



## The UCEF Approach to Tool Integration for HLA Co-Simulations

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#### Universal CPS Environment for Federation

An open-source development environment for federated experiments intended to make co-simulation more accessible



available at <a href="https://github.com/usnistgov/ucef">https://github.com/usnistgov/ucef</a>

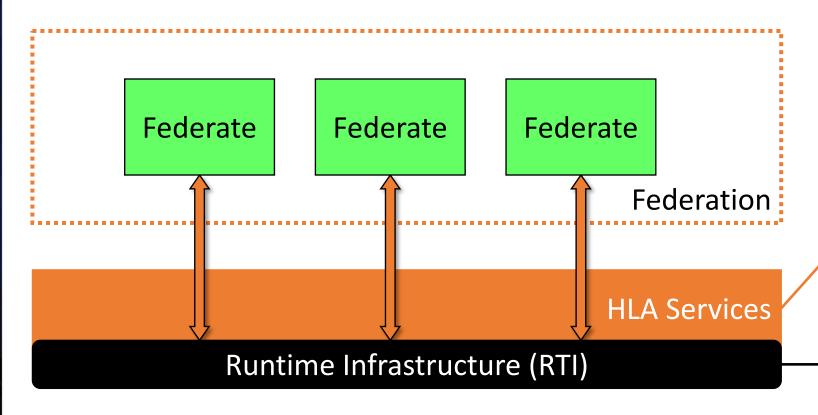






#### Federation in the High Level Architecture

UCEF uses the High Level Architecture (HLA), an IEEE standard that defines the services a set of *federates* can use in a *federation*.



IEEE Std 1516 1-2000

#### IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)—Federate Interface Specification

Spons

Simulation Interoperability Standards Committee

IEEE Computer Society

Approved 21 September 2

Abstract: The high level architecture (HLA) has been developed to provide a common architecture for distributed modeling and simulation. The HLA defines an integrated approach that provides a common framework for the interconnection of interacting simulations. This document, the second in a family of three related HLA documents, defines the standard services of and interfaces to the HLA Runtime infrastructure (RTI). These services are used by the interacting simulations to achieve a coordinated exchange of information when they participate in a distributed federation. The standards contained in this architecture are interrelated and need to be considered as a product set, when changes are made. They seach have value independently.

Keywords: architecture, class attribute, data distribution management, federation rederation execution, federation object model, high level architecture (FLIA), instance attribute instance attribute ownership, interaction class, object class, runtime infrastructure (RTT), simulation object model, time-constrained, time-regulating

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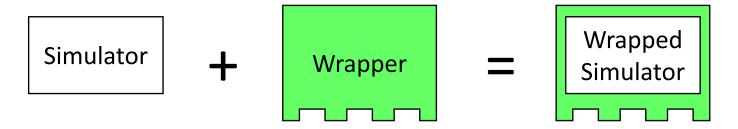
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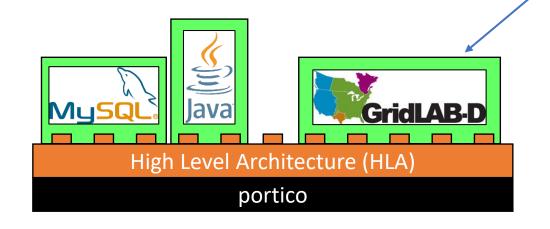


## Software wrappers integrate new things

• A wrapper is software that defines the method of *time synchronization* and *data exchange* used for a simulator in a federation.



• A simulator with a wrapper can be re-used in multiple federations:







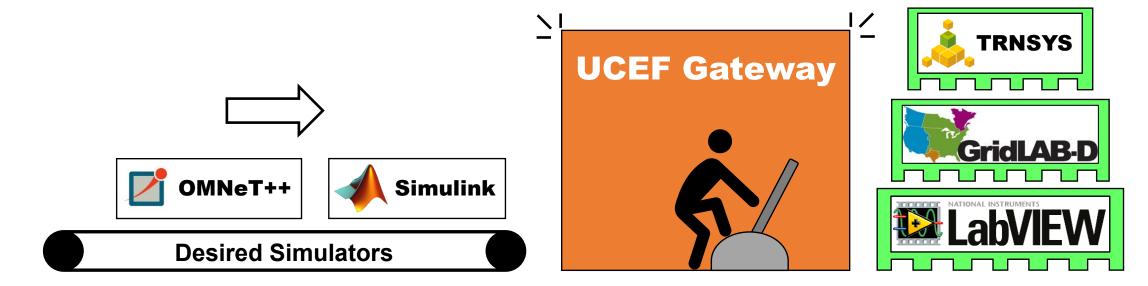




#### UCEF Gateway is used to create wrappers

#### A Java library designed to be:

- Usable with limited HLA expertise
- Easily integrated with new things
- Agnostic to the federation data model

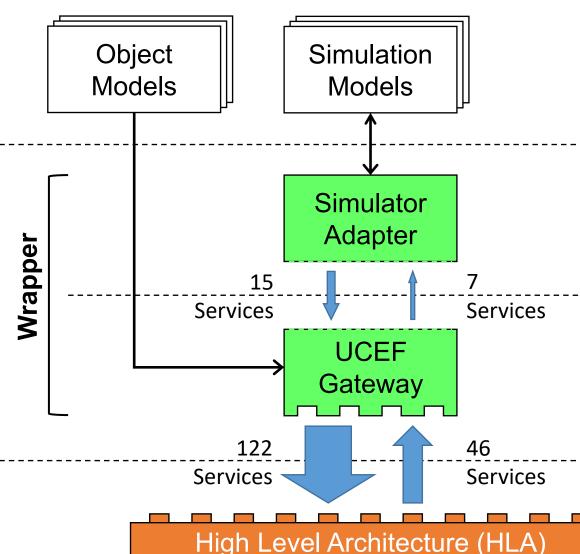




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# Universal CPS Environment for Federation

#### **UCEF Gateway Overview**



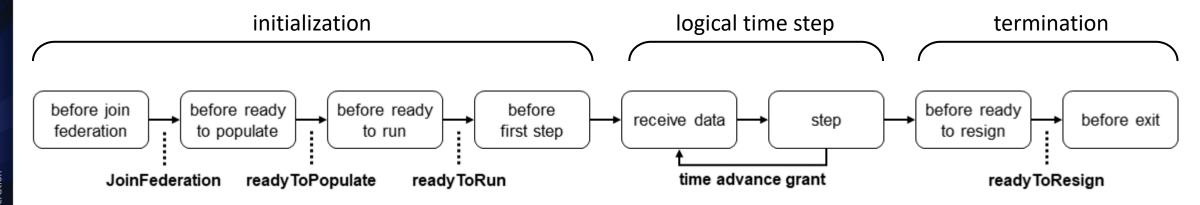
A **user** provides a simulation model and configuration file.

A wrapper developer implements HLA services related to time synchronization and data exchange.

**UCEF Gateway** provides a default implementation for most HLA services to simplify wrapper development.



### **UCEF Gateway Life Cycle**



- Defines hooks where a wrapper developer implements code
- Progresses logical time using a configurable step size
- Uses 3 federation-wide synchronization points

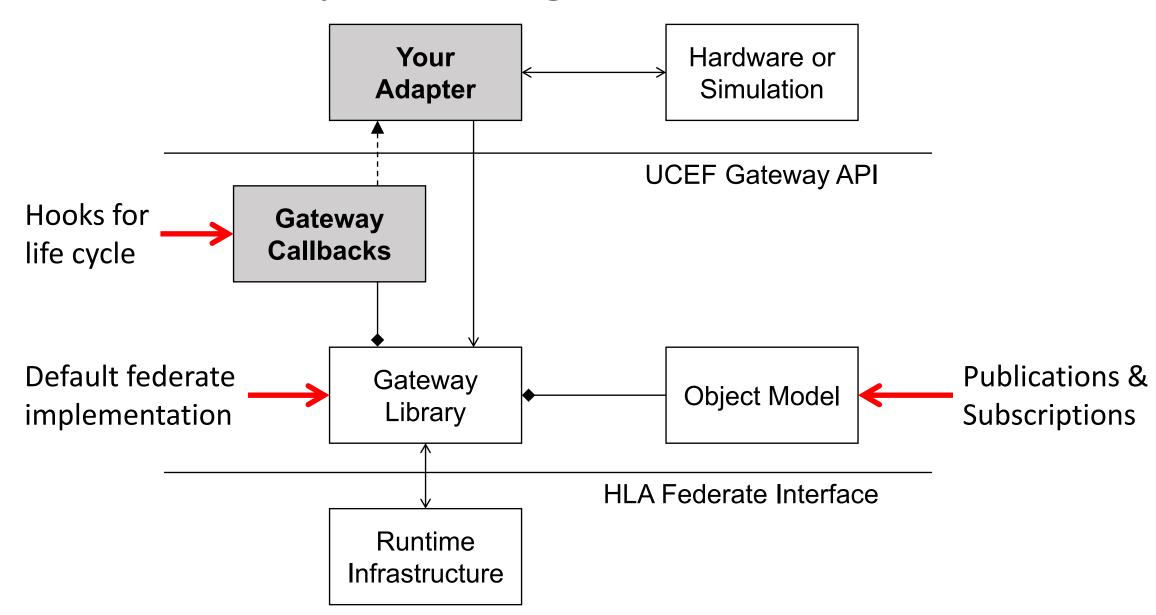




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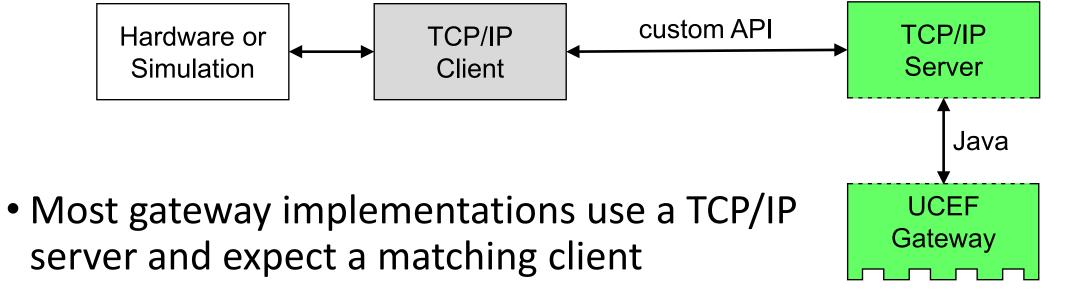
#### **UCEF Gateway Class Diagram**





### Common TCP/IP gateway implementation



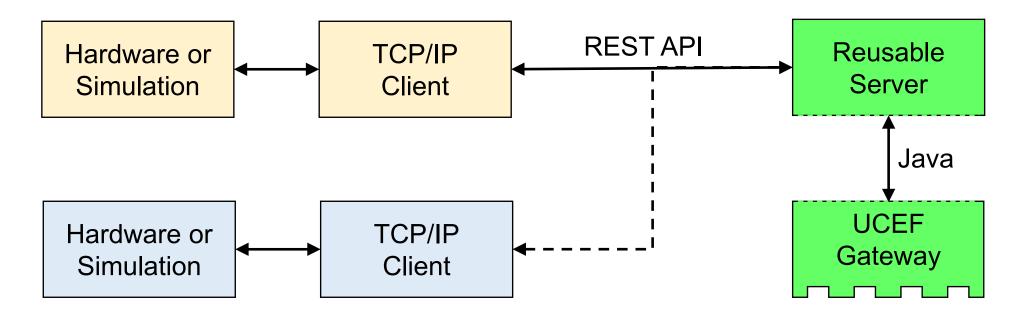


 The TCP/IP servers tend to implement an API dedicated to support a specific simulator



#### Reusable TCP/IP server with a REST API





A REST API was used to implement a reusable TCP/IP server



#### The REST API

NST

Endpoint
/status
/join
/dostep
/ping

Method GET POST POST POST Request Format
(none)
ClientPost
ClientPost
(none)

Response Format FederateStatus FederateStatus FederateStatus 200 OK

time progression

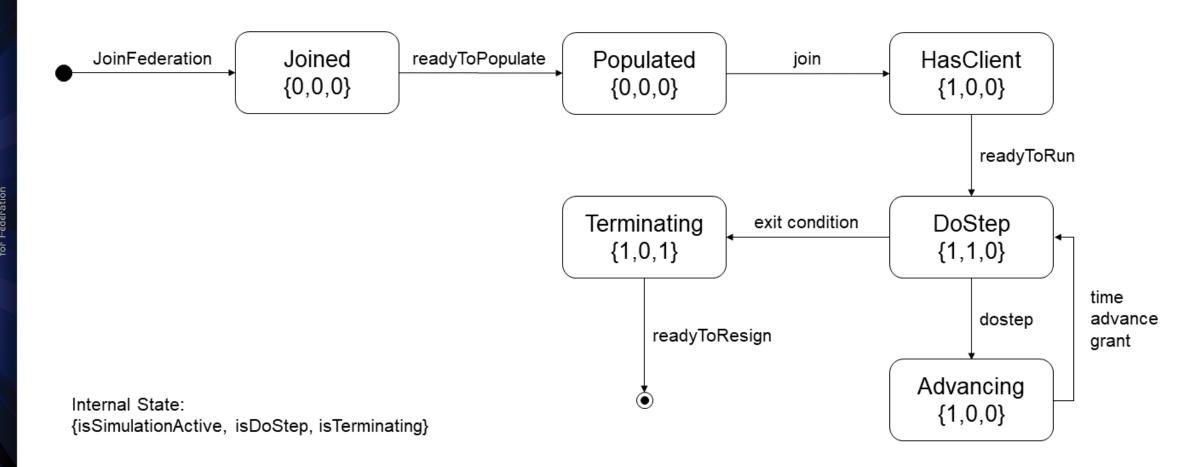
Client

/ping /join /dostep /status





#### State machine for the REST server





#### Conclusion

- UCEF is an open-source HLA development environment
- A Java library called the UCEF Gateway uses a fixed life cycle and default service implementations to integrate simulators
- The most common implementation of the UCEF Gateway is a paired TCP/IP client and server unique to each simulator
- NIST is working on a new REST API built on the UCEF Gateway to provide a reusable TCP/IP server implementation

