



vivo

3GPP TSG RAN Rel-19 workshop

Taipei, June 15 - 16, 2023

RWS-230060

Views on further sidelink enhancement in Rel-19

Source: vivo

Document for: Discussion

Agenda Item: 5

Background

General motivations for further sidelink enhancement

Key aspects to deploy commercial D2D services

Operator

- Low spectrum efficiency
 - requiring dedicated spectrum for sidelink operation
 - difficult of dynamic sharing between Uu and SL resources
- High Opex/Capex when complicated scheduler is employed

Consumer

- Bad user experience (XP)
 - poor network availability, low throughput, and high latency
 - due to limited FR1 spectrum and congested unlicensed band
 - difficult of device/network installation, administration and maintenance
- Not optimized for personal device
 - high power consumption
 - high device cost, limited device space/size, etc.

Further sidelink evaluations

Ignition of commercial SL business

Spectrum and User XP

Motivation:

- Enabling SL business on existing licensed spectrums
- Enabling better involvement of operators

Solutions:

- SL underlay
 - Dynamically sharing the Uu spectrum resources for SL transmissions
- Interference cancellation
 - SL→UL suppression (e.g., SL PSD limitation)
 - UL→SL cancellation

Power and cost

Motivation:

- Enabling low-cost and Energy-efficient commercial personal IoT device

Solutions:

- SL RedCap
 - Further power saving enh.
 - SL WUS/GTS, etc.
 - Very Low Power (VLP) UE
 - For both licensed and unlicensed spectrums
- PA-less devices

Throughput

Motivation:

- Enabling high-capacity commercial usage
- Enabling new SL operating spectrums

Solutions:

- SL on FR2
 - Beam management
 - Resource allocation enh.
 - Operating on both FR2-1 and FR2-2
 - For all the cast types

Agenda

1. **Topic 1: SL underlay**
2. **Topic 2: SL RedCap**
3. **Topic 3: SL FR2**

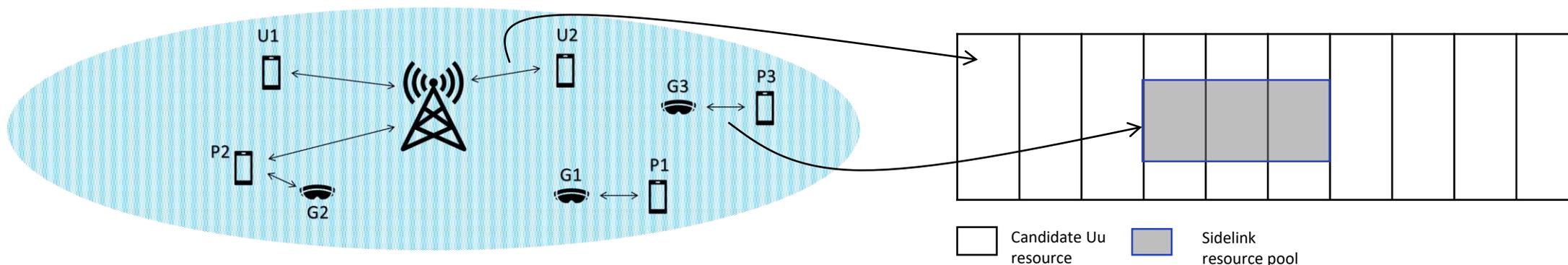
SL underlay

Further sidelink evaluations

Motivations

Sidelink Underlay

- In addition to traditional Uu communication, there is increasing demand for short range device to device (D2D) communication (e.g. P1-G1) due to XR services

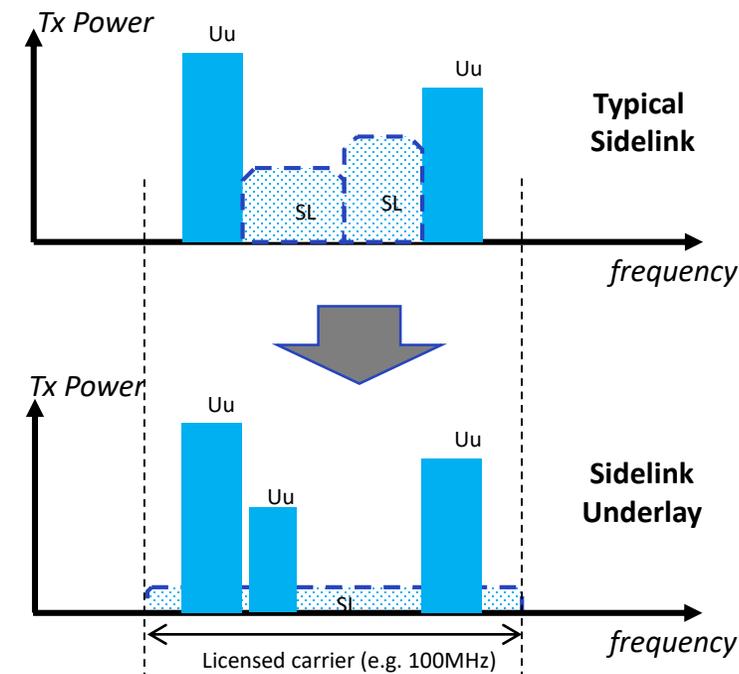
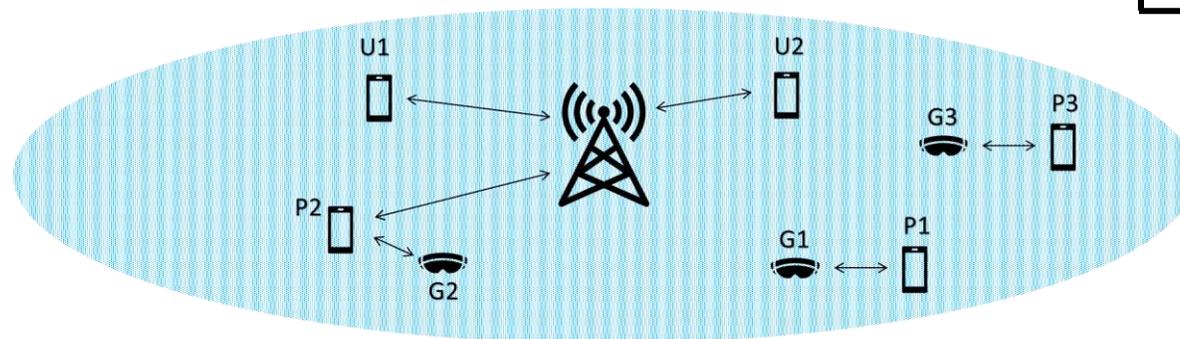


- NR sidelink technologies are designed for D2D but
 - Sidelink over dedicated ITS spectrum: Only available for V2X use cases.
 - Sidelink over licensed spectrum (Uu): The current design (and RAN4 spec) assumes that sidelink (if deployed) uses orthogonal resource than Uu, leading to capacity degradation to Uu and/or complicated NW scheduler.
 - Sidelink over unlicensed spectrum: Not reliable and need to employ complex channel access mechanism, with little/limited involvement of operators.
- **Observation:** It is desirable to enable operators to deploy high quality commercial D2D business on existing licensed spectrum without degradation to existing Uu cellular service.

Key idea for potential enhancement

Sidelink Underlay

- **Sidelink Underlay Transmission over licensed spectrum uses wide bandwidth and a stringent PSD restriction, to exploit higher spatial multiplexing gain from existing cellular spectrum.**
 - Power domain: Sidelink underlay transmission follows a UWB-like PSD restriction (e.g. $<-40\text{dBm/MHz}$)
 - Frequency domain: Sidelink underlay transmission spans a wideband (e.g. 100MHz) that is fully shared with cellular transmission (Uu)
 - Time domain: Sidelink underlay transmission is limited to in certain slots (e.g. UL slots)



- **Proposal:** Study the feasibility and benefit, and specify necessary specification changes to support Sidelink underlay transmission over licensed spectrum

Benefits

Sidelink Underlay

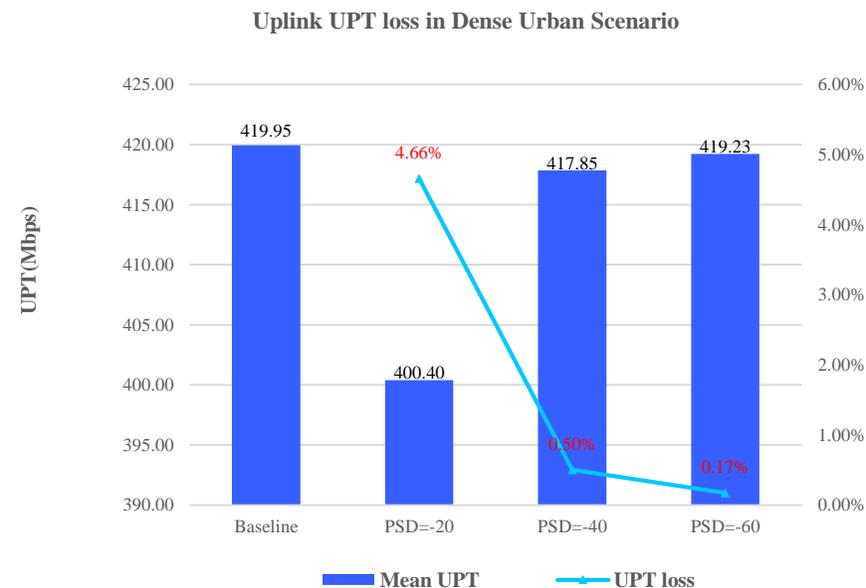
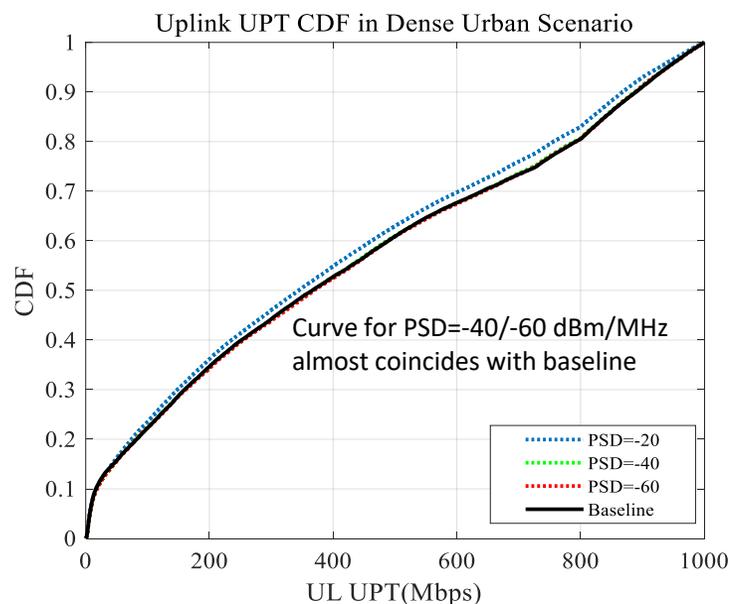
- **Sidelink underlay transmission over licensed spectrum can have the following benefits**
 - **Benefit 1:** Satisfy the increasing demand of commercial D2D communication by exploiting the existing spectrum
 - Relevance: No need to reserve dedicated orthogonal spectrum/resource(s) for sidelink services
 - **Benefit 2:** Provide better QoS (high robustness, low latency) than unlicensed spectrum
 - Relevance: No need to perform channel access due to competing spectrum with other systems
 - **Benefit 3:** Increase the spectrum efficiency (more spatial reuse of the spectrum) by serving D2D communication with no impact to cellular communications
 - Relevance: No reduction of Uu capacity due to very low power sidelink underlay transmission while additional D2D capacity is introduced
 - **Benefit 4:** Enable better involvement of operators into the commercial D2D business
 - Relevance: Operators can step into the business by providing higher quality/less interfering spectrum (than unlicensed band), as well as radio link/network management/administration.

Feasibility study (sidelink->cellular interference)

Sidelink Underlay

- **Interference from sidelink D2D to cellular Uu**

- Baseline: Dense Urban with cellular Uu users only (10 Uu UEs/cell, 100MHz carrier)
- Sidelink Underlay: Dense Urban with both cellular Uu users and sidelink D2D pairs (10 Uu UEs/cell, 5 D2D pairs/cell with full buffer traffic, 100MHz carrier)
- System level evaluation (assumption in Appendix) is performed to compare UPT performance of the above two scenarios



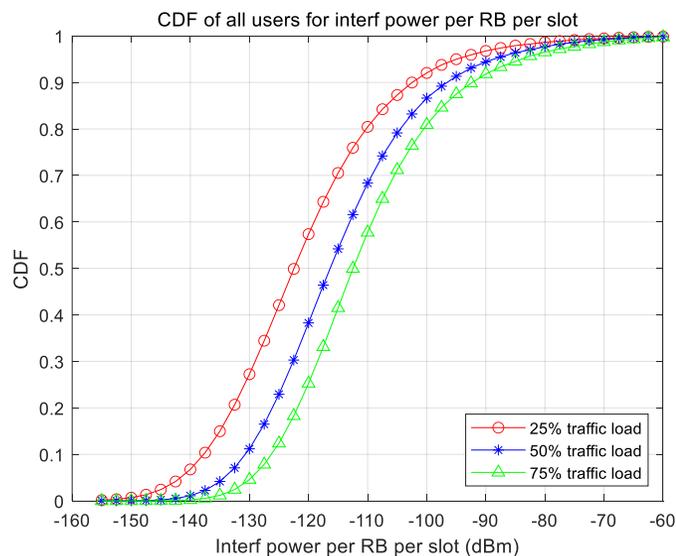
- **Observation:** When UL resource is used for SL underlay transmission, the impact to Uu UL from sidelink D2D can be ignored (UPT loss $\leq 0.5\%$) if sidelink transmission PSD ≤ -40 dBm/MHz

Feasibility study (cellular->sidelink interference)

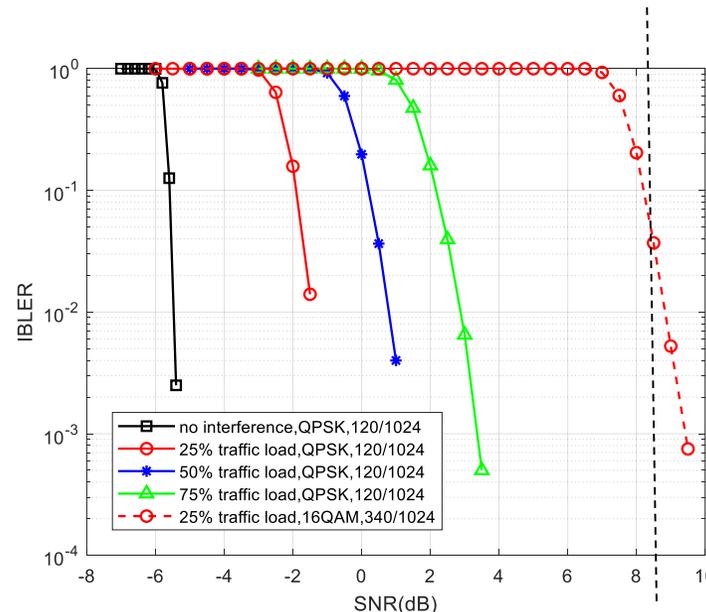
Sidelink Underlay

- **Interference from cellular Uu to sidelink D2D**

- Figure a: Interference CDF to SL in dense urban from Uu interface
- Figure b: SL Link level performance with interference according to Fig. (a) with different traffic load (RU)
- Table c: Equivalent sidelink (communication range 5m) SNR is ~ 8.5 dB when PSD is -40 dBm/MHz



(a)



(b)

Frequency (GHz)	4
SCS (KHz)	30
PRB number	273
Bandwidth (MHz)	98.28
PSD (dBm/MHz)	-40
Total Tx Power (dBm)	-20.07534852
Tx power Per PRB (dBm)	-44.43697499
Noise power Per PRB (dBm)	-109.437
Range (m)	5
Channel model	InH - Office LOS
Pathloss	56.5333809
Rx power Per PRB	-100.9703559
Equivalent SNR	8.466644106

(c)

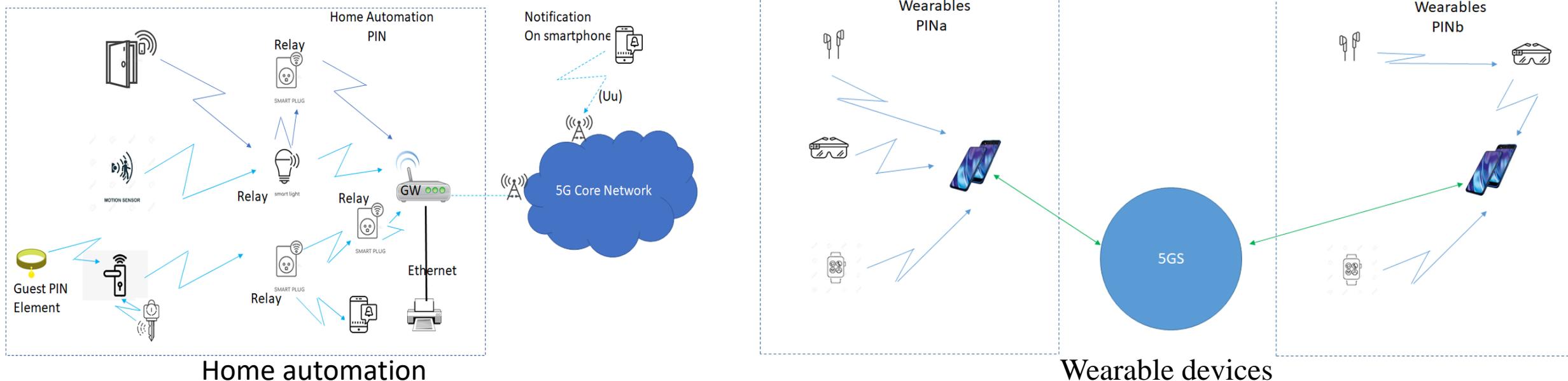
- **Observation:** Sidelink underlay transmission with PSD= -40 dBm/MHz can work (low MCS) even when the Uu UL traffic load is high, and higher MCS (e.g. 16QAM) can be possible when the Uu UL traffic load is low.

SL RedCap

Further sidelink evaluations

Personal local IoT Networks

SL RedCap



- Great demand in the industry on the non-cellular wireless commercial IoT use cases
 - Including such as the personal IoT device (earbuds, sensor, etc.), wireless docking, wireless streaming, etc.
- Personal local IoT networks
 - Becoming complex network topology while self organizing/management/maintenance is desirable
 - Typically installed/maintained by a consumer, not a telecom or wireless specialist/professional
 - Demanding high traffic volume, e.g., Hi-Res Audio/Music, Wireless Display, gaming, etc.
 - While devices are severely sensitive to the weight and size of the devices, and most highly battery constrained.
 - Usually constrained by the physical dimension limitations, such as sensor, earbuds, etc.
- **Observation:** NR sidelink has very high potentials to enable 3GPP system in this market, E.g., highly controllable and manageable with operators involved.

Motivation

SL RedCap

- NR sidelink has very high potentials to enable 3GPP system in the personal IoT market
 - E.g., highly controllable/manageable with operators involved
- However, the **power consumption and device complexity** level are not good enough for many commercial personal devices (HMD, watch, earbud, etc.).
- **Proposal:** Supporting SL RedCap in Rel-19
 - **Enabling PA-less sidelink device**
 - **Enabling very low power (VLP) operations (such as SL underlay, VLP channel access, etc.)**
 - **Introducing SL WUS signal and operations**

PA-less sidelink devices

SL RedCap

- UE power class
 - Power class 3 (23dBm), Power class 2(26dBm) supported for general use cases of Uu (as well as for sidelink)
 - LTE eMTC and NB-IOT supports power class 5 (20dBm) and power class 6 (14dBm) (Not supported for sidelink)

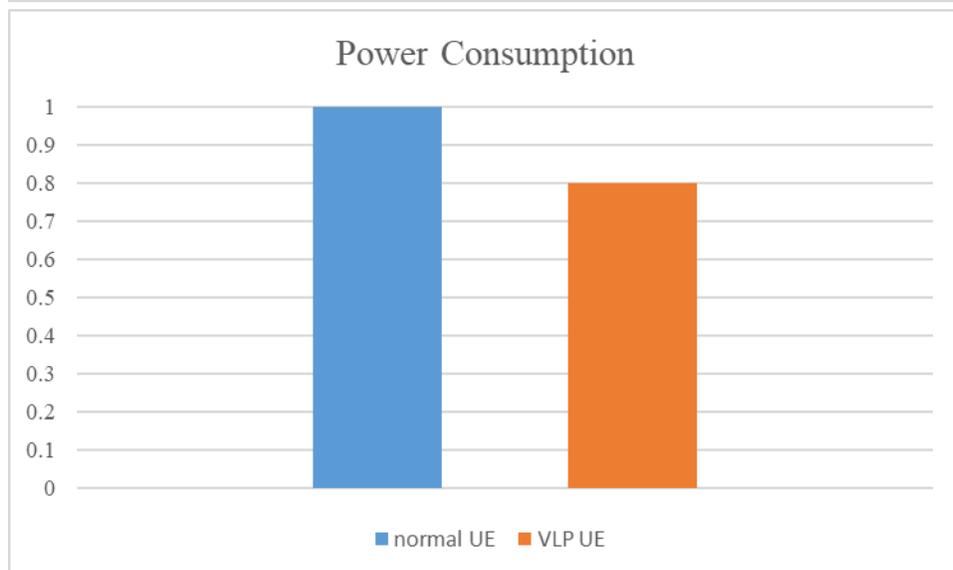
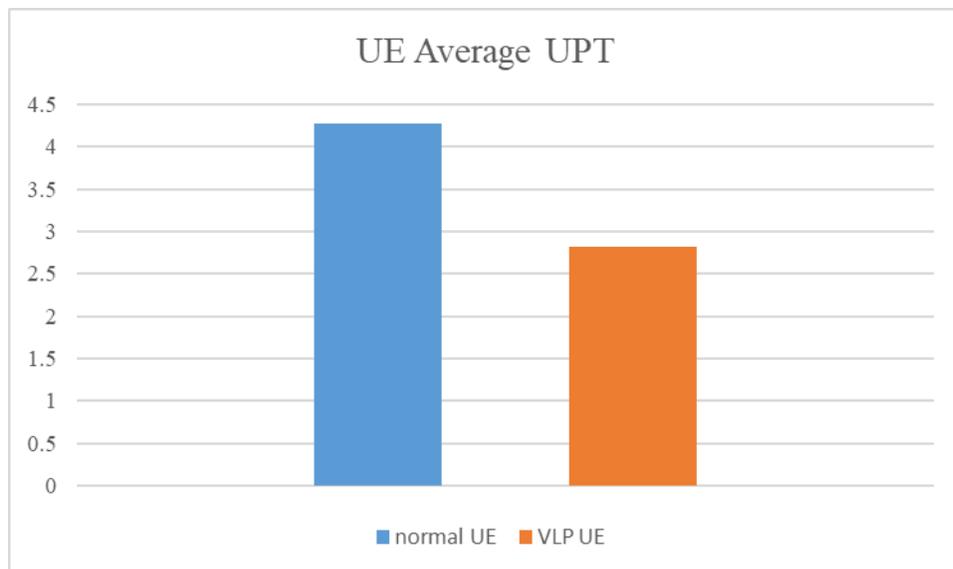
- GaAs based external PA is required to support 23dBm
 - The PAE (PA efficiency) is very low (less than 5%) at low power level, e.g. 0~10dBm
 - Typically for personal IoT or XR/gaming where the traffic is predominately within the localized area
- GaAs based PA also increases the device cost
 - 10-12% overall relative cost saving
- Consuming internal device space
 - Especially for some personal IoT device such as glasses frames, earbuds, blood pressure monitor, etc

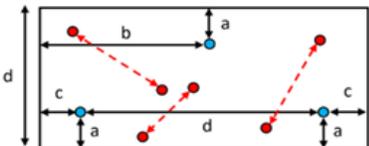
SET_POUT	N78						B41					
	4.2V			APT			4.2V			APT		
	P_DC (mW)	CALC_GAIN	CALC_PAE									
0	2673.65	28.37	0.04	188.02	23.71	0.53	2500.29	29.77	0.04	67.42	15.16	1.48
1	2759.09	28.40	0.05	187.12	23.69	0.67	2585.83	29.76	0.05	67.46	15.27	1.87
2	2726.63	28.40	0.06	191.74	23.33	0.83	2497.58	29.76	0.06	70.27	15.40	2.26
3	2707.14	28.39	0.07	184.32	23.67	1.08	2579.28	29.75	0.08	73.30	15.53	2.72
4	2682.96	28.38	0.09	186.50	23.58	1.35	2497.85	29.74	0.10	133.17	22.72	1.89
5	2660.94	28.38	0.12	186.97	23.53	1.69	2579.64	29.74	0.12	137.31	22.80	2.30
6	2739.27	28.42	0.15	188.31	23.46	2.11	2539.60	29.80	0.16	139.99	22.81	2.84
7	2703.60	28.43	0.19	189.72	23.39	2.64	2526.21	29.81	0.20	144.69	22.79	3.46
8	2656.93	28.46	0.24	191.71	23.30	3.29	2608.50	29.81	0.24	147.81	22.84	4.27
9	2751.45	28.47	0.29	190.54	23.07	4.17	2504.68	29.84	0.32	152.77	22.88	5.20
10	2727.13	28.47	0.37	185.63	22.73	5.39	2561.32	29.88	0.39	162.92	22.91	6.14
11	2697.57	28.48	0.47	191.68	22.32	6.57	2512.72	29.82	0.50	171.59	22.91	7.34
12	2736.01	28.37	0.58	187.96	21.28	8.43	2658.30	29.72	0.60	181.06	22.72	8.75
13	2715.69	28.37	0.73	758.32	26.66	2.63	2582.16	29.71	0.77	195.97	22.65	10.18
14	2703.74	28.35	0.93	760.49	26.61	3.30	2641.42	29.76	0.95	782.55	29.74	3.21
15	2682.39	28.35	1.18	768.14	26.53	4.12	2579.59	29.73	1.23	758.39	29.76	4.17
16	2751.31	28.41	1.45	993.01	27.45	4.01	2637.29	29.80	1.51	796.78	29.74	5.00
17	2707.97	28.45	1.85	1001.77	27.38	5.00	2632.75	29.83	1.90	1201.88	30.23	4.17
18	2705.55	28.42	2.33	1283.83	27.90	4.91	2629.49	29.88	2.40	1212.98	30.25	5.20
19	2780.00	28.49	2.86	1270.63	27.92	6.25	2714.94	29.92	2.93	1235.65	30.24	6.43
20	2723.12	28.56	3.67	1261.62	27.93	7.93	2829.67	29.96	3.53	1270.70	30.21	7.87
21	2789.83	28.65	4.51	1495.50	28.24	8.42	2841.21	30.04	4.43	2204.84	30.32	5.71
22	2869.40	28.73	5.52	1489.07	28.26	10.64	2876.02	30.11	5.51	2245.26	30.36	7.06
23	2826.35	28.81	7.06	2210.34	28.76	9.03	3034.57	30.13	6.58	2345.92	30.32	8.51
24	2888.24	28.74	8.70	2281.76	28.65	11.01	3162.94	30.00	7.94	2472.92	30.16	10.16
25	3043.21	28.80	10.39	2303.53	28.66	13.73	3312.55	30.00	9.55	3312.55	30.00	9.55
26	3089.46	28.88	12.89	2695.60	28.82	14.77	3507.55	29.97	11.35	3507.55	29.97	11.35
27	3254.55	28.94	15.40	2759.97	28.83	18.16	3676.45	29.91	13.63	3676.45	29.91	13.63
28	3346.26	28.96	18.86	3346.26	28.96	18.86	4000.57	29.82	15.77	4000.57	29.82	15.77
29	3521.70	28.91	22.56	3521.70	28.91	22.56	4307.99	29.56	18.44	4307.99	29.56	18.44

Figure 1. Power efficiency (marked red when less than 5%), N78 and N41
Two PA implementation choices: 1) Constant 4.2V P_DC; 2) APT (adaptive power tracking)

Preliminary evaluation results of SL VLP

SL RedCap

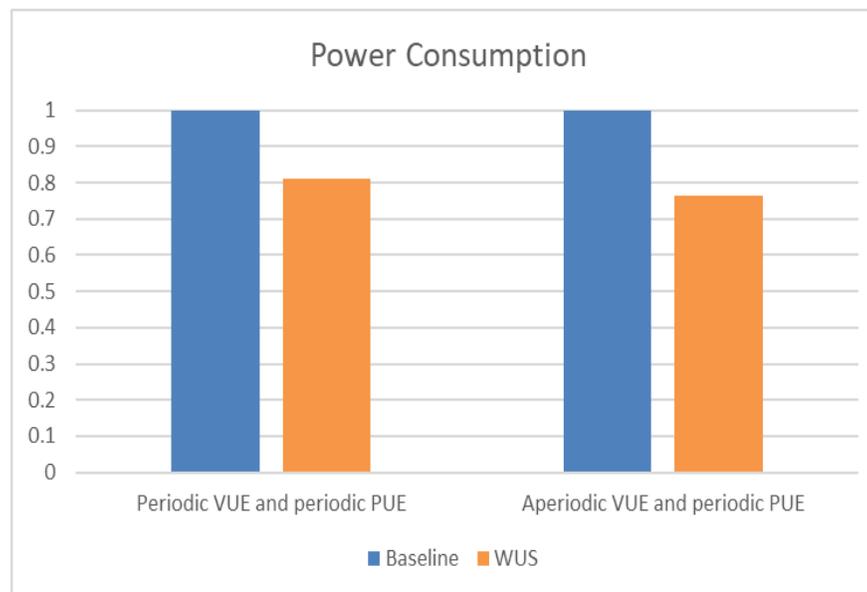
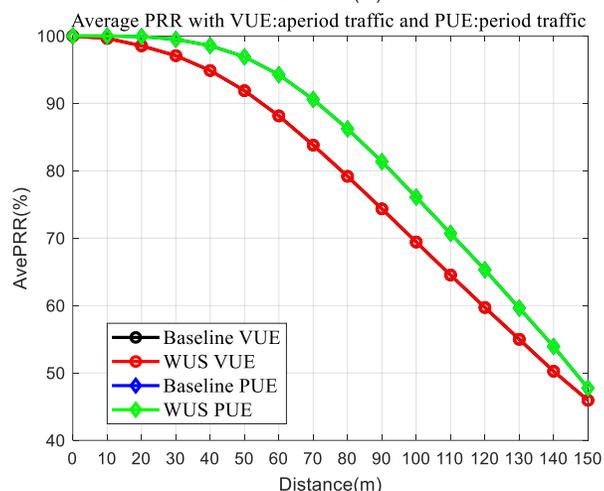
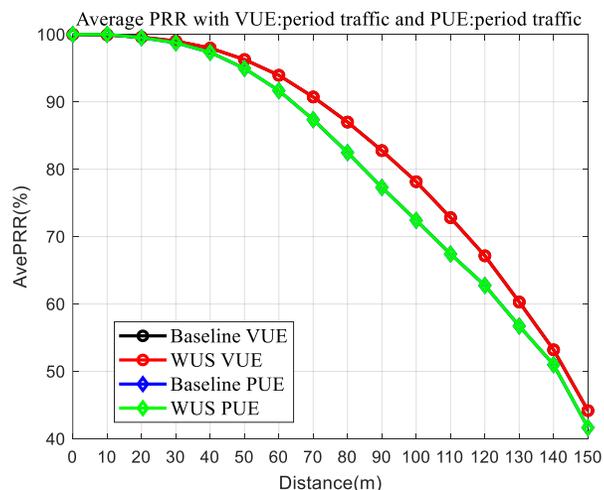


Parameter	value
Deployment	Indoor 120 * 80
Carrier Frequency	6GHz
Communication type	unicast
Bandwidth	20MHz
Subcarrier spacing	15KHz
Channel model	P2P link defined in TR 37.885
Channel Access	LBT type1 with CAPC P=2
Resource allocation scheme	R16 resource allocation mode 2 for single-slot based transmission
ED threshold	-70dBm
Traffic model	Normal UE: FTP 3 as in TR 38.889 $\lambda = 0.05$, packet size: 0.5M VLP UE: The packet size of VLP UE is half of normal UE Wi-Fi: same with normal UE
UE dropping model	 <p>6 SL-U pairs and 4 STAs per AP per 20 MHz Only one VLP UE exists per UE pair</p>

- **Observation:** SL VLP UE can maintain good UPT performance with lower power consumption and device complexity compared to normal UE.

Preliminary evaluation results of SL WUS

SL RedCap



Parameter	value
Deployment	Urban scenario
Link type	V2V, V2P, P2V
UE type	VUE : PUE = 2:1 (300:150)
Communication type	unicast
Bandwidth	40MHz
Subcarrier spacing	30KHz
DRX duration	250ms
Traffic parameter for Periodic VUE	Packet arrival interval of periodic traffic: 500ms Packet latency requirement of periodic traffic: 500ms Packet size of periodic traffic: 800 or 1200byte
Traffic parameter for Aperiodic VUE	Packet arrival interval of aperiodic traffic: 250ms + an exponential random variable with the mean of 250 ms Packet latency requirement of aperiodic traffic: 250ms Packet size of aperiodic traffic: 200 ~ 2000byte
Traffic parameter for PUE	Traffic type: Periodic traffic Packet arrival interval of periodic traffic: 1000ms Packet latency requirement of periodic traffic: 100ms Packet size of periodic traffic: 800 or 1200byte

- **Observation:** SL WUS can achieves significant power saving gain without notable PRR performance impact to both VUE and PUE.

SL FR2

Further sidelink evaluations

Motivation

SL FR2

- XR and gaming are the acknowledged killer applications for XR glasses, Head Mounted Displays (HMDs), etc.
 - SA2 has defined the corresponding PQI for such kinds of requirements.
 - RAN1 has evaluated and concluded that current NR SL cannot support the required data rate.



PQI Value	Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default Maximum Data Burst Volume	Default Averaging Window	Example Services
New value#1	Delay Critical GBR	5	5ms	10 ⁻⁴	20000 bytes	2000 ms	Interactive service - consume VR content with high compression rate via tethered VR headset
New value#2		6	10ms	10 ⁻⁴	20000 bytes	2000 ms	interactive service - consume VR content with low compression rate via tethered VR headset; Gaming or Interactive Data Exchanging;

- The NR SL over FR2 (licensed/unlicensed) band is attractive because of the potentially higher performance and reliability, and better device integration level, than the other competitive technologies (e.g., 802.11ad/aj/ay, etc.).
- **Proposal:** Supporting SL FR2 in Rel-19, including at least
 - **Beam management**
 - **Resource allocation enhancement**
 - **Operating on both FR2-1 and FR2-2**
 - **Supporting unified framework for all the cast types**

THANK YOU.

谢谢。

Appendix

SLS evaluation assumption for sidelink underlay

Parameters	Value
Scenario	Dense Urban single layer
Layout	hexagonal grid, 7 macro sites, 3 sectors per site with wrap around
Inter-BS distance	200m
Minimum BS-UE (2D) distance	35m
Minimum UE-UE (2D) distance	2m
Carrier frequency	4GHz
Simulation bandwidth	100MHz (273RB for 30kHz SCS)
Subcarrier spacing	30kHz
TDD	All UL slot
BS Tx power	49dBm
UE Tx power	23dBm, P0 = -80, Alpha = 0.8
UE distribution	80% indoor 3km/h and 20% outdoor 30km/h
BS receiver noise figure	5dB
UE receiver noise figure	9dB
UE number	10 uu users/cell, 5 D2D pairs/cell
BS antenna height	25m
UE antenna height	$h_{uT} = 3(nf_1 - 1) + 1.5$, nf_1 for outdoor UEs: 1, nf_1 for indoor UEs: $nf_1 \sim \text{uniform}(1, Nf_1)$ where $Nf_1 = 1$
BS antenna configurations	(M,N,P,Mg,Ng;Mp,Np) = (8,8,2,1,1;2,8), (dH, dV) = (0.5, 0.8) λ
Uu UE antenna configurations	(M,N,P,Mg,Ng;Mp,Np) = (1,2,2,1,1; 1,2)
SL UE antenna configurations	(M,N,P,Mg,Ng;Mp,Np) = (1,1,1,1,1; 1,1)
receiver	MMSE-IRC as the baseline receiver
Traffic model for Uu UL	0.5Mbytes/packet, 18 packet/s
Traffic model for sidelink	Full buffer