Verification of the Safe Driver Assisted Merge Protocol

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Outline

• Objective
• Description of the merge protocol
• Problem specification
• Simulation variables
• Simulation measurements
• Result analysis
• Proposed timeline
Objective

• Test the safe driver assisted merge protocol in a software environment to measure improvements in average vehicle throughput and average merge speed as a function of participation rate.

• Validate the protocol by also testing against the failures initially presented last year.
Driver-assisted Merging Protocol

- The merging protocol has direct controls of the following:
  - Cruise control
  - Sensors
  - Communication protocol

Figure 1. A modular architecture of a Safe Driver Assisted Merge Protocol
Driver-assisted Merging Protocol

- Goal of the protocol: When a driver wants to change lane, by means of inter-vehicle communication, the cars in the target lane create gap and the system will instruct driver to switch lane when it is the safe to merge.
The simulation environment

• Originally a Java-applet written by M.Treiber (http://www.traffic-simulation.de/)

• Intelligent Driver Model – Longitudinal Car-following model
  – Approximating the behavior of an actual driver

• MOBIL – Lane change model
Construction of merge section

1. A single-lane ramp merges with a single-lane highway

![Diagram of single-lane ramp merging with single-lane highway]

2. A single-lane ramp merges with a double-lane highway

![Diagram of single-lane ramp merging with double-lane highway]
Assumptions

• No erratic behaviors on the highway
• The subsystems of the merge protocol work for the main study
• All the drivers on the highway have the same safety spacing requirement and desired speed
• No trucks on the highway
Incorporate the protocol in simulator

• Simulate protocol’s handshake initialization
• Specify how cruise control respond to the instructions from the merge protocol
• Consider all the states of merge protocol
• Consider driver’s response time
Simulation Variables

- Protocol participation rate as a percentage of highway throughput
- Ramp throughput as a fraction of highway throughput
- Failure events
Simulation variables: Failure events

- Aborting the merge process due to a sudden brake from the front vehicle
- Loss of communication from the communications channel
- Detection of unauthorized RFID tagged vehicles
- Lasting disagreement in sensor readings from vehicles
- Unresponsive human behavior
- Hardware failures from timers
Simulation Measurements

- Total highway throughput (vehicles per hour)
- Number of lane changes/merges
- Number of times protocol is initiated
- Number of times protocol is successfully executed
- Number of accidents
Results analysis

• Determine the maximum throughput supported by the simulator for different participation rates before a traffic jam occurs
• Determine how participation rate influences the rate at which vehicles are able to merge
• How often will the protocol be implemented
## Proposed Timeline

| #  | Tasks                                                                 | Start  | Finish  | Week #: | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|----|----------------------------------------------------------------------|--------|---------|---------|---|---|---|---|---|---|----|----|----|----|
| 1  | Incorporate Protocol into Model                                      | 2/8/2012 | 3/6/2012 |         |   |   |   |   |   |   |    |    |    |    |
| 1.1| Establish programmable parameters from SDAM Protocol ¹               | 2/8/2012 | 2/15/2012|         |   |   |   |   |   |   |    |    |    |    |
| 1.1.1| Determine what can be programmed                                    |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 1.1.2| Modify the protocol if needed                                       |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 1.2 | Reproduce protocol in software model                                | 2/15/2012 | 2/25/2012|         |   |   |   |   |   |   |    |    |    |    |
| 1.2.1| Update merging application to include states presented in SDAM Protocol |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 1.3 | Incorporate failure modes into model                                | 2/25/2012 | 3/7/2012 |         |   |   |   |   |   |   |    |    |    |    |    |
| 2  | Run Simulations                                                       | 3/7/2012 | 4/4/2012 |         |   |   |   |   |   |   |    |    |    |    |
| 2.1 | Introduce variability of traffic simulation                          | 3/7/2012 | 3/14/2012|         |   |   |   |   |   |   |    |    |    |    |
| 2.1.1| Participation Rate                                                   |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.1.2| Failure Events                                                       |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.1.3| Highway Traffic to Ramp Traffic Ratio                               |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.2 | Evaluate performance                                                 | 3/14/2012 | 4/4/2012 |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.2.1| Establish baseline benchmark from original simulator                 |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.2.2| Identify favorable results                                           |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 2.2.3| Test behavior under failure events                                  |        |         |         |   |   |   |   |   |   |    |    |    |    |    |
| 3  | Summarize Results                                                     | 4/4/2012 | 4/18/2012|         |   |   |   |   |   |   |    |    |    |    |    |
| 3.2 | Presentation                                                         | 4/11/2012 | 4/18/2012|         |   |   |   |   |   |   |    |    |    |    |    |