



Review Open Call F4Fp-SME (Stage 1) VCOM experiment

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Allbesmart LDA

Remote Review

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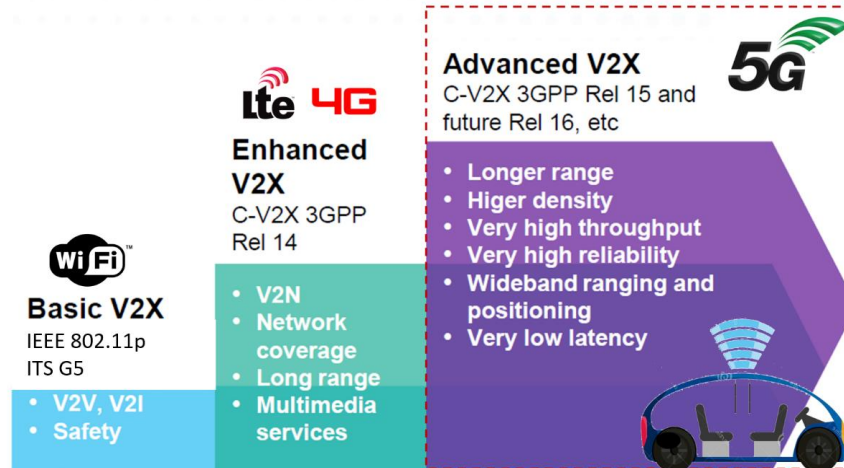
VCOM

Experimental validation
of vehicular
communication
protocols
(Stage 1)

IRIS testbed

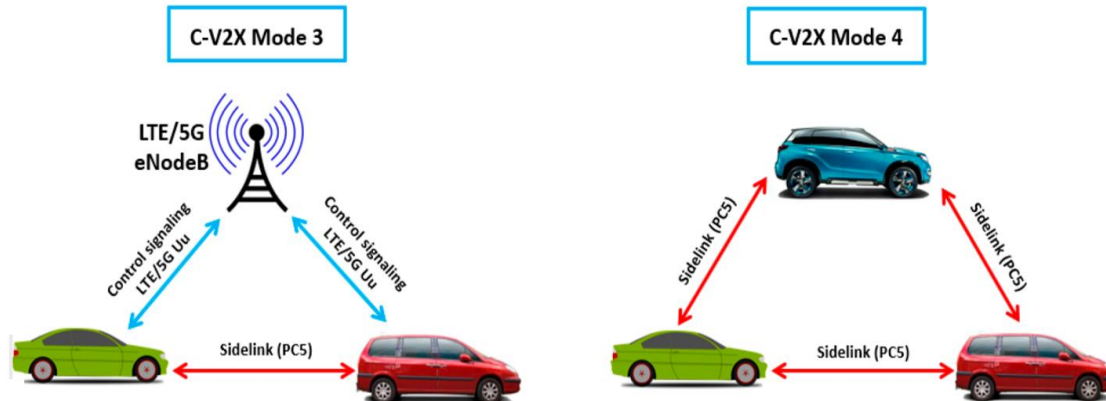
Concept

- Allbesmart LDA offers outsource engineering services to design and develop customized software implementations of 3GPP Radio Access Networks protocols.
- We work across a range of mobile and communication technologies to accelerate product development using Software Defined Radio (SDR) test solutions such as SRS and OAI.
- Vehicular communications are currently at the edge of a considerable technological evolution, which will create significant opportunities for solutions of the 3GPP C-V2X standard.



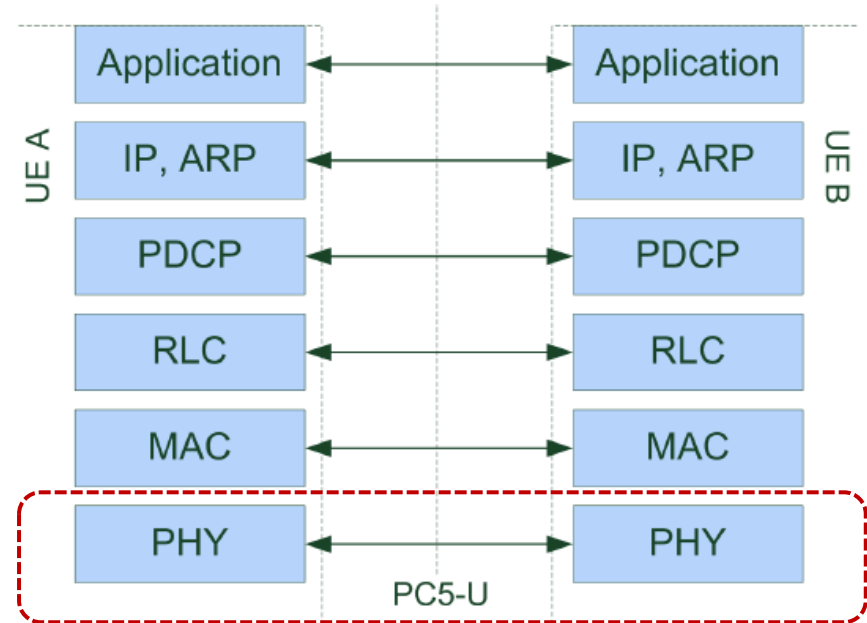
Concept

- 3GPP R14 introduces a new communication mode (Mode 4) specifically designed for V2V communications.
- Mode 4 can operate without cellular coverage. Vehicles autonomously select the radio resources for their direct V2V communications.



Concept

- 3GPP C-V2X establishes a Sidelink PC5 air interface between vehicles.
- PSCCH: Physical Sidelink Control Channel
- PSSCH : Physical Sidelink Shared Channel
- PSBCH: Physical Sidelink Broadcast Channel



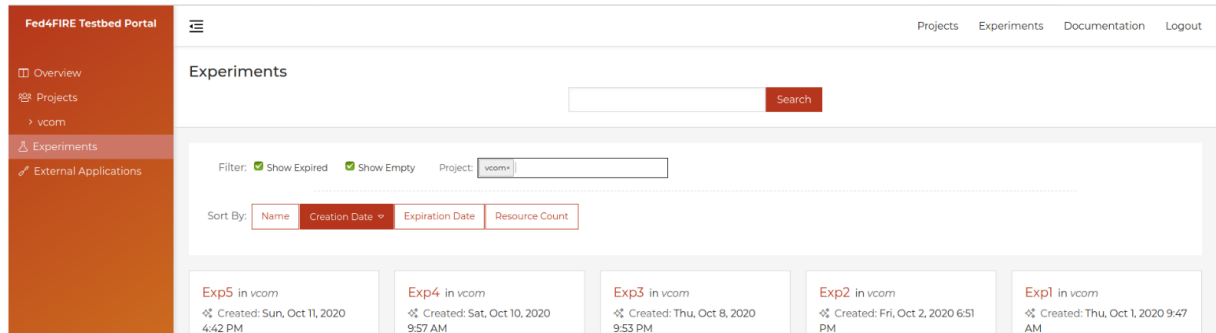
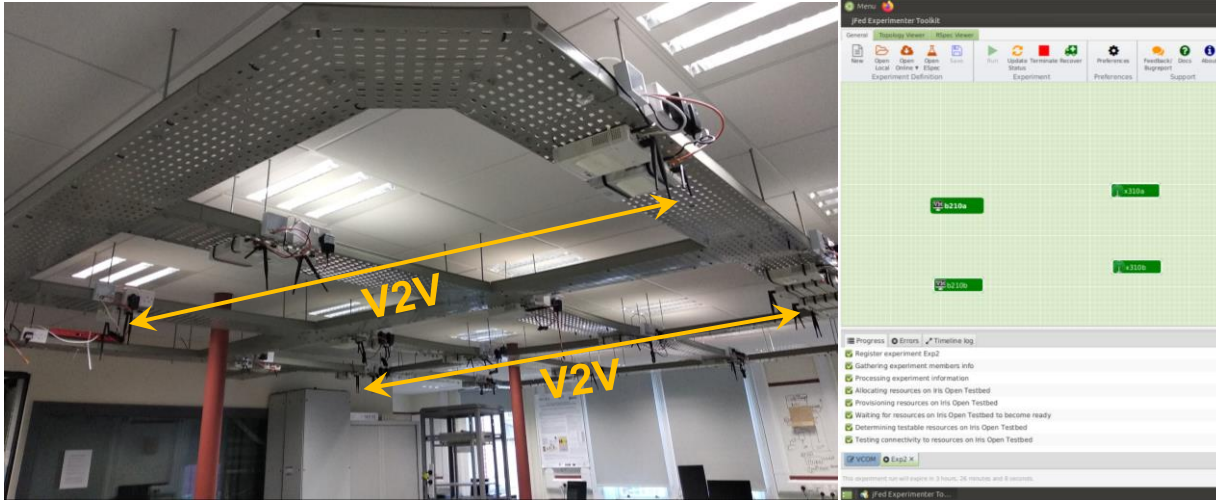
Concept

- A baseline implementation of the C-V2X mode 4 air interface, based on 3GPP LTE Rel 14, was recently released by SRS and is available under open-source license.
- An important innovation introduced in mode 4 is the distributed scheduling protocol, used by vehicles to autonomously select their radio resources.
 - The protocol is referred to as Sensing based Semi-Persistent Scheduling (SPS).
- Allbesmart has implemented the scheduling protocol SPS on top of the open source srsV2X implementation.

Objectives

- Main objectives of the VCOM (Stage 1) experiment, using the IRIS testbed:
 - **Test case 1:** Test and validate the SRS baseline C-V2X Mode 4 implementation.
 - **Test case 2:** Test and validate the Sensing based Semi-Persistent Scheduling protocol implemented by Allbesmart.

Setup – IRIS testbed @ TCD: OBU are USRPs



Test case 1: Test and validate the SRS baseline C-V2X Mode 4 implementation.

srsLTE C-V2X Tx (USRP B210)

```
TX count: 2980, len = 187
TX count: 2981, len = 287
TX count: 2982, len = 187
TX count: 2983, len = 187
TX count: 2984, len = 187
TX count: 2985, len = 187
TX count: 2986, len = 287
TX count: 2987, len = 187
TX count: 2988, len = 187
TX count: 2989, len = 187
TX count: 2990, len = 187
TX count: 2991, len = 287
TX count: 2992, len = 187
TX count: 2993, len = 187
TX count: 2994, len = 187
TX count: 2995, len = 187
TX count: 2996, len = 287
TX count: 2997, len = 187
TX count: 2998, len = 187
TX count: 2999, len = 187
TX count: 3000, len = 187
TX count: 3001, len = 287
TX count: 3002, len = 187
TX count: 3003, len = 187
TX count: 3004, len = 187
TX count: 3005, len = 187
```

srsLTE C-V2X Rx (USRP B210)

```
SC11: riv=1, mcs=5, priority=2, res_rsrv=0, t_gap=4, rtx=0
SC11: riv=8, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=1
SC11: riv=2, mcs=5, priority=2, res_rsrv=0, t_gap=4, rtx=1
SC11: riv=6, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=0
SC11: riv=8, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=1
SC11: riv=6, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=0
SC11: riv=8, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=1
SC11: riv=6, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=0
SC11: riv=8, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=1
SC11: riv=6, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=0
SC11: riv=1, mcs=5, priority=2, res_rsrv=0, t_gap=7, rtx=0
SC11: riv=8, mcs=6, priority=2, res_rsrv=1, t_gap=10, rtx=1
SC11: riv=2, mcs=5, priority=2, res_rsrv=0, t_gap=7, rtx=1
```

```

1 [|||||] 10.5% Tasks:
2 [|||||] 13.2% Load a
3 [|||||] 16.6% Uptime
4 [|||||] 11.6%
Mem[|||||] 427M/7.68G
Swp[|||||] 0K/2.00G
```

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+
23920	anpu	20	0	1290M	45768	35260	S	78.4	0.6	0:09.47
17159	anpu	20	0	107M	5420	4040	S	16.1	0.1	0:43.90
23957	anpu	20	0	1290M	45768	35260	S	12.5	0.6	0:01.35
23948	anpu	20	0	1290M	45768	35260	S	6.6	0.6	0:01.00

Sidelink PC5 interface transmission and reception – Successful decoding of the Sidelink Control Information Format 1 (SCI Format 1) messages.

Test case 1: Test and validate the SRS baseline C-V2X Mode 4 implementation.

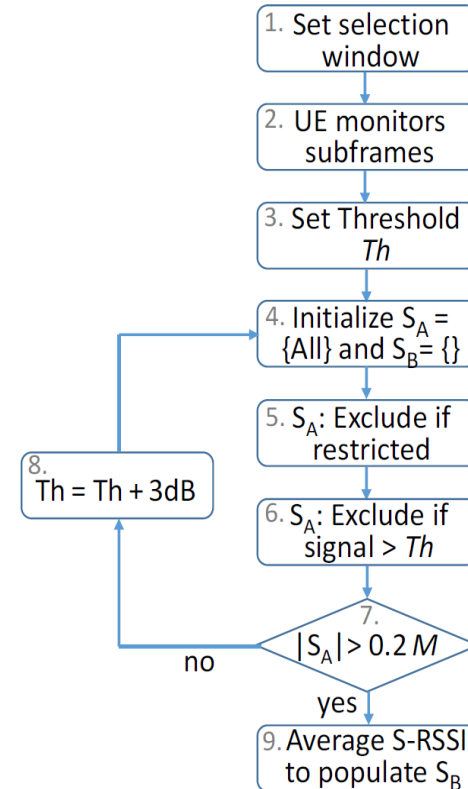
```
SCI len: 32 SCI: 01000001110001001101000000000000
----- SCI -----
Priority:          2
Resource reservation: 0
RIV:              7
Time gap:         1
I_mcs:            6
Retransmission:   1
-----
                    SCI OK
-----
PSSCH decoded in PRB: 20 nof_sci_decoded: 1
SCI1: riv=7, mcs=6, priority=2, res_rsrv=0, t_gap=1, rtx=1
PSSCH RSRP: -6,534746
pssch_prb_start_idx = 22 nof_prb_pssch = 18
[INFO]: CB Segmentation: TBS: 1864, C=1, C+=1 K+=1888, C-=0, K-=0, F=0, Bp=1888
0011000001110010111000000110011010101010101010101010101010001000111000000011000001000111110001100001100
00000000000000000000000000000000000010100010000000100000100111010010011110000110001001101010011011100
11001100110111001101000011000001100110011100100110101001110010011100000110110001100000110000011000
1001111100100000101000010010000110100010001000101010001100100011101001000010010010010010010110100
11000100110101001110010011101010000010100010101001001001101010100010101010101100101011010110000
10110010101101001000001010000100100001101000100010010100011001000110100100001001001001010010100
11010011000100110101001110101000001010001010010010011010101000101010101010100101110101
110000101100101011010010000010100001010000110100010001000101010001100100011101001000010010010100101
010010101001100010011010100111001001111010100000101000101010010010011010101000101010101011001010
11101011000010110010101101001000001010000100100001101000100010001010100011001000111010010000100100101
00101001001011010011000100110100111001001111010100000101000101000100100110101010001010101010101
0010101110101100001011001010110100100000101000010100001101000100010001010100011001000111010010000100
10010100101001001011010011000100110100111001001111010100000101000101001001001001010101010001010101
1010110010101110101100001011001010110100100000101000010100001101000100010001010100011001000111010001
000100100101001010010110100110001001101010011100100111101010000010100010101001001010101010100010
10101010101100101011101011000010110010101101001000001010000101000011010001000100010100011001000111
010010000100100100000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
Transport Block SUCCESS! TB count: 1
```

Successful decoding of the first SCI message (Sidelink Control Information) and its corresponding Transport Block (PSSCH).



Test case 2: Test and validate the Sensing based Semi-Persistent Scheduling protocol implemented by Allbesmart.

- We have implemented a sensing based Semi-Persistent Scheduling (SPS) protocol.
- SPS is not collision-free and therefore requires a careful configuration of two transmission parameters:
 - Number of subchannels allocated to Sidelink communications.
 - Resource reservation interval.



Source: European Telecommunications Standards Institute (ETSI), "Physical layer procedures (Release 14)," 3GPP TS 36.213, V14.2.0, April 2017.

Test case 2: Test and validate the Sensing based Semi-Persistent Scheduling protocol implemented by Allbesmart.

- Effect of the number of dedicated subchannels on the performance of the protocol
 - The overlap between the subchannels reserved by two or more transmitting UEs (Vehicles) causes the packets to collide at the intended receiver.
 - The larger number of SL (Sidelink) subchannels that is available to the UEs to select the resources from, the lower the probability that more than one UE chooses the same resource.

Number of SL subchannels	2	4	6	8	10
Packet Delivery Ratio	76 %	88%	92%	98%	100%

Test case 2: Test and validate the Sensing based Semi-Persistent Scheduling protocol implemented by Allbesmart.



- Effect of the SPS resource reservation interval on the performance of the protocol
 - As the resource reservation interval increases, the number of used resources by a UE within a given period decreases. Consequently, the probability of reserving the same resource by more than one UE decreases and the overall PDR increases.
 - It should be noted that increasing the resource reservation degrades the data rate and increases the packet delay. Consequently, there is a trade-off between these performance measures.

Resource reservation interval [ms]	100	200	300	400	500
Packet Delivery Ratio	71 %	81%	93%	97%	100%

Conclusion

The performance of C-V2X mode 4 is highly dependent on the right configuration of the distributed scheduling protocol that is used by vehicles to reserve resources for their transmissions.



Business impact

- With the growth of C-V2X technology, Allbesmart LDA is seeing significant commercial interest from existing partners such as Altice Labs and the lead road operator GLOBALVIA in custom-built V2X solutions.
- Allbesmart is currently running a C-V2X pilot in the A23 highway in Portugal in the context of the C-ROADS project, using commercial equipment.
- This experiment provided us the opportunity to test an open source implementation of C-V2X and optimize the performance of the scheduling protocol for several configuration parameters in a controlled environment (IRIS testbed).

Business impact

- This experiment allowed us to gain access to an advanced wireless infrastructure (IRIS) through remote access which is very important in pandemic times.
- This experiment has allowed us to mature the technology sufficiently to offer it to our commercial partners and to approach potential new partners for proof-of-concept testing and trials.

Feedback

- A very good point is that in OC projects the level of administrative burden for experimenters is very low compared with other H2020 projects.
- The documentation available for the IRIS testbed was sufficient to run the experiment.
- It would be good to have examples of simple experiments.
- IRIS is integrating the possibility of testing 5G NR technologies (OAI 5G) which is a very interesting addition (Stage2).
- 5G and C-V2X test equipment from different vendors would be useful to have available through Fed4FIRE+.

Feedback

- Without Fed4FIRE+ the experimental validation of the scheduling protocol SPS would have been limited to simulation.
- Stage 2 of this experiment will start by extending this lab validation to realistic road scenarios, provided by the Smart Highway testbed available in the City of Things Antwerp testbed (imec).
- We also aim to test other vehicular communication protocols and C-ITS services in the smart highway testbed in Antwerp.



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**MANY THANKS TO
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