Evolution of the Standard Simulation Architecture

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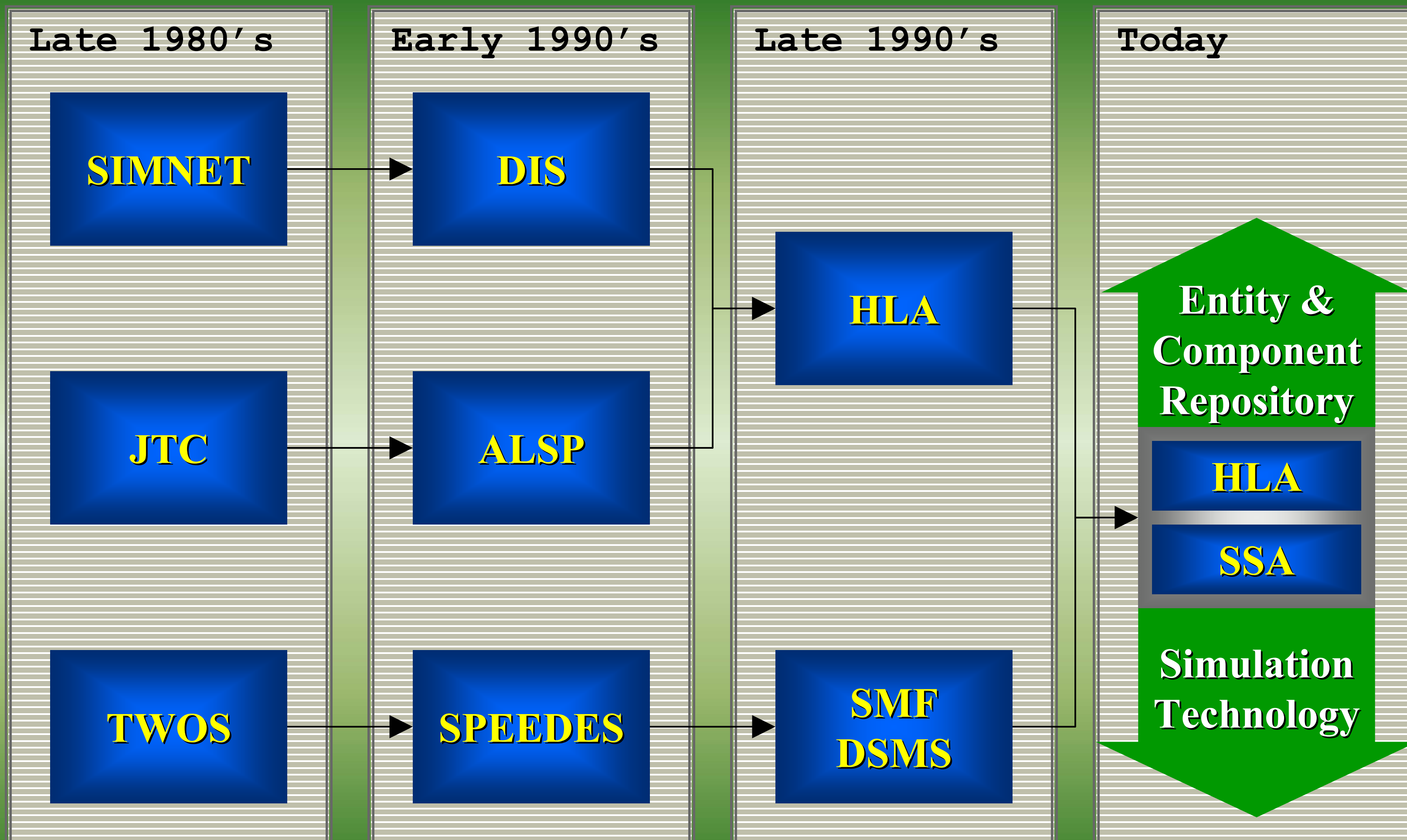
Benefits of a Standard Simulation Architecture

- **Reduce software development cost**
  - Modeling tools, constructs, and support utilities
  - Improve reliability by reducing code written by developers
- **Facilitate interoperability, composability, and reuse**
  - Entity and component repositories with object composition tools
  - Abstract interfaces decouple software implementations
  - Layered architecture supports technology insertion
- **Provide high performance**
  - Scalable parallel and distributed computing
- **Maximize configuration flexibility**
  - Flexible assignment of models to hardware platforms

Historical Evolution of the Standard Simulation Architecture



Development of the SSA

- Government & industry partnership
  - Investments made by both government and industry
  - SPEEDES, CCSE, WarpIV
- Layered architecture supports inclusive development
  - Academic R&D
  - Research laboratories
  - Multiple industry technology vendors
- Success requires government participation
  - Standards organizations
  - Government programs

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Layered Architecture: The Standard Simulation Architecture

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<table>
<tr><td colspan="2" rowspan="2">Direct Federate</td><td colspan="2">Abstract Federate</td><td colspan="2">HLA Federate</td><td colspan="2">HLA Federation</td><td colspan="2">External System</td></tr>
<tr><td colspan="2">CASE Tools</td><td colspan="2" rowspan="3">HPC-RTI</td><td colspan="2" rowspan="3">HLA Gateway</td><td colspan="2" rowspan="3">External Modeling Framework</td></tr>
<tr><td colspan="4">Entity Repository</td></tr>
<tr><td colspan="4">Component Repository</td></tr>
<tr><td colspan="10">SOM/FOM Translation Services</td></tr>
<tr><td colspan="10">Distributed Simulation Management Services</td></tr>
<tr><td colspan="10">Standard Modeling Framework</td></tr>
<tr><td colspan="10">Time Management</td></tr>
<tr><td colspan="10">Event Management Services</td></tr>
<tr><td colspan="10">Standard Template Library</td></tr>
<tr><td colspan="10">Persistence</td></tr>
<tr><td colspan="10">Rollback Utilities</td></tr>
<tr><td colspan="10">Rollback Framework</td></tr>
<tr><td colspan="5">Internal High Speed Communications</td><td colspan="5">External Distributed Communications</td></tr>
<tr><td colspan="10">Network Communications</td></tr>
<tr><td colspan="10">Utilities</td></tr>
<tr><td colspan="10">Threads</td></tr>
<tr><td colspan="10">System Services</td></tr>
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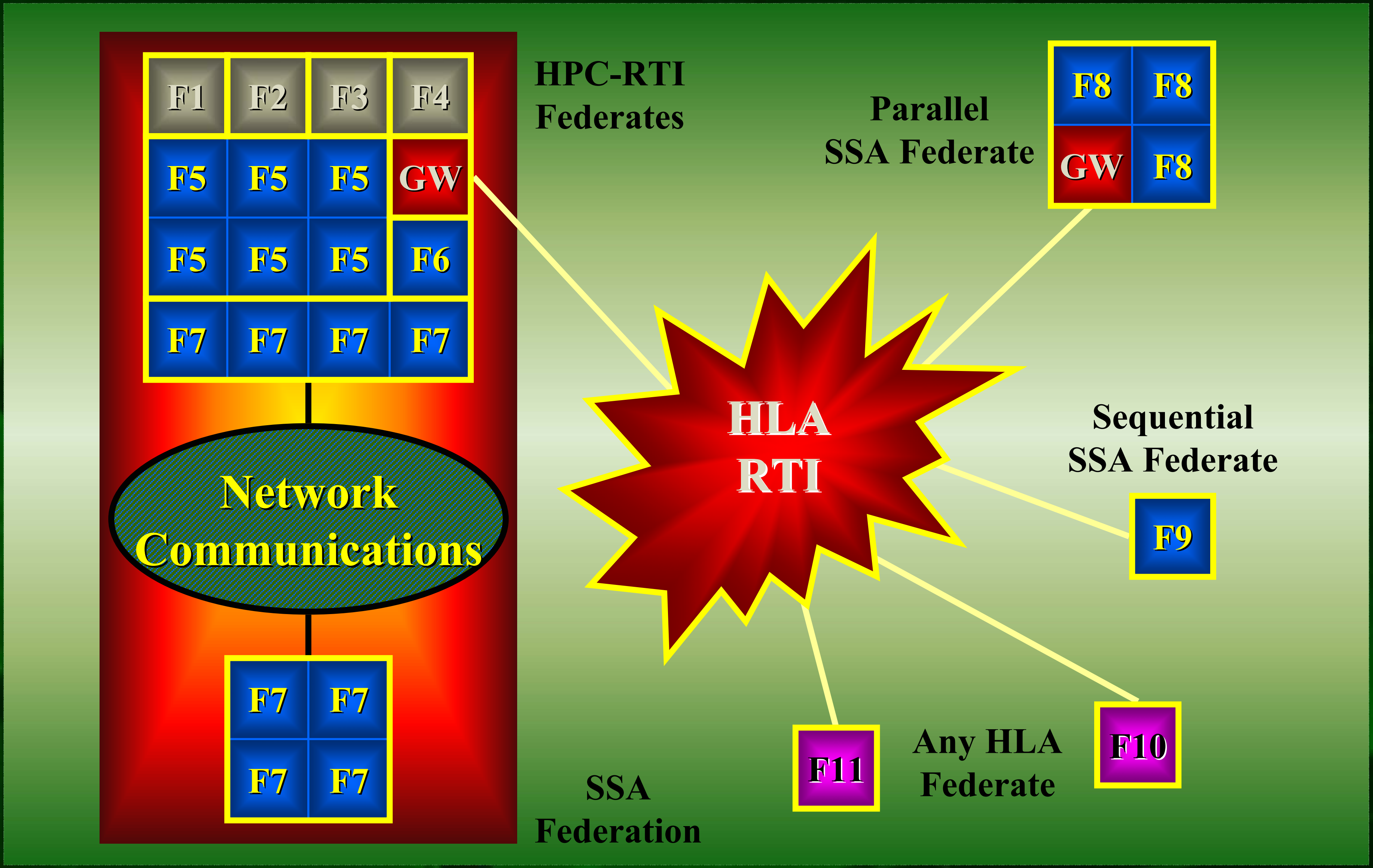
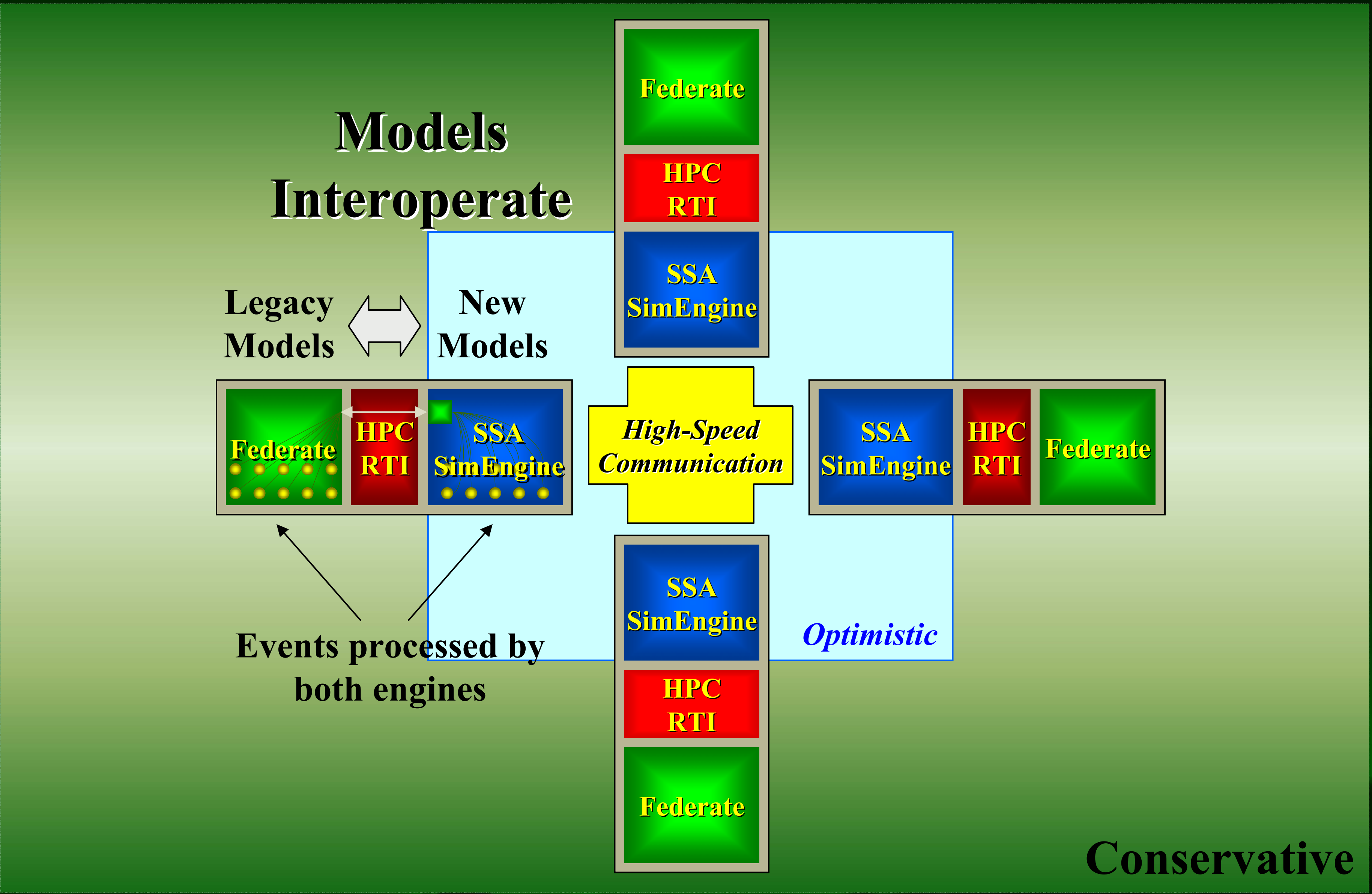
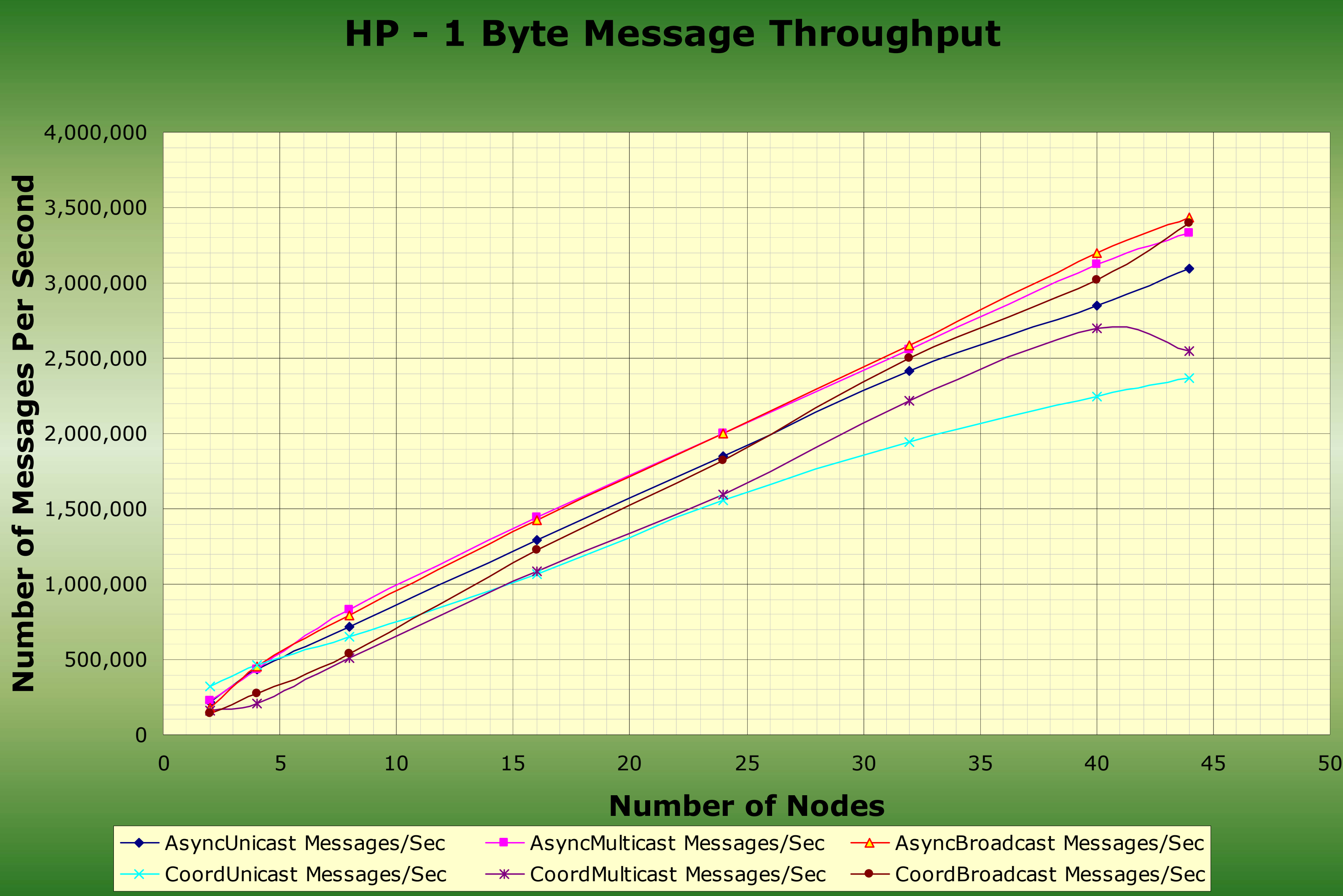
Interoperability and the Standard Simulation Architecture



High Performance Interoperability with Legacy Systems



Internal High Speed Communication is Critical for SSA Performance



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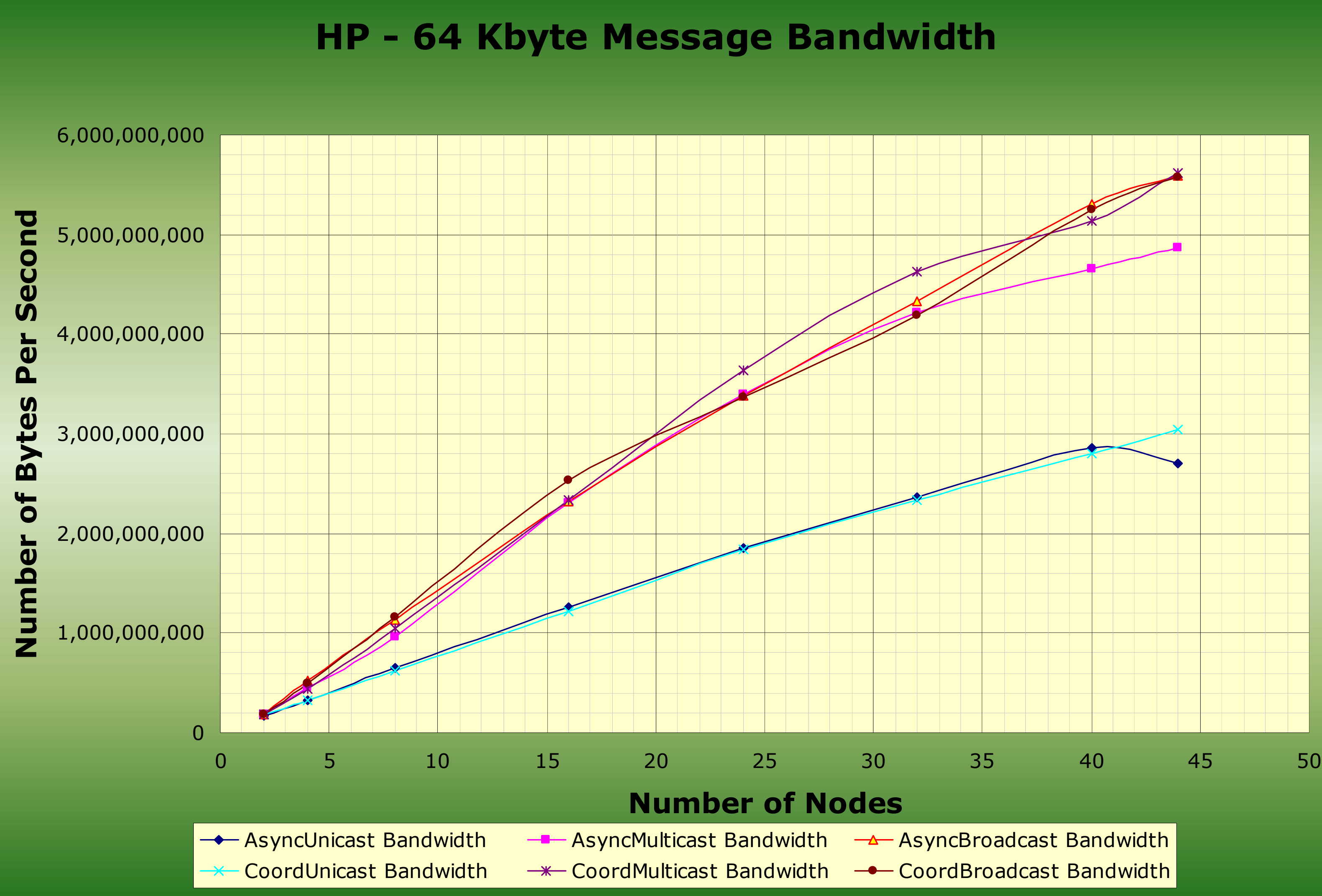
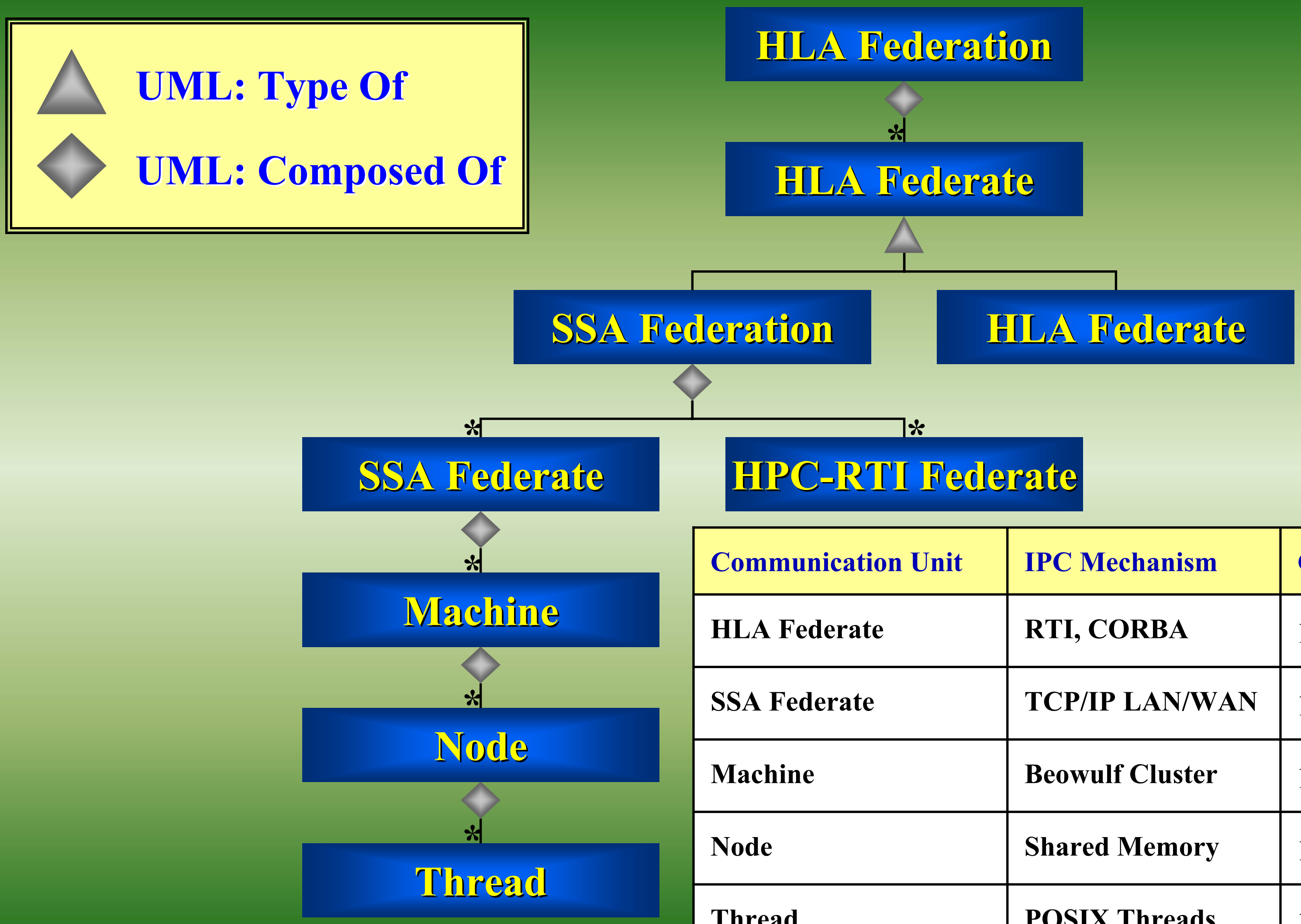
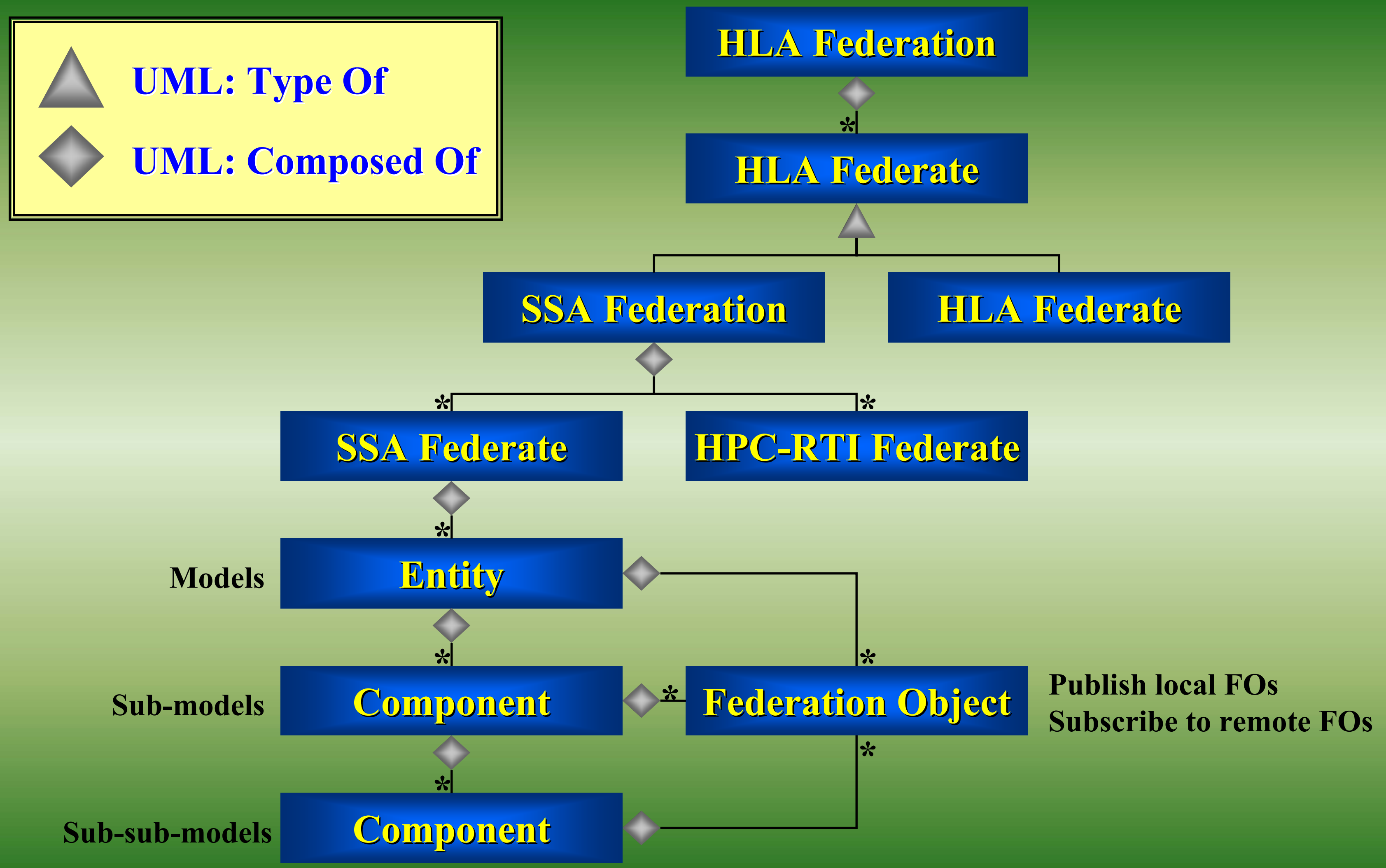


System Composability and IPC Overheads



Communication Unit	IPC Mechanism	Granularity (sec.)
HLA Federate	RTI, CORBA	10^{-3}
SSA Federate	TCP/IP LAN/WAN	10^{-4}
Machine	Beowulf Cluster	10^{-5}
Node	Shared Memory	10^{-6}
Thread	POSIX Threads	10^{-8}

Model Composability



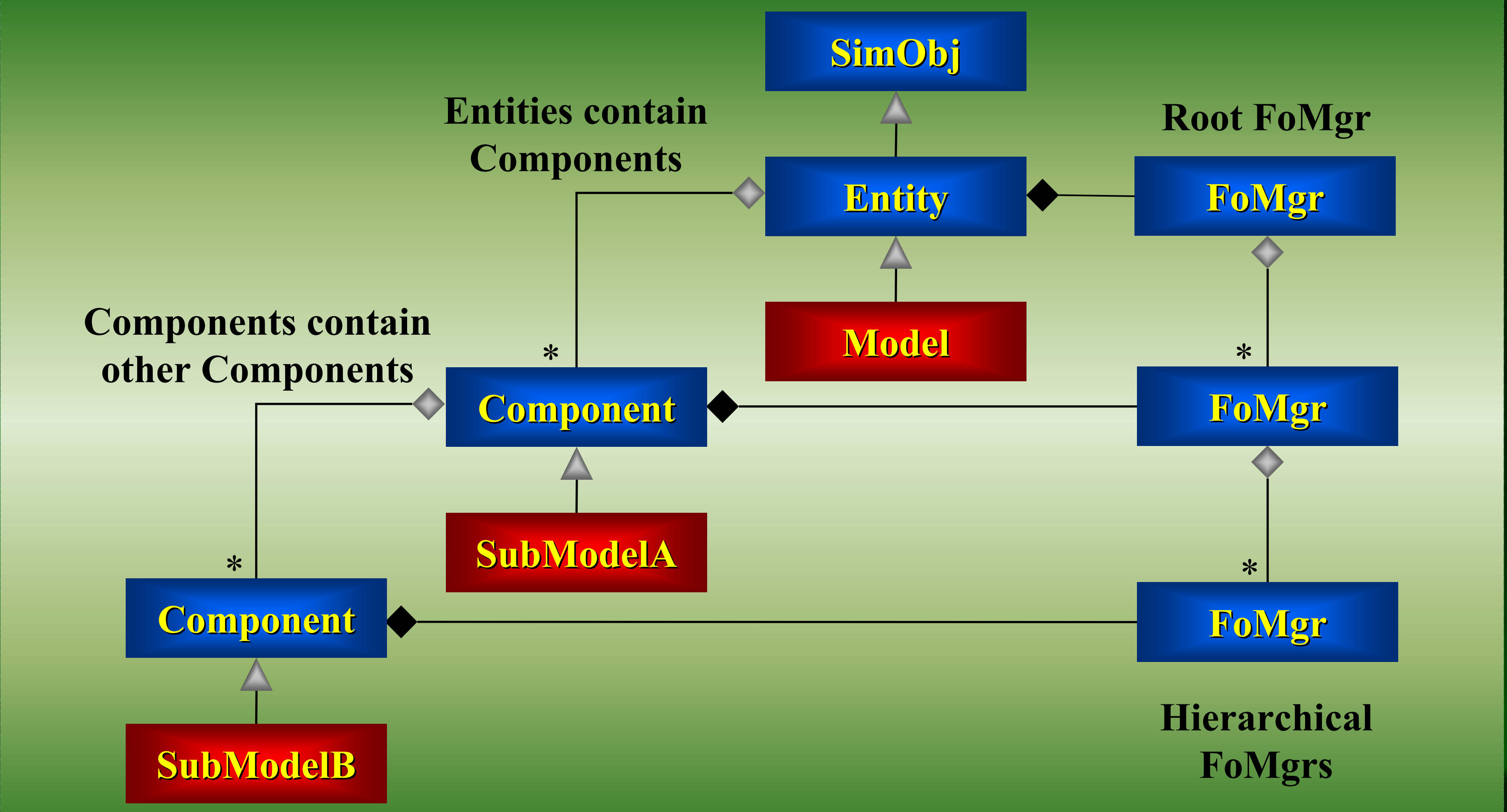
Interoperability

- **HLA provides standards for interoperability between multiple simulations**
  - Coarse grained interoperability
- **The Standard Simulation Architecture provides standards for interoperability for models at three levels**
  - Between **Federates** within an HLA federation
  - Between **Entities** within a (parallel or sequential) simulation
  - Between **Components** within an entity
- **The Standard Simulation Architecture also provides standards for technology insertion**
  - Layered architecture compartmentalizes functionality

Architecture Rules for Model Interoperability

- **Must preserve the abstraction that an entity may reside on any node when running in parallel, or within any federate when executing in an HLA federation**
  - Entity state exchanged with other entities must be provided exclusively through **Federation Objects**
  - Entities interact with other entities exclusively through HLA-style **Interactions**
- **Entities behave like miniature federates…**
  - DSMS Layer provides HLA functionality between entities
  - Operator overloading in C++ automates distribution of attributes
  - Interest management automatically operates on attributes

Hierarchical Composability

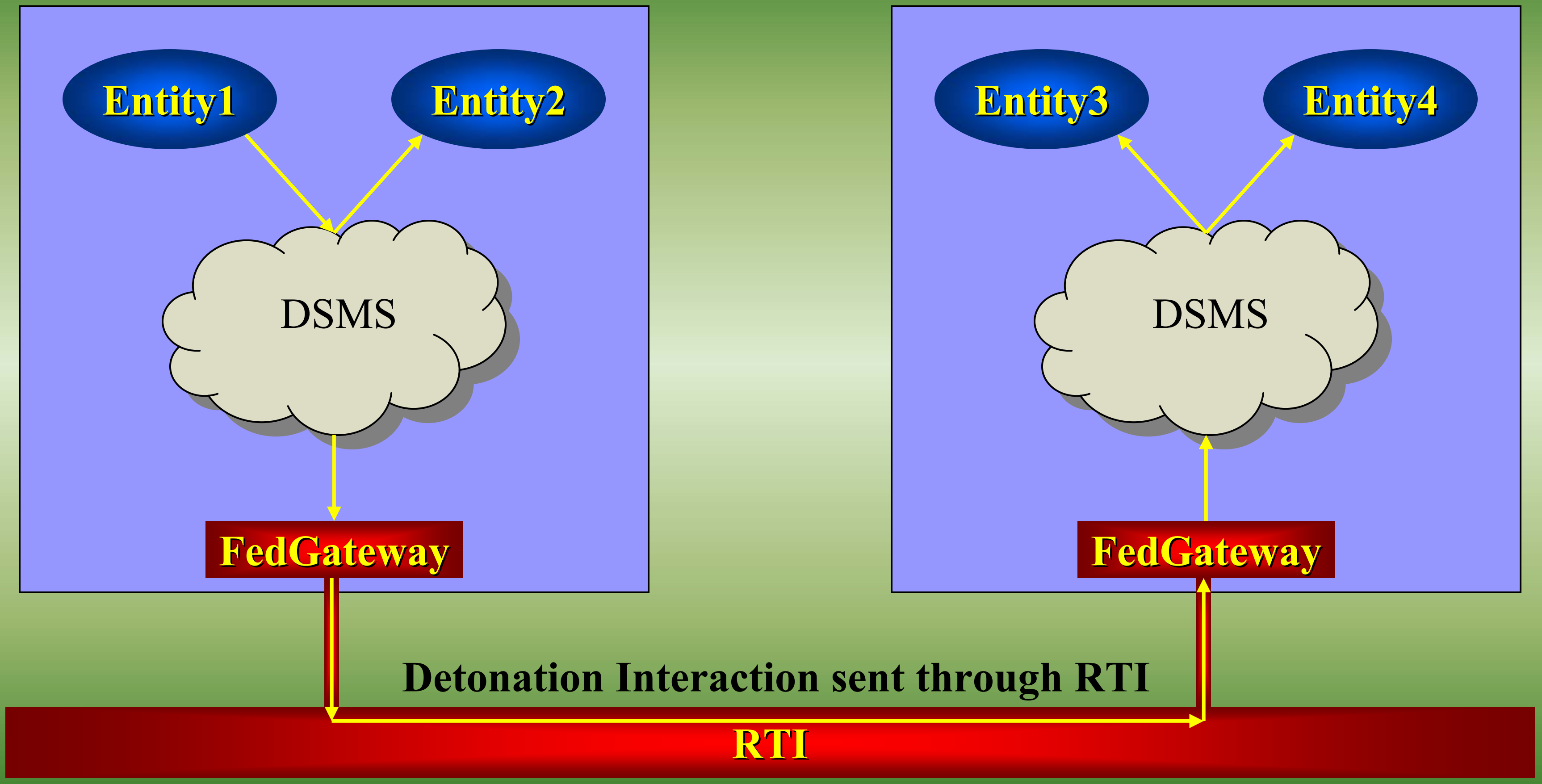


Federation Object Management

- **Interest Management is automatically provided between Entities**
  - Filtering is automatically performed on attributes as they change
  - Hierarchical grids supports multi-resolution scalability in parallel
- **Interest Management is automatically provided between Components**
  - FoMgrs filter FOs based on Component subscriptions
  - Special component for range-based filtering

Interactions Through the DSMS Layer and the HLA Gateway

Entity1 sends a Detonation Interaction



Double Abstraction Barrier Principle

- **Interactions between HLA Federates (~milliseconds)**
  - Federates do not know which other federates have subscribed
  - Federates do not know how interaction is processed
- **Interactions between Entities within an SSA federate (~microseconds)**
  - Entities do not know which other entities have subscribed
  - Entities do not know how interaction is processed
- **Polymorphic methods between Components within an SSA entity (~nanoseconds)**
  - Components do not know which classes have registered
  - Components do not know which methods are registered

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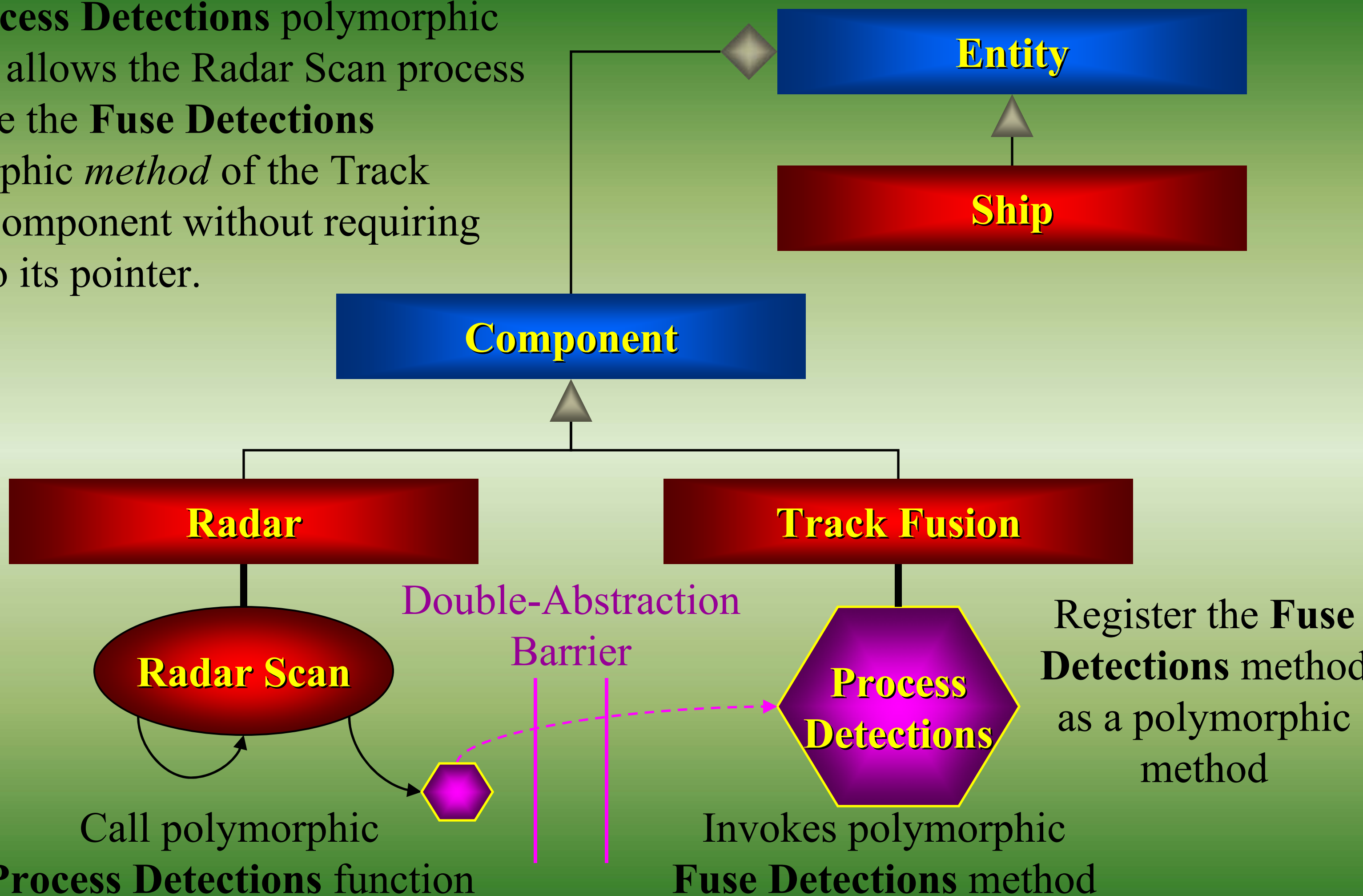
Components and Polymorphic Methods

The **Process Detections** polymorphic *function* allows the Radar Scan process to invoke the **Fuse Detections** polymorphic *method* of the Track Fusion component without requiring access to its pointer.



Standardization Encourages Three Business Models

- **Government Off The Shelf (GOTS)**
  - Development by government laboratories
  - Government provides life-cycle maintenance
- **Open Source**
  - R&D by research institutions and universities
  - Successful R&D feeds into real programs
- **Commercial Off The Shelf (COTS)**
  - Development by industry
  - Users buy software licenses with support contracts

Standardization Steps

- **Government sponsorship and oversight**
  - Establish SISO working group to study standards issues
  - Management of the standardization process
  - Requires appropriate level of funding and commitment
- **Architecture Participants**
  - **Engineering Team** comprised of proven simulation technologists to refine standards
    - Industry, Government, and University
    - Prototype standardized interfaces and services
    - Joint development of unit and system test suites
  - **Technology Panel** of specialists review individual layers
  - **User Group** generates feedback on services

Summary and Conclusions

- **The Standard Simulation Architecture addresses critical needs of DoD simulation community**
  - Interoperability between federates, entities, and components
  - Facilitates object composability
  - Layered architecture promotes technology infusion
  - High performance computing
  - Portability and flexibility
  - Reduces software development costs while improving reliability
- **Requires government sponsorship and oversight**
  - Commitment to standardize and implement the SSA layers
  - Programs must focus on model and component reuse
  - COTS, GOTS, and Open Source business models for technology insertion

WarpIV Simulation Kernel

- **WarpIV provides prototype development of the SSA**
- **RAM Laboratories is currently offering WarpIV to:**
  - Universities
  - Research Laboratories
  - Government Programs
  - Industry
- **For more information about WarpIV, see our website:**
  - http://www.ramlabs.com