

High Level Architecture

Module 2

Advanced Topics



Roy Crosbie
John Zenor

California State University, Chico

High Level Architecture Module 1 Basic Concepts

HLA Data Interchange Format (DIF) Standards



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2

References

- *Common Activities in Data Interchange format (DIF) Development*, Peggy D. Gravitz, Jack Sheehan, Thom McLean,
- *HLA OMT Data Interchange Format (DIF) v1.1*, April-97, <http://hla.dmsomil/hla/tech/omtspec/difbnf11.pdf>
- *High Level Architecture Interface Specification, v1.3*, 2 April 1998, pg 245-257, <http://hla.dmsomil/hla/tech/ifs/ifs-spec-d01-body.pdf>
- FED File for Helloworld Federation



- The *Gravitz* paper discusses the overall philosophy of DIFs and DIF development. It discusses the nature of DIF standards and the process for developing DIFs.
- HLA OMT Data Interchange Format* provides the DIF standard for the OMT DIF which provides for the interchange of SOM, FOM, and FED files between users of HLA.
- The *HLA Interface Specification* has a section containing a formal specification of the DIF for FED files.

What is a DIF?

- Definition (from Gravitz, et. al.)
 - “Formal specification of the structure and format of data to be interchanged between data producers and consumers.”
- DIF standards are developed to facilitate data sharing
 - Do **not** force all users to the same format
 - **Do** provide a common interchange format
- No **single** “DIF” standard!!
 - Separate standards for different types of shared data
- Sufficiently formal to allow use of automated tools to support the exchange of data.



It is important to note that there is no such thing as a standard for all DIFs. The Gravitz paper provides some of the only insights into the general nature of DIFs and how to proceed to create a new DIF.

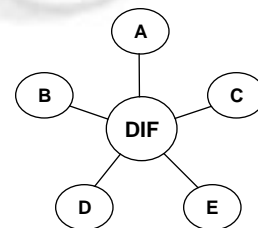
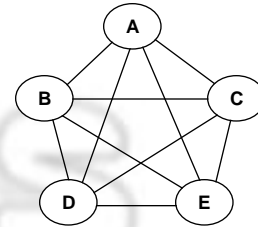
DIFs are created when common classes of data need to be exchanged between users of HLA simulations. Typically, a new DIF is prepared when there is a class of data common to an application area that is likely to be used and exchanged between many different models.

There is no attempt to standardize the representation of data items in all machines running all models, only to provide a standard that allows data to be exchanged in a commonly understood, formally specified format.

The DIF should be formal enough to allow automated tools to convert from local representations for data items into the exchange format.

Why do we need a DIF?

- $2n$ vs $n*(n-1)$ problem of exchanging data
- Useful where a larger user community requires interoperability or exchange of data between heterogeneous systems
- Reduces time and costs and removes ambiguity in transferring data between systems



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5

Assume we have N federates in a simulation --- all running on N separate computer systems, all having different data formats (e.g different internal floating point formats, or different units). Without standard interchange formats, each machine might have to carry out N different format conversions to send data to the other machines, yielding $n*(n-1)$ possible conversions on all of the machines.

With standards for data interchange, such as a DIF standard, each machine only needs to know how to convert to and from its local representation to the standard representation, yielding only $2N$ conversions on all of the N machines. No machine needs to know anything about the internal representations of data on any other machine!

The use of DIF greatly reduces the complexity of the conversion process and allows the flexibility of accommodating a change in the format required by a change in the type of any machine without having to change the code in any other machine.

DIFs for HLA Simulations

- Two DIFs that are specified as part of the HLA standard
 - Federation Execution Data (FED) DIF
 - Allows exchange of FED file data
 - DIF standard included in the *HLA Interface Specification*
 - Object Management Template (OMT) DIF
 - Allows exchange of FOM and SOM data
 - DIF standard included in annex of the *OMT Specification*
- Standalone DIFs, not part of the HLA standard
 - DIFs for data specific to a particular application area
 - Integrated Data Dictionary DIF



Only the two DIF standards that are included in the HLA specification will be addressed further in this presentation: the FED DIF, and the OMT DIF.

DIF Definition Styles

- Formal techniques used for defining DIFs
 - Backus Naur Form (BNF) (extended)
 - Provides complete, formal, language definition
 - Many tools available for automatic parsing of BNF descriptions
 - Current FED and OMT DIFs described using BNF
 - Very precise, but many find BNF incomprehensible in appearance
 - Extensible Markup Language (XML)
 - Document Type Definition (DTD) expresses structure
 - XML is a standardized language
 - Future FED and OMT DIFs may use XML
 - Interface Description Language (IDL)



Backus Naur Form (BNF) is attributed to John Backus and Peter Naur and was invented to describe the syntax of Algol 60. Several simple extensions have been added to simplify the specification of these DIFs in BNF form. This Extended Backus Naur Form (EBNF) has included syntax for repetitions and choice (alternation).

The current OMT and FED DIFs are defined in BNF. Draft 3 of the interface specification did not contain an updated DIF. Both the OMT and FED DIFs need to be updated to reflect changes in specifications (for example, the OMT tables).

As XML is emerging as an industry standard, its use for defining these DIFs is being explored. Interoperable “Dialects” of XML suitable for defining DIFs are defined by creating a *Document Type Definition*, or a DTD. The DTD specifies a grammar for an XML document. The use of a single XML DTD for both the OMT and the FED is being explored.

Typical DIF Components

- Purpose and scope of DIF
- Format definition (e.g. BNF or XML)
- Subject area DIF definition description
- Consistency rules and constraints
- DIF glossary with data element definitions
- Example DIF file



As there is no overall standard for DIFs, the DIF components mentioned above (from Gravitz, et. al.) are only suggestions for forming a clear, understandable, and complete DIF.

The OMT and FED DIFs from the HLA standards, each illustrate several, but not all, of these components. For the OMT DIF, the information from the subject area descriptions, constraints, and glossary, are found in the respective specification documents, but are not included separately as part of the DIF.

Both the OMT and the FED DIFs have a section explaining the syntax of Extended BNF (EBNF).

Backus Naur Format(BNF)

- Three Major Parts
 - Terminals, which require no further definition
 - Non-terminals which are defined in terms of other non-terminals and terminals
 - Productions (rules) for each non-terminal, precisely stating how the non-terminal is constructed
- Meta-Symbols
 - Symbols within the BNF having special meaning, such as: <, >, ", {, }, |, ::=



The OMT and FED DIFs are currently specified using EBNF, so a brief introduction to EBNF follows.

Terminals are represented in EBNF in **bold face type**. An example of a terminal is “**Federation**.” This is a term with meaning relevant to the subject area, and no further definition is required in BNF.

Non-terminals are “intermediate” words defined using BNF in terms of terminals and other non-terminals. Non-terminals are placed inside angle-brackets. An example is <ident>.

Productions are rules which provide the definition of a non-terminal. It is designated by using “::=” symbol to define the non-terminal on the left hand side in terms of the combination of terminals and non-terminals on the right-hand side. An example is <Digit> ::= “**0..9**” which states that the non-terminal <Digit> is any of the “terminal” symbols **0,1,2,3,4,5,6,7,8,9**.

Some Basic BNF Constucts

- $\langle \text{Integer} \rangle ::= 0..65536;$
- $\langle \text{NameString} \rangle ::= \langle \text{Letter} \rangle \{ \langle \text{Letter} \rangle | \langle \text{Number} \rangle | "." | "_" \};$
- $\langle \text{Letter} \rangle ::= "a..z" | "A..Z";$
- $\langle \text{Digit} \rangle ::= "0..9";$
- $\langle \text{NameCharacter} \rangle ::= \langle \text{Letter} \rangle | "_" | "." | \langle \text{Digit} \rangle;$
- $\langle \text{TextString} \rangle ::= \langle \text{TextString} \rangle \langle \text{TextChar} \rangle | \langle \text{TextChar} \rangle;$



Both the FED and OMT DIFs contain a section entitled “Basic BNF Constructs.” This slide contains a sample from this section of the OMT DIF. It defines some basic terms (non-terminals) that are used throughout the DIF and are of a general character. They are used primarily to make the BNF more readable.

EBNF uses the symbol “|” to represent choice. For example, the rule defining $\langle \text{Letter} \rangle$ states that a $\langle \text{Letter} \rangle$ is either a lower case character between **a** and **z** (inclusive), or it may be an uppercase character between **A** and **Z**.

It may be noted that the rule for $\langle \text{TextString} \rangle$ cannot be understood without the following line from the DIF that defines a $\langle \text{TextChar} \rangle$. This definition may be found in section 2.2 of the OMT DIF.

Special EBNF Notation

- **Double angle brackets:** used to indicate a reference to the glossary
 - Example: <<Mod_Name>>
- **Brackets:** optional items
 - Example: [<SpaceName>]
- **Curly Brackets: Repetition**
 - Example: <NameString> ::= <Letter>{<NameCharacter>}*
 - {...}* zero or more repetitions
 - {...}+ one or more repetitions



The special EBNF symbols for repetition are slightly different in the OMT and the FED DIFs. The OMT DIF uses neither the star nor the plus after the repetition symbols. In the OMT DIF all repetitions are zero, one or more times, and the star and plus are omitted.

Both DIFs include a section explaining their EBNF notation, followed by the BNF definition for the DIF. This is then followed in both DIFs by an example DIF.

OMT DIF

- Standard file exchange format used to store and transfer HLA Federation Object Models (FOMs) and Simulation Object Models (SOMs) between FOM/SOM Builders.
- Built On Common Meta-Model which represents the information needed to represent and manage models created using the HLA OMT standard.



The OMT DIF has been structured as a stream of Object Model meta-data, and does not specify the specific physical representation or transport media used to exchange this meta-data. One possible representation is an ASCII file, as used in the initial prototype. (Section 4 of the HLA OMT DIF.)

Types of DIF Instances

- Instance of a DIF defines a non-Terminal <DIFtypes> which categorizes an instance of a DIF into one of three types;
 - **Single:** It contains meta-data of one version of a single model
 - **Multiple:** Here multiple versions and/or models can be included
 - **Directory :** this is a response to the query of an object model repository for a “Directory-Listing” of the contents of the repository. It may contain only the Model and Version “clauses” which describe the Model and Version meta-data.



All instances of OMT DIFs indicate that they are one of three types: single, multiple, or directory. (The DIF is the standard, an instance is an actual set of data describing a particular model.)

- The *Single* type is a DIF instance for a single model.
- The *Multiple* type is a DIF instance for a “set” of models when a model may have multiple versions, or multiple models with the same DIF.
- The *Directory* type provides a mechanism to interchange just a directory listing of a repository's contents without having to exchange complete SOMs and FOMs.

Metadata Consistency

- Its important that the DIF constructs be consistent
 - The relationship between elements in a given application area may not be defined by the DIF syntax
- The relation defined in object models should be **enforced** in consistent and properly defined DIF
 - Automated tools must support and check the relationships
 - Example: If an attribute is listed as an “affected attribute” it should be present in the DIF, otherwise it is undefined
 - Table of consistency relationships to check is included in Section 6 of the OMT DIF



A number of OMT constructs have references whose consistency must be maintained:

Construct	References
AffectedAttribute	Attribute
AssociationMember	Class
Attribute	DataType
ComplexComponent	DataType
Components	Class
Interaction Members	Interaction
Parameter	DataType
ParticipatingClass	Class
Superclass	Class

OMT DIF BNF Definition

- `<HLA-OMT_DIF_v1.1> ::= <DIFHeader> {<ObjectModel>};`
- `<Interaction> ::= "(Interaction (Name " <<INT_Name>> [<NoteRef>])" "
"ISRTType " <<INT_ISRTType>> [<NoteRef>])" "
["(Description " <<INT_Description>> ")"] "
{<InteractionComponent> } ")";`
- `<Class> ::= "(Class (Name " <<CLS_Name>> [<NoteRef>])" "
["(PSCapabilities " <<CLS_PSCapabilities>> ")"] "
["(Description " <<CLS_Description>> ")"] "
{<ClassComponent> } ")";`



This slide shows a brief segment of the OMT DIF. The next slide shows an actual instance of this DIF with some sample data.

Sample OMT DIF

- (Class (Name "Beef")
(PSCapabilities PS)
(Description "Flesh of a cow for use as meat.")
(SuperClass "Main_Course")
)
- (Interaction (Name "Food_Arrives")
(Description "The base class that indicates the interaction of the
Food_Arrives process.")
(InteractionMember "Food_Arrives_at_Waiter")
(InteractionMember "Food_Arrives_at_Customer")
)



This is an example of some actual data, from the restaurant example, meeting the specifications of the OMT DIF section on the previous slide.

FED DIF

- Used to store and transfer HLA FED files between multiple tools (such as between the OMDT tool and the RTI)
- An instance of this DIF is the FED file which is required by the RTI to execute a federation



FED DIF BNF Definition

- `<HLA-FED-DIF-v1.3> ::= “(FED ” <Federation> <FEDversion> <Spaces>
<ObjectClasses><InteractionClasses> “)”`;
- `<ObjectClasses> ::= “(objects ”
“class ObjectRoot ”
“(attribute privilegeToDelete ” <<Transport>> <<Order>>
[<<SpaceName>>] “)”
“(class RTIprivate)”
{<ObjectClass>}* “)”`;
- `<ObjectClass> ::= “(class ” <<ObjectClassName>> {<Attribute>}* {<ObjectClass>}* “)”`;



This shows a section of the FED DIF. This is a rather lengthy DIF, and only a very brief section is shown to illustrate the correspondence between the BNF describing the DIF and an actual instance of this DIF, shown on the following slide.

Sample FED DIF

- (FED
 (Federation MOM)
 (FEDversion v1.3)
 (spaces
)
• (objects
 (class objectRoot
 (attribute privilegeToDelete transport order space)
 (class RTIprivate)
 (class Manager
 (class Federate
 (attribute FederateHandle transport order space)
 (attribute FederateType transport order space)



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10/13/99

19

The FED file is a rather long file, and only a very brief example is given. Information about MOM and system classes is found preceding information concerning user classes and attributes, so one must be careful to skip over this “boilerplate” and not miss the important sections describing the user-specific data. All of the information about class objectRoot would usually be considered boilerplate to a user. Roughly, there are the following sections in the FED DIF:

- “Header” information giving the federation name, FEDversion
- Space definitions, if any
- Class descriptions of “RTI” object classes, including class Federate, class Federation, and MOM classes
- **User Object Class Definitions**
- Class descriptions of “RTI” interaction classes, including class Federate, class Federation, and MOM classes
- **User Interaction Class Definitions**

It is interesting to look at the FED file for the HelloWorld Federate, and attempt to locate the Object and Interaction class information for the user’s classes. These user sections (shown in bold) are quite short and easy to understand.