Analysis of Access and Connectivity Probabilities in Vehicular Relay Networks

Summary of contributions

• In this paper, an analytical model with a generic radio channel model is proposed.

• access probability and connectivity probability are derived.

• Access probability: the probability that an arbitrary vehicle can access its nearby BSs within two hops.
• connectivity probability, i.e. the probability all vehicles can access at least one BS within two hops.

• Both one-hop (direct access) and two-hop (via a relay) communications between a vehicle and the infrastructure are considered.

• Reveal the trade-offs between key system parameters, such as inter-Bs distance, vehicle density, transmission ranges of a RSU and a vehicle, and their collective impact on access probability and connectivity probability.

• Two different communication channel models are specifically analyzed:
  1. Unit disc model
  2. Log-normal shadowing model
System Model

An Infrastructure-based Vehicular Relay Network.

- BSs are uniformly deployed along a long road.
- Vehicles are distributed on the road randomly according to a Poisson distribution.
- Investigate a sub-network bounded by two adjacent base stations with inter0distacnce “L” meters.
Performance Analysis

probability that the vehicle is directly connected to either BS1 or BS2.

\[ p_1(x) = 1 - (1 - g_b^C(x))(1 - g_b^C(L - x)). \]

Let \( p_2(x) \) be the probability that a vehicle located at \( x \) (distance to BS1) is directly Connected to at least one vehicle in this subnet between BS1 and BS2.

\[ p_2(x) = 1 - e^{-\int_0^L g_v^C(||x-y||)\rho p_1(y)\,dy} \]

Denote by \( p_a(x) \) the access probability of vehicle at \( x \), i.e. the probability that the vehicle at \( x \) is connected to either BS1 or BS2 in at most two hops.

\[ p_a(x) = 1 - (1 - p_1(x))(1 - p_2(x)) \]
Access probability with $L$ changing under the unit disk model, $R = 1000\text{m}$, $r = 500\text{m}$, $\rho = 1/5, 1/50, 1/500$ vehicles/m respectively.
Connectivity probability with \( L \) changing under the unit disk model, \( R = 1000\text{m}, r = 500\text{m}, \rho = 1/5, 1/50, 1/500 \) vehicles/m respectively.