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Function split and deployment scenarios for NGFI

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Next Generation Fronthaul Interface - Use Cases & Scenarios
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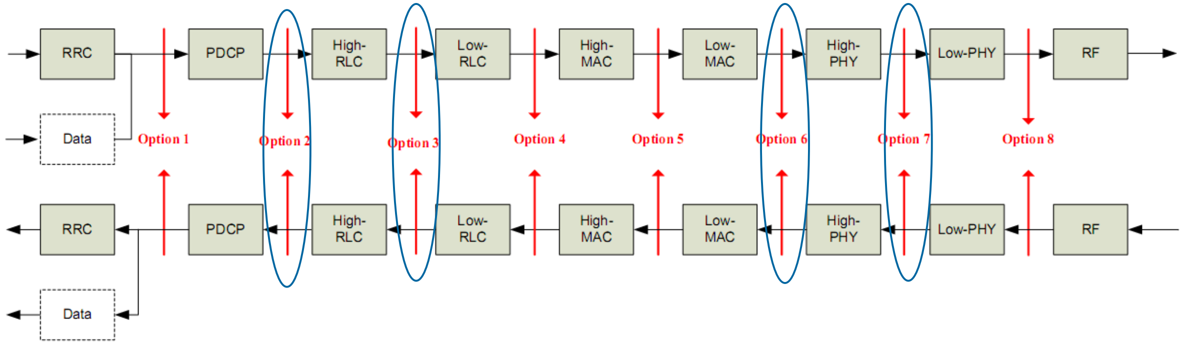
Preferred RAN functional split options

Preferred RAN function split options for transport



Option 2
- Split between PDCP & RLC
- Already standardized for LTE Dual Connectivity in 3GPP
- Benefits of aggregation of different transmission points

Option 3
- Intra-RLC split
- Candidate break point: Lower RLC: segmentation & concatenation, High RLC: ARQ retransmission & packet ordering
- Benefit: More robust under unreliable transport conditions

Option 6
- Already used in nFAPI (network Function API) specified by Small Cell Forum Release 7.0
- Benefit: Centralized scheduler

Option 7
- Intra-PHY split
- Split point consideration to facilitate:
  - Implementation of advanced receivers
  - Ability of joint processing (JR and JT)
  - Reasonable transport bandwidth requirement
- Candidate break point: after FFT &CP removal for uplink, and before layer mapping for downlink
- Benefits: realization of full CoMP gain and advanced receiver

Transport requirement for the preferred RAN split options

	Option 2	**Option 3**	**Option 6**	**Option 7**
	RLC&PDCP split	Intra-RLC split	MAC&PHY split	Intra-PHY split
Throughput requirement	Proportional to the user data rate	Proportional to the user data rate	Proportional to the user data rate	Proportional to channel BW, number of antennas, or MIMO layers
Throughput comparison	TP2≈<TP3≈<TP6<<P7	TP3≈<TP6<<P7	TP6<<TP7 (by factor of 5-10)	TP7
Latency requirement	ms range	ms range	User-plane: ms range Control-plane: μs range	μs range
CoMP performance	LTE: slow coordination NR: new CoMP scheme pending	LTE: slow coordination NR: new CoMP scheme pending	fast scheduling coordination	joint processing & fast scheduling coordination
Data types	RLC PDUs	ARQ packets	Physical channels	Sub-carrier symbols

- Option 2 & 3 have similar latency&BW requirement

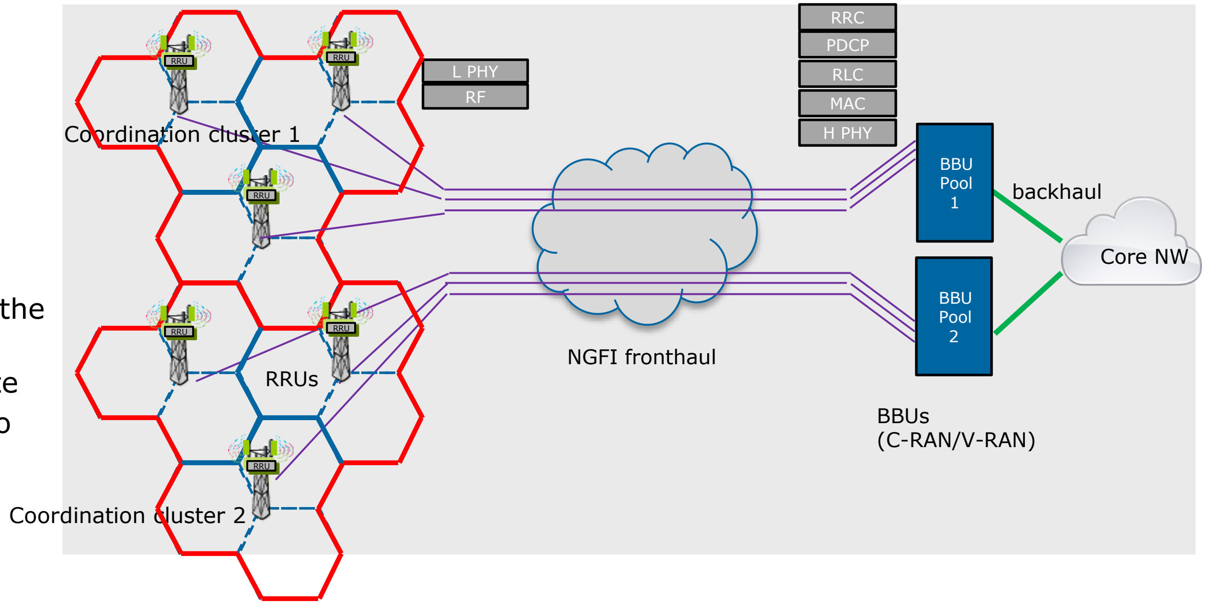
  ➔grouped into the same category in terms of transport aspect
- Option 6 requires separation of control-plane (fast) and user-plane (slow)
- Option 7 is another transport category with much different latency and BW requirements

➡ Transport requirements derived from above function split categories to be further discussed & studied

Deployment scenarios

Centralized-RAN based macro deployment

- Centralized/cloud-RAN
- Cell coordination to improve cell edge user experience
- BBUs in a coordination cluster co-located in the same BBU pool
- Joint Transmission(JT)/Joint Reception (JR) performed among the BBUs in the same cluster
- Multiple sector deployment per site
- Near term solution for evolution to 5G



Fronthaul requirement

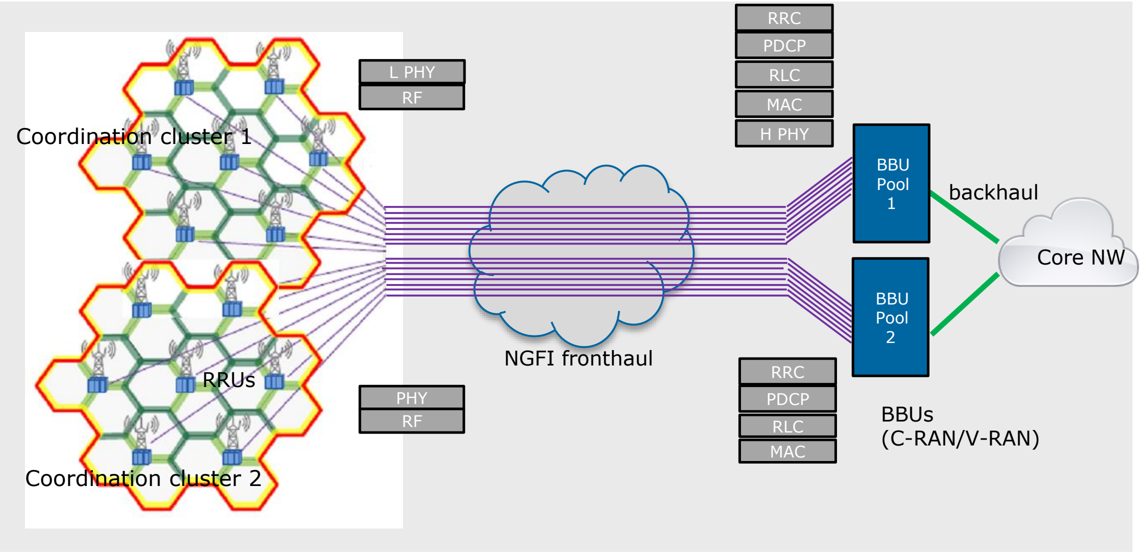
- Option 7 as candidate function splitting option to enable inter-site/intra-cluster fast coordination
- Site transport BW requirement (UL):

UL: *~(# of sectors/site)x(# of RX chains)x (signal BW)x(CP removal factor)x(sample data resolution)*
DL: *~(# of sectors/site)x(# of DL spatial layers)x (signal BW)x(CP removal factor)x(sample data resolution)*

- Stringent latency requirement: (e.g. ~100us)
- Average transport distance to BBU pools: large due to large ISD (inter-site distance)➔smaller cluster size due to transport cost concerns
- Possible legacy CPRI transport with function split option 8 as existing solution

Centralized-RAN based small cell deployment

- Micros/pico RRUs at poles/buildings for dense small cells
- Stadium/high-capacity venues
- Evolving to mmWave
- Omnidirectional or multi-sectors
- Advanced CoMP technology required for interference management
  - CS/CB
  - JT/JR
  - Dual connectivity
  - LAA
- Coordination within cluster

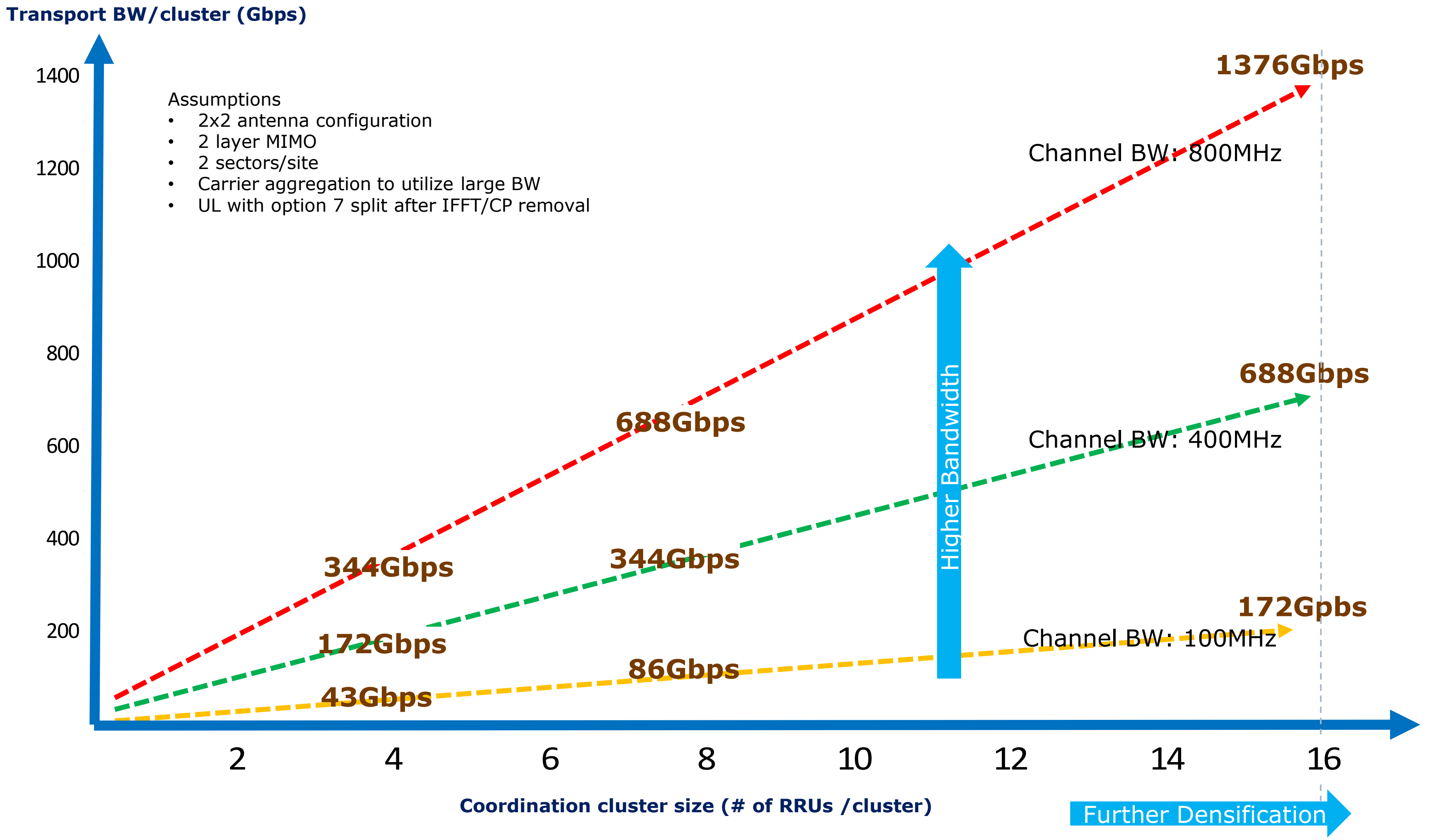


Fronthaul requirement

Option 7 as candidate function split to support advance CoMP	Option 6 as candidate function split
• Site transport BW requirement: UL: *~(# of sectors/site)x(# of RX chains)x (signal BW)x(CP removal factor)x(sample data resolution)* DL: *~(# of sectors/site)x(# of DL spatial layers)x (signal BW)x(CP removal factor)x(sample data resolution)* • Stringent latency requirement: (e.g. ~100us)	• To support nFAPI • To reduce the transport cost • Site transport BW requirement for user-plane: *~(# of sectors/site) x (peak user data rate)* • Stringent latency requirement for control-plane • Relaxed latency requirement for user-plane

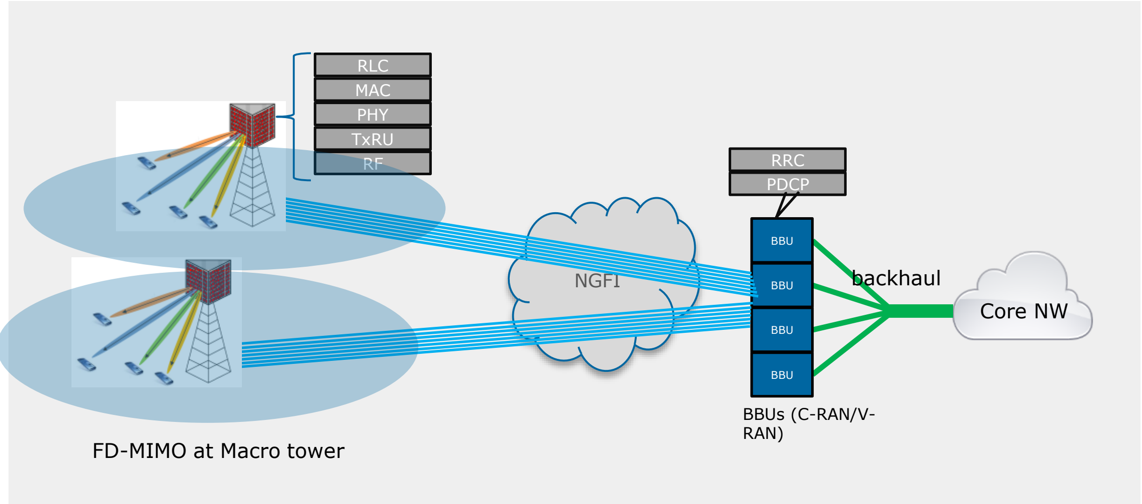
- Aggregated transport traffic/cluster: function of coordination cluster size
- Average transport distance to BBU pool: small

Transport BW requirement example for small cell deployment



Massive-MIMO macro deployment

- FD-MIMO/Massive-MIMO at Macro tower
- Active array systems (AAS) to steer beams in both azimuth and elevation directions
- Simultaneous narrow beams to support high order MU-MIMO
- Virtual small cells formed by narrow BF
- Multiple sector deployment
- Carrier aggregation
- Coordination among the virtual cells performed by massive MIMO processing



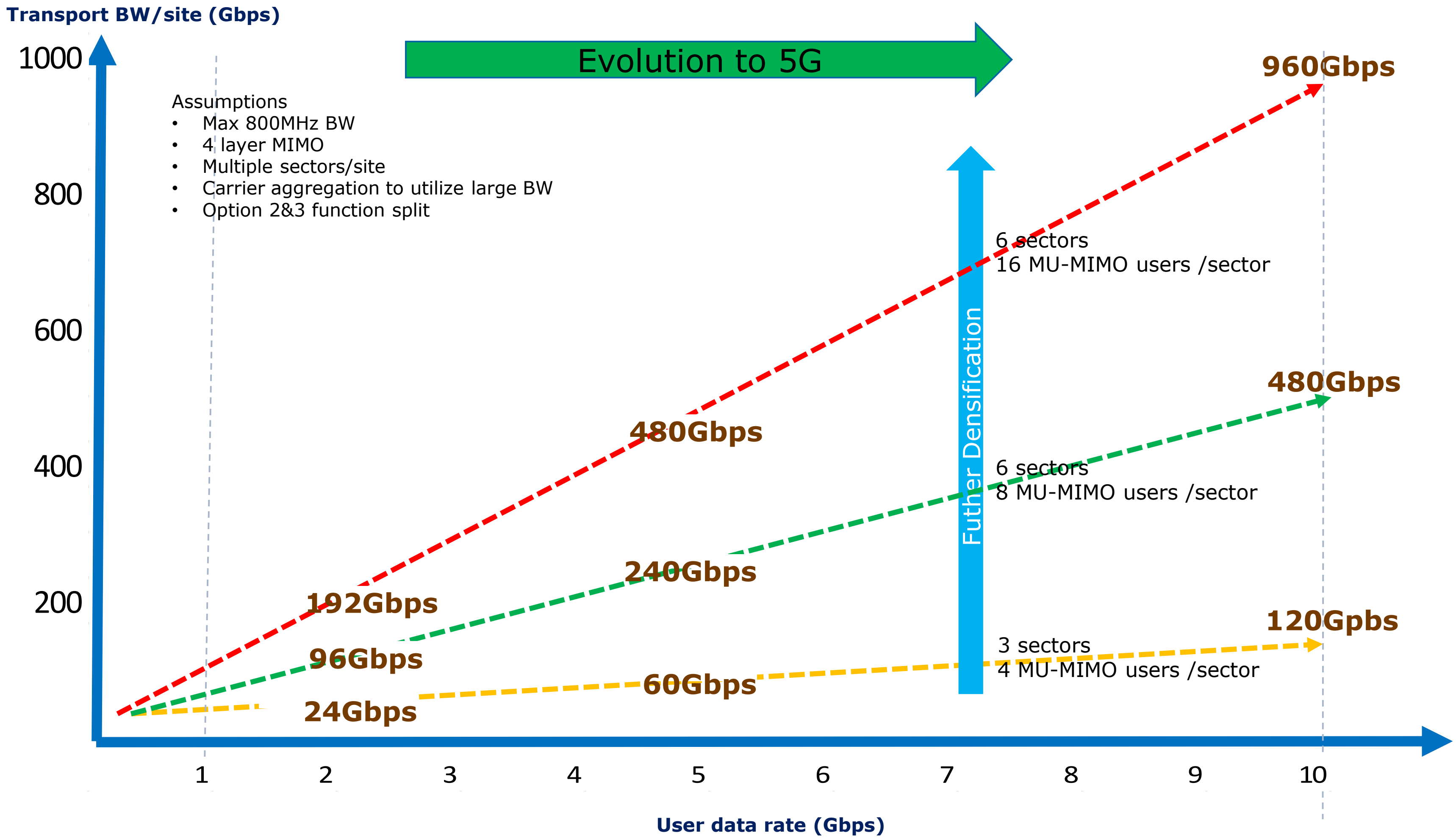
Fronthaul requirement

- Massive transport connections required to each cell site
- Option 2&3 as candidate function splitting option to cope with the large transport BW requirement
- Transport BW requirement/site:

~(# of sectors/site) x (peak user data rate) x (# of beams (virtual cells))

- Relaxed latency requirement
- Average transport distance to BBU pools: large due to large ISD

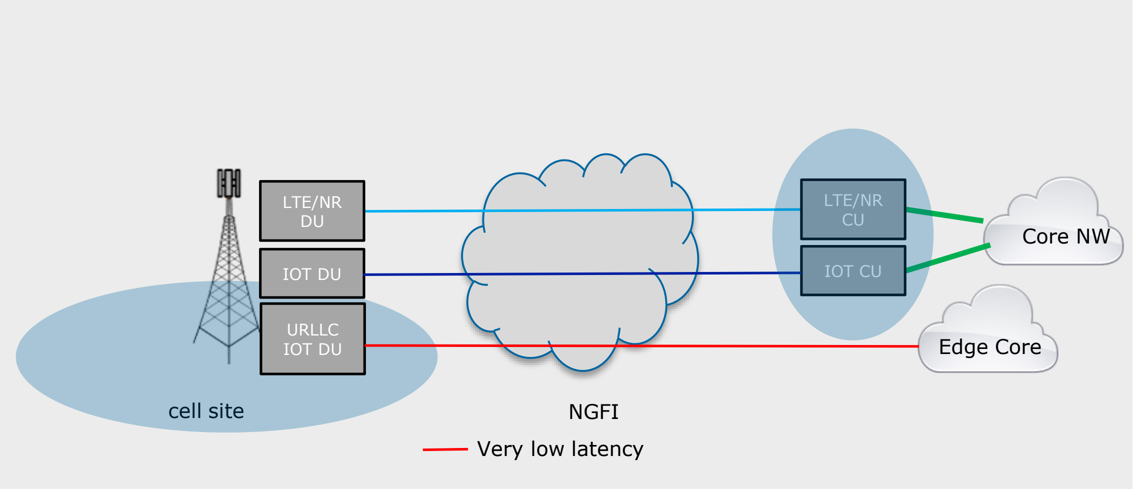
Transport BW requirement example for massive-MIMO deployment



IOT/MTC deployment

IOT use case categories

Non-critical apps	Critical apps
• Low cost/low power • Low mobility • Small data packets • Infrequent transmission • Massive numbers	• Ultra reliable • Very low latency • Very high availability



Current 3GPP IOT

	R13 Cat-M1	R13 NB-IOT
Max BW	1.4MHz	200kHz
Peak data rate	1Mbps	70kbps
RF Sample frequency	1.92MHz	480kHz
Modulation order	Max: 16QAM	QPSK
Operation mode	Standalone	Standalone Guard-band In-band

5G IOT/MTC

Low rate mMTC
URLLC based MTC

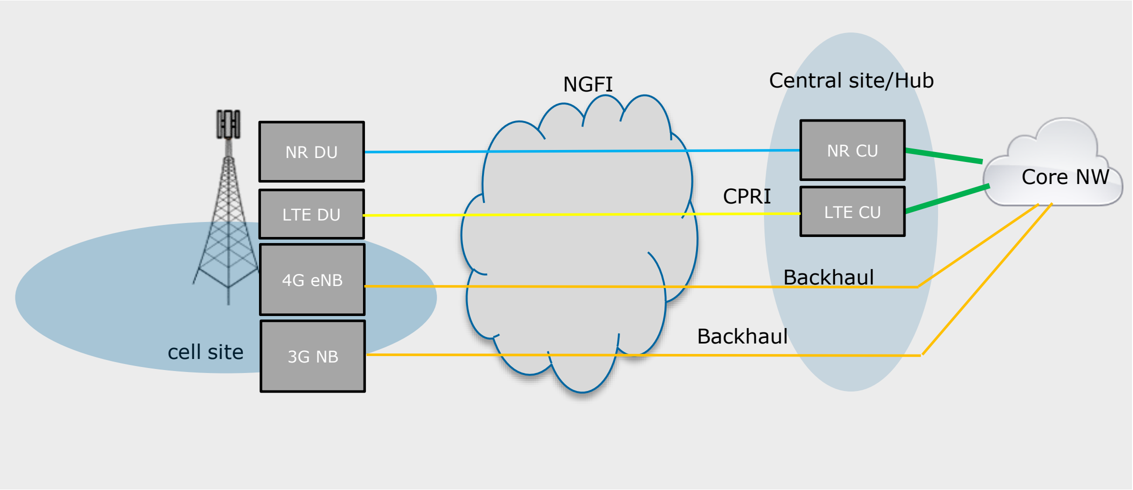
- Low bandwidth
- Low data rate
- Low sample rate
- Low modulation

Transport requirement

- Co-exist in the same cell site with other LTE/NR DUs
- Two types of transport traffic carried in NGFI:
  - Very low latency, small packets, ultra low error rate
  - Slow & small packets
- Requirement on scalability of aggregating massive small data packets

Support of legacy deployment by NGFI

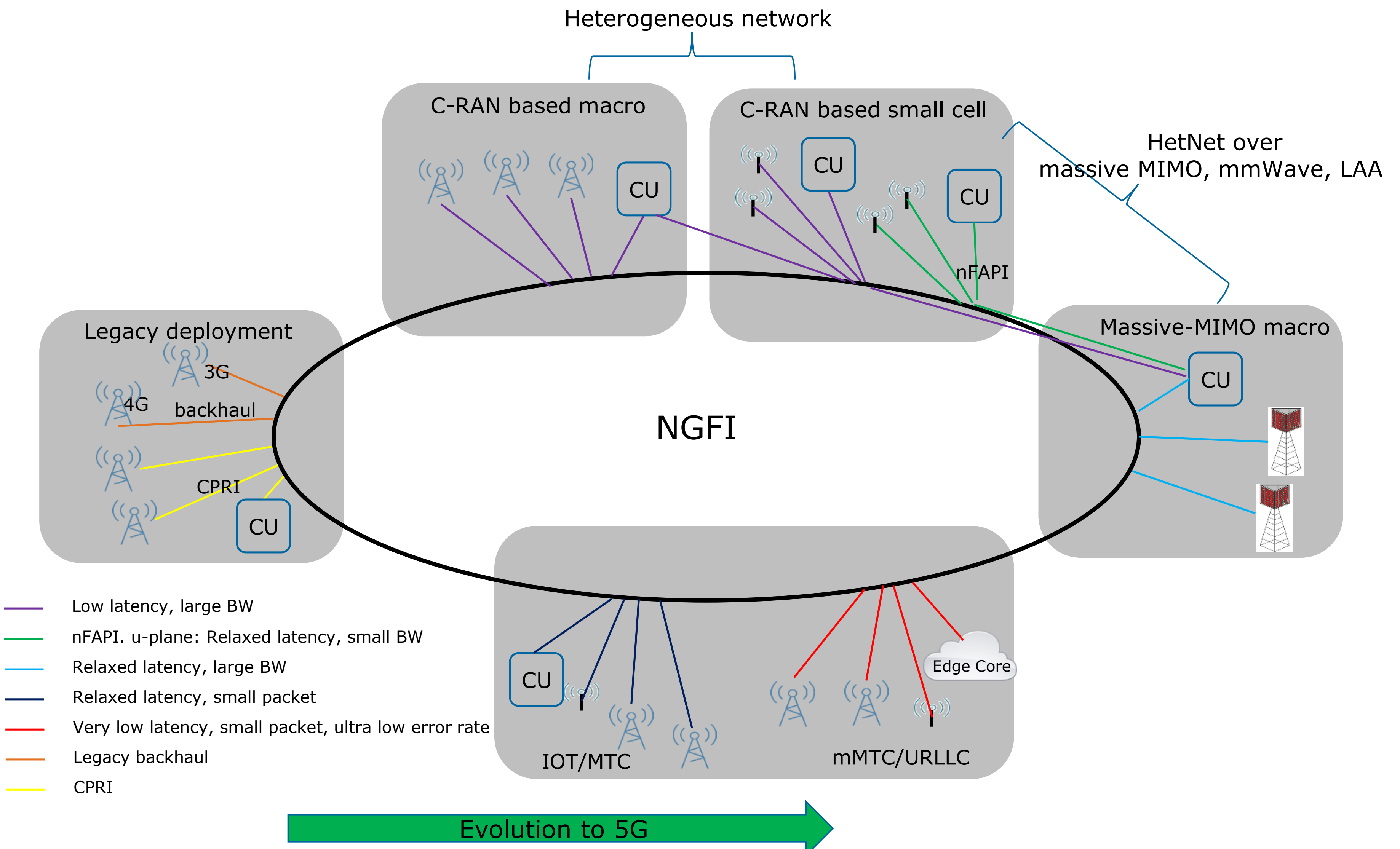
- Co-exist with legacy 3G/4G deployment in the same cell site
- Co-exist with 4G C-RAN deployment with CPRI fronthaul in the same cell site



Transport requirement

- To accommodate existing legacy services via converged transport
- Merge all transport traffics into NGFI for simplification of transport architecture & reduce deployment cost
  - 3G/4G Backhaul
  - CPRI fronthaul

Summary of NGFI deployment scenarios



Summary

- Selection of function split option alone is not sufficient to determine the needs of NGFI specifications
- Under consideration of the preferred function split options together with the intended deployment scenarios, a number of classes of service in terms of transport requirement may be of special interest:

Service class	Deployment scenario	Transport requirement
1	C-RAN based macro C-RAN based small cell	Low latency, large BW
2	nFAPI based small cell	Low latency control-plane Relaxed latency for user-plane, small BW
3	Massive-MIMO macro	Relaxed latency, very large BW
4	URLLC/critical IOT	Very low latency, small data packets, ultra low error rate
5	Non-critical IOT	Relaxed latency, small data packets
6	4G/3G backhaul	Relaxed latency, small BW
7	C-RAN based 4G	CPRI

- Consider priority mechanisms to combine multiple classes on one NGFI link
- Consider non-switching mechanism to accommodate the needs of ultra low latency& jitter classes

Proposal for the way forward:

- Define a sufficient set of classes of service according to NGFI scope and supported deployment scenarios
- FFS the class requirement parameters (range of latency, jitter, data rate, error rate, etc.) for each of the classes

High level requirements of NGFI

Desired NGFI features/challenges

- Backward compatibility
  - Include legacy 3G/4G backhaul traffic in case of co-site deployment with 5G NRs
  - Include CPRI to ensure fronthaul transport continuity for legacy RRUs/BBUs
  - Migration from CPRI/WDM architecture to CPRI/packet/WDM architecture
- Forward compatibility
  - Provide 'future proof' transport interface architecture
  - Maximally avoid replacement of equipment when migration occurs
  - Collaborate with eCPRI/TSN/nFAPI to support 5G transport network
- Scalability
  - Allow graceful migration on each stage of evolution from 4G to 5G
  - Accommodate vast BW requirement variation on each level of cell densification
- Flexibility/versatility
  - Support multiplexing of different Classes of Service, i.e. ability to carry both (e)CPRI and Ethernet traffic over the same interface.
  - Support multiple medium deployment (copper, fiber, MW, etc.)
  - Allow flexible switching of function split points in a DU/CU configuration for different applications
- Vendor interoperability
  - Enable multiple vendor deployment at both DU/CU ends
  - Interoperability over intra-PHY/intra-RLC function split