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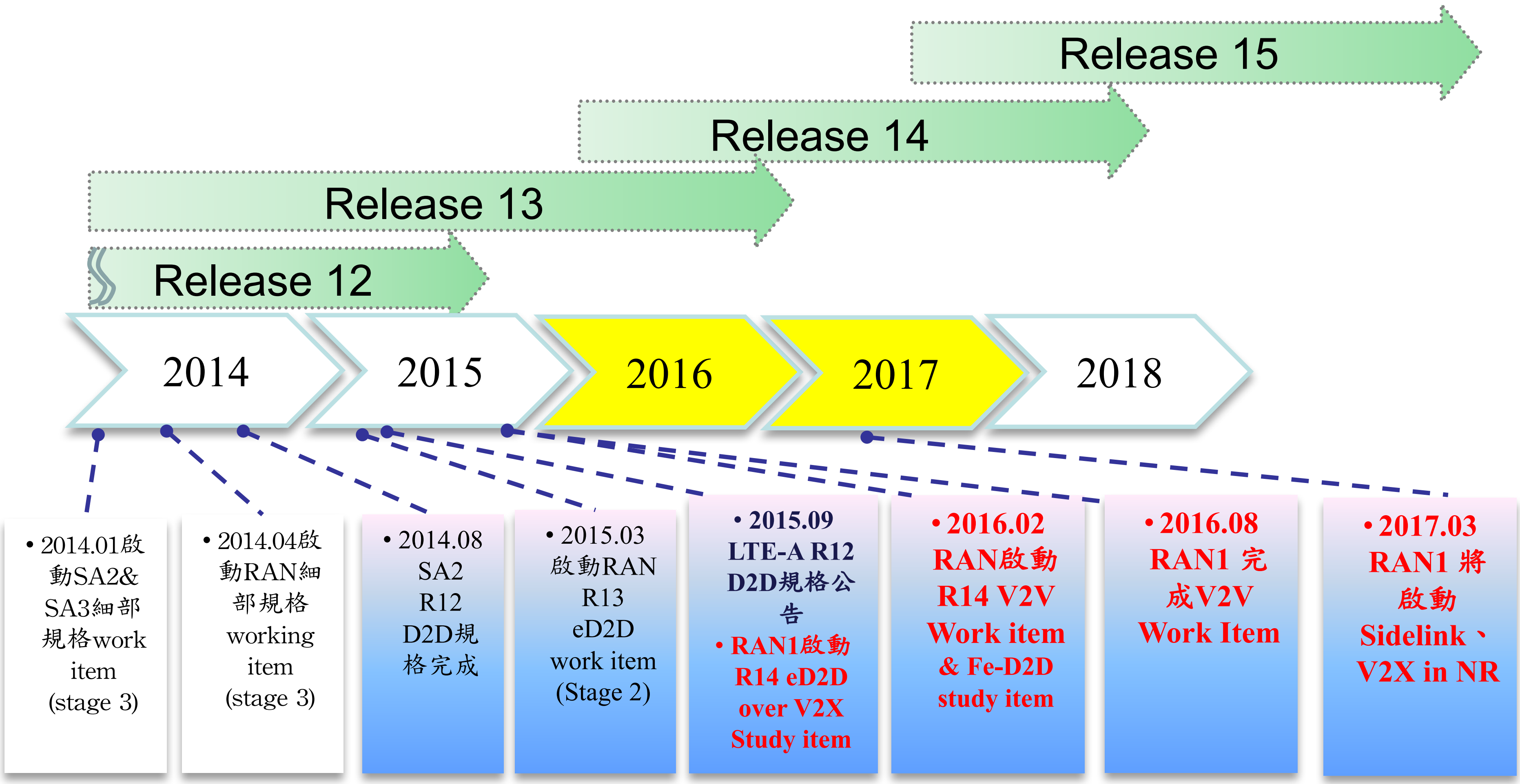
3GPP Cellular V2X

台北大學 魏存毅 Chun-Yi WEI, PhD

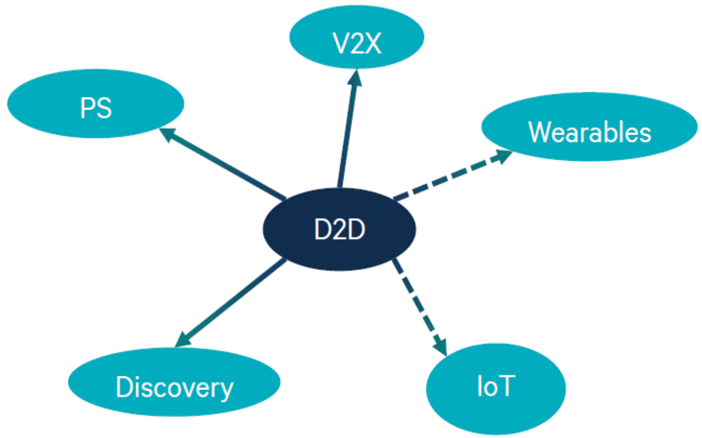
3GPP LTE D2D & V2X Timeline



5G Automotive Association

Mission Statement of 5GAA Develop, test and promote communications solutions, initiate their standardization and accelerate their commercial availability and global market penetration to address society's connected mobility and road safety needs with applications such as autonomous driving, ubiquitous access to services and integration into smart city and intelligent transportation

D2D and its enhancement



- D2D first introduced in Release 12
  - D2D discovery for commercial & Public Safety use cases
  - D2D group cast communication for Public Safety
- Enhancements to D2D continued in Release 13
  - D2D discovery enhancements to inter-frequency
  - D2D based UE to Network relays
- D2D based V2X being explored in Release 14
- D2D also has applications to IoT and wearables that need to be explored

Source : Intel, Qualcomm RP-160268

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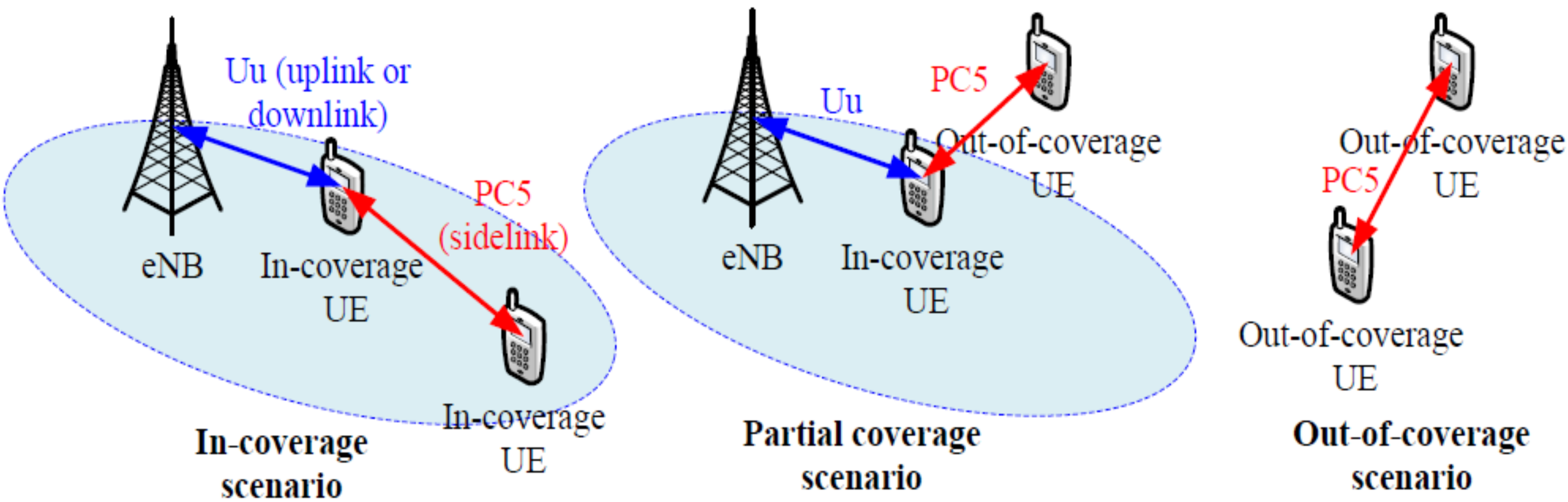
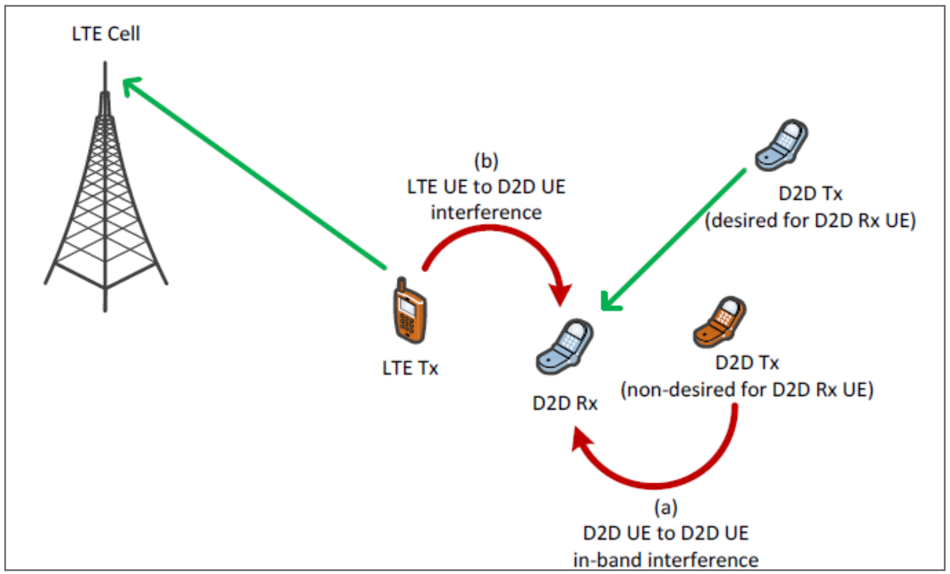
D2D ProSe support three scenarios



Source : appear in IEEE Communications Magazine "Enhanced LTE Device-to-Device Proximity Services 2016

The source of interference to D2D reception

- D2D operates on the UL resource, i.e. UL spectrum for FDD bands and UL subframes for TDD bands.
- D2D reception is hence subject to interference from:
  - a) D2D UEs operating on the same channel due to in-band emissions.
  - b) LTE UEs operating on adjacent channel due to both Tx emissions from the LTE UEs and the receiver blocking of the D2D UE (LTE UE is the blocker).



Classification

PS Case	In coverage	Partial	Out-Of-Coverage
Discovery	R12 (Inter-cell, intra-cell) R13 (inter-carrier, inter-PLMN	R13 (type1)	R13 (type1)
Communication	R12 (Inter-cell, intra-cell)	R12	R12
	R13 (UE-to-Network Relay, Group priority communications)		

Non- PS Case	In coverage	Partial	Out-Of-Coverage
Discovery	R12 (Inter-cell, intra-cell) R13 (inter-carrier , inter-PLMN)	X	X
Communication	X	X	X

Source : appear in IEEE Communications Magazine “Enhanced LTE Device-to-Device Proximity Services 2016

Major Feature Of D2D ProSe In Rel-12 & 13

Features	Release 12	Release 13
Discovery	Only supported in in-coverage	Supported in-coverage, partial-coverage, and out-of-coverage. UE-to-Network relay for discovery is supported.
Purposes of discovery	Public safety	Public safety and non-public safety for in-coverage, public safety for partial-coverage and out-of-coverage
Synchronization to facilitate discovery	Achieved by eNBs	Additional mechanisms are needed
Communications	Broadcast (without feedback channels) for in-coverage, partial-coverage, and out-of-coverage	Broadcast with Layer 3 relay for partial-coverage
Synchronization to facilitate Communications	Achieved by eNBs for in-coverage, ns while additional mechanisms are needed for partial-coverage and out-of-coverage	Reuse the mechanisms in Release 12
Priority Control	Not yet supported	Supported

Source :IEEE Communications Magazine “Enhanced LTE Device-to-Device Proximity Services

Introduction V2X

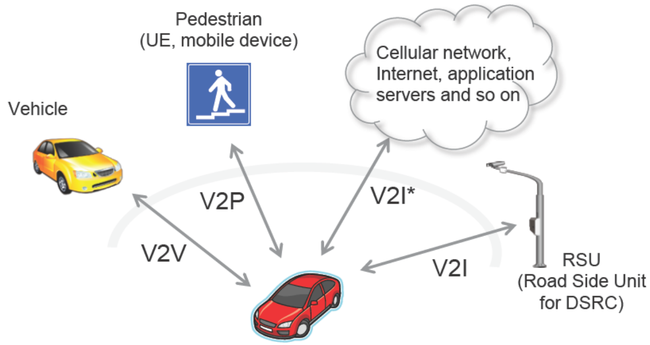
- China shows great interest in vehicular communications
  - In 2014, CCSA has finished the feasible study for vehicle safety application based on TD-LTE
  - The series of industrial standard of communication based on LTE for vehicle application began
  - In 2015, the frequency study of V2X also started
  - National Regulatory Authority in China will allocate the frequency of connected vehicles
- Vehicle manufacturers and cellular network operators also show strong interests in vehicle wireless communications for proximity safety services as well as commercial applications
- 3GPP's goal is to *realize "connected car" via LTE*

*CCSA (China Communications Standards Association) 中國通信標準化協會

V2X industry

LTE-V2X activities in China

- National key project “Standardization and prototyping for LTE-V wireless transmission technology (2016-2017)” was released by MIIT
- Shanghai Intelligent Connected Vehicle Pilot Area” was approved by MIIT, China . Initial plan was disclosed by Shanghai International Automobile City
  - Phase 1 (present-2016.6): 40 connected vehicles (802.11p and LTE-V2X)
  - Phase 2 (2016.7-2017.12): 400 connected vehicles (802.11p and LTE-V2X)
  - Phase 3 (2018.1-2019.12): 1000 connected vehicles (LTE-V2X)



Major Companies	Focus Topics	Important Contributions @ RAN# 70
Huawei & L.G.	V2V services based on LTE sidelink	- Enhancement to sidelink physical layer structure necessary for V2V - Enhancement to sidelink synchronization procedure necessary for V2V - Necessary sidelink resource allocation enhancement option(s) for V2V

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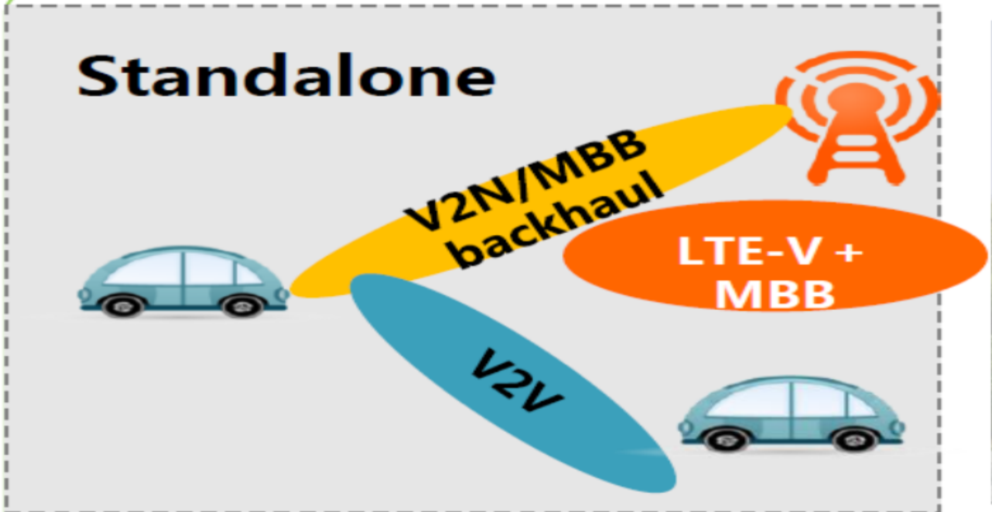
V2X industry

LTE-V Demonstration in G20 (Sep, 2016)



Small BS at lamppost

- V2N：20MHz@2.6GHz
- V2P/V2V/V2I: 10MHz@2.6GHz
  (*only for demo in G20*)
- RSRP ≧ -85dBm
- SINR ≧ 20dB
- Seamless coverage
  (Inter-site distance ~140m)

1 Macro BS, 33 Small BSs

CMCC, SAIC, Huawei, Ali

Initial Cellular V2X standard completed

Re1-13 SID
Feasibility Study on LTE-based V2X Services

- **New SI: Feasibility Study on LTE-based V2X Services (RP-151903)**
  - June. 2015, RAN#68
  - RAN1 leads this working item (LG, Huawei, CATT)
  - Objective:
    - To define the evaluation methodology for LTE-based V2V, V2I and V2P services to compare the performance of different technical options
    - For support of PC5 transport for V2V services (PC5 is specific for D2D)
    - For support of Uu transport for V2V, and Uu,PC5 transport for V2I and V2P services

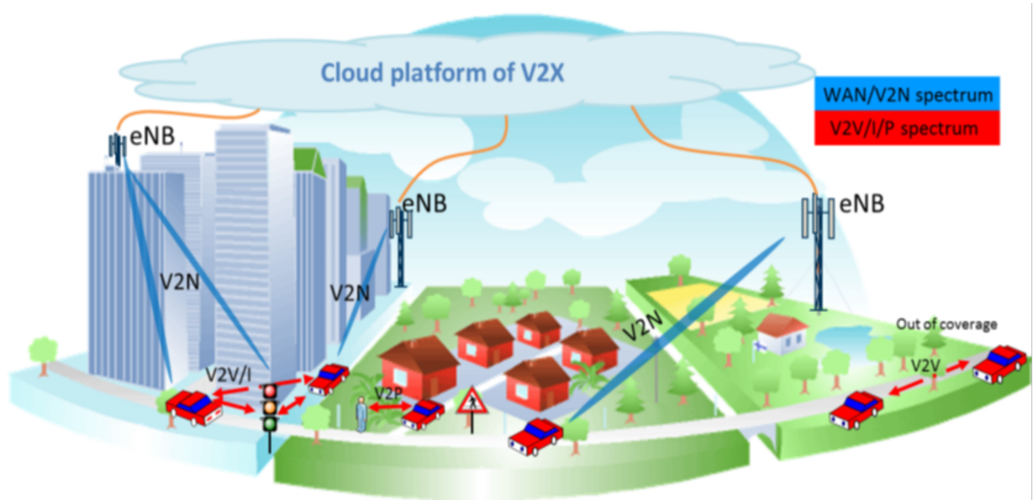
Rel.14 WID
Support for V2V services based on LTE sidelink

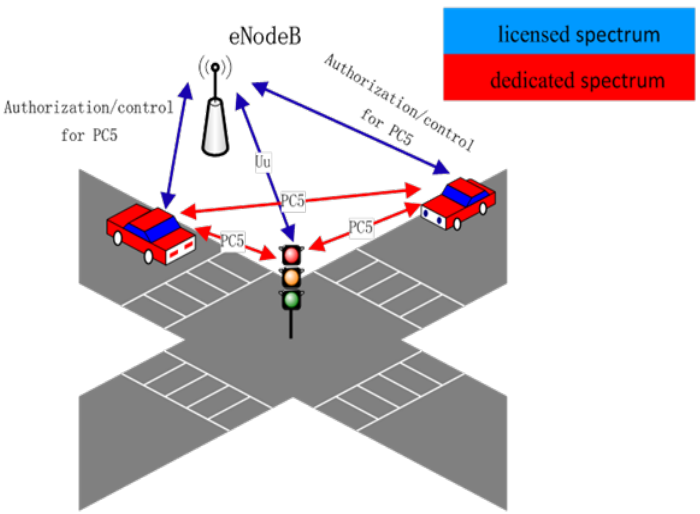
- **New WI proposal: Support for V2V services based on LTE sidelink (RP-152293)**
  - Dec. 2015, RAN#70
  - RAN1 leads this working item (LG Electronics, Huawei, HiSilicon, CATT, CATR)
  - Objective (RAN2):
    - To identify what are **necessary sidelink resource allocation enhancement** option(s) among the ones captured in TR 36.885 for V2V services and specify the identified option(s)
    - To specify a mechanism to enable E-UTRAN to **select between PC5 and Uu** for transport of V2V messages within network coverage, if necessary, in coordination with other working groups
    - To specify **necessary radio protocols and RRC signaling** to support the above features

Definition for V2X

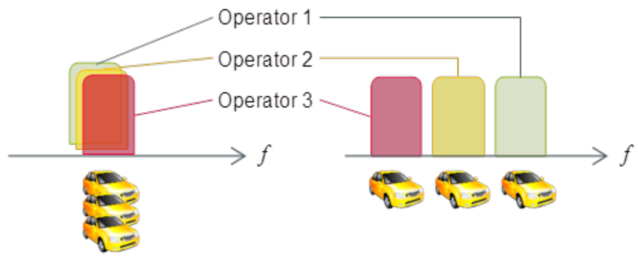
- **Road Side Unit**
  - an entity supporting V2I Service that can transmit to, and receive from a UE using V2I application. RSU is implemented in an eNodeB or a stationary UE.
- **V2I Service (Vehicular-to-Infrastructure/Network)**
  - a type of V2X Service, where one party is a UE and the other party is an RSU both using V2I application.
- **V2P Service (Vehicular-to-Pedestrian)**
  - a type of V2X Service, where both parties of the communication are UEs using V2P application
- **V2V Service (Vehicular-to-Vehicular)**
  - a type of V2X Service, where both parties of the communication are UEs using V2V application

Deployment





2GHz
6GHz



1 Tx chain and 1 Rx chain for PC5

Case 1-1: Single dedicated V2x carrier is used regardless of the operator. This carrier is owned by single operator or shared by multiple operators.

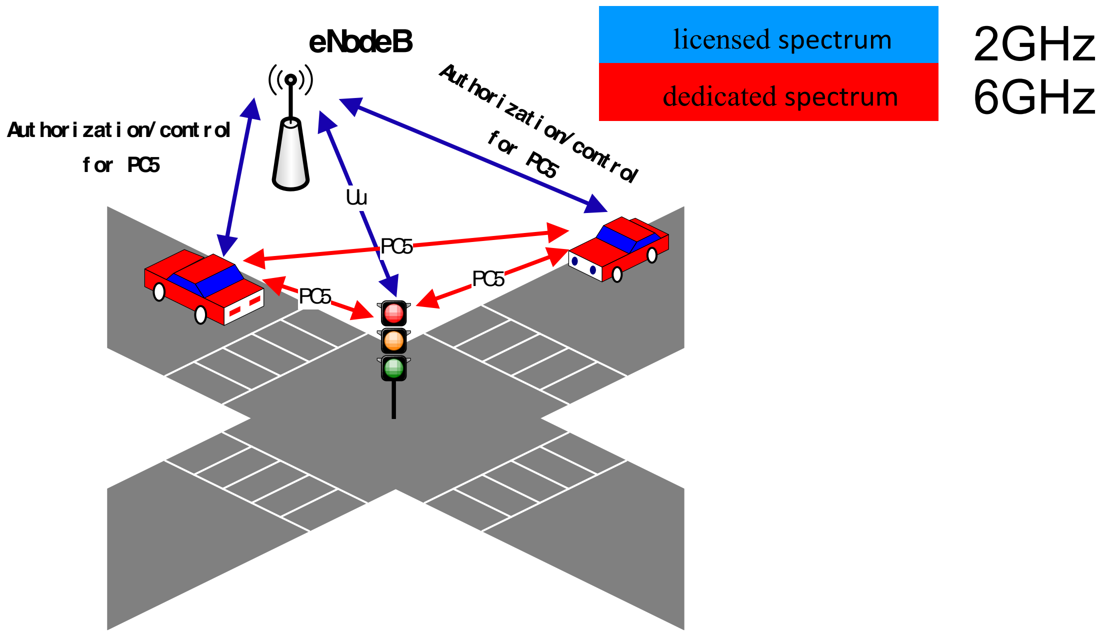
1 Tx chain and 3 Rx chain for PC5

Case 1-2: Multiple operators have each dedicated V2x carriers and UE is equipped with multiple Rx chain to monitor all the V2x carriers.

Source : CMCC & NTT DoCoMo

V2X –Spectrum

- PC5 transport uses a dedicated carrier
- Uu transport and authorization/control for PC5 transport could use a licensed carrier which is also used for LTE network coverage.



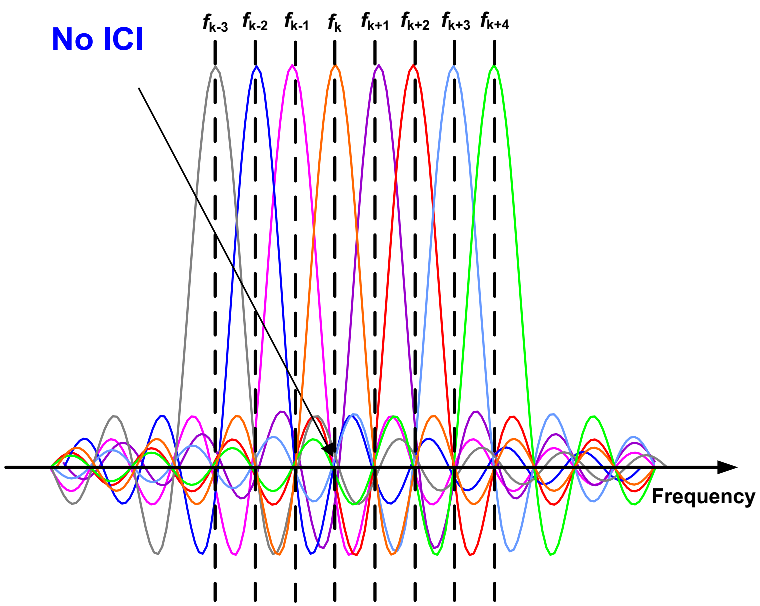
* SA: scheduling assignment

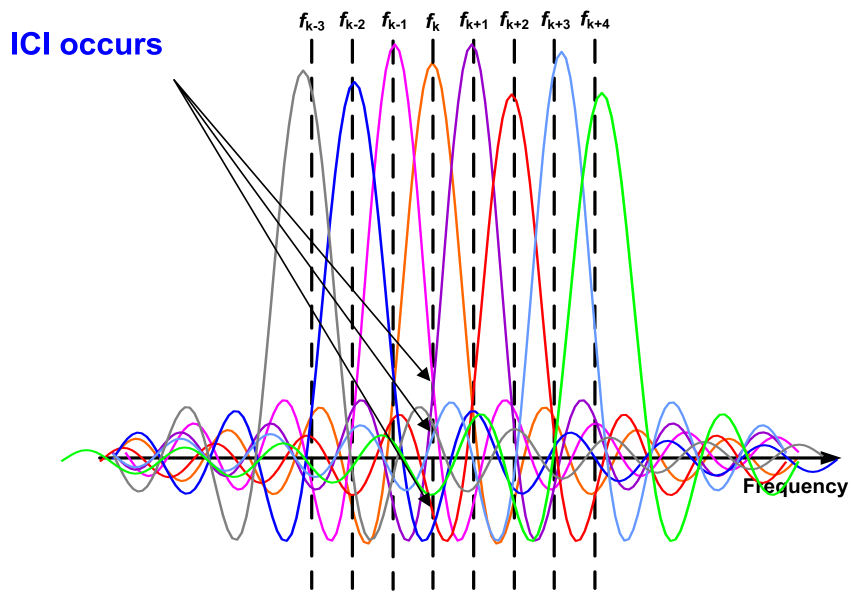
Issues in high Doppler case (1/3)

- Doppler Effect
  - When the UE locates in a fixed location, there is not inter-carrier interference (ICI). However, when the UE begins to move, the ICI occurs.

$$Y_k = X_k H_{k,k} + \sum_{\substack{m=0 \\ (m\neq k)}}^{N-1} X_m H_{k,m} + W_k = X_k H_{k,k} + ICI_k + W_k$$

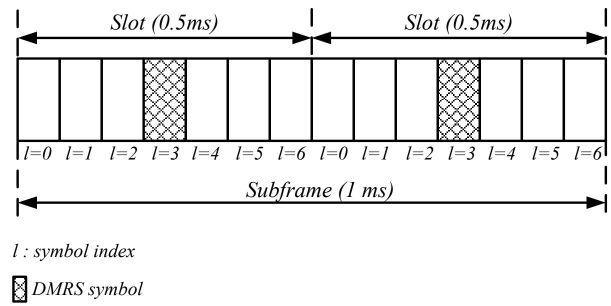
    - The OFDM received signal with ICI can be expressed as follows
      - X_k, Y_k, W_k, ICI_k are the frequency domain transmitted signal, received signal, noise and ICI terms at k-th sub-carrier, respectively. Besides, $H_{k,m}$ is the channel frequency response from m-th sub-carrier to k-th sub-carrier.





Issues in high Doppler case (2/3)

- High Doppler case for V2V scenario
  - In the high Doppler case for V2V, for example carrier frequency is 6GHz and the maximum absolute vehicle speed may be 280km/h
    - From the agreements of the V2X study item in RAN1#82 meeting, carrier frequency for PC5-based V2V is 6GHz and 2GHz. Besides, the vehicle speed is 70km/h and 140 km/h for freeway case.
    - The normalized Doppler frequency defined as $f_d * T_U$ where f_d is the maximum Doppler frequency and T_U is the useful symbol duration will be up to 10%.
- Issues in high Doppler case for V2V scenario
  - **Fast time-variant channel caused by high Doppler effect can't be efficiently estimated by current DMRS in LTE**
    - In high Doppler case, the number of the channel average fading cycle will be larger than 0.5 during two neighboring DMRS symbols, and hence the linearity of the channel will be destroyed and the current DMRS in LTE is not enough.
  - **ICI will degrade the system performance**



* DMRS: demodulation reference signal

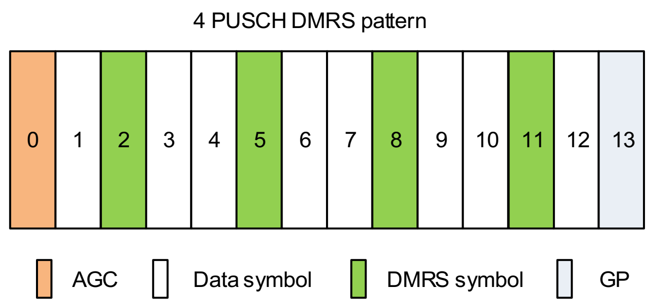
Issues in high Doppler case (3/3)

- **RAN Plenary revised the V2V WID in RAN#71 meeting (Mar. 2016) as follows,**
  - **The outcome of this work item should be able to support a relative speed of up to 500 km/h with enhancements/changes (e.g., adaptation of code-rate, the DMRS mapping/structure) (if necessary) to the physical layer structure designed for the relative speed up to 280 km/h**
    - In this case, the normalized Doppler frequency will be up to **18%.**

Enhancement for handling high Doppler case

- Alt 1:
  - "4V structure" for PSSCH/PSCCH is kept (which is already an agreement in RAN1)
    - In order to support 500 km/h relative speed case, lowering the coding rate can be used
      - FFS how to adapt MCS, RB size, and/or number of transmission subframes depending on the situation
        - » This may or may not have any specification impact
  - Confirm the working assumption:15 kHz subcarrier spacing with 1 msec TTI length
  - Supported by: LG Electronics, Huawei, HiSilicon, Samsung, CATT, ZTE, Nokia, ASB, OPPO (9)
  - Objected by: E///, QC

➔ Advantages: small standard impact
➔ Drawbacks: advanced receiver is needed for channel estimation and ICI cancellation

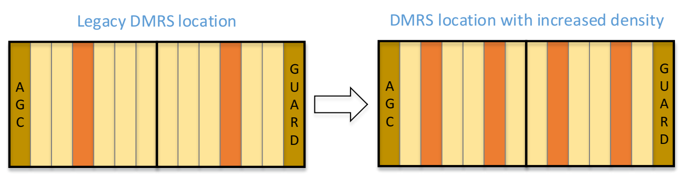


Sub-frame structure for 4V (4 DMRS symbols per subframe)

Source: Huawei/ R1-162118

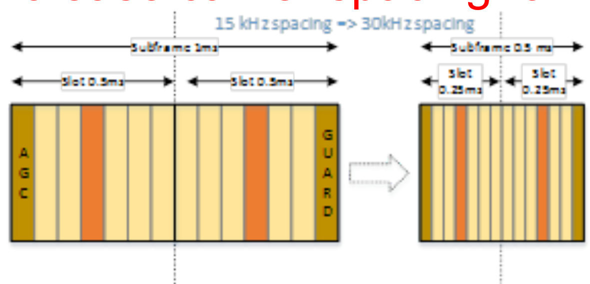
Enhance DMRS in high Doppler case

- Maximum Doppler frequency is about 1.5kHz (for 6GHz carrier frequency and 280km/hr vehicle speed)
- Maximum carrier frequency is about 6kHz (for 6GHz carrier frequency and 1ppm mismatch, carrier spacing is 15kHz)
- Enhanced DMRS design
  - ✓Increase DMRS density



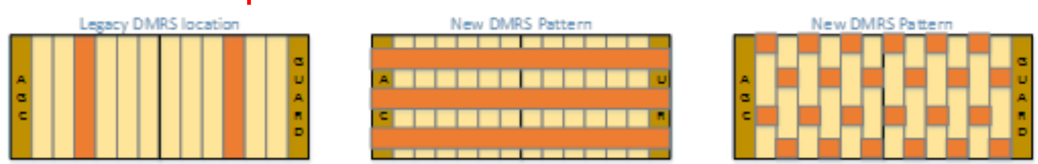
Each DMRS contains 6PRBs
➔144REs to 288REs

  - ✓increase carrier spacing for DMRS



PAPR issue and Standard Impact

  - ✓New DMRS pattern

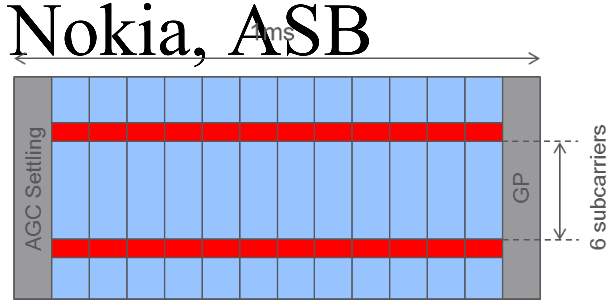


Enhancement for handling high Doppler case

- Alt 2:
  - For PC5-based V2V: A DMRS RE is transmitted every 6th subcarrier in all symbols of the scheduled transmission
    - DFT precoding is NOT applied to data REs
    - Offset of the DMRS RE within a RB is FFS
    - FFS between rate matching and puncturing
    - FFS details of the DMRS sequence
  - Confirm the working assumption:15 kHz subcarrier spacing with 1 msec TTI length
  - Supported by: Ericsson, Qualcomm, Vodafone (3)
  - Objected by: SS, HW, HiSi, CATT, Nokia, ASB

➔ Advantages: good for channel estimation

➔ Drawbacks: large standard impact, advanced receiver is needed for ICI cancellation, large PAPR



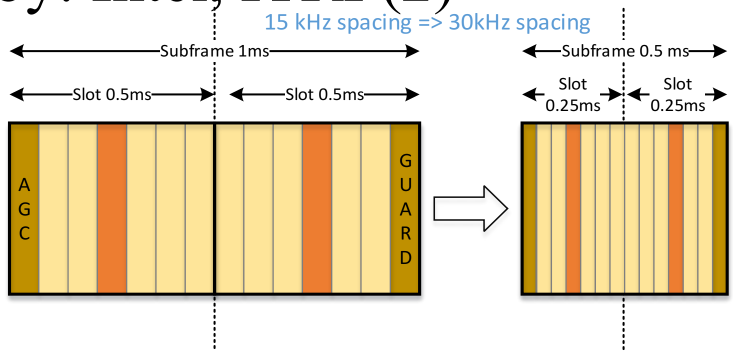
Sub-frame structure for 2H (2 “horizontal” DMRS REs/RB)

Source: Ericsson/ R1-157365

* PAPR: peak to average power ratio

Enhancement for handling high Doppler case

- Alt 3:
  - Increased subcarrier spacing from 15kHz to 60kHz is supported for LTE PC5 V2V communication
  - Supported by: Intel, ITRI (2)



Source: Intel / R1-156538

✓ Normalized Doppler frequency is about 18% for 6GHz carrier frequency, 500km/hr relative vehicle speed, and 15KHz subcarrier spacing

➔ Normalized Doppler frequency becomes 9% when subcarrier spacing is increased to 30KHz

➔ Normalized Doppler frequency becomes 4.5% when subcarrier spacing is increased to 60KHz

➔ Advantages: advanced receiver may not be needed

➔ Drawbacks: large standard impact

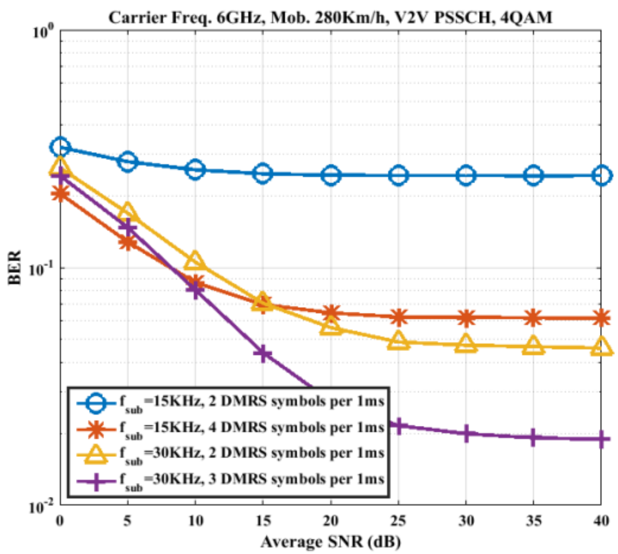
Enhancement for handling high Doppler case

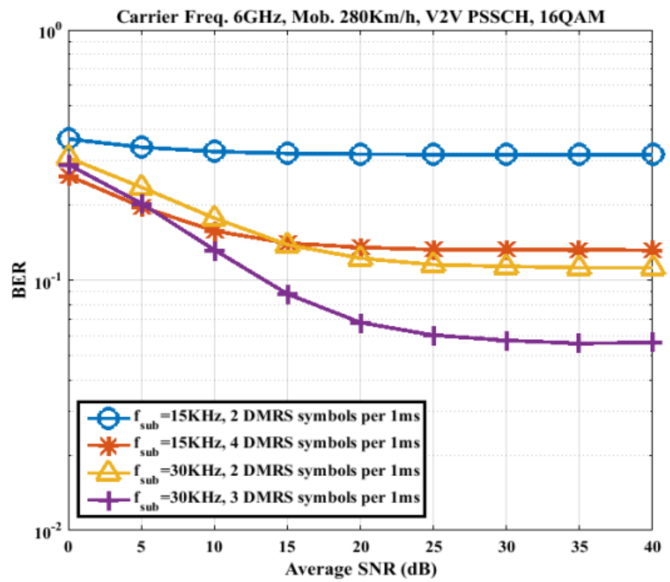
- Alt 4:
  - Alt 2 + Alt 3 (with 30kzh tone spacing)
  - Supported by: Intel, Ericsson, Qualcomm, ITRI (4)

- Alt 5:
  - Alt 1 + adapt MCS, the number of RBs, and number of transmission subframes depending on the UE absolute speed and UE synchronization source (e.g, GNSS or eNB)
    - FFS: One or more PSCCH format(s) need to be supported
  - Supported by: Ericsson, Huawei, HiSi, LGE, ZTE, CATT, Nokia net., Vodafone, CATR, Samsung, Sharp, Sony, ASB, Lenovo, OPPO, Xinwei (16)

Simulation Results for DMRS Enhancements

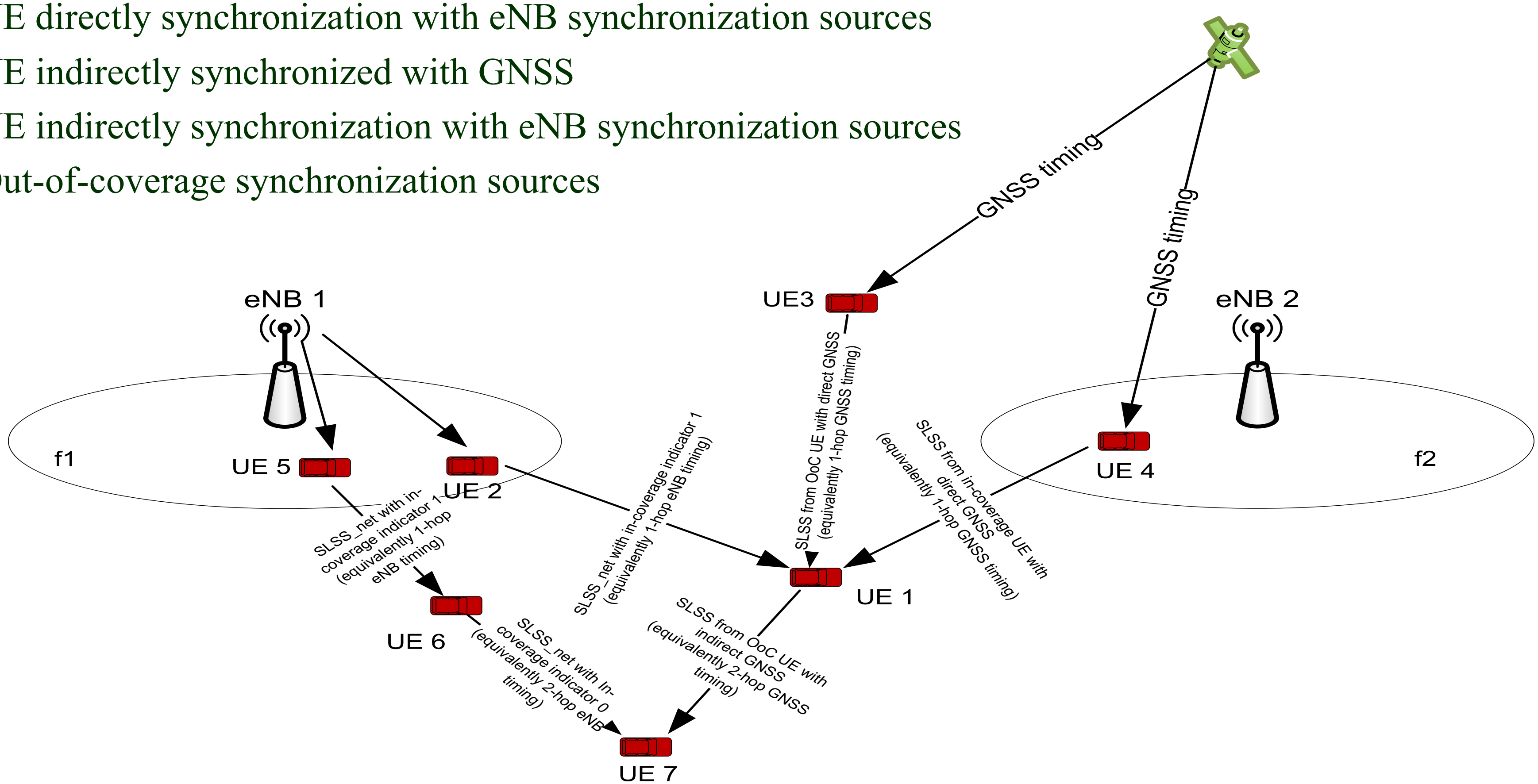
- For the high Doppler case: 6GHz carrier frequency and 280km/hr relative vehicle speed
  - **pre-coding bit error rate (BER) for 4QAM and 16QAM are simulated**
  - **From the simulation results, we can observe that both increase DMRS density and increase subcarrier spacing are needed in 16QAM case to mitigate the Doppler effect.**
    - When BER>0.1, the performance is not good enough





Type of Synchronization sources in V2V sildelink

- Multiple synchronization sources
  - GNSS/GNSS-equivalent synchronization sources
  - eNB
  - UE directly synchronized with GNSS
  - UE directly synchronization with eNB synchronization sources
  - UE indirectly synchronized with GNSS
  - UE indirectly synchronization with eNB synchronization sources
  - Out-of-coverage synchronization sources

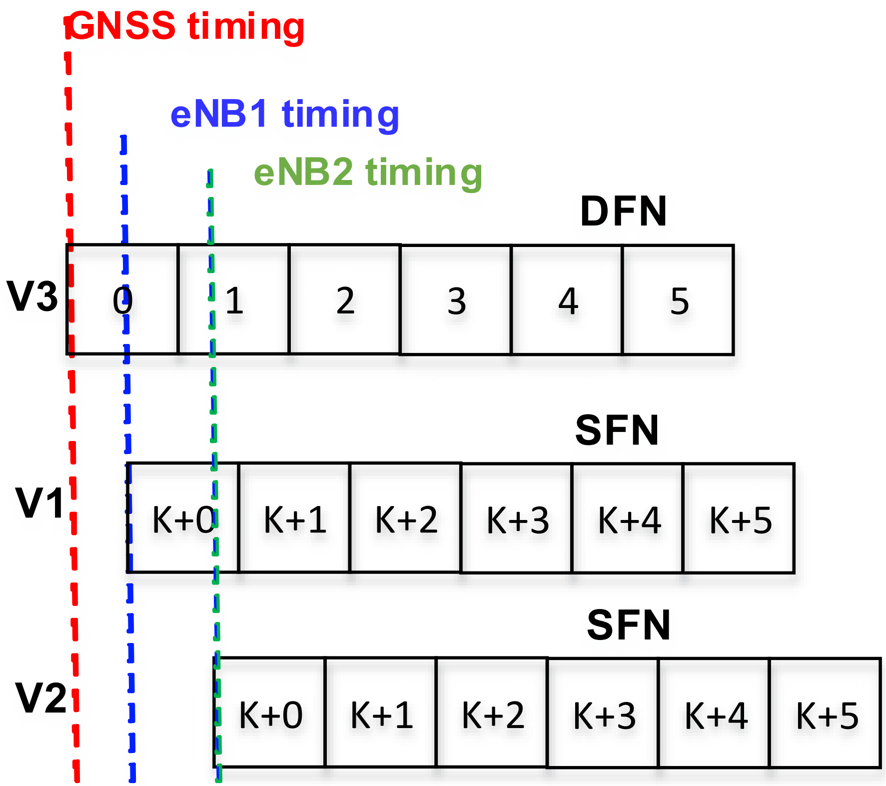


Synchronization source priorities for V2V sildelink

Highest priority	Second priority
GNSS	eNB
UE directly synchronized with GNSS	UE directly synchronized with eNB
UE indirectly synchronized with GNSS	UE indirectly synchronized with eNB
UE without any Synchronization Source	UE without any Synchronization Source

Continue discussion

Timing difference between eNBs and GNSS



Source :Huawei

RAN1 assumes that eNBs may not always have GNSS or GNSS-equivalent

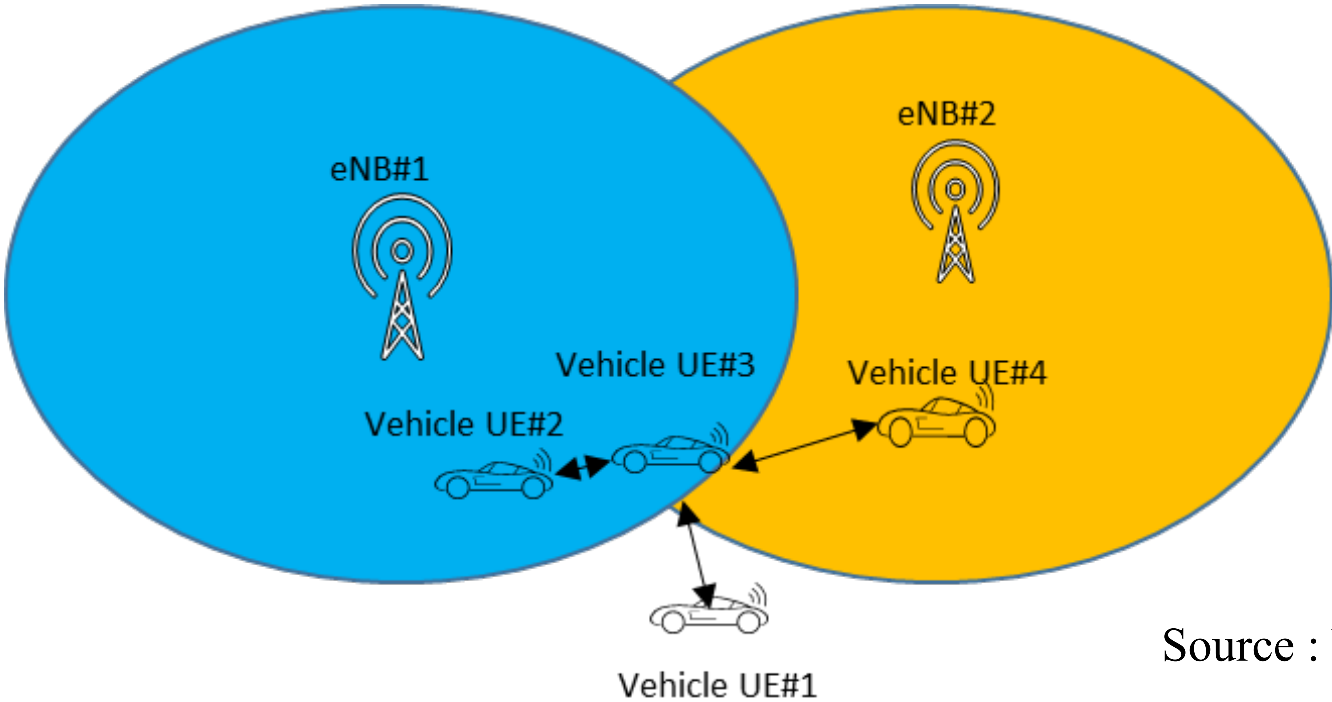
- Asynchronous network case should be supported.

Perspectives for further study:

- eNB assistant information, e.g.
  - Timing offset to UTC
  - TA or eNB location
  - others

Source :TR 36.885

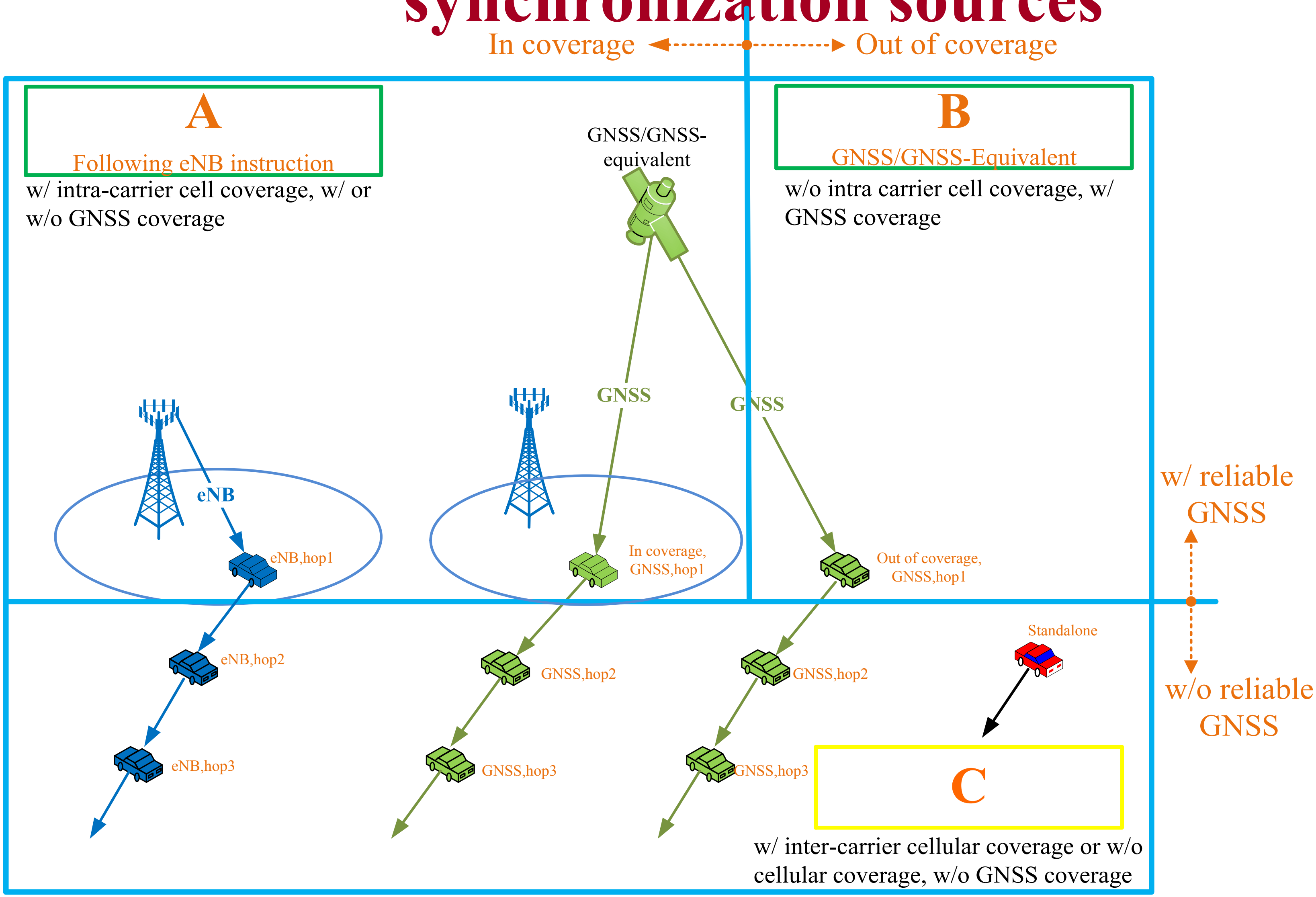
Mixed coverage scenario for V2V synchronization



Source : Nokia /ALB

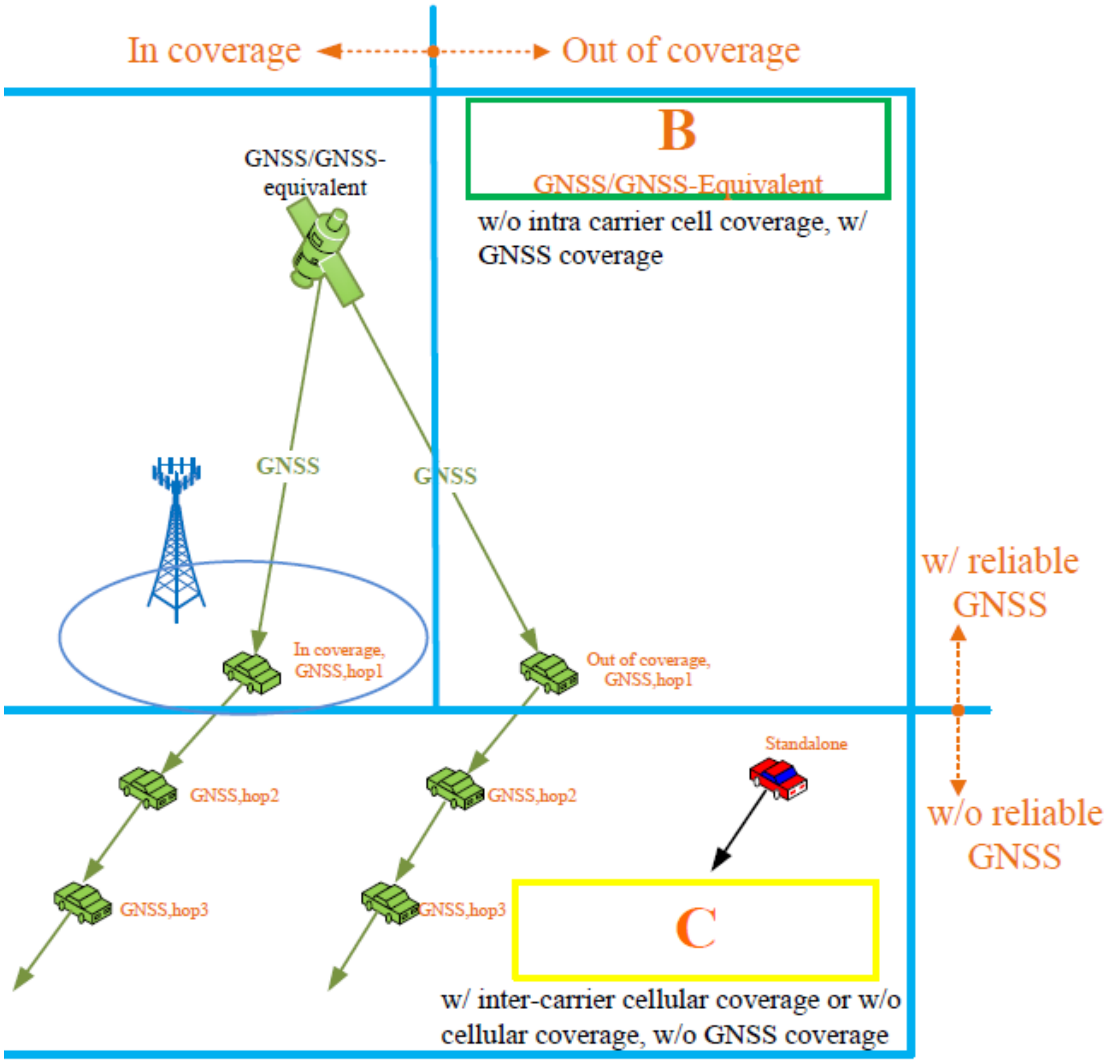
Resource pools from different cells and out-of-coverage UEs need to be time-aligned to allow UEs to follow transmissions from UEs in different cells and different coverage

Possible Synchronization scenarios on various synchronization sources



Source : Samsung

Prioritizing PC5-based V2V performance



1. GNSS
2. Synchronization signal from UEs directly synchronized to GNSS
3. Synchronization signal from UEs indirectly synchronized to GNSS
4. Synchronization signal generated by UE itself

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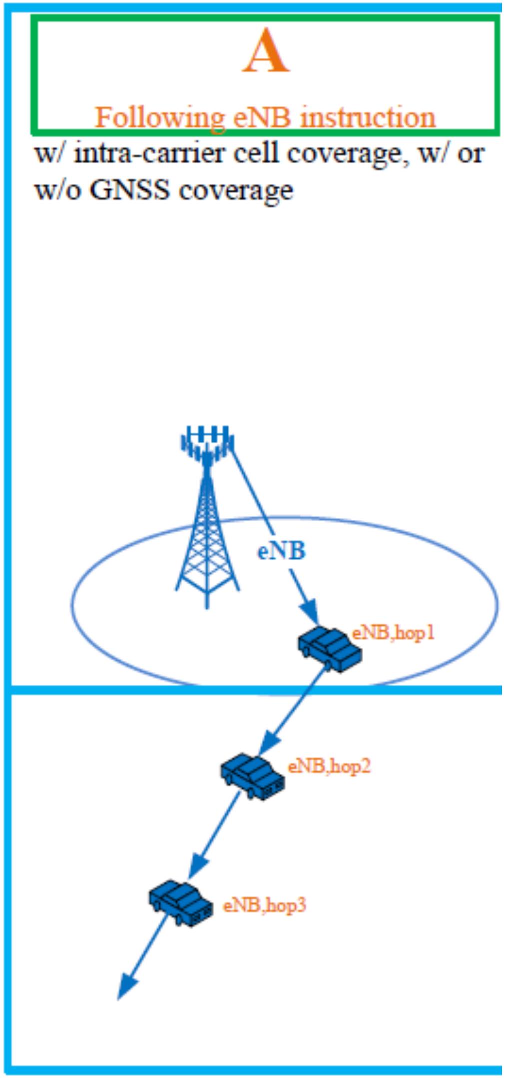
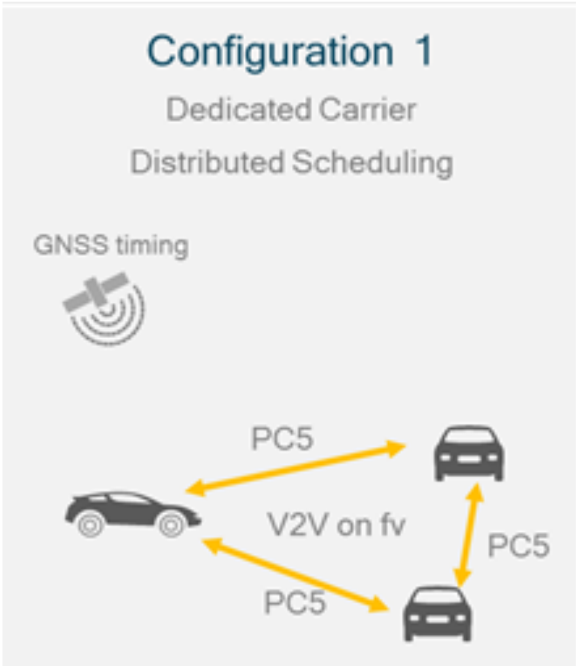
Prioritizing cellular performance



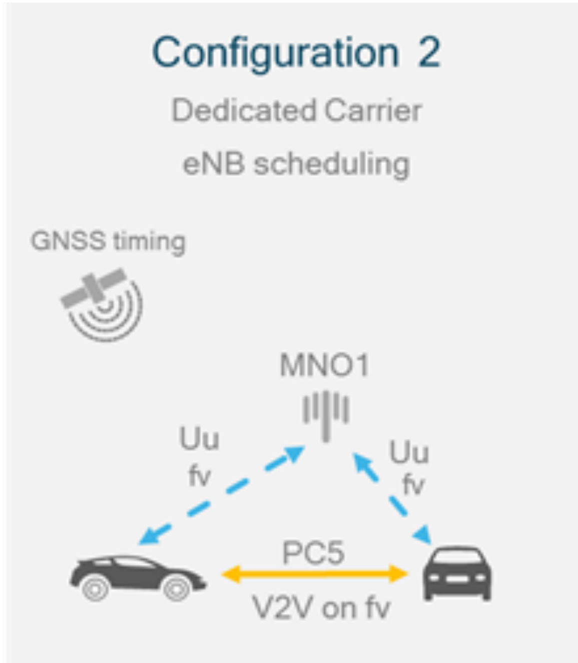
Reuse Rel. 12/13 synchronization procedure

1. eNB
2. Synchronization signal from UEs directly synchronized to eNB
3. Synchronization signal from UEs indirectly synchronized to eNB
4. Synchronization signal generated by UE itself

Why need the UE autonomous resource (re)selection mode?



Need the UE autonomous resource (re)selection mode

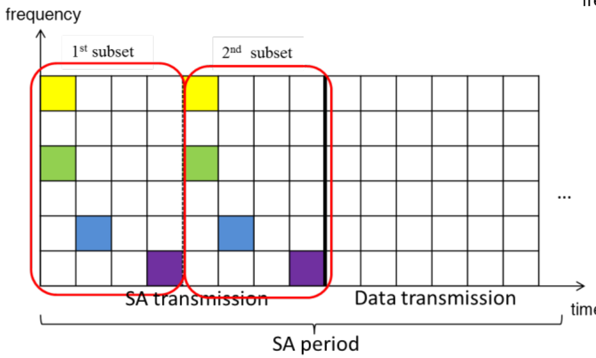


Some parts will move to V2X WID

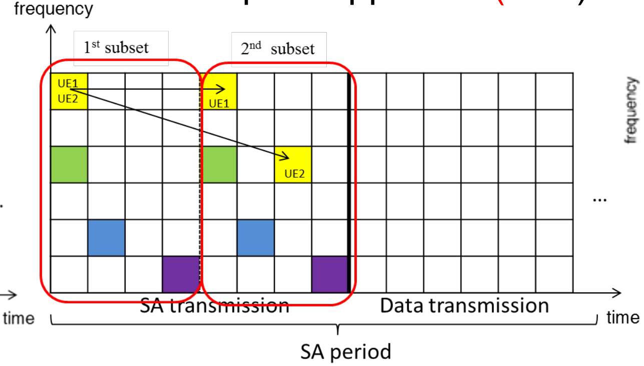
Source : Qualcomm

Why need the UE autonomous resource (re)selection mode?

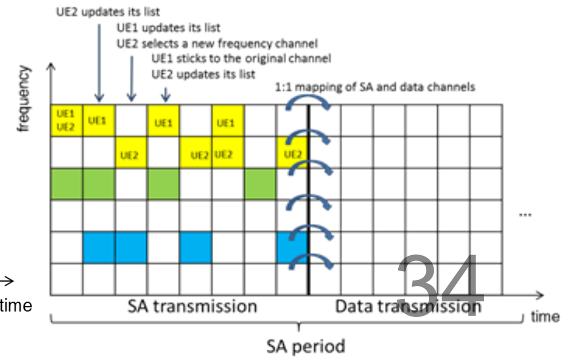
1:1 mapping (D2D)



Enhanced explicit approach (V2V)



Enhanced implicit approach (V2V)



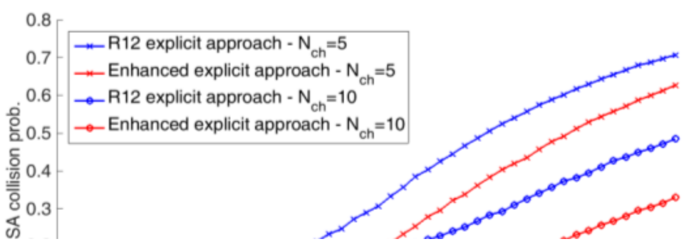


Figure 1. SA collision probability:
Rel-12 vs. enhanced explicit approach

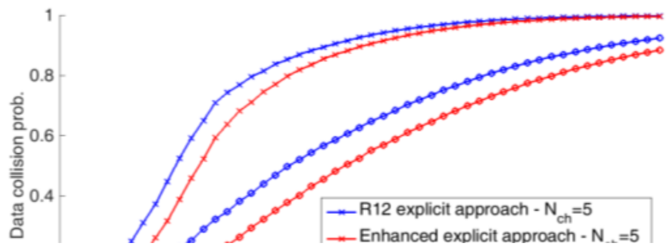
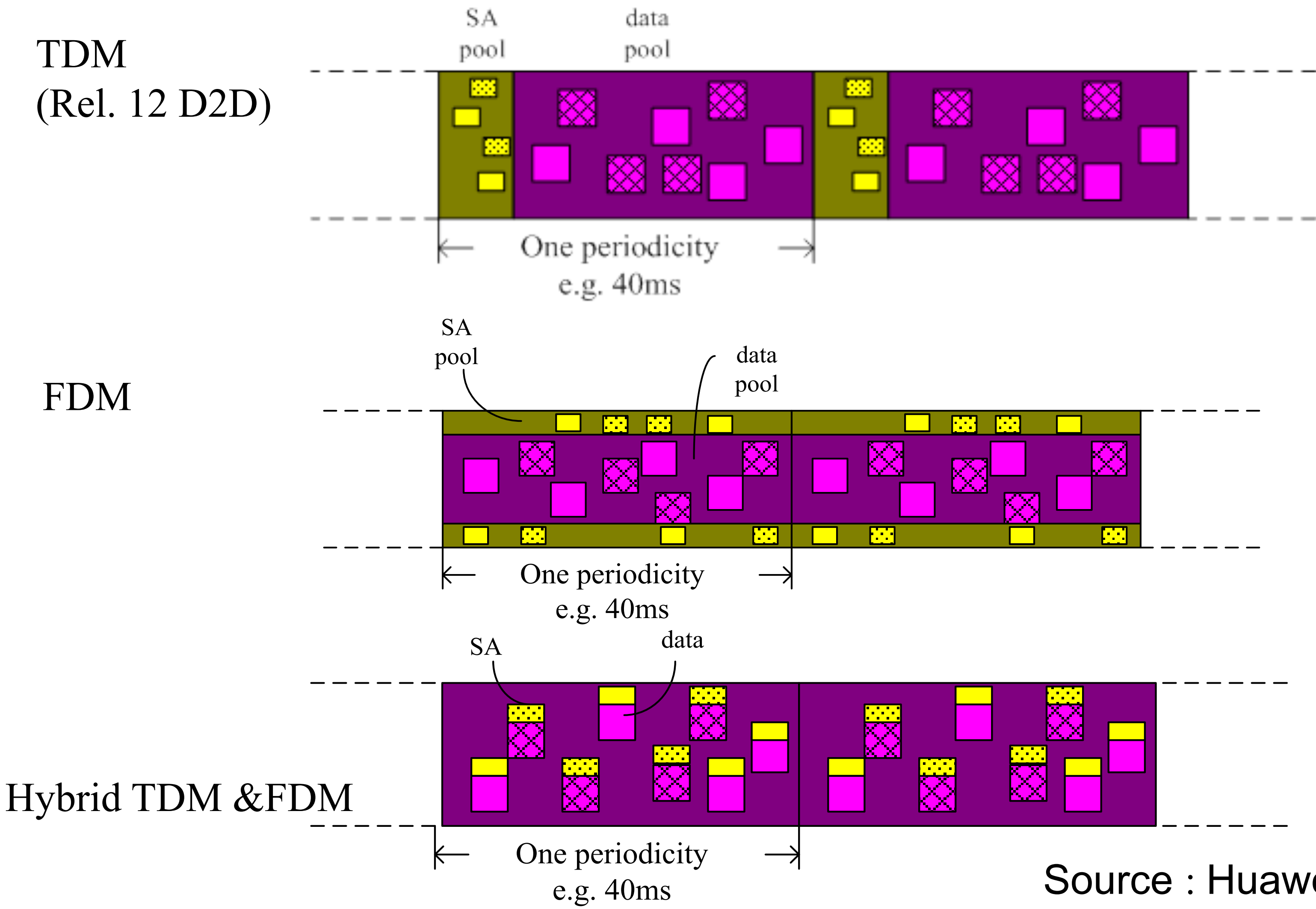


Figure 2. Data collision probability:
Rel-12 vs. enhanced explicit approach

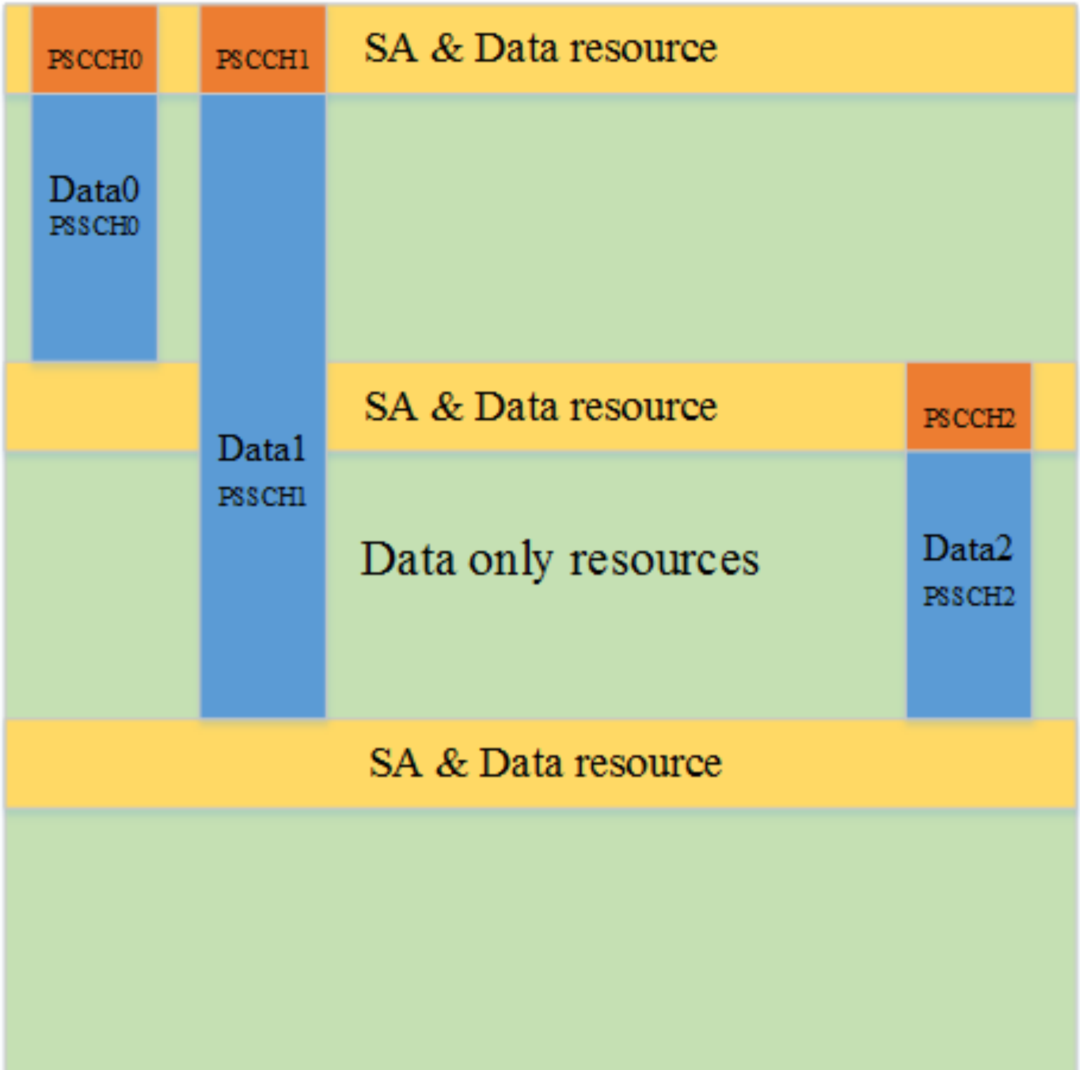
Source : ITRI

PC5 enhancements for V2V (Resource Allocation)



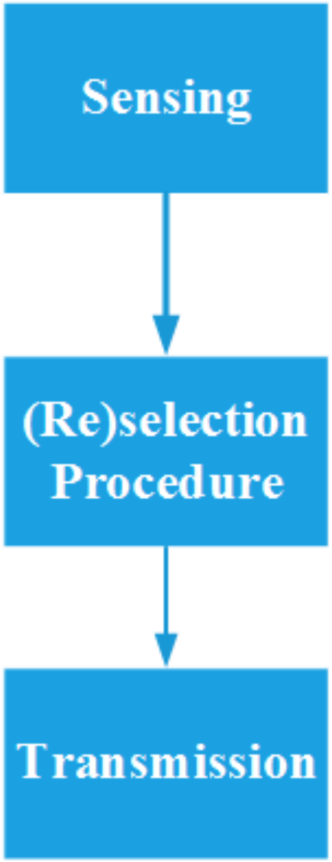
Source : Huawei

PC5 enhancements for V2V (Resource Allocation)



UE autonomous resource (re)selection mode

- Procedure of Resource Reselection Procedure



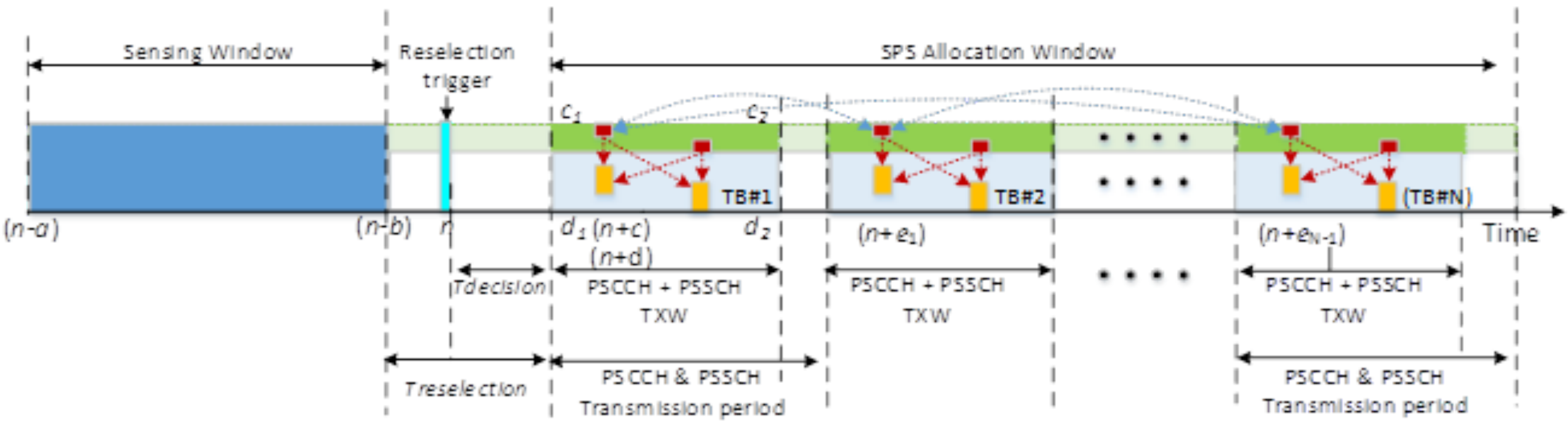
SA decoding +power/ energy measurement (detect event trigger/ resource collision)

Based on the sensing result, generate a subset(list) than random (re)select by the subset (list)

Semi-Persistent Scheduling (SPS)

UE autonomous resource (re)selection mode(cont'd)

- Terms and Definitions for UE autonomous Resource Reselection mode

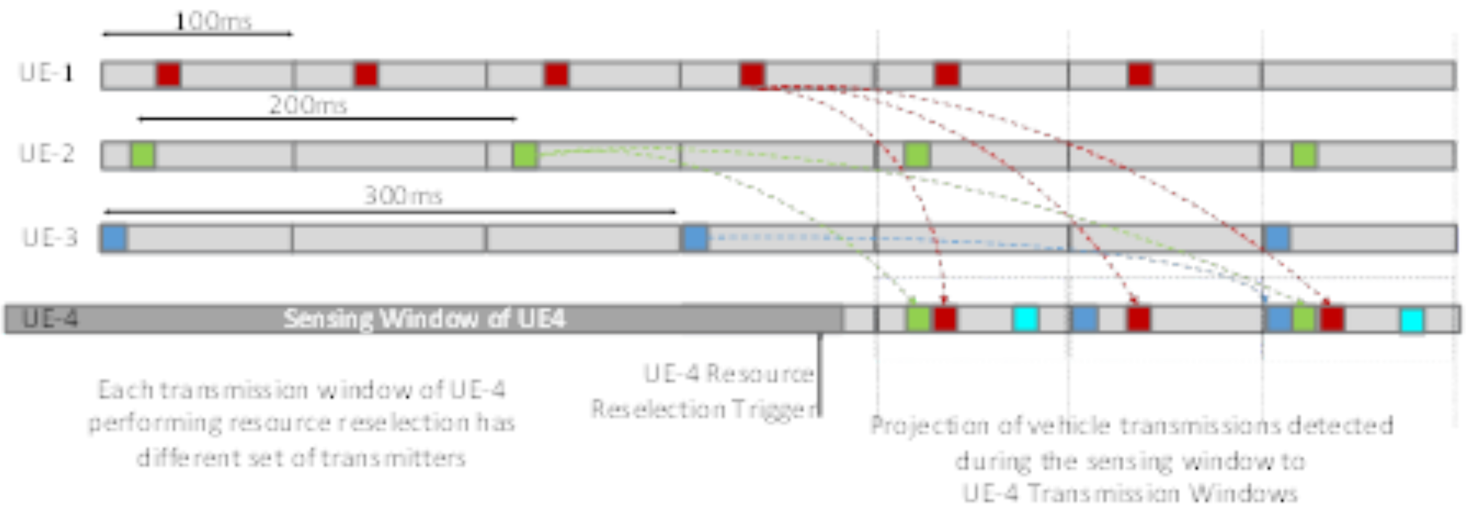


Resource reselection timing relationship (FDM)

Source : Intel

UE autonomous resource (re)selection mode(cont'd)

- Semi-persistent resource allocation

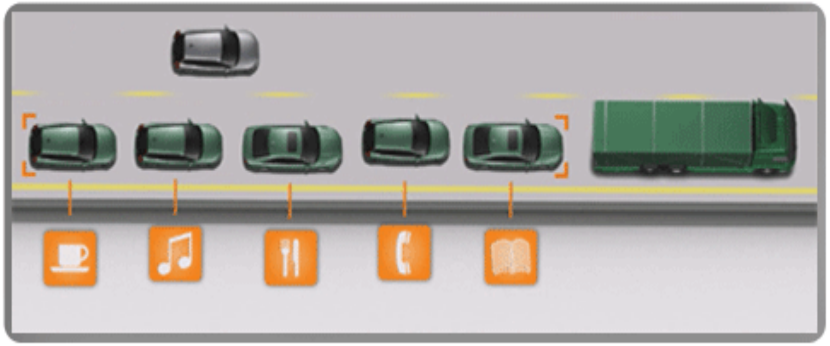


The information about transmission window period and SPS resource allocation window can be signaled in SCI

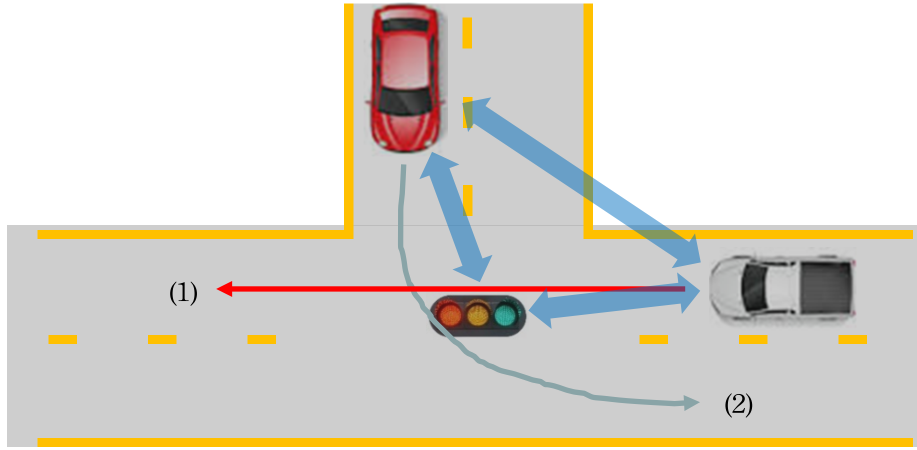
Source : Intel

Enhanced V2X services in SA1

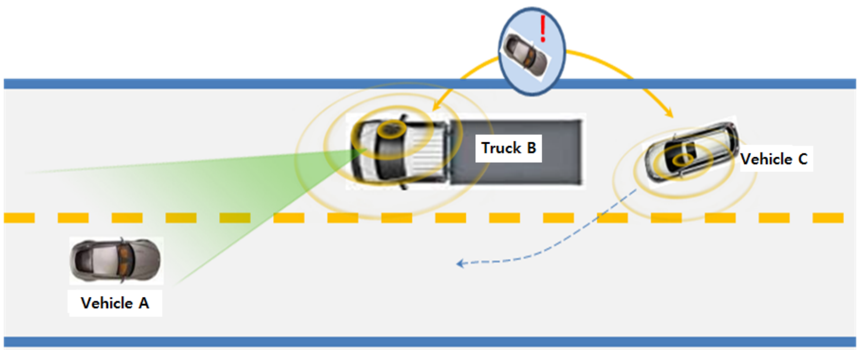
- SA1 study was completed with TR 22.886 and normative WI is approved in [1].
- Four categories of eV2X use cases



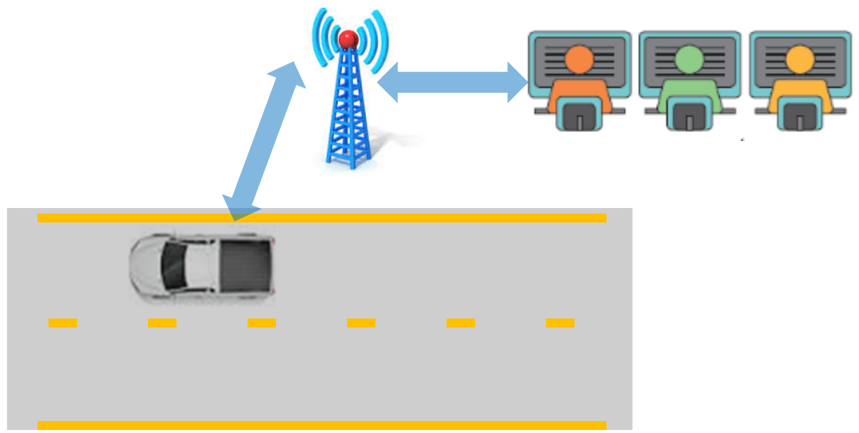
<Platooning>



<Advanced driving>



<Extended sensors>



<Remote driving>

Enhanced V2X services in SA1

➤ Summary of KPIs

	Latency	Reliability	Data rate	Communication range
Platooning	10 ~ 25 ms	90 ~ 99.99%	12 kbps ~ [65] Mbps	[5] ~ [10} sec * relative speed
Advanced driving	[3] ~ [100] ms	[99.99] ~ [99.999]%	65 kbps ~ [50] Mbps (inc. DL [0.5] UL [50] Mbps)	[5] ~ [10} sec * relative speed
Extended sensors	3 ~ 100 ms	90 ~ 99.999%	25 ~ 1000 Mbps	50 ~ 1000 meters
Remote driving	5 ~ [20] ms	[99.999]%	UL 25, DL 1 Mbps	
General requirement on positioning: Relative lateral position accuracy of 0.1 m between UEs				

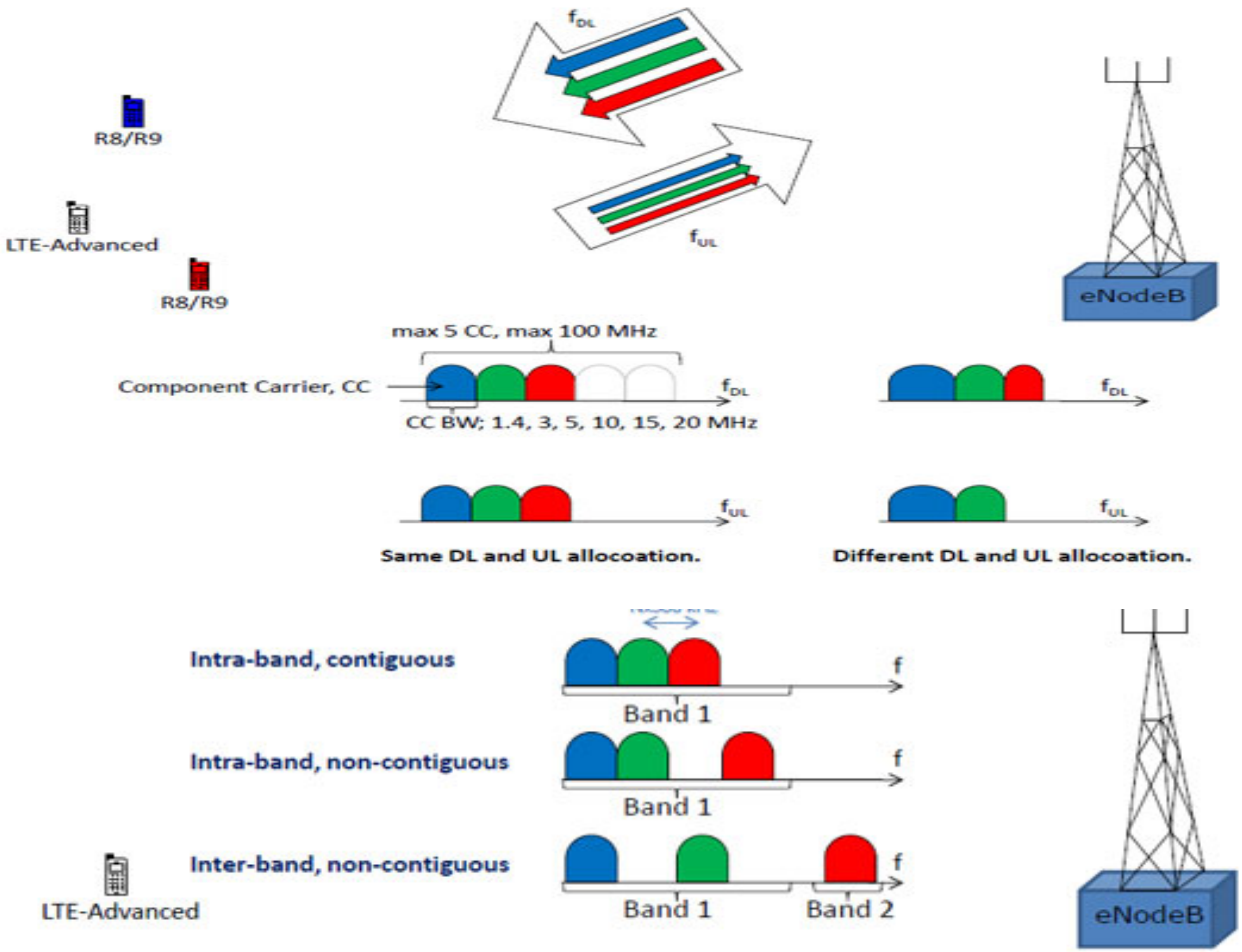
Design target of Rel-14 LTE V2X

- Latency: 20 ~ 100 ms
- Reliability: 90%
- Data rate: around 10 kbps
- Communication range: 100 ~ 300 meters

Rel.15 WID
3GPP V2X Phase 2

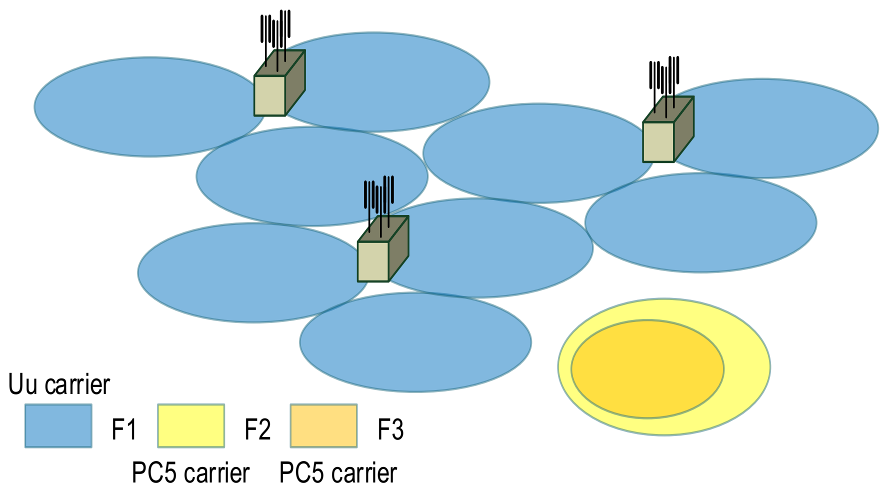
- **New WI proposal: 3GPP V2X Phase 2 (RP-170798)**
  - March. 2017, RAN#75
  - RAN1 leads this working item (Huawei, HiSilicon, LG Electronics, CATT, CATR)
  - Objective (RAN1):
    - Additional PC5 Functionalities
      - ✓ Carrier Aggregation (up to 8 PC5 carriers)
      - ✓ Support for 64-QAM
      - ✓ Mode 3 & Mode 4 sharing
    - Feasibility and gain of PC5 operation with Transmit Diversity
    - Feasibility and gain of PC5 operation with Short TTI

Carrier Aggregation



Carrier Aggregation for V2V(1)

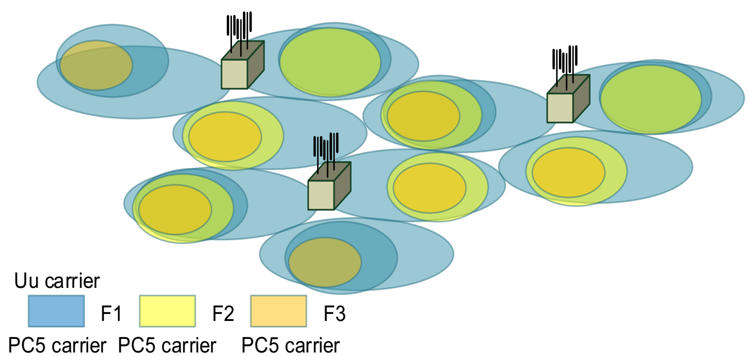
- Mode 4
  - At least two standalone PC5 carriers (f2, f3,…)
  - Operation on PC5 independent of operation on cellular carrier
  - Autonomous resource allocation (mode 4 operation)



Scenario 1:Mode 4

Carrier Aggregation for V2V(2)

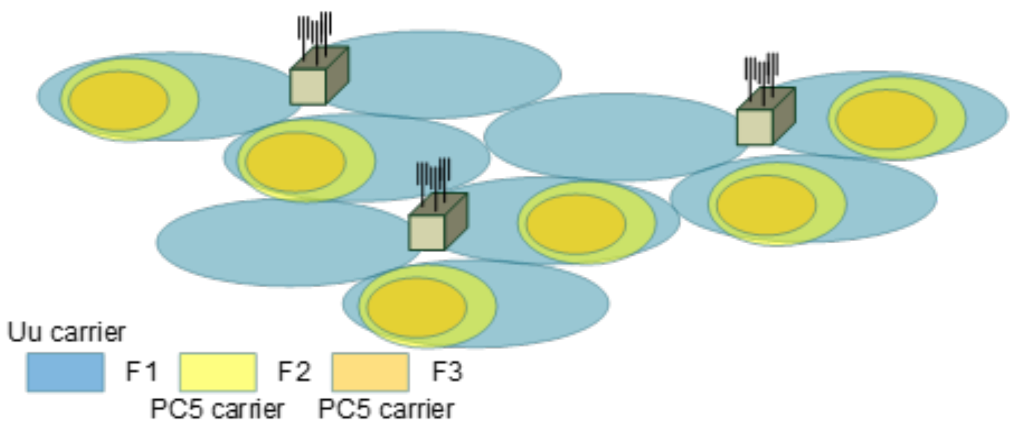
- Mode 3 or Mode 4 for individual carrier
  - One "anchor" carrier f1 that can be used to schedule UEs on the PC5 carriers (either in-coverage or in partial-coverage)
  - At least one dedicated PC5 carrier
    - O If anchor cell is included on PC5, at least one other dedicated PC5 carrier (f2, or f3,…)
    - O If anchor cell is not included on PC5, at least two other dedicated PC5 carriers (f2, f3,…)
  - Scheduled resource allocation (mode 3) or autonomous resource allocation (mode 4)
  - The scheduling carrier f1 could be Uu only or shared between Uu and PC5
  - Cross-carrier scheduling is needed for f2 and f3



Scenario 2 :Mode 3 & Mode 4

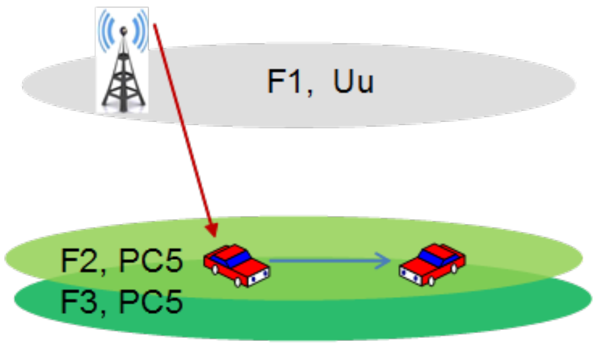
Carrier Aggregation for V2V(3)

- Mode 3 or Mode 4 for cross carrier
  - At least two PC5 carriers (f2, f3,…)
  - One "anchor" carrier f1 used to schedule UEs on the PC5 carriers (either in-coverage or in partial-coverage)
  - Scheduled resource allocation (mode 3) or autonomous resource allocation (mode 4)
  - The scheduling carrier f1 is Uu only: unlike scenario 2, no PC5 operation of f1
  - Cross-carrier scheduling is needed for f2 and f3

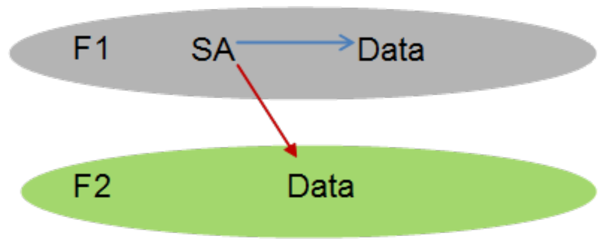


Scenario 3 :Mode 3 & Mode 4

Carrier Aggregation for Cross-carrier scheduling



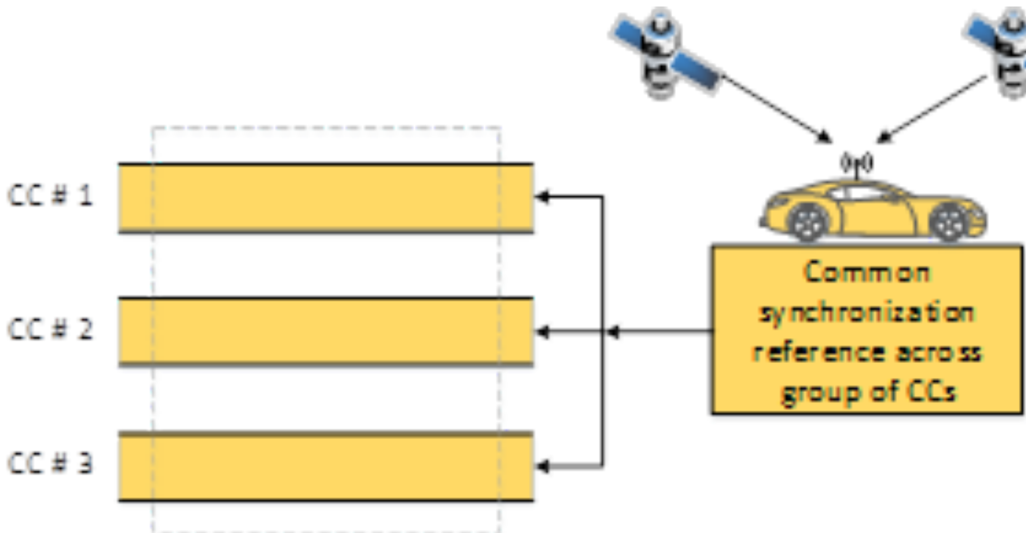
Cross-carrier scheduling at eNB

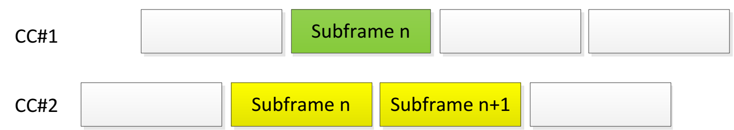


Cross-carrier scheduling at UE

- ***Support cross-carrier scheduling both at the eNB and at the UE***
- ***Frequency domain partial sensing is supported: The UE only monitors a subset of the PC5 carriers***
- ***Samsung suggest not support cross carrier scheduling***

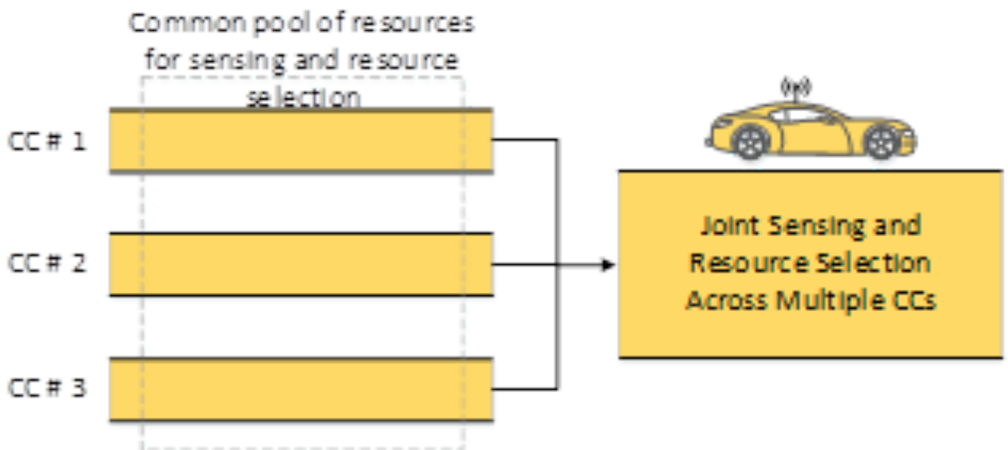
Carrier Aggregation for synchronization





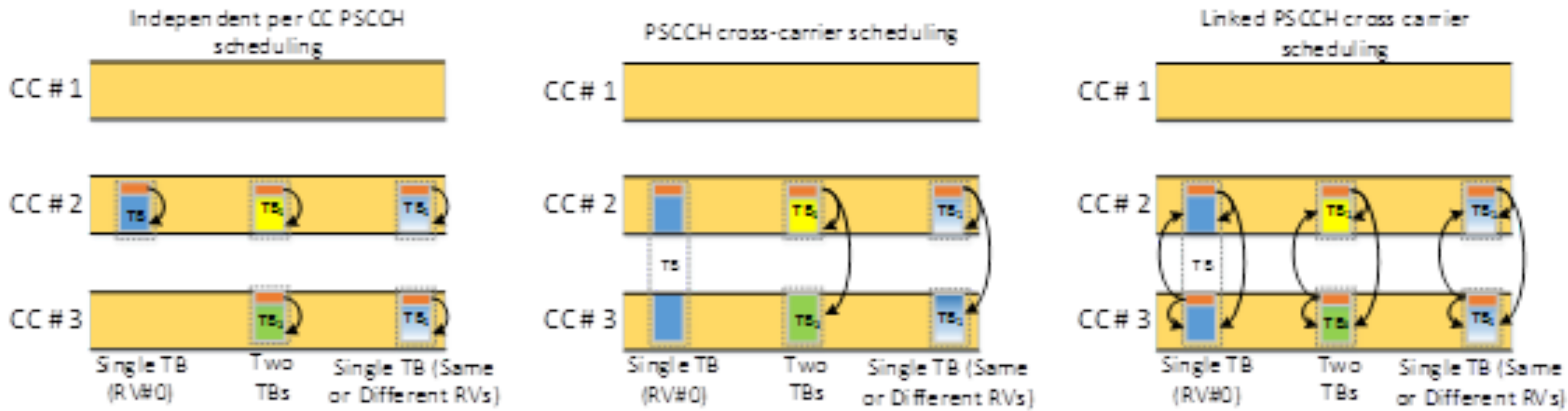
- Common synchronization reference and synchronization source selection rules are used for synchronous sidelink CCs.
- Synchronous sidelink CCs are aligned in time at subframe boundaries.
    - FFS in terms of DFN offsets
- Consider introduction of anchor sidelink CC to provide SLSS based synchronization for group of sidelink CCs.

Carrier Aggregation for Resource allocation(1)



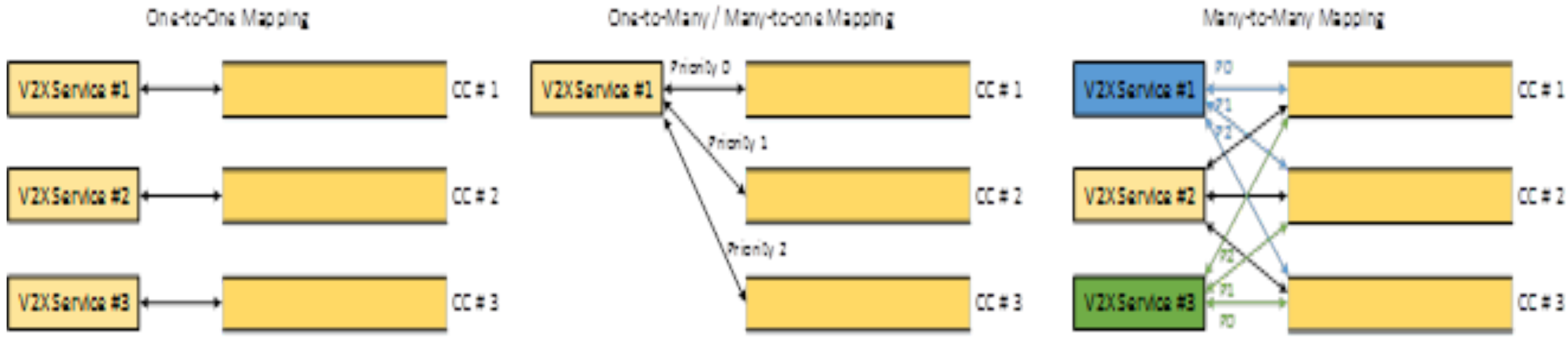
- Sensing and resource selection across group of sidelink CCs is supported.
- Common pool of resources across group of sidelink CCs can be allocated.

Carrier Aggregation for Resource allocation (2)

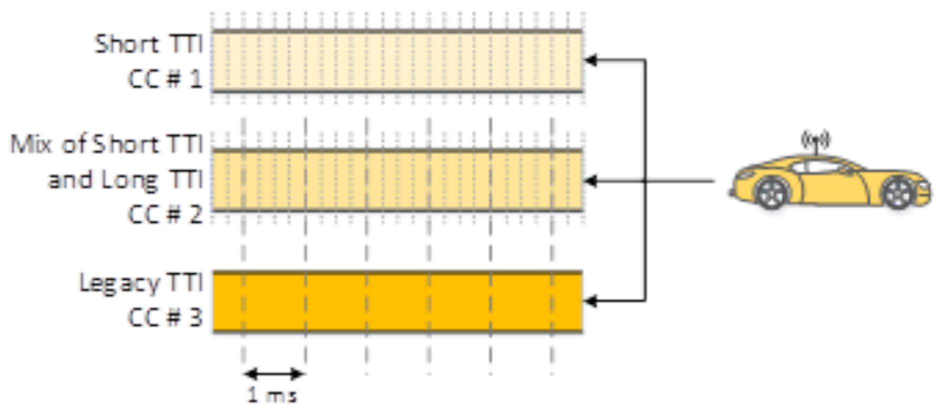


- For peak rate enhancements,
  - ✓ Further analyze benefits of mapping single TB across multiple CCs vs transmission of different TBs.
- For reliability enhancements,
  - ✓ Further analyze benefits of the same TB transmission across multiple CCs and proper format.
- For SA enhancements
  - ✓ Further study the SA format

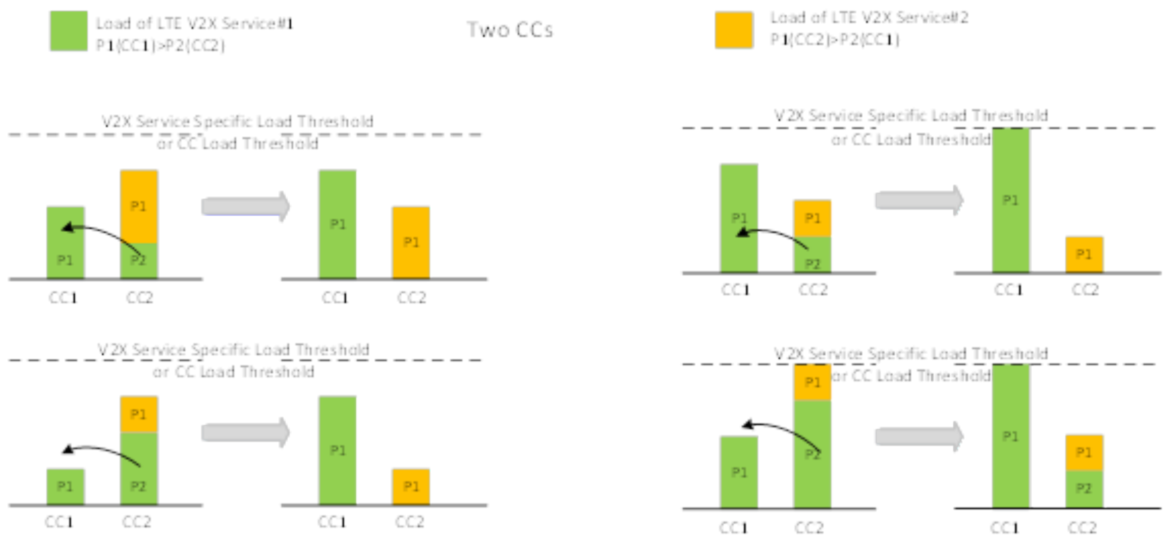
Carrier Aggregation for Multi-channel operation



- Intel (sTTI for CA)

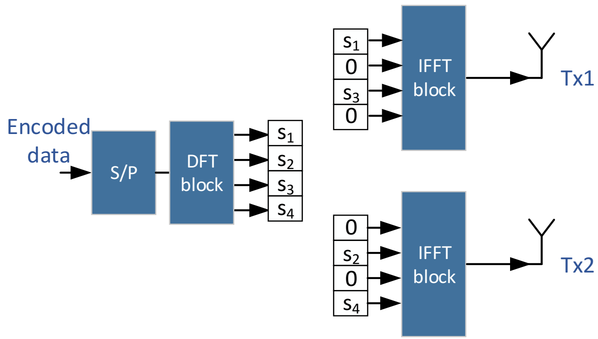


Carrier Aggregation for Loading balance

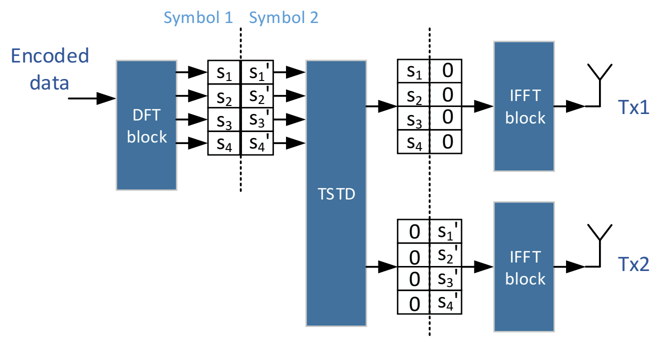


- CC Overload Indicator (LCC-OVLD)
- V2X Service Specific Overload Indicator (LSERVICE-CC-OVLD)
- V2X Service Specific Priority (PSERVICE-CC)
- V2X Service Specific CC Load (LSERVICE-CC)
- Overall CC Loading (LCC)

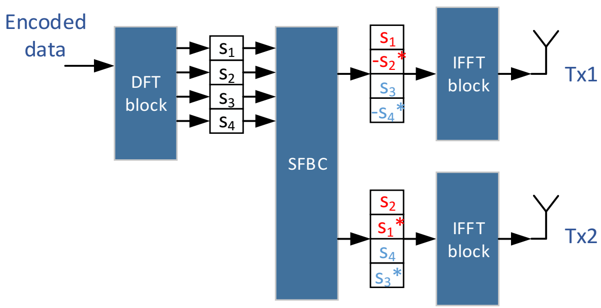
Feasibility and gain of PC5 operation with Transmit Diversity



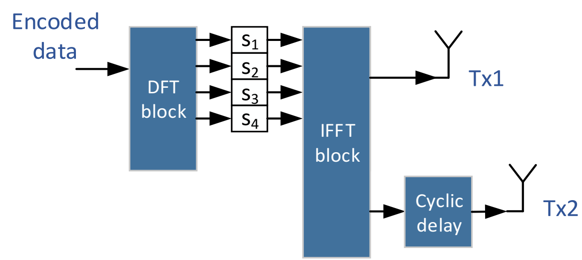
FSTD



TSTD

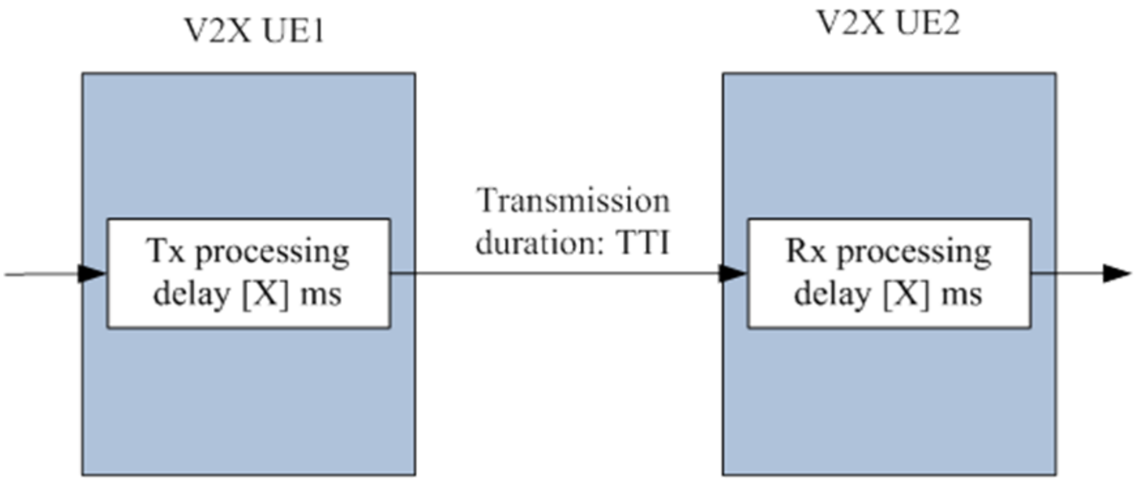


SC-SFBC



CDD

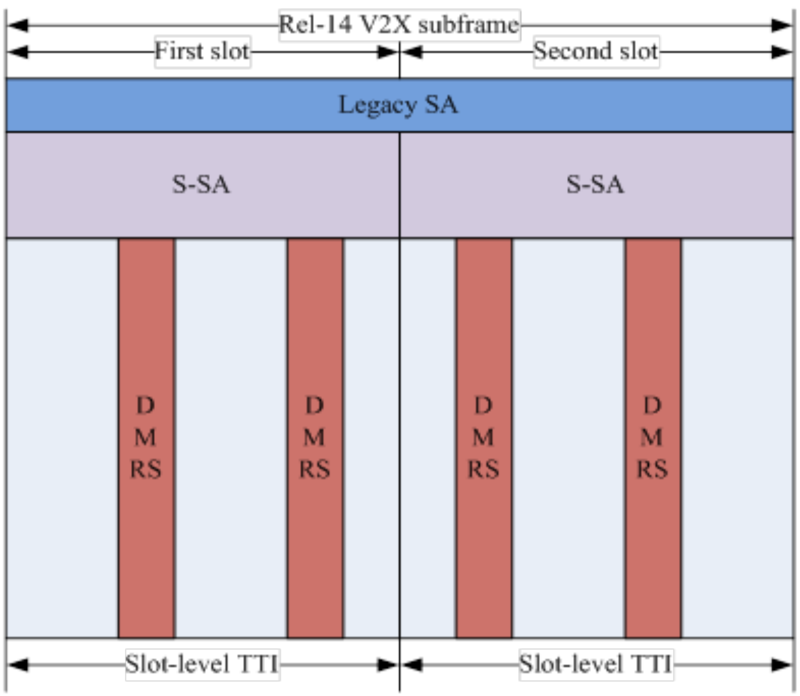
Feasibility and gain of PC5 operation with Short TTI Mode



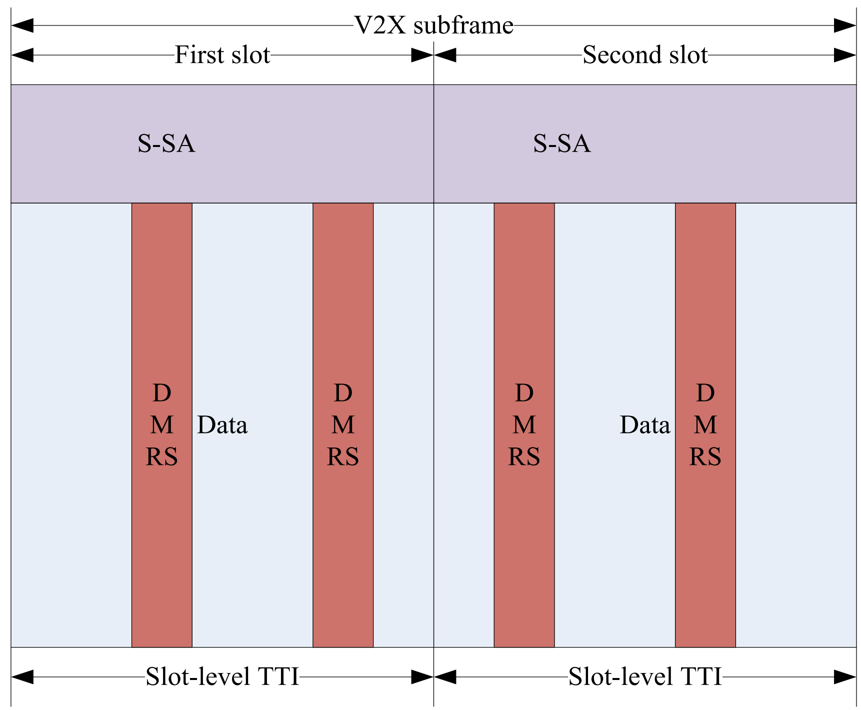
Use case #	Use case name	Key requirements
5.1, set 2	eV2X support for Vehicle Platooning	PC5: 50-1200bytes, 100Hz, 10ms
5.5, phase 2	Automated Cooperative Driving for Short distance Grouping	PC5: Up to 1200bytes, 100Hz, 10ms, [99.99%]
5.9	Cooperative Collision Avoidance (CoCA)	PC5: [10]Mbps, up to [2]Mbytes, [100]Hz, [10]ms. [99.99%]
5.20	Emergency Trajectory Alignment	PC5: [30]Mbps, [3]ms. [99.999%]

Source :CATT

Feasibility and gain of PC5 operation with Short TTI structure



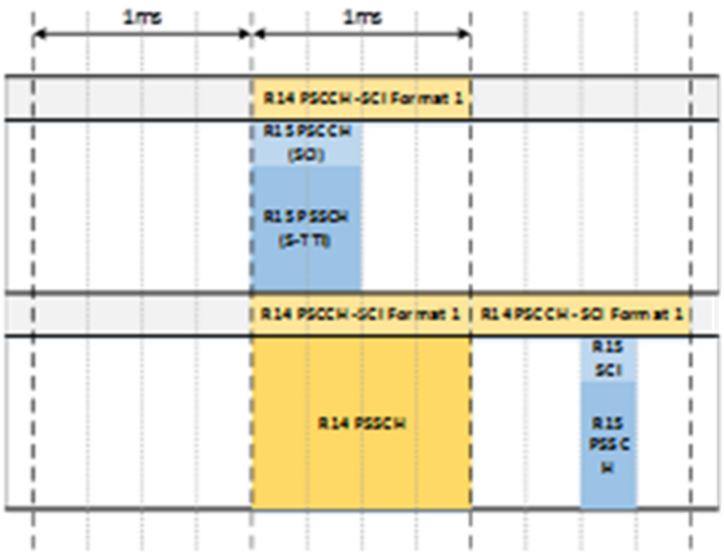
Shorten TTI structure in shared resource pool



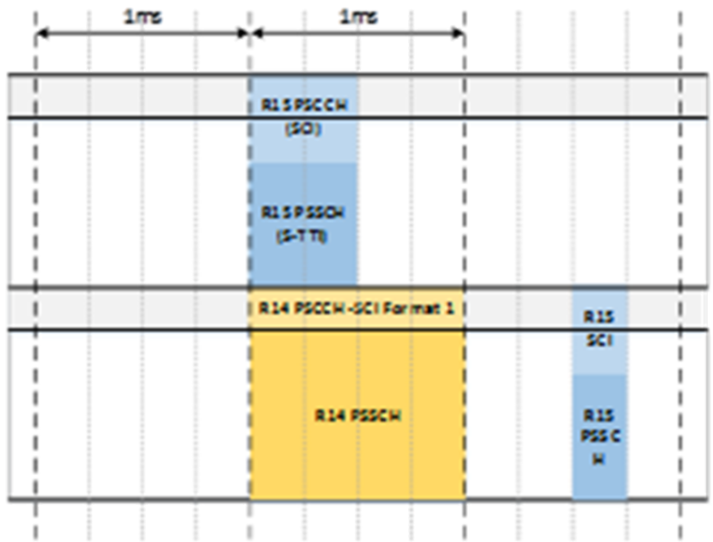
Shorten TTI structure in dedicate resource pool

Source :CATT

Feasibility and gain of PC5 operation with Short TTI transmission



SCI-F1 is transmitted by R15 UE



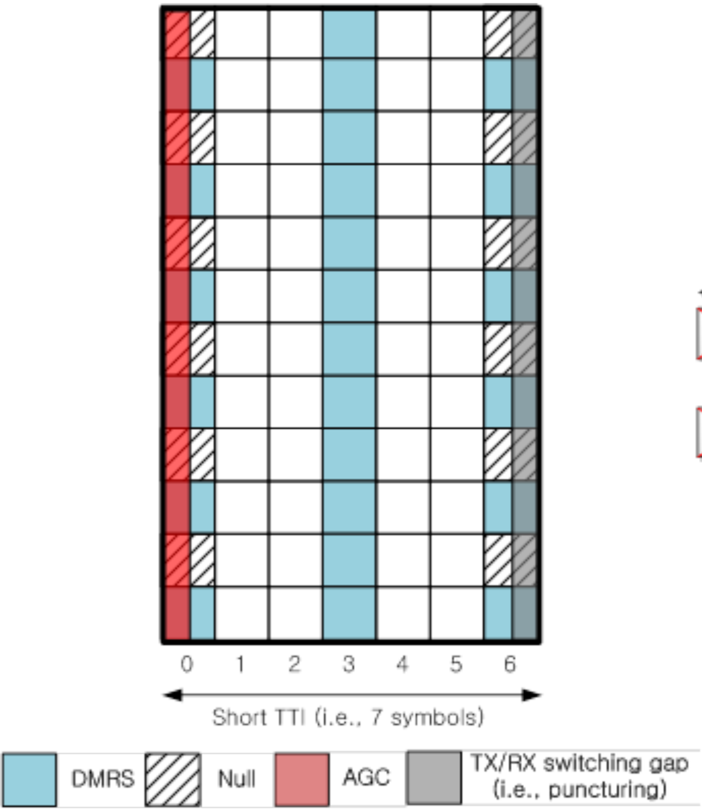
R14 UE is not aware about R15 UE transmissions

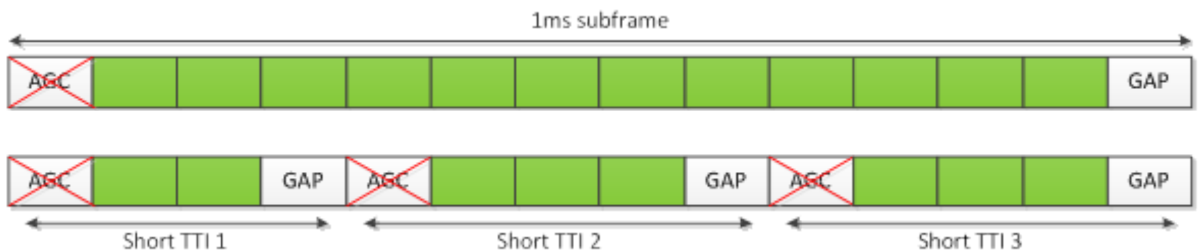
Source :Intel

工業技術研究院
Industrial Technology Research Institute

國立臺北大學
National Taipei University

Feasibility and gain of PC5 operation with Short TTI – AGC issue

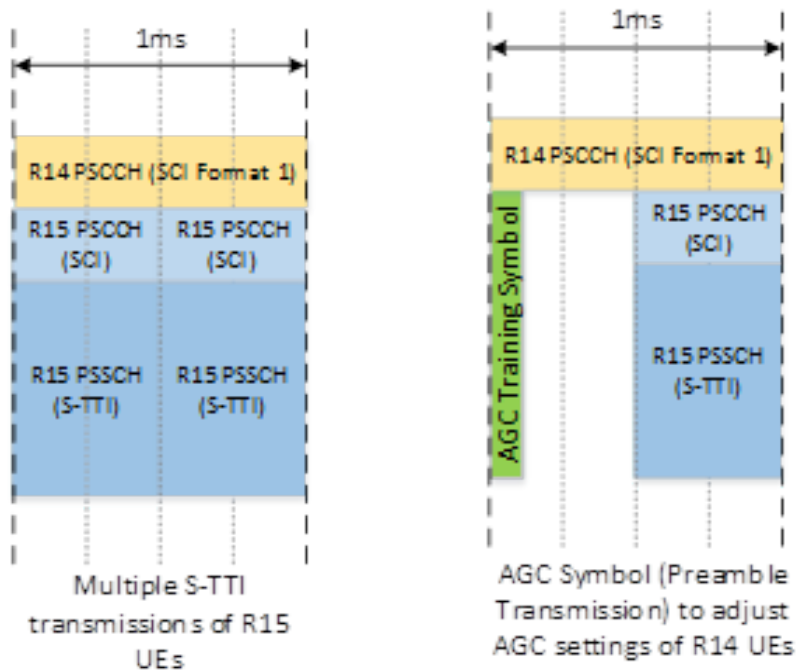




- ***Study the proposed Short TTI structure in Section 2 in order to check the feasibility and gain of PC5 operation with Short TTI.***
- ***Short TTI options for further study shall assume the overhead of AGC and TX/RX switching gap of Rel-14 design.***

Source :Intel & LG

Feasibility and gain of PC5 operation with Short TTI – AGC issue

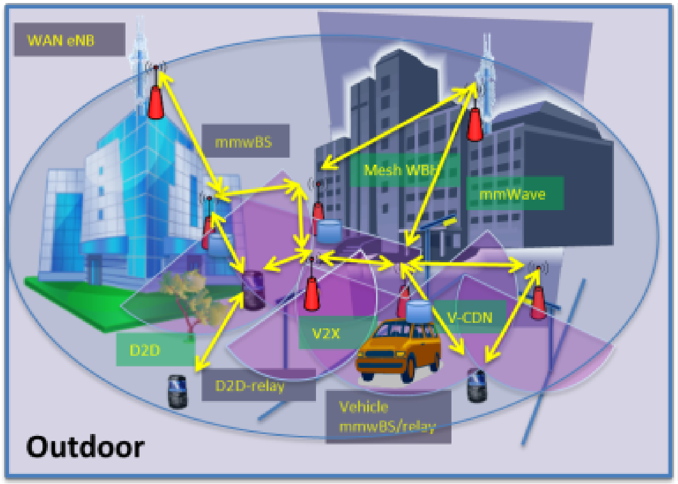


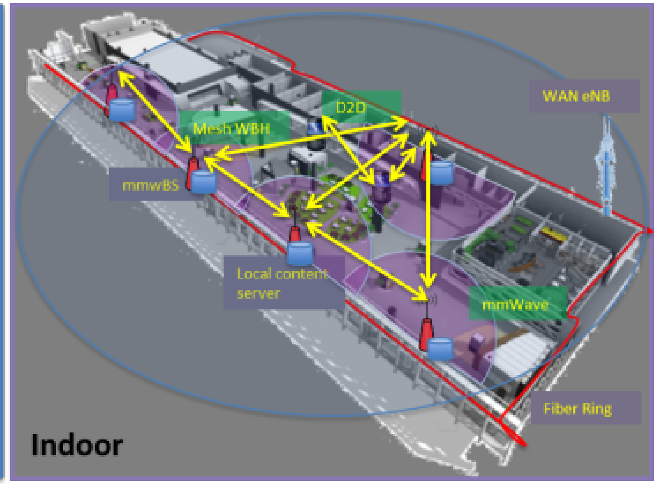
- *Significant near-far problem can be observed by R14 UEs if legacy TTI and short TTI transmissions coexist in the same resources.*
- *Short TTI design should include mechanism to minimize near-far problem (e.g. AGC training symbol transmitted in the beginning of legacy subframe).*

Source :Intel

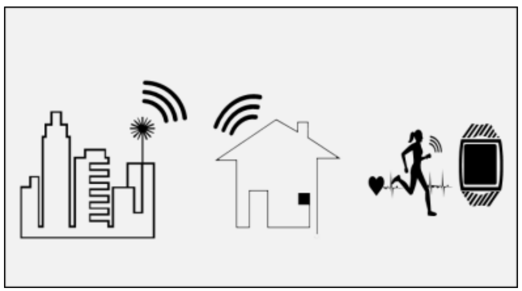
New Radio Technology in Sidelink

- **New Radio Technology in Sidelink (Qualcomm)**
  - eMBB





  - IoT &MTC



Source: R1-164709

Thank You