



3GPP TSG-RAN WG4 Meeting #86
Athens, Greece, 26 February – 2 March 2018
Agenda Item: 9

R4-1801764

Motivation for SI proposal: Study on Advanced Receivers for LTE V2X

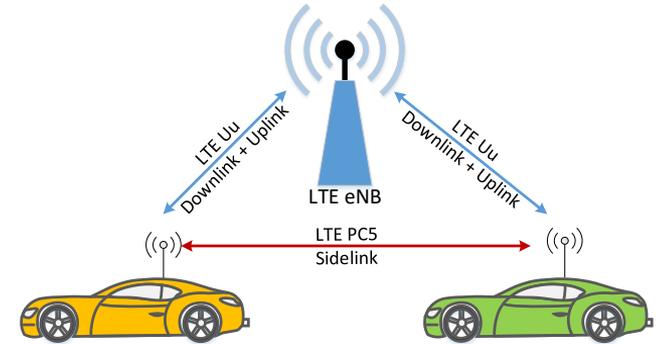
Intel Corporation

Study Item Justification

LTE Vehicular Communication

In the Rel-14/15 LTE V2V, V2X and eV2X WIs multiple enhancements of LTE PC5 and Uu air-interfaces, optimizing LTE technology for multiple V2X use cases, were introduced

- LTE PC5 (Sidelink-SL) V2X enhancements
 - eNB controlled mode: SL SPS scheduling + Reporting of location information
 - UE autonomous mode: Sensing & resource selection + Geo-zoning
 - Enhancements of L1 structure for robust performance at high speeds
 - GNSS synchronization (GNSS as sync reference for time/frequency)
- LTE Uu (downlink-DL/uplink-UL) V2X enhancements
 - MBMS and SC-PTM Downlink transmissions
 - Uplink SPS enhancements to efficiently handle quasi-periodic V2X traffic



Existing LTE advanced receivers framework is applicable to LTE Uu operation (e.g. Interference mitigation, multiple 4RX, etc.), however, the LTE PC5 link performance requirements are based on basic receivers.

Study Item Justification

PC5 V2X Scenarios

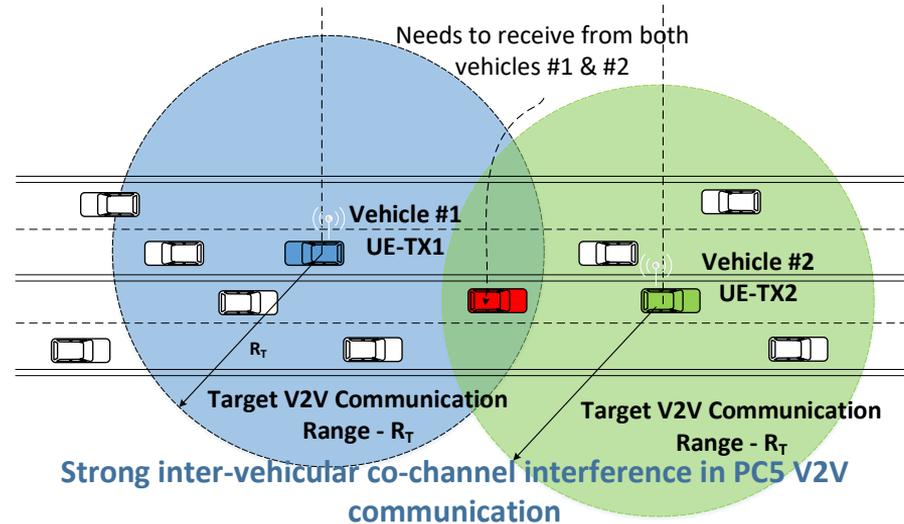
V2X performance will depend on the deployment and traffic scenarios and may vary depending on the density of V2X transmissions

Sparse V2X environments

- V2X performance depends on the V2X propagation distance and IBE level and is typically noise-limited
- RX performance is limited by UEs capability to perform receive signal combining

Dense V2X environments

- Multiple V2X transmissions (PSSCH/PSCCH) may collide in the same time/frequency resources leading to the interference-limited RX conditions
- V2X performance is limited by UEs capability to simultaneously receive multiple packets and to efficiently handle co-channel interference



Advanced UE receivers can be applied to enable joint reception of broadcast V2X PSSCH/PSCCH signals coming from different sources in dense V2X environments

Study Item Justification

PC5 V2X Receiver Enhancements

INTERFERENCE MITIGATION

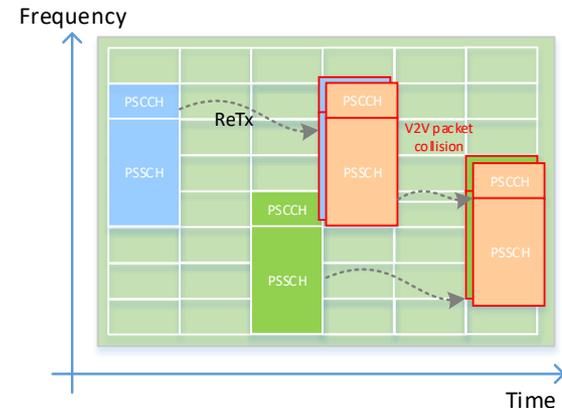
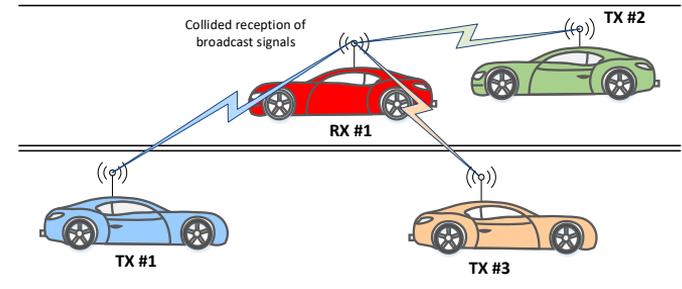
- Rel-14 requirements are based on interference unaware receivers and IS/IC receivers can be used to improve SL V2X performance
- SL V2X communication parameters are broadcasted via PSCCH and PSSCH interference signal parameters can be easily obtained
- Different IS/IC receiver types can be used to ensure improved UE demodulation performance including **LMMSE-IRC**

MULTI PACKET DECODING

- Rel-14 requirements imply that UE would make single packet decoding in case of collision of multiple PSSCH/PSCCH in the same time/frequency resources
- Advanced receivers may be capable to perform **multi PSSCH/PSSCH packet decoding**. At least 2 decoding iterations may be considered.

4 RX ANTENNAS

- Rel-14 V2X requirements are defined under assumptions of UEs equipped with 2RX chains.
- Vehicles typically don't have constraints for antenna placements and **4RX antennas** can be considered to improve performance in both noise- and interference- limited scenarios



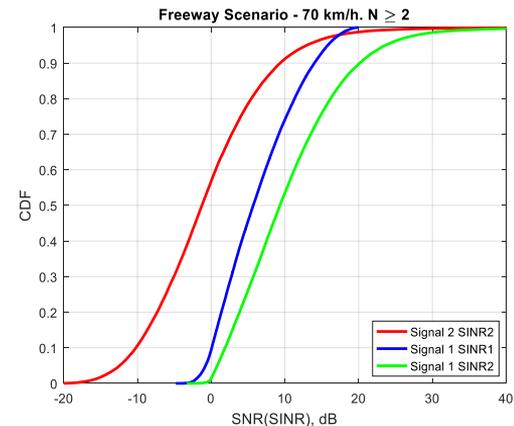
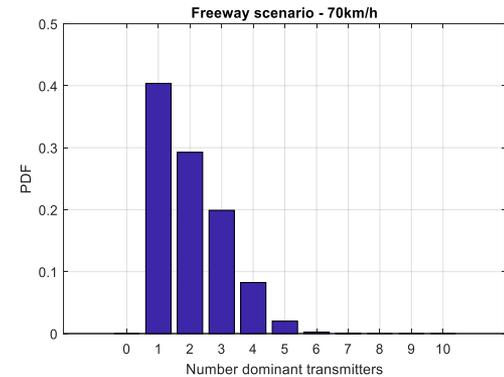
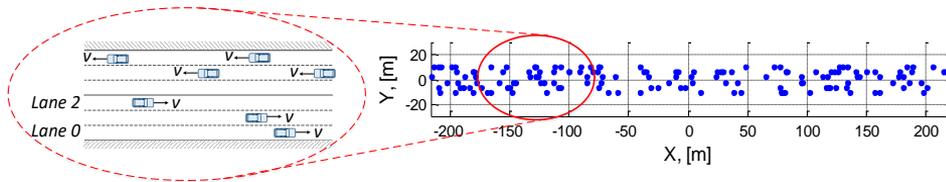
Study Item Justification

Interference Statistics

V2X interference statistics depends on multiple factors: deployment model, traffic model, resource allocation, and resource selection algorithm.

Freeway scenarios (70 km/h)

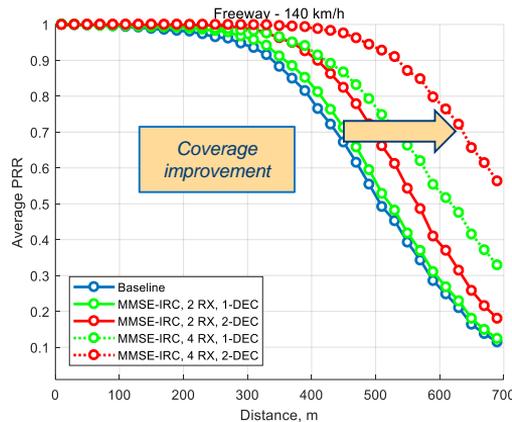
- Noise-limited scenarios with single dominant PSSCH transmissions have ~40% probability => *May benefit from 4RX enhancements*
- Scenarios with 2 or more dominant PSSCH transmissions have ~60% probability. Nearly 30% of all scenarios have strong 2nd dominant PSSCH transmission => *May benefit from IM, multi-packet decoding and 4RX enhancements*



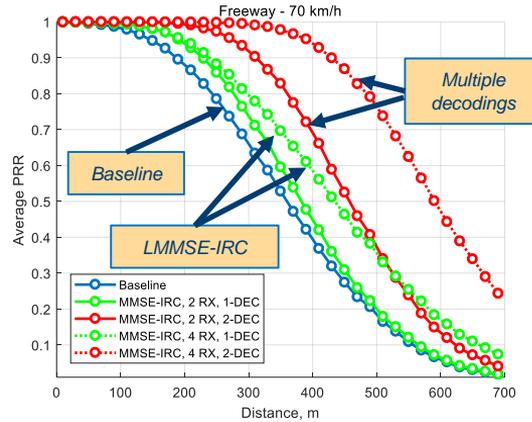
Study Item Justification

System-level performance

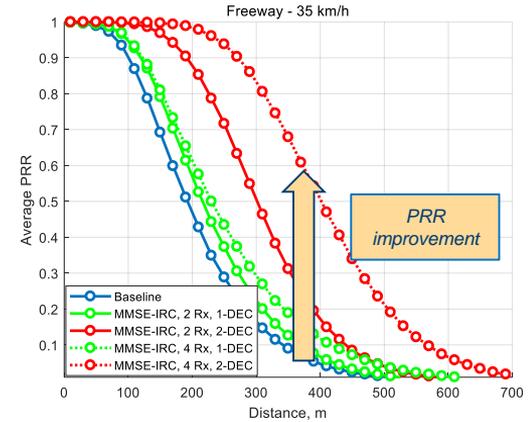
Freeway Sparse (140 km/h)



Freeway Dense (70 km/h)



Freeway Ultra Dense (35 km/h)

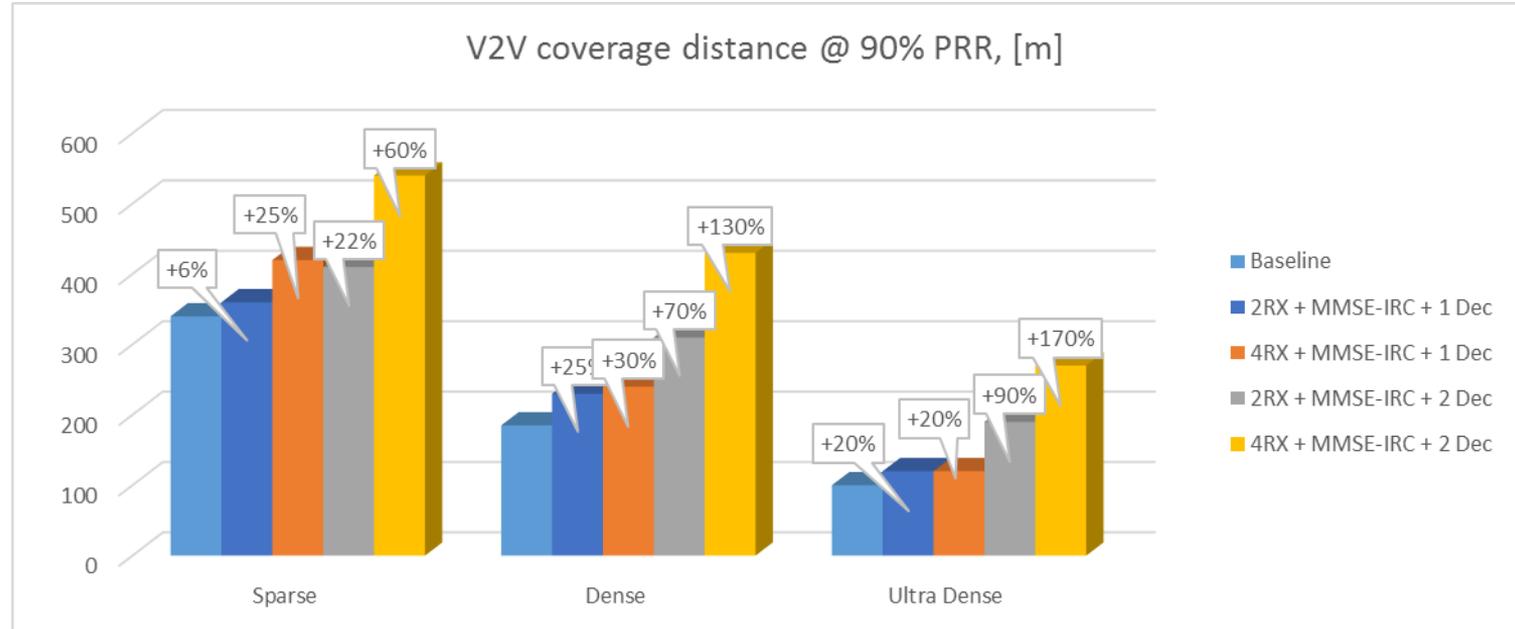


Deployment	Freeway Sparse (140 km/h) Freeway Dense (70 km/h) Freeway Ultra Dense (35 km/h)
V2V parameters	PSSCH - 20 PRB, 2 TTIs ; PSCCH – 2 PRB; 190 byte packet
Receiver	Baseline RX: 2RX, MMSE-MRC, 1 decoding Advanced RX: 2RX & 4RX, MMSE-IRC, 1 & 2 decodings

“MMSE-IRC” and “Multi-packet decoding” and “4RX” receivers provide substantial V2V coverage and PRR improvement

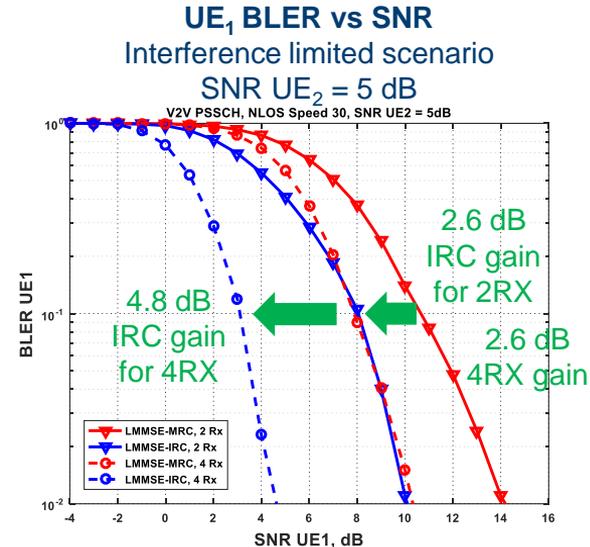
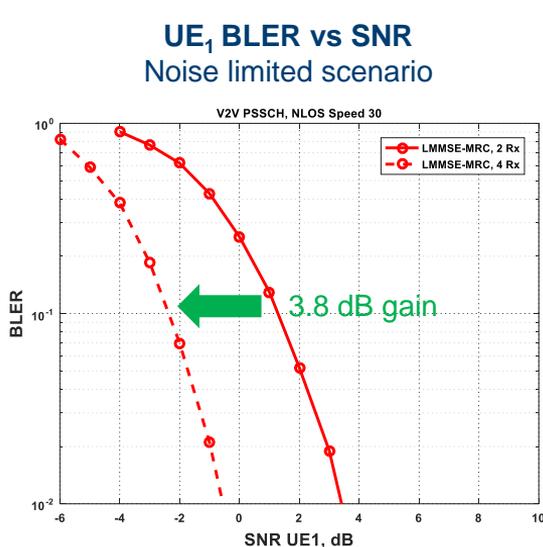
Study Item Justification

V2V Communication Coverage



Study Item Justification

Link-level performance



Increasing of number of receive antennas allows to achieve substantial performance improvement for both noise and interference limited conditions

Interference mitigation (MMSE-IRC) receivers provide substantial link-level performance improvement over legacy Rel-14 receivers for interference limited scenarios

Study Item Justification

Summary

CONCLUSIONS

- Support of efficient vehicular communication is one of the key directions of further LTE evolution
- In LTE Rel-14 initial V2V functionality was introduced. The Rel-14 LTE V2V demodulation requirements are based on the single packet decoding assumptions, non-interference aware processing and 2RX antennas.
- System- and link-level analysis show substantial benefits of supporting advanced V2V receivers based on the three key features:
 - Interference mitigation receivers
 - Multi-packet decoding
 - 4RX antennas

PROPOSAL

- Organize RAN4 LTE Advanced V2V receivers study item to investigate the proposed enhancements
- Focus on transparent solutions applicable to be used for LTE Rel-14/15 V2X devices

Study Item Objectives

Study feasibility of advanced LTE V2X receivers for Sidelink [RAN4]

- Identify and agree on the target scenarios and assumptions including
 - Realistic deployment scenarios (based on Rel-14 RAN1 work)
 - Simulation assumptions for link-level evaluations
 - Interference models for link-level evaluations
- Identify reference advanced LTE V2X receiver structures and evaluate their performance/complexity trade-off and implementation feasibility
 - Investigate feasibility of the following receiver structures
 - LMMSE-IRC with single PSCCH/PSSCH decoding (i.e. no decoding of multiple overlapping PSCCH/PSSCH transmissions)
 - LMMSE-IRC with multiple PSCCH/PSSCH decodings (i.e. decoding of multiple overlapping PSCCH/PSSCH transmissions)
 - Investigate feasibility of receiver structures with 2RX and 4RX antennas
- Evaluate advanced LTE V2X receivers performance benefits over baseline Rel-14/15 V2X receiver
 - Baseline receiver: LMMSE-MRC with single PSCCH/PSSCH decoding and 2RX antennas

