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Views on NTN enhancement in Rel-19

NR-NTN

Downlink coverage enhancement

Motivation

- Multiple beams operation is typically assumed within one satellite depending on the service distribution
- The satellite is typically power–limited and the DL power splitting may be needed among the beams

LEO-600km, 30 degree	CNR
Transmission mode	DL (1 beam)
Frequency [GHz]	2.00
TX: EIRP [dBm]	64.00
RX: G/T [dB/T]	-37.12
Bandwidth [MHz]	1.00
Free space path loss [dB]	159.10
Atmospheric loss [dB]	0.10
Shadow fading margin [dB]	3.00
Scintillation Loss [dB]	2.20
Polarization loss [dB]	3.00
Additional losses [dB]	0.00
CNR [dB]	-1.92

Channels	DL margin (dB)
SSB	-10.78
Msg2 PDSCH (Rep 1)	-6.98
Msg4 PDSCH	-7.08
PDCCH (AL 16)	-6.98
PDSCH(VoIP, MCS 0, rep 8)	-8.38
PDSCH(1Mbps, MCS 10, rep 8)	-4.88

Observation

- The DL data channel has the least link margin
- Under the assumption with the SSB performance as the benchmark, the identified DL coverage gap could be around [6] dB

Proposal

- Study link level and system level mechanisms for DL coverage enhancement in NTN.
- A SI is suggested before the normative work.
  - For link level, identify the limited channels;
  - For system level, identify potential beam hopping and power sharing solutions with reasonable assumption of satellite ERIP and power consumption of beams.
- Define mechanisms such as repetition for limited channels in normative phase.
- Define mechanisms to support dynamic power sharing between beams in normative phase.

Uplink Capacity Enhancement

- **Motivation**
  - It is expected that a large number of UEs within a cell considering the large satellite coverage.
  - The spectrum resources available to the network is limited for NTN.
  - Repetition mechanisim would be used to meet UL coverage requirment, which further reduce the capacity of PUSCH.
- **Proposals**
  - Study uplink capacity enhancement in NTN without sacrificing the UL coverage.
  - The use of orthogonal cover codes (OCC) to multiplex multiple UEs in the same PRB can be a starting point for PUSCH capacity enhancement.

Robust notification

Motivation

- Extreme poor reception condition can happen when UE are in NLOS scenario.
- UE would miss calls or paging message for public safety or emergency purpose when UE in poor reception condition.

Table 6.6.2-3 Shadow fading and clutter loss for Suburban and Rural scenarios[1]

Elevation	S-band			Ka-band		
	LOS	NLOS		LOS	NLOS	
	(dB)	σ_{SF} (dB)	CL(dB)	(dB)	σ_{SF} (dB)	CL(dB)
10°	1.79	8.93	19.52	1.9	10.7	29.5
20°	1.14	9.08	18.17	1.6	10.0	24.6
30°	1.14	8.78	18.42	1.9	11.2	21.9
40°	0.92	10.25	18.28	2.3	11.6	20.0
50°	1.42	10.56	18.63	2.7	11.8	18.7
60°	1.56	10.74	17.68	3.1	10.8	17.8
70°	0.85	10.17	16.50	3.0	10.8	17.2
80°	0.72	11.52	16.30	3.6	10.8	16.9
90°	0.72	11.52	16.30	0.4	10.8	16.8

Table 6.6.1-1 LOS probability [1]

Elevation	Dense urban scenario	Urban scenario	Suburban and Rural scenarios
10°	28.2%	24.6%	78.2%
20°	33.1%	38.6%	86.9%
30°	39.8%	49.3%	91.9%
40°	46.8%	61.3%	92.9%
50°	53.7%	72.6%	93.5%
60°	61.2%	80.5%	94.0%
70°	73.8%	91.9%	94.9%
80°	82.0%	96.8%	95.2%
90°	98.1%	99.2%	99.8%

Observation

- The cluster loss for NLOS is around 18dB when the elevation angle is 30 degree.
- The ratio for NLOS is around 10% for suburban and Rural scenarios when the elevation angle is 30 degree.

Proposal

- Study the potential solutions to support robust notification.
- Need to coordinate with SA1 on the message content.
- Need to coordinate with SA2 on the impact on the paging procedure

Mobilitity enhancement

- **Motivaiton**
  - The broadcast/groupcast handover commond is significant for reducing the handover signalling overhead considering that all the RRC CONNECTED UEs have to perform handover in the NGSO but it was not specified due to time limitation or lack of RAN3 support.
  - There are relaxed measurement criterions of low mobility and cell edge, but it seems not feasible for NTN since the near-far effect is not obviously.
  - The mobility focus on the NTN to NTN and NTN to TN in the previous releases.

- **Proposal**
  - Specify the signalling procedure for broadcast/groupcast handover commond for NTN;
  - Specify the procedure for supporting enhanced relaxed measurement, e.g. time base and/or location based relaxed measurement criterion;
  - The mobility enhancements on TN to NTN should be considered, e.g. solutions on unnecessary NTN measurement for UE in TN.

Enhanced GNSS Operation

- **Motivation**
  - RAN4 defines the UE initial transmission timing error Te_NTN = Te + Te_GNSS + Te_SAT, with the assumption that Te_GNSS =50m [2].
  - If the GNSS accuracy is not within 50m, Te_NTN defined in 38.133 is not applicable.
  - However, GNSS accuracy cannot be guaranteed within 50m if no enough satellites are available or satellite singal is weak. In some cases, UE is not even be able to acquire GNSS position.
  - If GNSS accuracy is beyond 50m but within certain limit, or UE is temporarily unable to acquire GNSS, UE may still be able to perform UL transmission, thanks to UE TA pre-compensation which absorbs the RTT. So CP only needs to absorb other factors(majorly GNSS error in this case) leading to UL sync error.
  - According to right table, UL transmission still works under relatively higher GNSS error.
- **Proposal**
  - Specify procedure to support the case that GNSS accuracy is temporarily below 50m and GNSS is temporarily unavailable for idle/inactive/connected mode UE.[RAN2][RAN4]

Table 7.1C.2-1: T_{e_NTN} Timing Error Limit

Frequency Range	SCS of SSB signals (kHz)	SCS of uplink signals (kHz)	T_e
1	15	15	$29*64*T_c$
		30	$24*64*T_c$
		60	N/A
	30	15	$24*64*T_c$
		30	$22*64*T_c$
		60	N/A
Note 1: T_c is the basic timing unit defined in TS 38.211 [6]			

Table: CP length and maximum cell radius

	CP length(K=64)	Maximum cell radius
PRACH format 0	3168K	15km
PRACH format 1	21024K	100km
PRACH format 2	4688K	22km
PRACH format 3	3168K	15km
OFDM signal except PRACH (Normal CP)	144K	700m
OFDM signal except PRACH (Extended CP)	512K	2500m

Regenerative payload

- **Motivation**
  - Only transparent payload is studied and supported in Rel-17 & Rel-18 NTN.
  - Regenerative payload, i.e., gNB on board is desired to rudece the communication delay and can provide UE-Satellite-UE communication without going through the ground network in some scenarios if UPF is also onboard.
  - Inter-satellite link can be considered if full gNB is onbaord for better usage of NTN.
  - When gNB is onboard, in cse of Non-GEO constellations, the NTN cells and gNBs are dynamic moving, this can be a challenge on cell identify handling.
- **Proposals**
  - Study and, if needed, specify enhancement to Xn/NG signalling to support Regenerative payload with full gNB e.g. NTN cell ID handling, NTN cell relation handling
  - Study and, if needed, identify any RAN impacts to support UE-satellite-UE communication
  - Note: coordination with SA2/SA5 is needed.

High power UE

- **Motivation**
  - In Rel-17, Handheld NTN UE is limited to PC3 (+23dBm) operating on FDD bands.
  - In Rel-17, PC2 (+26dBm) operating on FDD bands for general NR UE had already been introduced.
  - In future, higher power NTN UE are quite essential to further improve UL coverage, availability and throughput performance.
- **Proposals**
  - PC2 (+26dBm) with single component carrier UL operation for handheld UE
  - Considering all the existing NTN FR1 bands.
  - Develop PC2 NTN UE RF requirements, e.g. MOP, Tx power tolerance, A-MPR, REFSENS, etc.
  - PC1.5 (+29dBm) with single component carrier UL operation for handheld UE
  - Considering all the existing NTN FR1 bands.
  - Investigate the feasibility, if feasible, develop PC1.5 NTN UE RF requirements, e.g. MOP, Tx power tolerance, A-MPR, REFSENS, etc.

IoT-NTN

IoT-NTN Uplink Capacity Enhancement

- **Motivation**
  - IoT-NTN is expected to support massive capacity in terms of large number of and various types of UE, some of which have worse characteristics than others (e.g. low cost devices, wearables, etc) .
  - Current IoT-NTN UL system capacity is severely limited by the corresponding DL signalling overhead, due to the larger signalling overhead in the downlink.
- **Proposals**
  - Improve uplink capacity enhancement via orthogonal cover codes for NPUSCH and NPRACH in IoT-NTN system.
  - Specify enhancements to reduce the large signaling overhead in the downlink that limits the UL capacity in IoT-NTN system.

Store & Forward operation

- **Motivation**
  - The satellite is spares at the beginning of NTN deployment.
  - The traffic of IoT terminal is delay-tolerant, the corresponding services can be provided when satellite connectivity is intermittently/temporarily unavailable.
  - A store & forward operation enables the use of smaller LEO constellations that cannot guarantee full simultaneous geographic coverage.
  - A store & forward operation is not specified in Rel-17 & Rel-18 IoT-NTN.
- **Proposals**
  - Define the necessary enhancements into RAN to support store & forward operation for delay-tolerant services.
  - Note: coordinatioon with SA2 is needed

Summary

Consider the following topics for NTN enhancement in Rel-19.

- NR-NTN
  - Downlink coverage enhancement
  - Uplink capacity enhancement
  - Robust notification
  - Mobility enhancements
  - Enhanced GNSS Operation
  - Regenerative payload with full gNB
  - High Power UE
- IoT-NTN
  - Uplink capacity enhancement
  - Store & Forward operation

Reference

[1] 3GPP TR 38.811V1.0.0 (2018-06)

[2] R4-2115346, WF on GNSS-related and timing requirements for NR NTN, Xiaomi, 3GPP TSG-RAN4 Meeting #100-e.

Thank you