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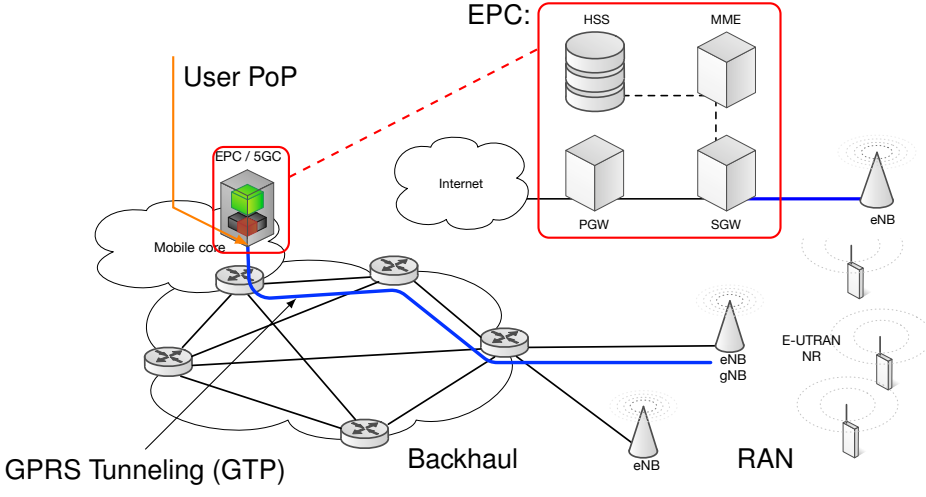
Modern Wireless Systems - 5G and Beyond
Mobile core and C-RAN

STEFAN HÖST

Network topology – Mobile network (EPS)



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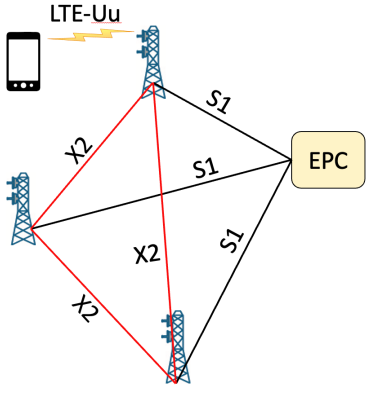
EPS interfaces



EPC ↔ eNB

- S1 interface
- Split in S1-MME and S1-U (Control plane and data plane)
- No centralised eNB

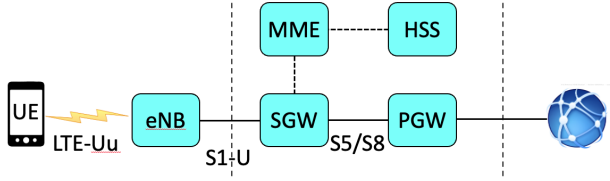
eNB ↔ eNB

- X2 interface
- Coordination and positioning

UE ↔ eNB

- LTE-Uu (or E-UTRAN-Uu)

EPC – Data plane



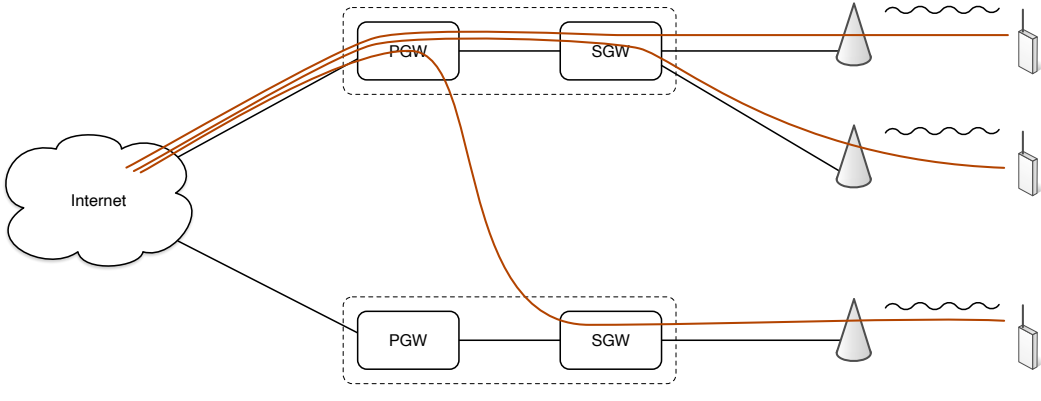
Packet GW

- IP edge for user
- IP address allocation to UE
- QoS filtering
- Mobility anchor
  Does not change during session.
  Preserves IP address

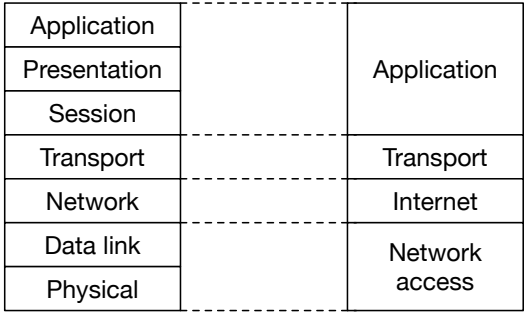
Serving GW

- Collect charging information
- Local anchor towards eMB
  Can change during session

User mobility



Protocol stack – OSI and TCP/IP



Application specific. User interaction

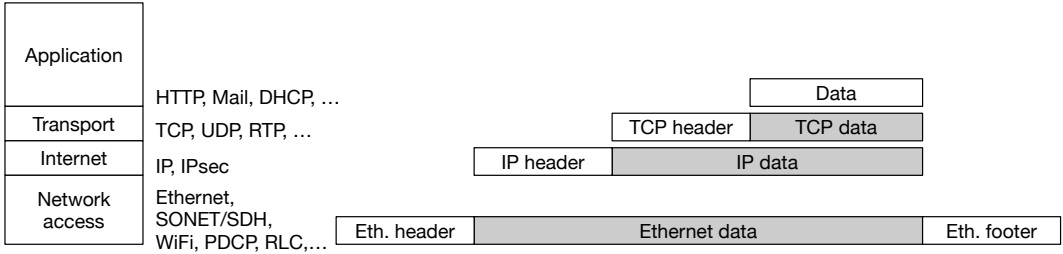
Communication between processes at units

Routing between end units

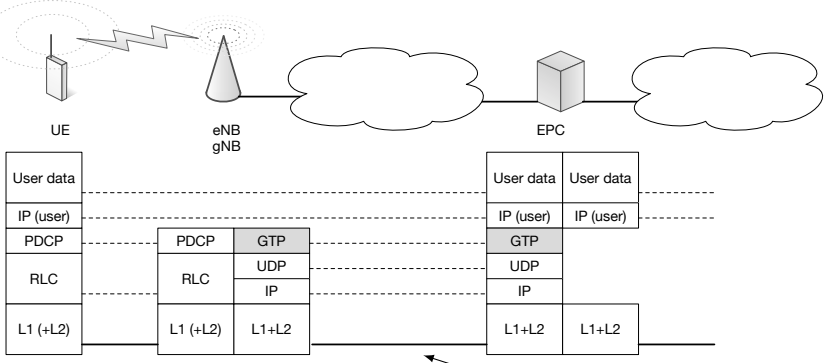
Framing. Error control. Local addressing

Access to media. Signal propagation

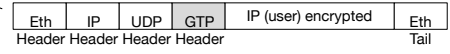
Protocol stack – Layered traffic and framing



Tunneling in mobile network



- GTP: GPRS Tunneling Protocol
- PDCP: Packet Data Convergence Protocol
- RLC: Radio Link Control



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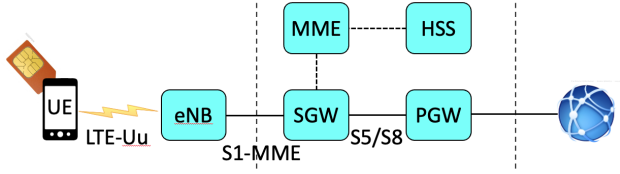
EPC – Control plane



MME (Mobility Management Entity)

- Communicates with eNB and SGW
- Manage stunnels and encryption

HSS (Home Subscriber Server)

- Subscriber database
- SIM card key exchange
- AAA
  (Authentication, Authorisation, Accounting)

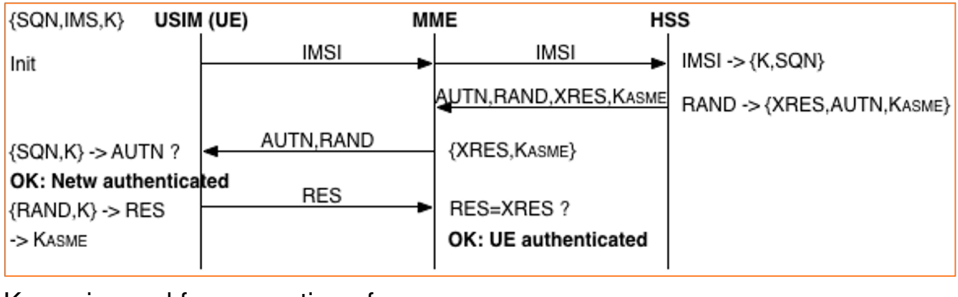
SIM card

UMTS Subscriber Identity Module

The (U)SIM card is an application on a smart card and contains:

- IMSI (International mobile subscriber identity) 15 digits
- Authentication key K and sequence number SQN

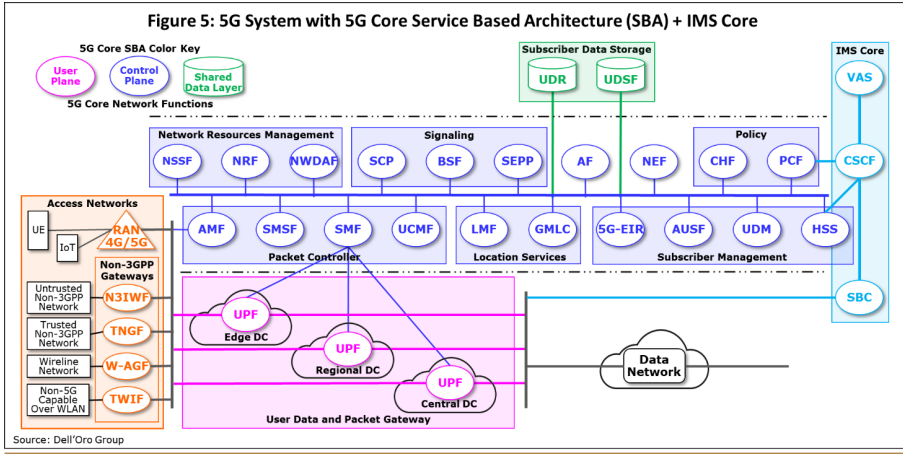
Authentication process:



K_{ASME} is used for encryption of messages

5G core

The 5G core (5GC) is by design service oriented and software based
Example:



Source: Dell'Oro Group

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eNB equipment

BBU (Baseband unit)

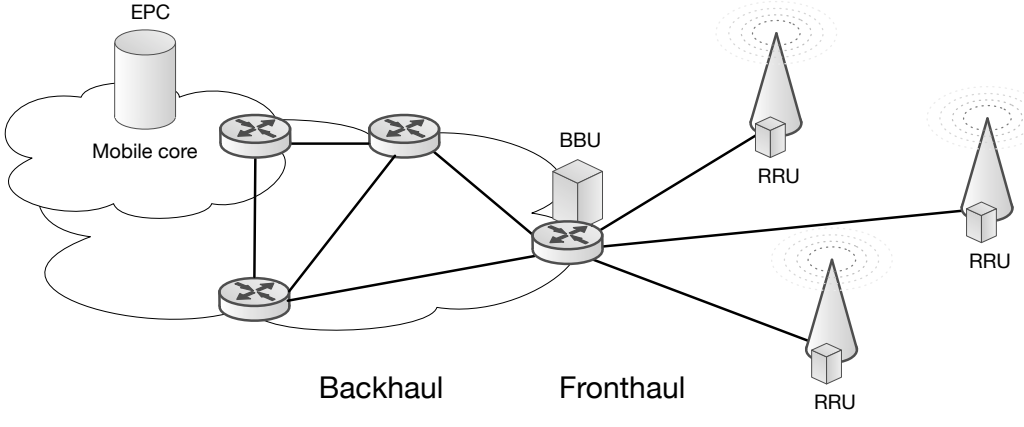
- Coding
- Scheduling
- Rate matching
- Modulation
- Beam forming
- (Rec Equalization)
- IFFT
- Cyclic prefix

RU (Radio unit)

- DA / AD
- Frequency mix
- Analog front-end (amplifiers)
- Antenna connection

Communication between BBU and RU over fibre using CPRI

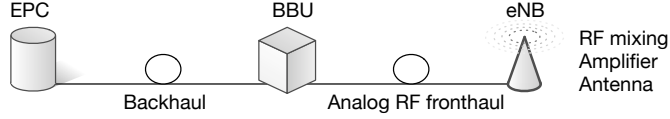
Mobile network and C-RAN (Cloud RAN)



Possible splits

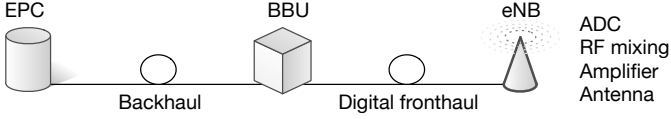
- Analog fronthaul

  Analog RF split



- Digital fronthaul

  Digital split



CPRI

CPRI: Common Public Radio Interface
Defined by: Ericsson, Huawei, NEC and Nokia

A protocol intended for transport of mobile digital baseband samples.

- Frames are containers for radio frames
- Supports GSM/EDGE (2G), UTRA (3G), E-UTRA/LTE (4G), WiMAX
- Normally point-to-point, but also support for (physical) multiplexing
- Can operate over at least 10 km
- At most 5 μs delay (excl. propagation delay) and at most 10^{-12} BER

CPRI framing

Hierarchical framing structure

- Basic frame: samples for 260.416 ns radio signal
- Hyper frame: 256 basic frames $\Rightarrow$ 66.7 μs
- CPRI frame: 150 hyper frames $\Rightarrow$ 10 ms (one LTE frame)

Line coding: 8B/10B or 64B/66B
Sampling 8-20 b/real sample. Normally 15 b/real sample ($\Rightarrow$ 30 b/sample)
$\Rightarrow$ data expansion by a factor of about 10-14

Number antenna signals and required bitrates

Option	Rate[Mbps]	Line coding	W_{LTE}[MHz] / R_b[Mbps] 1.25 77	2.5 154	5 307	10 614	15 921	20 1 228
1	614	8/10	8	4	2	1	—	—
2	1 228	8/10	16	8	4	2	1	1
3	2 457	8/10	32	16	8	4	2	1
4	3 072	8/10	40	20	10	5	3	2
5	4 915	8/10	64	32	16	8	5	4
6	6 144	8/10	80	40	20	10	6	5
7	9 830	8/10	128	64	32	16	10	8
8	10 138	64/66	160	80	40	20	13	10
9	12 165	64/66	192	96	48	24	16	12

CPRI

Problems with CPRI

- Point-to-point connection, not routable
- Very high traffic load (Major problems with 5G scenarios)
- Not traffic dependent
- Not settings dependent, e.g. number of bits / carrier
- Very high demands on clock synchronisation
- Up- and down-link must have the same latency (max diff 8 ns)

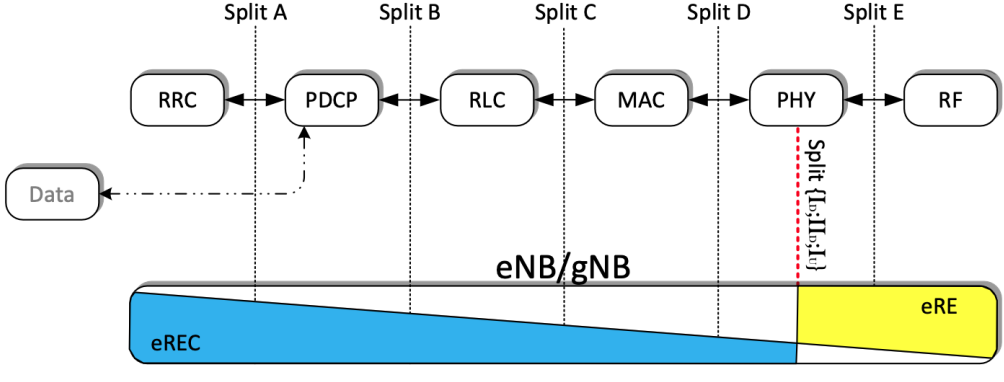
Packet based fronthaul and eCPRI

eCPRI: Evolved CPRI (V1.1 2018-01-10)

- Main alternative for future C-RAN
- New functional splits
- Required data rate scales with user data
- Physical layer from IEEE 802.3 Ethernet
- Layer 2: Ethernet, MPLS (IP address routing on L2)

eCPRI – Functional splits

From documentation V2.0



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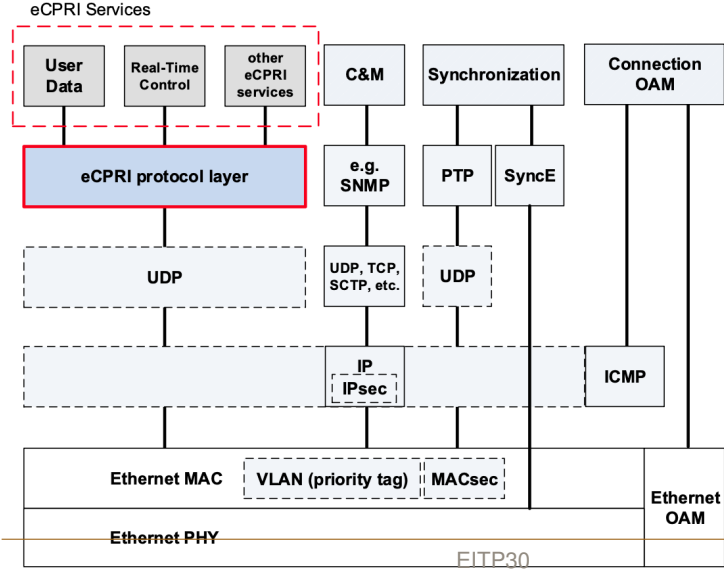
eCPRI – Protocol transport

From documentation V2.0



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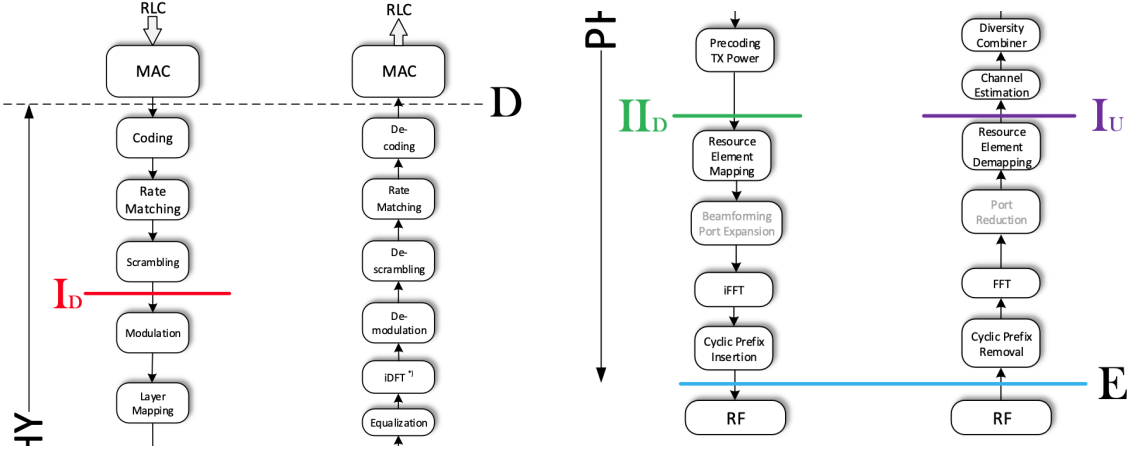
eCPRI – Phy layer splits (I)

From documentation V2.0



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Example – Split ratess

From documentation V2.0

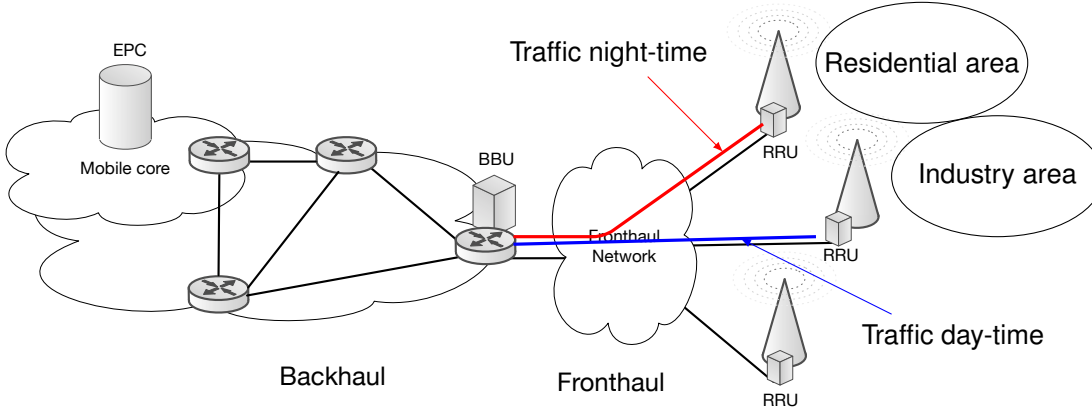
- Utilization 3/1.5 Gbps at 100 MHz
- DL MIMO layers: 8, UL MIMO layers: 4
- Beamforming i eREC
- Code rate: 0.8
- Modulation: 256 QAM
- Sub-carrier spacing: 15 kHz
- IQ sampling frequency: 122.88 Msps
- IQ-quantisation: 30 bits per IQ-sample

eCPRI – Phy layer split rates

From documentation V2.0

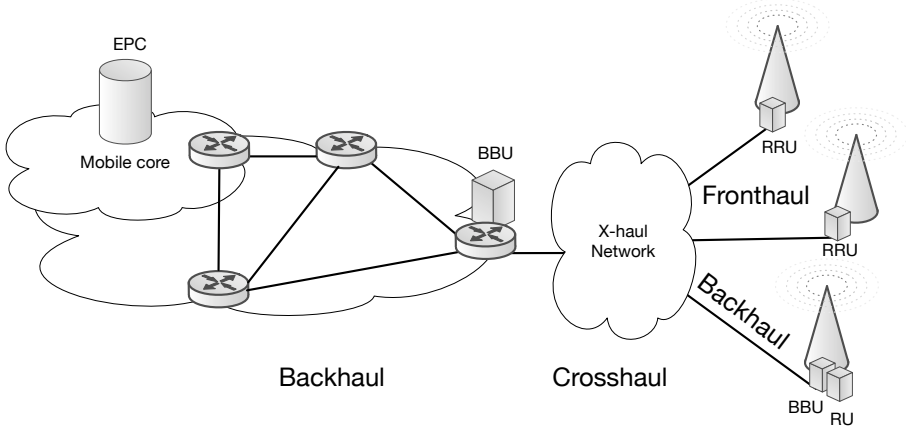
	Split D		Split I_D		Split II_D		Split E
	User Data [Gbps]	Control [Gbps]	User Data [Gbps]	Control [Gbps]	User Data [Gbps]	Control [Gbps]	User Data [Gbps]
eREC→ eRE	3 (assumption)	<< 1	< 4	< 10	~ 20	< 10	236
			Split I_U				
eRE → eREC	1.5 (assumption)	<< 1	~ 20	< 10	~ 20	< 10	236

Packet switched fronthaul



X-haul

A Crosshaul is a network that transports both backhaul and fronthaul traffic.



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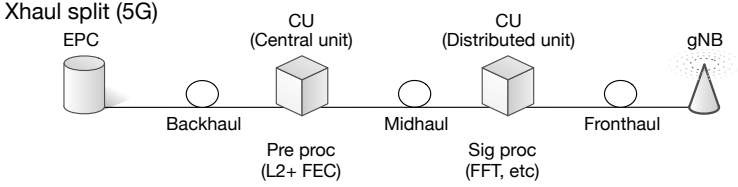
X-haul splits

Split traffic in backhaul, midhaul and fronthaul at diferent functional splits, e.g.,



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