Non-Terrestrial Networks (NTN)

3GPP Standardization

Sasha Sirotkin, 3GPP RAN3 vice chair, Intel Corporation

Nicolas Chuberre, Thales Alenia Space

3GPP Structure

Project Coordination Group (PCG)		
TSG RAN Radio Access Network	TSG SA Service & Systems Aspects	TSG CT Core Network & Terminals
RAN1 Physical Layer	SA1 Services	CT1 Non-access Stratum
RAN2 Radio Protocols	SA2 Architecture	CT3 Interworking with external networks
RAN3 Radio Access Network	SA3 Security	CT4 MAP/GTP/BCH/SS
RAN4 Performance Requirements	SA4 Codecs	CT6 Smart Card Application Aspects
RAN5 Conformance Testing	SA5 Telecom Management	
	SA6 Mission-critical applications	

Standardization Timeline

Release	Working Group	Title	Completion
15	RAN	Study on New Radio (NR) to support Non-Terrestrial Networks	June 2018
	SA1	Study on using Satellite Access in 5G; Stage 1	June 2018
16	RAN3	Solutions for NR to support non-terrestrial networks (NTN)	Dec 2019
	SA1	Service requirements for the 5G system; Stage 1	Dec 2018
	SA2	Study on architecture aspects for using satellite access in 5G	June 2020
	SA5	Study on management and orchestration aspects of integrated satellite components in a 5G network	Dec 2020
17	RAN2	Solutions for NR to support non-terrestrial networks (NTN)	[2021]
	SA2	Integration of satellite systems in the 5G architecture	March 2021
	RAN1	Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN)	[2021]

Solutions for NR to support NTN

- LEO, GEO, and HAPS
- FDD, Earth fixed Tracking Area, UEs with GNSS, transparent payload
- PHY
  - Timing relationship
  - UL time and frequency synchronization
  - Enabling/disabling of HARQ feedback
- Protocols
  - User plane: RACH, UL scheduling, DRX, timer and sequence numbers range
  - Control plane: cell selection/reselection, hand-over and measurements
- RAN
  - Feeder link switch, network identities, registration, paging handling, cell relation

Integration of NTN in 5G architecture

- Mobility in large and moving coverage areas
- QoS (in satellite access and backhaul)
- Delay
- Regulatory services with super-national satellite ground station
- RAN mobility

Study on NB-IoT/eMTC support for NTN

- Sub 6GHz, LEO and GEO, transaprent payload, PC3 or PC5 devices
- Random access
- Time/frequency adjustment including Timing Advance
- Timing offset for scheduling and HARQ-ACK feedback
- Mobility (RLF-based for NB-IoT, Handover-based for eMTC)
- System information enhancements
- Tracking area enhancements

Final remarks

- **Intel Corporation** is a leading silicon provider for 5G infrastructure. Intel actively participates in the standards development process in 3GPP, O-RAN, IEEE and other SDOs and industry fora.
- **Thales Alenia Space** is a key European player in space telecommunications, navigation, Earth observation, exploration and orbital infrastructures. Thales is driving the integration of satellite in 5G in 3GPP and ETSI.

5G Radio Access Network Architecture

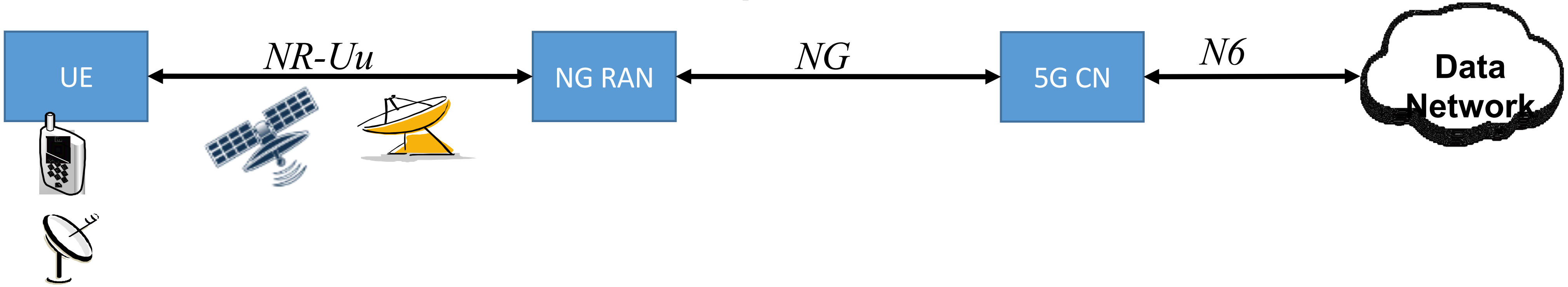
The Dark Side of 5G

(Wiley - IEEE)

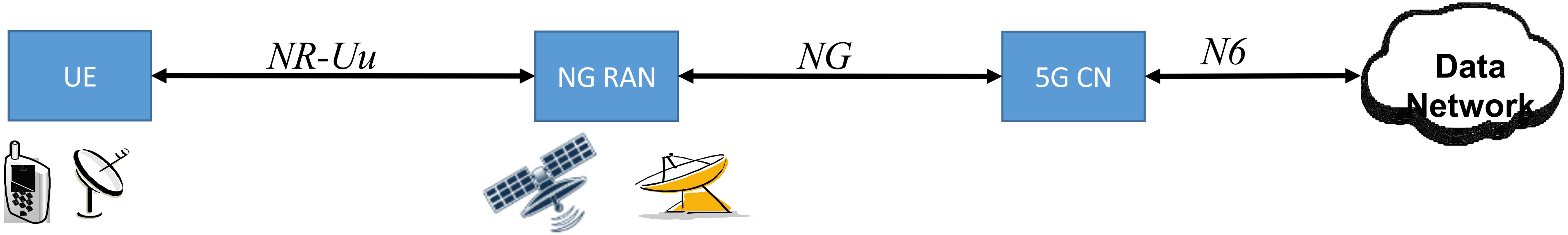
Backup

Reference NTN architectures

1) Satellite access with transparent satellite



2) Satellite access with regenerative satellite (example)



Capabilities of NTN platforms

	HAPS (8 to 50 km)	LEO (300 to 2000 km)	MEO (8000 to 25000 km)	GEO (35 786 km)	HEO (Note 1) (higher than MEO/GEO)
Coverage	Area of several hundred kilometers diameter	Up to Worldwide.	Up to Worldwide.	Regional between +/-70) latitude and up to 100° longitude span	Typically to address polar or high latitude regions
5G services support with 3GPP class 3 devices (FR1), (Note 3)	eMBB, mMTC, uRLLC	eMBB, mMTC	mMTC, [eMBB]	mMTC, [eMBB]	link budget challenge
5G services support with Directional antenna devices (FR1 or FR2), (Note 4)	eMBB, mMTC, uRLLC	eMBB, mMTC	eMBB, mMTC	eMBB, mMTC	eMBB, mMTC
Latency (Note 2)	Latency comparable to NG-RAN based Cellular network	Latency comparable to LTE based Cellular network	Latency comparable to UTRAN based Cellular network	Latency comparable to GSM/GPRS based cellular network	Similar or greater than GEO
Added value for 5G system	Service coverage extension through direct access, network resiliency + Backhaul(IAB)				Backhaul(IAB)

Note 1: The added value of HEO being very specific, it is proposed to consider this scenario in a future release.

Note 2: The QoS over a high latency access may be degraded for delay sensitive applications. This can be mitigated by combining the high latency access with a relatively low latency access technologies (e.g. cellular, HAPS or LEO based access) and the use of appropriate traffic steering techniques across these access technologies.

Note 3: Targeted services with possible service rate limitation (e.g. edge coverage performances)

Note 4: Directional antenna devices may refer to building or vehicle mounted devices with directional antenna such as parabolic or phased array antenna but also handset with high gain antenna (e.g. protuberating)

NTN impacts om 5G systems

Effects		HAPS	LEO	MEO	GEO	HEO
Motion of the space/aerial vehicles	Moving cell pattern	Yes if beams are moving on earth	Yes if beams are moving on Earth (hence high speed)		No	Yes if beams are moving on Earth (hence high speed)
		No if beams are fixed on Earth				No if beams are fixed on earth
	Delay variation	No	High (Note 3)	Medium (Note 3)	No	Low (Note 3)
	Doppler	Low	High (Note 3)	Medium (Note 3)	Negligible	Low (Note 3)
Altitude	Latency	Negligible	Low	Medium	High	High
Cell size	Differential delay	Small	Typically relatively medium	Typically relatively medium	Possibly relatively high	Possibly relatively high
Propagation channel	Frequency selectiveness impairments	Note 4	Note 4	Note 4	No	No
	Delay spread impairments	Note 4	Note 4	Note 4	No	No
Duplex scheme	Regulatory constraints	FDD and Possibly TDD	FDD and Possibly TDD	Only FDD	Only FDD	Only FDD

Note 3: Doppler and Delay variation can be pre compensated at beam centre. In such case residual Doppler and Delay variation is commensurate to the ones in cellular and can be accommodated by the UE

Note 4: Some delay spread and frequency selective effect can be experienced in case of omni-directional antenna device especially at low elevation angle