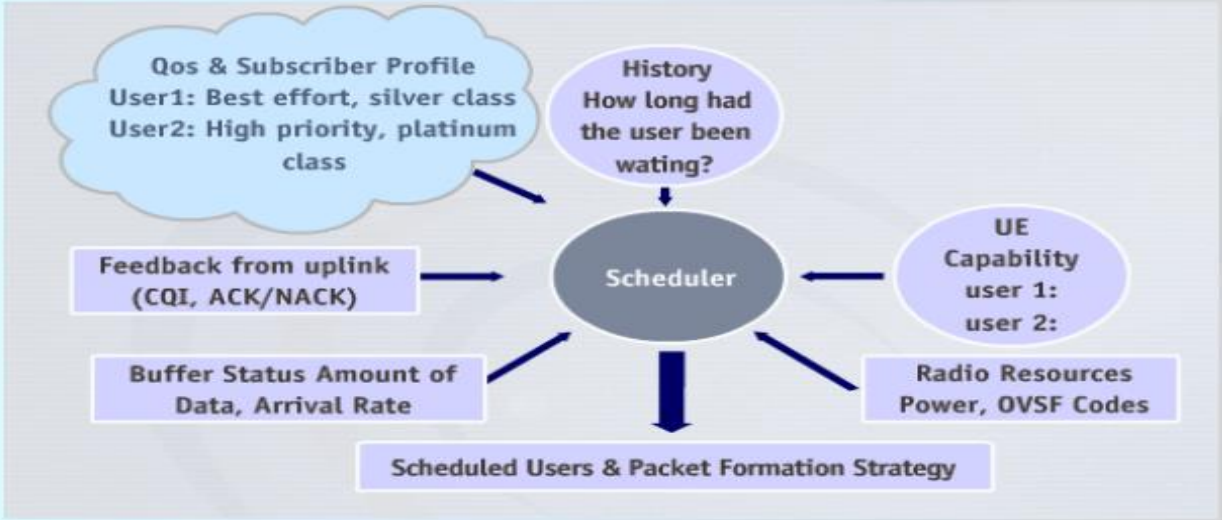
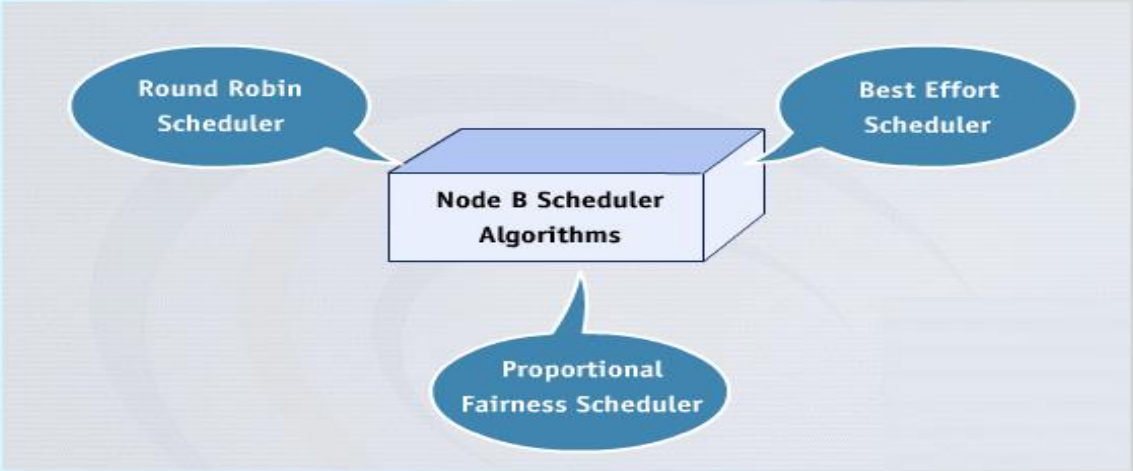
HSDPA

Category	Max. number of HS-DSCH codes	Modulation	MIMO - Dual Carrier	code rate required to achieve max. data rate	Max. data rate [Mbit/s]
1	5	QPSK and 16-QAM		.76	1.2
2	5	QPSK and 16-QAM		.76	1.2
3	5	QPSK and 16-QAM		.76	1.8
4	5	QPSK and 16-QAM		.76	1.8
5	5	QPSK and 16-QAM		.76	3.6
6	5	QPSK and 16-QAM		.76	3.6
7	10	QPSK and 16-QAM		.75	7.2
8	10	QPSK and 16-QAM		.76	7.2
9	15	QPSK and 16-QAM		.70	10.1
10	15	QPSK and 16-QAM		.97	14.4
11	5	QPSK only		.76	0.9
12	5	QPSK only		.76	1.8
13	15	QPSK, 16-QAM and 64-QAM		.82	17.6
14	15	QPSK, 16-QAM and 64-QAM		.98	21.1
15	15	QPSK, 16-QAM	MIMO		23.4
16	15	QPSK, 16-QAM	MIMO		27.9
19	15	QPSK, 16-QAM	MIMO		35.3
20	15	QPSK, 16-QAM, 64-QAM	MIMO		42.2
21	15	QPSK, 16-QAM	DC		23.4
22	15	QPSK, 16-QAM	DC		27.9
23	15	QPSK, 16-QAM, 64-QAM	DC		35.3
24	15	QPSK, 16-QAM, 64-QAM	DC		42.2
25	15	QPSK, 16-QAM	DC + MIMO		46.8
26	15	QPSK, 16-QAM	DC + MIMO		55.9
27	15	QPSK, 16-QAM, 64-QAM	DC + MIMO		70.6
28	15	QPSK, 16-QAM, 64-QAM	DC + MIMO		84.4

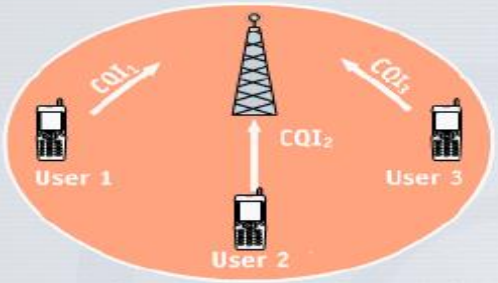
Node B Scheduler



Posibles tipos de Algoritmos



Proportional Fairness Scheduling



R1, R2 & R3 ⟶
moving average over period T

Translate CQI into the data rate for each mobile.

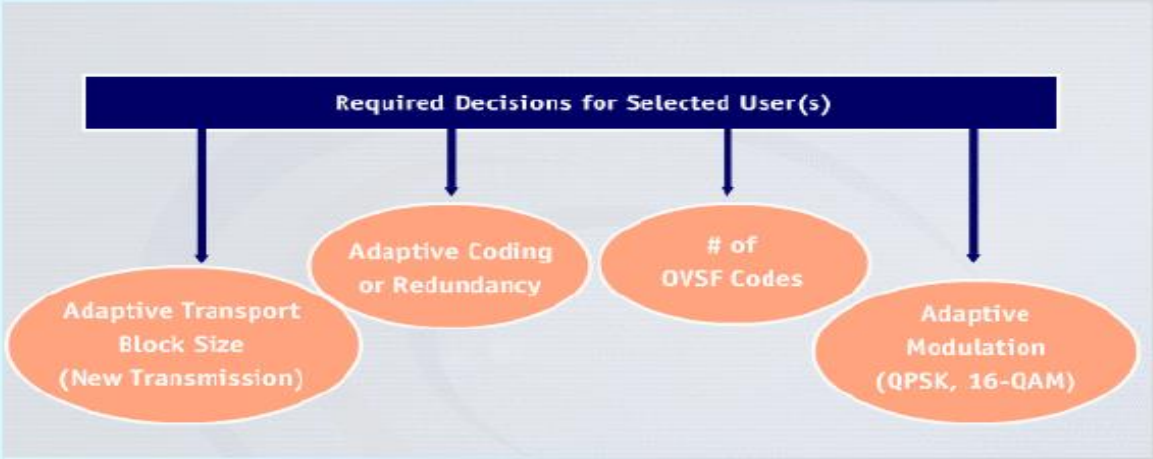
Compute

User 1 Data Rate Computed/R1	User 2 Data Rate Computed/R2	User 3 Data Rate Computed/R3

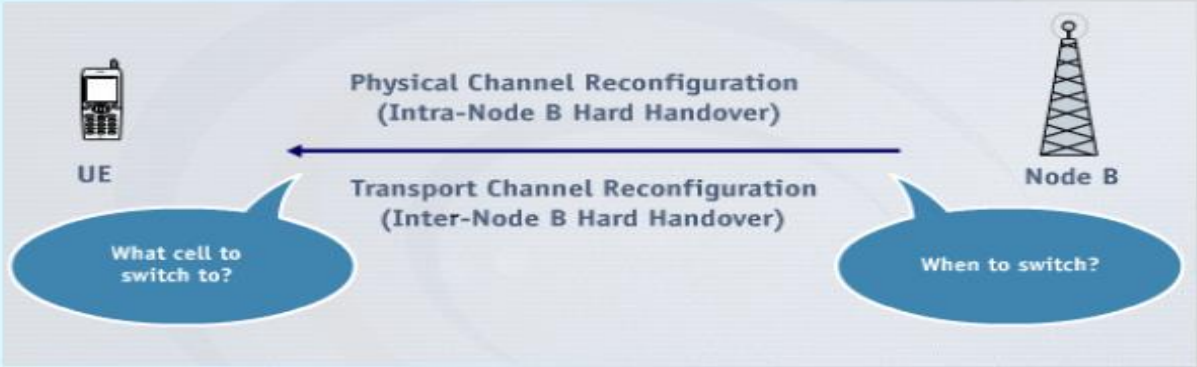
User with highest ratio will be scheduled

(1 of 1)

Decisiones a tomar por el Nodo B



Handover Execution



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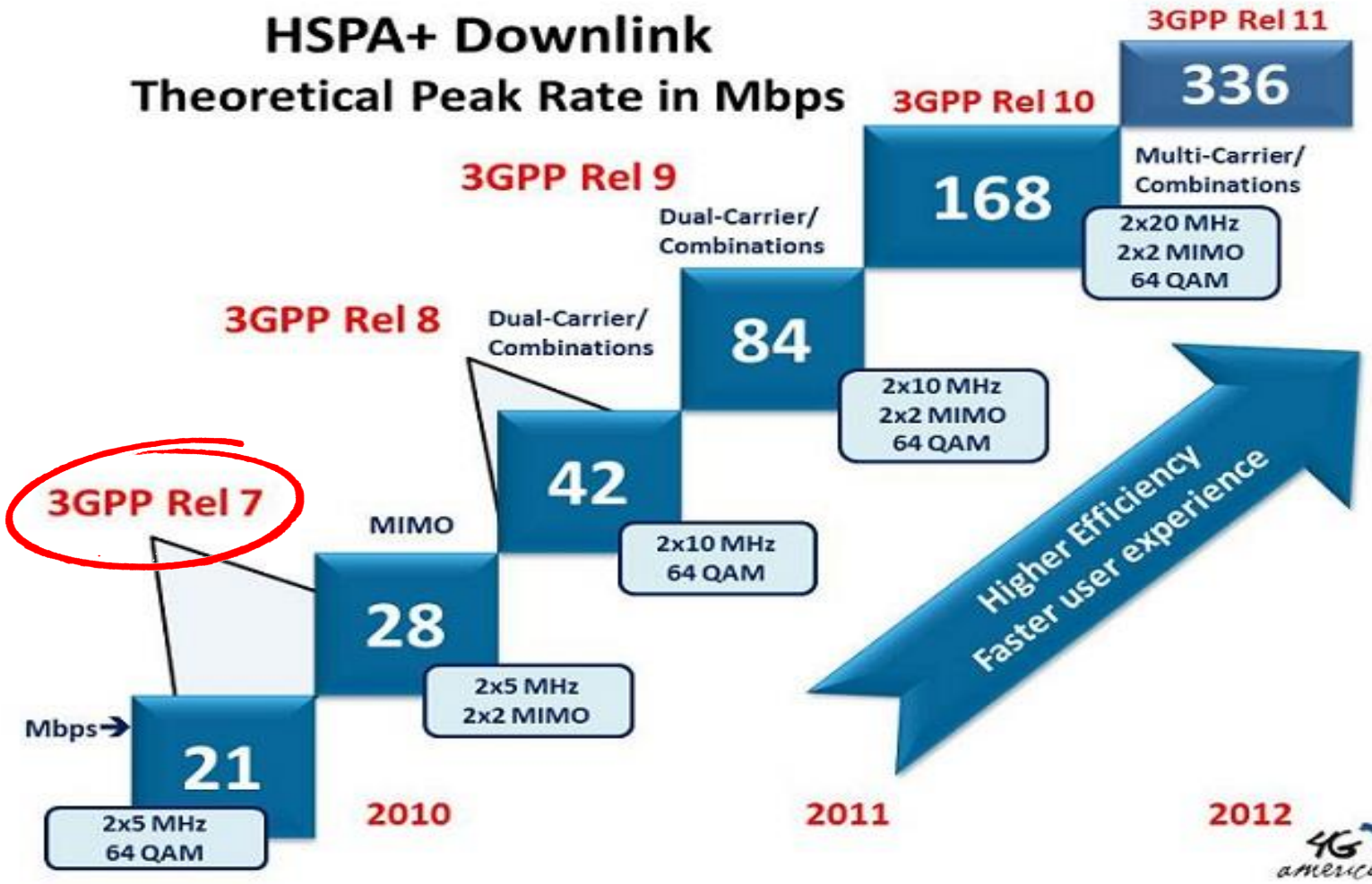
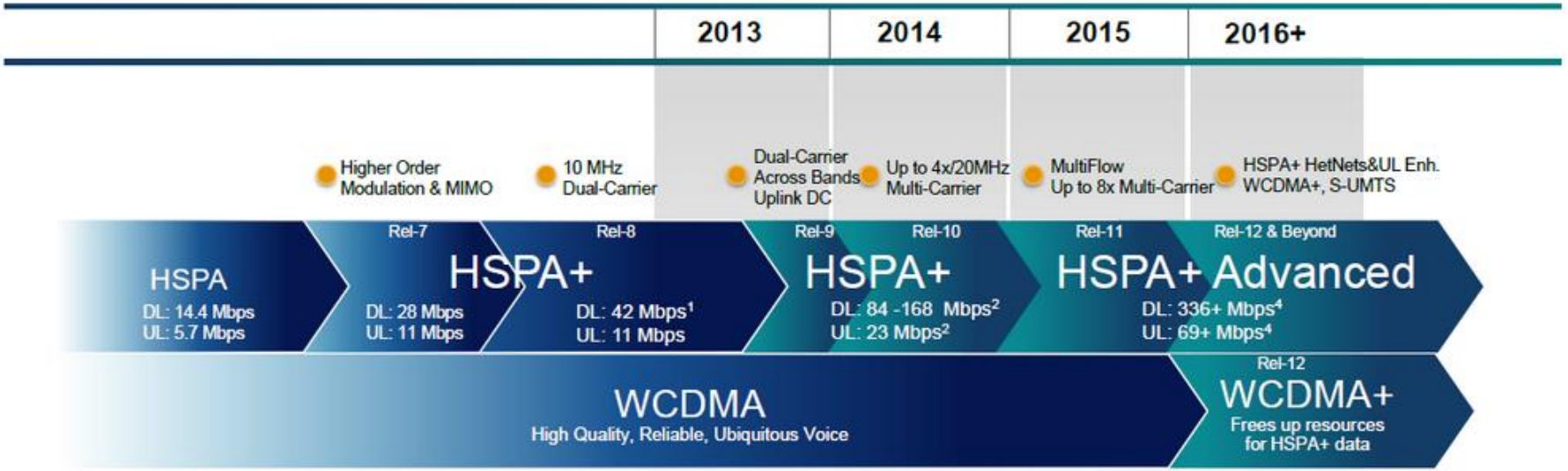
Sistemas de 3era Generación (HSPA+)

*Mg. David Ramirez de los Reyes_*


HSPA+ Downlink
Theoretical Peak Rate in Mbps
3GPP Rel 11
336
3GPP Rel 10
168
Multi-Carrier/
Combinations
2x20 MHz
2x2 MIMO
64 QAM
3GPP Rel 9
Dual-Carrier/
Combinations
84
2x10 MHz
2x2 MIMO
64 QAM
3GPP Rel 8
Dual-Carrier/
Combinations
42
2x10 MHz
64 QAM
3GPP Rel 7
MIMO
28
2x5 MHz
2x2 MIMO
Mbps
21
2x5 MHz
64 QAM
Higher Efficiency
Faster user experience
2010
2011
2012
4G americas

HSPA+ continues to evolve



[1]R8 reaches 42 Mbps by combining 2x2 MIMO and HOM (64QAM) in 5 MHz, or by utilizing HOM (64QAM) and multicarrier in 10 MHz.
[2]R9 combines multicarrier and MIMO in 10 MHz to reach 84 Mbps. Uplink multicarrier doubles uplink peak data rate to 23 Mbps in 10 MHz.
[3]R10 expands multicarrier to 20 MHz to reach up to168 Mbps with 2x2 MIMO.
[4]R11 expands multicarrier up to 40 MHz to reach 336 Mbps with 2x2 MIMO, or 20Mhz with 4x4 MIMO. Uplink 2x2 MIMO with 64QAM reaches 69Mbps.

Commercial
Note: Estimated commercial dates.

5
Created 4/16/2013

HSPA+ UE Categories

3GPP Release	Category	Max. number of HS-DSCH codes	Modulation[3]	MIMO, Dual-Cell	Code rate at max. data rate[4]	Max. data rate [Mbit/s][5]
Release 5	1	5	16-QAM		.76	1.2
Release 5	2	5	16-QAM		.76	1.2
Release 5	3	5	16-QAM		.76	1.8
Release 5	4	5	16-QAM		.76	1.8
Release 5	5	5	16-QAM		.76	3.6
Release 5	6	5	16-QAM		.76	3.6
Release 5	7	10	16-QAM		.75	7.2
Release 5	8	10	16-QAM		.76	7.2
Release 5	9	15	16-QAM		.70	10.1
Release 5	10	15	16-QAM		.97	14.0
Release 5	11	5	QPSK		.76	0.9
Release 5	12	5	QPSK		.76	1.8
Release 7	13	15	64-QAM		.82	17.6
Release 7	14	15	64-QAM		.98	21.1
Release 7	15	15	16-QAM	MIMO	.81	23.4
Release 7	16	15	16-QAM	MIMO	.97	28.0
Release 7	19	15	64-QAM	MIMO	.82	35.3
Release 7	20	15	64-QAM	MIMO	.98	42.2
Release 8	21	15	16-QAM	Dual-Cell	.81	23.4
Release 8	22	15	16-QAM	Dual-Cell	.97	28.0
Release 8	23	15	64-QAM	Dual-Cell	.82	35.3
Release 8	24	15	64-QAM	Dual-Cell	.98	42.2
Release 9	25	15	16-QAM	Dual-Cell + MIMO	.81	46.7
Release 9	26	15	16-QAM	Dual-Cell + MIMO	.97	55.9
Release 9	27	15	64-QAM	Dual-Cell + MIMO	.82	70.6
Release 9	28	15	64-QAM	Dual-Cell + MIMO	.98	84.4

De 4G a 4G Lte…

HSPA+

HSPA+ vs LTE

HSPA+

Similar Peak Data Rates

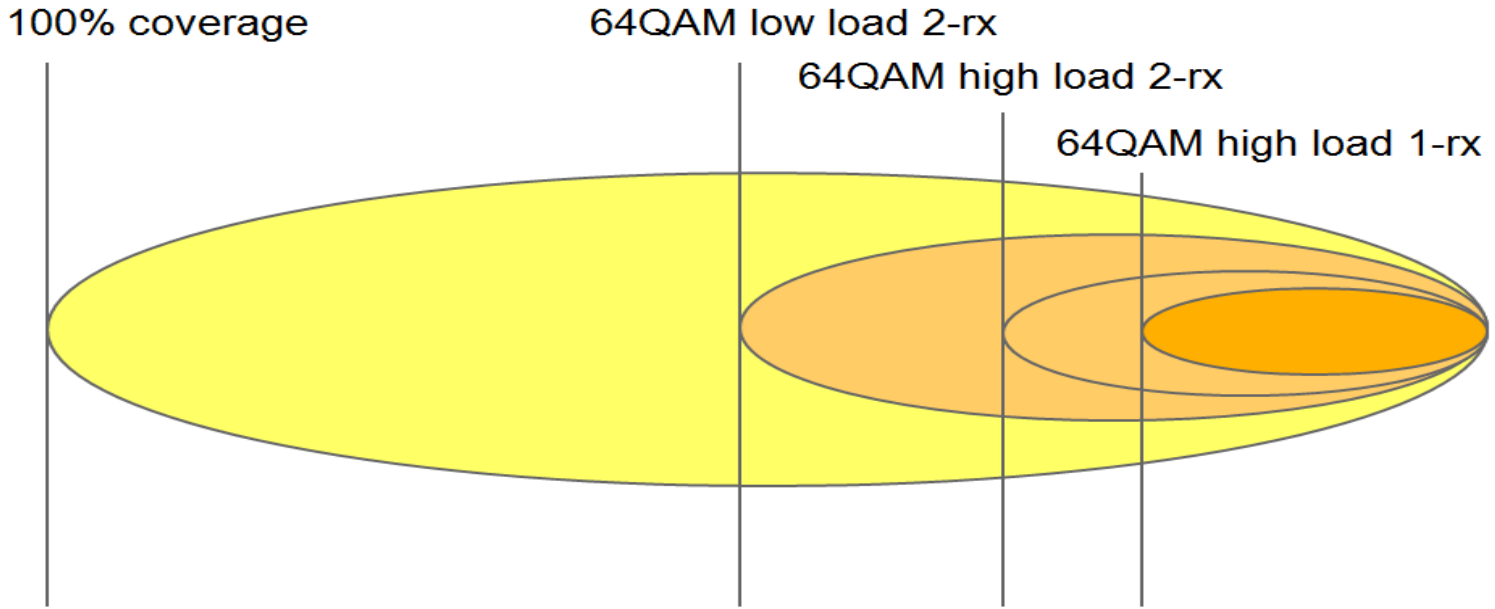
with same bandwidth and number of antennas
(Downlink peak data rate)

Bandwidth	HSPA+	LTE
5 MHz	42 Mbps	37 Mbps
10 MHz	84 Mbps	73 Mbps
20 MHz	168 Mbps[2]	150 Mbps

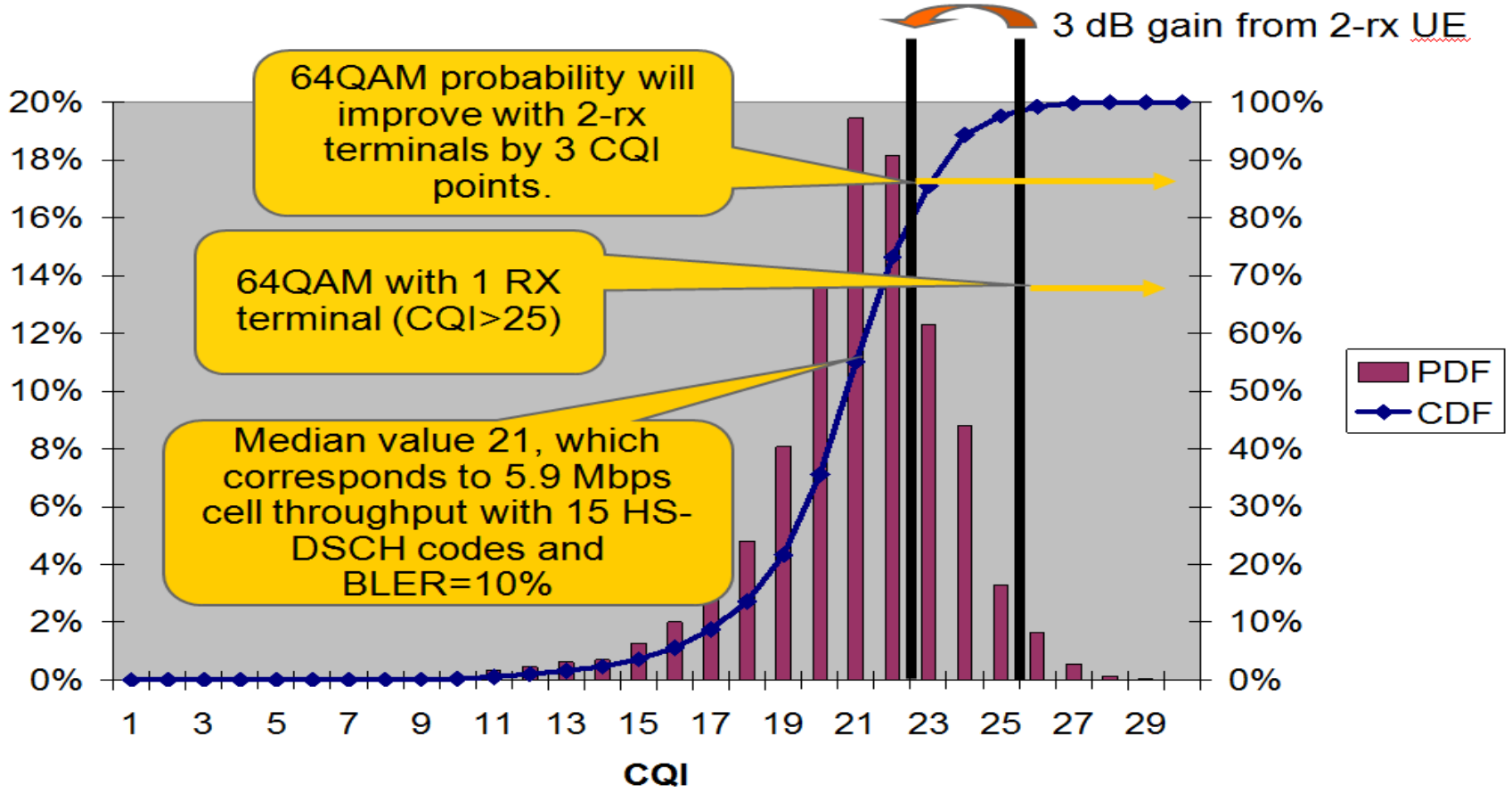
Note: Assuming 2x2MIMO. LTE supports 4x4MIMO but initial deployments will be 2x2 MIMO. LTE takes required overhead into account, 172 Mbps possible per standards

Cobertura de Celda HSPA+

64QAM is used for DL throughput above approx 10 Mbps
High load case → 64QAM used in 6…11% of cell area
Low load case → 64QAM used 14…27% of cell area



Typical CQI Distribution Corresponds to 6 Mbps Cell Throughput



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