Mobile Radio Networks

❑ Long Term Evolution (LTE)

Radio Interface
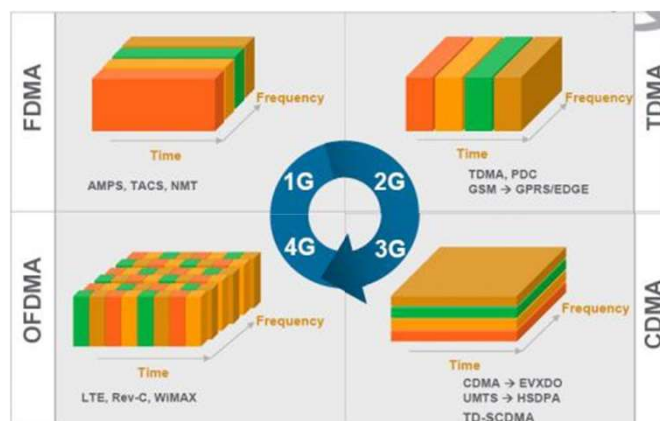
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Multiple Access

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OFDM (1/2)

- In Orthogonal Frequency Division Multiplexing (OFDM) we have to distinguish between temporal and frequency domain
- The band is divided into several **orthogonal subcarriers**
  - The data flow is "divided" and transmitted in parallel on the different subcarriers
  - Each subcarrier, since orthogonal, is received independently

- In the temporal domain we speak of **OFDM symbol**, formed by a data component and a cyclic prefix
  - The cyclic prefix is formed by copying the final portion of the symbol at the beginning of the symbol
  - This procedure is used to reduce the phenomena of ISI and delay spread (distortion of the signal due to several replications arrived at different times)
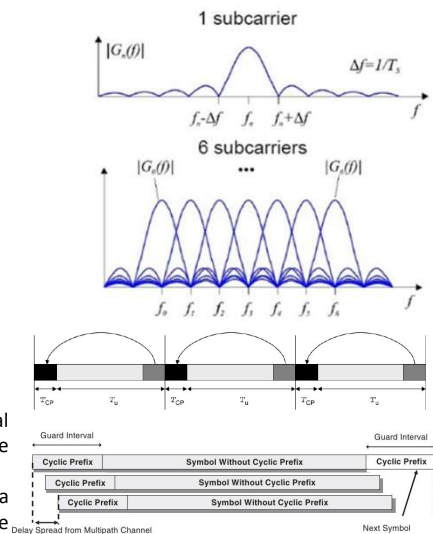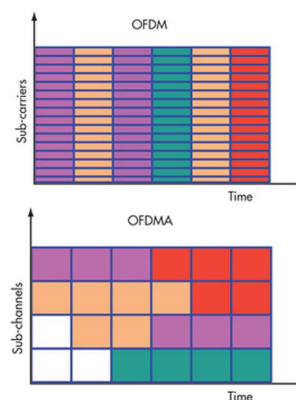
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Multiple Access with OFDM

- In OFDM in an instant of time all the subcarriers are assigned to the same user
- Multiple access takes place over time

Downlink
- In Orthogonal Frequency Division Multiple Access (OFDMA) in a given instant the available subcarriers are divided among multiple users
- Each subcarrier carries information related to a single symbol

What the advantages of OFDMA with respect to FDMA ?

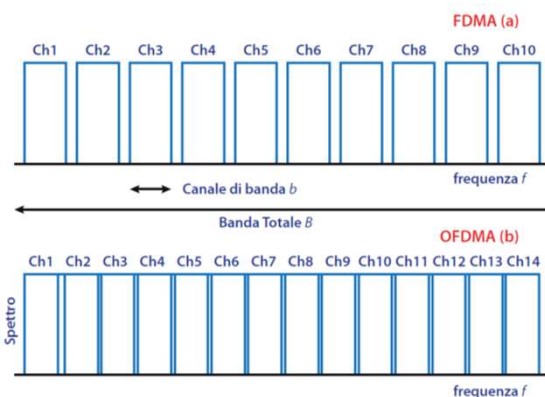Mobile Radio Networks– 2024/25   43   Antonio Iera

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OFDMA vs. FDMA

- With OFDMA a spectrum overlapping is allowed, thanks to:
    - maintenance of the orthogonality property
    - appropriate choice of subcarrier spacing
    - choice of the duration of the symbols that modulate them

FDMA (a)
Ch1 Ch2 Ch3 Ch4 Ch5 Ch6 Ch7 Ch8 Ch9 Ch10
Canale di banda b
Banda Totale B
frequenza f

OFDMA (b)
Ch1 Ch2 Ch3 Ch4 Ch5 Ch6 Ch7 Ch8 Ch9 Ch10 Ch11 Ch12 Ch13 Ch14
Spettro
frequenza f

- Within the same bandwith B a number of equivalent channels $N_{OFDMA} > N_{FDMA}$
- Increased spectral efficiency of the OFDMA compared to the FDMA by being able to transmit more information in the same band.

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Multiple access with OFDM: uplink

Uplink

- In the Single Carrier Frequency Division Multiple Access (SC-FDMA) technique, each subcarrier contains information on all the symbols transmitted by the user
- The fluctuations of the transmitted signal are reduced, with a consequent decrease in transmission power
- Technique of lower spectral efficiency, but more suitable for amplification by the terminals.

OFDMA vs. SC-FDMA

45
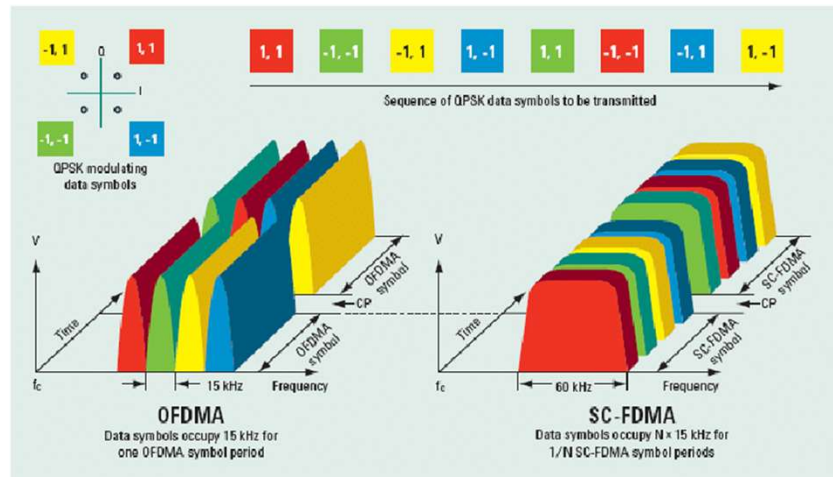
OFDM vs. SC-FDMA
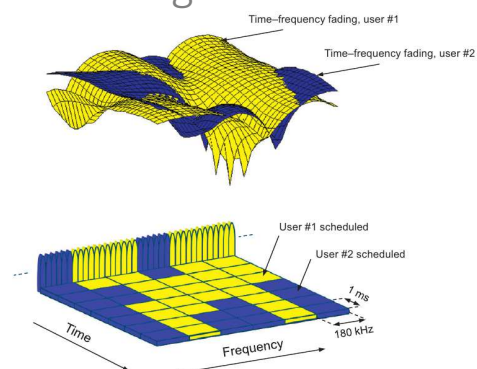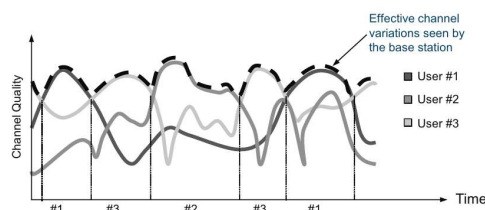
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Channel Dependent Scheduling

- **Frequency selectivity:** consists in selecting the portion of the band to be assigned to a user

- **Multiuser diversity:** each user measures different channel qualities on the different portions of the band, so each user can have assigned the "best" portions by optimally exploiting the radio channel

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Physical frame

- A sub-frame is named **Transmission Time Interval (TTI)** and its duration is 1 ms
  - Channel conditions are assumed to be constant during one TTI
  - The transmission parameters (modulation scheme and code rate) are updated every TTI

- one **slot** lasts 0.5 ms and is composed of more OFDM symbols
  - 7 symbols with normal prefix
  - 6 symbols with extended prefix
  - 3 symbols in case of MBSFN
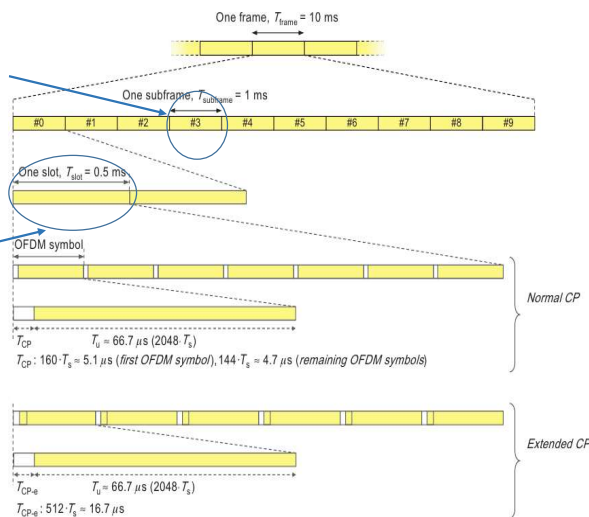
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TDD vs. FDD

Frequency Division Duplex:
- bandwidth divided in two parts, allowing simultaneous downlink and uplink data transmissions; the LTE frame is composed of 10 consecutive identical sub-frames.

Time Division Duplex (TDD):
- the LTE frame is divided into two consecutive half-frames, each one lasting 5ms. Several frame configurations allow different balance of resources dedicated for downlink or uplink transmission.
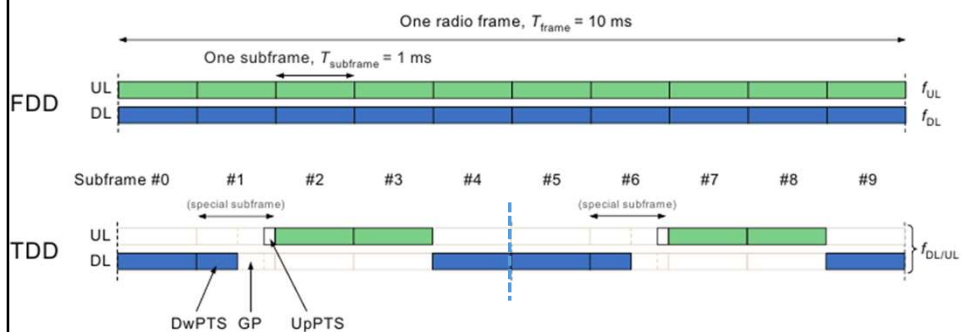
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Resource Block (1/3)

- A **Resource Block** (**RB**) is formed from:
  - **12 adjacent subcarriers** (for a total of 180 kHz)
  - **1 slot** (0.5 ms)
  - An RB can be imagined as a box where user data, signals and control data are allocated. Number of RB and number of subcarriers depend on channel frequency bandwidth
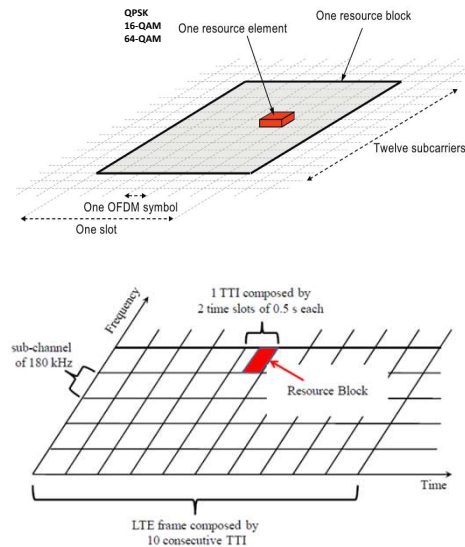
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Resource Block (2/3)

- The scheduler assigns the RBs every TTI (i.e., every millisecond)
- An RB lasts 0.5 ms, so each TTI has 2 RBs assigned in the time domain (**RB block pair**)

- **Virtual RB** (VRB): are RBs managed by the scheduler
- **Physical RB** (PRB): are RB physically sent over the channel

Localized VRB-to-PRB mapping

Distributed VRB-to-PRB mapping
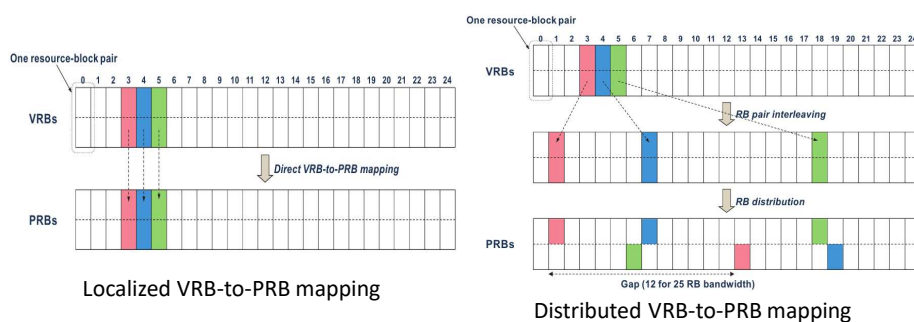
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LTE - Introduzione   6

Mobile Radio Networks

❑ Long Term Evolution (LTE)

Radio Resource Management

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Radio Resource Management

Il Radio Resource Management (**RRM**) deals with:
• Efficiently managing radio resources (frequency and time domain)
• Dynamically adapting the transmission parameters
• Ensuring the QoS requirements for each flow

	User-plane	Control-plane	RRM functions		
Layer-3	PDCP	RRC	QoS management	Admission control	Persistent scheduling
Layer-2	RLC / MAC	RLC / MAC	Hybrid ARQ manager	Dynamic scheduling	Link adaptation
Layer-1	PHY	PHY	PDCCH adaptation	CQI manager	Power control
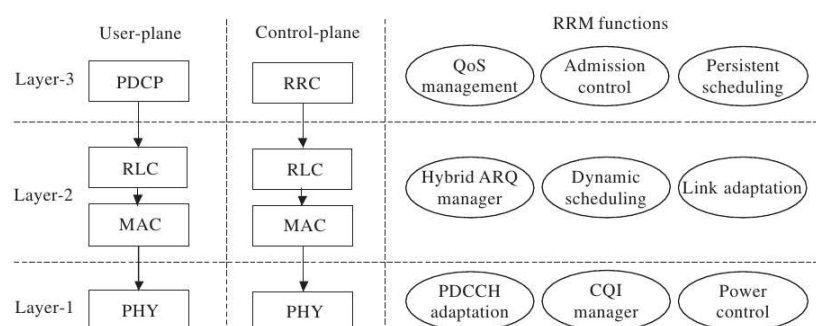
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Admission Control & QoS

Admission Control (**AC**)
- Decides whether or not to accept a new request (an EPS bearer)
- The choice is made by considering the QoS and priority requirements of the new bearer and of all bearers already active in the cell
- The request is accepted only if the QoS requested by the new bearer can be guaranteed without affecting the QoS of the already active flows
- AC algorithms are not standardized by 3GPP and an operator is free to implement its own algorithm

QCI	Resource type	Priority	Packet delay budget (ms)	Packet error loss rate	Example services
1	GBR	2	100	10^{-2}	Conversational voice
2	GBR	4	150	10^{-3}	Conversational video (live streaming)
3	GBR	5	300	10^{-6}	Non-conversational video (buffered streaming)
4	GBR	3	50	10^{-3}	Real time gaming
5	Non-GBR	1	100	10^{-6}	IMS signalling
6	Non-GBR	7	100	10^{-3}	Voice, video (live streaming), interactive gaming
7	Non-GBR	6	300	10^{-6}	Video (buffered streaming)
8	Non-GBR	8	300	10^{-6}	TCP-based (e.g. WWW, e-mail) chat, FTP, p2p file sharing, progressive video, etc.
9	Non-GBR	9	300	10^{-6}	

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Scheduling & Link Adaptation

Packet Scheduler (**PS**) is the RRM entity at layer 2 that:
- Performs scheduling operations every TTI (TTI = 1ms)
- Allocates Resource Blocks (RBs) to users selected for transmission
- Chooses the transmission parameters (modulation and coding scheme, MCS) for the RB (link adaptation)

PS objectives are:
- Maximize cell capacity (in terms of users served)
- Ensure adequate QoS for each flow
- Offer an adequate number of resources to best-effort flows (web browsing, mail, etc.)

- Although a user has multiple active streams, PS decisions are made on a user basis
- Each stream has a unique identifier (Logical Channel Identification, LCID)
- Once the PS selects the resources to be assigned to each user, the MAC level will take care of selecting the amount of data to be sent from each LCID

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Packet Scheduler

Buffer information — QoS Parameters

Step 1 Schedulability check — Schedulable user set → **Step 2** QoS Time Domain Scheduler — N_mux users → **Step 3** Frequency Domain Scheduler → subframe builder

Link Adaptation Information
Channel Quality Indicator
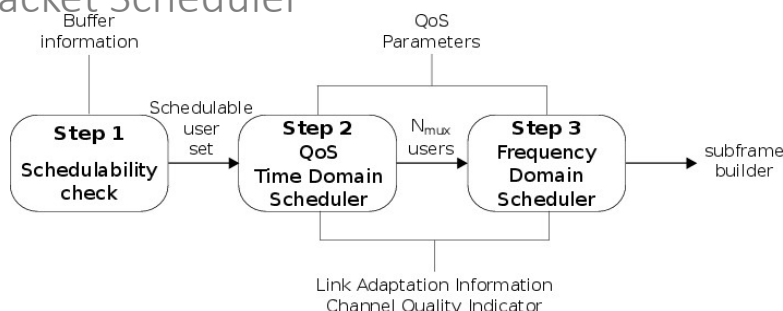
Step 1
• Users with pending traffic in their respective buffers are selected
Step 2
• Based on the QoS parameters of the user traffic, the amount of data (i.e. the number of packets) to be taken from each queue is selected
**Step 3**
• Based on the amount of data to be sent to the user, the number of RB to be assigned to the user is selected
• The RBs are assigned to the user and the modulation scheme for the assigned RBs

Channel Quality Indicator Reporting

• The choice of the modulation scheme for the different RBs assigned to a user is made on the basis of the quality of the channel perceived by the users
• The Signal to Interference plus Noise Ratio (**SINR**) is calculated for each subcarrier
  • Path Loss
  • Slow fading (shadowing)
  • Fast Fading (multipath)
  • Interference (intra- and inter-cell)

• The SINR value obtained is "converted" into **Channel Quality Indicator** (**CQI**)
  • The CQI indicates the *maximum modulation and coding scheme (MCS) supported by the user in order to guarantee traffic reception with a Block Error Rate (BLER) of less than 10%*
  • The CQI is transmitted to the eNB by the User

Adaptive Modulation and Coding

- The CQI reporting procedure is strictly related to the **Adaptive Modulation and Coding (AMC)** module
- It selects the proper Modulation and Coding Scheme (MCS)
- Objective: maximize the supported throughput with a given target Block Error Rate (BLER)
- Limited number of allowed modulation and coding schemes, hence, system throughput is upper-bounded: over a certain threshold an increase in the Signal to Interference plus Noise Ratio (SINR) does not bring to any throughput gain. [Dahlman et al., 2008].
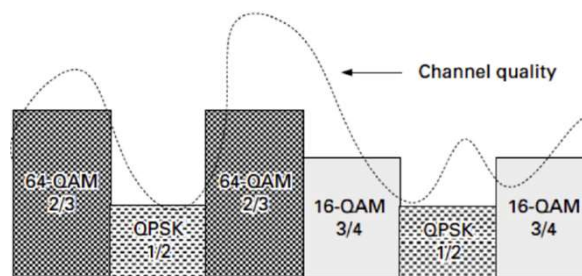
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Channel Quality Indicator

CQI value	Modulation	Code rate	Minimum Rate [kbps]	Maximum Rate [kbps]
1	QPSK	0.076	25.59	1279.32
2	QPSK	0.120	39.38	1968.96
3	QPSK	0.190	63.34	3166.80
4	QPSK	0.300	101.07	5053.44
5	QPSK	0.440	147.34	7366.80
6	QPSK	0.590	197.53	9876.72
7	16-QAM	0.370	248.07	12403.44
8	16-QAM	0.480	321.57	16078.44
9	16-QAM	0.600	404.26	20212.92
10	64-QAM	0.450	458.72	22936.20
11	64-QAM	0.550	558.15	27907.32
12	64-QAM	0.650	655.59	32779.32
13	64-QAM	0.750	759.93	37996.56
14	64-QAM	0.850	859.35	42967.68
15	64-QAM	0.930	933.19	46659.48

A CQI value does not affect the maximum data rate supported by the user. The data rate depends exclusively on the number of RB assigned
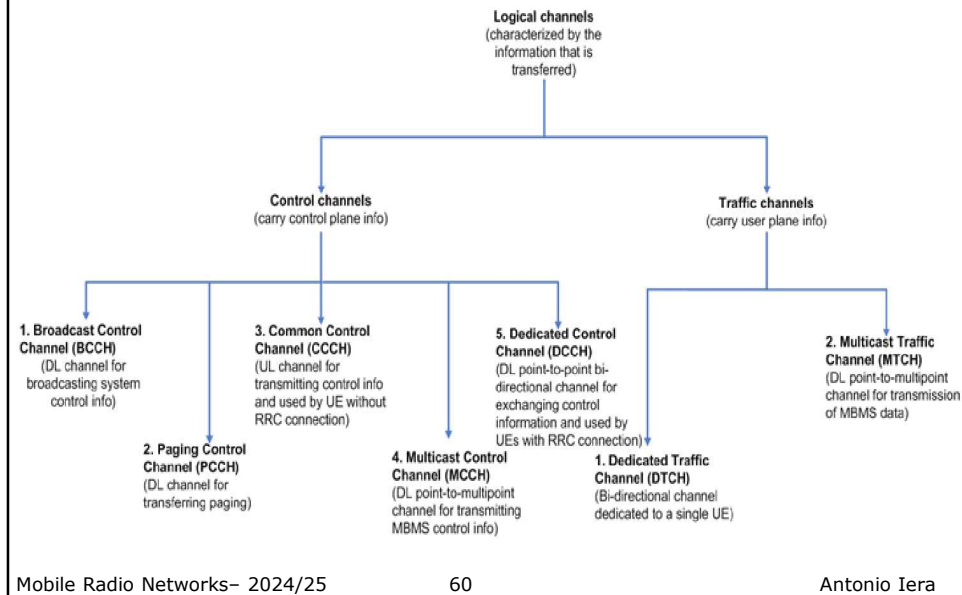
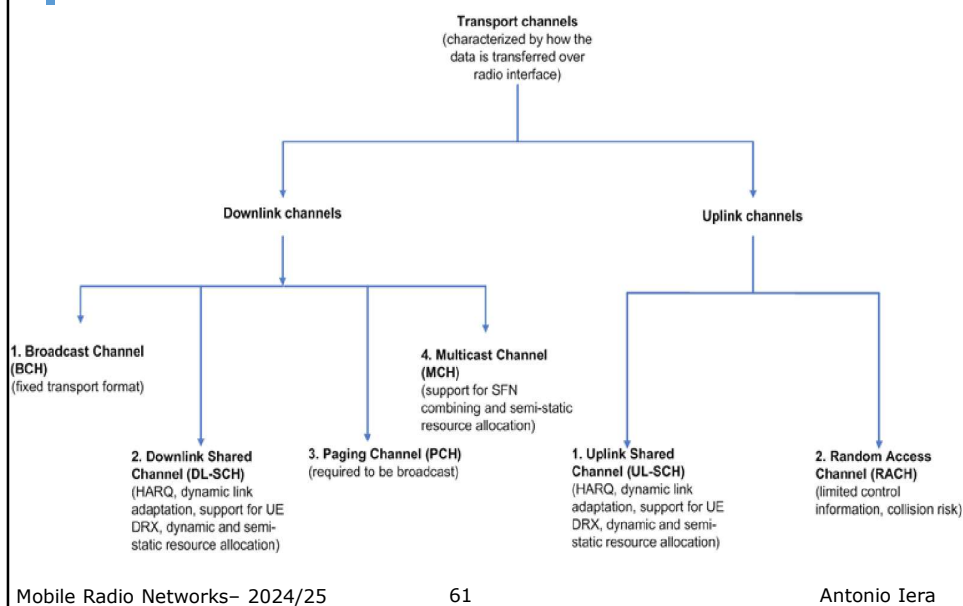Mobile Radio Networks– 2024/25   59   Antonio Iera

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Logical Channels

Logical channels
(characterized by the information that is transferred)

Control channels
(carry control plane info)

Traffic channels
(carry user plane info)

1. Broadcast Control Channel (BCCH)
(DL channel for broadcasting system control info)

3. Common Control Channel (CCCH)
(UL channel for transmitting control info and used by UE without RRC connection)

5. Dedicated Control Channel (DCCH)
(DL point-to-point bi-directional channel for exchanging control information and used by UEs with RRC connection)

2. Multicast Traffic Channel (MTCH)
(DL point-to-multipoint channel for transmission of MBMS data)

2. Paging Control Channel (PCCH)
(DL channel for transferring paging)

4. Multicast Control Channel (MCCH)
(DL point-to-multipoint channel for transmitting MBMS control info)

1. Dedicated Traffic Channel (DTCH)
(Bi-directional channel dedicated to a single UE)

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Transport Channels

Transport channels
(characterized by how the data is transferred over radio interface)

Downlink channels

Uplink channels

1. Broadcast Channel (BCH)
(fixed transport format)

4. Multicast Channel (MCH)
(support for SFN combining and semi-static resource allocation)

2. Downlink Shared Channel (DL-SCH)
(HARQ, dynamic link adaptation, support for UE DRX, dynamic and semi-static resource allocation)

3. Paging Channel (PCH)
(required to be broadcast)

1. Uplink Shared Channel (UL-SCH)
(HARQ, dynamic link adaptation, support for UE DRX, dynamic and semi-static resource allocation)

2. Random Access Channel (RACH)
(limited control information, collision risk)

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Physical Channels: Downlink

Downlink Data
- Transmitted by the eNB on the Physical Downlink Shared Channel (PDSCH).
- PDSCH shared among all users: no reservation.
- PDSCH payloads transmitted only in given portion of the spectrum and time intervals.

Downlink Control Signaling
- Carried by 3 physical channels
- Physical Downlink Control Channel important for scheduling
- PDCCH carries assignments for downlink resources and uplink grants, including the used MCS.

Notes
- Control overhead has influence on downlink performance
- Every TTI a significant amount of radio resources is used for signaling

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Physical Channels: Uplink

Physical Uplink Shared Channel
- Used for data transmission in uplink
- Uplink control signals multiplexed on PUSCH when UE scheduled for data transmission
- Different control fields, e.g., ACK/NACK and CQI

Physical Uplink Control Channel
- No data foreseen in a given TTI
- Signaling, e.g., ACK/NACK related to downlink transmissions, downlink CQI, requests for uplink transmission

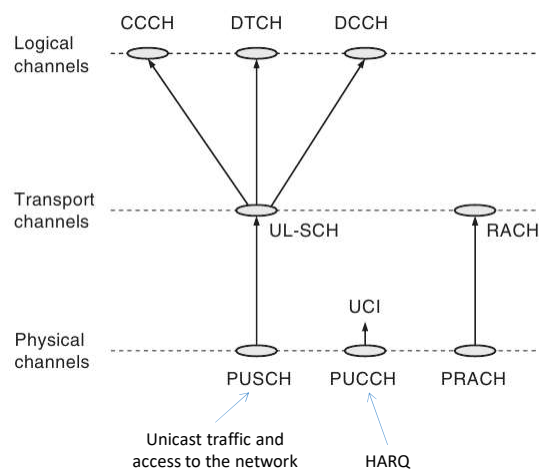Due to single carrier limitations, simultaneous transmission on both channels is not allowed.

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Mapping (downlink)

Logical channels: PCCH BCCH CCCH DTCH DCCH MTCH MCCH

Transport channels: PCH BCH DL-SCH MCH

Physical channels: PBCH PDSCH PDCCH PHICH PCFICH PMCH

DCI

HARQ

Control traffic (scheduling, PDSCH reception, grants in uplink)

information for demodulating PDCCH

unicast & paging traffic
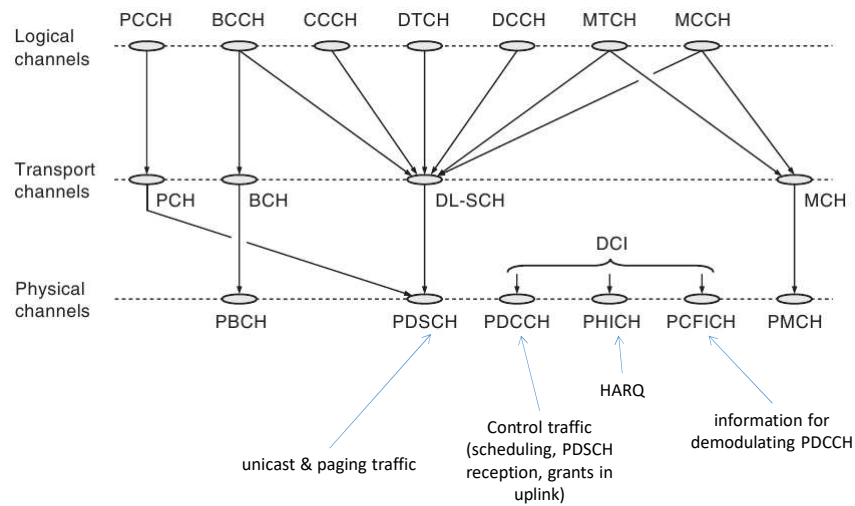
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Mapping (uplink)

Logical channels: CCCH DTCH DCCH

Transport channels: UL-SCH RACH

Physical channels: PUSCH PUCCH PRACH

UCI

Unicast traffic and access to the network

HARQ

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Mobile Radio Networks

❑ – Long Term Evolution – Advanced (LTE-A)

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IMT Advanced

- The fourth generation (**4G**) wireless is defined within the project International Mobile Telecommunications Advanced (IMT-Advanced) published by ITU-R in July of 2008:
  - **LTE-Advanced** (**LTE-A**) is the solution proposed by 3GPP (LTE Rel. 10)
  - **IEEE 802.16m** (mobile WiMAX) is the solution proposed by IEEE

Item		Antenna configuration	IMT Advanced	LTE (Rel. 8)	LTE Advanced
Peak data rate	DL	8 × 8	1 Gbps	300 Mbps	1 Gbps
	UL	4 × 4	–	75 Mbps	500 Mbps
Peak spectrum efficiency (bps/Hz)	DL	8 × 8	15	15	30
	UL	4 × 4	6.75	3.75	15
		2 × 2	–	1.69	2.4
Capacity (bps/Hz/cell)	DL	4 × 2	2.2	1.87	2.6
		4 × 4	–	2.67	3.7
	UL	1 × 2	–	0.74	1.2
		2 × 4	1.4	–	2.0
		2 × 2	–	0.05	0.07
Cell-edge user throughput (bps/Hz/cell/user)	DL	4 × 2	0.06	0.06	0.09
		4 × 4	–	0.08	0.12
	UL	1 × 2	–	0.024	0.04
		2 × 4	0.03	–	0.07

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LTE –Key Features in Release 10

Support of Wider Bandwidth(Carrier Aggregation)
- Use of multiple component carriers(CC) to extend bandwidth up to 100 MHz
- Common physical layer parameters between component carrier and LTE Rel-8 carrier
-> Improvement of peak data rate, backward compatibility with LTE Rel-8
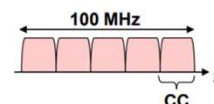
Advanced MIMO techniques
- Extension to up to 8-layer transmission in downlink
- Introduction of single-user MIMO up to 4-layer transmission in uplink
- Enhancements of multi-user MIMO
-> Improvement of peak data rate and capacity
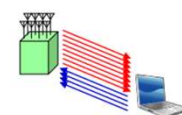
Heterogeneous network and eICIC(enhanced Inter-Cell Interference Coordination)
- Interference coordination for overlaid deployment of cells with different Tx power
-> Improvement of cell-edge throughput and coverage
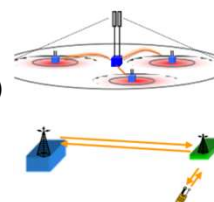
Further optimizations to support:
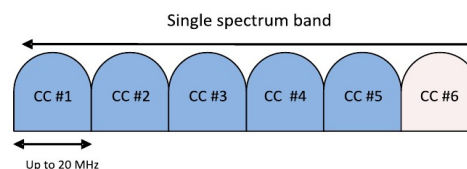- M2M (Machine-to- Machine) traffic and Internet browsing

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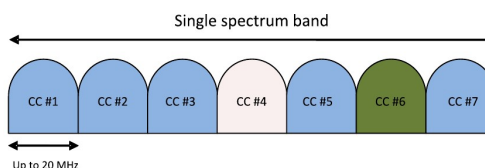
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Carrier Aggregation (1/2)

- LTE-A aims to bring broadband to mobile radio systems:
- LTE-A considers a maximum bandwidth of 100 MHz
- In addition to the portions of the band already allocated for LTE, the use of additional bands is envisaged
    - 450-470 MHz
    - 698-862 MHz
    - 790-862 MHz
    - 2.3-2.4 GHz
    - 3.4-4-2 GHz
    - 4.4-4.9 GHz

- Carrier Aggregation techniques are used to reach 100 MHz of bandwidth
    - Multiple LTE Component Carriers (CC) are grouped together
    - 5 CC maximum (20 MHz x 5 CC)
    - An LTE-A user "sees" a 100 MHz spectrum since he will be able to use all the CCs simultaneously
    - An LTE user "sees" only one CC
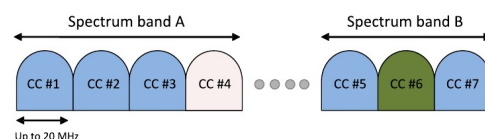   - Backward compatibility with Rel. 8 systems is ensured

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Carrier Aggregation (2/2)

- Contiguous bands in the same portion of the spectrum

Single spectrum band

| CC #1 | CC #2 | CC #3 | CC #4 | CC #5 | CC #6 |

Up to 20 MHz

- Non contiguous bands in the same portion of the spectrum

Single spectrum band

| CC #1 | CC #2 | CC #3 | CC #4 | CC #5 | CC #6 | CC #7 |

Up to 20 MHz

- Non contiguous bands in different portions of the spectrum

Spectrum band A   Spectrum band B

| CC #1 | CC #2 | CC #3 | CC #4 | • • • • | CC #5 | CC #6 | CC #7 |

Up to 20 MHz

Enhanced MIMO techniques (1/2)

- Single-User MIMO (**SU-MIMO**)
  - multiple simultaneous streams (transmit diversity)
  - Increased reception power
  - Data rate increase

- Multi-User MIMO (**MU-MIMO**)
  - SU-MIMO + beamforming
  - Exploits Spatial Division Multiple Access (SDMA)

- **Cooperative MIMO**
  - Multiple antennas coordinate to transmit the same signal to a user
  - Increase in reception power with a consequent increase in the quality perceived by the user
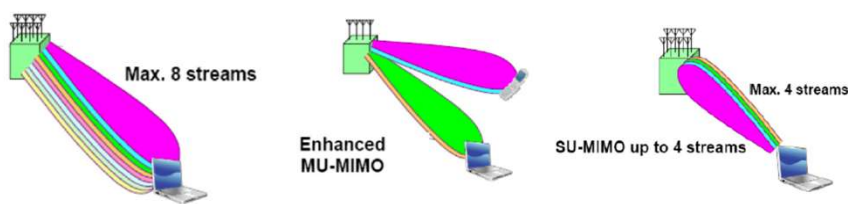
Cooperative MIMO
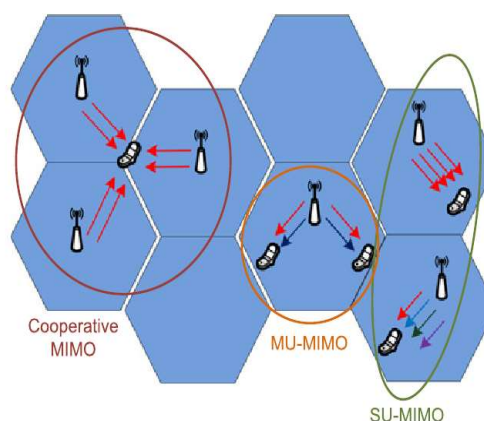
MU-MIMO

SU-MIMO

Enhanced MIMO techniques (2/2)

- Extension up to 8-layer transmission (increased from 4 layers in Rel-8/9) in the downlink direction

- Support for enhanced Multi-user MIMO (MU-MIMO) in downlink

- Introduction of Single-user MIMO (SU-MIMO) up to 4-stream transmission in uplink

Max. 8 streams

Enhanced MU-MIMO

SU-MIMO up to 4 streams   Max. 4 streams

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Heterogeneous Network

Heterogeneous Network (**HetNet**)

- Coexistence of long range cells (macro cell) and short range cells (micro cell) (macro cell 5-40W; micro cell 250mW-2W)
- Extension of coverage in shaded areas
- Increase in the number of users served
- Increased throughput for cell edge users
- Increase in the coverage radius of the macro cell
- Hot-spot
- Reduction of installation costs (a micro cell costs less than eNB)
- Decreased power consumption of mobile terminals
- Decreased transmission power of the base stations
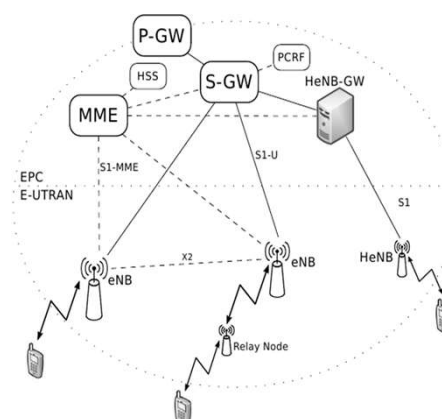
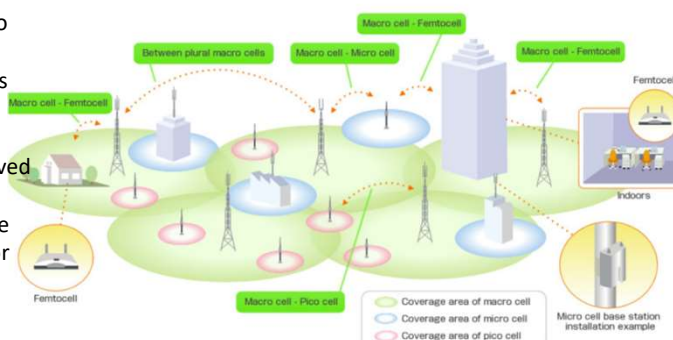Mobile Radio Networks– 2024/25   73   Antonio Iera

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Heterogeneous Network

A Heterogeneous Network (**HetNet**) consists of a mix of *macro cells*, handled by a common LTE base station (i.e., the eNB) and *small-range cells* managed by low-power nodes (i.e., micro, pico, relay, and femto).

- *micro*, *pico*, and *relay* devices are conceived to enhance coverage and capacity in some regions inside the macro cell

- *femto* nodes are conceived to offer broadband services in indoor (home and offices) and outdoor scenarios with a very limited geographical coverage.

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Micro cell

Picocell
- It is a normal eNB
- Indoor/Outdoor
- The only difference compared to an eNB macro is that it has a lower transmission power (250mW-2W in outdoor; <100mW indoor)
- Omni-directional transmission
- From an architectural point of view it is a "normal" eNB, therefore equipped with the X2 interface for interconnection with other picocells and with other eNBs

Femtocell (aka **HeNB**)
- Typically they are nodes for indoor coverage
- Omni-directional transmission with power less than 100mW
- They use the user's data line (DSL, modem, etc.) for interconnection with the network
- They are divided into open femtocells (guarantee access to anyone) and closed femtocells (guarantee access only to a limited set of users)

Relay Node (RN)
- It is an "extension" of the eNB
- For the eNB, the RN is as if it were an EU
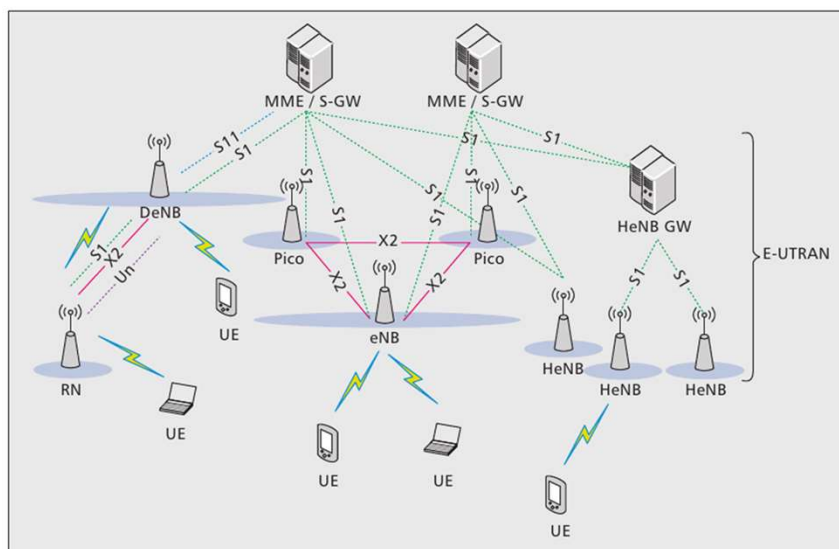- For the EU, the RN is as if it were an eNB

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Micro cell (2/2)

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Interference mitigation in HetNets

In a scenario with macro and pico/micro cells, the interference level may really downgrade the network performance

This effect is more evident for mobile operators having few frequencies and interested in using the whole spectrum in each cell

The interference level is more disruptive for users attached to pico/micro cells due to the lower transmission power of their target base station

It is necessary to introduce enhanced schemes able to mitigate the impact of the interference

To this aim, LTE-A uses enhanced Inter-cell interference coordination (eICIC) schemes: Range Expansion (RE) and Almost Blank Subframe (ABS)
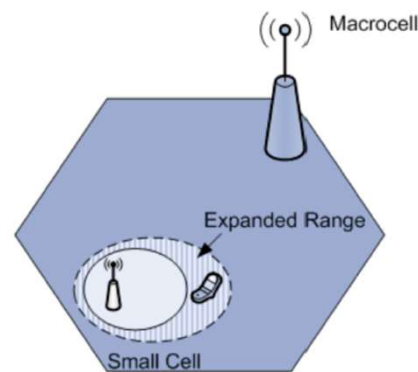
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eICIC scheme: Range Expansion (RE)

The Range Expansion (RE) technique introduces a bias that artificially increases the SINR of the pico/micro cell (suggested values [3-12] dB)

This would increase the number of UEs connected to the small cell even if the macro cell SINR is stronger

All users will experience an increased amount of available bandwidth

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eICIC scheme: Almost Blank Subframe

- A techniques used to further reduce the interference level generated by the macro cell to all the other small cells by introducing an inter-cell interference coordination
- The base stations of macro cells, which cause severe interference to others base cells, are periodically muted for entire subframes, i.e., the ABS subframes
- During ABS subframes, hence, only small cells can handle packet transmission
- In this way, the chance to serve users suffering from severe interference levels (users at the cell edge) is given to the small cells
- During not-ABS subframes, instead, all the base stations transmit data at the same time.

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LTE – Key Features in Release 11
Higher layer aspects

Enhancement of Minimization of Drive Tests (MDT)
- Intention is to provide mechanisms to collect radio measurements together with location information from eNB/UE to reduce operator costs for performing manual drive tests
- QoS measurements (e.g. throughput, traffic volume)

RAN overload control for Machine-Type Communications (MTC)
- Intention is to protect the NW from potentially very large number of MTC terminals
- CN/RAN overload avoidance specific to MTC terminals

Further self optimizing networks (SON) enhancements
- Procedures for inter-RAT MRO

Network Energy Saving
- Procedures for inter-RAT energy saving

LTE RAN Enhancements for Diverse Data Applications
- Intention is to specify RAN improvements considering various data traffic
- Signaling for optimization of terminal battery consumption

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LTE – Key Features in Release 12

Small cells enhancements
- Small cells were supported since beginning with features like ICIC and eICIC in release 10. Release 12 introduces optimization and enhancements for small cells including deployments in dense areas. Dual connectivity i.e. inter-site carrier aggregation between macro and small cells is also a focus area

Carrier aggregation enhancements
- Release 12 now allows carrier aggregation between co-located TDD and FDD carriers. In addition to carrier aggregation between TDD and FDD, there is also now three carrier aggregations possible for total of 60 Mhz spectrum aggregated
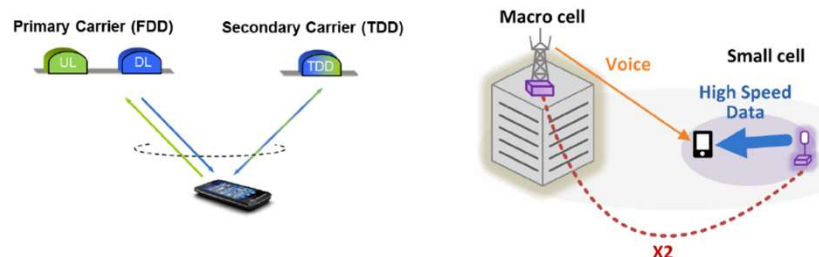
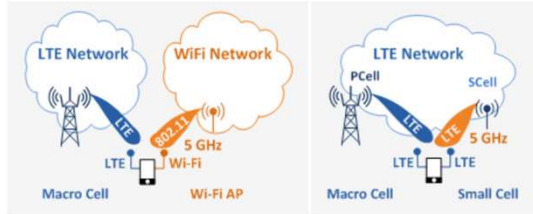© Nex-G Exuberant Solutions Pvt. Ltd.

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LTE – Key Features in Release 12

Multi-RAT CA
(Carrier aggregation between LTE and WiFi)

LTE-U: CA using licensed LTE and unlicensed LTE

Wifi integration with LTE
- With integration between LTE and Wifi, operators will have more control on managing WiFi sessions. In release 12, the intent is to specify mechanism for steering traffic and network selection between LTE and WiFI
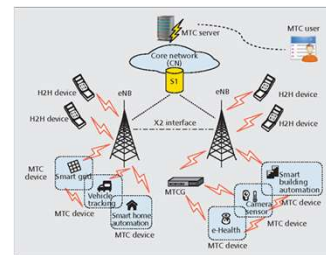
Figure 1. *Machine-to-machine communication in LTE-A networks.*

Machine Type communication (MTC)
- Huge growth is expected in machine type communication in coming years which can result in tremendous network signaling, capacity issues. To cope with this, new UE category is defined for optimized MTC operations

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Mobile Radio Networks

❑ Release 13, and 14 : LTE Advanced <u>Pro</u>

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LTE – Key Features in Release 13

Carrier Aggregation enhancements
- The goal in release 13 is to support carrier aggregation of up to 32 CC (component carriers) where as in release 10, the carrier aggregation was introduced with support of only up to 5 CC.

LTE in unlicensed spectrum enhancements
- Licensed spectrum is operators' top priority to deliver advanced services and user experience, but opportunistic use of unlicensed spectrum will help to meet the growing traffic demand
- The focus in release 13 is the aggregation of primary cell from licensed spectrum with secondary cell from unlicensed spectrum:
  - Wi-Fi (via LTE/Wi-Fi interworking)
  - Licensed Assisted Access to unlicensed spectrum, aka LAA

Indoor Positioning
- work is going on improving existing methods of indoor positioning and also exploring new positioning methods to improve indoor accuracy

Enhanced multi-user transmission techniques
- potential enhancements for downlink multiuser transmission using superposition coding

MIMO enhancements
- Up to 8 antenna MIMO systems are currently supported, the new study in this release will look into high-order MIMO systems with up to 64 antenna ports

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LTE – Key Features in Release 14

Cellular IoT

- In Release-13 3GPP made a major effort to address the **IoT** market by defining:

  - 1. eMTC   Further LTE enhancements for Machine Type Communications
  - 2. NB-IoT   New radio added to LTE platform optimized for the low-end of the market
  - 3. EC-GSM-IoT   EGPRS enhancements which make GSM/EDGE markets prepared for IoT

- In Release-14 3GPP is enhancing the above technologies

  - **Positioning** enhancements [eMTC, NB-IOT, EC-GSM-IOT]
  - **Multicast**, **mobility** enhancements for [eMTC, NB-IOT]
  - New **power classes**, **access/paging** enhancements [NB-IOT]
  - **Higher data rates** and VoLTEsupport for [eMTC]

Scaling up in performance and mobility — Scaling down in complexity and power

Today	New narrowband IoT technologies (3GPP Release 13+)		
LTE Cat-1 and above	LTE Cat-0	LTE Cat-M1 (eMTC)	Cat-NB1 (NB-IoT)
>=10 Mbps	Up to 1 Mbps	Variable rate up to 1 Mbps	10s of kbps
n x 20 MHz	20 MHz	1.4 MHz narrowband	200 kHz narrowband

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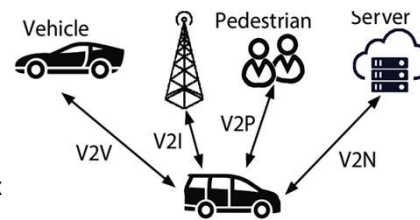Mobile Radio Networks– 2024/25   85   Antonio Iera

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LTE – Key Features in Release 14

LTE-based V2X

- In Release 14 3GPP is expanding the LTE platform to support V2X applications

- V2X will include two complementary transmission modes
  - Direct communication:
    - Building upon LTE D2D with enhancements for high speeds, high density, improved synchronization and low latency
  - Network communication:
    - Enabling broadcast of messages from a V2X server to vehicles and beyond; Vehicles can send messages to server via unicast

- The initial features needed to support V2V safety applications were finalized in September 2016

- The broader V2X framework were finalized in 2017
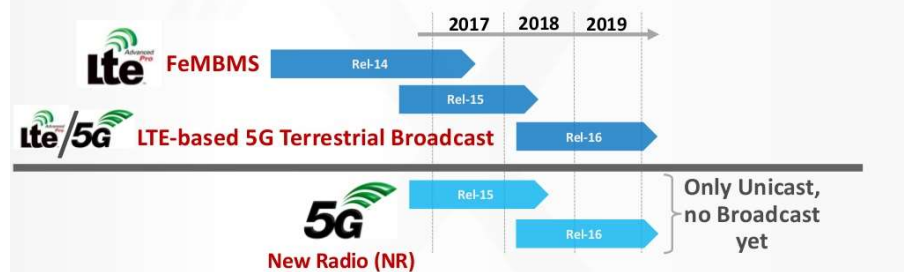

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LTE – Key Features in Release 15 & 16

Two Tracks

FeMBMS — Rel-14
Rel-15
LTE-based 5G Terrestrial Broadcast — Rel-16

New Radio (NR) — Rel-15, Rel-16 — Only Unicast, no Broadcast yet

- In March SA2 started a SI on "Architectural enhancements for 5G multicast-broadcast services" (TR 23.757)
- There are good chances of **NR-Mixed Mode** being standardized in **Rel-17**
- **NR-Terrestrial Broadcast** will not happen before **Rel-18**

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