Design Automation Challenges for Automotive Systems

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Connected and Autonomous Vehicles

- A good application may need both of "connectivity" and "autonomy"
  - Intersection Management [T-IV '18]
Design Complexity

- **Software**
  - Various functions for sensing, perception, planning, decision, control, etc.
  - Number of lines of code
    - $1 \rightarrow 10+ \rightarrow 100$ million from 2000 $\rightarrow$ 2010 $\rightarrow$ 2020
  - Values to vehicle's total value
    - Embedded software: 2% $\rightarrow$ 13% from 2000 to 2010
    - Electronics system: expected to be 50% in 2030

- **Hardware**
  - Number of Electronic Control Units (ECUs)
    - 20 $\rightarrow$ 50+ $\rightarrow$ more in the past decade
  - New computational components and communication protocols
Fundamental Challenges

How do you know

- Your design is correct, i.e., satisfying its requirements?
- Your implementation is correct, i.e., satisfying its specification?

The **compatibility** is also one challenge

- Different components, systems, and vehicles are designed and implemented by different companies
Compatibility of Systems [DAC '18]

- Integration of two systems
  - Cooperative Pile-up Mitigation System (CPMS)
  - False-start Prevention System (FPS)

- Property specification language and automation tool
  - Signal Temporal Logic (STL)
  - Breach [Donze '10]

- A violation can be detected
An incompatible example of lane-changing
- Two autonomous vehicles always accelerate or decelerate together
  - Different automotive makers develop different types of systems by their own
- They always keep the same longitude along a road segment
- They fail to exchange their lanes before the end of the road segment

A methodology to verify if lane-changing systems (finite-state machines or hybrid systems) are compatible
- If not, we will need requirements engineering or runtime monitoring
More Viewpoints

- **Levels of "contracts"**
  - Interfaces of components
  - Preconditions and post-conditions of components
    - **Functional behavior**
  - Timing to the dependency between components
  - Performance of components

- **Decomposition and composition**
  - Horizontal or vertical (right figure)
Consider design metrics
- Safety
- Reliability
- Robustness
- Power
- Performance
- Security

Assist system designers for early design decisions
- More efficient process
EDA vs. Automotive Design Automation

Modeling

Design

Analysis

Electronic Design Automation (EDA)

- intensity induced by aperture p
- intensity induced by aperture q

A current path from A to VCC3A
A current path from VCC to B

input

output

periodic activation

periodic activation

GND

VCC

A

B

C

G

E

F

H

VCC3A
Thank You!