3GPP TSG RAN WG1 Meeting #83 *R1-157534*

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**Agenda item:**  **6.2.8.1.1**

**Source: Beijing Xinwei Telecom Techn.**

**Title: Discussion on enhancement of V2X resource allocation**

**Document for: Discussion and Decision**

# **Introduction**

In RAN #82bis meeting, resource allocation strategies for PC5-based V2V were discussed with the following agreements:

*Agreements:*

* *Rel-13 sidelink resource allocation is not sufficient for some of the scenarios for PC5-based V2V*
  + *Enhancements to Rel-13 sidelink resource allocation are necessary for PC5-based V2V*

There are more resource allocation principles listed in [1] for further discussion. Based on the study scopes, this contribution considers benefits of current enhancement principles for V2X design in Section 2.1. Subsequently, a resource allocation scheme utilizing cooperative diversity to improve reliability of emergency triggered V2X messages is discussed in Section 2.2, and corresponding simulation result is provided in Section 2.3.

# **Discussion**

## **Potential enhancements on V2X resource allocation**

In this contribution, some schemes to enhance V2X resource allocation are discussed:

* Resource pool

For the purpose of alleviating collision, defining multiple resource pools is considerable for V2X resource allocation. One possible scheme is to define exclusive resource pool for crucial messages, i.e. emergency triggered messages in V2X, which is similar to Rel-13 D2D communication pool design. Crucial messages can be transmitted in both exclusive pool and normal pool while normal periodical messages can only use normal pool. This scheme avoids collisions between crucial messages and periodical messages thus crucial message can be more reliable. On the other hand, separating vehicles into different resource pools on the basis of geographical distribution or driving direction are effective schemes which could take advantage of the nature attribute of V2X. For instant, zoning is a location based scheme in which resources are partitioned into different groups and each resource group can be reused for multiple non-adjacent zones. This scheme could introduce significant system gain [2]. Detailed strategies of multiple resource pool definition can be on the basis of scenarios, e.g. using multiple location-based resource pools only in urban cases while multiple priority-based resource pools applied for all cases.

As above, defining multiple SA pools can improve SA reliability. For a given message with credible enough SA reception ratio, it can be assumed that most adjacent vehicles are aware of the corresponding data resource location and will try to avoid collision when they transmit own data messages. Thus to combine multiple data resource pools into one is feasible, which means multiple SA pools can be associated with the same data pool.

***Proposal 1: Multiple resource pools should be defined to avoid collision and improve performance of emergency messages. Multiple SA can be associated with the same data pool.***

* Scheduling assignment

Apart from TDM scheme, FDMed SA and data pools are proposed for the purpose of latency reduction. At the expense, if SA pool and data pool are separated in time domain there will be a waste of frequency resources while non-separated pools may introduce a new possibility of collision that due to half duplex constraint a UE cannot receive SA when it is transmitting a data message. In addition, receivers should detect more subframes rather than only the original SA pool, which will result in power consumption increase.

When SA and data from a single transmitter are transmitted in the same subframe, the decline of transmission power on each RB will negatively impact BLER performance, but the number of subframes restricted by half duplex will decrease. This tradeoff should be measured in more detail to decide whether it is beneficial.

Transmission numbers of SA and data messages should be variable for different scenarios. Based on existing simulation results, 2 transmissions of SA and data can be an option. Furthermore, we suggest that emergency triggered messages can use higher transmission number that periodical messages. Since the quantity of emergency messages should be far lower than of periodical messages, above higher transmission number will not sensibly impact PRR of periodical messages while the performance requirement of emergency messages can be satisfied more easily.

***Proposal 2: SA transmission number should be variable based on scenarios and corresponding data message types.***

* Enhancement to resource selection/structure

Collision avoidance is an important issue in V2X resource allocation. Energy-based resource selection is widely discussed with the main point that UEs should transmit on resources with low receiving energy level to alleviate collision. In this scheme, since in a geographical area (e.g. a street) the adjacent vehicle status is relatively fixed for most V2X scenarios and V2X messages are mainly periodically generated messages with predictable length, resource selection/reselection interval can be multiple transmission period to reduce scheduling overhead. Resource selection and reselection procedure can be periodical. The period length is deployed based on scenarios, and also can be triggered by certain situations e.g. aware of collision through receiving SA of other vehicle or realizing significant growth of average receiving energy level in current pool.

In addition, if UE senses the lowest energy level in resource pool is still excessively high, which means current pool is crowded, UE may select another resource pool (if support multiple resource pools) or use lower MCS to offset system interference. eNodeB can also monitor resource pool load and announce that to UEs, then UEs apply collision avoidance schemes autonomously or by eNodeB scheduling.

***Proposal 3: Resource selection/reselection procedure can be periodical and additionally triggered by sensing collision or high load on current resource pool. For the purpose of enhancing reliability, UE can reduce MCS or reselect resource pool.***

* Transmission power control and/or setting

Power control can be beneficial for V2X system performance. Reducing transmission power results in lower communication range, in some high vehicle density scenarios this scheme can reduce number of neighbour vehicle thus alleviates collision. Muting can also be used to mitigate message density. Furthermore, since power consumption problem in V2X is relatively less severe than in D2D, increasing transmission power can be applied for some certain message types, e.g. 300-byte periodical messages or emergency triggered messages.

## **Cooperative transmission in the blind-retransmission process**

On the basis of current resource allocation schemes, we propose a cooperative transmission scheme which focuses on enhancing the reliability of V2X emergency messages.

Cooperative diversity is applied in this scheme. The kernel of cooperative diversity is to schedule multiple nodes transmit or forward same message on same time and frequency resource. In the transmission process, signal from multiple nodes present a superposition effect, which introduces power gain and diversity gain to QoS performance.

This mechanism can be effectively applied in the blind-retransmission process of emergency triggered messages without extra PC5 interface cost. In our scheme, relay nodes cooperatively forward received emergency message (including data and SA) on the retransmission resource of source node. Figure 1 is an example with SA and data transmission number set to 2 (1 transmission and 1 retransmission). Vehicle 0 generates a emergency message, transmits SA on subframe M1 in SA pool; Vehicle 1~4 receive the SA message; on subframe M2 in the SA pool, Vehicle 0 retransmits SA and Vehicle 1~4 transmit the same SA message as cooperative forwarding (also using same frequency resource). Then the SA blind retransmission process of Vehicle 0 is finished and Vehicle 1~4 will not perform retransmission of the forwarding SA message. Similarly, Vehicle 0 transmits data on subframe N1 in data pool, and Vehicle 1~4 assist Vehicle 0 performing data retransmission on subframe N2 with cooperatively forwarding. In this process, no extra resource cost or latency is introduced while multi-node relay enhances reliability of the emergency message. This scheme is called as “cooperative retransmission forwarding”.



Figure 1 Cooperative retransmission forwarding with multiple relay vehicles

In the cooperative retransmission forwarding scheme, relay nodes forward received emergency message in a cooperative way as assistance until the source node finishes blind-retransmission process. This means the blind-retransmission numbers of relay nodes are lower than that of source node and depend on the hop count of given relay nodes.

In data transmission process, relay nodes are easy to learn local hop count (which means number of finished retransmission at the source node) through comparing resource information indicated in received SA and data message receiving resource. On the basis of hop count, relay nodes can decide whether the received message should be forwarded and local retransmission number. For SA transmission, we suggest that emergency messages could use fixed resource sets in which time of retransmission can be learned by resource mapping. This scheme is similar to separate SA resource pool of emergency messages from SA pool of periodical messages.

Since the power and diversity gain introduced by assistance of multiple cooperative relay nodes, this scheme can significantly enhance the QoS performance of emergency messages. Furthermore, the scheme has obvious simplicity and can be applied without substantially changing standard.

***Proposal 4: Emergency triggered messages can be forwarded in a cooperative way during the blind retransmission process. Relay nodes which successfully receive emergency triggered messages will forward the message on retransmission time and frequency resources of source node.***

If service has higher requirement for message reliability, the forwarding process can be re-triggered at relay nodes. A relay node can transmit received emergency message as its own service, and the transmission can be independent or dependent of the origin transmission. Since the message transmitted at relay node is completely same as the original one, the new transmission can be seen as enhancement of original PRR.

Whether to use variable transmission number is discussed in RAN1 #82bis meeting. For the purpose of enhancement on reliability of emergency messages, we propose that emergency triggered messages could use higher transmission number combined with cooperative retransmission forwarding. If periodical message transmission number is set to 1, 2 or 4, emergency triggered message transmission number can be set to 2, 4 or 6 respectively.

***Proposal 5: Emergency triggered messages can use higher transmission number combined with cooperative retransmission forwarding. If periodical message transmission number is set to 1, 2 or 4, emergency triggered message transmission number can be set to 2, 4 or 6 respectively.***

## **Simulation results**

The gain of cooperative retransmission forwarding and higher transmission number for emergency triggered messages is simulated in the contribution. In the following simulations, Freeway case is used with absolute vehicle speed set to 140km/h, SA period is assumed 40ms with 8 subframes used for SA transmission and 32 subframes used for data transmission. Detailed simulation parameters are listed in the Appendix.

 

Figure 2 Simulation result of comparison between normal and cooperative retransmission forwarding schemes (transmission number = 2, X = 0.01)

Figure 2 illustrates the PRR gain of emergency message with cooperative retransmission forwarding. SA and data transmission number are set to 2 (1 transmission and 1 retransmission) in above simulation.

In the normal scheme without cooperative scheme involved, the PRR performance of emergency messages is worse than periodical messages due to MCS differentiation. After introducing cooperative retransmission forwarding scheme, with emergency event arrival rate *X* set to 0.01 per second, the effect on PRR of periodical messages is negligible, while the PRR of emergency messages is significantly improved. Although there is only slight gain for close vehicles, for distant vehicles the performance gain is obvious, e.g. at *d* = 300m, the average PRR of emergency message growth is ~0.57 (from 0.09 to 0.66) and the PRR of emergency messages is ~0.12 higher than the PRR of periodical messages.

***Observation 1: Cooperative retransmission forwarding scheme can significantly improve PRR of emergency triggered messages especially for distant vehicles, while not impacting PRR of periodical messages.***

 

Figure 3 Simulation result of comparison between normal scheme and cooperative retransmission forwarding scheme with higher transmission number (transmission number = 2 for normal scheme and SA transmission number = 2, data transmission number = 4 for cooperative scheme, X = 0.01)

The gain introduced by higher transmission number of emergency triggered messages is shown in Figure 3. In above simulation, SA and data transmission of periodical messages number are set to 2 while SA transmission number of emergency triggered messages is set to 2 and data transmission number is set to 4. Due to higher transmission number, in the normal scheme the PRR performance of emergency messages increase obviously at close distance and even for distant vehicles there is slight gain. In cooperative retransmission forwarding scheme, the combination of cooperative retransmission forwarding and retransmission number increase can significantly and effectively enhance the reliability of emergency triggered messages.

***Observation 2: Higher retransmission number of emergency triggered message in cooperative retransmission forwarding scheme introduces substantial enhancement on emergency message reliability.***

# **Conclusion**

***Observation 1: Cooperative retransmission forwarding scheme can significantly improve PRR of emergency triggered messages especially for distant vehicles, while not impacting PRR of periodical messages.***

***Observation 2: Higher retransmission number of emergency triggered message in cooperative retransmission forwarding scheme introduces substantial enhancement on emergency message reliability.***

***Proposal 1: Multiple resource pools should be defined to avoid collision and improve performance of emergency messages. Multiple SA can be associated with the same data pool.***

***Proposal 2: SA transmission number should be variable based on scenarios and corresponding data message types.***

***Proposal 3: Resource selection/reselection procedure can be periodical and additionally triggered by sensing collision or high load on current resource pool. For the purpose of enhancing reliability, UE can reduce MCS or reselect resource pool.***

***Proposal 4: Emergency triggered messages can be forwarded in a cooperative way during the blind retransmission process. Relay nodes which successfully receive emergency triggered messages will forward the message on retransmission time and frequency resources of source node.***

***Proposal 5: Emergency triggered messages can use higher transmission number combined with cooperative retransmission forwarding. If periodical message transmission number is set to 1, 2 or 4, emergency triggered message transmission number can be set to 2, 4 or 6 respectively.***

# **References**

1. R1-156301, Offline summary on resource allocation in PC5-based V2V, LGE
2. R1-155755, V2V System Level Performance, Qualcomm
3. R1-155221, Enhancement of resource allocation mechanism in PC5-based V2V
4. R1-155411, 3GPP TR36.885 v.0.1.0 Study on LTE-based V2X Services LG Electronics
5. R1-155908, Link Comparison for Potential V2V L1 Formats Ericsson

# **Appendix**

Table 1: simulation assumptions

|  |  |
| --- | --- |
| **Parameters** | **Value** |
| Carrier frequency | 6 GHz |
| System bandwidth | 10MHz |
| Number of carriers | one carrier |
| Tx power | 23dBm |
| Antenna gain | 3dBi |
| Synchronization | Ideal |
| Carrier frequency offset | +/-0.1 PPM |
| UE drop and mobility model | Freeway, absolute vehicle speed is 140km/h as described in [4] |
| Vehicle density | 10 vehicles/lane/km as described in [4] |
| SA period | 40ms, SA resource pool length is 8ms, and data resource pool length is 32ms |
| Channel model | As described in [4] |
| Traffic model | periodic traffic as described in [4] with 100ms period  event-triggered traffic as described in [4] with X=0.01 |
| Retransmission times | 2 for SA, 2 for periodic traffic  {2 4} for event-triggered traffic |
| Number of DMRS symbols | 4 as described in [5] |
| Modulation | QPSK |
| Number of RBs for data | 12 for 190B, 25 for 300B, 50 for 800B |
| Resource selection method | Random selection for all data messages and SA of periodical messages, fixed resource mapping for SA of emergency triggered messages |