KARYON: Kernel-Based Architecture for safetY-critical cOntrol

Cooperation with Disagreement Correction in the Presence of Communication Failures

KARYON Workshop, Borås, Sweden, Dec 11, 2014

KARYON

Kernel-Based ARchitecture for safetY-critical cONtrol

Introduction

- Self-driving vehicles plan their trajectories
  - by using sensory information about their vicinity
- Cooperative vehicular systems
  - use V2X for sharing that sensory information
- The limitation is that V2X is failure prone
  - and thus we cannot bound the communication delay

How can safety-critical cooperative systems attain the highest performance in the presence of communication failures?

Motivation

- The cooperative system computes its trajectory based on exchanged information
  - $s = \mathrm{U}_{v \in \text{vehicles}} \{s_v\}$
  - where s_v can be
    - LoS, acceleration, speed, e

- Consider two vehicles *A* and *B* in platooning
  - Suppose that *A* does not receive s_B but *B* receives s_A
  - Could *A* computes its safe trajectory according to $\{s_A\}$ and B according to $\{s_A\} \cup \{s_B\}$?
  - This would inevitably lead to disagreement about *s*!

Problem Definition

- <u>Minimum Longest Uncertainty Period</u>: Is there an upper-bound on the longest period that cooperative systems spend disagreeing on *s*?

- This period is longer than zero!

We show a solution that uses 1 communication round in which, in the absence of failures, all vehicles exchange messages.

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Timed Protocol for Cooperation with Disagreement Correction

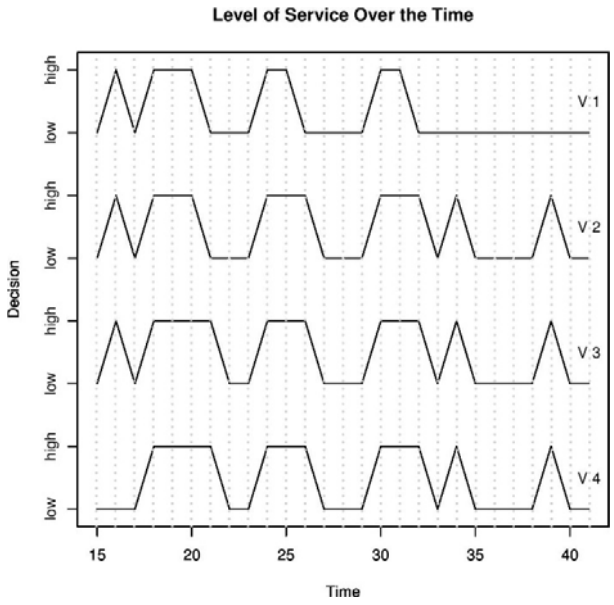
Vehicular Control

Timed Protocol for Cooperation with Disagreement Correction

Communication Protocol

Correctness

- **Theorem 1.** The system disagreement period is bound by one communication round

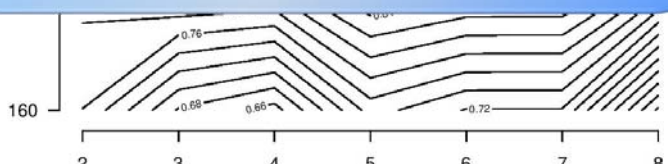


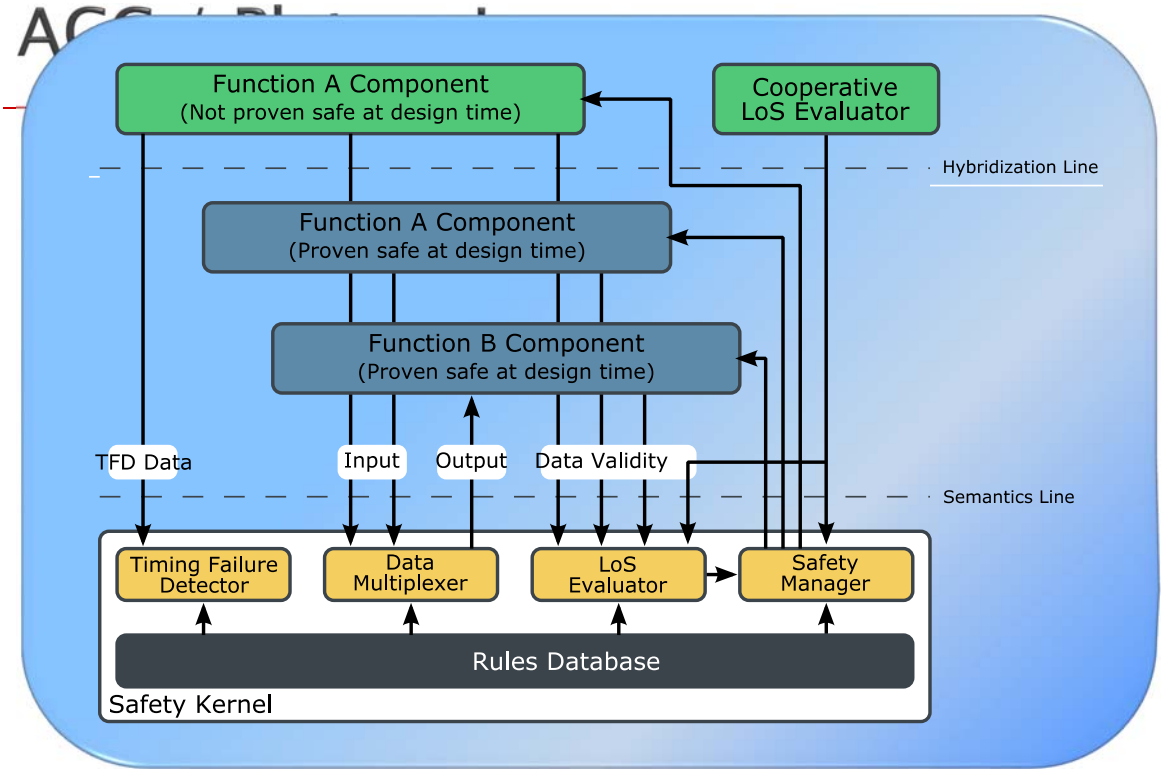
Implementation and Evaluation

- **Authenticity**: ratio of rounds in which the system agrees on s (without using $\perp$)
  - We use a gossip algorithm with 2 retransmissions

Trade-off between round length and authenticity

- Shorter rounds, shorter disagreement period but lower authenticity
- Longer rounds, longer disagreement but higher authenticity





Conclusion

- We show how to attain the highest performance in the presence of failures
  - Resolves disagreements in at most one round
  - Bounded exposure to risk (that is due to failures)
  - Trade-off: authenticity and disagreement period
  - Simulations show high performance (and still safe)
- We demonstrate cooperative applications

Ponce, Schiller, Falcone, "Cooperation with Disagreement Correction in the Presence of Communication Failures," 17th Inter. IEEE Intelligent Transportation Systems (ITSC'14), CoRR abs/1408.7035