Vehicular Transmission Reliability over Blind Intersections

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Vehicle-to-vehicle (V2V) communication can improve road safety and traffic efficiency, particularly around critical areas such as intersections. We analytically derive V2V success probability near an urban intersection, based on empirically supported line-of-sight (LOS), weak-line-of-sight (WLOS), and non-line-of-sight (NLOS) channel models. The analysis can serve as a preliminary design tool for performance assessment over different system parameters and target performance requirements. The most interesting outcome of this research is the ability to design the network and explicitly quantify the tolerated number of simultaneous transmissions that could occur at the same time-frame of the wanted transmission, while still meeting the pre-determined target reliability. Meanwhile, we will also discuss means to determine the fraction of vehicular traffic realizations that achieve the target reliability. This is a more granular finely detailed analysis, and it will basically builds on the results presented earlier.

Fig. 1. Blind intersections are estimated to cause ~ 47% of all accidents. V2x can overcome this challenge, since packet reliability can lead to road-safety.

Link: https://research.chalmers.se/en/publication/?id=253554
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Motivation
5G Use-Cases
- media
- smart cities
- automotive
- manufacturing
- healthcare

V2x Communications
- packet reliability
- road-safety

Intersections/Corners
- ~ 47% of all accidents

Target Reliability
- Vehicle to Vehicle
  - transmission distance ~ 100m [urban]
  - 200m [suburban]

Research Questions
1. How to quantify/evaluate V2x packet reliability in blind intersections?
2. How to design vehicle ad hoc network (VANET) to meet a fail-safe target reliability?
3. How to go beyond misleading averages and explicitly study reliability of each vehicular traffic realization?

our research attempts to uncover the collection of these important unknowns!

Quantifying Reliability

\[ P_s(\beta, x_{2x}, x_{2x}) = P_{\text{sol}} P_s P_x \]

Network Design
- road dimension: \( R \geq 2d \)
- target reliability: \( P_{\text{Target}} < P_{\text{sol}} \)
- requirements: \( P_{\text{sol}} P_x P_s \geq P_{\text{Target}} \)
- design guidelines:
  - \( P_s(\beta, x_{2x}, x_{2x}) = P_{\text{sol}} P_s P_x \)

Average Reliability

Meta Distribution
- basic analysis (averages)
- advanced granular analysis (Palm Calculus)

System Parameters
- channel: breakpoint distance
- reference distance
- AWGN floor
- receiver noise
- channel bandwidth

Fine-Grained Reliability

Conclusion
- Metrics for packet reliability are necessary for network analysis & design.
- Traditional metrics based on averages are not precise enough for ultra-reliable and delay-sensitive applications such as V2x com.
- Fine-grained reliability per traffic realization reveals a bimodal distribution outcome.
- Smaller road-segment “R” results in a more polarized reliability outcome.
- This striking revelation would have never been obvious by simply exploring averages for reliability.