

# Developments in vehicle-to-vehicle communications

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# Overview

- ◆ The networked vehicle in the networked world
- ◆ ITS communications technologies
- ◆ *Ad hoc* networks
- ◆ Routing protocols
- ◆ Simulation results

# Technology trends

- ◆ Historically
  - ◆ Vehicle systems autonomous
  - ◆ Roadside systems autonomous
- ◆ Now
  - ◆ Vehicle systems interact
  - ◆ Roadside systems interact with each other and with control centres
- ◆ In the future
  - ◆ Vehicles will interact with each other and the infrastructure

# Vehicle technology trends

- ◆ Inter-system communications e.g. CAN bus
- ◆ Distributed control systems
- ◆ Vehicle–vehicle communications
- ◆ Increasing safety-related functionality
  - ◆ e.g. throttle-by-wire

# Roadside technology trends

- ◆ Inter-system communications e.g. NTCIP
- ◆ Distributed control systems
- ◆ Vehicle–infrastructure communications
- ◆ Increasing safety-related functionality
  - ◆ e.g. active traffic management

# Possible applications

- ◆ Safety oriented
- ◆ Platooning
- ◆ Cooperative driving
- ◆ Collision warning and avoidance
- ◆ Incident warning
- ◆ Emergency vehicle priority
- ◆ Consumer oriented
- ◆ Traffic information
- ◆ Local points of interest
- ◆ Route planning
- ◆ Mobile business transactions
- ◆ Multimedia services
- ◆ Diagnostic data

# Communications technologies

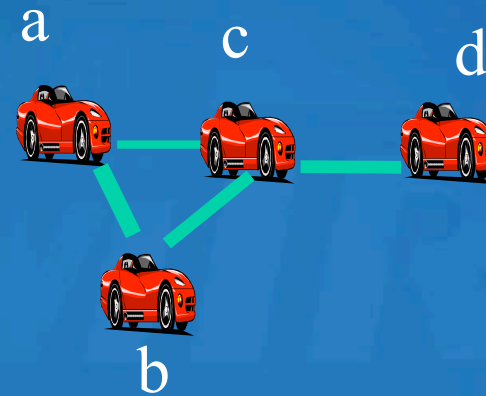
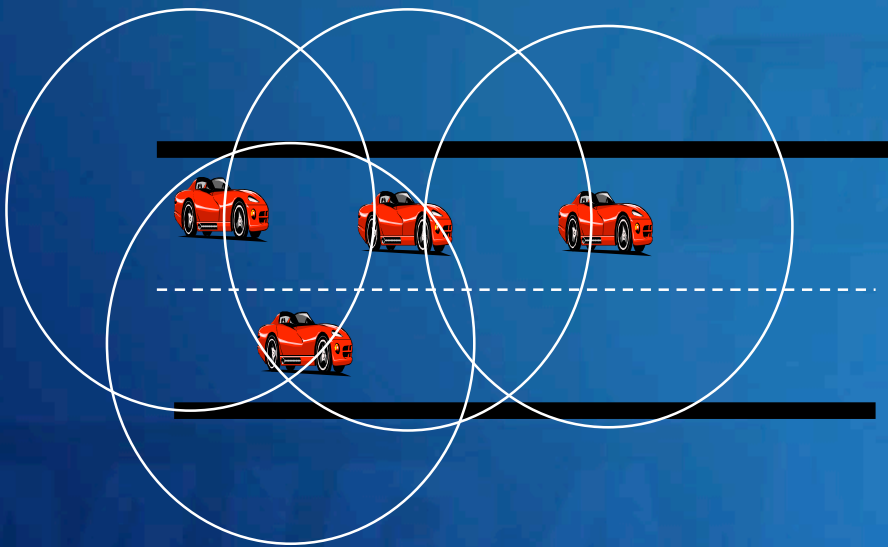
- ◆ Broadcast technology
- ◆ Cellular technology
- ◆ Wi-Fi (IEEE 802.11b)
- ◆ DSRC
- ◆ *Ad hoc* networks

# *Ad hoc network*

- ◆ A network with minimal or no infrastructure
- ◆ A network that is self-organizing
- ◆ Each node can act as the source of data, the destination for data and a network router
- ◆ Vehicle *ad hoc* network
  - ◆ Uses equipped vehicles as the network nodes
  - ◆ Nodes move at will relative to each other but within the constraints of the road infrastructure

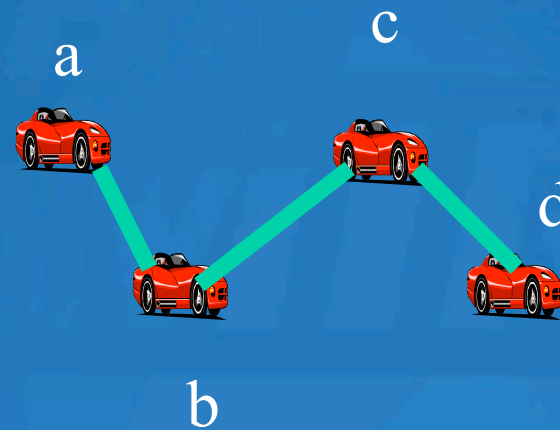
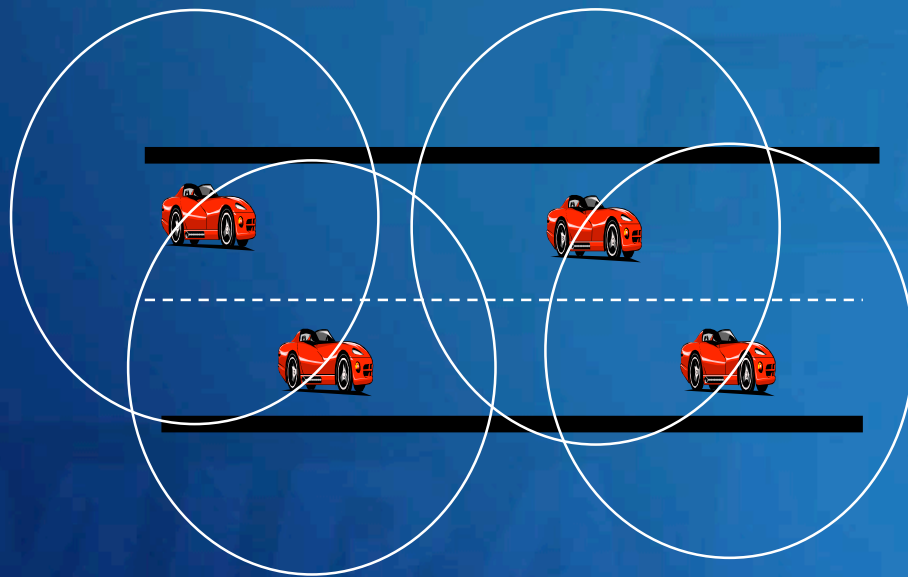
# *Ad-hoc networks*

- ◆ Message propagates to destination using a number of intermediate links



# Ad-hoc networks

- ◆ If vehicle mobility causes links to break, message rerouted using a different path



# Why use *ad hoc* networks?

- ◆ Potential ease of deployment
  - ◆ Decreased dependency on fixed infrastructure
- ◆ Sparse network of roadside beacons
- ◆ Permit gradual introduction of technology
- ◆ “Local” services can be provided with little or no running costs to the users

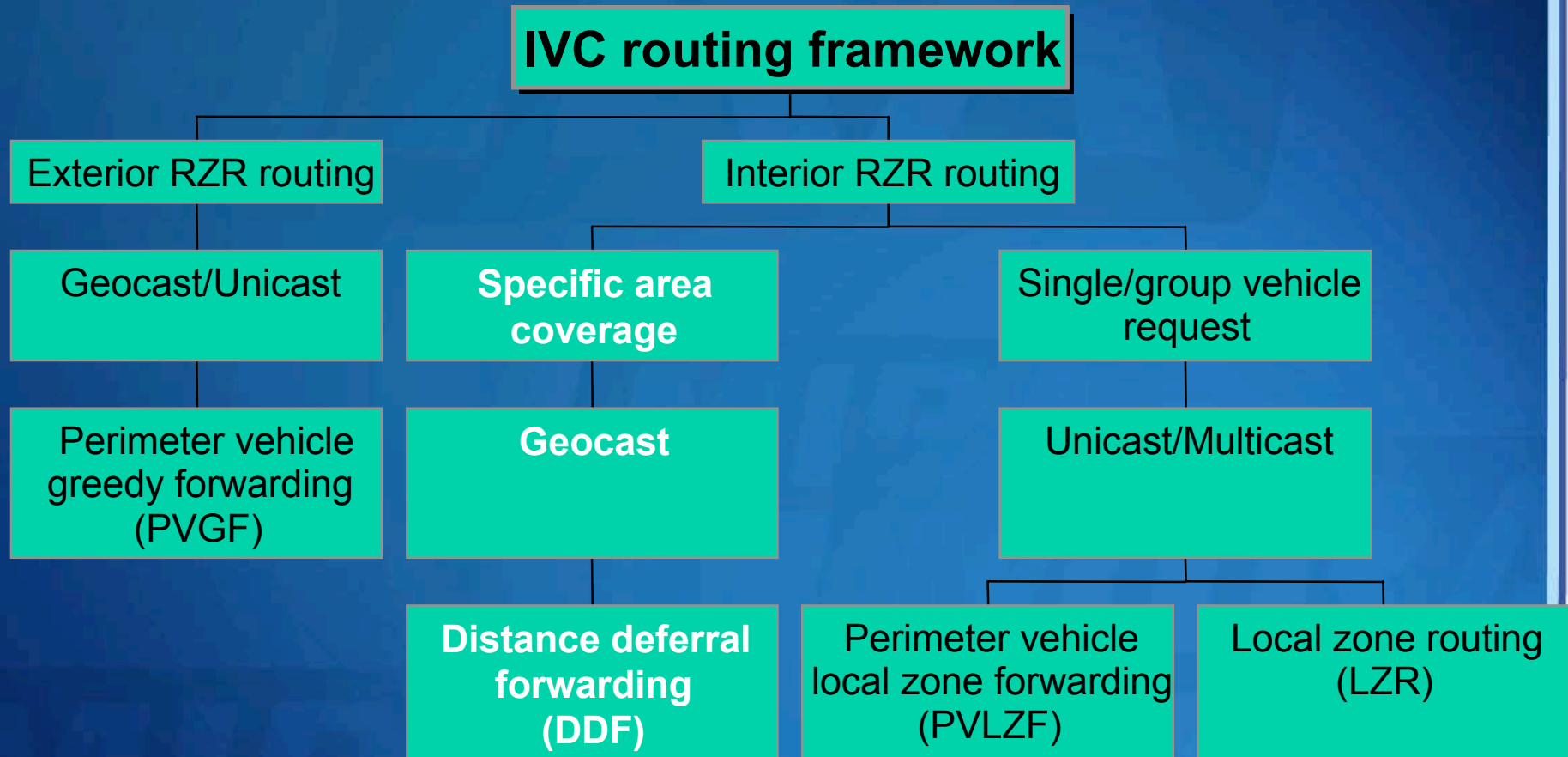
# Technical challenges

- ◆ Spectrum allocation and efficiency
  - ◆ Systems such as WiFi operate in unlicensed ISM bands which may be congested
- ◆ Level of fixed infrastructure required
  - ◆ Application dependent?
- ◆ Routing protocol
  - ◆ Address differing applications needs e.g. latency, QoS, region of relevance of the data
  - ⇒ Routing zone of relevance (RZR)

# *Ad hoc* routing schemes

- ◆ Topology-based
  - ◆ Proactive
  - ◆ Reactive (on-demand)
  - ◆ Hybrid
- ◆ Position-based
  - ◆ Restricted flooding
  - ◆ Geographic forwarding

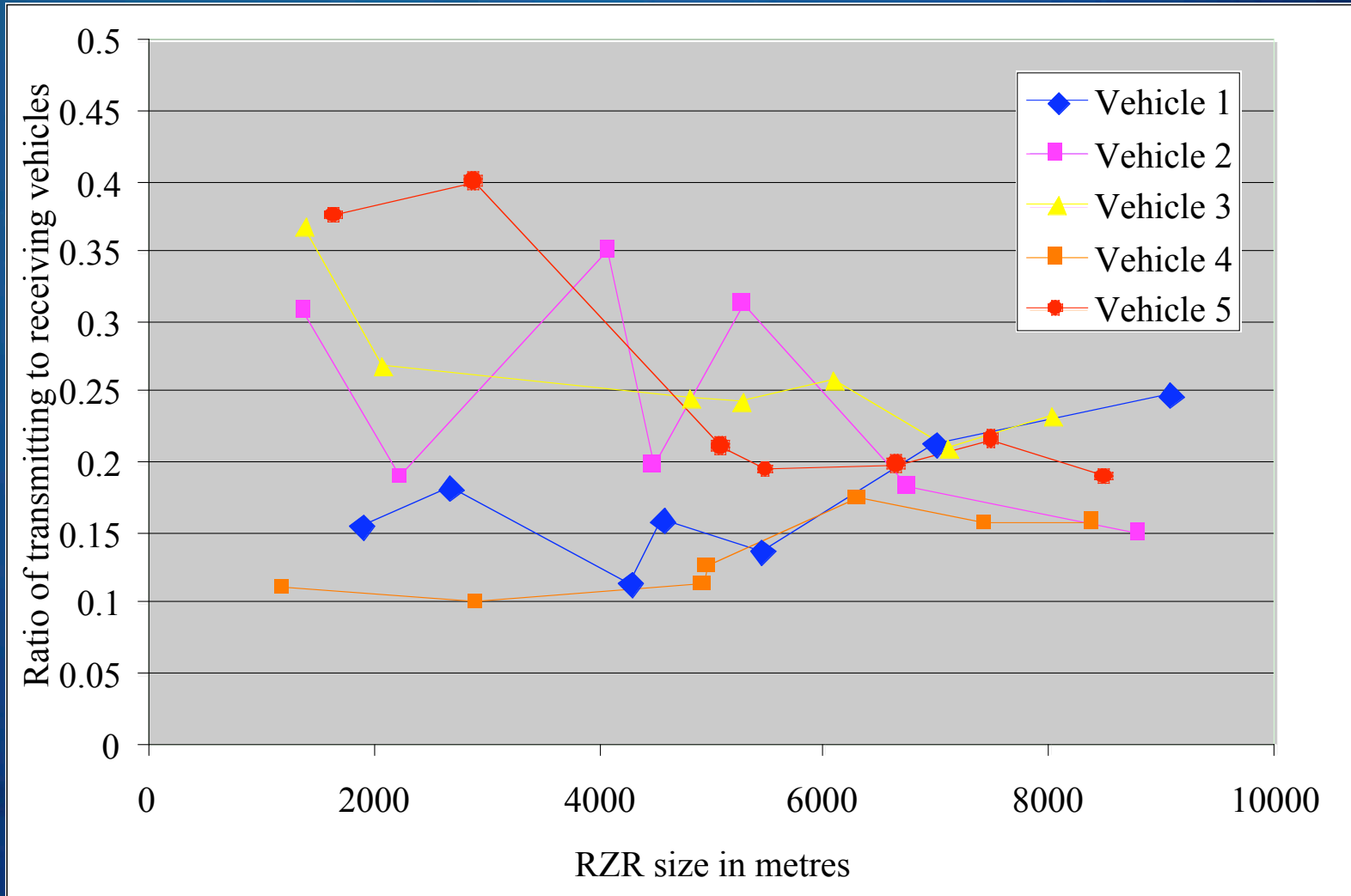
# Routing framework



# Simulations

- ◆ Protocol performance simulated using an industry standard network simulator
- ◆ Node mobility modelled using a microscopic traffic flow simulator
  - ◆ 5 km x 3 km rectangular highway
  - ◆ Closed track of 16 km circumference
  - ◆ Both clockwise and anticlockwise traffic
  - ◆ Two lanes per traffic flow

# Protocol performance



- ◆ Delivery ratio = 100% throughout, irrespective of partitions, size of RZR and vehicle mobility

# Conclusions

- ◆ Future co-operative applications dependent on vehicle-to-vehicle communications
- ◆ Hybrid approach to routing protocols for mobile *ad hoc* networks presented
- ◆ Preliminary simulation results show
  - ◆ 100% delivery achievable
  - ◆ Protocol scales well