

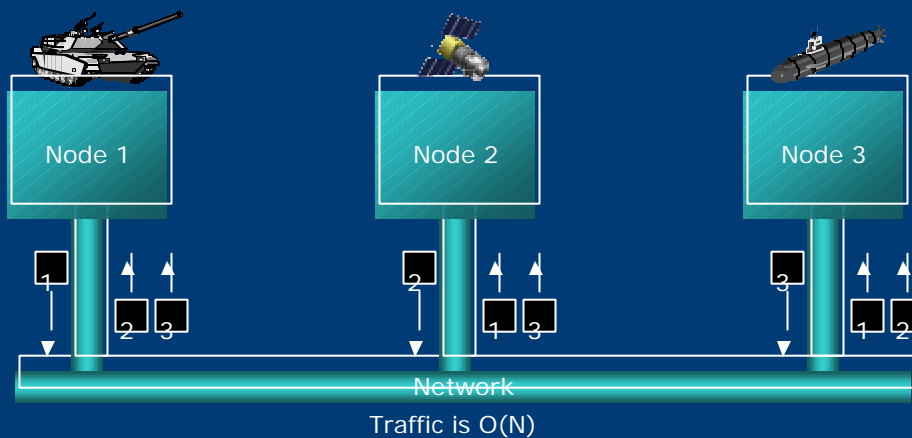
High Level Architecture

Class 11
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<http://www.simulationfirst.com/ein5255/>

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Problem 1: No Filtering



- All messages go everywhere
- Each simulator must contend with a blizzard of information
- No infrastructure to support the simulator

Problem 2: Fixed Message Content

| Field Size (Bits) | Entity State PDU Fields | Field Description |
|-------------------|--------------------------------------|--|
| 96 | PDUHEADER | Protocol Version - 8-bit enumeration Exercise ID - 8-bit unsigned integer PDU Type - 8-bit enumeration Protocol Family - 8-bit enumeration Time Stamp - 32-bit unsigned integer Length - 16-bit unsigned integer |
| 48 | ENTITY ID | Pad - 16 bits unused Entity ID - 16-bit unsigned integer |
| 8 | FORCE | Entity Kind - 8-bit enumeration |
| 8 | ARTICULATION | Entity Kind - 8-bit enumeration |
| 64 | ENTITY TYPE | Entity Kind - 8-bit enumeration Domain - 8-bit enumeration Country - 16-bit enumeration Category - 8-bit enumeration Subcategory - 8-bit enumeration Specific - 8-bit enumeration Extra - 8-bit enumeration |
| 64 | ALTERNATIVE ENTITY TYPE | Entity Kind - 8-bit enumeration Domain - 8-bit enumeration Country - 16-bit enumeration Category - 8-bit enumeration Subcategory - 8-bit enumeration Specific - 8-bit enumeration Extra - 8-bit enumeration |
| 96 | ENTITY VELOCITY | X Component - 32-bit floating point Y Component - 32-bit floating point Z Component - 32-bit floating point |
| 192 | ENTITY LOCATION | X Component - 64-bit floating point Y Component - 64-bit floating point Z Component - 64-bit floating point |
| 96 | ENTITY ORIENTATION | Psi - 32-bit floating point Theta - 32-bit floating point Phi - 32-bit floating point |
| 32 | ENTITY APPEARANCE | 32-bit record of enumerations |
| 320 | DEAD RECKONING PARAMETERS | Algorithm - 8-bit enumeration Other Parameters - 120 bits unused Entity Linear Accel - 3x32-bit floating point Entity Angular Accel - 3x32-bit floating point |
| 96 | ENTITY MARKING | Character Set - 8-bit enumeration 11 8-bit unsigned integers |
| n X 128 | CAPABILITIES ARTICULATION PARAMETERS | 32 Boolean fields Parameter Type Designator - 8-bit enumeration Change - 8-bit unsigned integer ID - attached to - 16-bit unsigned integer Parameter Type - 32-bit parameter type record Parameter Value - 64-bit |

DISCIPLINE

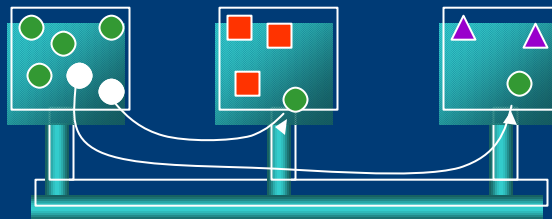
What about ...?

- Simulated Command and Control
- Perception Exchange
- Satellite Orbital Parameters
- Filter Settings
- (more ...)

Problem 3: No Ownership Transfer

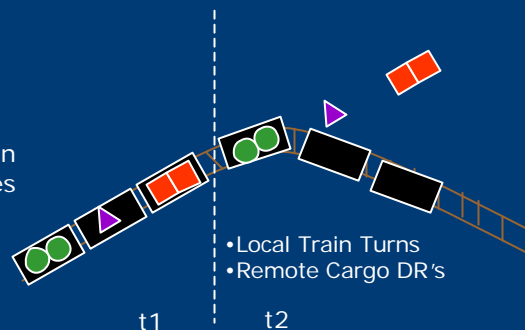
Load Balancing

- Distribute Work
- Use Best Model
- Mitigate Crashes

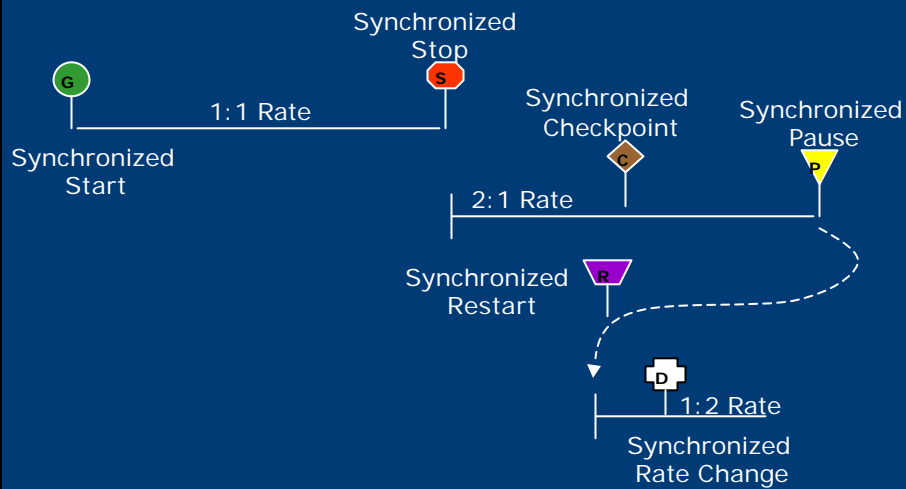


Object Synchronization

- Lag Interferes with Coordination
- Requires Unnecessary Messages
- Oscillates in/out of synch



Problem 4: No Time Management

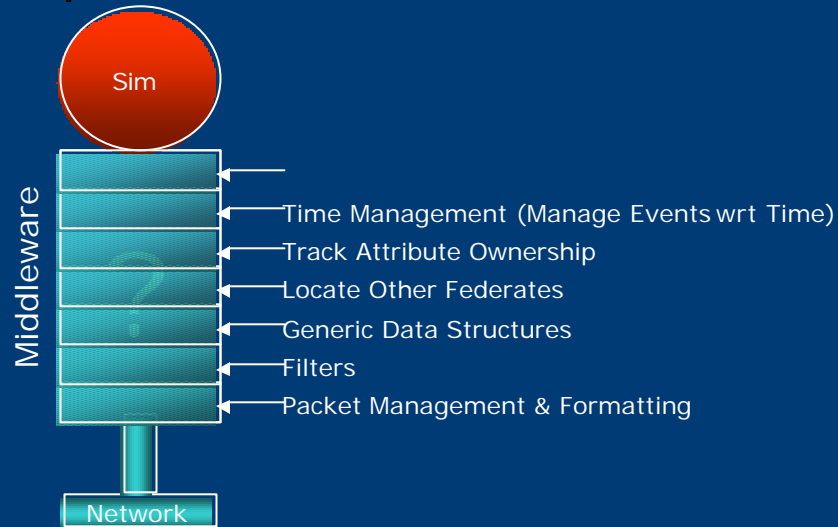


Synchronized in Simulation Time AND/OR Real Time

Solutions

- **P1: No Filtering**
 - Publish/Subscribe
 - Data Distribution Management
- **P2: Fixed Message Content**
 - User Defined Federation Object Model
- **P3: No Ownership Transfer**
 - Ownership Management
- **P4: No Time Management**
 - Multiple Time Management Services

Solution Implementation Requires Standard Middleware



What About CORBA? Common Object Request Broker Architecture

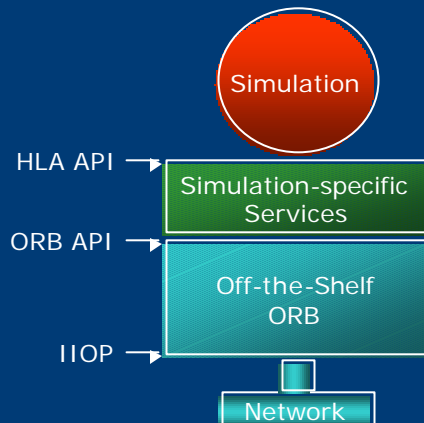


- CORBA Can Provide
- Dynamic Discovery
 - Skeleton Connectors
 - ID Remote Users
 - IIOP
 - Pub/Sub Services
 - Transaction Synch



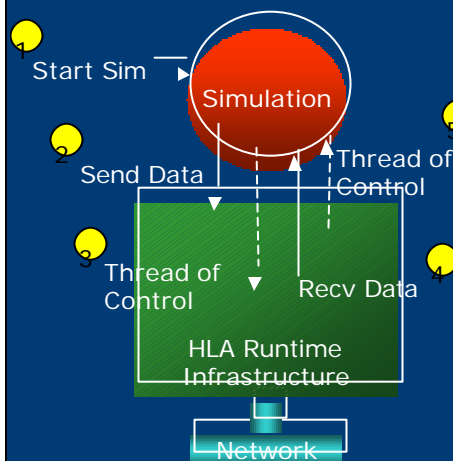
- Simulation Still Needs
- Time Management
 - Geographic Filtering

Building on the ORB

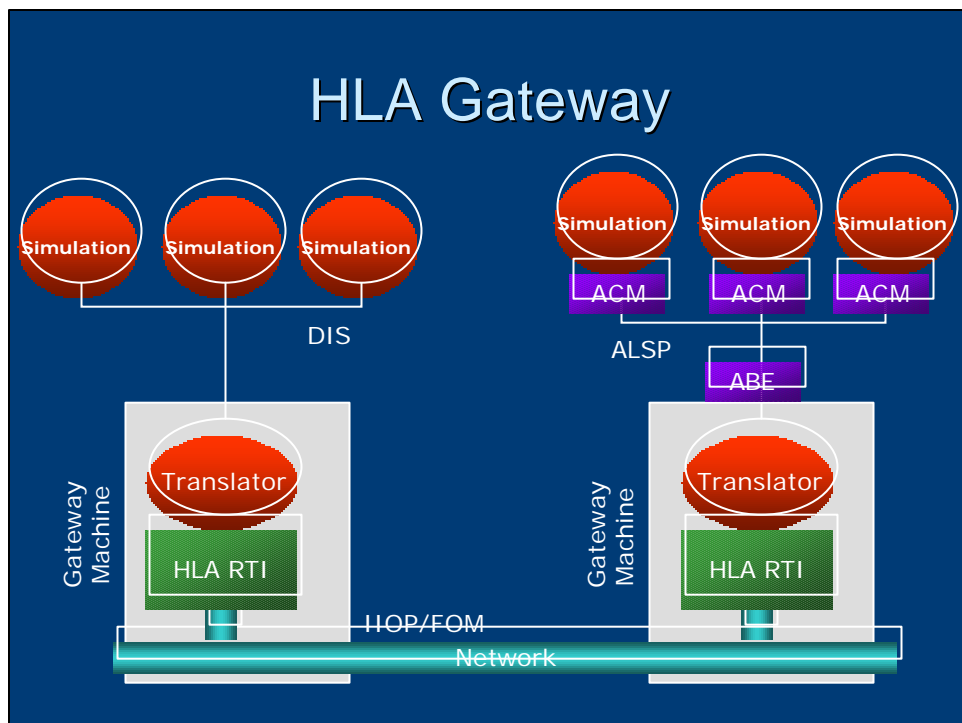
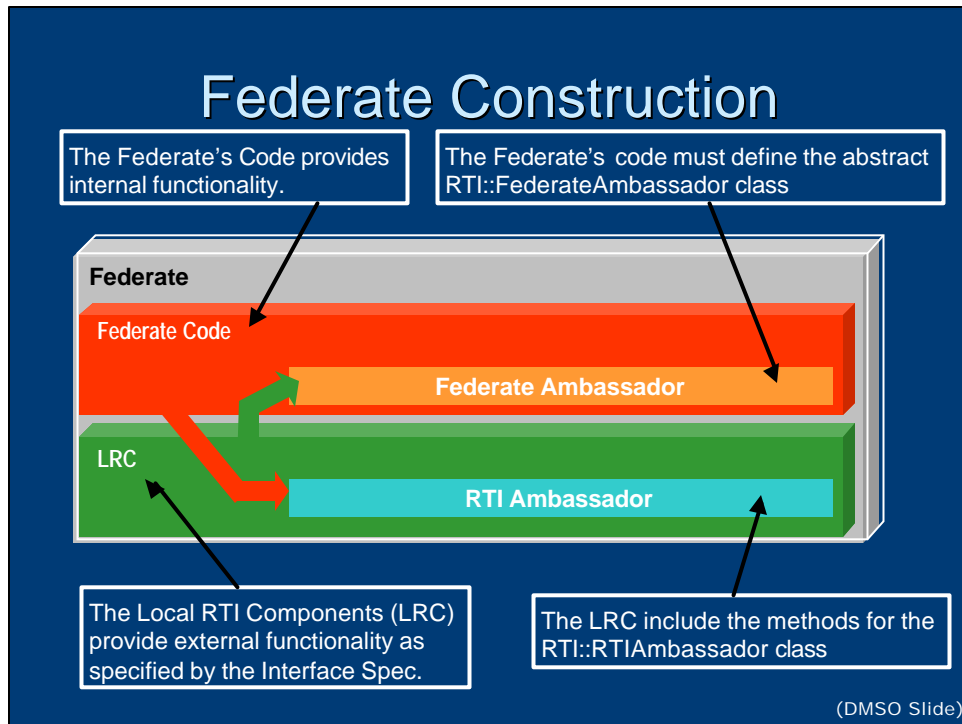


- ORB Looks like a simulation-specific middleware to the Simulation
- Middleware has simulation-specific capabilities
- IIOP provides interoperability between different ORB's (different vendor products)
- Sim Middleware inherits performance of ORB

2-Way Communications



- Pass data both ways
 - Send Out
 - Receive In
- Share thread of control
- Lose ability to completely budget resources
- RTI requires CPU, RAM, Time



HLA Gateway

Positive

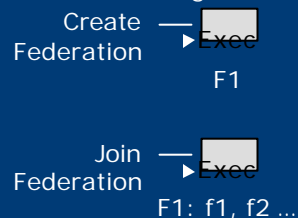
- Project Control
- Performance Control
- Keep Existing Applications
- (more ...)

Negative

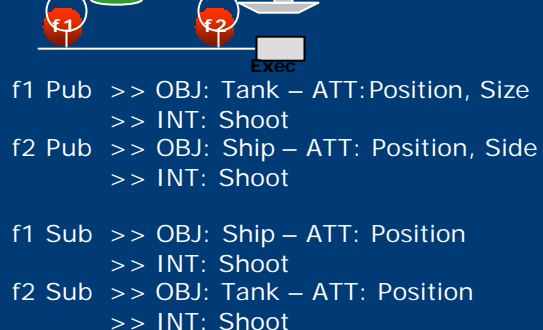
- Duplicate Software
 - Network Packaging
 - Synchronization
- Compromises Compatibility
 - Native-to-RTI-to-Native
- 2-step Transmit
- (more ...)

HLA Service Categories

1 Federation Management



2 Declaration Management



HLA Service Categories

3 Object Management



f1 Create Tank (T1, T2)
 f1 Update T1(Position, Size)
 f1 Update T1(Position, Size)

f2 Create Ship (S1, S2)
 f2 Update S1(Position, Side)
 f2 Update S1(Position, Side)

f1 Publish Shoot(T1, T2)
 f2 Publish Shoot(S1, T2)

4 Ownership Management



f2 Request Own T1(Position)
 f1 Grant Own T1(Position)

f2 Update T1(Position)
 f2 Create S1(Position), T1(Position)

HLA Service Categories

5 Time Management



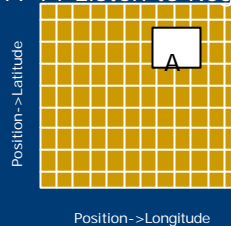
f1 What time is it?
 f1 Events in Increasing Order
 RTI1 Deliver Events

f2 Get Next Event

6 Data Distribution Management



f1 Create Region A
 f1 T1 Listen to Region A



Note: Grid Previously defined in FOM

Y = Position->Latitude

X = Position->Longitude

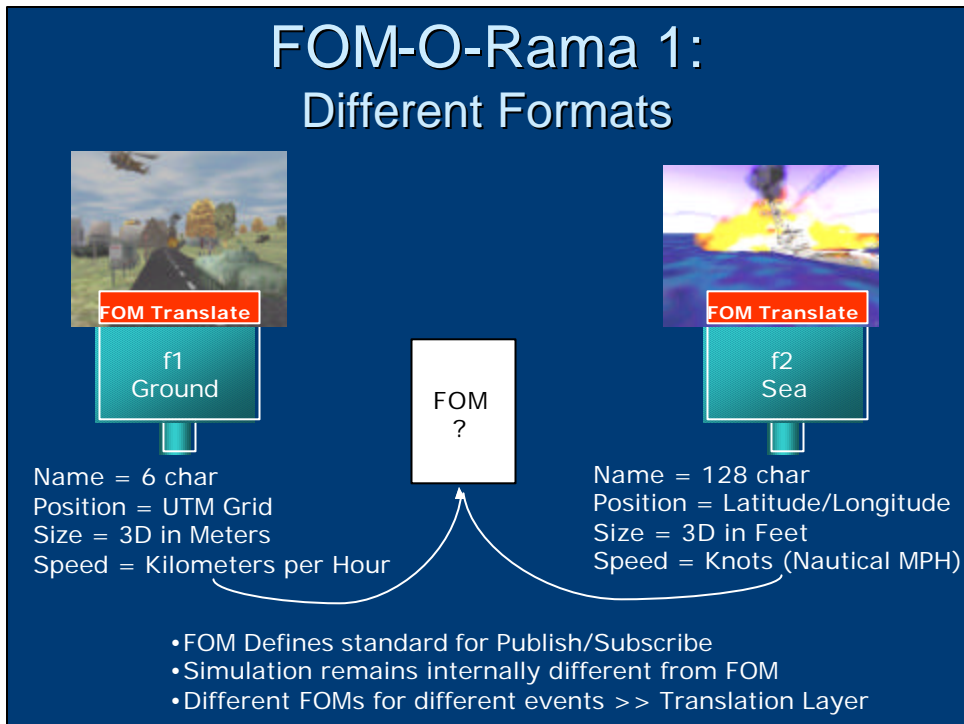
HLA Interface Specification

| Category | Functionality |
|-------------------------------------|--|
| Federation Management | Create and delete federation executions Join and resign federation executions Control checkpoint, pause, resume, restart |
| Declaration Management | Establish intent to publish and subscribe to object attributes and interactions |
| Object Management | Create and delete object instances Control attribute and interaction publication Create and delete object reflections |
| Ownership Management | Transfer ownership of object attributes |
| Time Management | Coordinate the advance of logical time and its relationship to real time |
| Data Distribution Management | Support efficient routing of data |

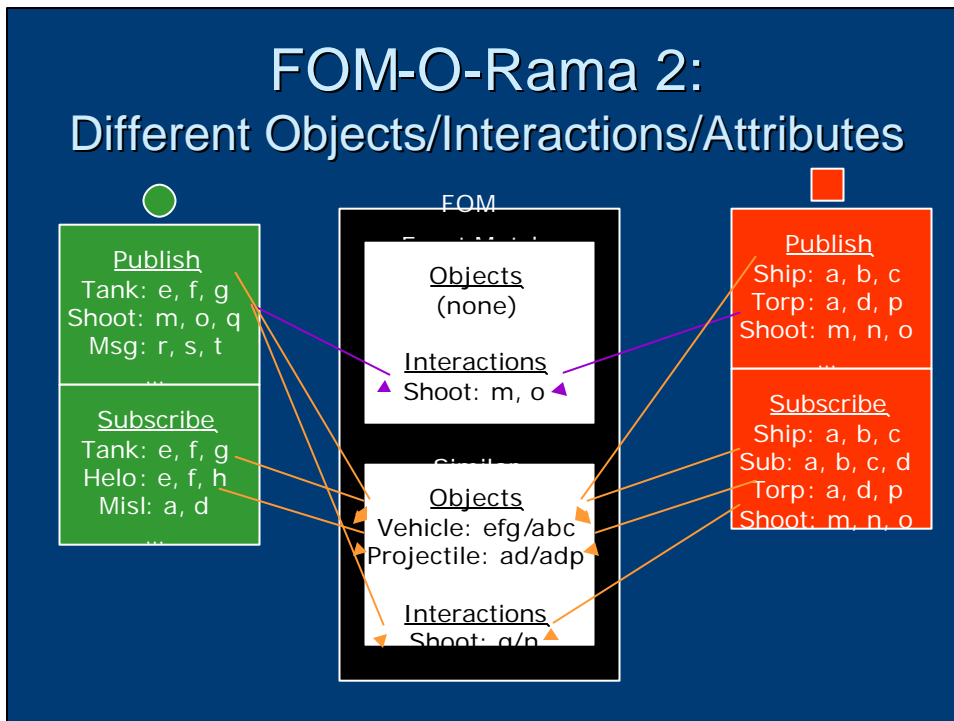
Federation Object Model

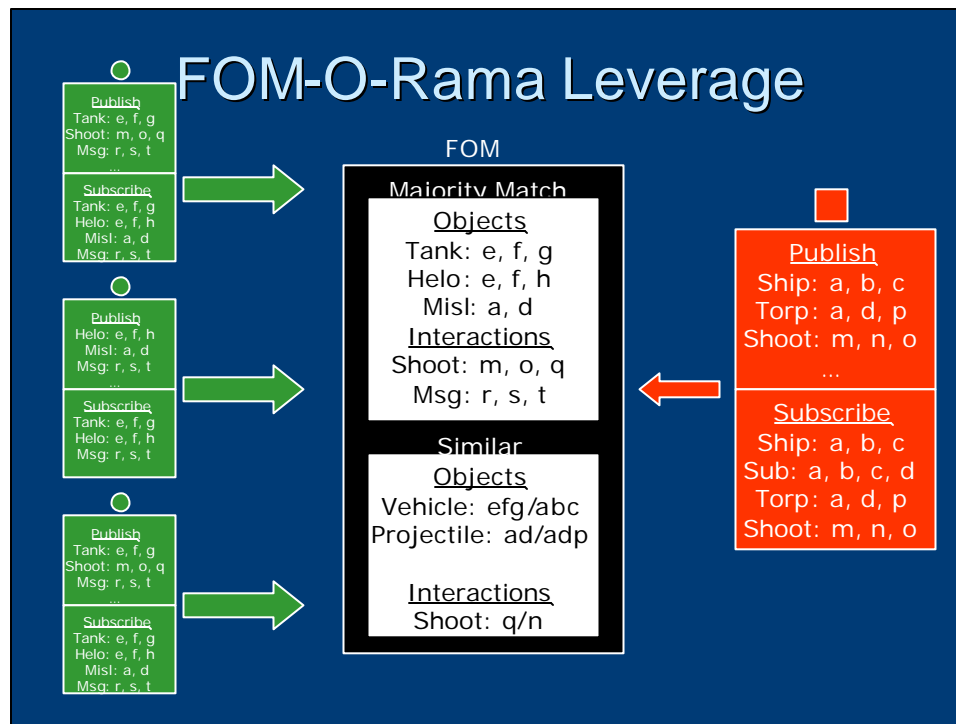
- Format of data to be Exchanged Between Sims
 - Object Classes
 - Object Attributes
 - Interaction Classes
 - Interaction Parameters
- Includes
 - Name of Field
 - Format of Field
 - Enumeration List for Field

FOM-O-Rama 1: Different Formats



FOM-O-Rama 2: Different Objects/Interactions/Attributes






Quick & Useful FOM's

- Convert DIS PDUs
 - Real-time Platform Reference FOM
- Convert ALSP Messages
 - JTC FOM
- Convert other existing data exchange formats to the HLA/RTI delivery mechanism and structure
 - CCSIL
 - (more ...)

HLA Compliant

- HLA Rules 1 2 3 4 5 6 7 8 9 10
 - A set of rules which must be followed to achieve proper interaction of simulations in a federation. These describe the responsibilities of simulations and of the runtime infrastructure in HLA federations.
- Interface Specification A P I
 - Definition of the interface functions between the runtime infrastructure and the simulations subject to the HLA.
- Object Model Template O B J E C T S I N T E R A C T I O N S R O U T I N G S P A C E S
 - The prescribed common method for recording the information contained in the required HLA Object Model for each federation and simulation.

Object Model Templates



| Routing Space Table | | | | | | Accuracy | Routing Space | Update Condition | T/A | U/R | Routing Space |
|---------------------|---------------|-----------|-----------|-----------|---------------|------------|---------------|----------------------|------|------|---------------|
| P=publish | S=subscribe | Dimension | Dimension | Range/Set | Normalization | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| transferable | Routing Space | Type | Type | Units | Function | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| mutable | Routing Space | Type | Type | Units | Function | condition> | <r_space> | ... | ... | ... | ... |
| updateable | Routing Space | Type | Type | Units | Function | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| reflectable | Routing Space | Type | Type | Units | Function | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| ... | ... | ... | ... | ... | ... | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| <r_space> | dimension | type | range/set | units | function | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| ... | dimension | type | range/set | units | function | condition> | <r_space> | <rate> <condition> | <ta> | <ur> | <r_space> |
| Location | X_dim | float | (0-100) | km | linear(x) | always | N/A | scene events | T/A | UR | N/A |
| | Y_dim | float | (0-100) | km | linear(x) | always | N/A | scene events | T/A | UR | Location |

Object Model Identification Table



| Object Model Identification Table | |
|-----------------------------------|---|
| Category | Information |
| Name | |
| Version | |
| Date | |
| Purpose | |
| Application Domain | |
| Sponsor | |
| POC | |
| POC Organization | |
| POC Telephone | |
| POC Email | |
| Name | Strike Simulation SOM |
| Version | 1.0 Alpha |
| Date | 1 Jan 1998 |
| Purpose | To provide an example of an object model for a federate that simulates strike operations. |

Object Class Structure Table



| Object Class Structure Table | | | |
|------------------------------|------------------|--------------------|---|
| <class> (<ps>) | [<class> (<ps>)] | {<class> (<ps>)} | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | | {<class> (<ps>)} | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | | {<class> (<ps>)} | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | | ... | ... |
| | | {<class> (<ps>)} | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | [<class> (<ps>)] | {<class> (<ps>)} | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | | ... | ... |
| | | [<class> (<ps>)] | [<class> (<ps>)] {<class> (<ps>)} {<ref>} |
| | ... | ... | ... |
| Air Vehicle (S) | Fixed Wing (S) | Fighter-Attack (S) | F-14 (PS) |
| | | | F-16 (PS) |
| | | | F-18 (PS) |
| | | Bomber (S) | B-1 (PS) |
| | | | B-2 (PS) |
| | Rotary Wing (PS) | | |

Interaction Class Structure Table



| Interaction Class Structure Table | | | |
|-----------------------------------|-------------------|--|--|
| <class> (<isr>) | [<class> (<isr>)] | [<class> (<isr>)] | [<class> (<isr>)][<class> (<isr>)*][<ref>] |
| | | [<class> (<isr>)] | [<class> (<isr>)][<class> (<isr>)*][<ref>] |
| | | ... | ... |
| | [<class> (<isr>)] | [<class> (<isr>)][<class> (<isr>)*][<ref>] | |
| [<class> (<isr>)] | [<class> (<isr>)] | [<class> (<isr>)][<class> (<isr>)*][<ref>] | |
| | ... | ... | |
| | [<class> (<isr>)] | [<class> (<isr>)][<class> (<isr>)*][<ref>] | |
| ... | ... | ... | |

| | | | |
|---------------------|-------------------------------------|-------------------------------------|-----------------------------------|
| Weapon Detonate (S) | Weapon Detonate at Sea Target (R) | Weapon Detonate at Surface Ship (R) | Weapon Detonate at Cruiser (IR) |
| | | | Weapon Detonate at Carrier (IR) |
| | | | Weapon Detonate at Destroyer (IR) |
| | | Weapon Detonate at Submarine (IR) | |
| | Weapon Detonate at Land Target (IR) | | |
| | Weapon Detonate at Air Target (R) | Weapon Detonate at Fighter (IR) | |
| | Weapon Detonate at Bomber (IR) | | |

Object Attribute Table



| Object Attribute Table | | | | | | | | | | | | |
|------------------------|-------------|------------|-------------|---------|--------------|------------|--------------------|-------------|----------------------|------|------|---------------|
| Object | Attribute | Data-type | Cardinality | Units | Resolution | Accuracy | Accuracy Condition | Update Type | Update Condition | T/A | U/R | Routing Space |
| <class> | <attribute> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <conditions> | <type> | <rate> <condition> | <ta> | <ur> | <space> |
| | <attribute> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <conditions> | <type> | <rate> <condition> | <ta> | <ur> | <space> |
| <class> | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | <attribute> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <conditions> | <type> | <rate> <condition> | <ta> | <ur> | <space> |
| Aircraft | Area | Float | 1 | m2 | 0.1 | perfect | always | cond | scen events | T/A | UR | N/A |
| | Velocity | Double | 1 | m/sec | .01 | .01 | none | periodic | 10 Hz | T/A | UR | N/A |
| | State | Activity_e | 1 | n/a | n/a | n/a | n/a | cond | scen events | T/A | UR | Location |
| | Position | Loc_c | 1 | n/a | n/a | n/a | n/a | periodic | 10 Hz | T/A | UR | Location |

Interaction Parameter Table



| Interaction Parameter Table | | | | | | | | |
|-----------------------------|-----------------|----------------|-------------|---------|--------------|------------|--------------------|---------------|
| Interaction | Parameter | Data-type | Cardinality | Units | Resolution | Accuracy | Accuracy Condition | Routing Space |
| <interaction> | <parameter> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <condition> | <r_space> |
| | <parameter> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <condition> | |
| | ... | ... | ... | ... | ... | ... | ... | |
| <interaction> | <parameter> | <datatype> | <size> | <units> | <resolution> | <accuracy> | <condition> | <r_space> |
| | ... | ... | ... | ... | ... | ... | ... | |
| Weapon Detonate | Weapon Location | Loc_c | 1 | N/A | N/A | N/A | N/A | N/A |
| | Warhead Size | Unsigned Short | 1 | lbs | 1.0 | perfect | always | |
| | Warhead Type | WH_Type | 1 | N/A | N/A | N/A | N/A | |

Routing Spaces Table



| Routing Space Table | | | | | |
|---------------------|-------------|----------------|---------------------|-----------------|------------------------|
| Routing Space | Dimension | Dimension Type | Dimension Range/Set | Range/Set Units | Normalization Function |
| <r_space> | <dimension> | <type> | <range/set> | <units> | <r_function> |
| | <dimension> | <type> | <range/set> | <units> | <r_function> |
| | <dimension> | <type> | <range/set> | <units> | <r_function> |
| ... | ... | ... | ... | ... | ... |
| <r_space> | <dimension> | <type> | <range/set> | <units> | <r_function> |
| | <dimension> | <type> | <range/set> | <units> | <r_function> |
| Location | X_dim | float | (0-100) | km | linear(X) |
| | Y_dim | float | (0-100) | km | linear(Y) |