3GPP TSG RAN Rel-18 workshop
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RWS-210240

Motivation for new WI: Further MIMO enhancements for NR

Simultaneous Transmission across Multiple Panels [1/2]

- **Motivation**
  - Multi-beam feature has been evolved in releases, but UL performance in FR2 is still vulnerable to UE mobility, rotation and beam blockage due to the limitation of single beam/panel transmission.
  - Simultaneous reception across multiple panels(SRxMP) is already supported for single/multi-DCI based MTRP DL transmission from Rel-16. Meanwhile for UL, simultaneous transmission across multiple panels(STxMP) has not been supported although UL is a bottle-neck for FR2 performance.
- **Scope**
  - Main target is for higher reliability (i.e. same layer/channel is repeated from different panels).
  - Higher throughput or efficiency can also be considered as well(e.g. different layer/channel from different panels).

Simultaneous Transmission across Multiple Panels [2/2]

- **Evaluation Result (SLS, 3 panel UE)**
  - SFN-like same layer transmission using two strongest panels among three panels shows a prominent cell edge throughput gain
    - For STxMP evaluation, UEs with < 6dB RSRP difference between the strongest and the second strongest UE panels were selected for STxMP. Portion of the selected UEs for STxMP was 68%.

Comparison between one panel Tx and two panel Tx in dense urban macro scenario

Scheme	Cell edge UE throughput [Mbps]	Average UE throughput [Mbps]
1-panel selection (baseline)	**0.6 (100 %)**	**25.9 (100 %)**
2-panel STxMP (w/ strongest two panels)	**1.3 (198.0 %)**	**26.7 (103.1 %)**

Enhanced UL synchronization for multi-panels/TRPs [1/2]

- **Motivation**
  - Multi-TRP transmission is a useful tool for improving throughput and reliability, but its applicability is still limited especially in FR2 due to the limitation of using same TA for different TRPs.
    - It is well-known how imperfect UL synchronization can degrade UL system performance (e.g. 0.2CP difference between UEs results in non-negligible performance degradation[1][2]).
  - For UE panel-specific transmission, a common TA has been assumed across different panels although each panel can transmit UL signal to different TRP.
    - From UE implementation perspective, it is much straight-forward that each synch parameter is managed per panel together with other parameters(e.g. for power control) due to the discrepancy of measurement quality of different panel
    - Considering distributed panels for vehicles[3], inter-panel delay is another factor to create different delay for each panel-TRP pair.

[1] R1-062834, UL Timing Control Accuracy and Update Rate, Nokia
[2] R1-071479, Simulation of Uplink Timing Error Impact on PUSCH, Texas Instruments
[3] TR 37.885, Study on evaluation methodology of new Vehicle-to-Everything V2X use cases for LTE and NR

Enhanced UL synchronization for multi-panels/TRPs [2/2]

- **Evaluation Result (SLS, 2-panel UE)**
  - Following results show the portion of UEs of which round-trip delay difference between two panel-TRP pairs exceed the CP length among all UEs(X%) and among all MTRP UEs(Y%), respectively, where UEs with RSRP difference <6dB are assumed as MTRP UEs
    - A large portion of UEs experience the delay difference exceeding CP length in outdoor at both 30GHz and 60GHz and even in indoor at 60GHz
    - Increased portions are expected if additional delay from implementation (i.e. inter-panel delay, inter-TRP delay) is taken into account

Table 1. Portion of MTRP/panel UEs exceeding CP length at 30GHz: X%/Y%

SCS	CP length	UMa	UMi	InH
60 kHz	1.17 us	**13.0 % / 38.4 %**	**7.9 % / 26.6 %**	**0 % / 0 %**
120 kHz	585.93 ns	**18.8 % / 55.6 %**	**15.1 % / 51.0 %**	**0 % / 0 %**

Table 2. Portion of MTRP/panel UEs exceeding CP length at 60GHz: X%/Y%

SCS	CP length	UMi	InH
240 kHz	292.96 ns	**12.0 % / 46.3 %**	**1.1 % / 4.0 %**
480 kHz	146.48 ns	**16.0 % / 61.9 %**	**5.8 % / 19.9 %**

Other MIMO enhancements

- **Cross-link interference mitigation in FR2**
  - **Motivation:** Cross-link interference (i.e. gNB-to-gNB interference, UE-to-UE interference) becomes more severe in FR2 TDD due to beamforming based transmission/reception. Enhanced MIMO techniques, e.g. cross-link BM, can help to avoid severe cross-link interference.
- **Reliability enhancement for multi-DCI based MTRP transmission**
  - **Motivation:** MTRP reliability schemes such as repetition and SFN are useful tool for coverage and reliability in FR2, but these schemes are only supported with single DCI based MTRP although multi-DCI based MTRP is an attractive tool due to its ability to support per-TRP link adaptation and scheduling as well as its applicability to various backhaul conditions.
- **Enhancements for vehicular Distributed Antenna System (DAS) UE transmission**
  - **Motivation:** 5GAA, the 5G automotive association, provided input to 3GPP for ten important features for Rel-18 evolution in **RWS-210360**, which includes vehicular DAS UE transmission. We see some room to optimize NR MIMO features for this type of UE, e.g. extending FR2 BM features to FR1, enhanced RRM, etc.

Proposed WI objective for Rel-18 MIMO

- **Enhancements on multi-beam operation**
  - Identify and specify features to support simultaneous UL transmission across multiple UE panels to improve reliability, robustness and throughput
  - Identify and specify features to support per-panel UL synchronization mainly targeting multi-TRP reception scenario
- **Enhancements on multi-TRP operation**
  - Identify and specify features to improve reliability and robustness for multi-DCI based MTRP transmission
  - Evaluate, and if needed, specify extended multi-TRP transmission (e.g. more than 2 TRPs, combined multi-TRP schemes)
- **Cross-link interference mitigation in FR2**
  - Identify and specify features to mitigate cross-link interference in FR2
- **Enhancements for vehicular Distributed Antenna System (DAS) UE**
  - Study, and if needed, specify necessary DL/UL enhancements for vehicular DAS UE transmission and reception

Annex

Evaluation assumptions on selected topics

Annex1: Evaluation assumption for simultaneous multi-panel Tx

Parameters	Values
Scenarios	Dense Urban Macro
Carrier frequency	30GHz
Simulation bandwidth	80 MHz
Subcarrier spacing for data	120 kHz
Transmission power	41 dBm
BS antenna configurations (M,N,P,Mg,Ng,Mp,Np)	16ports=(4,8,2,1,1,1,8), (dH,dV) = (0.5, 0.5)
BS antenna element radiation pattern	According to TR38.802
UE antenna configurations	(M, N, P, Mg, Ng; Mp, Np) = (2, 4, 2, 1, 3; 1, 1); (dV, dH) = (0.5, 0.5) λ. (dg,V, dg,H) = (0, 0) λ. Number/location of panels: 3 panels (left, right, and back)
UE antenna element radiation pattern	According to TR38.802, Front-to-back ratio = 40dB

Annex2: Evaluation assumption for UL synchronization

Parameters	Values
Scenario	UMa, UMi - street canyon, InH-office
Carrier frequency	30GHz, 60GHz
Channel model	TR38.901
TRP antenna configuration	2 ports: (8,8,2,1,1), (dH, dV) = (0.5, 0.8)λ for UMa 30GHz 2 ports: (8,4,2,1,1), (dH, dV) = (0.5, 0.8)λ for UMi 30GHz 2 ports: (8,16,2,1,1), (dH, dV) = (0.5, 0.5)λ for UMi 60GHz 2 ports: (4,8,2,1,1), (dH, dV) = (0.5, 0.5)λ for InH 60GHz
UE antenna configuration	2 ports: (2, 4, 2, 1, 2); (dV, dH) = (0.5, 0.5)λ. (dg,V, dg,H) = (0, 0)λ, Ω0,1=Ω0,0+180 for 30GHz 2 ports: (4, 4, 2, 1, 2); (dV, dH) = (0.5, 0.5)λ. (dg,V, dg,H) = (0, 0)λ, Ω0,1=Ω0,0+180 for 60GHz