3GPP LTE Channels and MAC Layer

LTE MAC Layer Functions

Mapping between Transparent and Logical Channels

Error Correction Through Hybrid ARQ

MAC

Priority Handling with Dynamic Scheduling

Logical Channel Prioritization
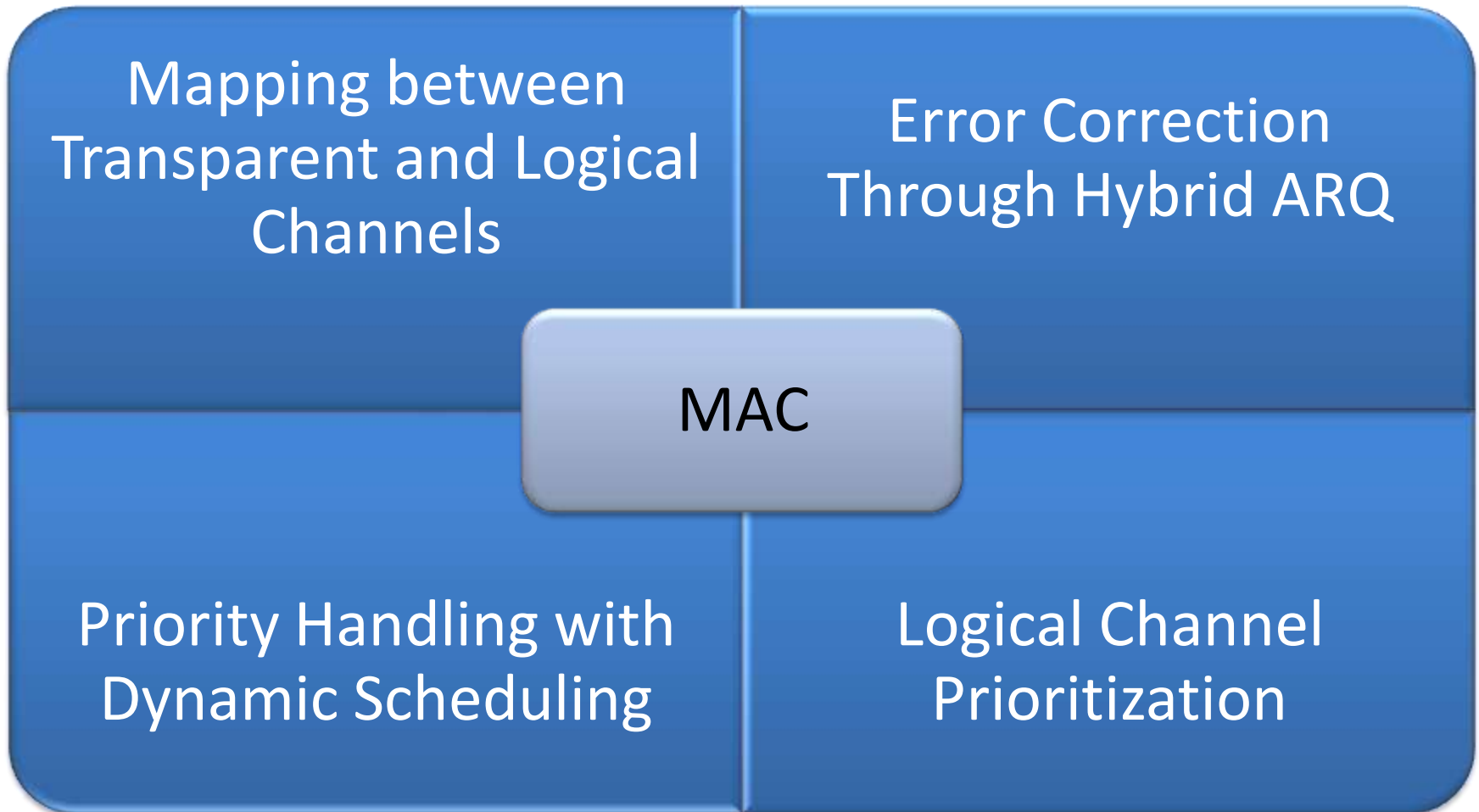
MAC in the LTE Protocol Stack

MME

NAS

eNodeB

RRC
PDCP
RLC
MAC
PHY

UE

NAS
RRC
PDCP
RLC
MAC
PHY
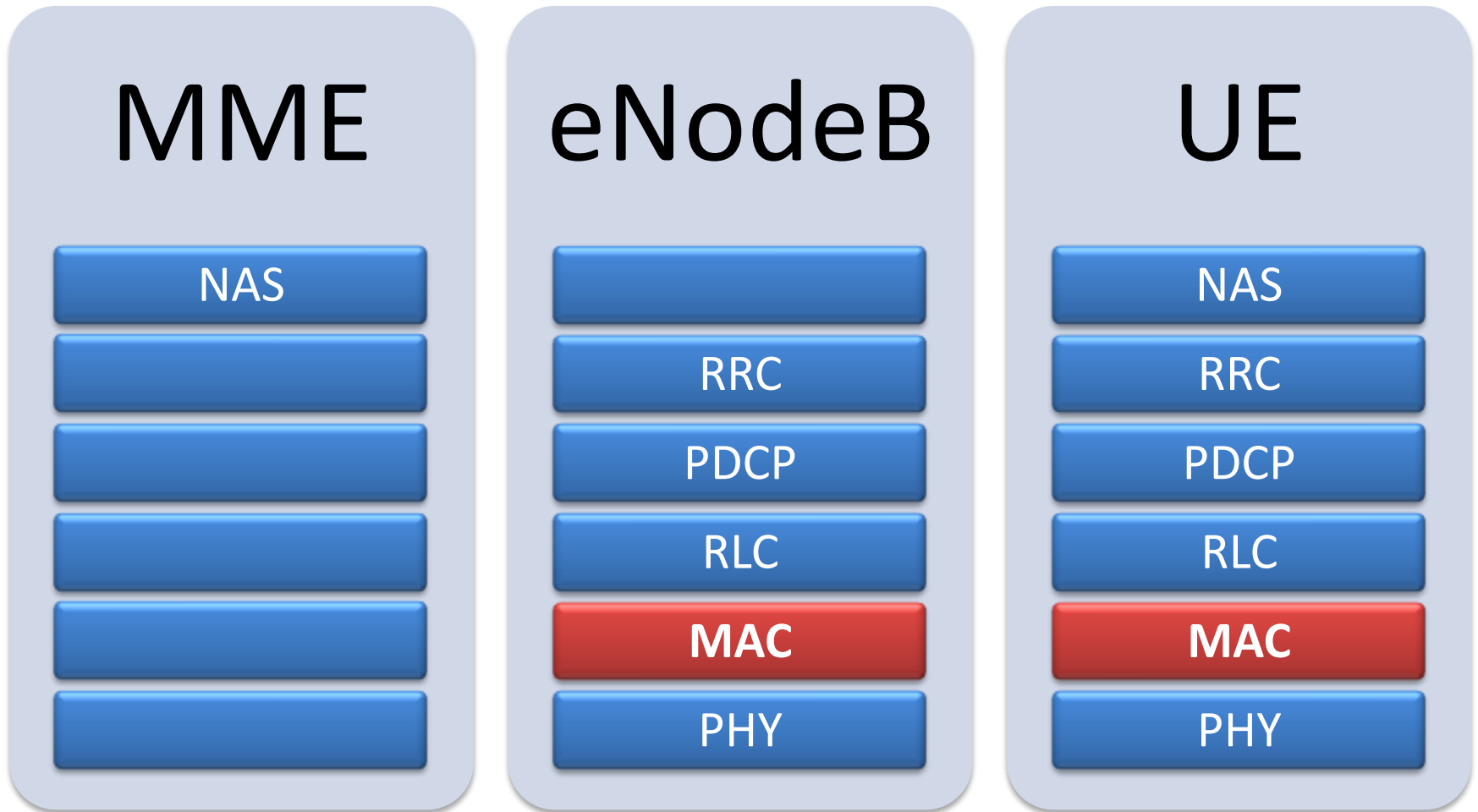
LTE Channel Architecture

RLC
Logical Channels

⬇

MAC
Transport Channels

⬇

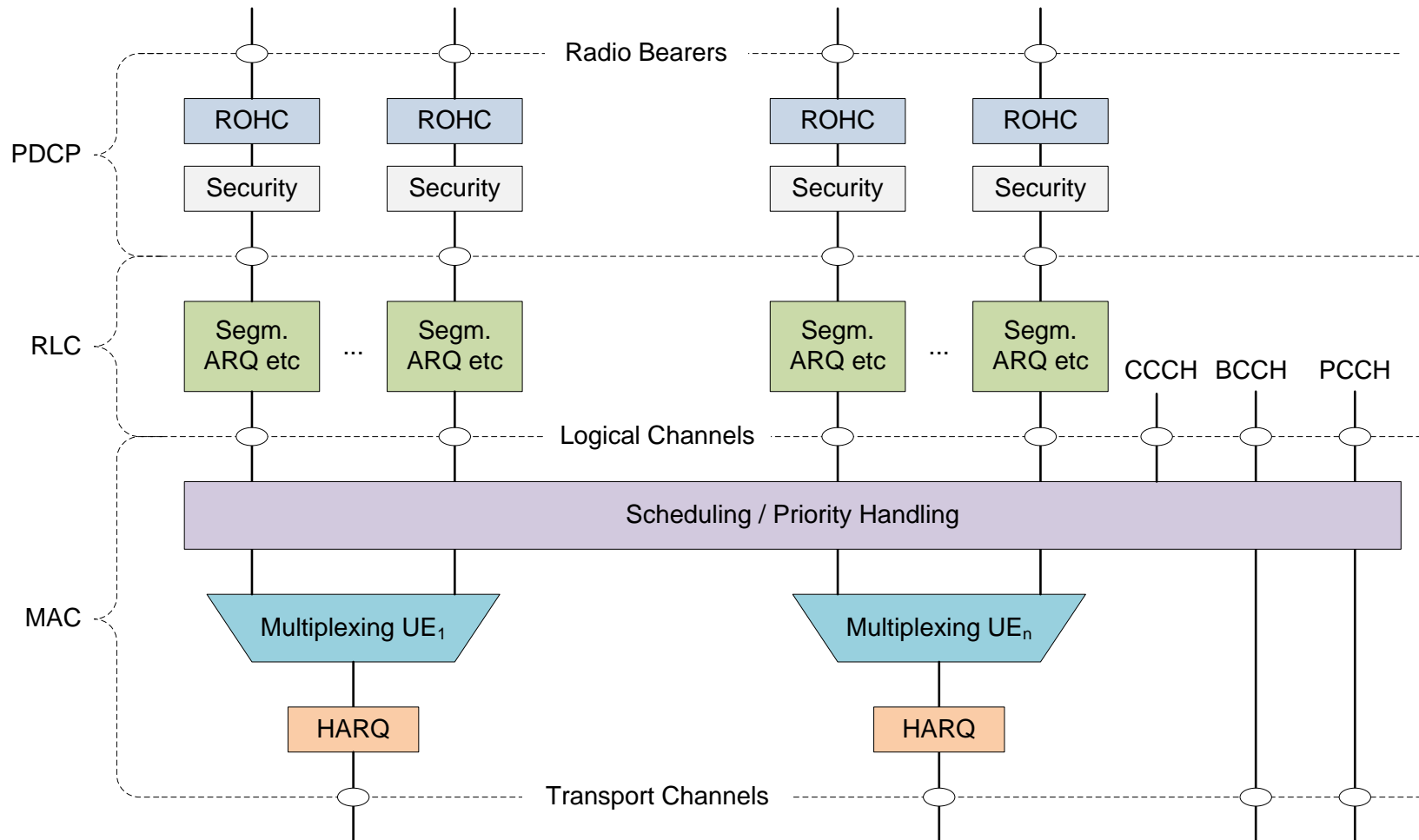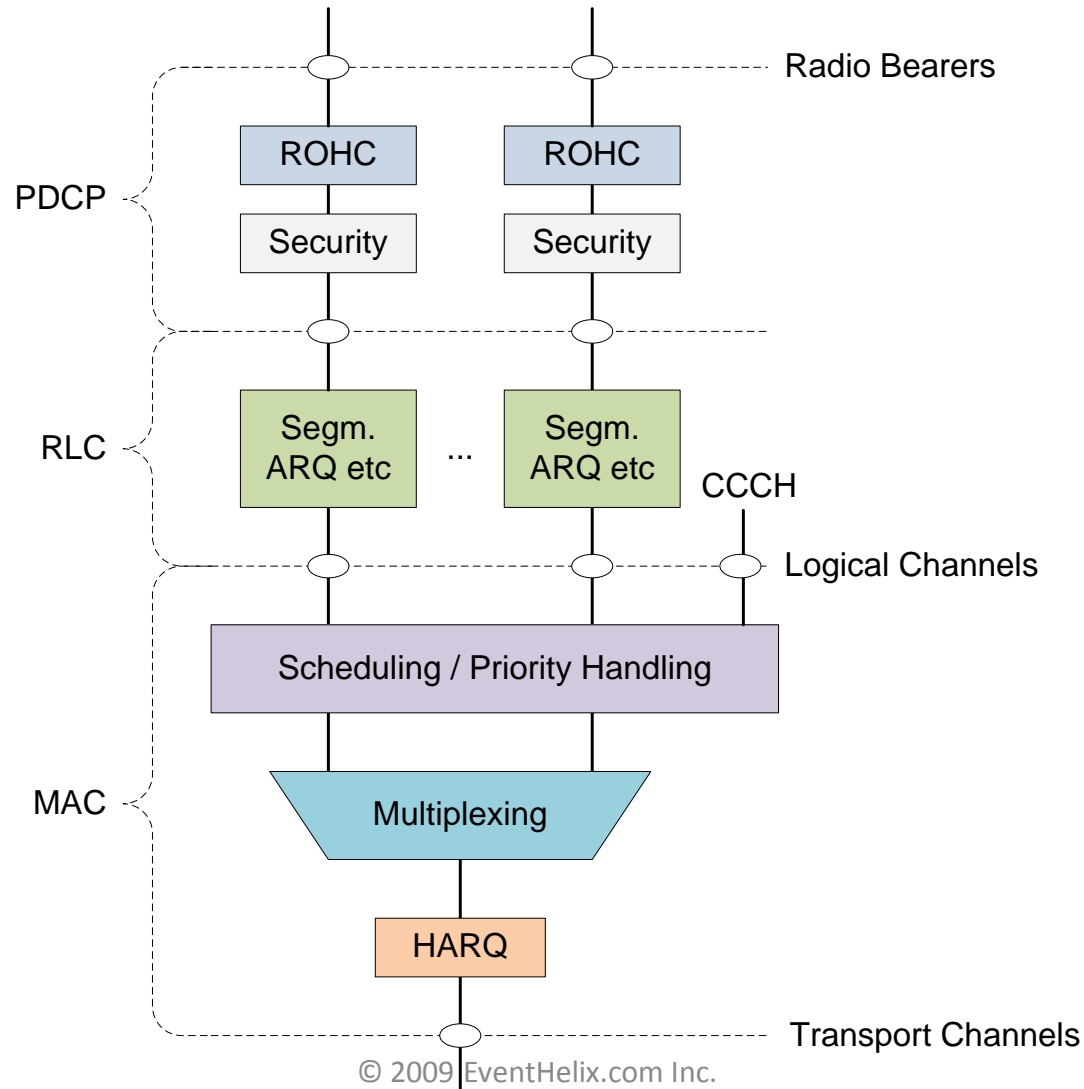| PHY |
|---|
| **Physical Channels** |
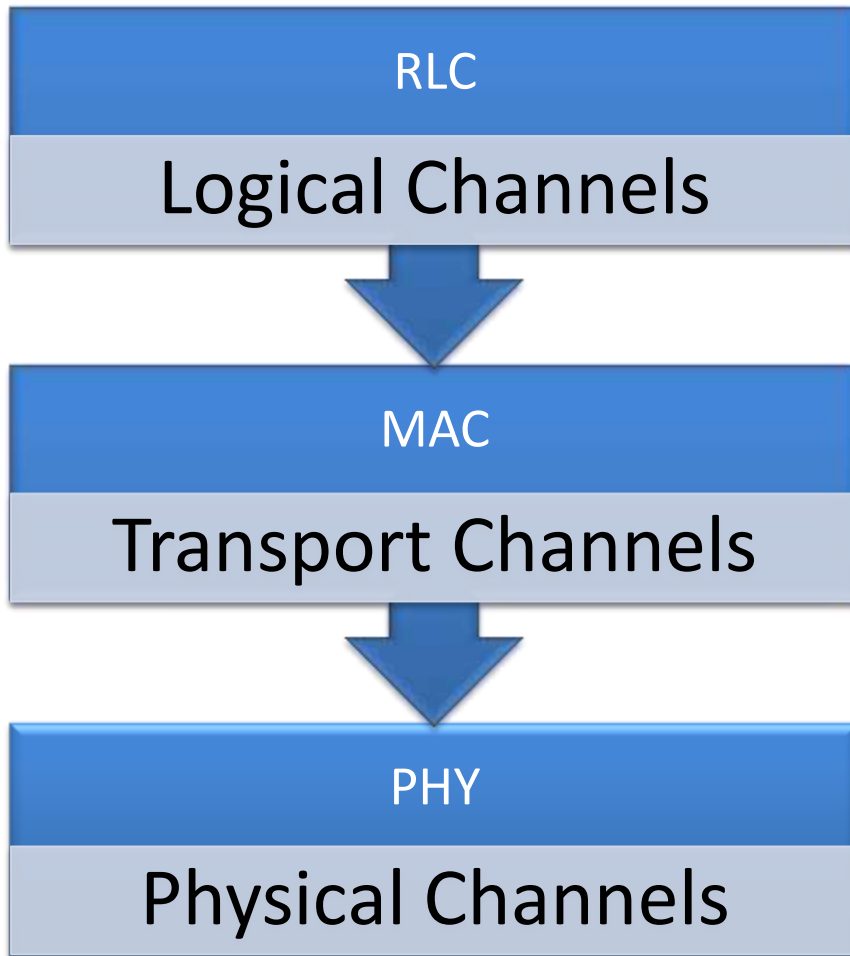
1. RLC layer passes data to the MAC layer as logical channels.

2. The MAC layer formats and sends the logical channel data as transport channel.

3. The physical layer encodes the transport channel data to physical channels.

Downlink PDCP, RLC and MAC Sublayer Organization

Uplink PDCP, RLC and MAC Sublayer Organization

LTE Downlink Channels

PCCH BCCH CCCH DCCH DTCH MCCH MTCH Downlink Logical channels

PCH BCH DL-SCH MCH Downlink Transport channels

PBCH PDSCH PMCH PDCCH PHICH Downlink Physical channels
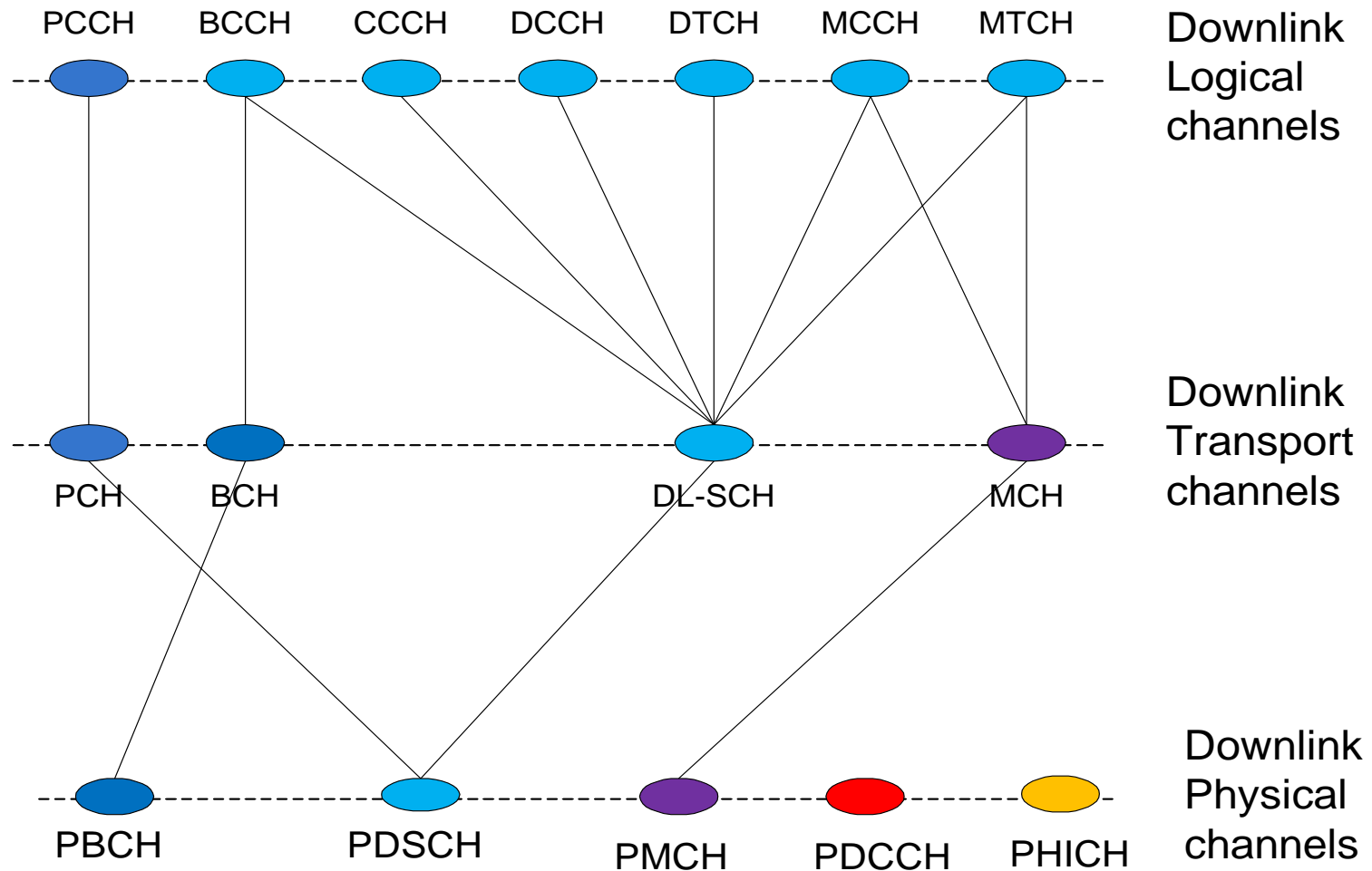
LTE Downlink Logical Channels 1

Paging Control Channel (PCCH)
- A downlink channel that transfers paging information and system information change notifications.
- This channel is used for paging when the network does not know the location cell of the UE.

Broadcast Control Channel (BCCH)
- A downlink channel for broadcasting system control information.

Common Control Channel (CCCH)
- Channel for transmitting control information between UEs and network.
- This channel is used for UEs having no RRC connection with the network.

LTE Downlink Logical Channels 2

Dedicated Control Channel (DCCH)	• A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. • Used by UEs having an RRC connection.
Dedicated Traffic Channel (DTCH)	• A point-to-point channel, dedicated to one UE, for the transfer of user information. • A DTCH can exist in both uplink and downlink.
Multicast Control Channel (MCCH)	• A point-to-multipoint downlink channel used for transmitting MBMS control information from the network to the UE, for one or several MTCHs. • This channel is only used by UEs that receive MBMS.
Multicast Traffic Channel (MTCH)	• A point-to-multipoint downlink channel for transmitting traffic data from the network to the UE. • This channel is only used by UEs that receive MBMS.

LTE Downlink Transport Channels 1

Paging Channel (PCH)

- Supports UE discontinuous reception (DRX) to enable UE power saving
- Broadcasts in the entire coverage area of the cell;
- Mapped to physical resources which can be used dynamically also for traffic/other control channels.

Broadcast Channel (BCH)

- Fixed, pre-defined transport format
- Broadcast in the entire coverage area of the cell

Multicast Channel (MCH)

- Broadcasts in the entire coverage area of the cell;
- Supports MBSFN combining of MBMS transmission on multiple cells;
- Supports semi-static resource allocation e.g. with a time frame of a long cyclic prefix.

LTE Downlink Transport Channels 2

Downlink Shared Channel (DL-SCH)

- Supports Hybrid ARQ
- Supports dynamic link adaptation by varying the modulation, coding and transmit power
- Optionally supports broadcast in the entire cell;
- Optionally supports beam forming
- Supports both dynamic and semi-static resource allocation
- Supports UE discontinuous reception (DRX) to enable UE power saving
- Supports MBMS transmission

LTE Downlink Physical Channels 1

Physical Downlink Shared Channel (PDSCH)
- Carries the DL-SCH and PCH
- QPSK, 16-QAM, and 64-QAM Modulation

Physical Downlink Control Channel (PDCCH)
- Informs the UE about the resource allocation of PCH and DL-SCH, and Hybrid ARQ information related to DL-SCH
- Carries the uplink scheduling grant
- QPSK Modulation

Physical Hybrid ARQ Indicator Channel (PHICH)
- Carries Hybrid ARQ ACK/NAKs in response to uplink transmissions.
- QPSK Modulation

LTE Downlink Physical Channels 2

Physical Broadcast Channel (PBCH)

- The coded BCH transport block is mapped to four sub-frames within a 40 ms interval. 40 ms timing is blindly detected, i.e. there is no explicit signalling indicating 40 ms timing
- Each sub-frame is assumed to be self-decodable, i.e. the BCH can be decoded from a single reception, assuming sufficiently good channel conditions.
- QPSK Modulation

Physical Multicast Channel (PMCH)

- Carries the MCH
- QPSK, 16-QAM, and 64-QAM Modulation

LTE Uplink Channels

CCCH   DCCH   DTCH

Uplink Logical channels

RACH   UL-SCH

Uplink Transport channels

PRACH   PUSCH   PUCCH

Uplink Physical channels
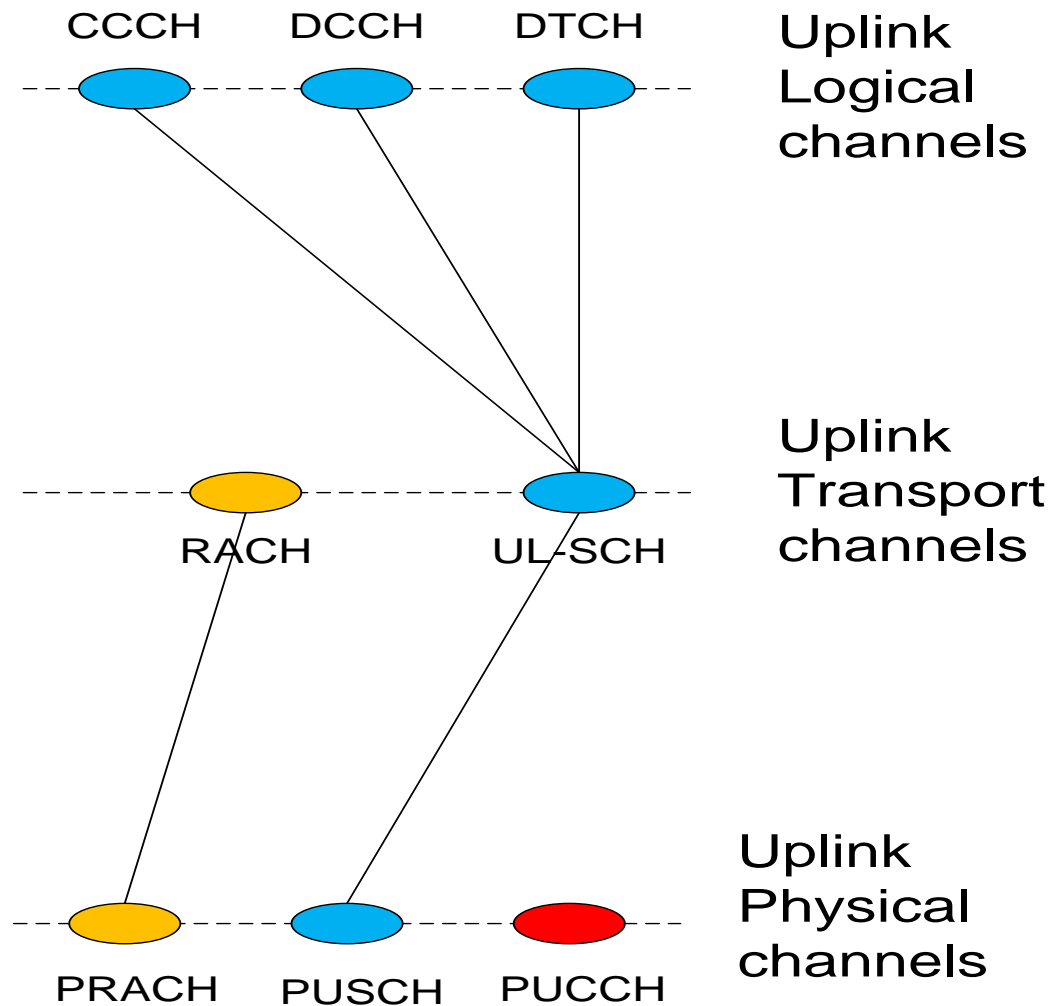
LTE Uplink Logical Channels

Common Control Channel (CCCH)

- Channel for transmitting control information between UEs and network.
- This channel is used for UEs having no RRC connection with the network.

Dedicated Control Channel (DCCH)

- A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network.
- Used by UEs having an RRC connection.

Dedicated Traffic Channel (DTCH)

- A point-to-point channel, dedicated to one UE, for the transfer of user information.
- A DTCH can exist in both uplink and downlink.

LTE Uplink Transport Channels

Random Access Channel (RACH)

- Channel carries minimal information
- Transmissions on the channel may be lost due to collisions

Uplink Shared Channel (UL-SCH)

- Optional support for beam forming
- Supports dynamic link adaptation by varying the transmit power and potentially modulation and coding
- Supports Hybrid ARQ
- Supports dynamic and semi-static resource allocation

LTE Uplink Physical Channels

Physical Radio Access Channel (PRACH)

- Carries the random access preamble
- The random access preambles are generated from Zadoff-Chu sequences with zero correlation zone, generated from one or several root Zadoff-Chu sequences.
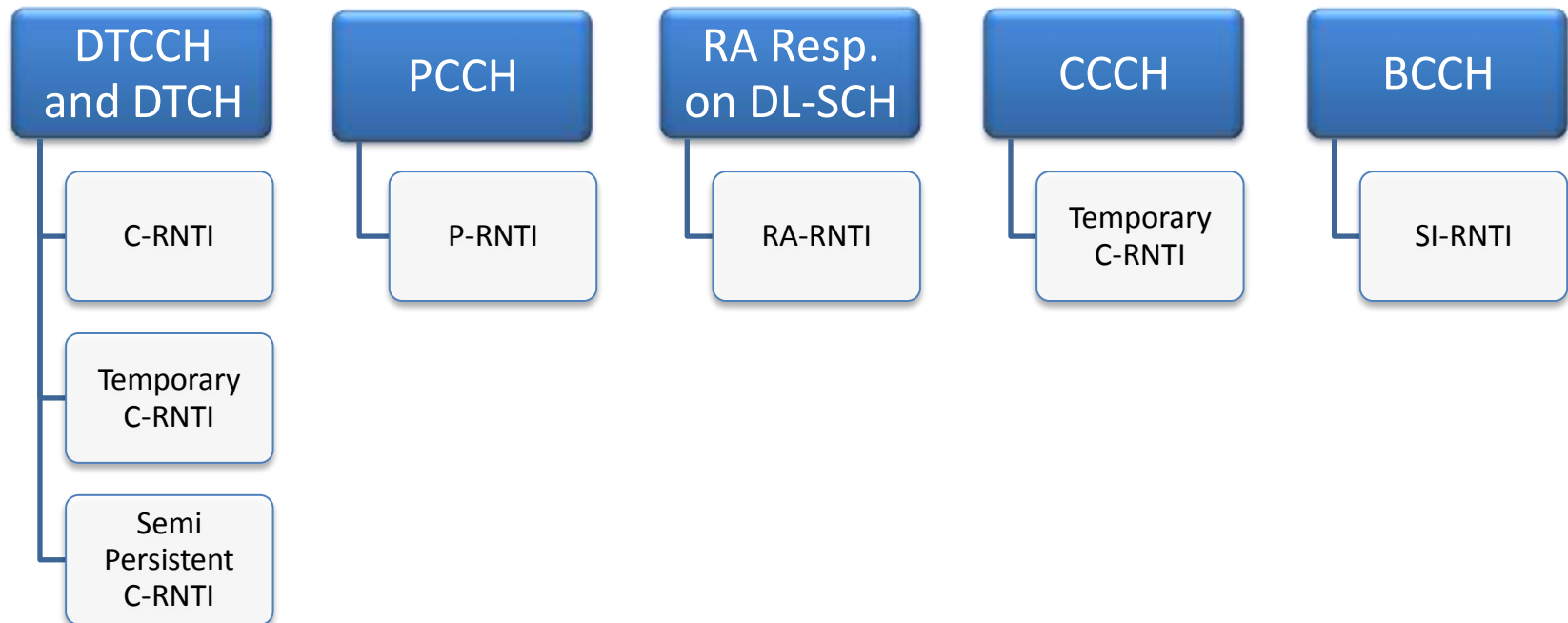
Physical Uplink Shared Channel (PUSCH)

- Carries the UL-SCH
- QPSK, 16-QAM, and 64-QAM Modulation

Packet Uplink Control Channel (PUCCH)

- Carries Hybrid ARQ ACK/NAKs in response to downlink transmission
- Carries Scheduling Request (SR)
- Carries CQI reports
- BPSK and QPSK Modulation

RNTI Mapping

- When MAC uses the PDCCH to indicate radio resource allocation, the RNTI that is mapped on the PDCCH depends on the logical channel type:

DTCCH and DTCH	PCCH	RA Resp. on DL-SCH	CCCH	BCCH
C-RNTI	P-RNTI	RA-RNTI	Temporary C-RNTI	SI-RNTI
Temporary C-RNTI				
Semi Persistent C-RNTI				

Random Access Procedure

Random Access Resource Selection

Select Random Access Preamble	Determine the next available PRACH Sub-frame

Random Access Preamble Transmission

Set Preamble Target Power	Ask Physical Layer to Transmit Preamble

Random Access Response Reception on PDCCH

Match the preamble to receive the response	Apply the timing advance in the message	Process uplink resource grant

Contention Resolution

Uplink control message is transmitted on the granted uplink resource and the contention resolution timer is started	The contention resolution timer is stopped when the lower layers indicate that the message has been acknowledged

DL-SCH Data Transfer

Downlink Assignment Received on PDCCH

Message indicates if there is transmission on the DL-SCH for the UE.	New Data Indicator (NDI) is updated

Hybrid ARQ Operation

If received NDI != previous NDI or first transmission: Soft buffer contents are replaced with new data	If received NDI == previous NDI: Soft buffer data is chase combined with the new data

Data Delivery and Acknowledgement

If data in the Soft buffer is successfully decoded and no error is detected, send positive acknowledgement	If data decoding in the Soft buffer results in an error, a negative acknowledgement is sent.

UL-SCH Data Transfer

Scheduling Request (SR) is sent to initiate uplink data transfer.

Buffer Status Report (BSR) is sent to report pending data in uplink buffers.

Power Headroom Report (PHR) communicates the additional return power available at the UE.

Uplink Grant assigns uplink resources for transmission

UE transmits the uplink data on the assigned resources. Hybrid ARQ is used.

Explore More

Specification	Title
3GPP TS 36.300	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); **Overall description**; Stage 2
3GPP TS 36.321	Evolved Universal Terrestrial Radio Access (E-UTRA); **Medium Access Control (MAC) protocol specification**
3GPP TS 36.211	Evolved Universal Terrestrial Radio Access (E-UTRA); **Physical channels and modulation**

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Telecom Call Flows	GSM, SIP, H.323, ISUP, LTE and IMS call flows.
TCP/IP Sequence Diagrams	TCP/IP explained with sequence diagrams.
Real-time and Embedded System Articles	Real-time and embedded systems, call flows and object oriented design articles.