

# Development of CID-free Hardware-in-the-Loop Simulation Framework (No. 17-04066)

Zijia Zhong, Joyoung Lee, PhD.

John A. Reif, Jr. Department of Civil & Environmental Engineering  
New Jersey Institute of Technology

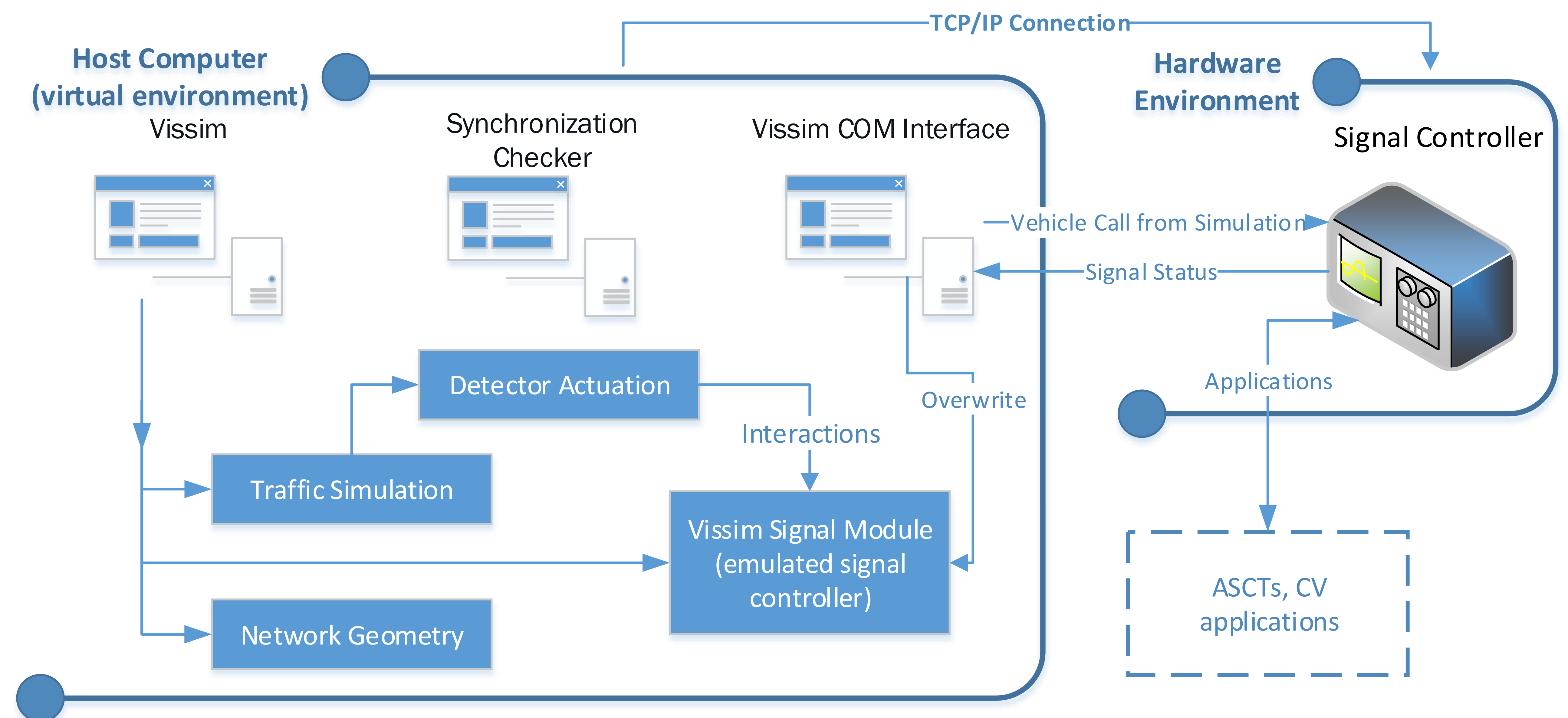
## Introduction

Hardware-in-the-loop simulation (HILS) has gained great attention for its applicability dealing with real-time simulation by factoring in the complexity of hardware signal controllers. In conducting signalized intersection HILS, controller Interface Devices (CIDs) had been necessary components. However, the use of CIDs often makes the simulation framework more redundant by adding an extra hardware component. CIDs also add communication overhead between simulation software and the signal controllers, which may reduce the feasibility of conducting HILS. Besides, modern controllers embedded with advanced control algorithms which are hard to emulate by generic simulation software. To improve exiting HILS framework, the concept of CID-free HILS is proposed. By replacing CIDs with a software module based on National Transportation Communication for Intelligent Transportation System Protocol (NTCIP), HILS becomes more efficient with less hardware redundancy. In view of the interchangeability and interoperability of NTCIP, the proposed CID-free HILS is expected to expand the scope of simulation as well as improve the degree of realism of HILS. The proof-of-concept (POC) test demonstrates that the CID free HILS can be successfully conducted and it can provide comprehensive evaluation for transportation agencies who are planning to enlist advanced adaptive signal control technologies (ASCTs). Moreover, the propose framework show its promising applications in evaluation connected vehicle technologies.

## Research Objective

- To propose a CID-free simulation framework for more realistic Hardware-in-the-Loop simulation by integrating NTCIP
- To harness the interchangeability and interoperability of NTCIP for intersection signalization simulation
- To conduct the proof-of-concept test and provide recommendations for advanced adaptive signal control as well as connected vehicle technologies simulation

## CID-free HILS Framework Simulation

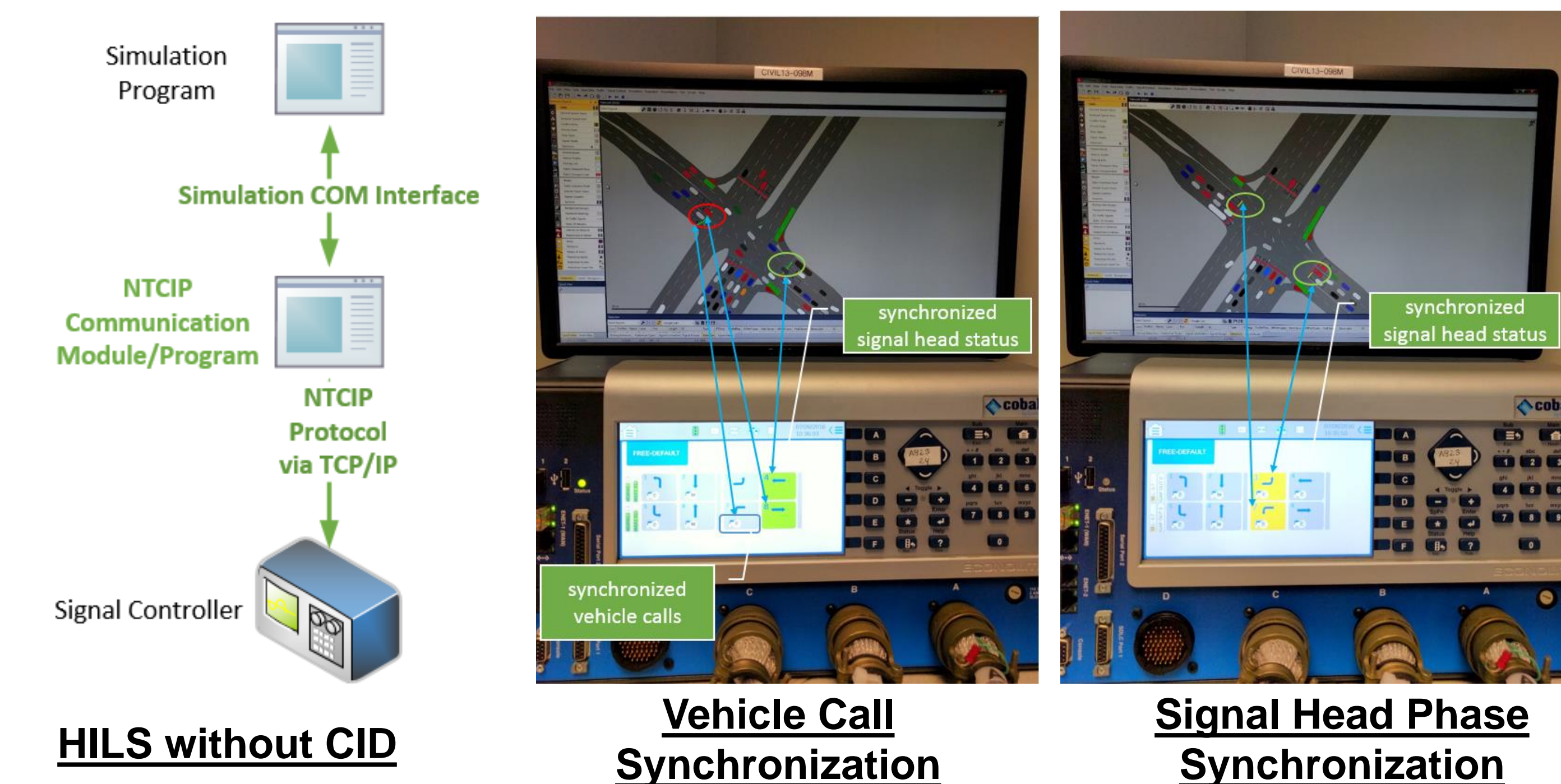


## NTCIP

The National Transportation Communication for ITS Protocol (NTCIP) is developed to provide communication standards which ensure the interoperability and interchangeability among traffic controllers and ITS devices

Object ID	Object Name	NTCIP Accessibility
1.3.6.1.4.1.1206.4.2.1.1.4.1.4	phaseStatusGroupGreen	read-only
1.3.6.1.4.1.1206.4.2.1.1.4.1.3	phaseStatusGroupYellow	read-only
1.3.6.1.4.1.1206.4.2.1.1.4.1.2	phaseStatusGroupRed	read-only
1.3.6.1.4.1.1206.4.2.1.1.5.1.6	phaseControlGroupVehicleCall	read-write
1.3.6.1.4.1.1206.4.2.1.1.5.1.7	phaseControlGroupPedestrianCall	read-write

## Proof-of-Concept Test



HILS without CID

Vehicle Call Synchronization

Signal Head Phase Synchronization

## Conclusion

- POC study successfully demonstrated the proposed CID-free HILS framework
- the CID-free HILS can be employed to test CV technologies for intersection control with minimal risk and enhanced realism
- Solutions for potential issues (e.g., communication lagging, detector overlook) have been proposed.