A New Clustering-based Resource Allocation Scheme for C-V2X

SORBONNE UNIVERSITÉ

LIP6

Presented by

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INTRODUCTION:
Communication Technologies in Vehicular Networks

INTRODUCTION

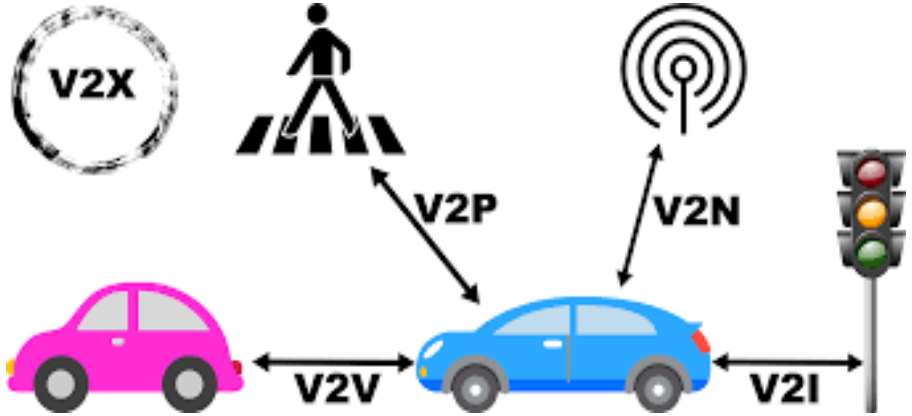
vehicular networks

objective

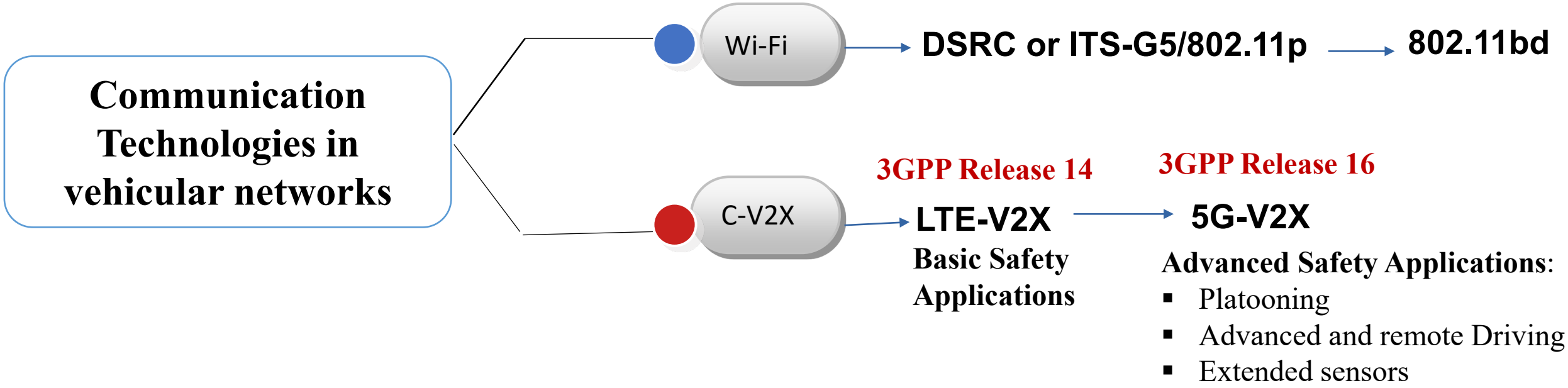
Road safety service:
The reduction of the number of accidents

Integration of wireless communication technologies in automotive sector

V2X : Vehicle-to-everything



INTRODUCTION

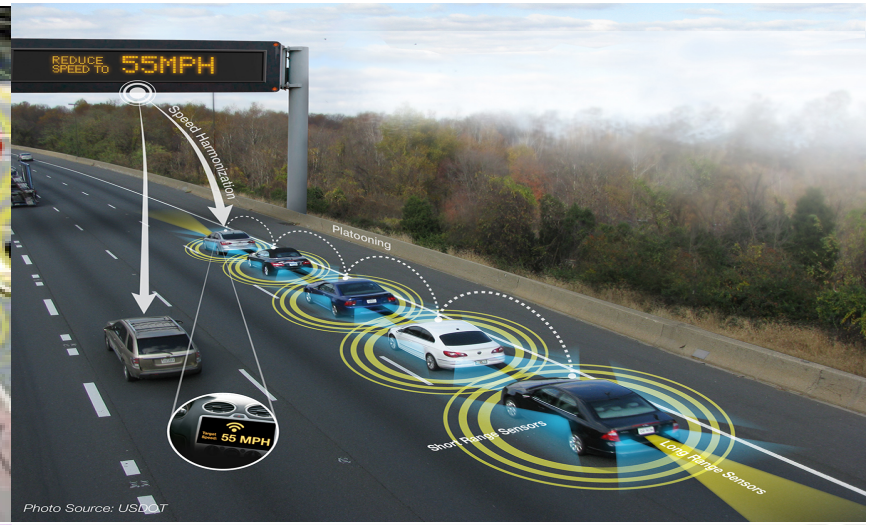


Basic Safety service

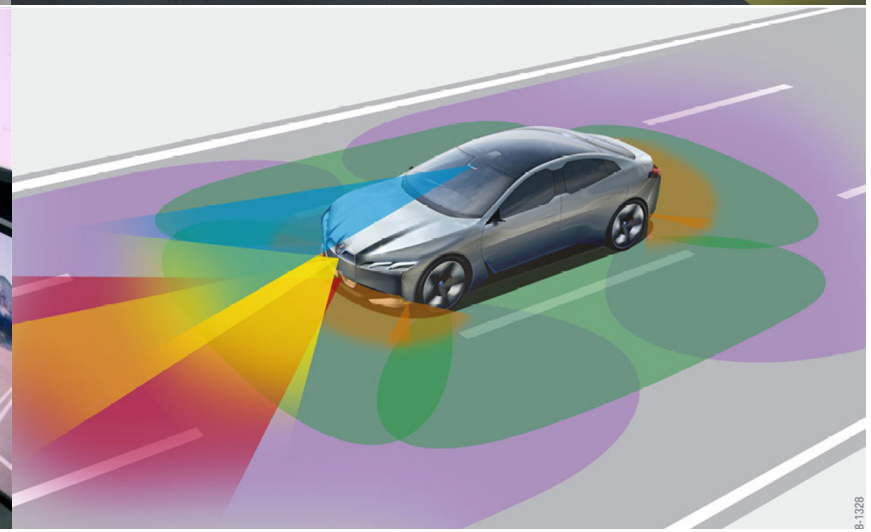
CAM or BSM

- ❑ Emergency vehicle warnings
- ❑ Intersection collision warnings

Platooning



Advanced and remote Driving

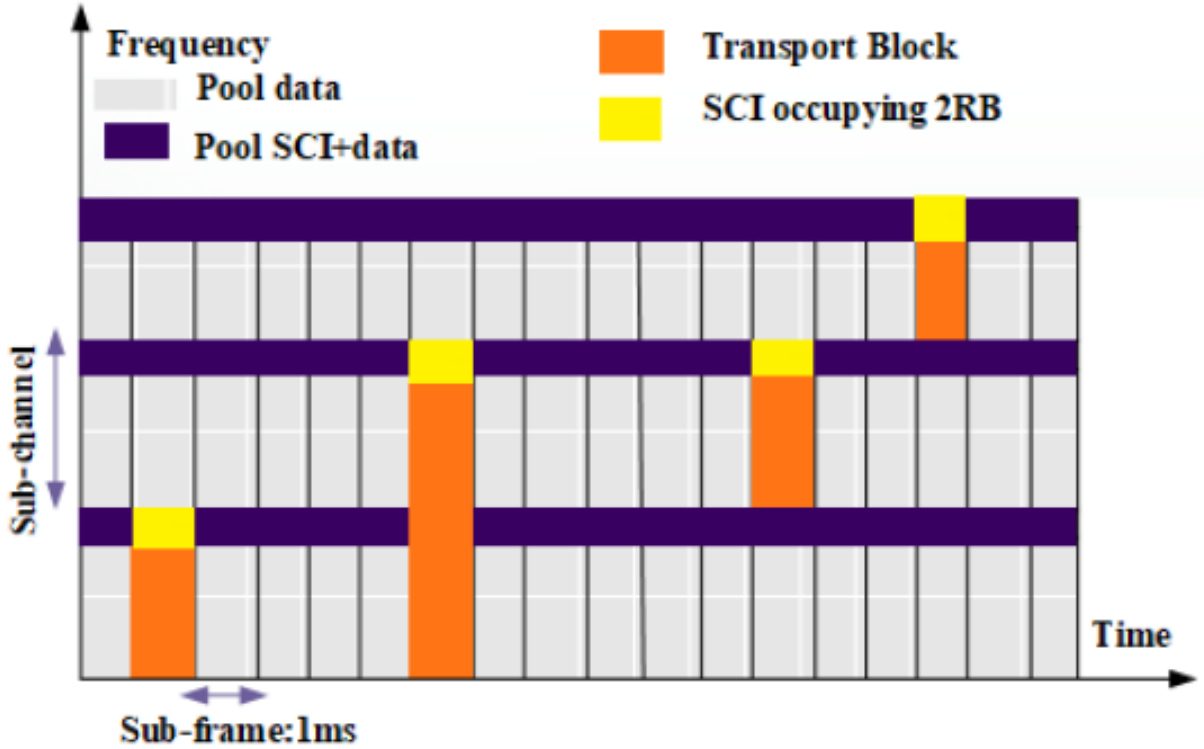


Extended sensors

RESOURCE ALLOCATION MODES IN C-V2X

PHYSICAL LAYER IN LTE-V2X

- LTE-V2X adopts the OFDM in the physical layer and SC-FDMA at the MAC layer.
- The Transport Channel (TCH) transporting data is carried by the Physical Side-link Shared Channel (PSSCH).
- The Physical Side-link Control Channel (PSCCH) carries the side-link control information (SCI).

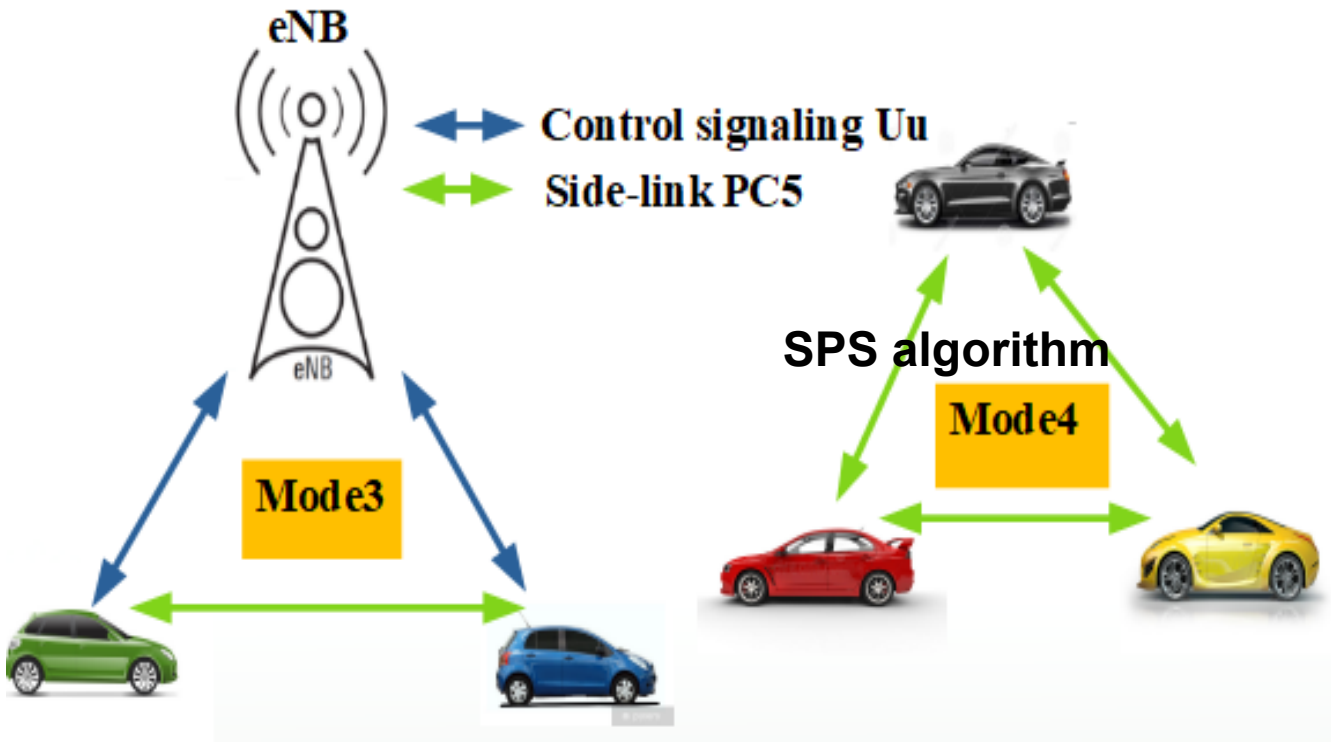


RESOURCE ALLOCATION MODES IN LTE-V2X

LTE-V2X

V2V : exchange of Cooperative Awareness Messages (CAM).

- Mode 3: the resources are scheduled and allocated by eNB to vehicles.
- Mode 4: vehicles autonomously select their radio resources using the sensing-based Semi-Persistent Scheduling (SPS) algorithm.



RESOURCE ALLOCATION MODES IN LTE-V2X

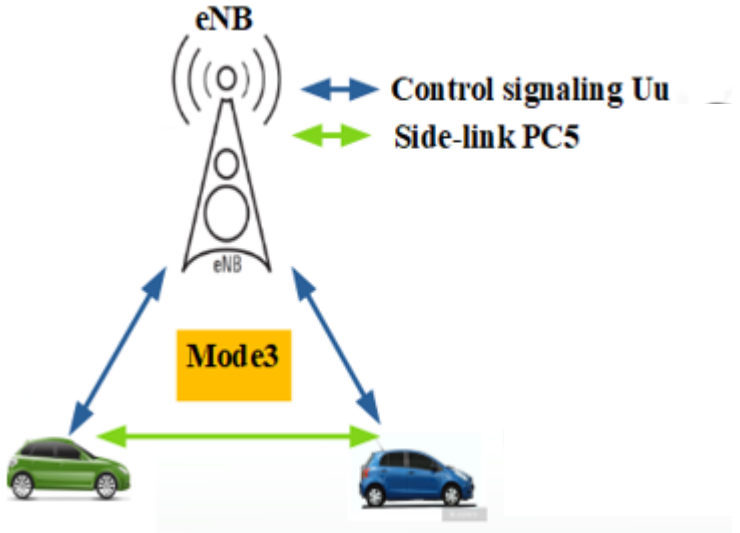
LTE-V2X

Mode 3

- 3GPP has not standardized a specific resource allocation algorithm for mode 3.
- Two choices for resource allocation in mode 3:

a) The dynamic allocation: each vehicle requests sub-channels from the eNB for each CAM packet transmission.

b) The semi-persistent scheduling (SPS): the eNB reserves sub-channels for periodic transmissions of the vehicle.

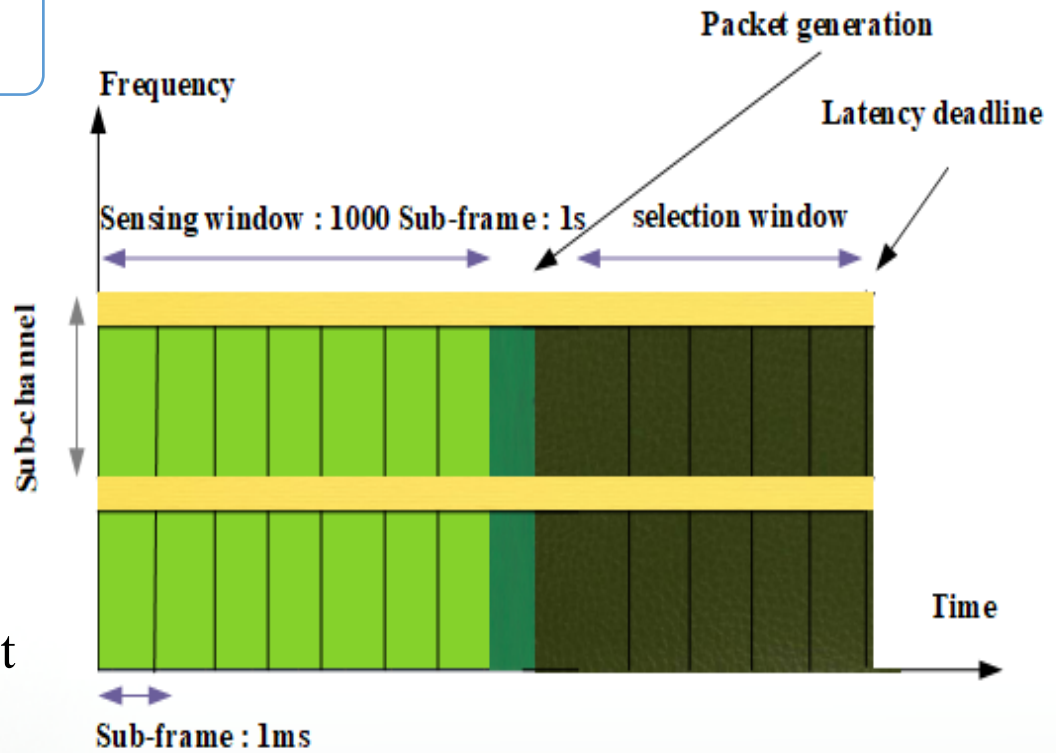


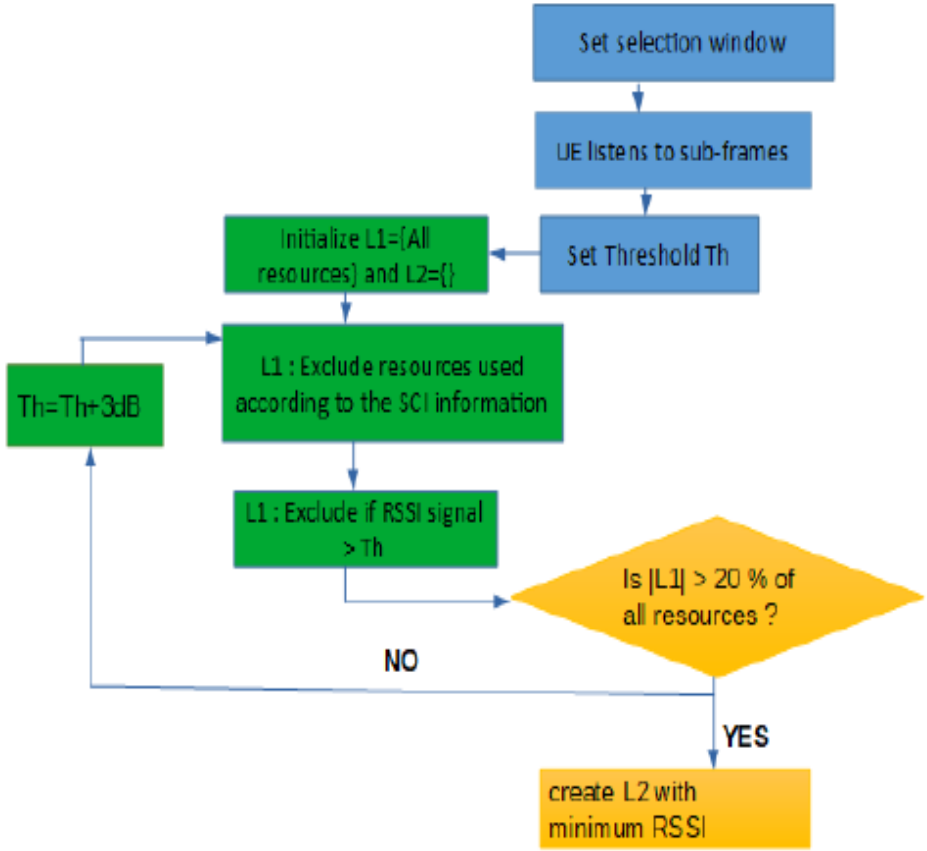
RESOURCE ALLOCATION MODES IN LTE-V2X

LTE-V2X

Mode 4

The sensing-based Semi-Persistent Scheduling (SPS) is based on the sensing within a (pre)-configured resource pool before choosing a resource from a list of candidate resources.

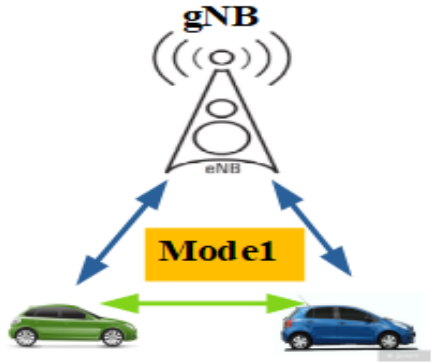


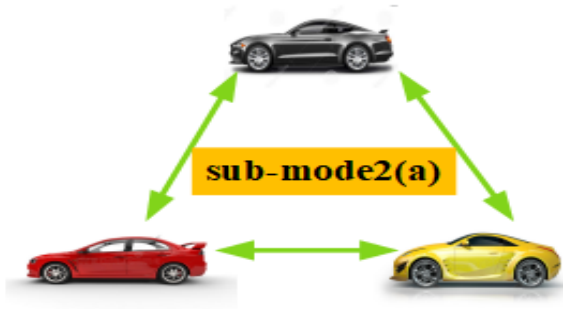


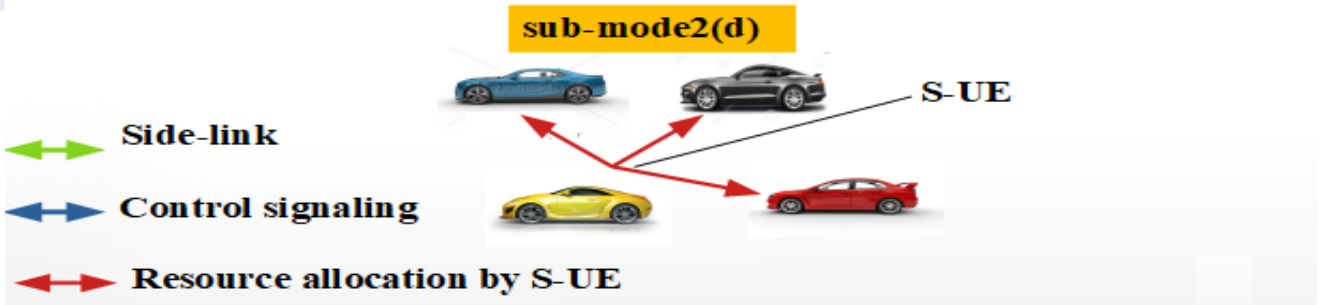
NR-V2X

RESOURCE ALLOCATION MODES IN 5G-V2X

Mode	LTE-V2X	NR-V2X
In-coverage	Mode 3	Mode 1
Out-of-coverage	Mode 4	Mode 2 (sub-mode 2(a), sub-mode 2(d))







- Sub-mode 2(a): UE autonomously selects side-link resources for its transmission
- Sub-mode 2(d): UE schedules and allocates side-link resources for other UEs

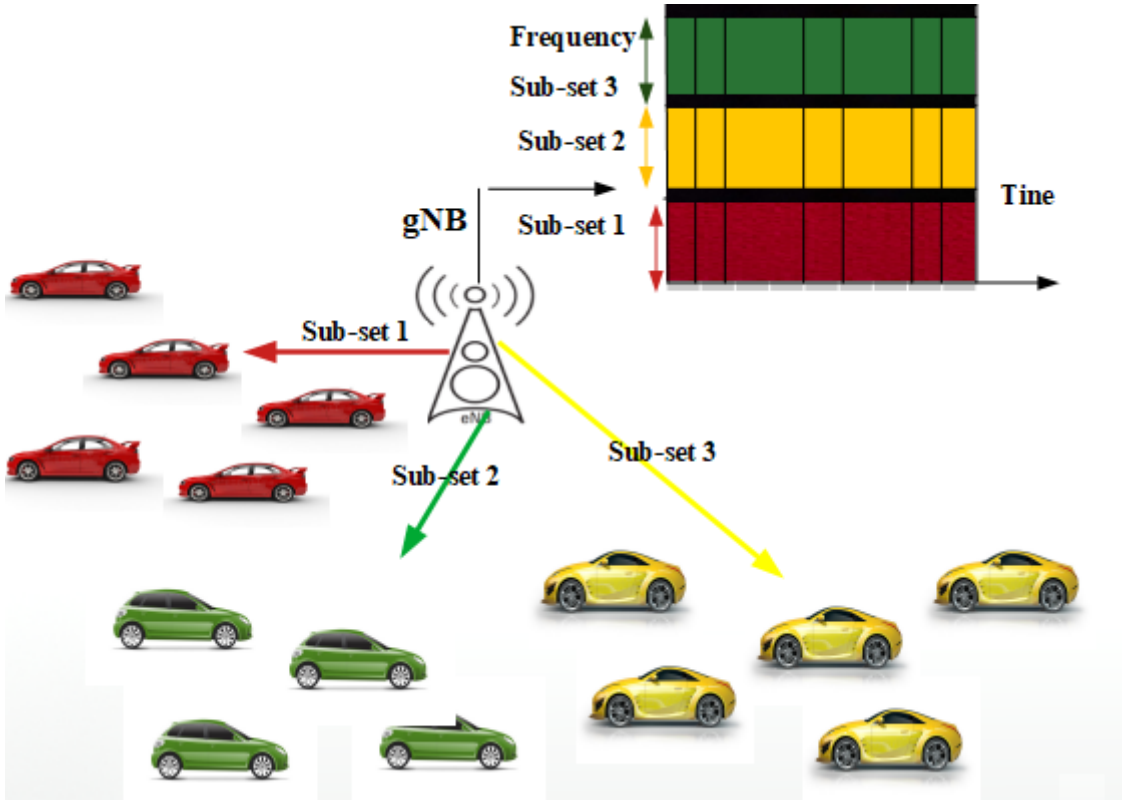
- ✓ How the S-UE is chosen?
- ✓ Which resource the S-UE should use when allocating resources to its members?
- ✓ How the S-UE can indicate the allocated resources to its members?
- ✓ Is there a probability of the interference between vehicles allocated by different S-UEs?
- ✓ What is the procedure of UE(s) when the S-UE disappears?

CONTRIBUTION:
New clustering-based resource allocation scheme for C-V2X mode 3

PRESENTATION

This new resource allocation solution is based on three steps:

- The clustering of vehicles according to their geographical position.
- The division of beacon resources into a sub-groups of resources..
- The application of a distance based resource reuse approach..



New clustering-based resource allocation scheme for C-V2X mode 3

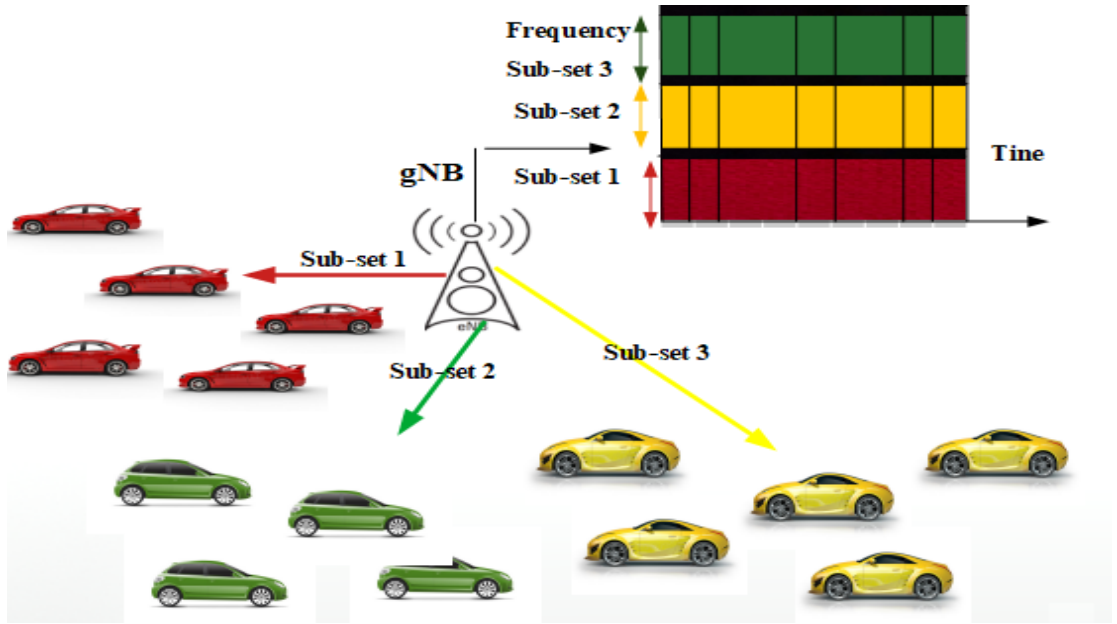
PRESENTATION

Clustering of vehicles:

- The eNB groups the vehicles into clusters according to their geographical positions.
- The eNB retrieves the geographical positions of vehicles either by the Up-link Time Difference Of Arrival (UTDOA) technique or by the Global Navigation Satellite System (GNSS).
- A cluster is defined by its centroid and its radius.

Clustering of resources:

- The division of resources into a sub-groups of resource takes into account the Half-duplex nature of the PC5 interface.
- Allocation of an orthogonal resources in time domain to vehicles belonging to the same cluster.

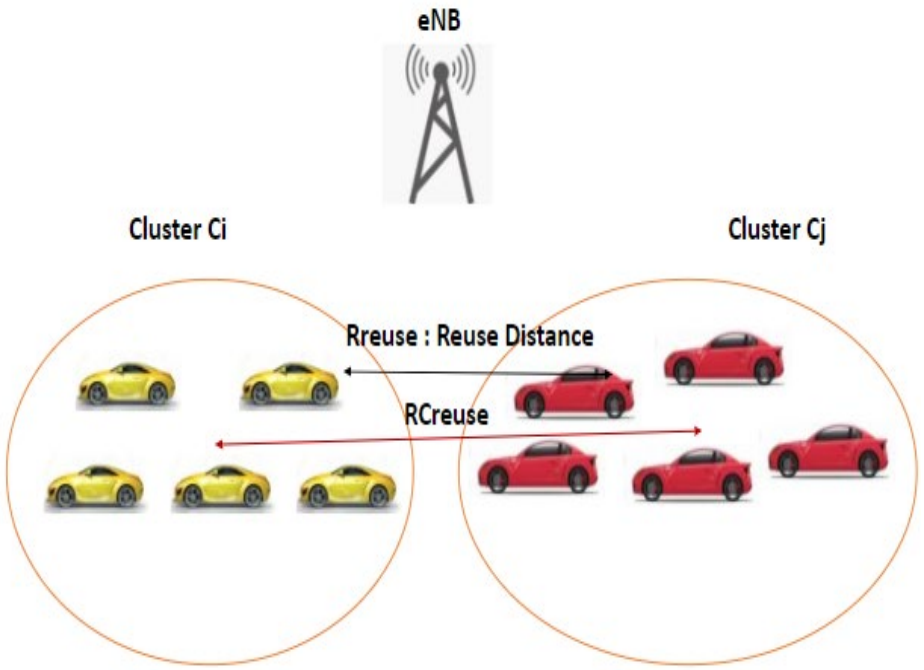


PRESENTATION

New clustering-based resource allocation scheme for C-V2X mode 3

The distance-based resource reuse approach is based on:

- The Computation of the inter-centroid distances of all cluster pairs.
- The selection of the clusters whose inter-centroid distances are greater than the fixed threshold **Rcreuse**.
- The minimization of the distance between the clusters reusing the same resources.



Algorithm 1 Algorithm for reusing of resources

C = $C1, C2, C3, ...Cm$: group of clusters
m: number of clusters
$S = S1, S2, S3, ...Sn$: sub-groups of resources
$RCreuse$ = resource reuse distance between clusters
Compute the inter-centroids distance for all cluster pairs
$A = RCreuse$: Initialize the vector containing the inter-centroids distances of clusters
for $i = 1 : n$ **do**
  for $j = i + 1 : n$ **do**
    Dij = inter-centroids distance for clusters Ci and Cj
    if (Dij <= RCreuse) **then**
      $A \leftarrow (A, Dij)$
      $B = A$ sorted in an ascendant order
      p = index of the minimum distance Dij in B
      Cluster Ci reuses the sub-group of resources used by cluster Cp
    end if
  end for
end for

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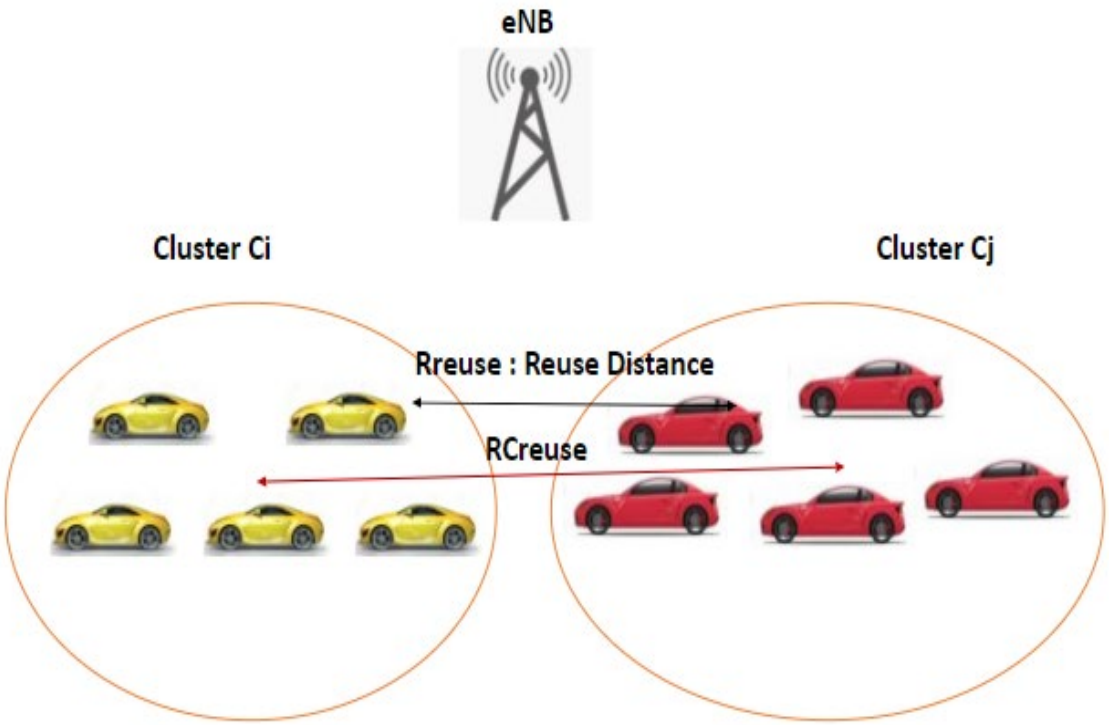
PRESENTATION

New clustering-based resource allocation scheme for C-V2X mode 3



$$Rcreuse = Rreuse + 2 * R$$

- The Rreuse is computed following the equations presented in [1] and it depends on the choice of the Modulation and Coding Scheme (MCS).

PRESENTATION

New clustering-based resource allocation scheme for C-V2X mode 3

Benchmark Algorithms

- **Benchmark algorithm 1 (Algo 1)** :The Beacon Resources (BR) are allocated by the network with an ordered manner. The eNB sorts the resources and assigns to each vehicle the first free BR .
- **Benchmark algorithm 2 (Algo 2):** The BRs are assigned to vehicles with the reuse of resources between them. Here, the resource reuse approach is based on the maximum distance for reuse denoted as Rreuse parameter.

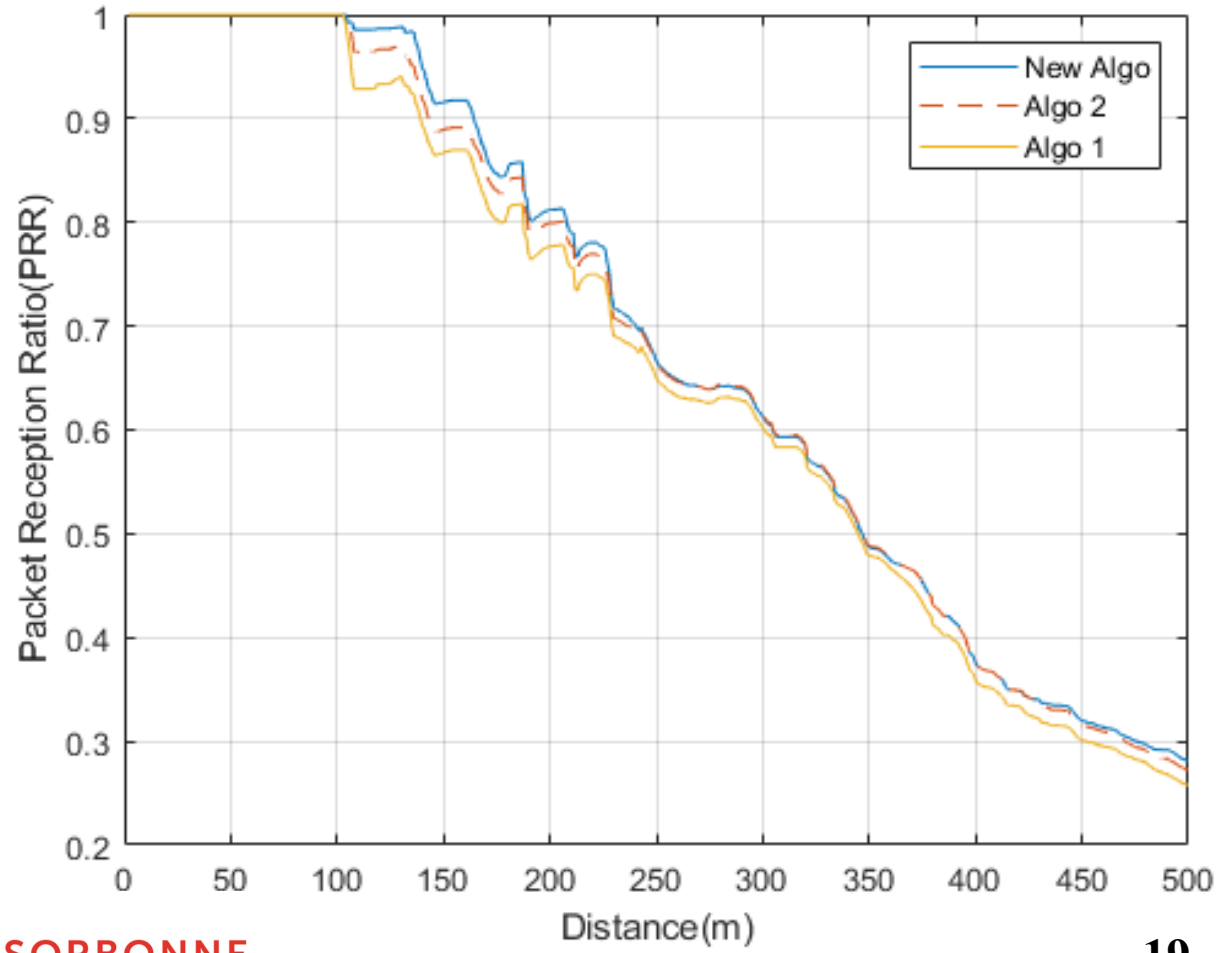
Simulation scenario

- The simulation is conducted through the LTEV2VSim: a Matlab-based open-source simulator dedicated for resource allocation in LTEV2Vcommunications.
- The vehicular scenario is based on a realistic traffic traces generated with PTVVISim simulator of an urban scenario of Bologna.
- We choose a scenario with **40 vehicles grouped into 6 clusters.** The radius of the cluster is 200 m.

Key Performance Indicators (KPI)

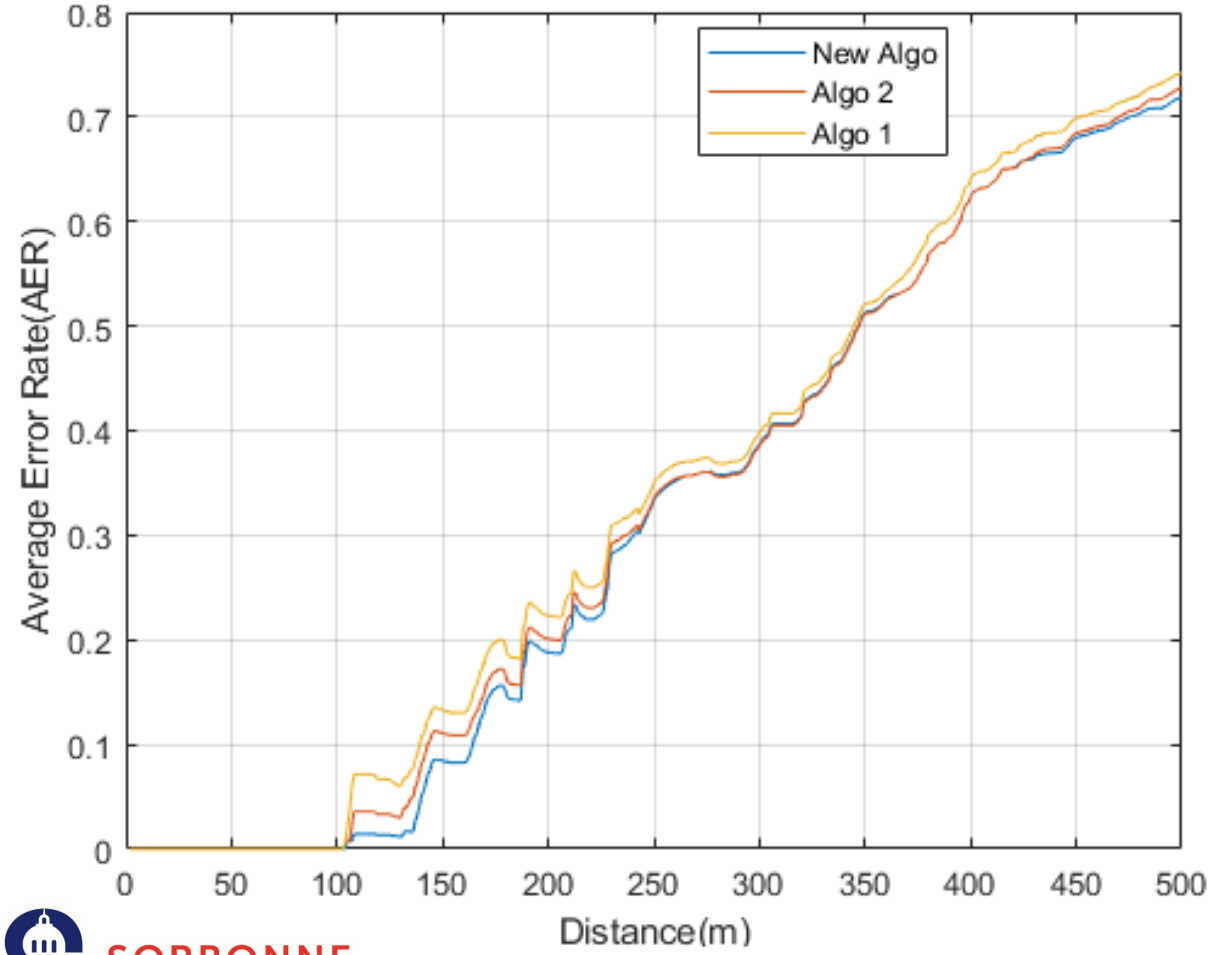
- The **Packet Reception Ratio** (**PRR**) is defined as the ratio between the number of successfully received beacons and the total number of neighbors.
- The **Average Error Rate** (**AER**) is defined as the ratio between the number of not correctly decoded beacons and the total number of beacons expected to be received.
- **The Resource Reuse Rate** (**T**) that we define by the ratio between the number of clusters reusing resources and the total number of clusters in the scenario.

Analysis of Results



- The PRR decreases with the increase of the distance between transmitter and receiver.
  - For distances under 100 m, the three algorithms present a high performance level with a high PRR value of about 99.99%.
- For the same distance of 150 m, the PRR of our algorithm is about 92%, while the PRRs of the two benchmark algorithms Algo1 and Algo2 are respectively of about 86% and 88%.

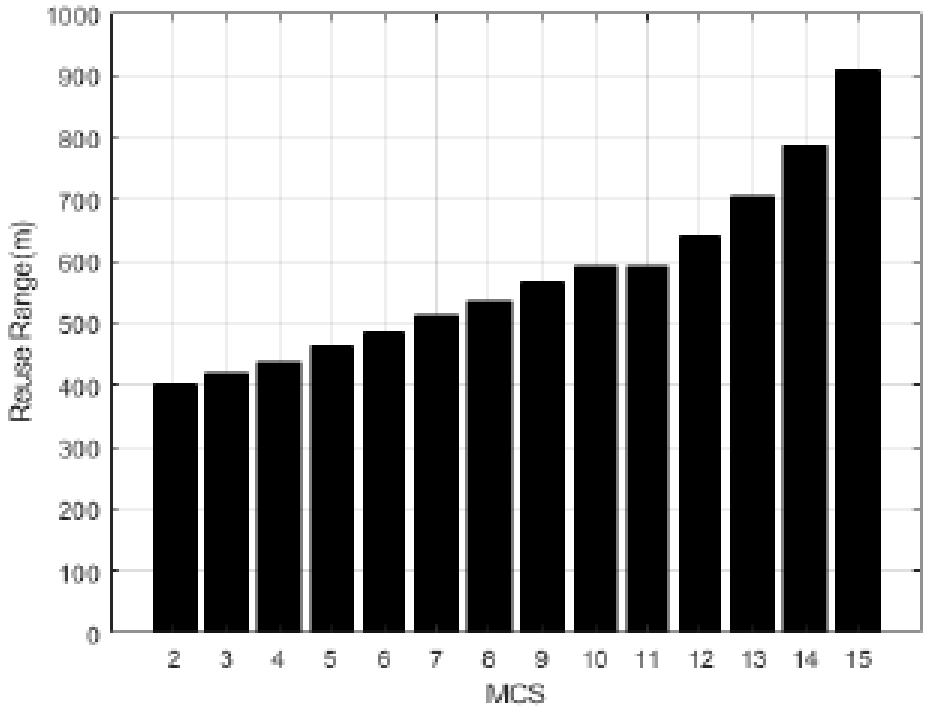
Analysis of Results

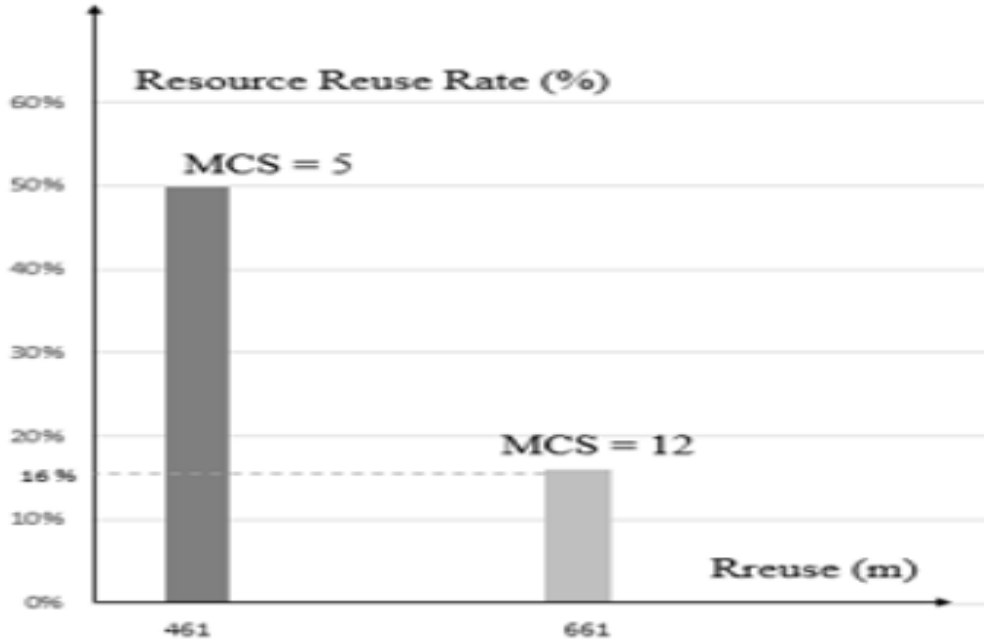


- The Average Error Rate (AER) increases with the increase of the distance between transmitter and receiver.
- For the distance of 150 m, the AER of our proposal is about 0.09 while the AERs of the two benchmark algorithms Algo1 and Algo2 are respectively 0.14 and 0.11.

Analysis of Results

New clustering-based resource allocation scheme for C-V2X mode 3



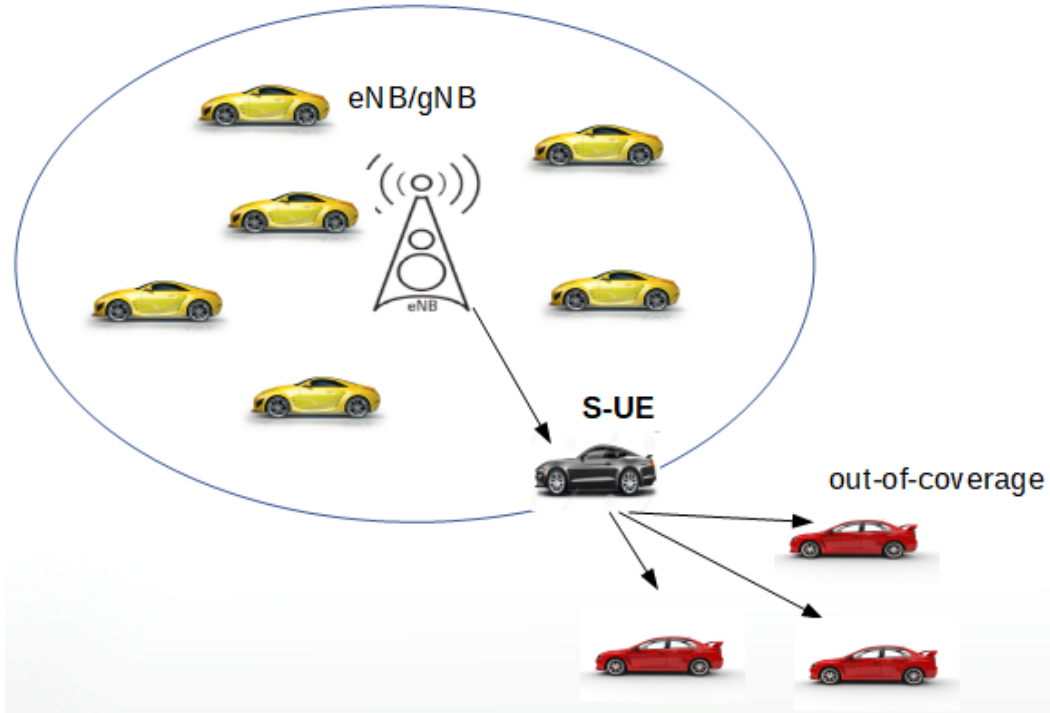


- ✓ The resource reuse rate decreases with the increase of the Rreuse.
- ✓ For T = 50%, the resource allocation capacity is also increased by 50%.
- ✓ The resource allocation capacity is defined as the total number of resources that can be allocated to vehicles without collisions.

New approach for network-assisted resource allocation scheme in out-of-coverage scenario

Perspectives

- ❑ Extend this under coverage clustering-based architecture to the out-of-coverage scenario.
- ❖ The vehicles situated out-of-coverage scenario are grouped into clusters.
- ❖ The same sub-sets of resources used in mode 3 will be re-assigned to the out-of-coverage clusters through an intermediate vehicles.
- ❖ The intermediate vehicles are those vehicles situated at the border of the cellular coverage.



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FOR YOUR
ATTENTION