A Distributed Simulation Backbone for Executing HLA-based Simulation over the Internet

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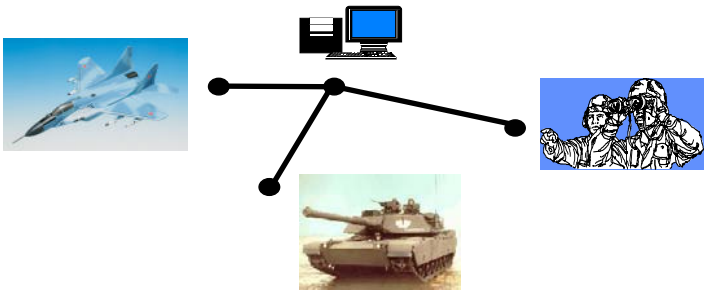
Outline

- Distributed simulation, Grid and HLA
- Related work
- Design
- Implementation
- Conclusion & future work

Distributed Simulation

Provides a way of linking simulation components (federates) of various types at possibly different locations to create a common virtual environment (federation).



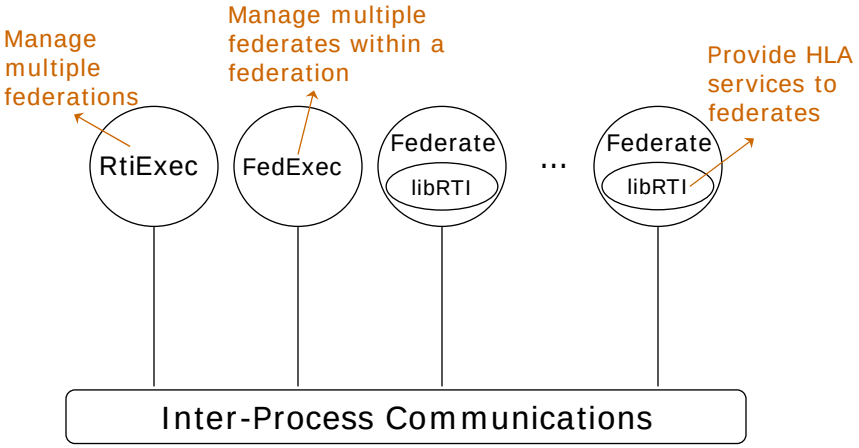
HLA (High Level Architecture)

- The High Level Architecture (HLA) is a general purpose architecture for simulation reuse and interoperability.
- The HLA was developed under the leadership of the Defense Modeling and Simulation Office (DMSO)
- The HLA was approved as IEEE Standard 1516 - in September 2000.
- Terminology: Federations are comprised of federates that exchange information in the form of objects and interactions.

RTI (Run-Time Infrastructure)

- Implements the interface specification and provides services for simulation systems.
- RTI services:
  - Separate simulation and communication
  - Facilitate construction and destruction of federations
  - Support object declaration and management
  - Assist with federation time management
  - Provide efficient communication to logical group of federates
  - .....

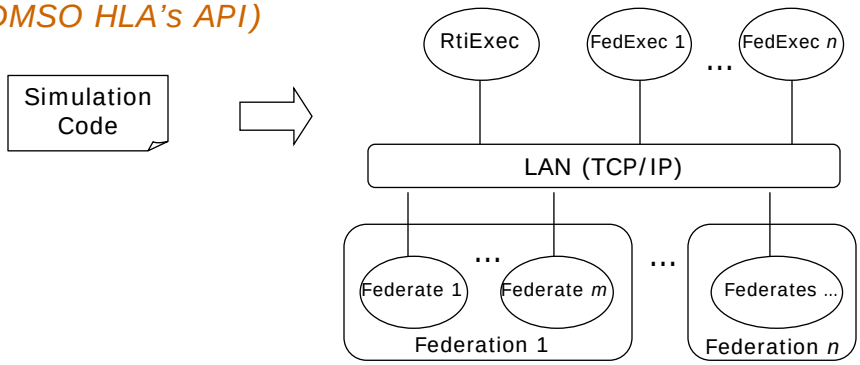
RTI Components



Cluster/LAN-based HLA Simulation

1. Develop Simulation (DMSO HLA's API)

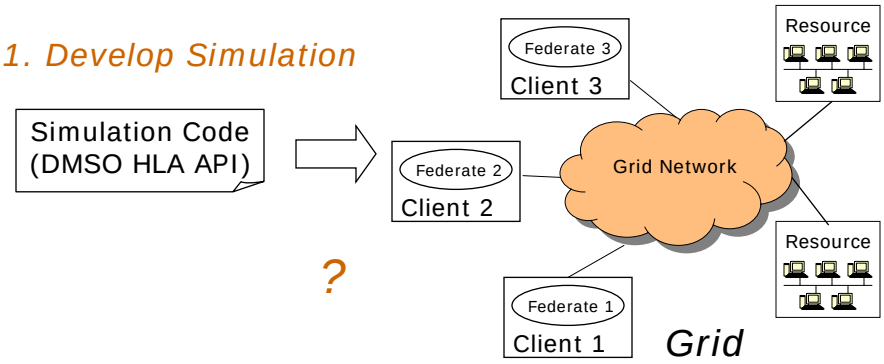
2. Execute Simulation (DMSO HLA Implementation)



Grid-based HLA Simulation

1. Develop Simulation

2. Execute Simulation



Related Work

- XMSF (Extensible Modeling and Simulation Framework) – based on web services
- Re-implement all RTI services
- Extend RTI software as backbone over WAN
- Proxy-based approach – wrap RTI services as grid services (this paper)
- ..

Our Approach

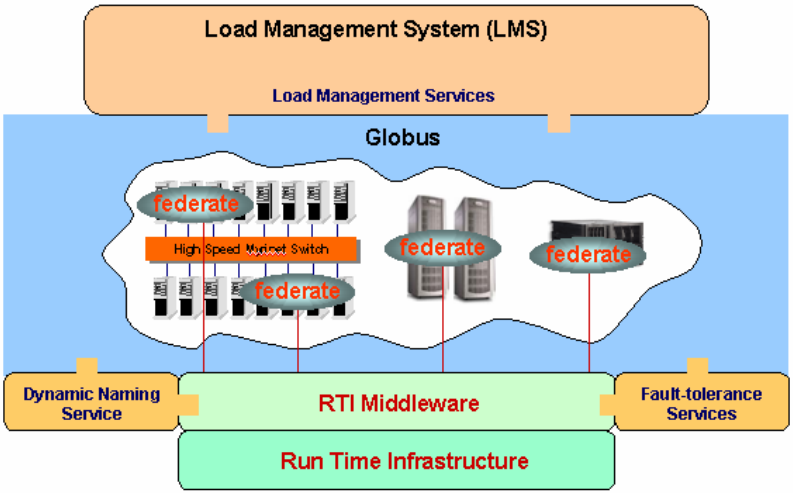
Grid-Enabled Distributed Simulation

Main objectives:

- To develop a framework for executing large-scale distributed simulations over Grid environments
- To develop grid services, e.g., resource monitoring and management services, required by the framework
- To develop runtime library to support plug-in HLA-based distributed simulations in the framework
- To develop applications to demonstrate the feasibility and advantages of the framework

HLA (High Level Architecture) for distributed simulation, IEEE Standard 1516, Sep 2000)

Architecture of Grid-Enabled Distributed Simulation



Approach: DMSO + Grid Services

2. Execute Simulation

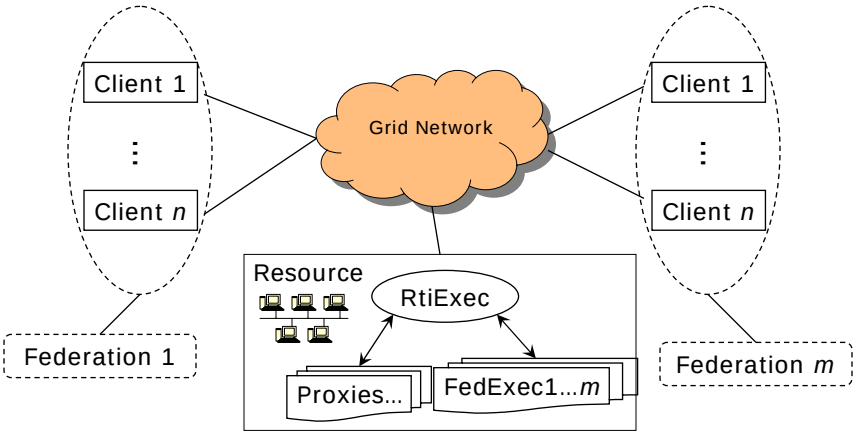
1. Develop Simulation

Simulation Code (DMSO HLA API)

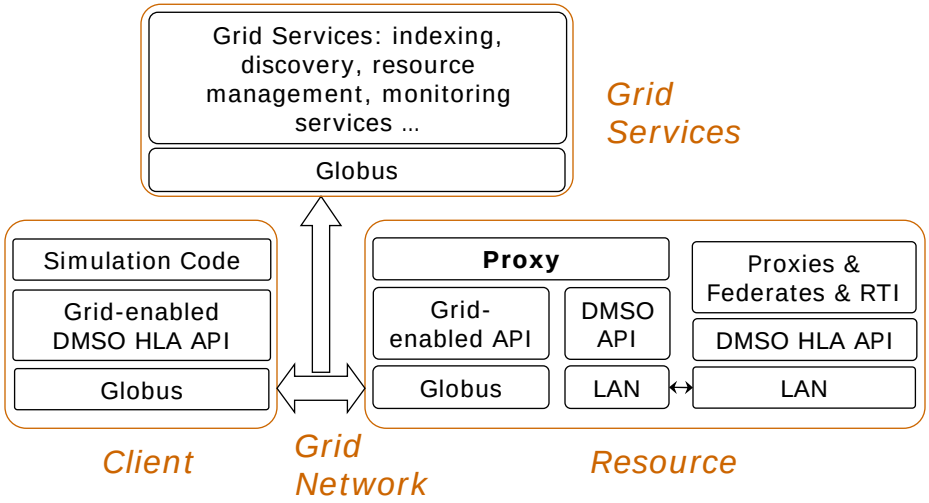
Grid Services: *deployment, execution, monitoring, load management, fault-tolerance services ...*

Grid Middleware e.g. Globus

Design – Proxy-based Approach



Design



Why Proxy-based Approach

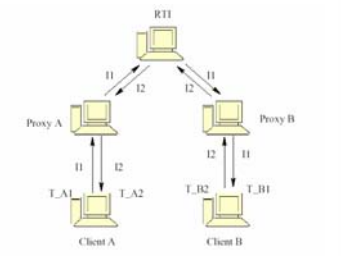
- separation of client federate & RTI
  - Ensures the security of the simulation model
  - reduced (no) firewall issue
  - Provides user transparency and simulator reusability
  - Easy migration of federates that sit on client and also migration/distribution of simulation backbone
  - Interoperability based on standard interface
  - Backbone implemented in Java – supports interoperability of heterogeneous platforms
  - .....

Disadvantage: Overhead of communication

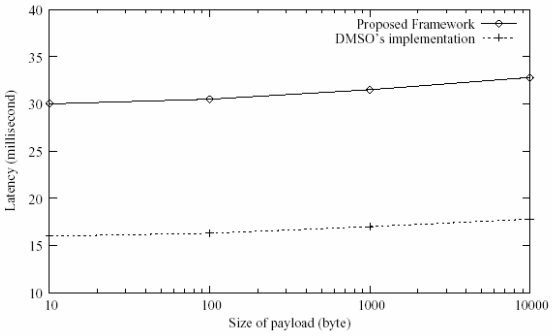
HLA-Grid Simulation Service API

- Create RTI
- Create Federation
- Join Federation
- Start federate execution
- Leave execution
- Destroy RTI
- …….

Preliminary Result - Latency



$$Latency = \frac{(T\_A2 - T\_A1) - (T\_B2 - T\_B1)}{2}$$

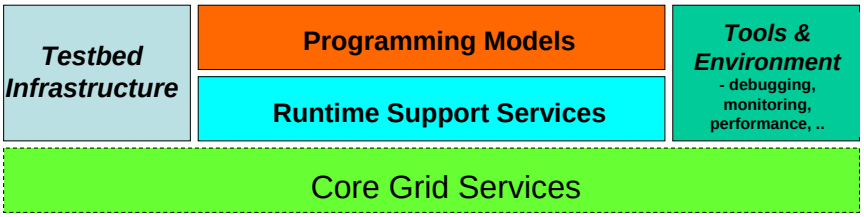


Conclusion & Future Work

- Design infrastructure to enable distributed simulation using HLA on Grid
- Implement prototype based on Globus Toolkit version 3
- Performance analysis – ongoing NTU-NUS-Birmingham University (UK)
- research issues - federation dynamic naming, federate migration, fault tolerance, etc.

Grid Computing Research at Computer Systems Lab, NUS

A framework for supporting the development and execution of large-scale collaborative distributed applications.



1. GRAPES (Grid Application Programming Environments & Systems): grid memory abstraction models, code optimizations, mobile code safety, grid application performance, etc.
2. **GES3: Grid-Enabled Self-Organizing and Scalable Services**
3. Fault-tolerant Consensus in Distributed Systems
4. A Framework for Large-Scale Grid-Enabled Distributed Simulation

Thank you

www.comp.nus.edu.sg/~teoym/alice.htm