A Framework for Extensibility-Driven Design of Cyber-Physical Systems

CPS: Breakthrough: Collaborative Research: CCF-1646497 & CCF-1646381

Wenchao Li (Boston University), Qi Zhu (UC Riverside), September 1, 2016 – August 31, 2019

Challenges

- ❑ CPSs today are one-off designs
- ❑ Current methodologies ineffective in coping with design updates
- ❑ Costly re-design and re-verification

Information management system still uses the long discontinued AMD Am2950 microprocessor.

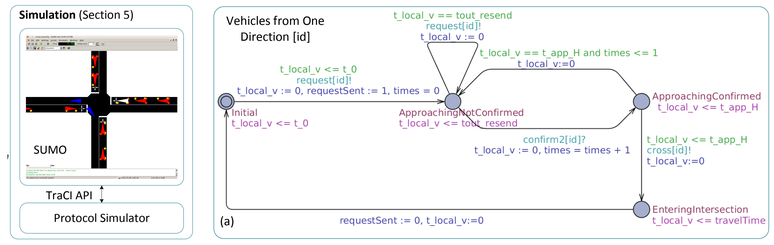
Technical Approach

- ➢ Extensibility metrics across design layers and update scenarios
- ➢ Priced Time Automata (PTA) to tie together **timing**, **resource usage** and **functionality** in CPS
- ➢ Extensibility-driven software architecture synthesis
- ➢ Verification of time-dependent and resource-dependent properties

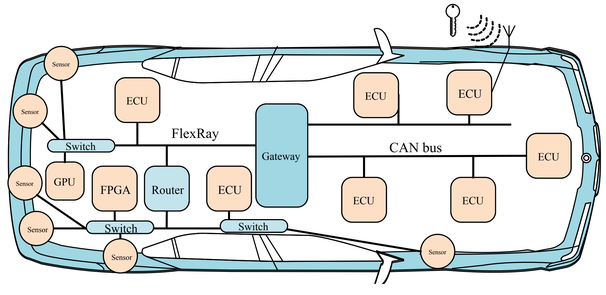
Impacts

- ✓ Extensibility-driven design flow
- ✓ New Framework for integrating synthesis and verification
- ✓ Enable engineers to cope with continual changes in CPS design components

Intelligent Transportation Systems



Extensibility for Intra-Vehicle Communication



- ✓ Extensibility-Driven Schedule Synthesis
- ✓ Extensibility-Driven Mapping

CAN-bus extensibility metric

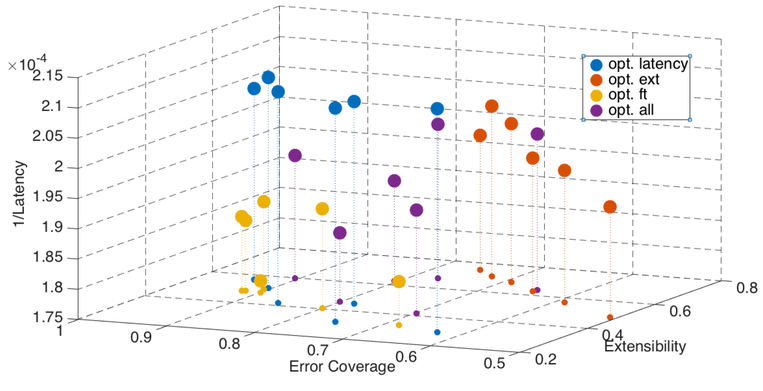
$$\max\ E = \sum_{\tau_i \in \mathrm{T}} \omega_{\tau_i} \frac{\Delta e_{\tau_i}}{t_{\tau_i}}$$

FlexRay-based extensibility metric

$$E_{FR} = \frac{1}{N+M} \sum_{S_j=1}^{N+M} E(S_j)$$

[Zhu et al. "Extensibility-driven automotive in-vehicle architecture design," DAC'17]

Trade-offs among System Extensibility, Error Coverage and Path Latency



[Liang et al. "Addressing Extensibility and Fault Tolerance in CAN-based Automotive Systems," NOCS'17]

- ✓ Verification for Intelligent Intersection [SMARTCOMP'17]
- ✓ Timing & Security Analysis of VANET-based Systems [ICCAD'17]
- ✓ PTA-guided Extensibility Analysis of Object Detection & Tracking Systems

Year 2 Plan

- ❑ Cross-Layer Metrics
- ❑ Integrate Synthesis and Verification for Extensibility

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