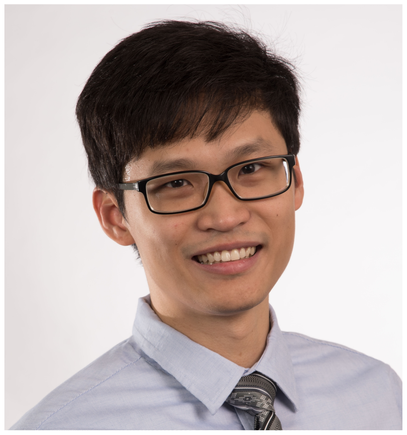
2019 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

# CPS: Breakthrough: Collaborative Research: A Framework for Extensibility-Driven Design of Cyber-Physical Systems

**Award: CCF-1646497 & CCF-1646381**



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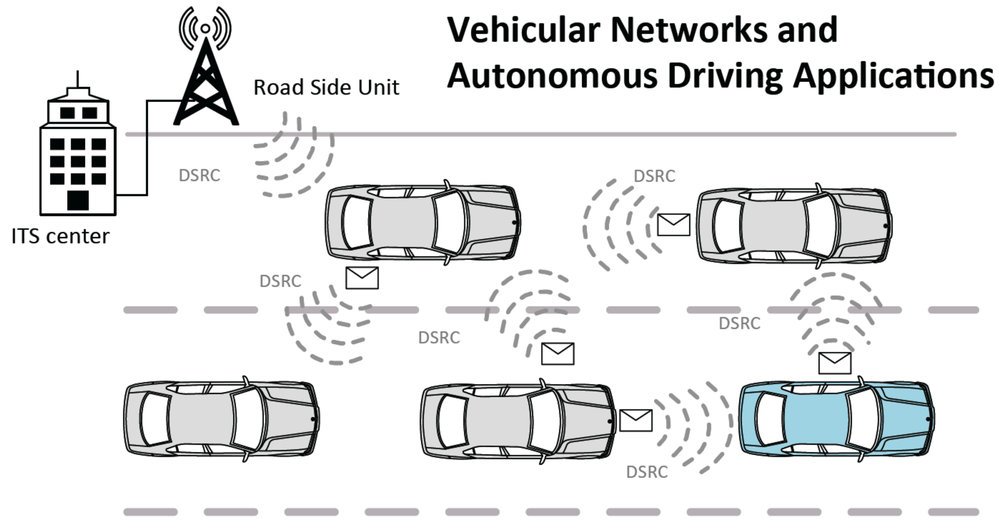
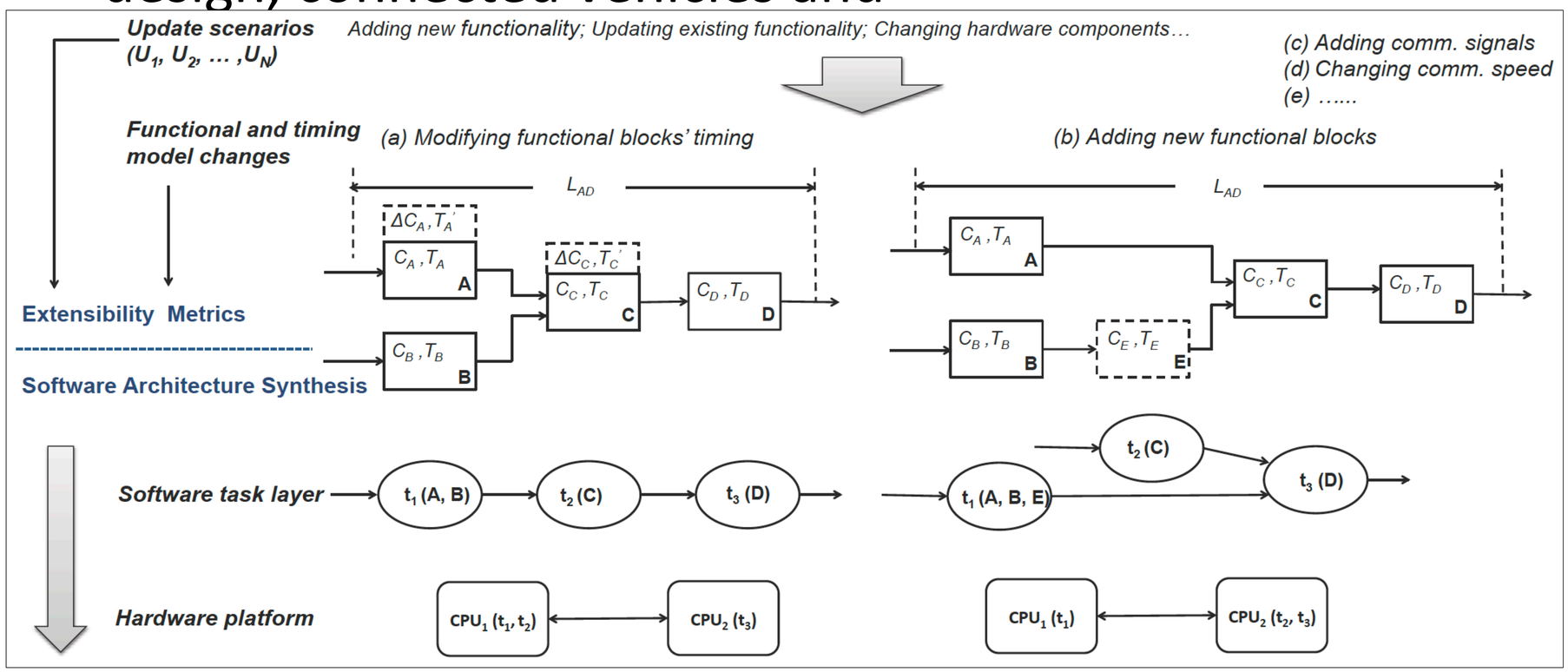
**Project Goal**: Develop a framework that enables CPS to cope with challenges in design updates, avoiding costly re-design and re-verification.

- Develop extensibility metrics and an extensibility-driven design flow.
- Develop a framework for integrating functional verification and platform synthesis to facilitate design updates.
- Application to in-vehicle architecture design, connected vehicles and

## Extensibility challenges facing CPSs today


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




## Example Extensibility Metric for Intra-Vehicle Communication

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

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


# Key Findings:

- Ensure functional safety in system design and updates:
  - ➢ Counter-example guided approach to meet safety specification for controller learned from demonstration (CAV'18).
  - ➢ Reachability analysis of neural-network controlled systems (EMSOFT'19, ICCAD'19)
  - ➢ Safety verification of nonlinear control systems with deadline misses (HSCC'19).
- Design-space exploration & platform synthesis for extensibility:
  - ➢ Task mapping and message scheduling w.r.t. extensibility and schedulability (NOCS'17, DAC'17)
  - ➢ Application-aware scheduling of networked CPSs over the low-power wireless bus (DATE'20)
  - ➢ Improve extensibility with weakly-hard constraints (in submission)
- Integrated verification & synthesis for extensible design:
  - ➢ Design and validation of connected vehicle