Reliable Neighborcast:
A New Communications Paradigm for Vehicle-to-Vehicle Applications

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During this presentation I will; 1) describe a set of applications for vehicle-to-vehicle networks, 2) describe a new communication paradigm called "Reliable Neighborcast," and 3) describe a protocol, RNP, that implements reliable neighborcast.

Vehicle-to-vehicle networks use wireless links to communicate between nearby trains, planes or automobiles. The networks are used to provide warnings and coordinate the operation of the vehicles. The applications

1. provide safer, more fuel efficient use of trains, planes and automobiles,
2. increase the volume of traffic that can be handled by existing airports, highways and railways, thereby reducing the need to construct new transportation facilities, and,
3. can lead to new ways to use our subways and buses to make mass transit faster and more convenient.

The applications are implemented on ad hoc networks and do not require a large investment in new networking infrastructure.

The applications require reliable delivery, delay bounds and message sequencing. Each vehicle communicates with a set of nearby vehicles that comprises its neighborhood. Every vehicle has a different set of neighbors, and the sets of neighbors change as vehicles move with respect to one another. The wireless communications environment has less bandwidth and higher error rates than wired networks, and obstacles may prevent direct communications between neighbors.

We describe a new paradigm for vehicle-to-vehicle networks called Reliable Neighborcast. Reliable broadcast or multicast protocols provide message delivery guarantees to all of the members of a group. In vehicle-to-vehicle applications the group of vehicles may be very large and cover a large area. For instance, in an automotive application the group may consist of all of automobiles on a highway. However, vehicles do not use the information from vehicles that are far away, and providing the delivery guarantees to the entire group results in messages being forwarded and recovered unnecessarily. Reliable neighborcast is more focused than the conventional group communications protocols, and only provides the delivery guarantees to those vehicles that need a message.

RNP is a protocol that implements reliable multicast. It guarantees that 1) a vehicle reliably receives the messages transmitted by all of its neighbors, 2) messages that are received by multiple vehicles are placed in the same order at each of the vehicles, and 3) a vehicle knows which other vehicles have received each message that it receives. Most group communications protocols that have changing groups are quasi-stationary. They provide guarantees to a fixed group of receivers, use a different protocol to change the group, then provide the guarantees to the new group. RNP is a dynamic protocol. It uses a voting procedure to continuously change the group as the protocol operates. This makes RNP well suited to the rapidly changing groups in vehicle-to-vehicle networks. RNP efficiently uses the limited bandwidth in the wireless network. Messages are broadcast and there are between 1 and 4 control messages per transmitted message depending on the dimensionality of the network. A highway is a 1-dimensional network, the surface of an airfield is a 2-dimensional network, and an air space is a 3-dimensional network. The number of messages is only weakly dependent on the number of receivers. RNP provides the guarantees within a delay bound. It quickly provides guarantees that all of the receivers in the neighborhood have recovered and sequenced a message, independent of the number of receivers in the neighborhood. In a time that is proportional to the number of receivers in the neighborhood, it learns which receivers are in the neighborhood and which neighbors have acquired the message. The trade-off between delay and guarantees makes RNP useful in a range of applications that require different guarantees.