

October 30th, 2019

Beijing

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5G NR V2X Spectrum Needs Study: Groupcast Traffic Model and Spectrum

FuTURE&TIAA V2X WG #17 meeting

5G NR V2X Spectrum Needs Study:Phase 2

Unicast

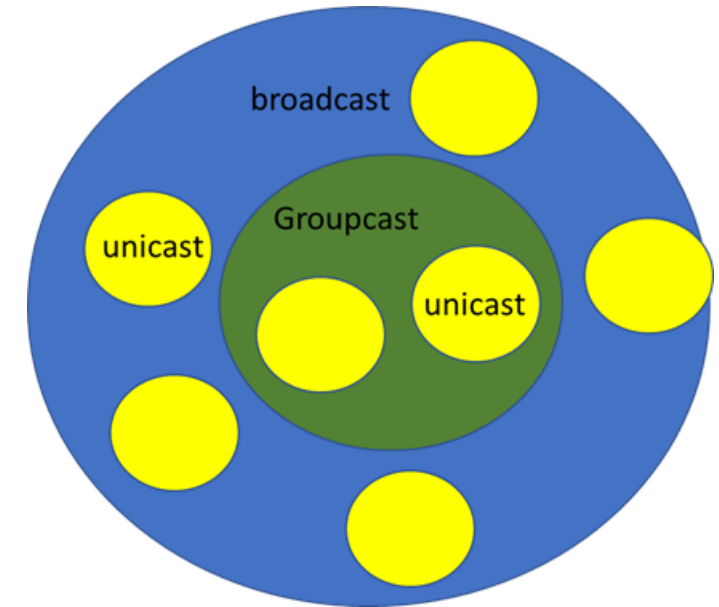
- Uu interface: IMT licensed spectrum, V2N, telematics
- PC5 interface: special case of groupcast

Groupcast

- PC5 interface
- ITS dedicated spectrum
- V2V, platooning

Broadcast

- PC5 interface
- ITS dedicated spectrum
- V2V, V2I, BSM, sensor sharing, intention/trajectory sharing

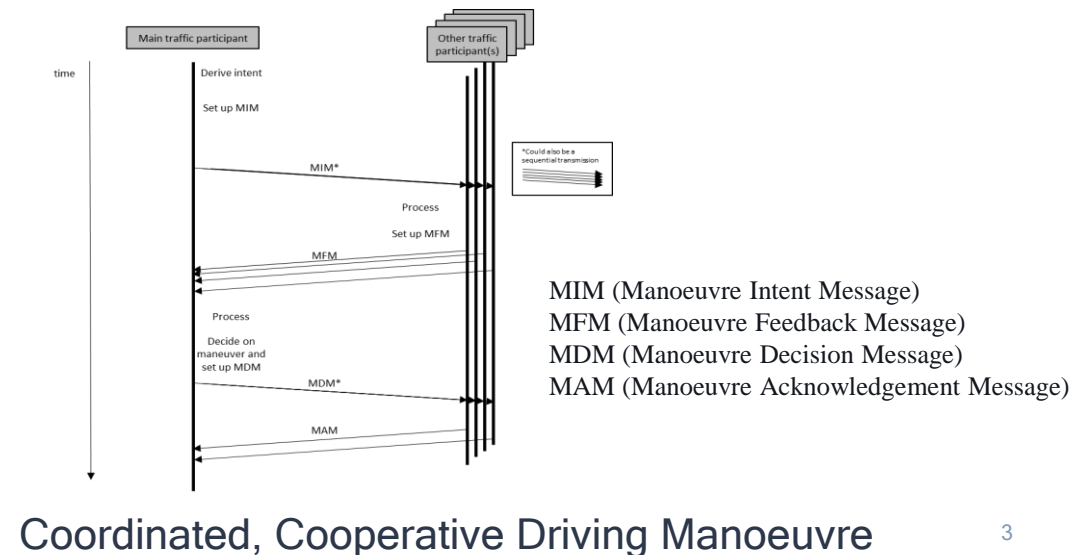
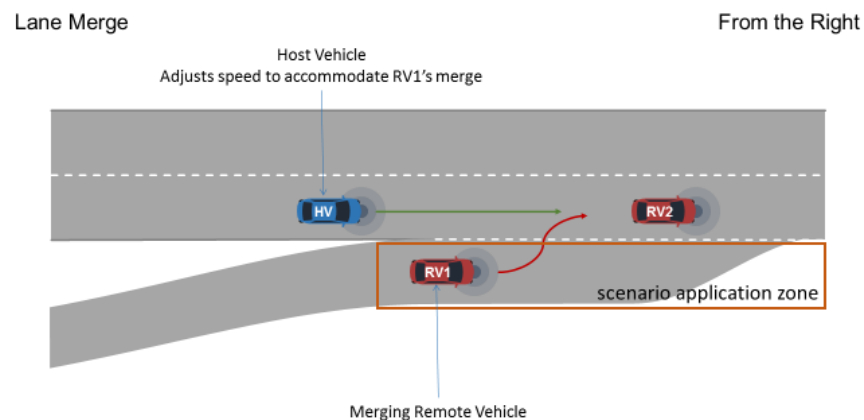
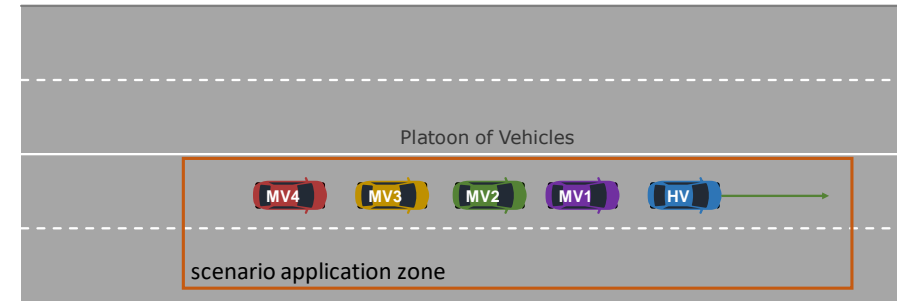
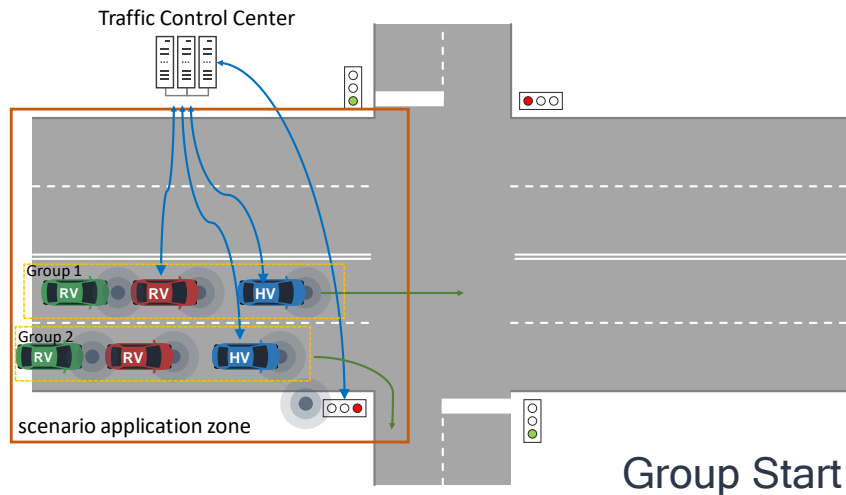


$$\text{Spectrum} = S_{\text{broadcast}} + S_{\text{groupcast}} + S_{\text{unicast}}$$

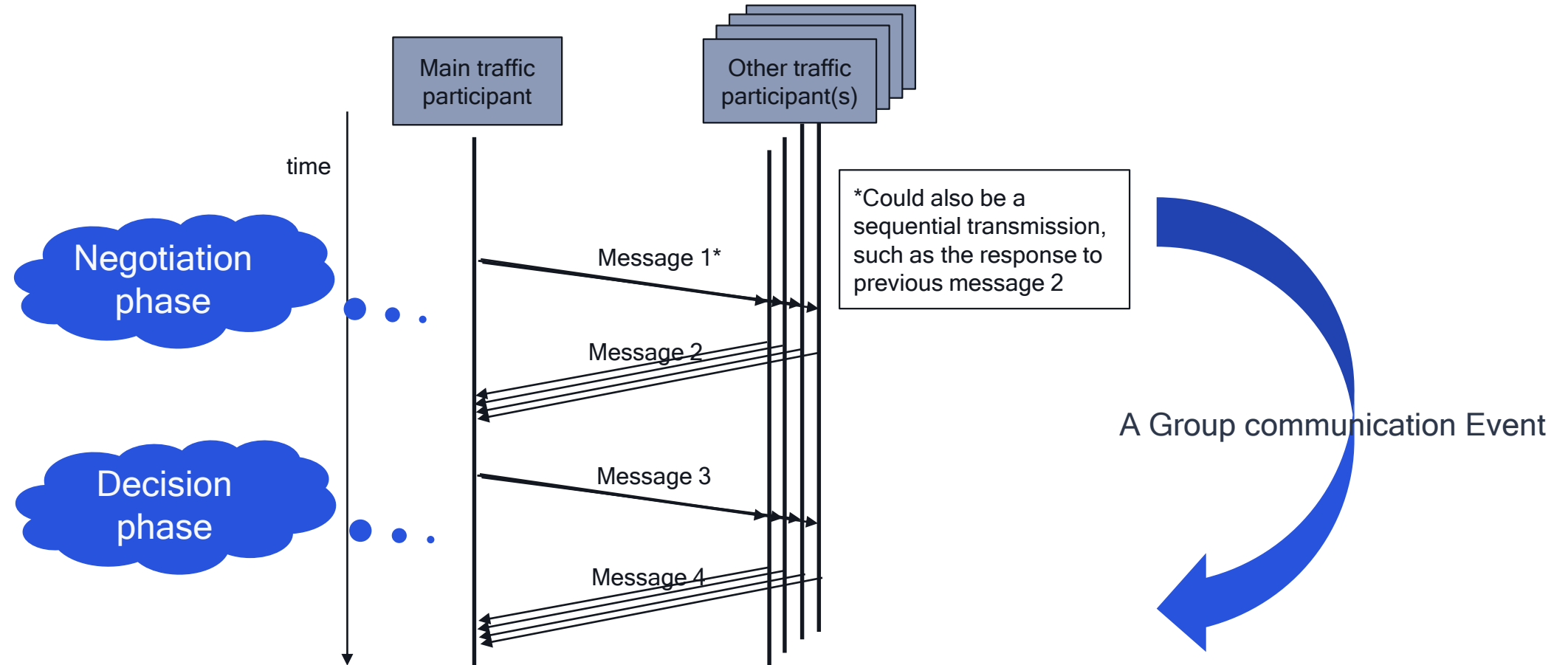
- Broadcast spectrum needs of NR V2X has been addressed in phase 1 study and improved in phase 2 with more precise traffic model.
- Groupcast spectrum needs are addressed in phase 2.

Group Communication Use Cases

5GAA 5G Use Cases and Requirements - Wave 2.1 and Wave 2.2

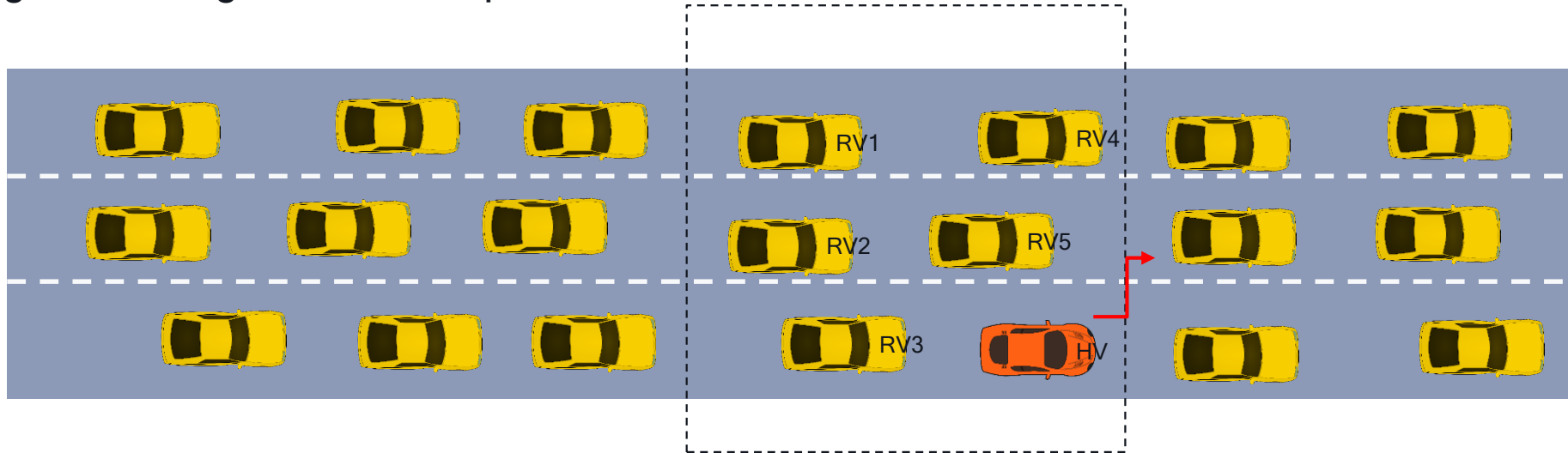


Modelling of Groupcast Message Flow



Methodology to Study Spectrum Needs for Groupcast Based Use Cases

Using lane change as an example



Event modelling of lane change

- Assume that 6 vehicles formulate a virtual group when a lane change event is triggered by HV. The host vehicle (red one) is initiating the lane change with assistance of coordinated cooperative driving group communication.

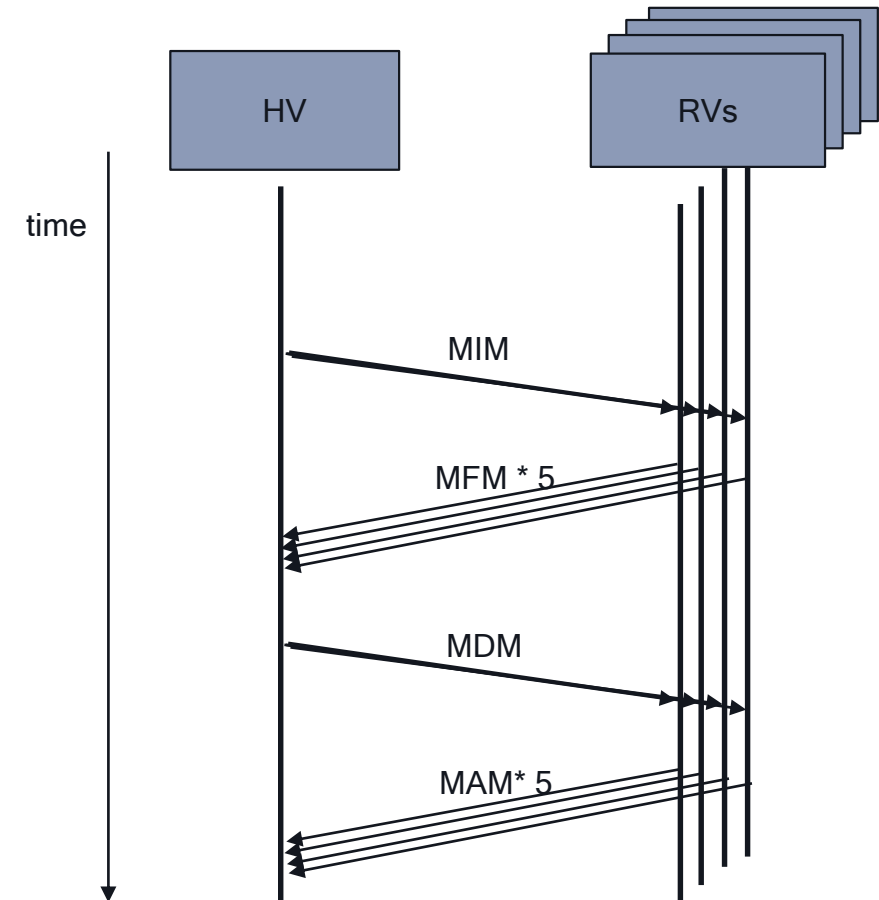
Behavior assumption

- It is assumed that a driver conducts the lane change every T seconds.

Message Flow of Lane Change

Message assumption

Message	Message Payload Size (Bytes)
MIM (Manoeuvre Intent Message)	300
MFM (Manoeuvre Feedback Message)	300
MDM (Manoeuvre Decision Message)	300
MAM (Maneuver Acknowledgement Message)	100



Evaluation Methodology for NR-V2X Groupcast Traffic

Aggregated groupcast data rate of an active group

$$= \frac{(Msg_1 + Msg_2 \times (N_{group} - 1) + Msg_3 + Msg_4 \times (N_{group} - 1)) \times N_{average}}{T_{event}}$$

N_{group} : group size (the number of the traffic participants per virtual cluster)

Msg_1 : Message 1 payload size (bit)

Msg_2 : Message 2 payload size: (bit)

Msg_3 : Message 3 payload size (bit)

Msg_4 : Message 4 payload size (bit)

T_{event} : the average event duration (s)

$N_{average}$: the average retransmission times of the groupcast messages

H-ARQ Modeling in Groupcast

- The average retransmission time $N_{average}$ with HARQ mechanism is estimated by following equation

$$N_{average} = P_g + (1-P_g)*P_g * 2 + \dots + (1 - P_g)^{N_{max}-1} * P_g * N_{max}$$
$$= \frac{1 - (1 - P_g)^{N_{max}} (1 + N_{max} P_g)}{P_g}$$

While, P_g is PRR of single groupcast transmission

- The maximum retransmission time N_{max} can be estimated by the following equation

$$N_{max} = \left\lceil \frac{\log (1 - P_r)}{\log (1 - P_g)} \right\rceil$$

While, P_r is the service reliability requirement, P_g is PRR of single groupcast transmission

Note: The maximum retransmission time N_{max} can be decided by expected receiving probability or the max latency requirement. N_{max} would be decided by the maximum latency of time sensitive application if the reliability requirement is very high. To simplify the study, it is estimated by the expected receiving probability only .

An Example for Lane Change

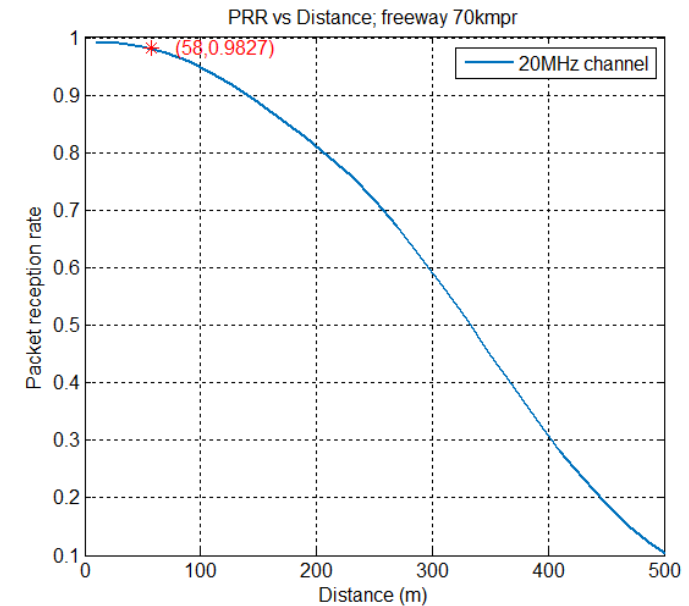
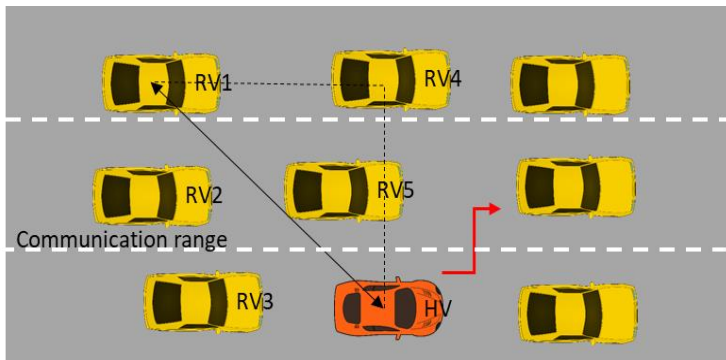
The groupcast communication range

$$= \sqrt{(\text{longitue vehicle spacing} + \text{vehicle length})^2 + [(\text{lane number} - 1) * \text{lane width}]^2}$$

Pg is 0.98.

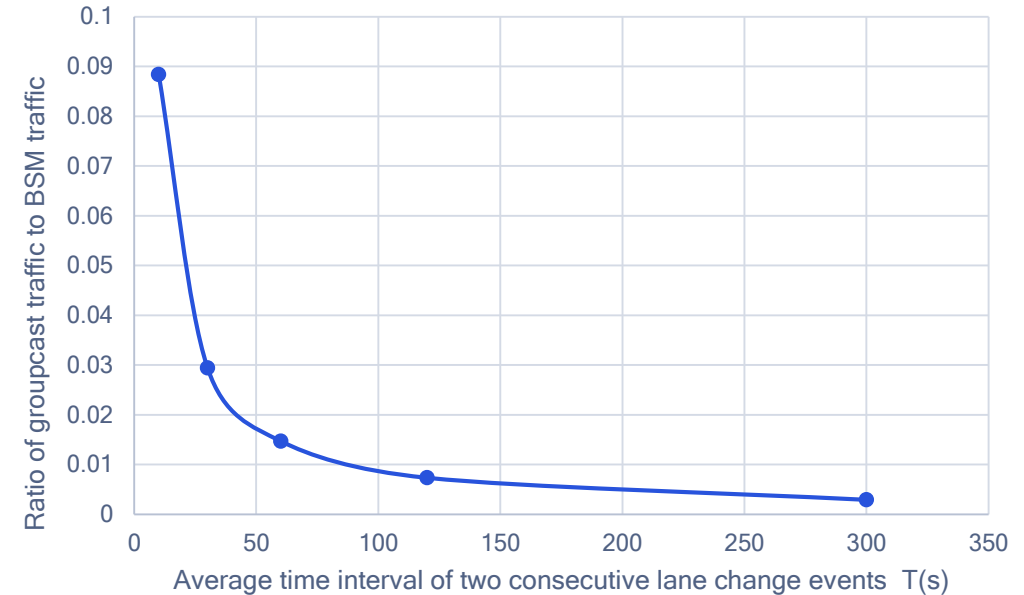
Pr is 0.999. Nmax is 2.

Naverage is approximately 1.02.



Lane Change Traffic Loading Analysis for Freeway

Parameters	Values
Lane numbers in the single direction	3
Average interval of lane changing events (s)	T
The number of traffic participants	6
BSM Tx frequency (Hz)	10
BSM message size (bytes)	300
Sensor sharing Tx frequency (Hz)	10
Sensor sharing message size (Bytes)	1250
BSM traffic load of HV (bytes)	143*300
MIM message size (bytes)	300
MFM message size (bytes)	300
MDM message size (bytes)	300
MAM message size (bytes)	100
Lane change traffic load (bytes)	2652
TTC (s)	2.5
Vehicle velocity (km/h)	70
Vehicle length (m)	4.5
Vehicle spacing (m)	53.11
Lane width (m)	3.75
Groupcast communication range (m)	58.09
PRR of single transmission	0.98
Reliability	0.999
Average retransmission times	1.02



- The average time interval between lane changes depends on the road conditions.
- The groupcast traffic of lane change could be marginal, compared to the traffic of BSM.

Parameter Set for NR-V2X Groupcast Traffic Evaluation

Parameters	Group Start	Vehicles Platooning in Steady State	Co-operative Lane Merge	Coordinated, Cooperative Driving Manoeuvre (parameters for lane change as example)
Group size (the number of the traffic participants)	TBD	TBD	2	6
Message1 payload size (byte)	TBD	TBD	300	300*
Message 2 payload size: (byte)	TBD	TBD	300	300*
Message 3 payload size (byte)	TBD	TBD	TBD	300*
Message 4 payload size (byte)	TBD	TBD	TBD	100**
The average event duration (s)	TBD	TBD	TBD	4.35
Service level reliability	0.99999	0.999	0.999	0.999
Groupcast communication range (m)	15m between vehicles, and 150m between vehicle and RSU	HV-MV:175 m MV-MV: 5m-15m	300m	58m meters for 70km/h speed in 3 lane freeway
NR-V2X PRR performance curve of single transmission	TBD	TBD	TBD	Reuse LTE-V2X temporarily

*Payload size of lane change Message 1, 2 and 3 refers to message 1 and 2 of cooperative lane merge.





**Payload size of lane change Message 4 is estimated based on the ACK and simplified certificate payload size.

Conclusions and Suggestions

- Using lane change as an example, we noticed the spectrum needs to accommodate lane changes is marginal compared to the amount of spectrum for transmitting the broadcast message such as CPM, BSM or CAM.
- To progress the more accurate spectrum needs study of NR V2X groupcast based applications, we seek more input to collect the completed parameter set, such as the message flow of the use case, the message payload size of the use case, the typical group size, the average group communication event duration, NR-V2X PRR performance curves of single transmission, etc.



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