3GPP TSG RAN Rel-18 Workshop RWS-210039
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Document for: Discussion and decision

Enhancements for advanced sidelink features for Rel-18

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Background and Motivations

- Sidelink for V2X:
  - High data rate requirements are specified in TS22.186 for advanced V2X scenarios, i.e., higher degree of automation
  - Sensor information sharing and video sharing require as high as 700-1000Mbps data rate

Communication scenario description		Req #	Payload (Bytes)	Tx rate (Message /Sec)	Max end-to-end latency (ms)	Reliability (%)	Data rate (Mbps)	Min required communication range (meters)
Scenario	Degree							
Sensor information sharing between UEs supporting V2X application	Lower degree of automation	[R.5.4-001]	1600	10	100	99		1000
	Higher degree of automation	[R.5.4-002]			10	95	25 (NOTE 1)	
		[R.5.4-003]			3	99.999	50	200
		[R.5.4-004]			10	99.99	25	500
		[R.5.4-005]			50	99	10	1000
		[R.5.4-006] (NOTE 2)			10	99.99	1000	50
Video sharing between UEs supporting V2X application	Lower degree of automation	[R.5.4-007]			50	90	10	100
	Higher degree of automation	[R.5.4-008]			10	99.99	700	200
		[R.5.4-009]			10	99.99	90	400

NOTE 1: This is peak data rate.

NOTE 2: This is for imminent collision scenario.

Performance requirements for sensor sharing in V2X (TS 22.186)

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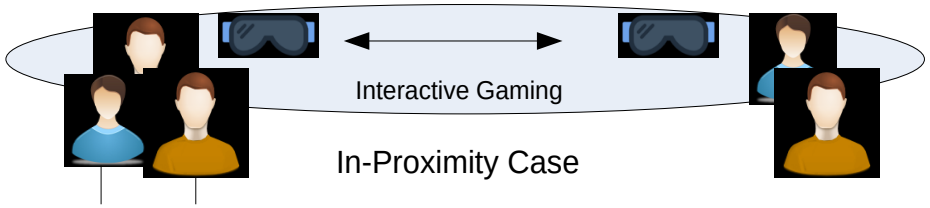
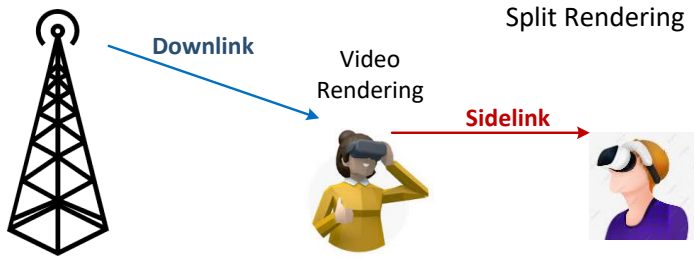
Background and Motivations

- Sidelink in Network Controlled Interactive Service (NCIS)
  - As described in TR22.842, new interactive services require frequent information exchange
  - Online gaming and AR/VR based interactive services require high-rate data exchanging among UE's
    - Communication and computing offloading
    - Split rendering
  - Low mobility and better channel condition (LoS, high SNR, stable) in NCIS use cases facilitate high data transmissions in sidelink



Interactive gamming among UEs in proximity (TR 22.842)



Split video rendering between XR server and some HMDs.

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Background and Motivations

- Sidelink in cyber-physical applications in vertical domains
  - As described in TS22.104 and TR22.832, D2D communication is beneficial for low-latency and high reliability in NPN network, e.g., a private network in an indoor factory.
    - Highly cooperative robots' operation to complete some joint tasks
    - Mobile robots/AGVs carrying large/heavy work pieces move along factory floor
    - Human-machine interactions with AR
  - High rate and/or low-latency data exchange among cooperative robots
  - To avoid interfering public licensed network, the devices within the shielded product-cell may use mmWave bands (e.g., 29GHz) to conduct direct communication to each other.

Factory automation

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Sidelink Enhancement for NR Rel-18

To increase throughput for sidelink transmission for both V2X and NCIS-D2D communications, the following topics can be considered for sidelink enhancement in NR Rel-18

- Spatial multiplexing: Sidelink MIMO enhancement
- Large bandwidth: Sidelink Enhancement for FR2
- Additional bandwidth: Unlicensed bands

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Existing Sidelink MIMO Features[1]

- CSI-RS on PSSCH
  - Less frequent
- CQI and RI feedback: up to 2 layers
  - Feedback with a delay requirement, i.e., latency bound
- Open-loop multi-antenna transmissions: up to layer 2
  - Less efficient due to interference between the two layers.
- Support unicast only
- No specific optimization for FR2

[1] L. Wan, A. C. K. Soong, J. Liu, Y. Wu, B. Classon, W. Xiao, D. Mazzarese, Y. Zhao, and T. Saboorian, 5G System Design: An End to End Perspective, 2nd Ed., Springer, 2021.

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SL MIMO Enhancement in Rel-18

- MIMO Features
  - More than 2 layers: high throughput for single sidelink provided by spatial multiplexing
  - MU-MIMO: high sidelink system throughput due to user diversity and spatial diversity
    - 8Tx could provide good MU-MIMO performance
  - Broadcast and groupcast: efficient resource utilization for common information delivery

- RAN1 Designs
  - CSI signaling
  - CSI reporting
  - Channel reciprocity
  - Hybrid broadcast/groupcast and unicast transmissions

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SL MIMO Enhancement: CSI Signaling

- Flexible CSI-RS configurations:
  - Not limited to PSSCH, e.g., PSFCH or PSFCH like structure

- CSI signaling design
  - Periodic and aperiodic CSI-RS configuration
  - Wideband, BWP, and subband CSI-RS
  - CSI-RS configurations between Tx and Rx UE once connection is established
  - CSI-IM configuration

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SL MIMO Enhancement: CSI Reporting

- Channel is stable in low-mobility scenarios as for use cases in NCIS. Advanced CSI reporting can be utilized for better spatial multiplexing performance.
- PMI reporting/Amplitude and phase reporting
- Beam index reporting
- SL CSI report to gNB
  - Centralized SL resource allocation for interference suppression

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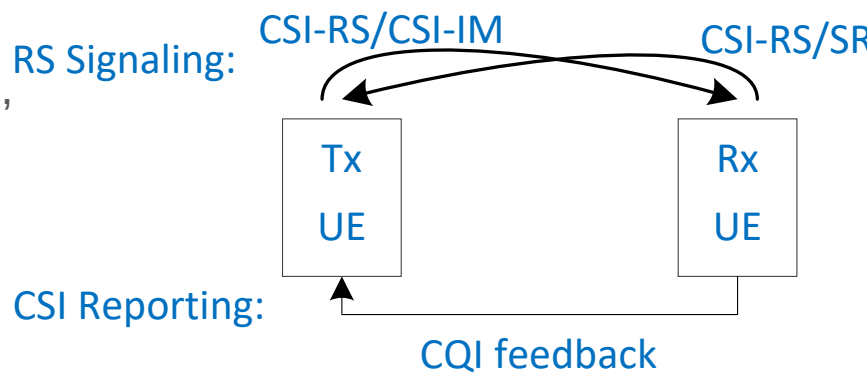
SL MIMO Enhancement: Channel Reciprocity

- Sidelink transmissions are on the same frequency carrier
- Sidelink channel reciprocity can be explored: TDD-like CSI acquisition
  - Tx UE measures the channel through CSI-RS or SRS transmissions from Rx UE to form sidelink beamforming/precoding
  - RX UE measures the channel and interference from CSI-RS and CSI-IM, respectively, and sends CQI feedback for link adaptation purpose
- Requirement: RF phase calibration
  - Can be done for high end UE chip with long life span
    - Vehicle UE: longer life ~10yrs
    - Head-mounted display (HMD)
    - High end smartphones
  - UE capability
- Advantages
  - Better utilization of reference signals
  - Reduce CSI feedback overhead
  - Fast scheduling, transmission, low latency
  - Flexible configuration: hybrid full CSI report and TDD-like CSI acquisition



SL MIMO Enhancement: Broadcast/Groupcast

- In Rel-16
  - MIMO is supported for unicast only
  - Possible reasons for MIMO not supported for broadcast/groupcast
    - Large feedback overhead: CSI feedback from multiple UEs
    - Transmission based on the worst CSI in the group
- Enhanced SL MIMO for broadcast/groupcast in Rel-18
  - New CSI acquisition with low feedback overhead
  - Flexible transmissions: Hybrid broadcast/groupcast and unicast transmissions
    - Adopt Rel-17 MBS adaptive broadcast/groupcast and unicast for retransmissions for throughput efficiency

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Sidelink Enhancement for FR2

- Beamforming management
- Multiple beam panels
- Enhanced sidelink sensing
- Assistance from sidelink FR1
  - Broadcast is efficient in FR1
  - Fast beam acquisition
- Sidelink power control in FR2
  - SL power control for beam based transmission
  - Beam dependent DL or SL pathloss measurement
  - SL beam Tx power may not be limited by DL pathloss on the DL Tx beam

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Sidelink and Unlicensed Spectrum in 3GPP

- 3GPP developed V2X (Rel 14-16) and sidelink enhancements (Rel 17) technologies suitable for dedicated spectrum and licensed spectrum
- More recently for the unlicensed spectrum 3GPP specifications for NR-U (Rel 16), IIOT and URLLC unlicensed (Rel17) and Beyond 52.6 GHz (Rel 17) unlicensed were developed or are under development
- We propose the extension of sidelink to unlicensed spectrum
  - Pros: The large spectrum availability at no cost
  - Cons: When coexisting with other RAT may result in additional latency (for instance due to LBT) and lower reliability due to interference

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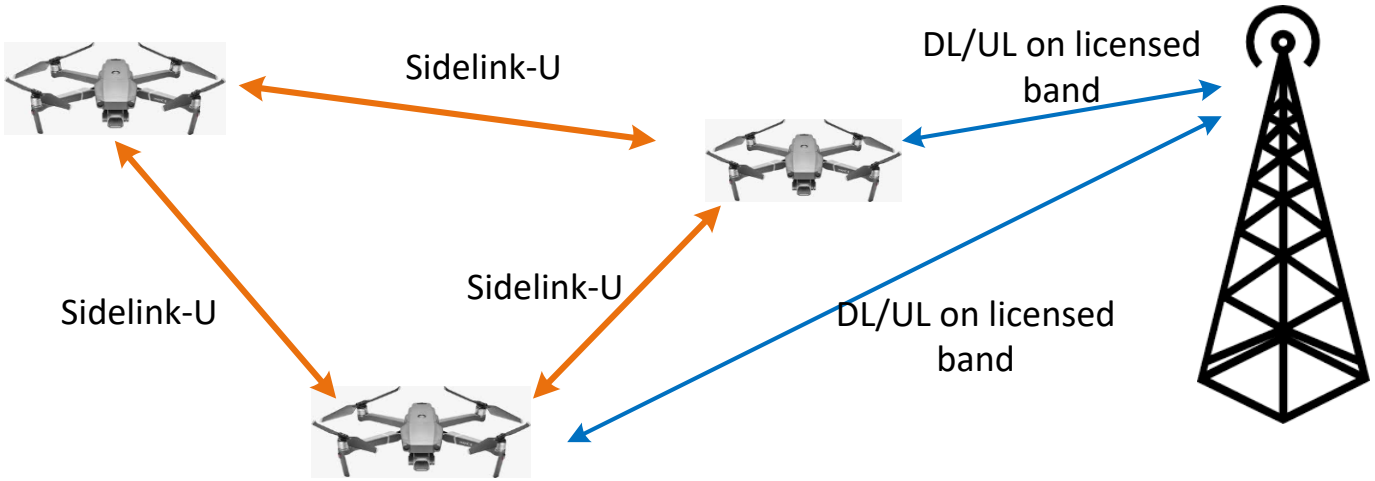
Use Cases for Sidelink in Unlicensed Spectrum

- Possible use cases of **sidelink in unlicensed spectrum (Sidelink-U)**:
  - **IIOT enterprise applications** – the enterprise unlicensed spectrum is less prone to other RAT interference
  - **Personal and home networks** – these applications may require less power, and may tolerate larger delay or delay jitter :
    - UE to Reduced Capacity (RedCap) like personal sensors and health monitoring devices
    - UE to cameras, UE to personal drones
  - **NTN mesh communication** (drone control/ avoidance, video streaming routing, etc.)



Sidelink in Unlicensed Spectrum (Sidelink-U) for Rel-18

- Support for sidelink in NR-U and 60GHz: the current spec does not support UE to UE in unlicensed spectrum

- Technical Directions
  - UE to UE shared COT
  - LBT and DBTW for sidelink (including SSB design)
  - Co-existence with 3GPP-P device (LAA, NR U) and non-3GPP-P device (WiFi)
  - Enhanced sidelink sensing capabilities for LTE-LAA, NR-U, WiFi detection

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Conclusions

- Sidelink enhancement in Rel-18 should target for throughput improvement to satisfy high data rate and/or low latency requirement in various uses cases, including, V2X, NCIS D2D communications, and NPN indoor factory, etc.
- The work item for Rel-18 sidelink enhancement shall focus on following topics
  - Sidelink MIMO enhancement
  - Sidelink enhancement for FR2
  - Support sidelink in unlicensed spectrum

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