

## Medium Access Protocols for Cooperative Collision Avoidance in Vehicular Ad-Hoc Networks

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### Outline

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- Overview of CCA in VANETs
- Overview of MAC protocols
- Standardization activities
- Existing analytical models
- Conclusion

# Overview of CCA in VANETs



Figure: VANET scenario overview

# Overview of CCA in VANETs

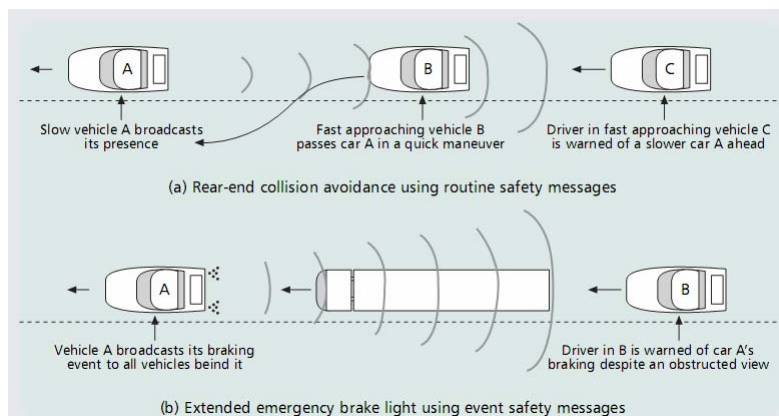


Figure: Safety applications for VANETs

## Overview of MAC Protocols



- MAC protocol plays an important role in
  - sharing wireless medium efficiently
  - disseminating safety messages
    - to all nearby vehicles
    - within time constraint
- In VANETs main considerations should be
  - Topology changes due to fast moving vehicles
  - Low priority for energy constraint
  - Predictable directionality
  - Time synchronization using GPS device

## Overview of MAC Protocols



- Types of MAC protocols considered for VANETs
  - Time schedule-based
  - Space division multiple access (SDMA) based
  - Cluster-based
  - Directional antenna-based
  - CSMA-based

# Time schedule based-MAC protocols

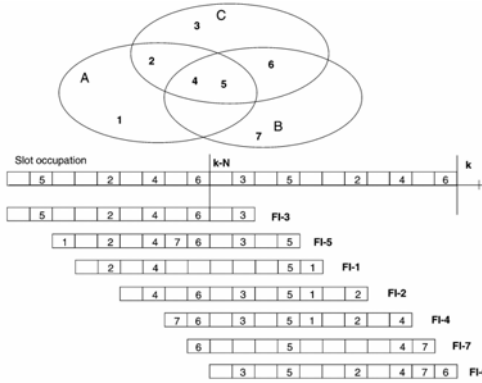


Figure: Example of FI information propagation in ADHOC MAC

Reference: Borgonovo, F., Capone, A., Cesana, M., & Fratta, L. (2004). ADHOC MAC: new MAC architecture for ad hoc networks providing efficient and reliable point-to-point and broadcast services. *Wireless Networks*



# SDMA-based MAC Protocols

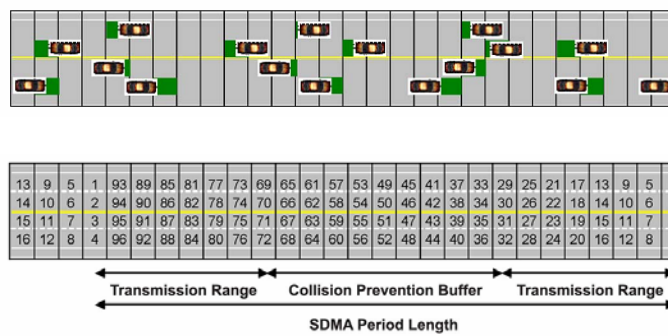


Figure: Cell mapping in SDMA protocol

Reference: Jeremy, J. B., & Azim, E. (2007). A reliable link-layer protocol for robust and scalable intervehicle communications. *IEEE Transactions on Intelligent Transportation Systems*



## SDMA-based MAC Protocols



- Extended to provide multiple vehicles in a single cell
- Utilize the unused channels
  
- Drawbacks
  - Optimum mapping function for all types of highways scenarios
  - Synchronize among all the vehicles when the road structure changes
  - Imperfect position accuracy and time synchronization can degrade SDMA performance
  - Accurate power control to manage interference with other space divisions using the same channel

## Cluster-based MAC Protocols

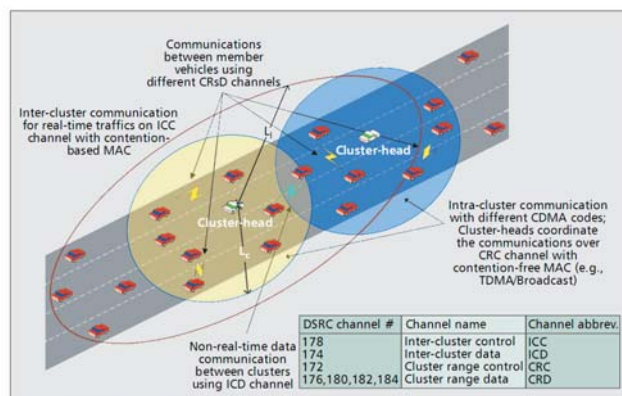


Figure: Cluster-based multichannel communications architecture

## Directional antenna-based MAC Protocols

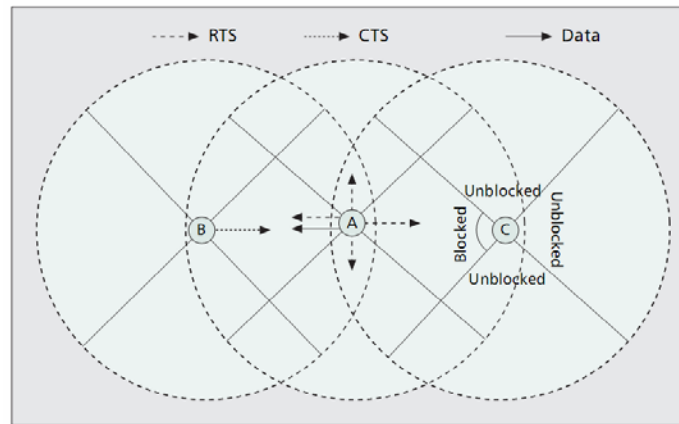


Figure: The D-MAC process

## CSMA-based MAC Protocols

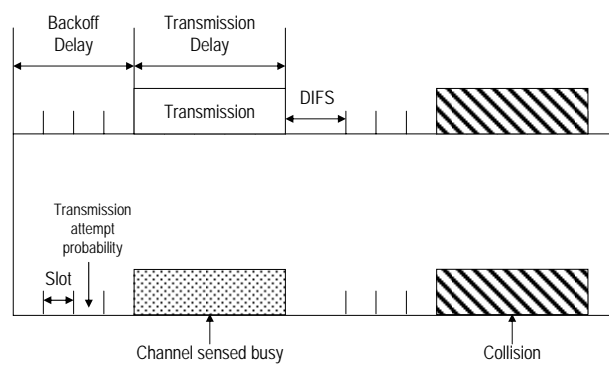


Figure: Backoff mechanism in IEEE 802.11 DCF

## Standardization activities



- US FCC allocated 75 MHz of spectrum at 5.9 GHz for Dedicated Short Range Communications
- ASTM developed a standard for the PHY and the MAC layer based on IEEE 802.11
- IEEE 802.11p amendment for DSRC PHY & MAC
  - PHY layer based on IEEE 802.11a 10MHz OFDM
  - Improved receiver performance requirements
  - MAC layer consists DCF and EDCAF
  - Reduced overhead for efficient group setup
- In Europe ETSI is working on a set of standards for ITS architecture

## Existing analytical models



- Performance evaluation for MAC protocol is essential
  - to investigate whether safety message requirements are met
  - to optimize protocol parameters
- Analytical models for wireless LANs
  - Suitability in VANETs environment
  - Different performance metrics

## Existing analytical models



### Bianchi (2000) model

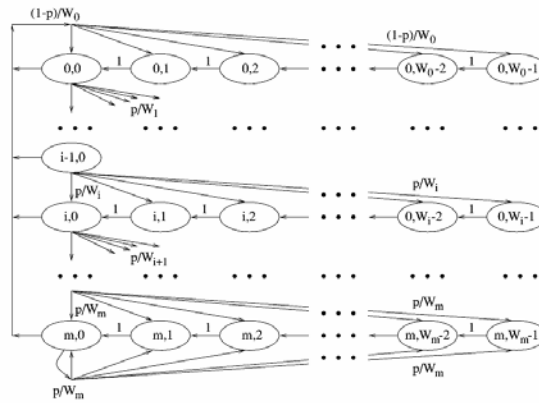


Figure: 2D Markov chain model for backoff process

## Existing analytical models



### Malone (2007) model

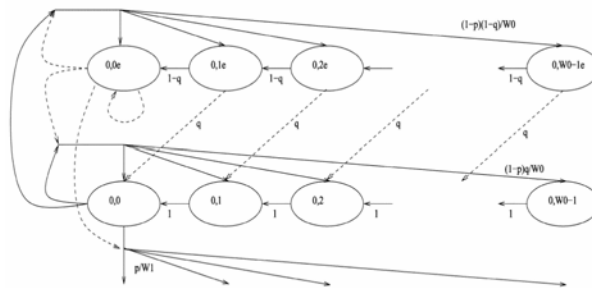


Figure: Nonsaturated Markov chain

## Existing analytical models



Tickoo (2008) model

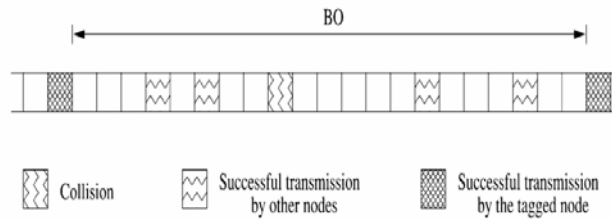


Figure: Interleaving of transmissions and collisions contributing to the service time

Reference: Tickoo, O., & Sikdar, B. (2008). Modeling queueing and channel access delay in unsaturated IEEE 802.11 random access MAC based wireless networks. *IEEE/ACM Transactions on Networking*

## Existing analytical models



□ Tsertou (2008)

- Markov chain based model assumes renewal point
- Hidden terminals are not synchronized
- Geometric distribution based models require no transmission from hidden node in vulnerable period
- Transmission probabilities in successive slots are dependent
- Fixed length slot instead of variable length slot
- First order dependence of two successive channel states

## Existing analytical models

Chen (2007) model

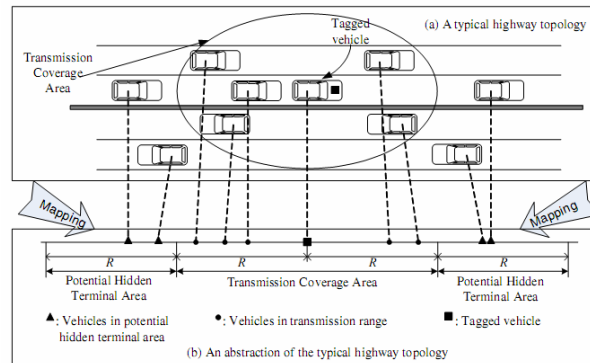


Figure: Highway topology abstraction

## Discussions



- VANETs promise better traffic safety in the future
- MAC protocol plays a critical role
- Different MAC protocols
- Enhancements to the current MAC protocols
- Standards for safety applications
- Analytical tools for
  - approximating the performance achievable
  - Comparison among various enhancements

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## Q/A Session

