RAN and Key technologies in 5G NR

Zhixi Wang

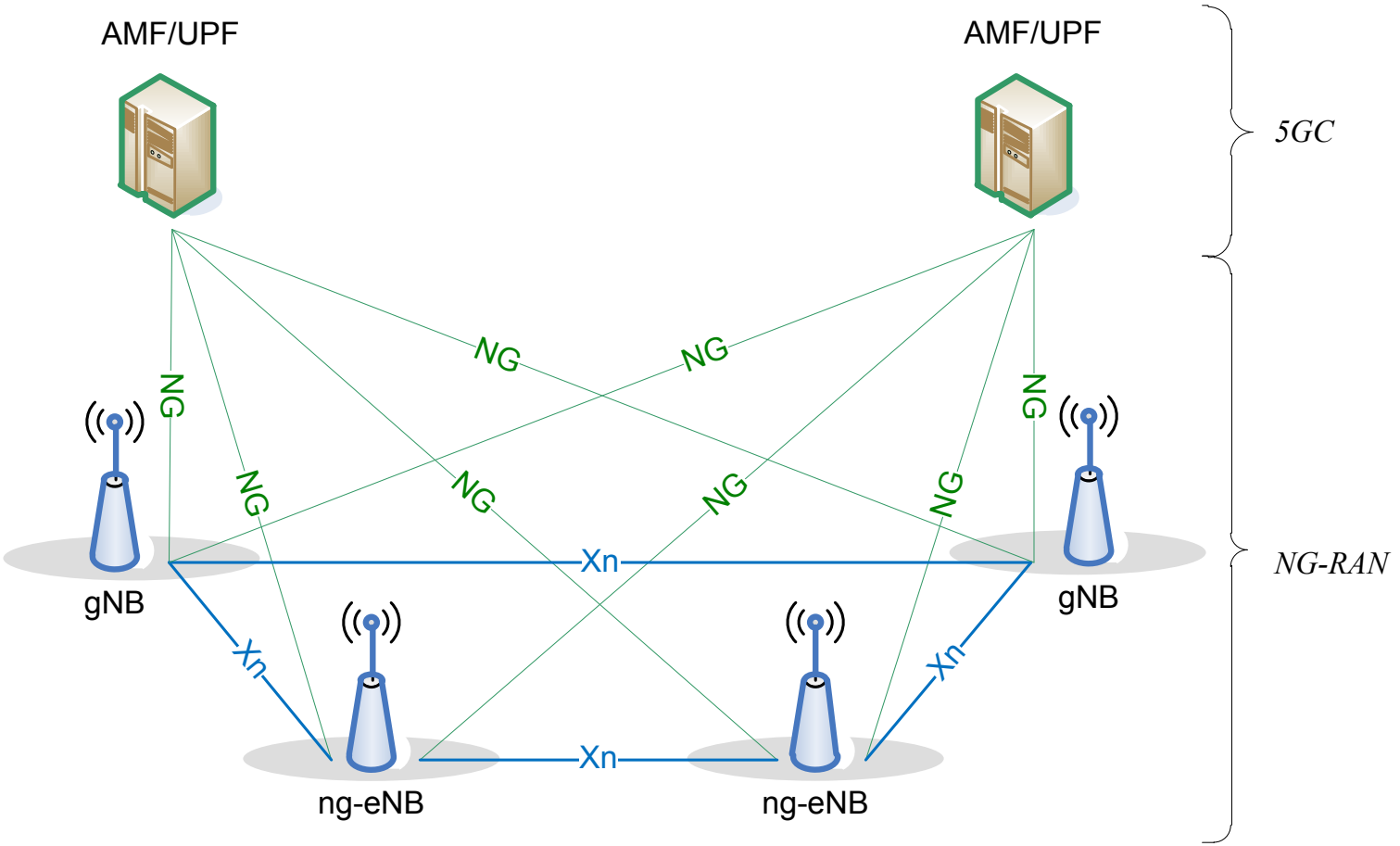
Huawei Technology

September,2018

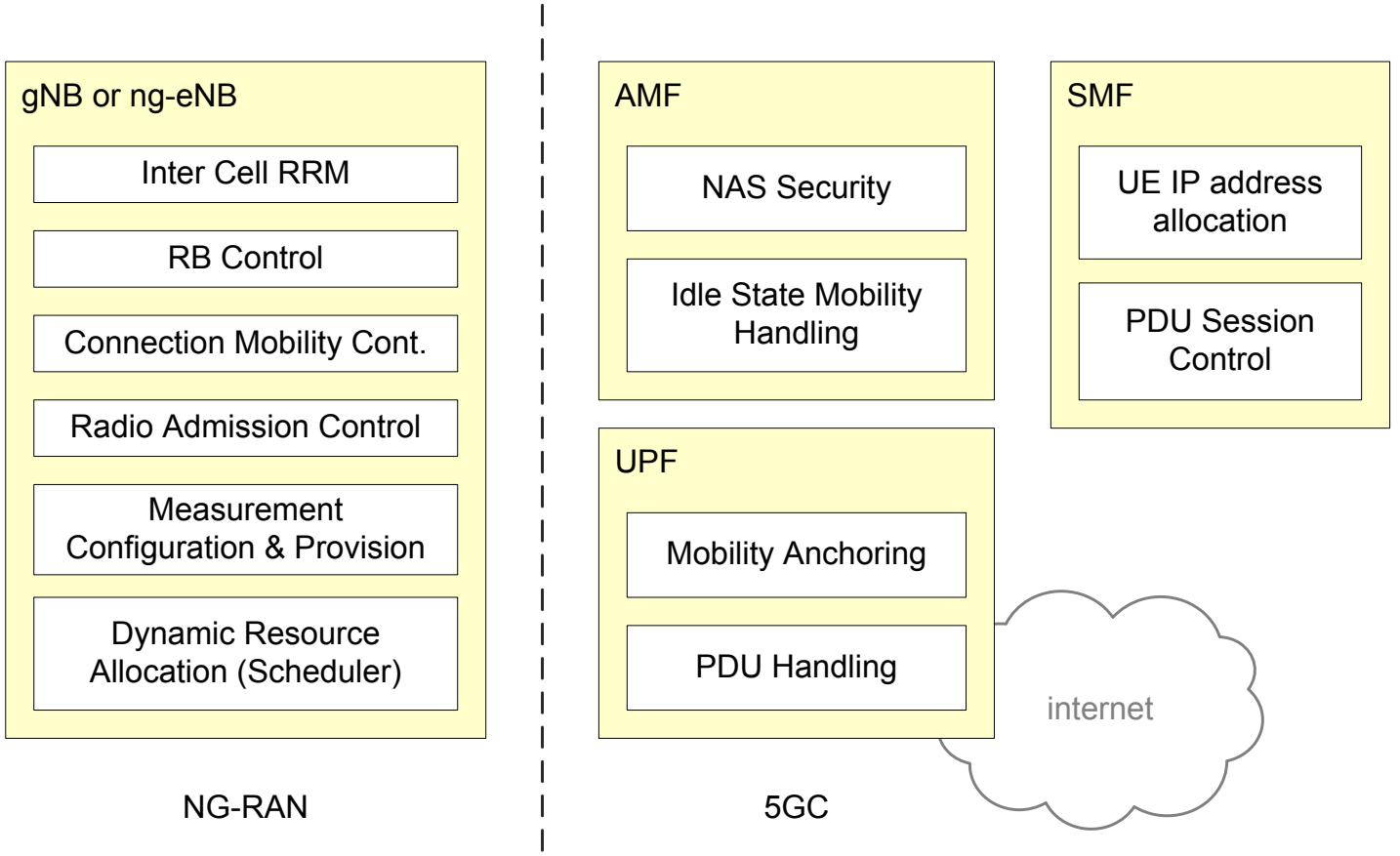
Agenda

- NR Overall Architecture and Network Interfaces
- Physical Layer
- Layer 2 and RRC
- Deployment Architecture and Scenarios
- Core Network

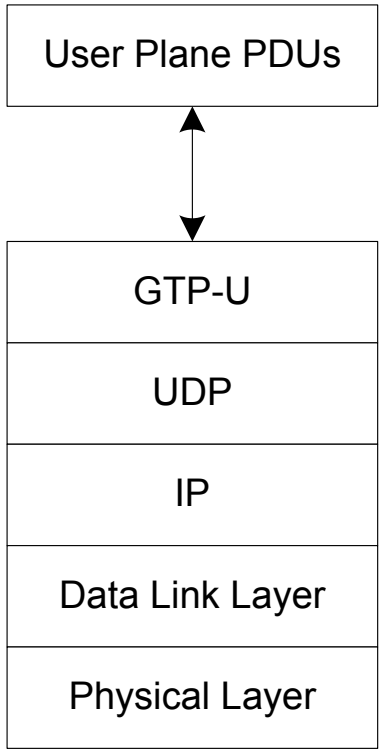
Overall Architecture



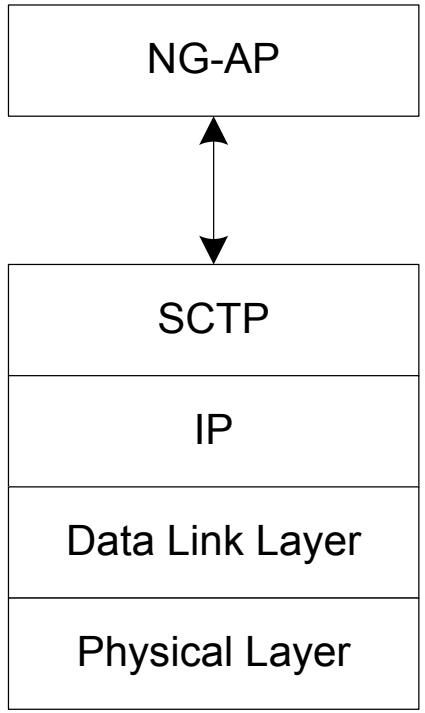
Functional Split



NG interface

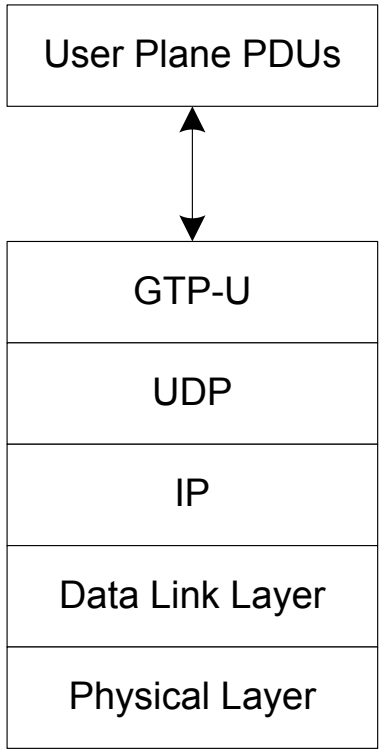


User Plane Protocol Stack

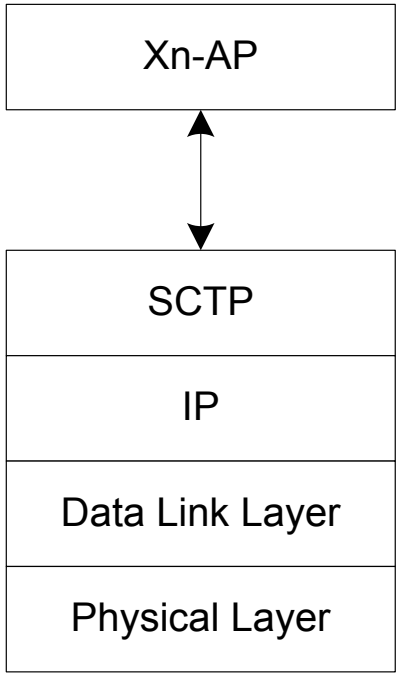


Control Plane Protocol Stack

Xn interface

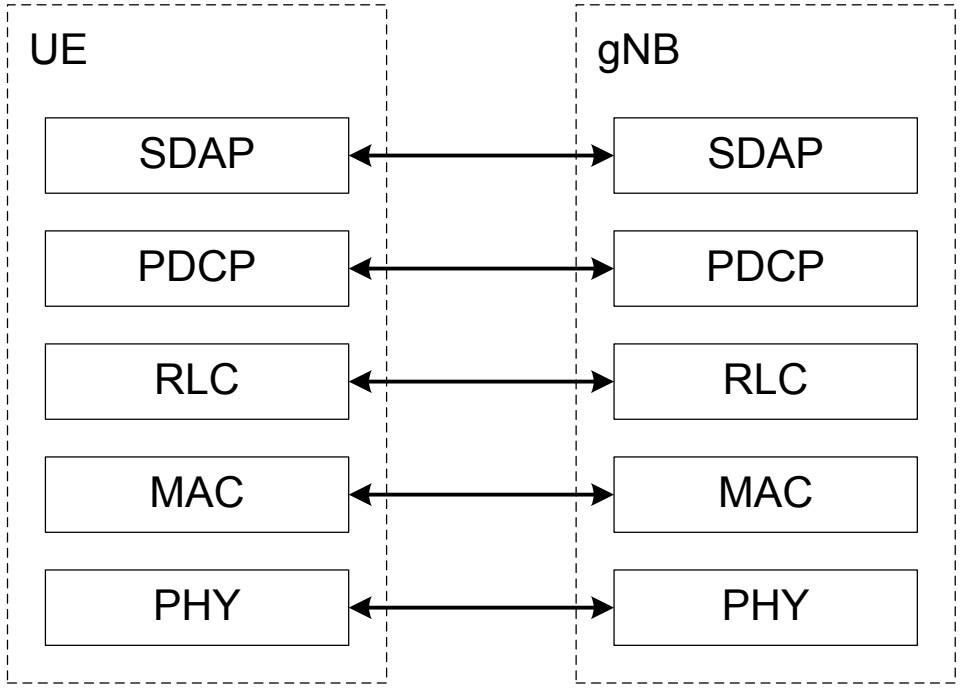


User Plane Protocol Stack

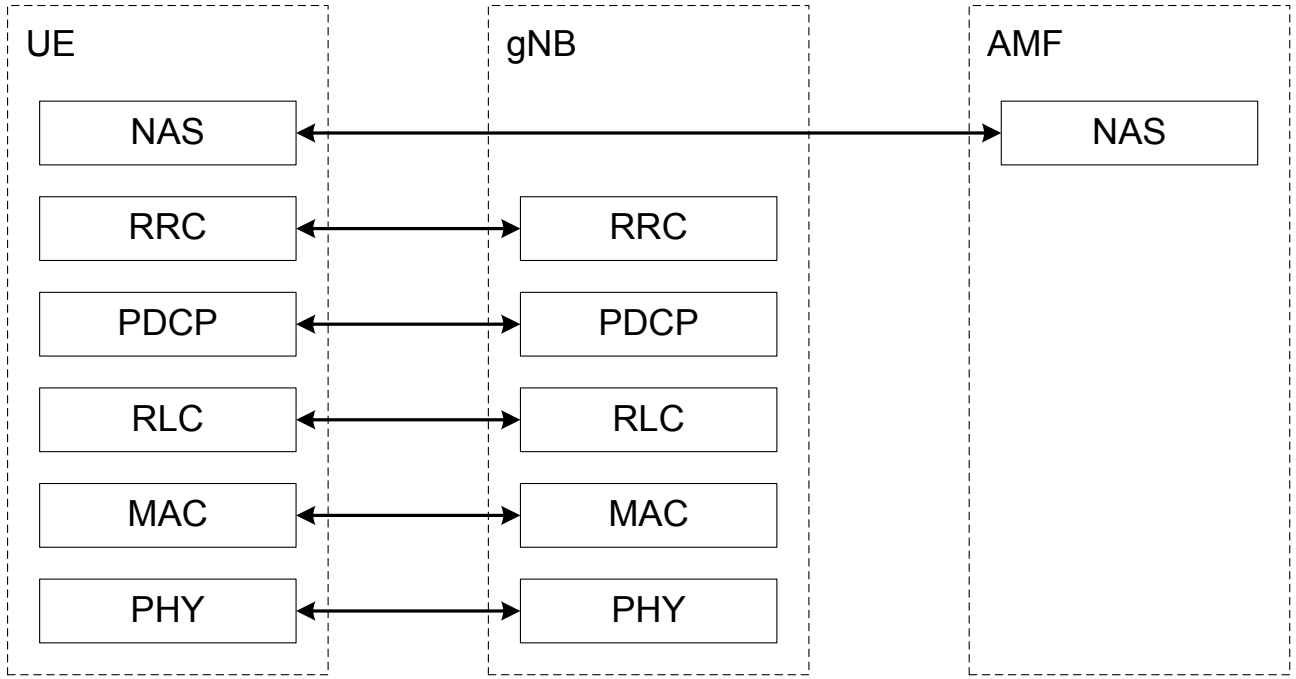


Control Plane Protocol Stack

Radio Protocol Architecture



User Plane Protocol Stack



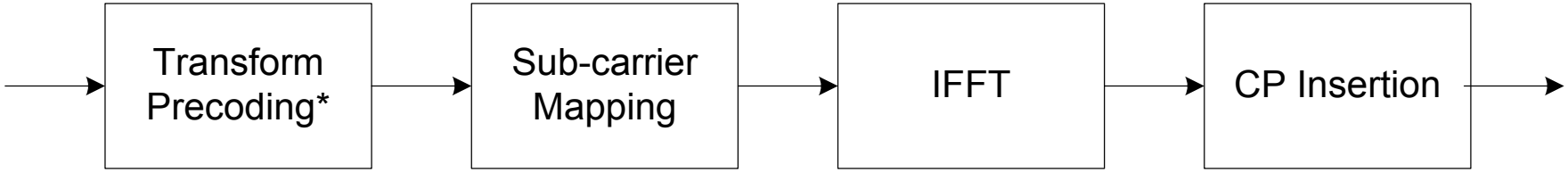
Control Plane Protocol Stack

Agenda

- NR Overall Architecture and Network Interfaces
- Physical Layer
- Layer 2 and RRC
- Deployment Architecture and Scenarios
- Core Network

Waveform and MA

- Waveform for up to 52.6GHz eMBB and URLLC
  - DL Waveform: CP-OFDM (QPSK to 256QAM)
  - UL Waveform: CP-OFDM or DFT-s-OFDM (π/2 BPSK to 256QAM)
    - CP-OFDM targeted at high throughput scenarios
    - DFT-s-OFDM targeted at power limited scenarios
- Multiple Access
  - Orthogonal Multiple Access
  - Non-Orthogonal Multiple Access (NOMA) not supported in Rel-15



**Optionally present in UL, not present in DL*

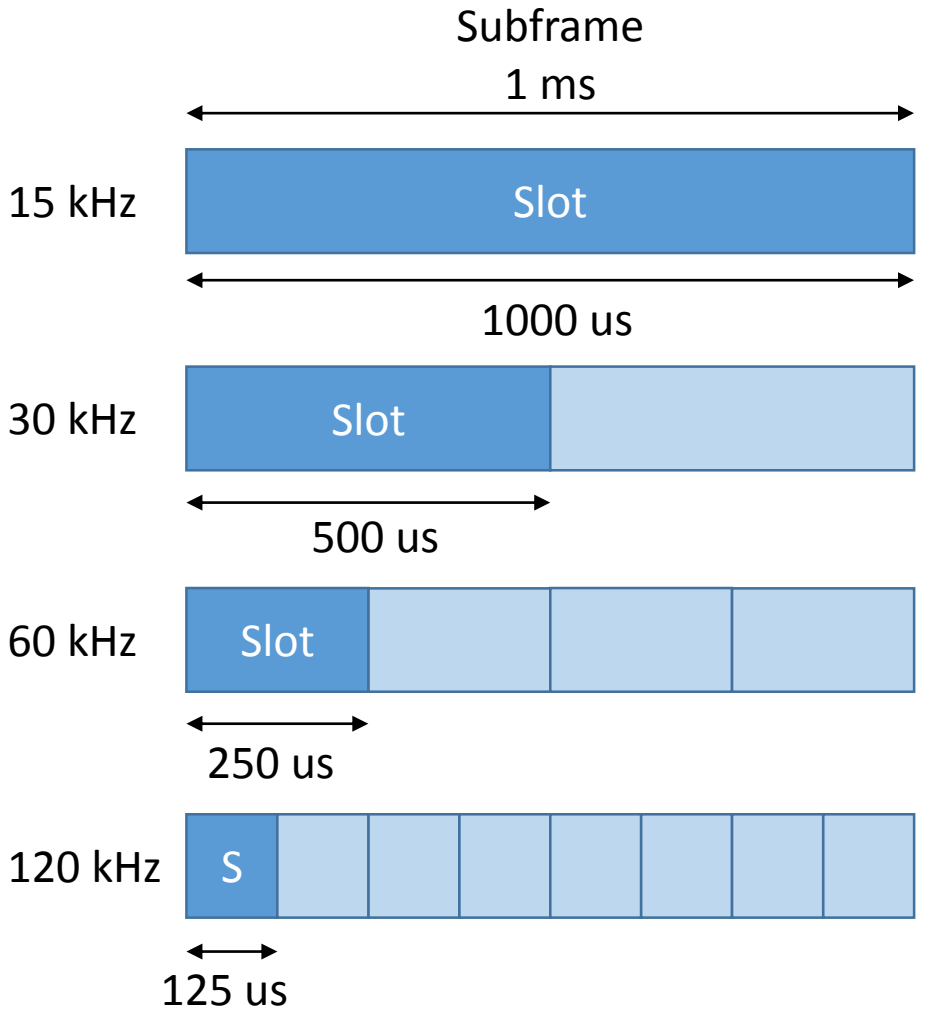
Numerology - SCS

- Scalable subcarrier spacing
  - $\Delta f = 2^{\mu} \times 15$ kHz
- SCS for PSS, SSS and PBCH
  - Sub 6 GHz: 15 or 30 kHz
  - 24~52.6 GHz: 120 or 240 kHz
- SCS for NR
  - Below 1 GHz: 15/30 kHz
    - UE Mandatory: 15k, 30k
  - 1~6 GHz: 15/30/60 KHz
    - UE Mandatory: 15k, 30k
    - UE Optional: 60k
  - 24~52.6 GHz: 60/120 kHz, 240 kHz (only for SS)
    - UE Mandatory: 60k, 120k

μ	$\Delta f = 2^{\mu} \cdot 15$ [kHz]	Cyclic prefix	Supported for data	Supported for synch
0	15	Normal	Yes	Yes
1	30	Normal	Yes	Yes
2	60	Normal, Extended	Yes	No
3	120	Normal	Yes	Yes
4	240	Normal	No	Yes

Frame Structure - Slot

- Frame: 10 ms
- Subframe: 1 ms
- Slot
  - For all SCS with NCP: 14 symbols
  - For 60kHz SCS with ECP: 12 symbols
  - Duration time: $1/\ 2^{\mu}$
- Mini-Slot
  - a minimum scheduling unit with 7, 4 or 2 OFDM symbols



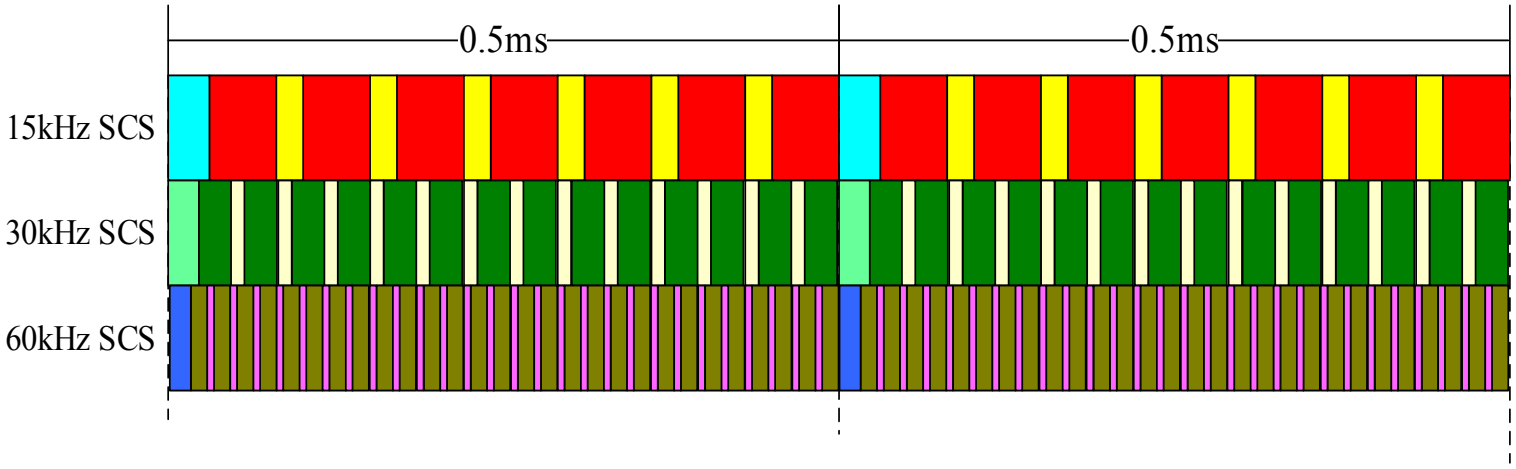
Numerology – CBW & FFT Size

- Channel Bandwidth
  - Frequency Range 1 (FR1) Sub 6 GHz: 100 MHz
  - Frequency Range 2 (FR2) 24~52.6 GHz: 400 MHz
- UE can support different maximum channel bandwidth in DL and UL (agreed for data channel)
- For single numerology, maximum number of subcarriers per NR carrier is 3300 in Rel-15, i.e. 275 RB
- Resource block
  - A resource block is defined as 12 consecutive subcarriers in the frequency domain

Frequency range	SCS (kHz)	Min CHBW (MHz)	Max RB	Max CHBW (MHz)
FR1	15	5	270	50
	30	5	273	100
	60	10	135	100
FR2	60	50	264	200
	120	50	264	400

Numerology - Symbol Alignment

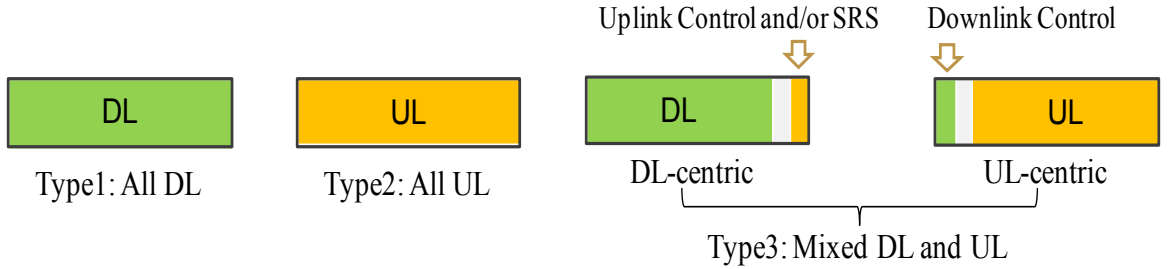
- The numerology with 15 kHz and scaled numerology with different subcarrier spacing with the same CP overhead align at a symbol boundary every 1ms in a NR carrier
- For NCP, 15kHz and scaled SCS are aligned at the symbol boundary of 15kHz



NCP Length in Ts (1/2048/15k)			
SCS (KHz)	1st CP within 0.5ms	Other CPs within 0.5ms	Symbol length
15	160	144	2048
30	88	72	1024
60	52	36	512
120	34	18	256
240	25	9	128

Frame Structure – Slot Type

- 3 types
  - DL-only slot
  - UL-only slot
  - Mixed DL and UL slot
- Slot Format
  - OFDM symbol in a slot can be classified as Downlink, Uplink or Flexible



Format	Symbol number in a slot													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	D	D	D	D	D	D	D	D	D	D	D	D	D	D
1	U	U	U	U	U	U	U	U	U	U	U	U	U	U
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	D	D	D	D	D	D	D	D	D	D	D	D	D	X
4	D	D	D	D	D	D	D	D	D	D	D	D	X	X
5	D	D	D	D	D	D	D	D	D	D	D	X	X	X
6	D	D	D	D	D	D	D	D	D	D	X	X	X	X
7	D	D	D	D	D	D	D	D	D	X	X	X	X	X
8	X	X	X	X	X	X	X	X	X	X	X	X	X	U
9	X	X	X	X	X	X	X	X	X	X	X	X	U	U
10	X	U	U	U	U	U	U	U	U	U	U	U	U	U
11	X	X	U	U	U	U	U	U	U	U	U	U	U	U
12	X	X	X	U	U	U	U	U	U	U	U	U	U	U
13	X	X	X	X	U	U	U	U	U	U	U	U	U	U
14	X	X	X	X	X	U	U	U	U	U	U	U	U	U
15	X	X	X	X	X	X	U	U	U	U	U	U	U	U
16	D	X	X	X	X	X	X	X	X	X	X	X	X	X
17	D	D	X	X	X	X	X	X	X	X	X	X	X	X
18	D	D	D	X	X	X	X	X	X	X	X	X	X	X
19	D	X	X	X	X	X	X	X	X	X	X	X	X	U
20	D	D	X	X	X	X	X	X	X	X	X	X	X	U
21	D	D	D	X	X	X	X	X	X	X	X	X	X	U
22	D	X	X	X	X	X	X	X	X	X	X	X	U	U
23	D	D	X	X	X	X	X	X	X	X	X	X	U	U
24	D	D	D	X	X	X	X	X	X	X	X	X	U	U
25	D	X	X	X	X	X	X	X	X	X	X	U	U	U
26	D	D	X	X	X	X	X	X	X	X	X	U	U	U
27	D	D	D	X	X	X	X	X	X	X	X	U	U	U
28	D	D	D	D	D	D	D	D	D	D	D	D	X	U
29	D	D	D	D	D	D	D	D	D	D	D	X	X	U
30	D	D	D	D	D	D	D	D	D	D	X	X	X	U
31	D	D	D	D	D	D	D	D	D	D	D	X	U	U
32	D	D	D	D	D	D	D	D	D	D	X	X	U	U
33	D	D	D	D	D	D	D	D	D	X	X	X	U	U

Channel coding

- Channel coding for eMBB
  - LDPC coding for data
  - Polar coding for control including PBCH
- Channel coding for URLLC – not yet discussed

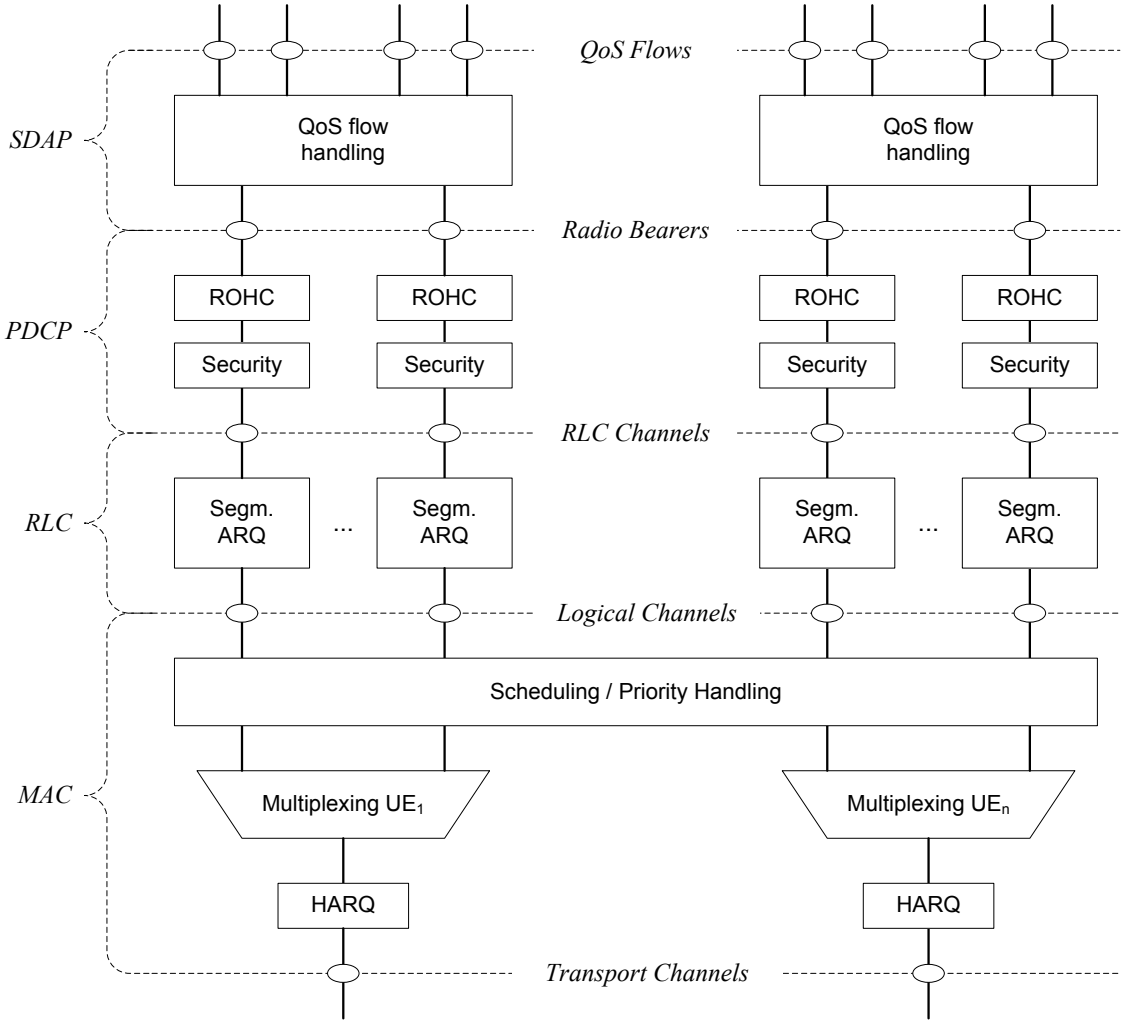
Physical Channel

- Downlink Physical channels
  - PDSCH (Physical Downlink Shared Channel)
  - PDCCH (Physical Downlink Control Channel)
  - PBCH (Physical Broadcast Channel)
- Downlink physical signals
  - PSS (Primary Synchronization Signal)
  - SSS (Secondary Synchronization Signal)
  - CSI-RS (Channel State Information Reference Signal)
  - DM-RS (Demodulation Reference Signal)
  - PT-RS (Phase-tracking Reference Signal)
- Uplink physical channels
  - PUSCH (Physical Uplink Shared Channel)
  - PUCCH (Physical Uplink Control Channel)
  - PRACH (Physical Random Access Channel)
- Uplink physical signals
  - SRS (Sounding Reference Signal)
  - DM-RS (Demodulation Reference Signal)
  - PT-RS (Phase-tracking Reference Signal)

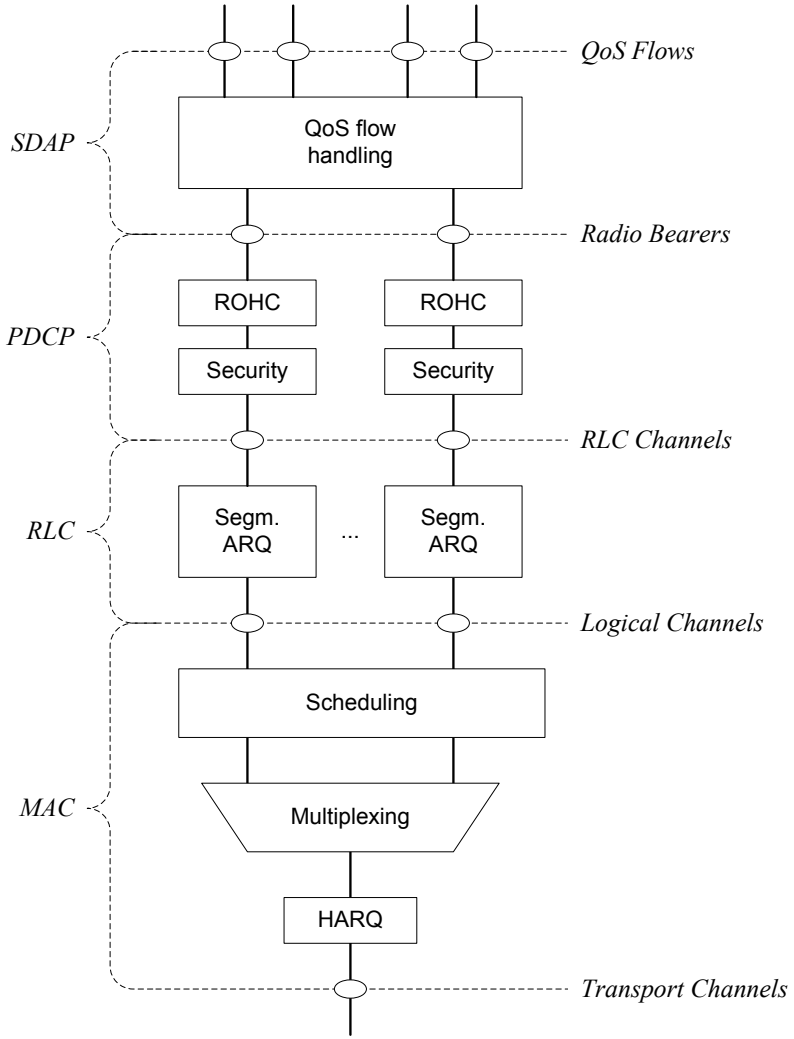
Agenda

- NR Overall Architecture and Network Interfaces
- Physical Layer
- Layer 2 and RRC
- Deployment Architecture and Scenarios
- Core Network

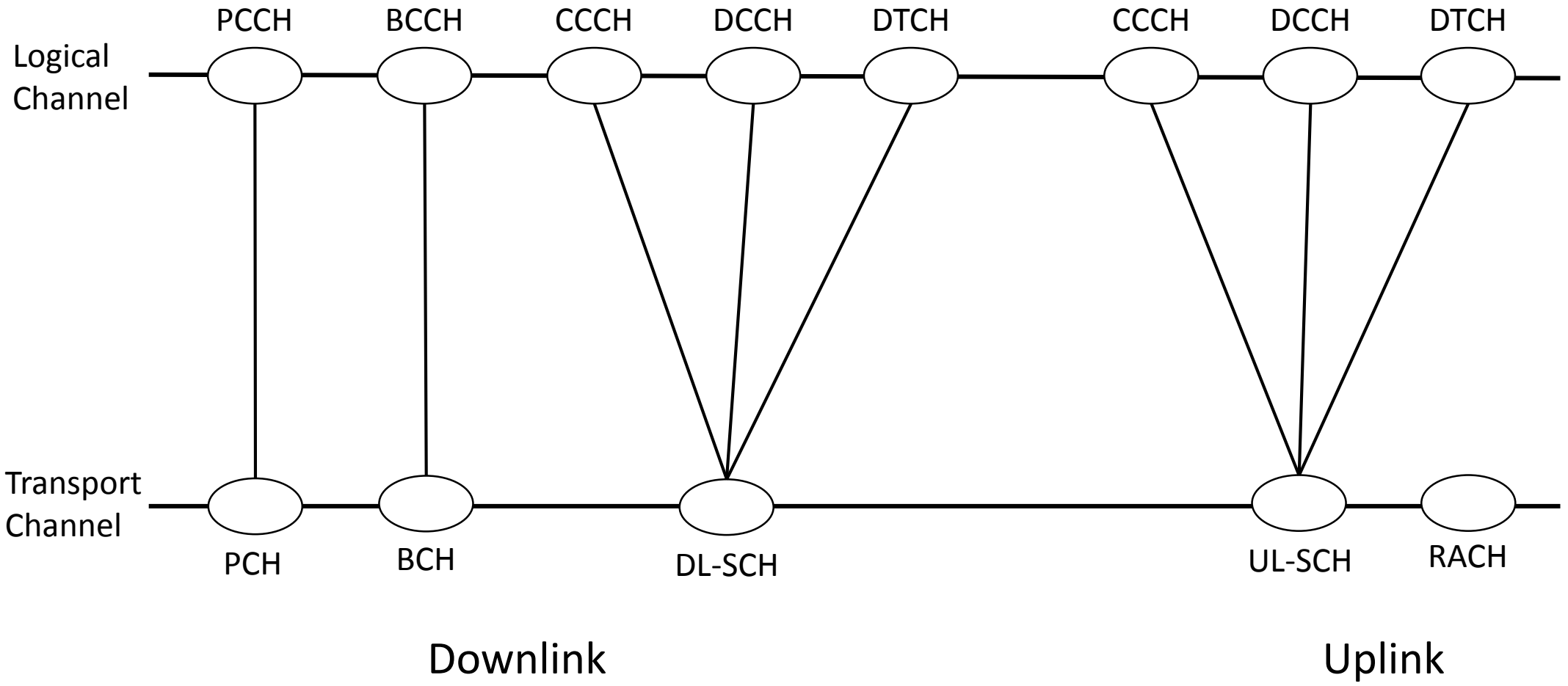
Downlink Layer 2 Structure



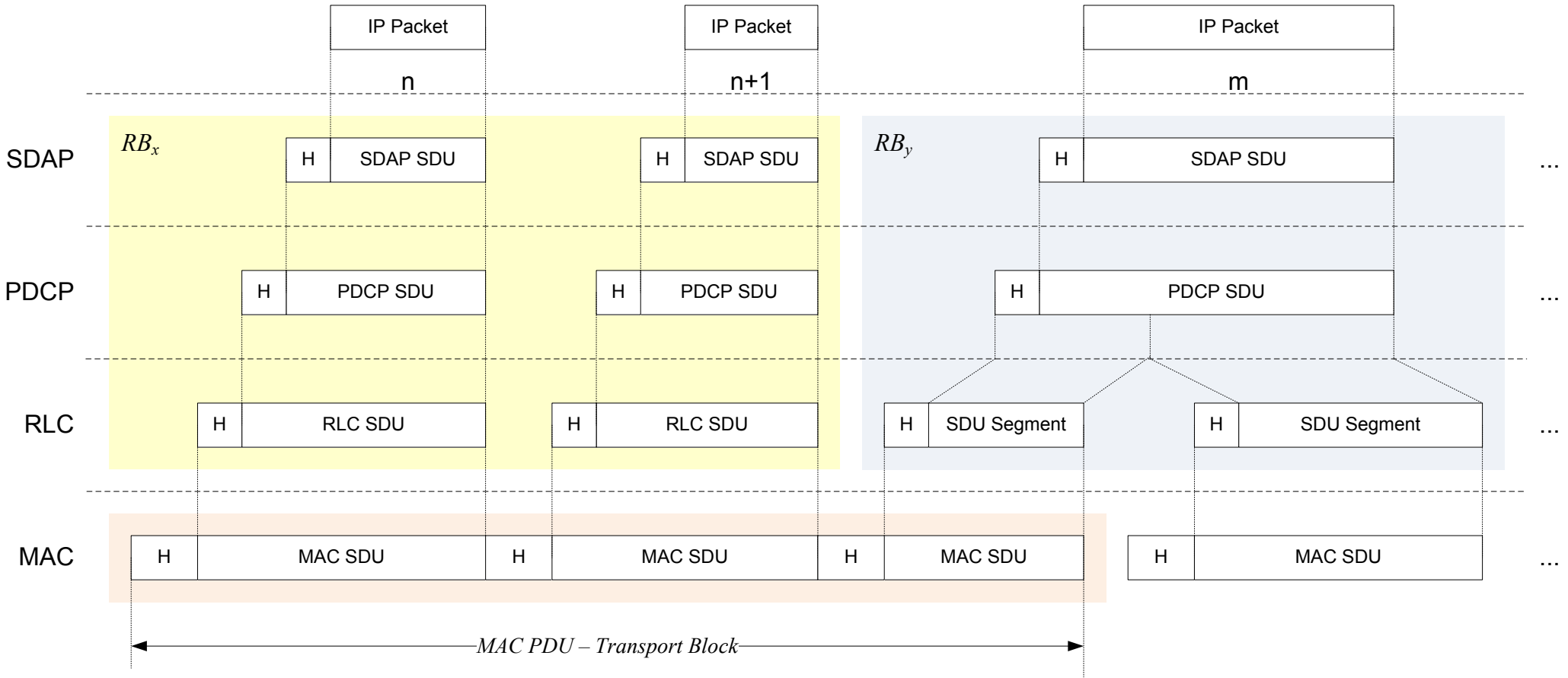
Uplink Layer 2 Structure



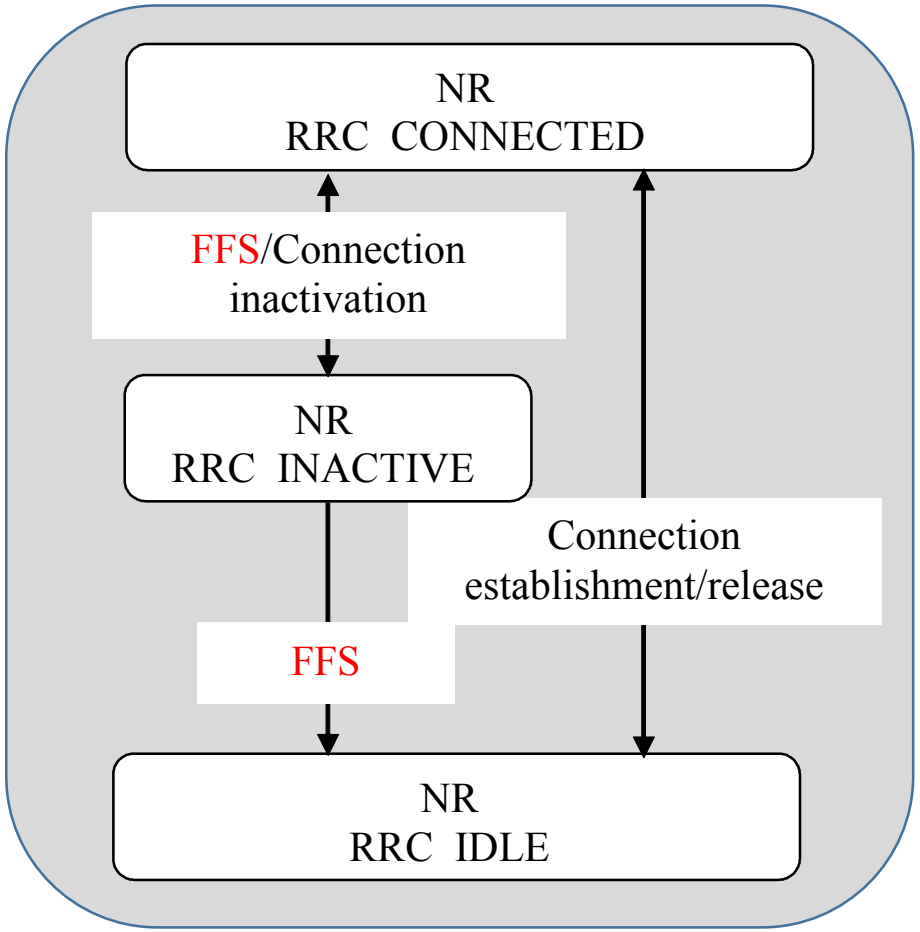
Channel Mapping



Layer 2 Data Flow



NR UE RRC states

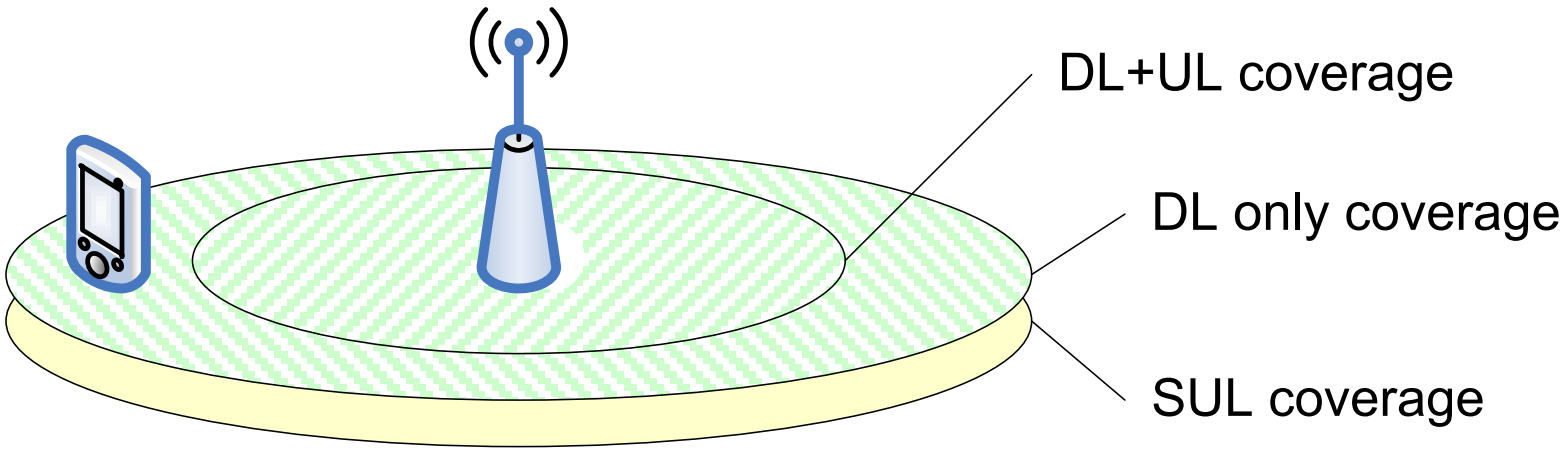


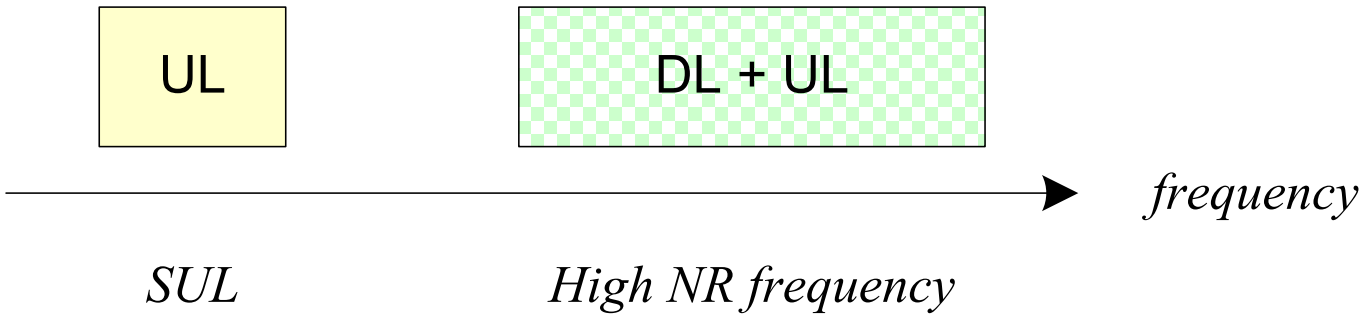
- RRC_IDLE and RRC_CONNECTED, same as LTE
- RRC_INACTIVE
  - Motivation of RRC_INACTIVE is Signaling/Latency reduction
- Characteristics of RRC_INACTIVE
  - Cell re-selection mobility;
  - CN – NR RAN connection (both C/U-planes) has been established for UE;
  - The UE AS context is stored in at least one gNB and the UE;
  - Paging is initiated by NR RAN;
  - RAN-based notification area is managed by NR RAN;
  - NR RAN knows the RAN-based notification area which the UE belongs to

Agenda

- NR Overall Architecture and Network Interfaces
- Physical Layer
- Layer 2 and RRC
- Deployment Architecture and Scenarios
- Core Network

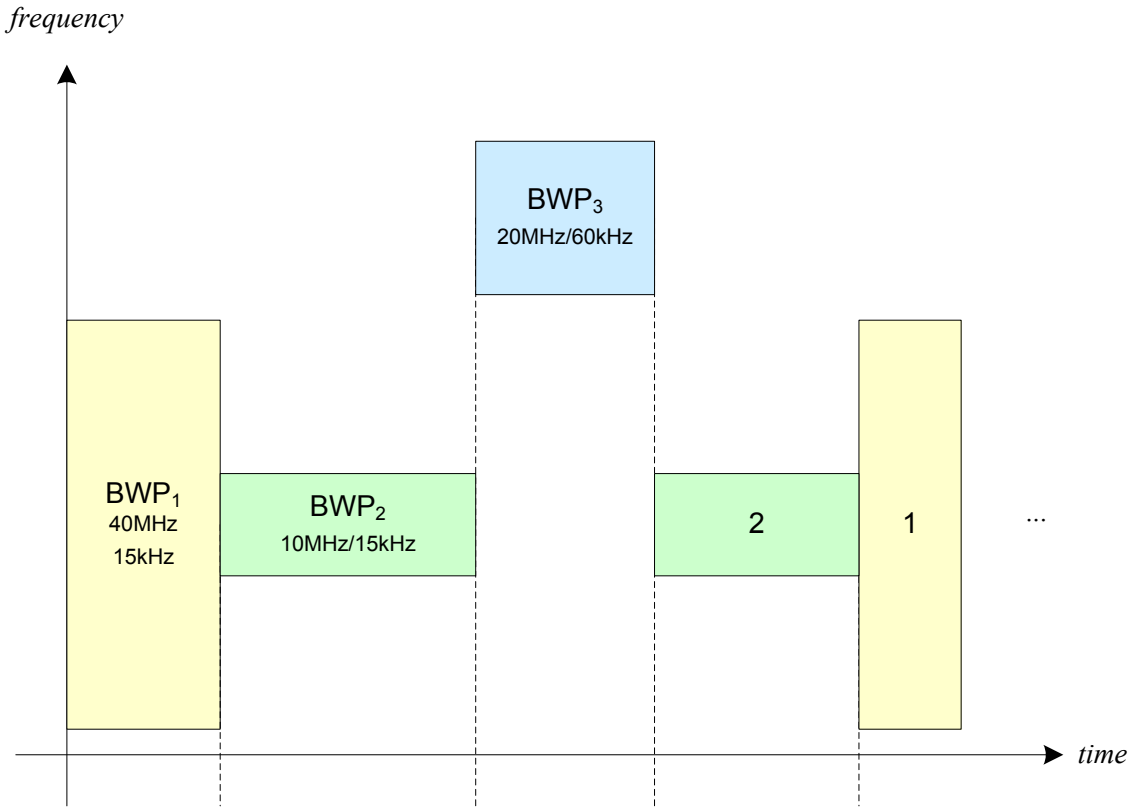
Deployment Scenario – SUL



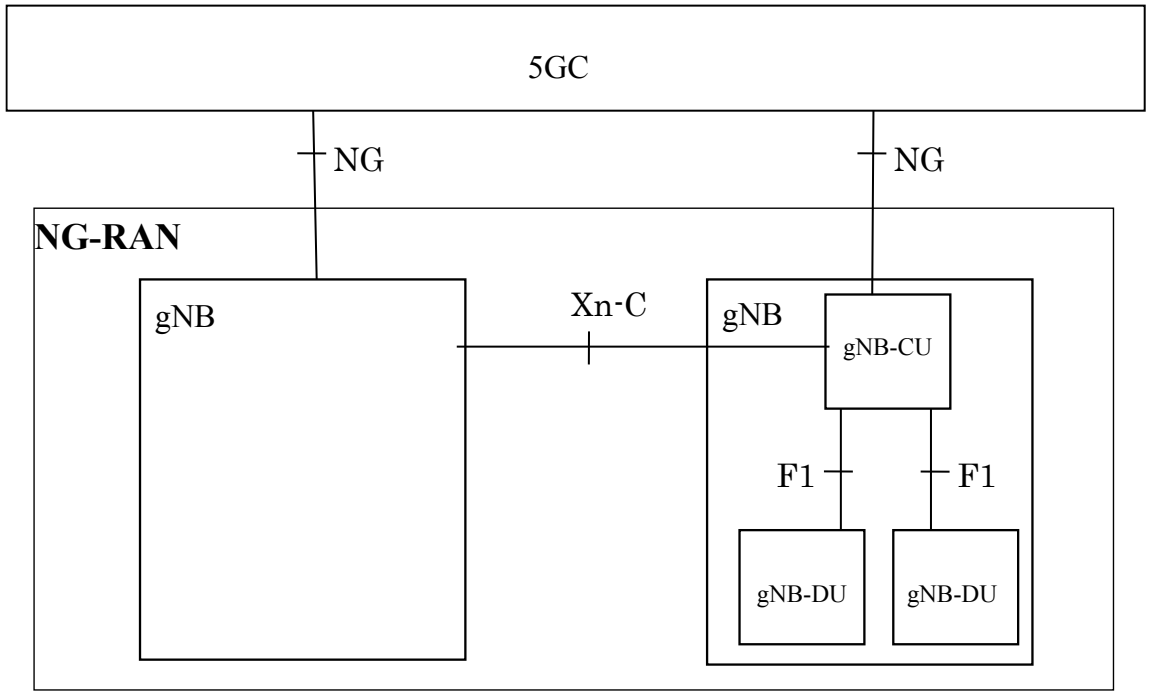


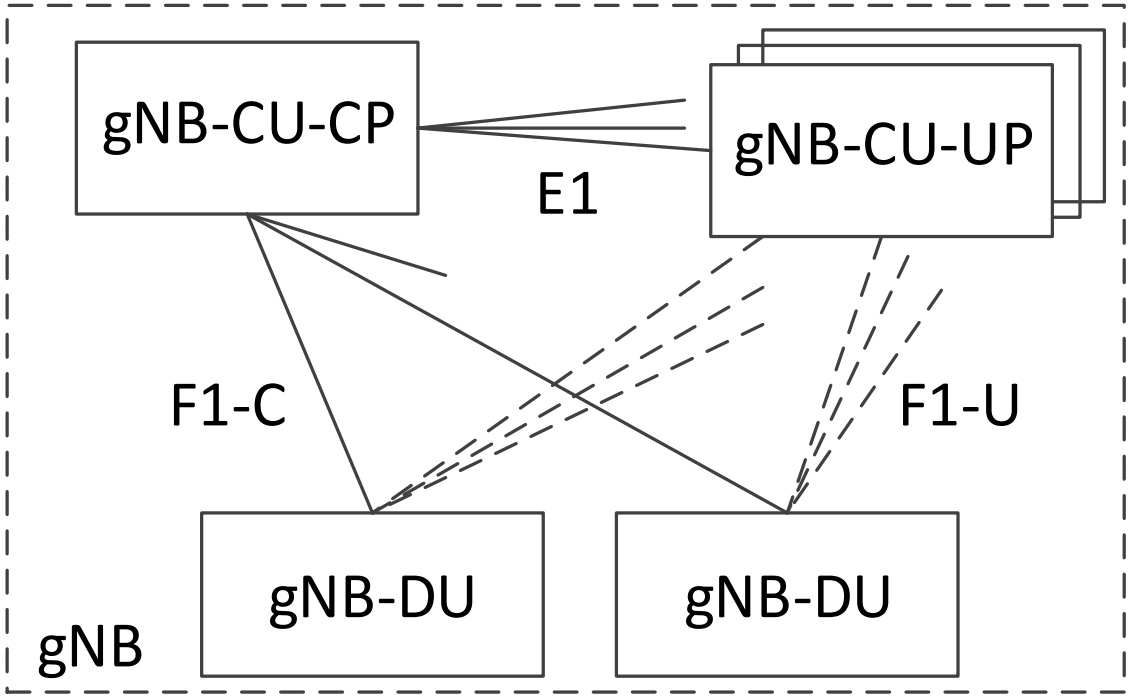
Bandwidth Part (BWP)

- Bandwidth Adaptation
  - UE bandwidth can be shorter than the bandwidth of the cell and can be adjusted
  - Save power during period of low activity
  - Increase scheduling flexibility
  - Allow different services

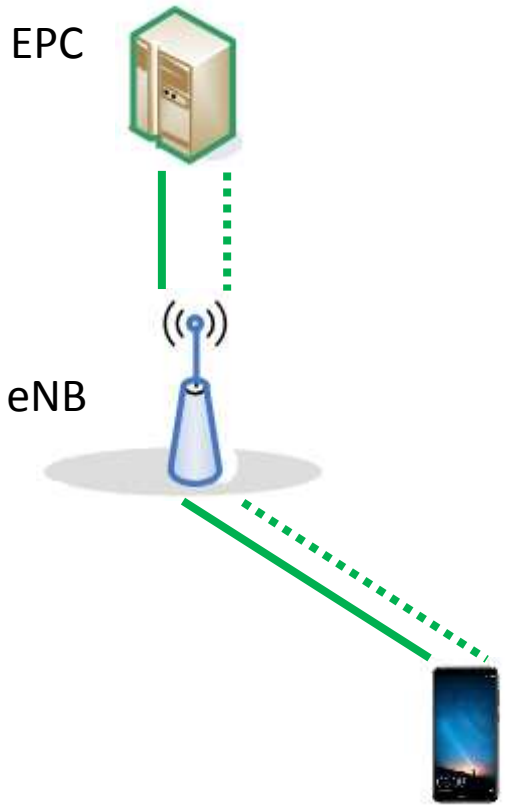


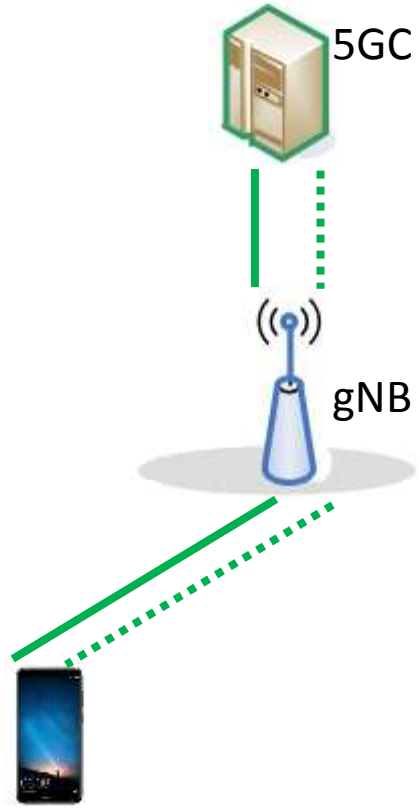
CU/DU split and CP/UP separation





5G Architecture – Option 1/2

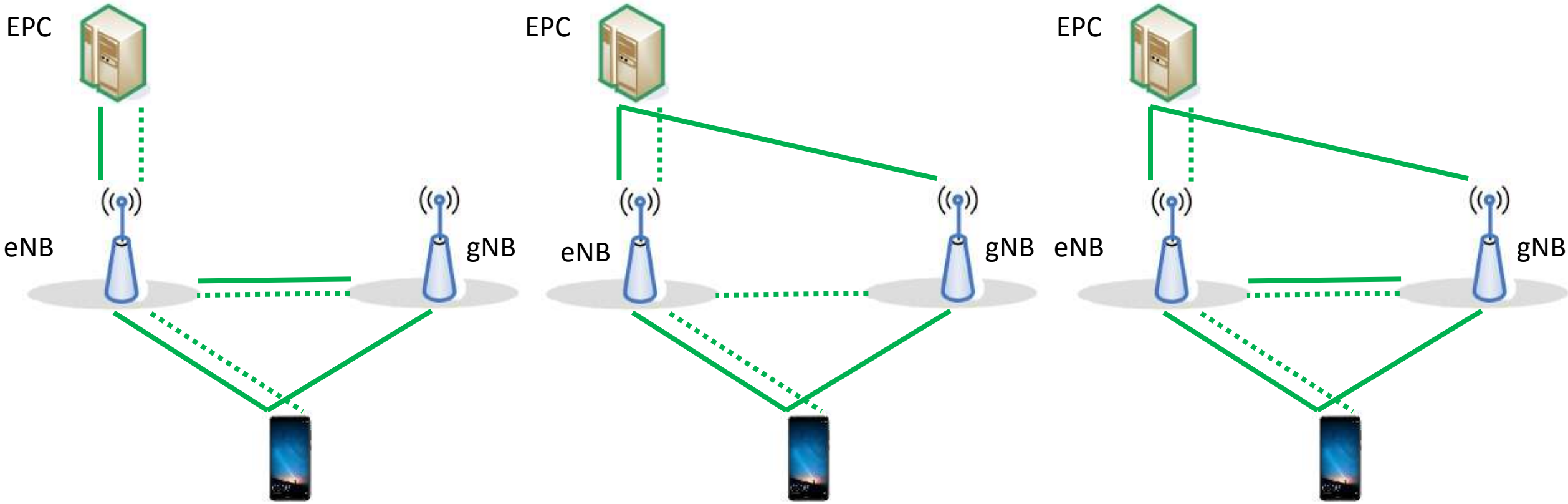




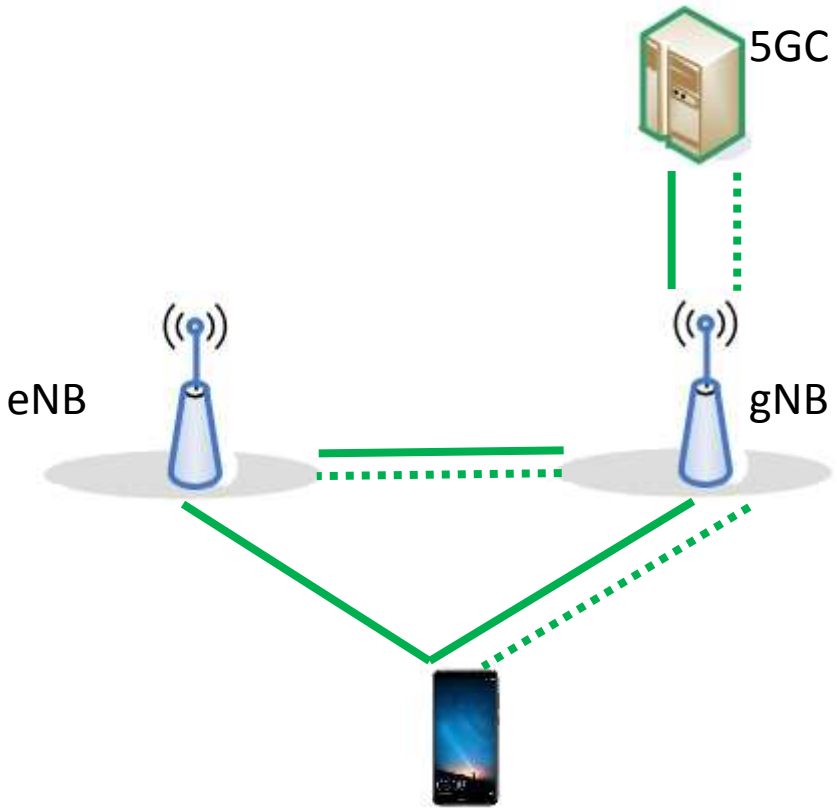
User Plane

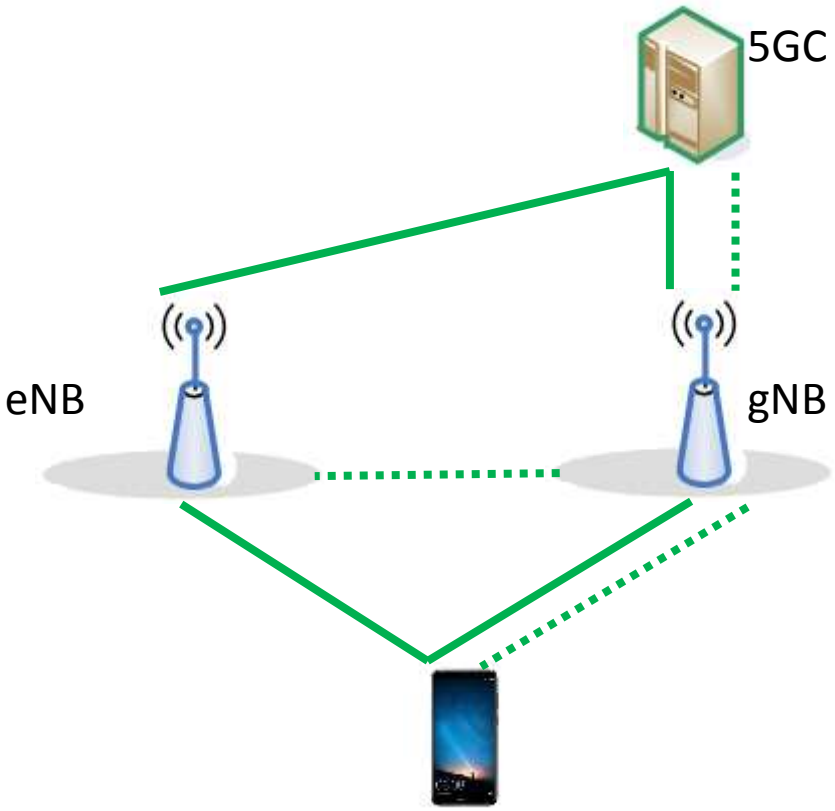
Control Plane

5G Architecture – Option 3/3a/3x



5G Architecture – Option 4/4a

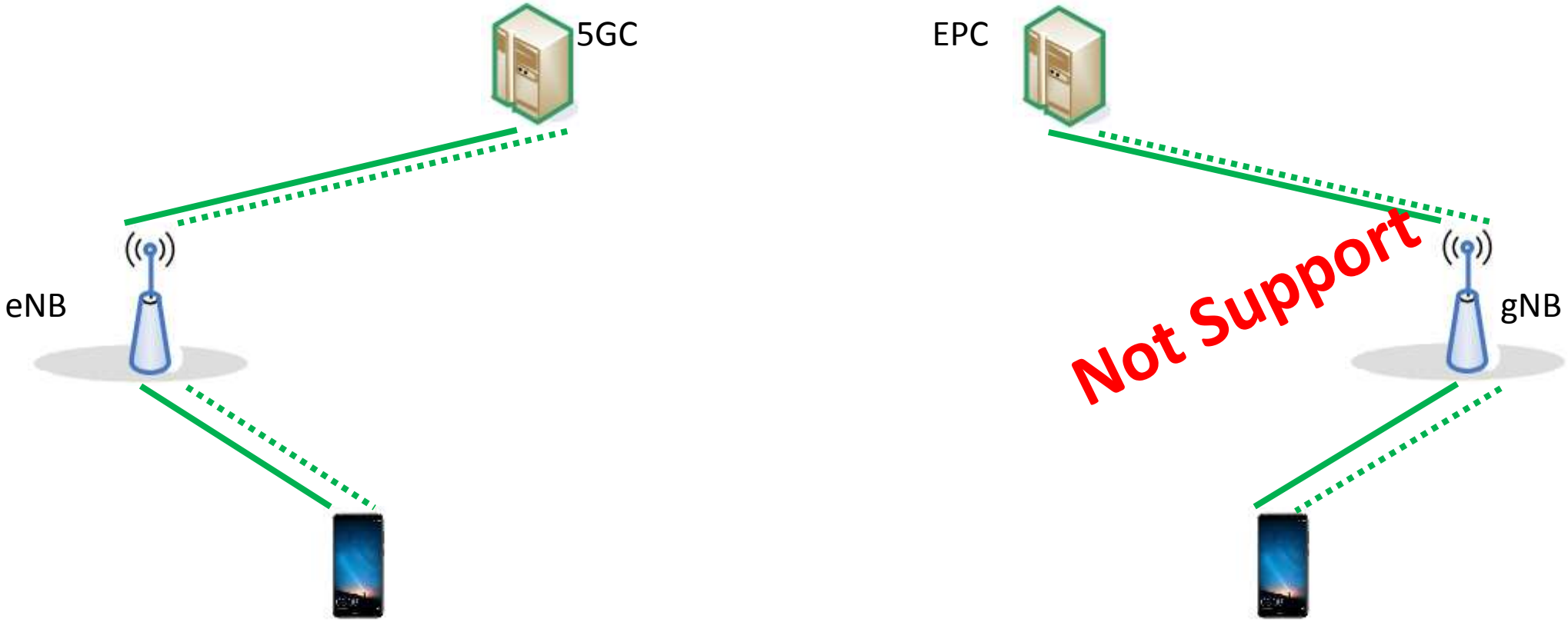




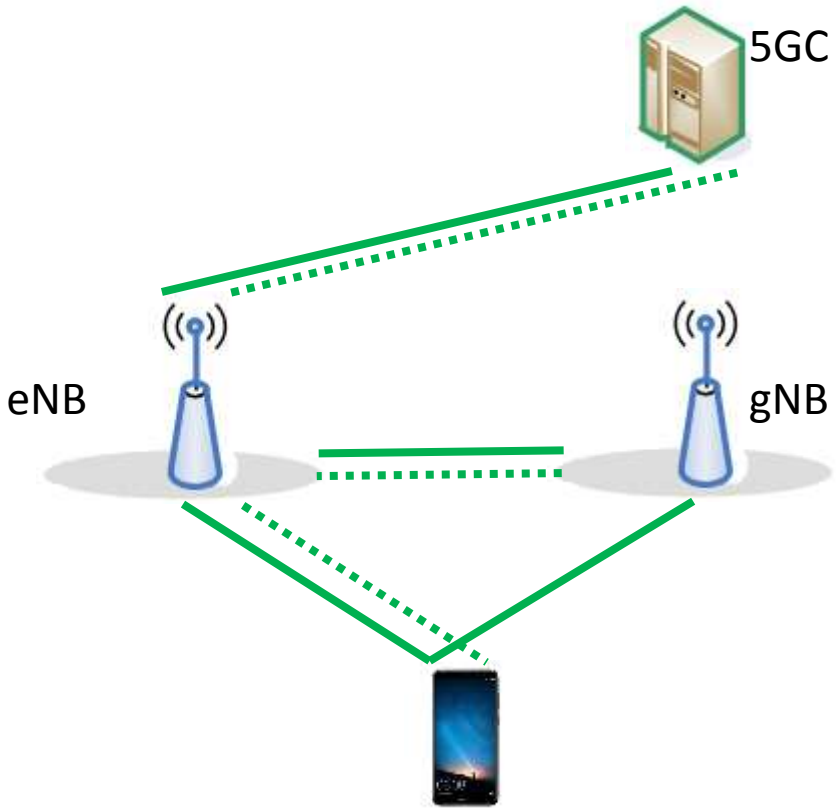
User Plane

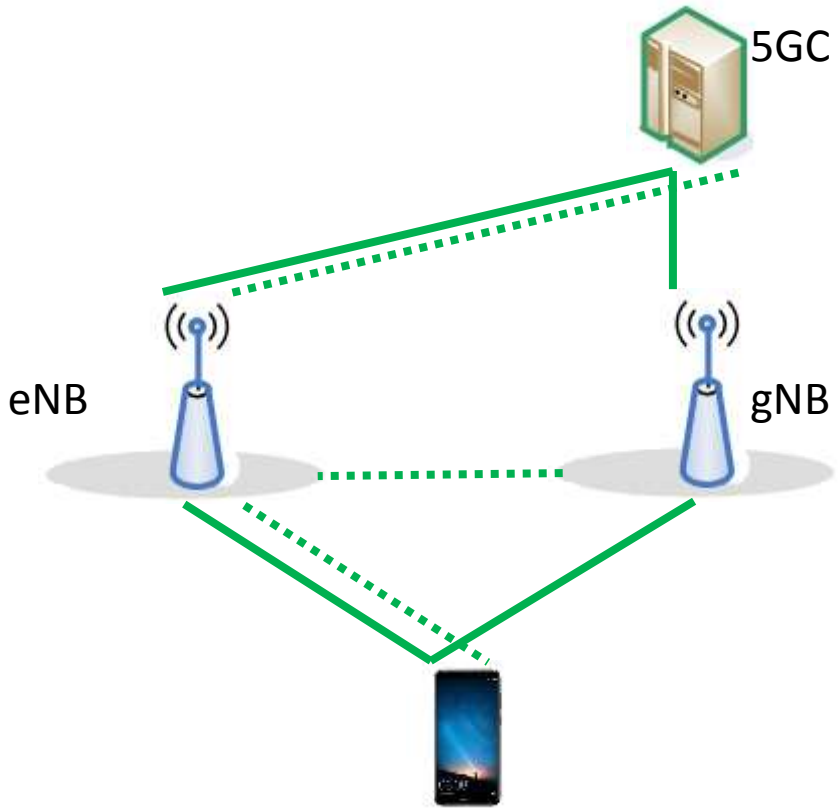
Control Plane

5G Architecture – Option 5/6



5G Architecture – Option 7/7a

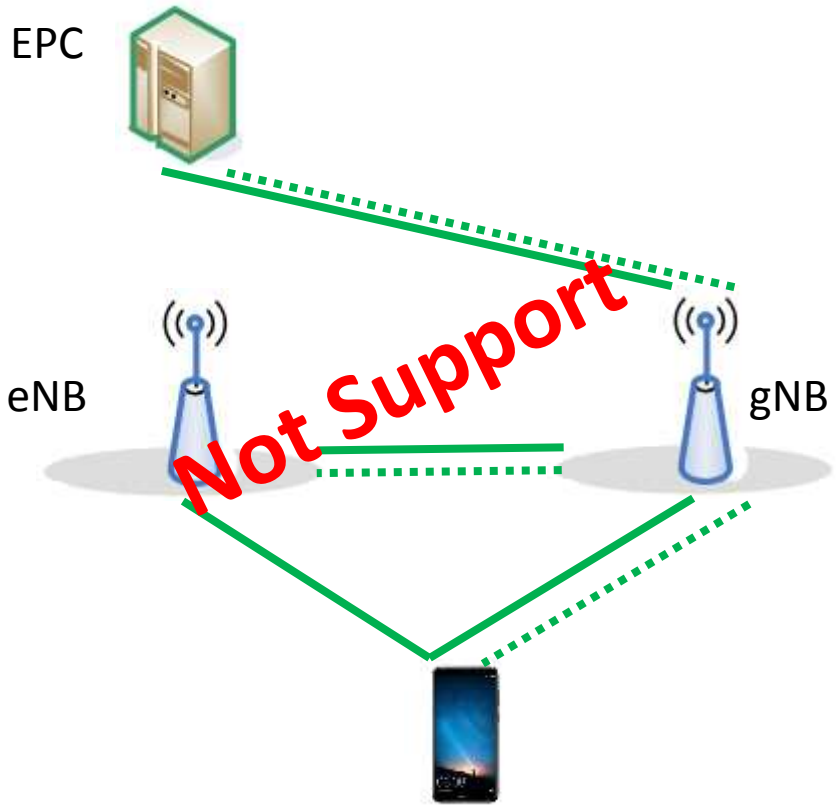


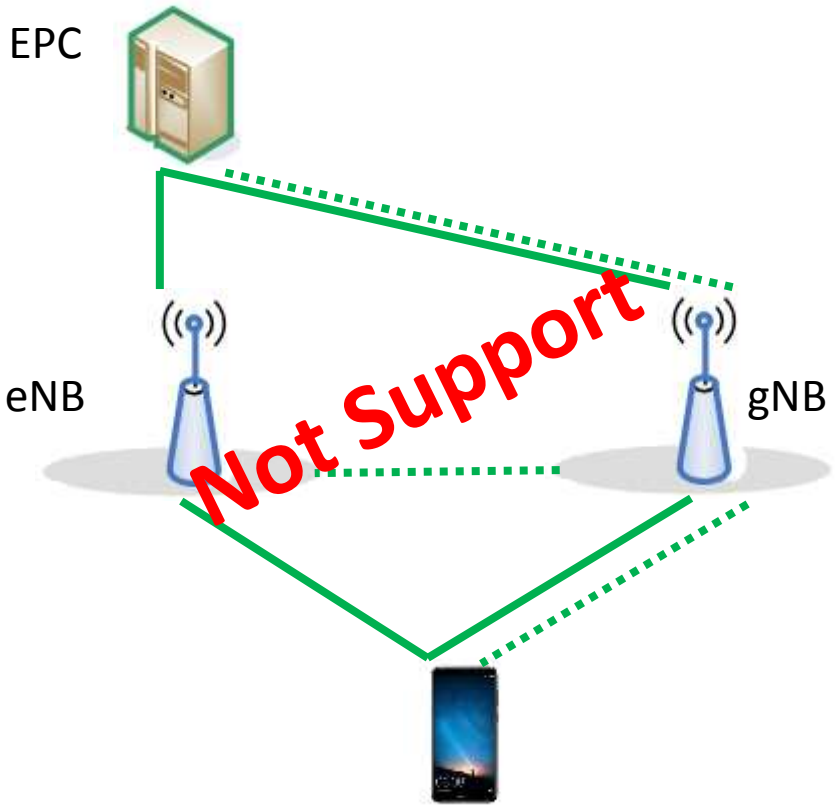


User Plane

Control Plane

5G Architecture – Option 8/8a





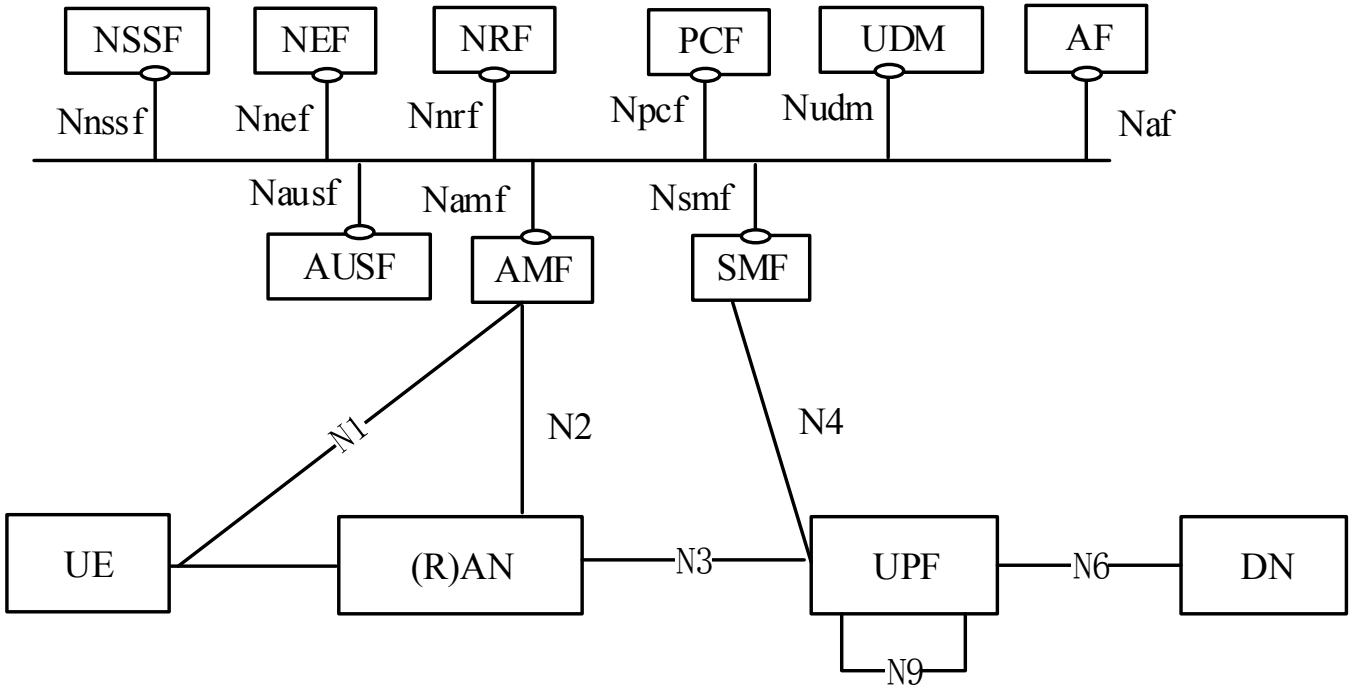
User Plane

Control Plane

Agenda

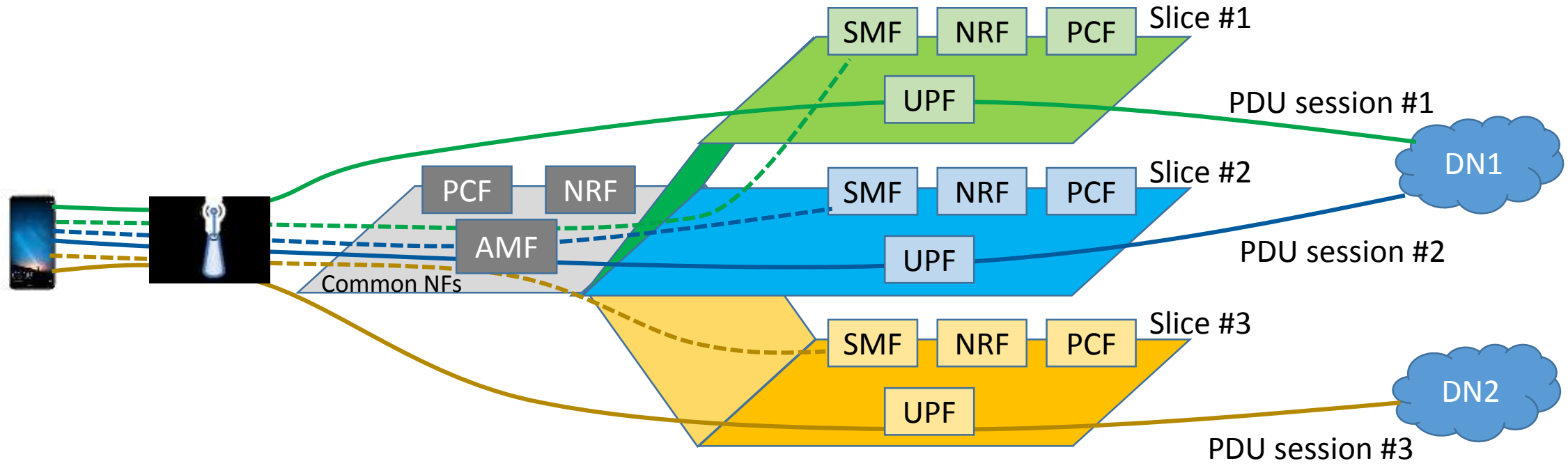
- NR Overall Architecture and Network Interfaces
- Physical Layer
- Layer 2 and RRC
- Deployment Architecture and Scenarios
- Core Network

Service based network architecture



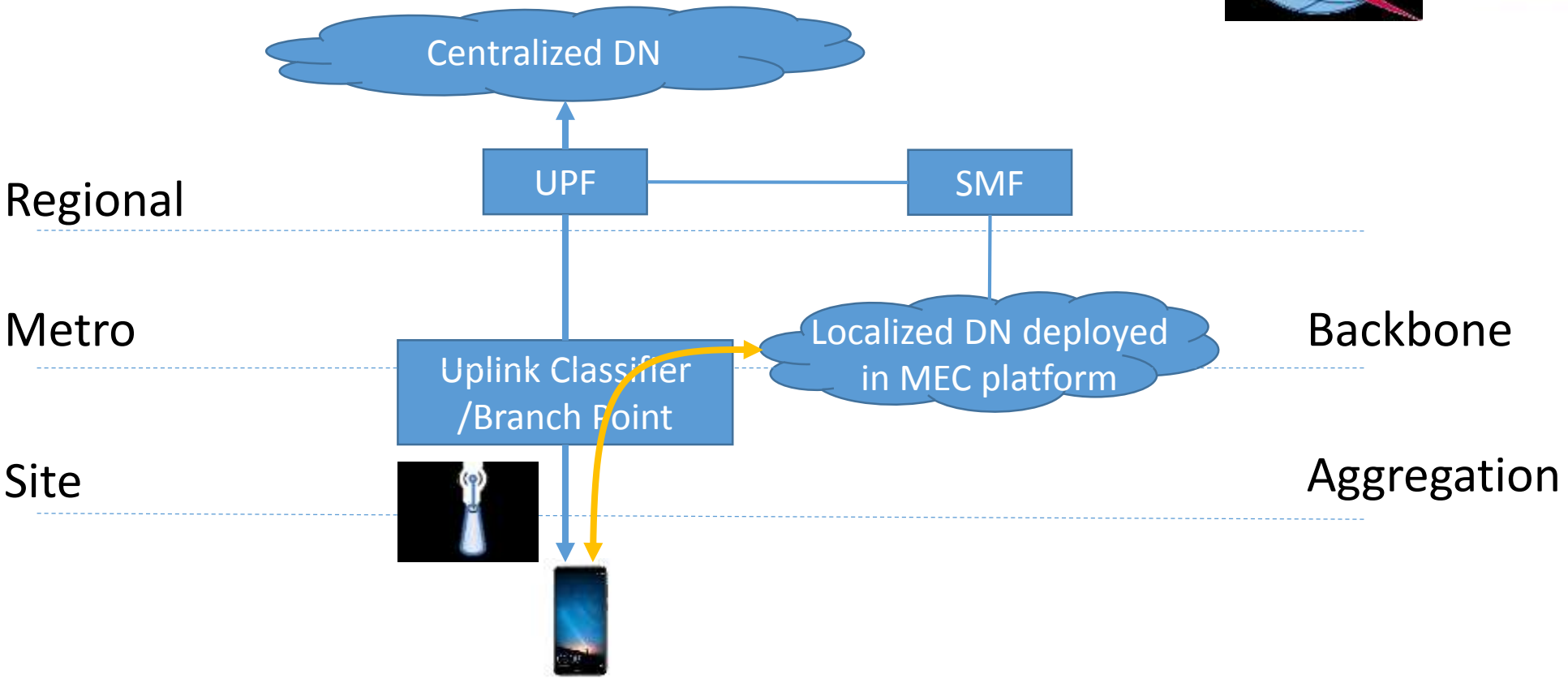
- Each CP NF exposes its capabilities as one or multiple services
- Service is neutral to NF service consumers
- All interactions are abstracted as: Request-Response, Subscription-Notify
- System procedures are described as a sequence of NF service invocations

Network Slicing



- The network resources are sliced into multiple isolated logic networks
- One UE can access to multiple network slices simultaneously

Native support Edge Computing



- Support local routing of traffics to MEC platform
- Cooperation between application and network for path optimization

(Trainer information)

Trainer: Wang Zhixi

E-mail: wangzhixi@huawei.com

Department: Huawei Company

Address: Shenzhen

Photo：

(End Page)

中国信息通信研究院 http://www.caict.ac.cn