China Academy of Telecommunication Technology

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Dynamic Uu/SL Resource Allocation

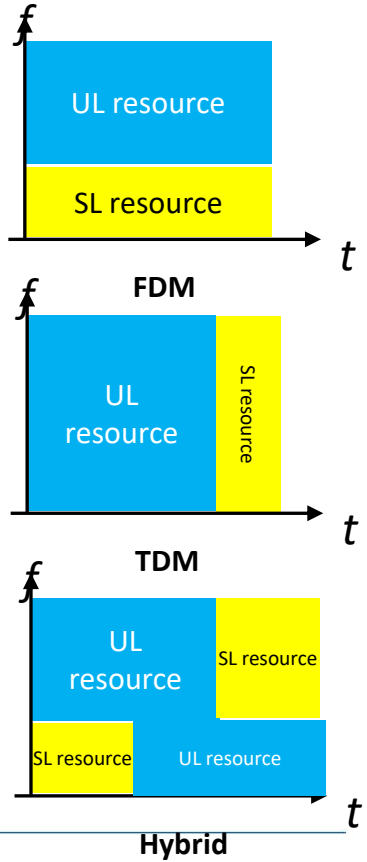
CATT

Motivation of Dynamic Uu/SL Resource Allocation

- Statistically multiplexing gain –
  - Uu and SL are multiplexed statistically to improve the resource utilization
  - Scheduling gain in resource allocation through link adaptation of Uu and SL.
- Increasing the spectrum efficiency with spectrum reuse between SL and Uu links
  - The same set of spectrums are reused for both Uu and SL to increase the system capacity
  - SL is scheduled by the gNB in addition to DL/UL for UEs in proximity direct communication
    - SL is considered as the embedded small cell for proximity direct communication
    - SL resource allocation and MIMO schemes for direct communication is by gNB to optimize the SL link adaptation gain
      - SL CSI is fed back to the gNB scheduler in addition to DL CSI for dynamic link adaptation between SL and Uu
- Dynamic co-channel interference management between SL and Uu
  - Co-channel interference are dynamically managed by gNB scheduler for spectrum reuse and cross-link interference management (CLI)
  - Extension of CLI framework for the support of dynamic TDD
- Seamless connection for SL
  - Dynamic switching of SL unicast communication to the Uu link when UEs are out of proximity.

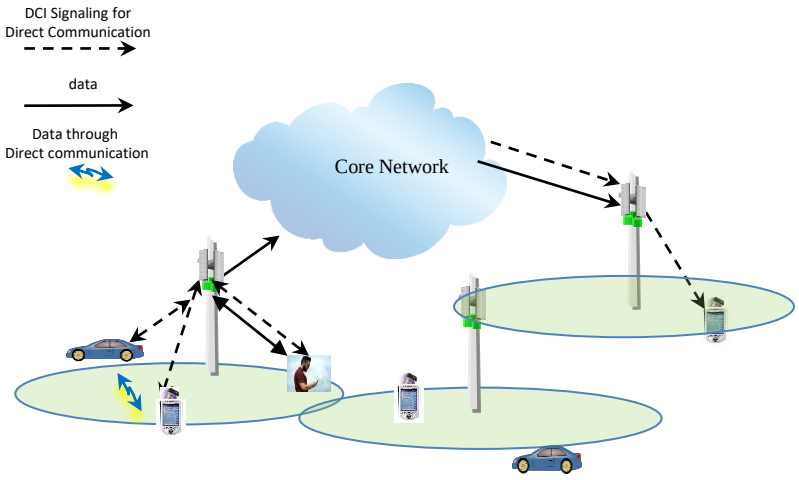
NR Radio Resource allocation for Sidelink

- Semi-static radio resource allocation for Uu links and Sidelink
  - Radio resource for sidelink is partitioned statically or semi-statically with independent interference management with that of Uu link
  - Sidelink radio resource control
    - Central control – sidelink radio resource by gNB, e.g., NR V2X mode 1 resource allocation
      - Interference management through implementation
    - Distributed control – sidelink radio resource are based on contention scheme with interference avoidance
- Applications and deployment scenarios
  - Applications and use cases for sidelink are not considered cross over to those used for Uu links
  - In real deployment, applications would be beneficial with both Uu link and sidelink



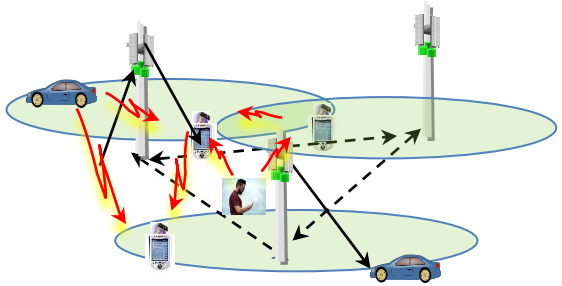
NR Capacity Enhancement with SL Proximity Direct Communication

- SL and Uu link are jointly considered at the gNB scheduler for resource allocation of an end-to-end connection when both UEs are in proximity
  - gNB schedules the SL resource on Uu DCI to both Tx UE and Rx UE for proximity direct communication
    - There is no SCI indication on PSCCH for PSSCH transmission
    - HARQ-ACK to the gNB for the resource allocation of HARQ retransmission
  - SL link adaptation and dynamic co-channel interference managements between Uu/SL
    - Enable spectrum reuse between Uu/SL in a cell



Dynamic Uu/SL Resource allocation and Dynamic TDD UL/DL Interference management

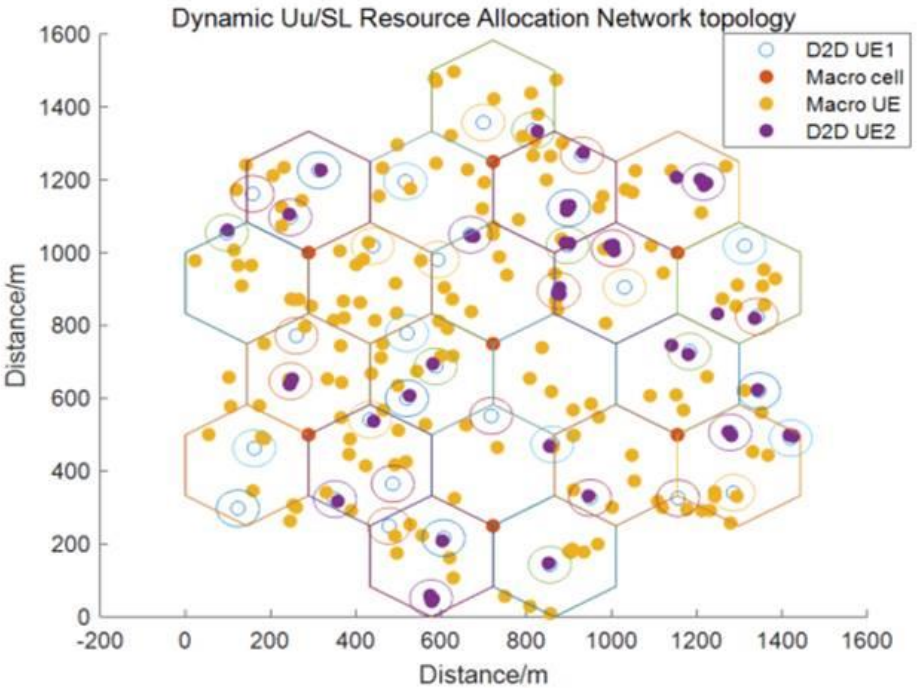
- Detection of UEs and gNBs in the proximity
  - Uu link – cell search and mobility management
  - Sidelink – L1 discovery
- UE Measurements of RS from the detected UEs and gNBs for Uu/SL link selection and interference managements
  - DL SSB from gNBs
  - SL L1 discovery signals
- UE report on the channel quality of detected UEs and gNBs for link adaptation and interference management
  - Link adaptation: CSI measurements
  - Interference estimation: CSI-IM resource or SL discovery signals
- Dynamic link adaptation and resource allocation between Uu and SL by gNB scheduler for NR capacity enhancements
- Dynamic TDD -Dynamic TDD UL/DL interference management based on UE measurements of detected UEs and gNBs



Evaluation Assumptions of Uu & Proximity Direct Communications

- Evaluation of dynamic SL/Uu resource allocation

	Dense Urban	Dynamic Uu/SL resource allocation
Topology	7 macro sites	7 macro sites 2/4 D2D links per sector
Cell type	3 sectors per site	3 sectors per site
Carrier frequency	2.6 GHz	
SCS	30 kHz	
Duplex mode	TDD	
System bandwidth	100M	
Channel Model	ITU-UMI	Uu link: ITU-UMI D2D link: Winner + B1
Transmission Power	gNB Tx power: 46 dBm	gNB Tx power: 46 dBm UE Tx Power: 23 dBm
Antenna	gNB: 192 TxRU ; UE: 4 TxRU	
Antenna Height	gNB: 10m; UE: 1.5m	
Antenna gain	gNB: 17 dBi; UE: 0dBi	
Noise Figure	9dB	
Traffic Model	FTP3, 200ms inter-arrival time 0.5Mbytes per packet	



Capacity Gain with Uu & Proximity Direct Communication

- Up to 22.8% cell average UPT gain, and up to 84% cell edge UPT gain with dynamic Uu/SL resource allocation
- The UPT gain increases as the number of SL UEs increases in a cell
- The UPT gain increases as the total number of UEs increases in a cell

Table1: Evaluation results of Dynamic Uu/SL resource allocation (5 UEs per cell)

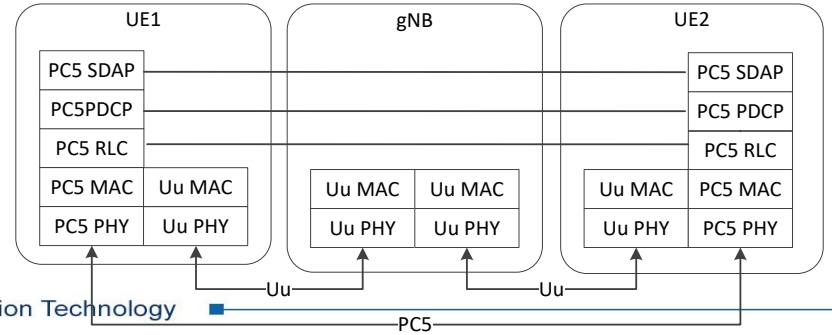
Scenario	Uu RU	Average UPT		5% UPT	
		Mbps	Gain(%)	Mbps	Gain(%)
DU(baseline)	45.9%	234.1	--	102.4	--
2 SL UEs per cell	15.0%	253.6	8.3%	129.3	26.3%
4 SL UEs per cell	8.4%	265.9	13.6%	154.1	50.5%

Table2: Evaluation results of Dynamic Uu/SL resource allocation (10 UEs per cell)

Scenario	Uu RU	Average UPT		5% UPT	
		Mbps	Gain(%)	Mbps	Gain(%)
DU (baseline)	94.5%	183.9	--	50.0	--
2 SL UEs per cell	33.0%	209.2	13.8%	74.0	48.0%
4 SL UEs per cell	19.1%	225.8	22.8%	92.0	84.0%

Higher Layer Enhancement for Uu/PC5 dynamic switching

- Limitation of Higher layer protocols and procedures in support Uu/PC5 dynamic switching
  - Limitation of Uu/PC5 path switching in Rel-18 UE relay
    - Path switch policy (PC5 permitted, or Uu permitted, or both path) can be (pre-)configured in UE or provided by PCF
    - Uu/PC5 path switching is semi-statically configured
  - Limitation of service continuity and system capacity optimization
- Dynamic switching between Uu and SL is controlled by the gNB
  - Dynamic switching between Uu and SL based on SL and Uu CSI report
  - UP/CP procedures enhancement to support dynamic switching between Uu and SL
  - Support service continuity between Uu and SL
    - When UEs in SL direct communication are out of communication range, dynamic switching to the Uu link to ensure the service continuity.



Summary

- Benefit of dynamic Uu/SL resource allocation
  - Statistical multiplexing of Uu and SL resource to increase resource utilization
  - UE detection of UEs and gNBs in the proximity for link adaptation and dynamic interference managements
    - Detection of co-channel Interference sources from UEs and gNB supports the interference managements of dynamic TDD DL/UL
  - Increasing spectrum reuse for NR system capacity enhancement
    - Up to 22.8% cell average UPT gain, and up to 84% cell edge UPT gain with dynamic Uu/SL resource allocation
    - The UPT gain increases as the number of SL UEs increases in a cell
    - The UPT gain increases as the total number of UEs increases in a cell
  - Ensure the service continuity of SL with UE mobility
    - Dynamic switching of SL and Uu links would ensure the service continuity and link adaptation gain when UEs move in and out of SL coverage area.

THANK YOU