Chapter 3: Broadcasting in VANET

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Goals of this chapter

- Study existing broadcasting results in VANETs

Outline

3-3: **Broadcasting in VANET**

3-4: **On the Broadcast Storm Problem in Ad hoc Wireless Networks**

3-3: Broadcasting in VANET

Ozan Tonguz, Nawapom Wisitpongphan

IEEE 2007 Mobile Networking for Vehicular Environments

Section Outline

- Introduction
- Different Regimes for Broadcasting in VANET
- Distributed Vehicular Broadcast Protocol (DV-CAST)
- Discussion & Conclusion

Introduction

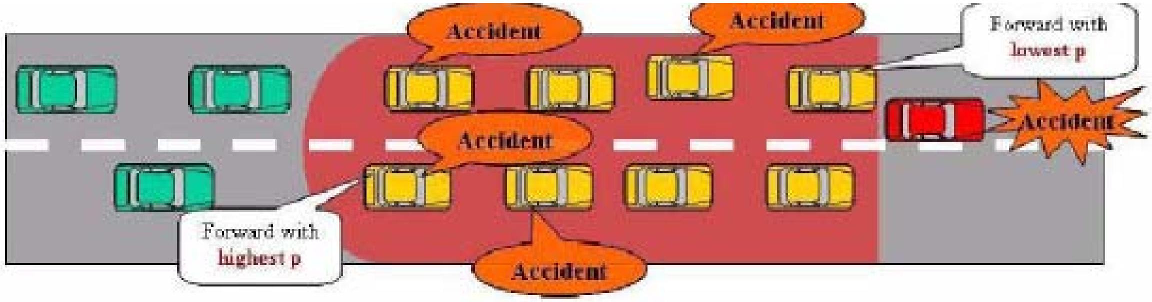
- Broadcasting in VANET is very different form routing in mobile ad hoc networks (MANET).
  - Network topology
  - Mobility patterns
  - Demographics
  - Traffic patterns at different times of the day
- Conventional ad hoc routing protocols such as **DSR** and **AODV** will not be appropriate in VANETs for most vehicular broadcast applications.

Different Regimes for Broadcasting in VANET

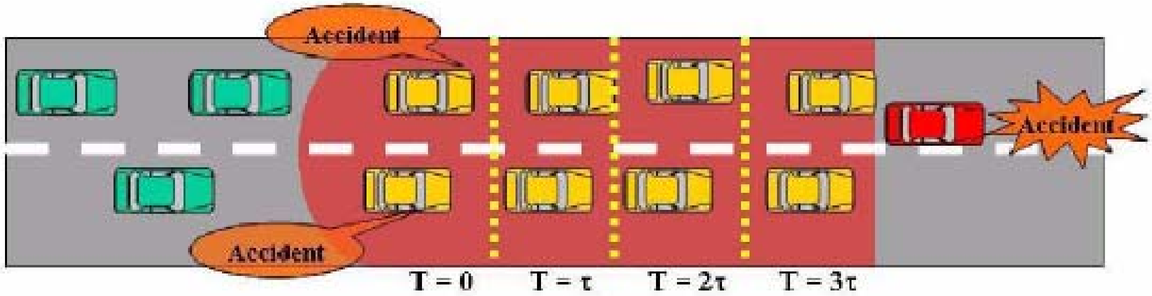
- **On the Broadcast Storm Problem in Ad hoc Wireless Networks (**IEEE Wireless Communications, to appear**)**
- There are three different regimes of operation in VANET：
  - **Dense Traffic Regime**
    - Blindly broadcasting the packets may lead to frequent contention and collisions in transmission among neighboring node.
  - **Sparse Traffic Regime**
    - The network re-healing time, which capture the delay that incurs in delivering messages between disconnected vehicles, can vary from a few seconds to several minutes.
  - **Regular Traffic Regime**
    - In a regular traffic regime, however, not every vehicle see the same local topology, i.e., some may have very few neighbors while some have many neighbors.

Dense Traffic Regime

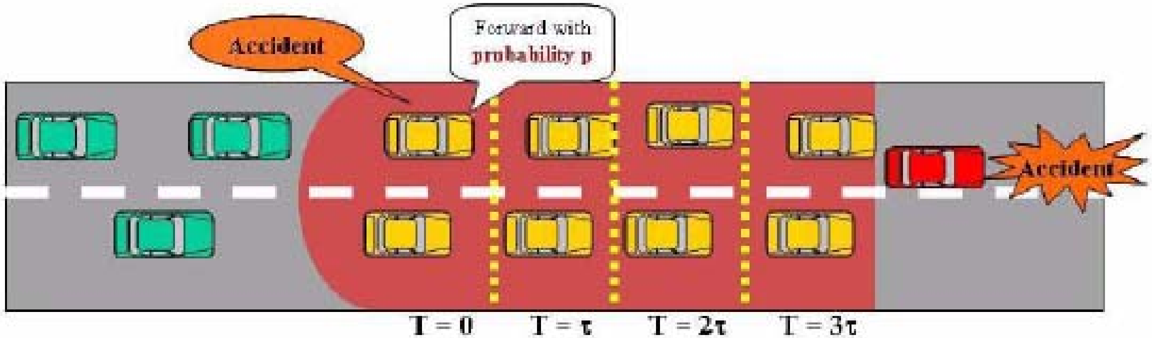
Broadcast Suppression Techniques.



(a) Weighted p-persistence

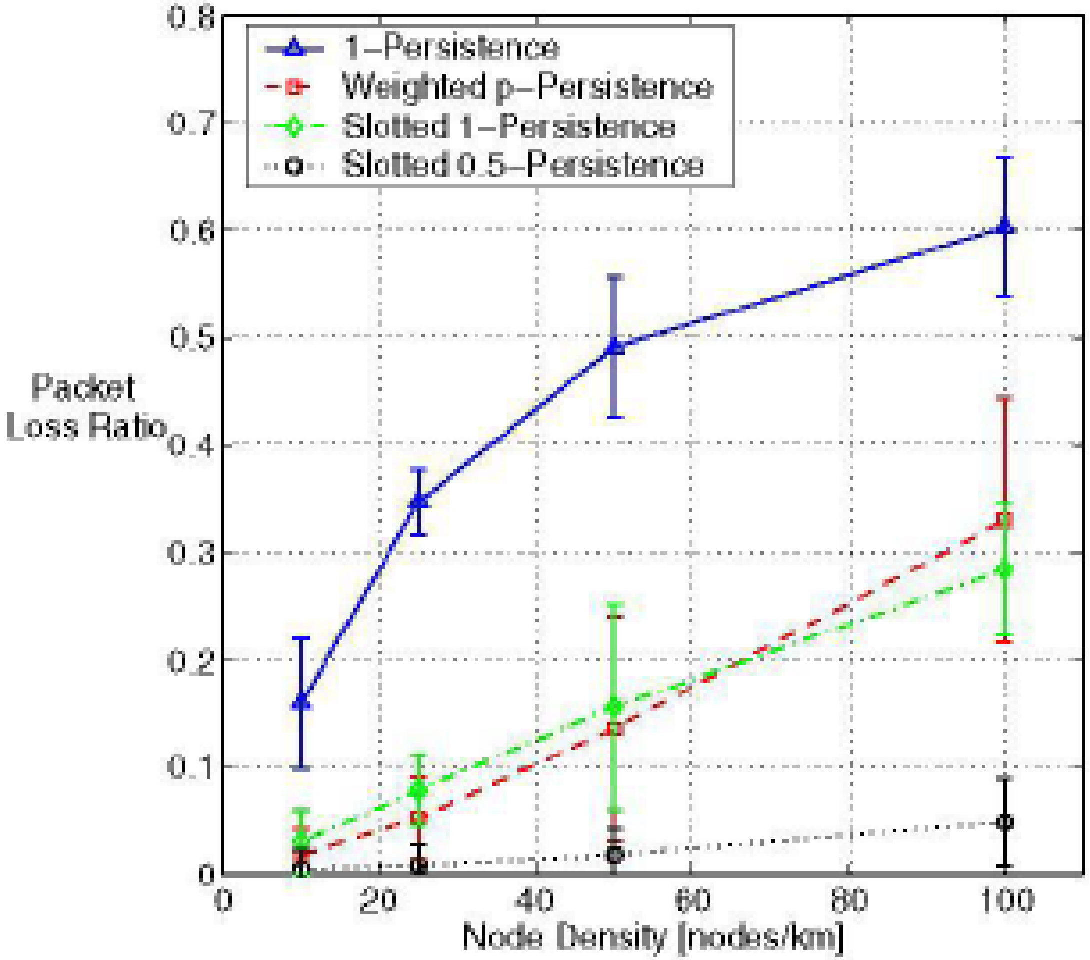


(b) Slotted 1-persistence scheme



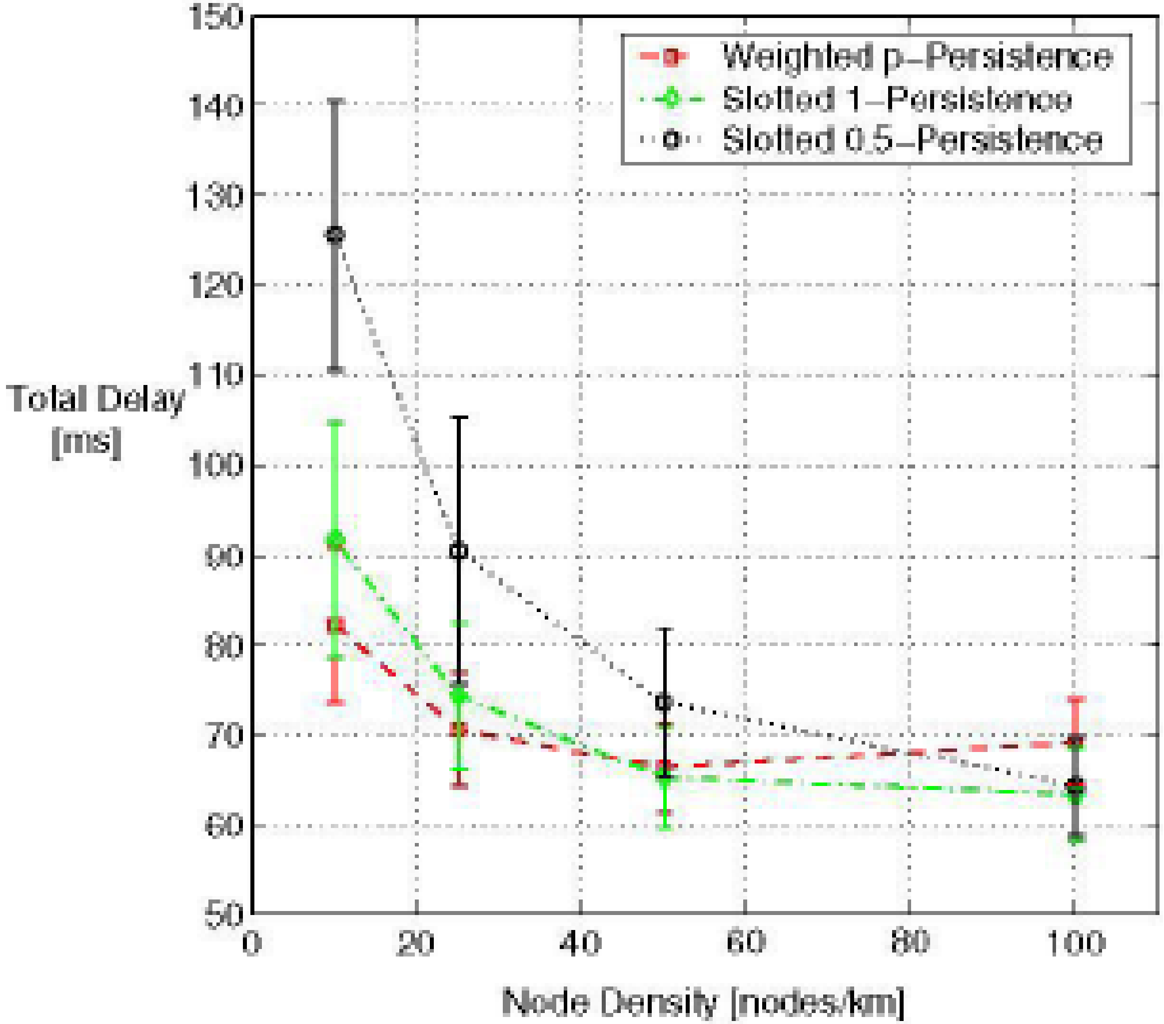
(c) Slotted p-persistence scheme.

Packet Loss Ratio



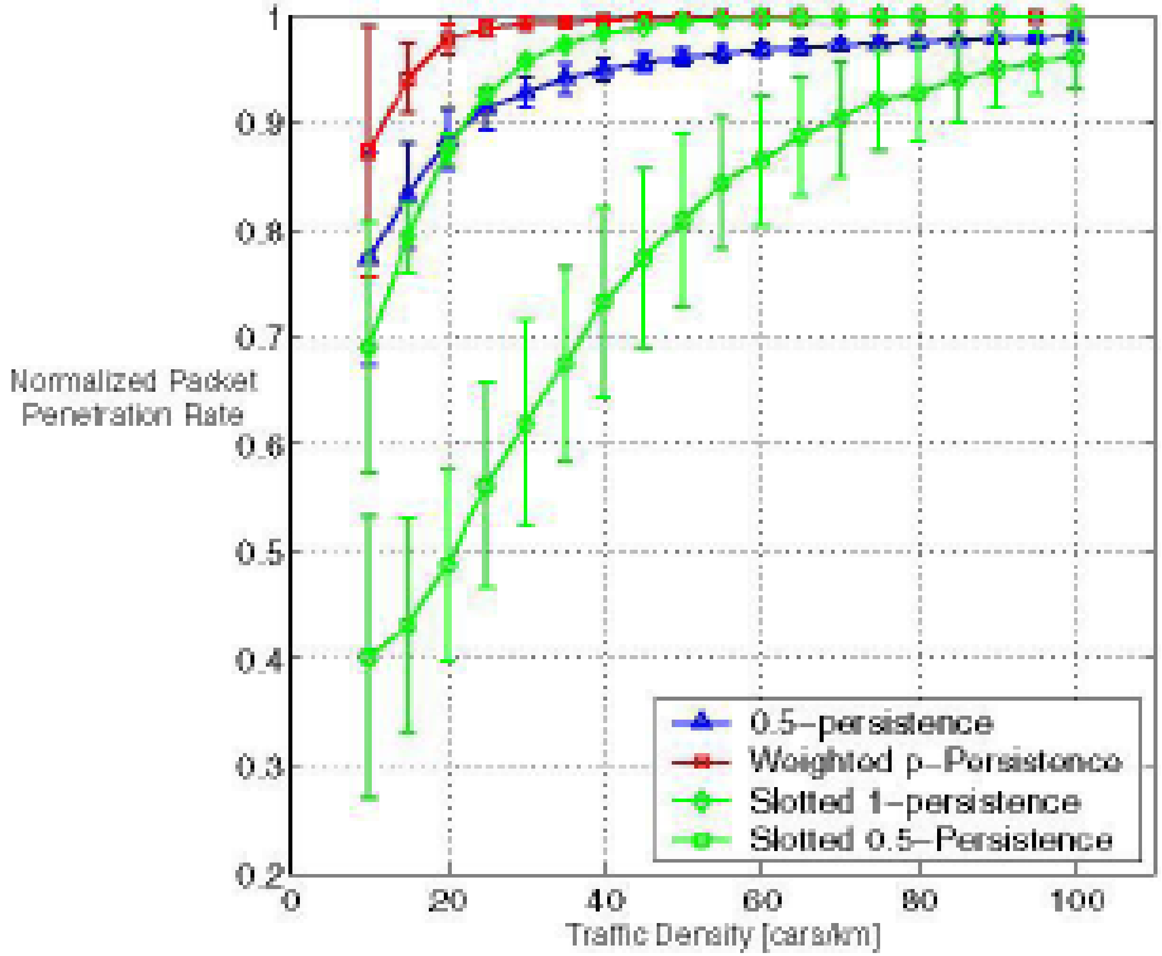
(a) Packet Loss Ratio in VANET.

Total Delay



(b) Time required to disseminate the broadcast message to nodes that are 10 km away.

Normalized Packet Penetration Rate



(c) Normalized Packet Penetration Rate

Cont.

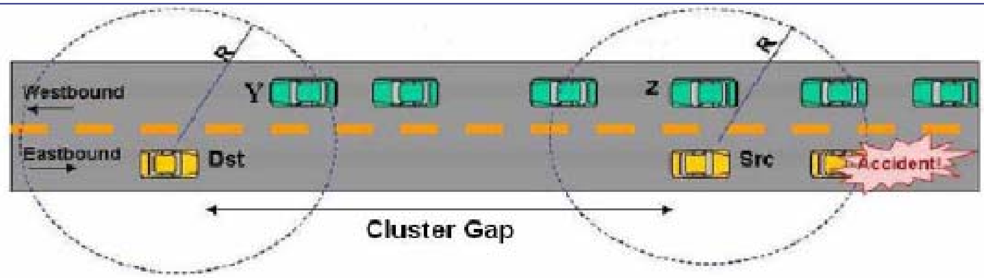
- Observe that the slotted p-persistence scheme can substantially reduce the packet loss ratio at the expense of a slight increase in total delay and reduced penetration rate.

Cont.

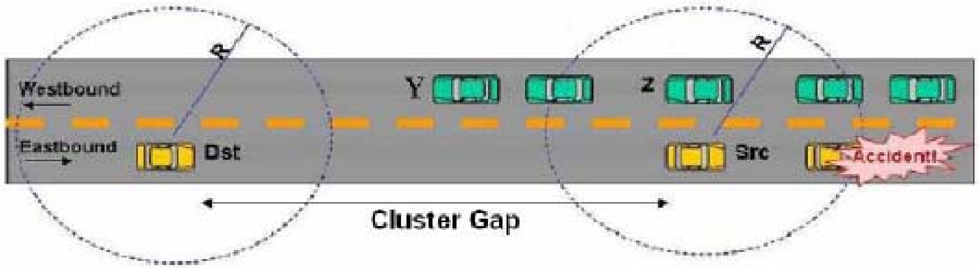
- Wisitpongphan, O. Tonguz, F. Bai, P. Mudalige, and V. Sadekar, "**On the Routing Problem in Disconnected Vehicular Ad Hoc Networks**," Proc. IEEE INFOCOM, 2007.

Sparse Traffic Regime

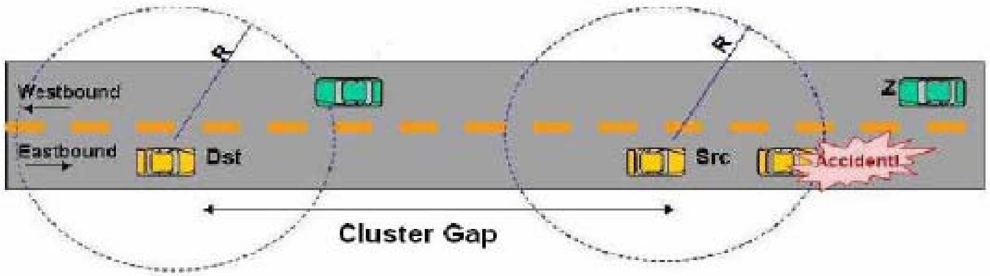
Illustration of the disconnected VANETs.



(a) Best case scenario: packet can immediately be relayed to the target vehicles via vehicles in the opposite traffic

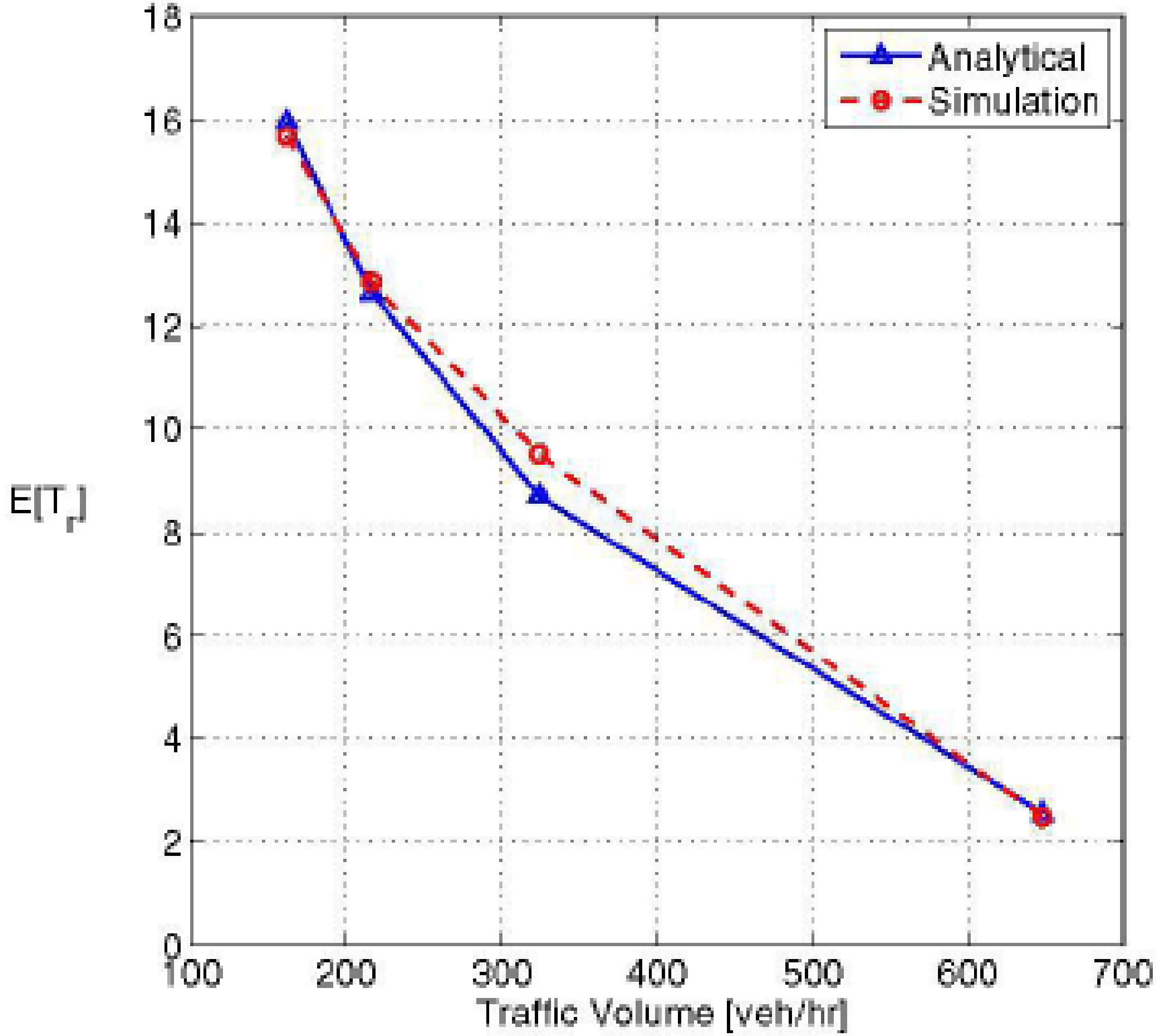


(b) Intermediate case scenario: vehicles in the opposite direction is responsible for store-carry-forward the message back to vehicles in the message forwarding road



(c) Worst case Scenario: packet cannot immediately be relayed to vehicles in the opposite direction

Average per-gap re-healing time



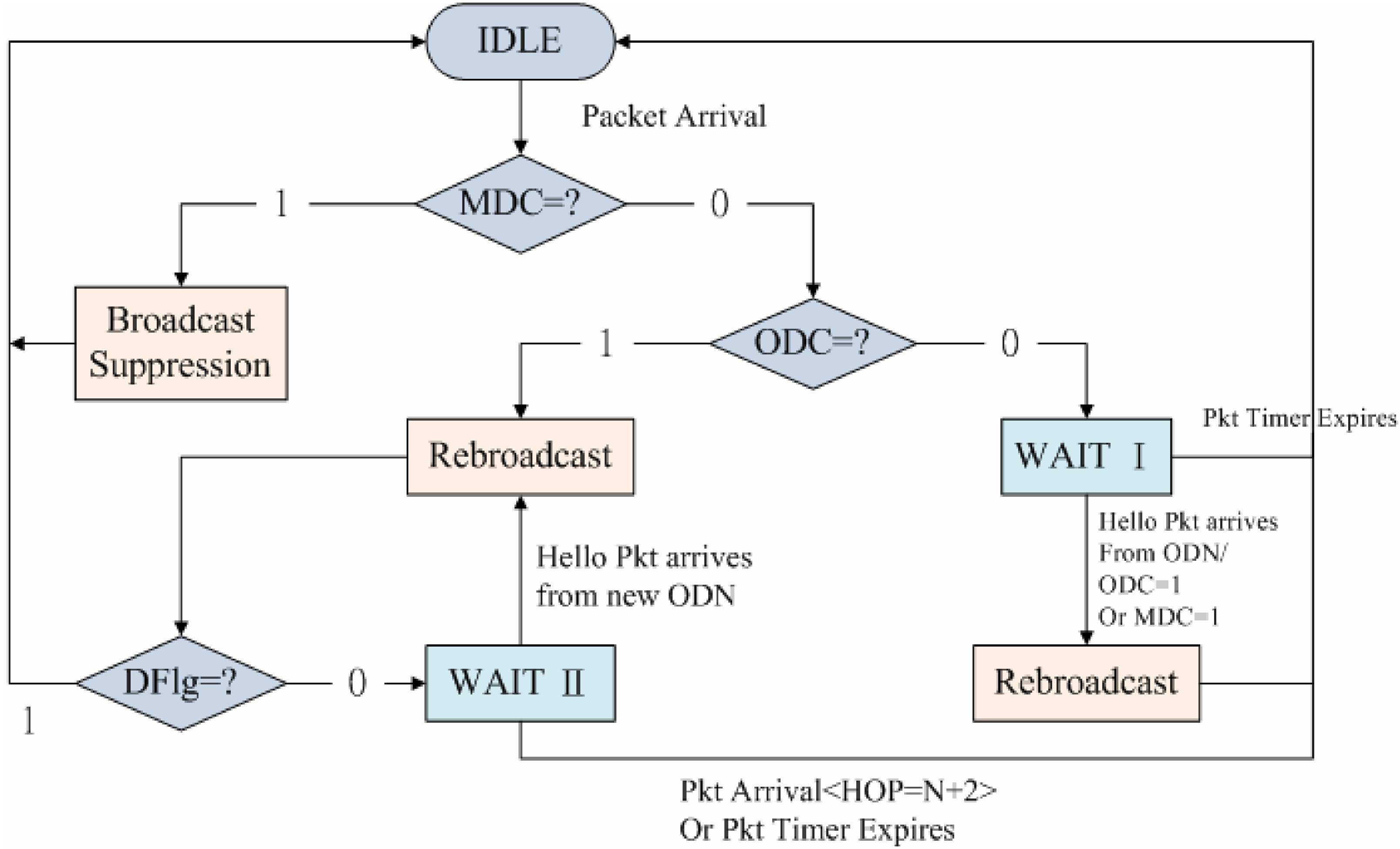
Distributed Vehicular Broadcast Protocol (DV-CAST)

- In designing DV-CAST protocol, the following assumptions were made：
  - It assume that the infrastructure is not available in the network considered.
  - Assume that each vehicle, which has a Global Positioning System (GPS) and a wireless communication device.
- Use a per-hop routing based approach which uses only local connectivity information to make a routing decision.
- Each vehicle continuously monitors its local connectivity in order to determine which state it is operating in at the time of the packet arrival.

DV-CAST Protocol

- Routing Parameters：
  - Destination Flag (**DFlg**)
    - Determine whether it is the intended recipient of the message that is moving in the same direction as the source.
  - Message Direction Connectivity (**MDC**)
    - Determine whether it is the last vehicle in the group/cluster.
  - Opposite Direction Connectivity (**ODC**)
    - Determine whether it is connected to at least one vehicle in the opposite direction.

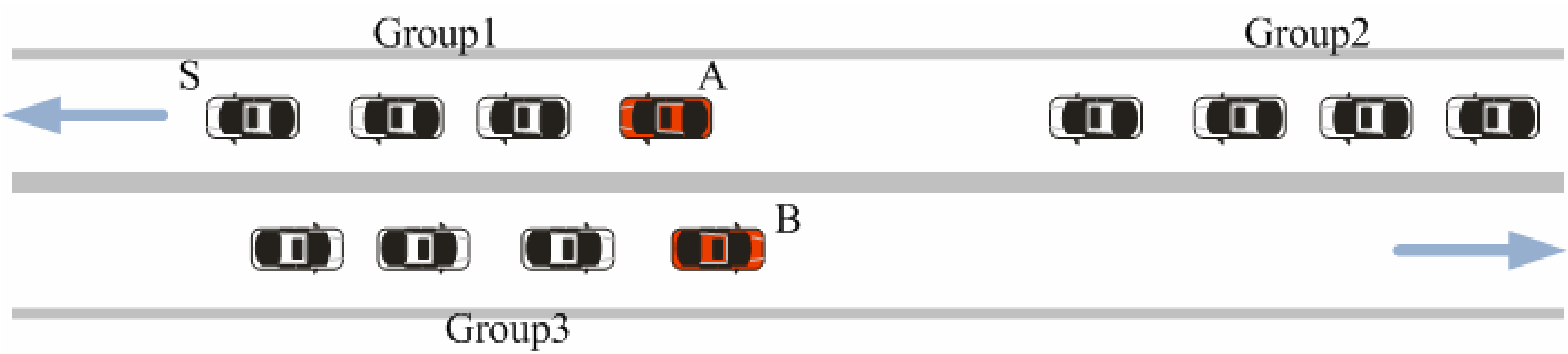
Decision Tree for DV-CAST Protocol



ODN=Opposite Direction Neighbor

Case Ⅰ：Well-Connected Neighborhood

- A vehicle is said o be in well-connected neighborhood if it has at least one neighbor in the message forwarding direction (**MDC=1**)
- Using the Dense Traffic Regime ways.

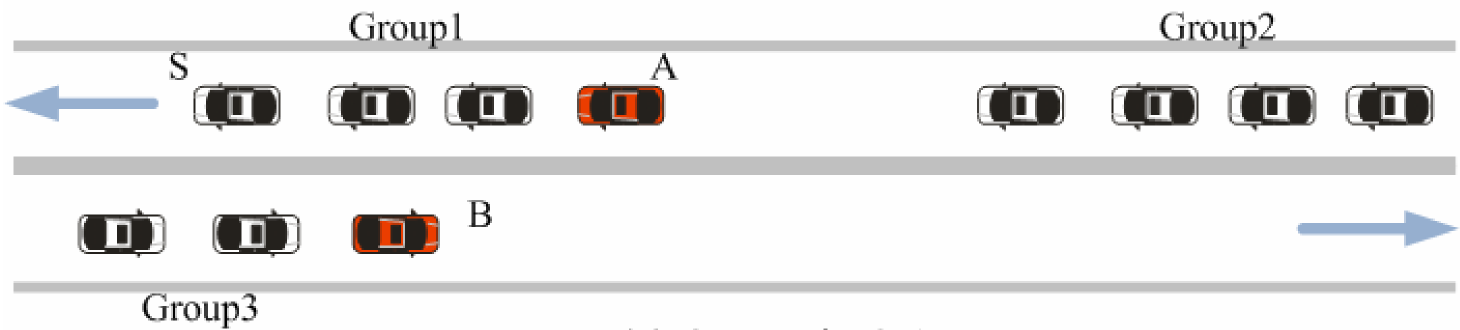


Cont.

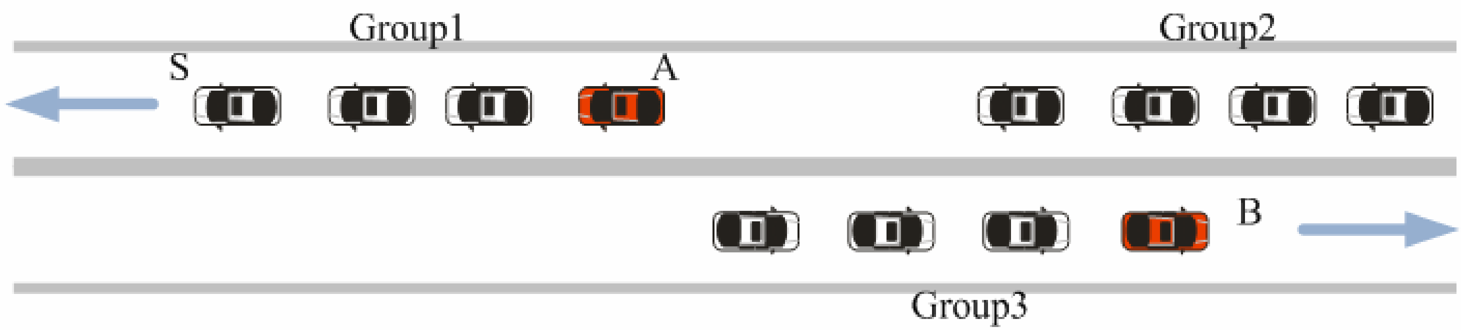
- Each vehicle in Group 1, except for **A** which is the last vehicle in the cluster (MDC = 0), uUpon receiving the broadcast message from S, will have the following flags <MDC =1, ODC = 1/0, DFlg = 1>.
- Vehicles Group 3 except for **B** will also have similar flags, i.e., <MDC = 1, ODC = 1/0, DFlg = 0>.
- Each vehicle from both groups except for A & B will apply the broadcast suppression algorithm.

Case Ⅱ ：Sparsely-Connected Neighborhood

- A vehicle is operating in a sparse traffic regime if it is the last one in a cluster.



(a) Scenario 2.1

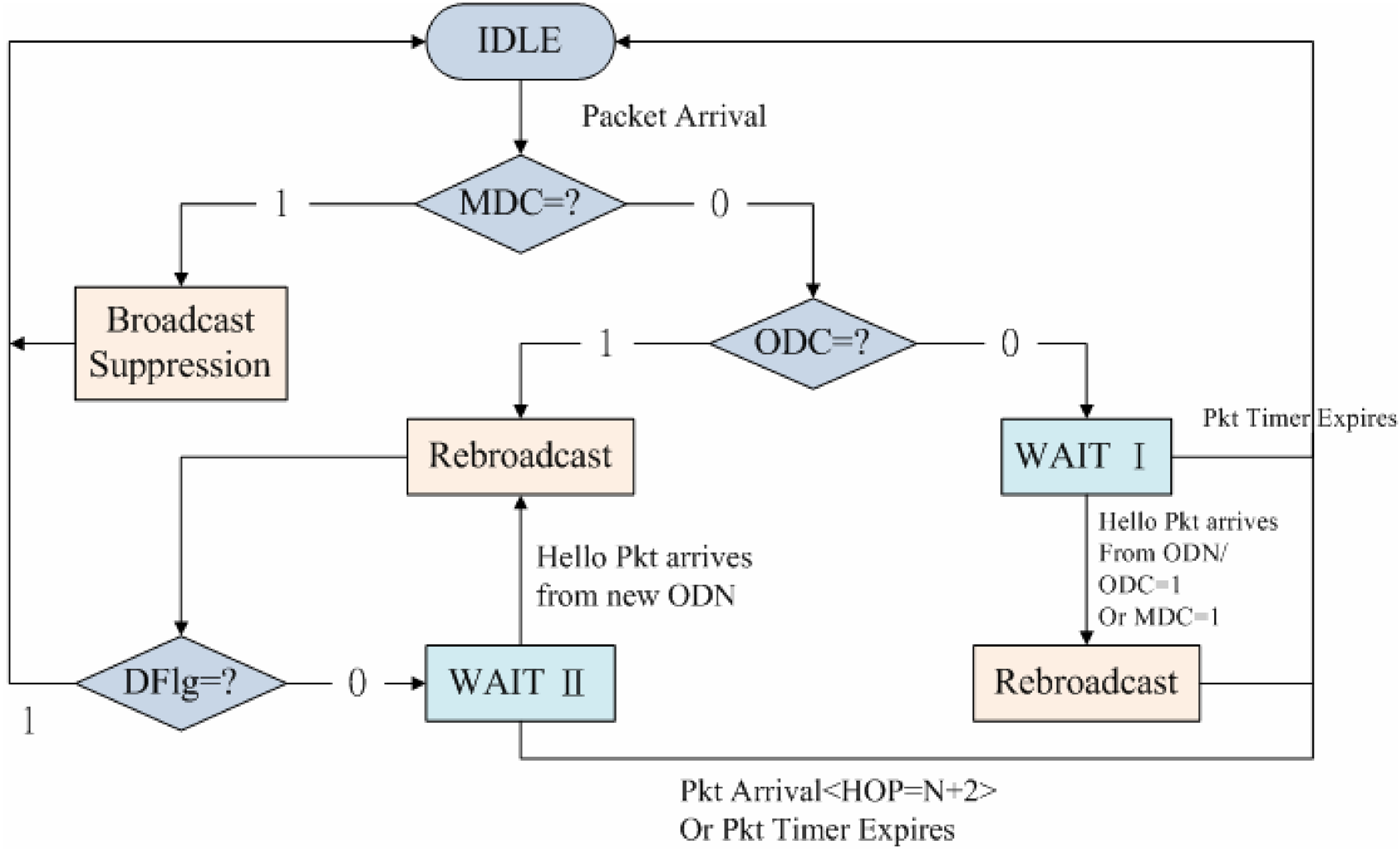


(b) Scenario 2.2

Cont.

- A vehicle in this regime is said to be in a sparsely-connected neighborhood if there is least one neighbor in the opposite direction as in the case vehicles A and B in last Figure.
- The parameters for these vehicle should be set to <**MDC = 0, ODC = 1**, DFlg = 0/1>.

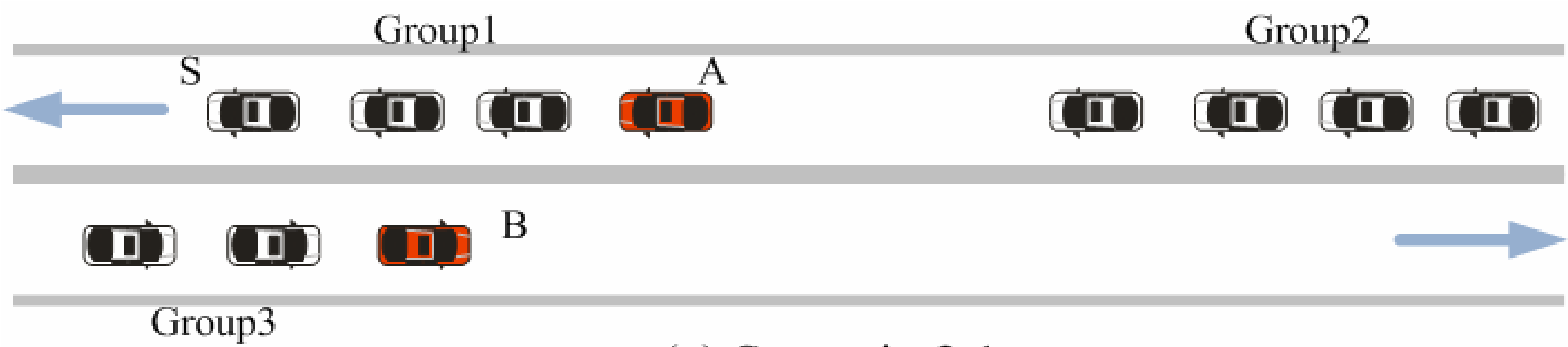
Decision Tree for DV-CAST Protocol



ODN=Opposite Direction Neighbor

Scenario 2.1:

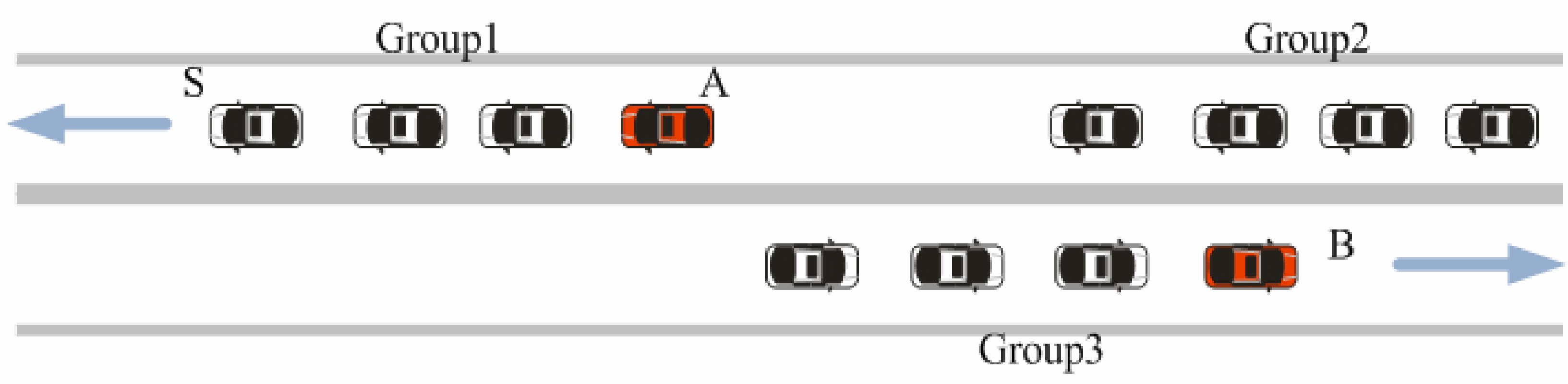
- After the rebroadcast, if B comes into contact with vehicles in Group 2, B will rebroadcast and go into the WAIT II state again.
- This time, however, B will have to wait for an implicit acknowledgment that is the rebroadcast of the message with greater hop count and go into the IDLE state.



(a) Scenario 2.1

Scenario 2.2:

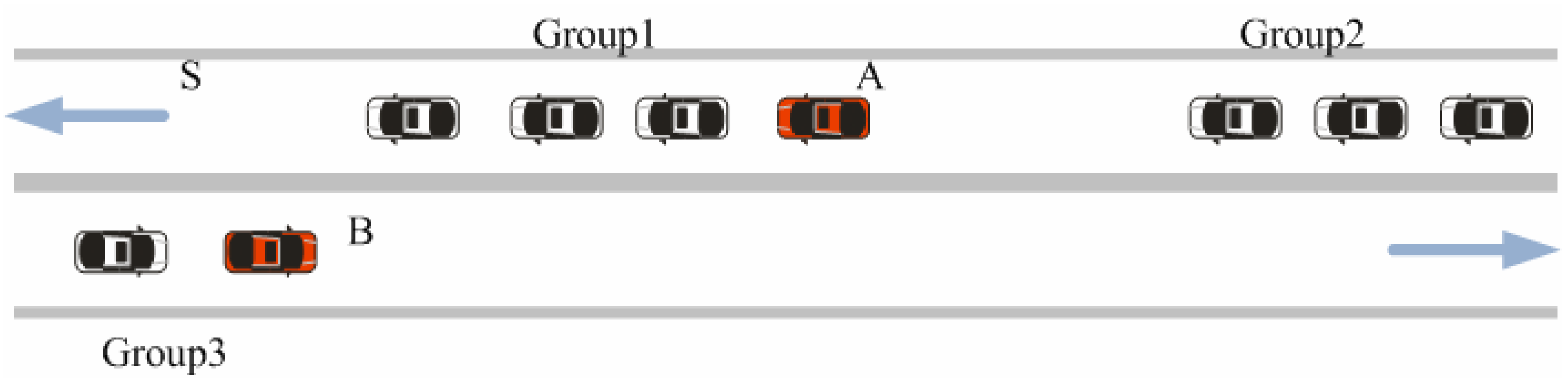
- After A and B rebroadcast, they will go into WAIT I state.
- Since Group 3 is connected both Group 1 & 2, both A and B will hear a rebroadcast with greater hop count and will make a transition into the IDLE state.



(b) Scenario 2.2

Case Ⅲ：Totally Disconnected Neighborhood

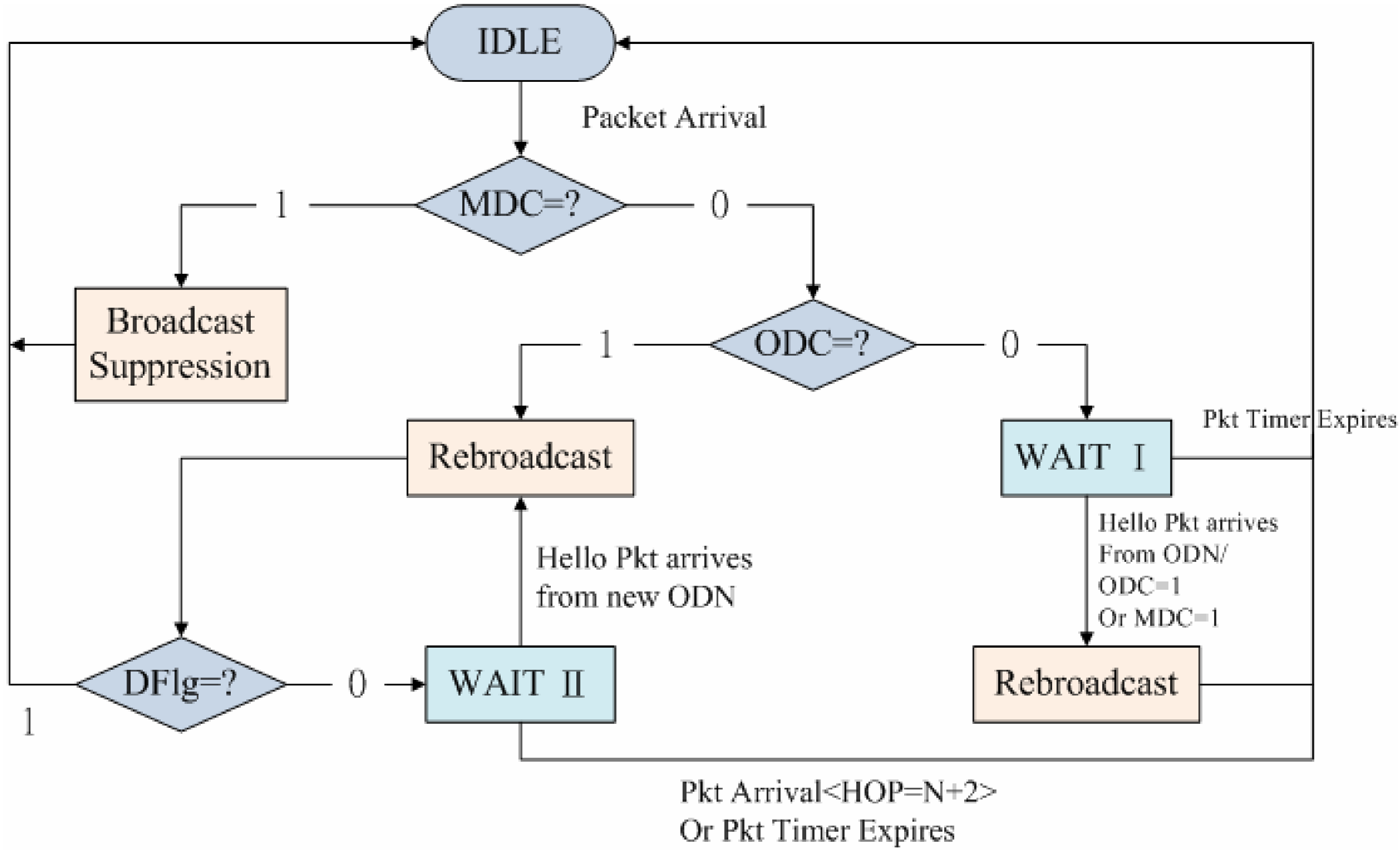
- A vehicle, operating in a sparse traffic regime, is said to be a totally disconnected neighborhood if it has no neighbor in the message forwarding direction and is not connected anybody in the opposite direction.



Cont.

- A is disconnected from Group 3 and Group 2. The flags should be set to <**MDC = 0, ODC = 0,** DFlg = 1>.
- For this scenario, A will have to go to the **WAIT state** and wait for the hello packet from vehicles in Group 3 or from vehicle in Group 2 who may have caught up with Group 1 while A is in the WAIT I state.

Decision Tree for DV-CAST Protocol



ODN=Opposite Direction Neighbor

Discussion & Conclusion

- Additional information such as GPS trails may be needed in irregular topologies such as highway exit or urban areas.
- Another important factor that could cause the protocol to fail is the accuracy of the local topology information.
- The proposed DV-CAST protocol is fully distributed and relies on the local information provided by one-hop neighbors via periodic hello messages.