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IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)

IEEE Computer Society

Sponsored by the
Simulation Interoperability Standards Committee



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IEEE-SA Standards Board

Abstract: The processes and procedures that should be followed by users of the High Level Architecture (HLA) to develop and execute federations are defined in this recommended practice. This recommended practice is not intended to replace low-level management and systems engineering practices native to HLA user organizations, but is rather intended as a higher-level framework into which such practices can be integrated and tailored for specific uses.

Keywords: federate, federation, Federation Development and Execution Process (FEDEP), High Level Architecture (HLA), Object Model (OM), runtime infrastructure (RTI)

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Introduction

[This introduction is not part of IEEE Std 1516.3-2003, IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP).]

The High Level Architecture (HLA) has been designed to facilitate interoperability among simulations and to promote reuse of simulations and their components. The HLA is composed of three major components:

- *HLA rules*: A set of ten basic rules that together describe the general principles defining the HLA.
- *HLA interface specification*: A description of the functional interface between simulations (federates) and the HLA runtime infrastructure (RTI).
- *HLA Object Model Template (OMT)*: A specification of the common format and structure for documenting HLA object models.

In an HLA application, any number of physically distributed simulation systems can be brought together into a unified simulation environment to address the needs of new applications. These types of environments are known as HLA federations. The HLA specifications together define an overarching framework for the construction and execution of federations.

Within the various government and commercial organizations that comprise the HLA community, many different approaches to project management and systems engineering are being used. Such practices, procedures, and methodologies have evolved over time based on how well they serve the different functional areas and user communities for which they are intended. Many of these approaches currently use modeling and simulation (M&S) as a key enabler of certain functions, such as concept evaluation, testing, and training. However, a significant number of organizations adopting the HLA have not yet determined how to tailor their native management and engineering processes to take advantage of the HLA. For instance, while many in the analysis community have established procedures for non-runtime exchange of data from one simulation to another, the opportunities provided by the HLA for more dynamic exchange of data at runtime require that existing engineering processes be modified or augmented in order to take advantage of such opportunities. Even in communities in which distributed simulation is more commonplace (e.g., training), migration to the HLA generally requires some modification to existing management and engineering processes to capture the benefits offered by the HLA. As simulation users perform this migration, it is critical that guidance be available to orient new users to the specific set of tasks and activities necessary to develop and execute HLA federations.

This recommended practice describes the HLA FEDEP. The purpose of this recommended practice is to describe a generalized process for building and executing HLA federations. It is not intended to replace the existing management and systems design/development methodologies of HLA user organizations, but rather to provide a high-level framework for HLA federation construction and execution into which other systems engineering practices native to each individual application area can be easily integrated. In addition, the HLA FEDEP is not intended to be prescriptive, in that it does not specify a “one size fits all” process for all HLA users. Rather, the FEDEP defines a generic, common sense systems engineering methodology for HLA federations that can and should be tailored to meet the needs of user applications.

Although every HLA application requires a basic agreement among all federates as to the systems engineering approach that will be used to develop and execute the federation, there can be significant variability in the degree of formality defined in the chosen process. The primary driver for how much formality is required is typically the size and complexity of the application. For example, in large complex federations, requirements and associated schedules for delivery of federation products are generally very explicit, as is the content and format for documentation of these products. In smaller or less complex applications, a less structured process with fewer constraints on the types, formats, and content of federation products may be perfectly reasonable and may have certain efficiency advantages as compared to a more formalized process.

Other secondary factors may also influence how the FEDEP is tailored (or adapted) for a specific application. For instance, some communities may have documentation requirements that are unique to their application area. In this case, the activities required to produce these products must be accounted for in the overall process. The reuse potential of these and other required federation products may also influence the nature and formality of the activities that produce them. Another factor is the availability of reusable federation products and persistent federation development teams as opportunities for shortcuts, whereby it may be possible to identify and take advantage of a more streamlined, efficient development process. Finally, practical resource constraints (i.e., cost, schedule) may dictate how certain activities are performed and how the associated federation products are produced and documented.

In summary, it is recognized that the needs and requirements of the distributed simulation community are quite diverse. The HLA provides a generalized architecture for simulation interoperability; however, strict adherence to the HLA specifications is not, by itself, sufficient to ensure a fully consistent, interoperable distributed simulation environment. For instance, issues such as the need for consistent environmental databases and for consistent behavior representations of objects modeled by more than one federate are critical to achieving interoperability; however, these types of issues cannot be fully addressed solely through adherence to the HLA specifications. Although some technical or managerial issues may be unique to a given application, many other issues associated with building and executing a fully interoperable HLA federation are more general in nature. The HLA FEDEP is offered to the HLA community as a starting framework for identifying and addressing these more general issues, as discussed within the context of a full end-to-end process model for the development and execution of distributed simulation environments (federations) that fully conform with the HLA specifications. This framework can and should be tailored as appropriate to address the unique issues, requirements, and practical constraints of each individual application. It is expected that this framework will provide a viable foundation for all HLA applications and will assist the users in defining the specific tasks and activities necessary to support their particular needs.

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IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)

1. Overview

1.1 Scope

This recommended practice defines the processes and procedures that should be followed by users of the High Level Architecture (HLA) to develop and execute federations. It is not intended to replace low-level management and systems engineering practices native to HLA user organizations, but is rather intended as a higher-level framework into which such practices can be integrated and tailored for specific uses.

1.2 Purpose

The HLA has been designed to be applicable across a wide range of functional applications. The purpose of this architecture is to facilitate interoperability among simulations and promote reuse of simulations and their components.

A named set of applications (e.g., simulations, loggers, viewers) interacting via the services of the HLA runtime infrastructure (RTI) in accordance with a common rule set and a common HLA Object Model (OM) is known as an HLA *federation*. The purpose of this recommended practice is to describe a high-level process by which HLA federations can be developed and executed to meet the needs of a federation user or sponsor. It is expected that the guidelines provided in this recommended practice are generally relevant to and can facilitate the development of most HLA federations.

2. References

The three specifications that together compose the HLA provide the technical foundation for designing and developing all HLA federations. These specifications are described in the following documents:

HLA IEEE 1516 version

IEEE Std 1516TM-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)—Framework and Rules.^{1, 2}

IEEE Std 1516.1TM-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)—Federate Interface Specification.

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²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

IEEE Std 1516.2™-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)—Object Model Template (OMT) Specification.

HLA Version 1.3³

High-Level Architecture Rules, Version 1.3, U. S. Department of Defense, Apr. 1998.

A set of ten basic rules that together describe the general principles defining the HLA.

High Level Architecture Interface Specification, Version 1.3, U. S. Department of Defense, Apr. 1998.

A description of the functional interface between simulations (federates) and the HLA RTI.

High-Level Architecture Object Model Template (OMT) Specification, Version 1.3, U. S. Department of Defense, Apr. 1998.

A specification of the common format and structure for documenting HLA OMs.

3. Definitions, abbreviations, and acronyms

3.1 Definitions

The following terms and definitions, as drawn from the IEEE 1516 series of HLA specifications and other relevant sources (see Annex A—Bibliography), shall apply throughout this recommended practice.

3.1.1 conceptual model: An abstraction of the real world that serves as a frame of reference for federation development by documenting simulation-neutral views of important entities and their key actions and interactions. The federation conceptual model describes what the federation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user's requirements. Federation conceptual models are bridges between the real world, requirements, and design.

3.1.2 federate: An application that may be or is currently coupled with other software applications under a Federation Object Model Document Data/Federation Execution Data (FDD/FED) and a runtime infrastructure (RTI). This may include federation managers, data collectors, real world ("live") systems (e.g., C4I systems, instrumented ranges, sensors), simulations, passive viewers, and other utilities.

3.1.3 federation: A named set of federate applications and a common Federation Object Model (FOM) that are used as a whole to achieve some specific objective.

3.1.4 Federation Object Model (FOM): A specification defining the information exchanged at runtime to achieve a given set of federation objectives. This includes object classes, object class attributes, interaction classes, interaction parameters, and other relevant information.

3.1.5 Federation Object Model (FOM) Document Data (FDD): The data and information in a FOM document that is used by the Create Federation Execution service to initialize a newly created federation execution. Also called "Federation Execution Data," or "FED," in HLA Version 1.3 specifications.

3.1.6 runtime infrastructure (RTI): The software that provides common interface services during a High Level Architecture (HLA) federation execution for synchronization and data exchange.

³HLA Version 1.3 specifications are available at <http://www.dmsomil>.

3.1.7 scenario: (A) Description of an exercise. It is part of the session database that configures the units and platforms and places them in specific locations with specific missions (see IST-SP-96-01 [B3]⁴). **(B)** An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives (see *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B2]).

3.1.8 Simulation Object Model (SOM): A specification of the types of information that an individual federate could provide to High Level Architecture (HLA) federations as well as the information that an individual federate can receive from other federates in HLA federations. The standard format in which SOMs are expressed facilitates determination of the suitability of federates for participation in a federation.

3.2 Abbreviations and acronyms

The following abbreviations and acronyms pertain to this recommended practice.

BOM	Base Object Model
CASE	Computer-Aided Software Engineering
COTS	commercial off-the-shelf
CPU	Central Processing Unit
FDD	FOM Document Data
FED	Federation Execution Data
FEDEP	Federation Development and Execution Process
FOM	Federation Object Model
GOTS	government off-the-shelf
HLA	High Level Architecture
IEEE	Institute of Electrical and Electronics Engineers, Inc.
LAN	Local Area Network
M&S	modeling and simulation
MOM	Management Object Model
OM	Object Model
OMT	Object Model Template
RTI	runtime infrastructure
SOM	Simulation Object Model
VV&A	verification, validation, and accreditation
WAN	Wide Area Network

4. FEDEP model: top-level view

One of the design goals identified early in the development of the HLA was the need for a high degree of flexibility in the process by which HLA applications could be composed and executed to achieve the objectives of particular applications. Because of this basic desire to avoid mandating unnecessary constraints on how HLA applications are constructed and executed, it was recognized that the actual process used to develop and execute HLA federations could vary significantly within or across different user applications. For instance, the types and sequence of low-level activities required to develop and execute analysis-oriented federations is likely to be quite different from those required to develop and execute distributed training exercises. However, at a more abstract level, it is possible to identify a sequence of seven very basic steps that all HLA federations should follow to develop and execute their federations. Figure 1 illustrates each of these steps and is summarized as follows:

⁴The numbers in brackets correspond to those of the bibliography in Annex A.

- *Step 1: Define federation objectives.* The federation user, the sponsor, and the federation development team define and agree on a set of objectives and document what must be accomplished to achieve those objectives.
- *Step 2: Perform conceptual analysis.* Based on the characteristics of the problem space, an appropriate representation of the real world domain is developed.
- *Step 3: Design federation.* Existing federates that are suitable for reuse are identified, design activities for federate modifications and/or new federates are performed, required functionalities are allocated to the federates, and a plan is developed for federation development and implementation.
- *Step 4: Develop federation.* The Federation Object Model (FOM) is developed, federate agreements are established, and new federates and/or modifications to existing federates are implemented.
- *Step 5: Plan, integrate, and test federation.* All necessary federation integration activities are performed, and testing is conducted to ensure that interoperability requirements are being met.
- *Step 6: Execute federation and prepare outputs.* The federation is executed and the output data from the federation execution is pre-processed.
- *Step 7: Analyze data and evaluate results.* The output data from the federation execution is analyzed and evaluated, and results are reported back to the user/sponsor.

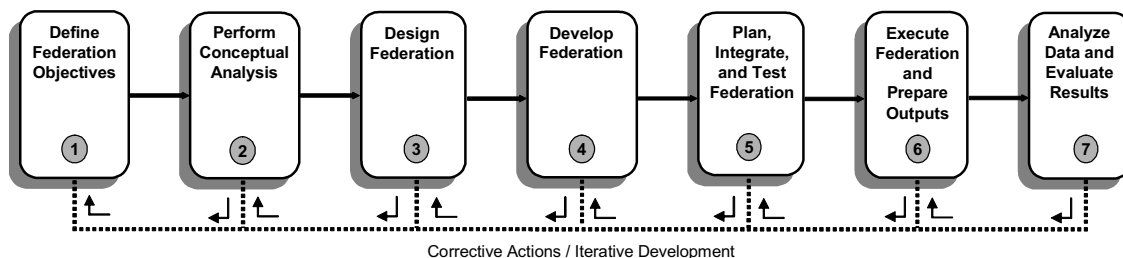


Figure 1—Federation development and execution process (FEDEP), top-level view

Since this seven-step process can be implemented in many different ways depending on the nature of the application, it follows that the time and effort required to build and execute an HLA federation can also vary significantly. For instance, it may take a federation development team several weeks to fully define the real world domain of interest for very large, complex applications. In smaller, relatively simple applications, the same activity could potentially be conducted in a day or less. Differences in the degree of formality desired in the process can also lead to varying requirements for federation resources.

Personnel requirements can also vary greatly depending on the scope of the federation application. In some situations, highly integrated teams composed of several individuals may be needed to perform a single role in a large, complex federation, while a single individual may perform multiple roles in smaller applications. Examples of the types of roles individuals can assume in HLA federations include the federation user/sponsor; the federation manager; technologists; security analysts; verification, validation, and accreditation (VV&A) agents; functional area experts; federation designers; execution planners; federation integrators; federation operators; federate representatives; and data analysts. Some roles (e.g., operators) are unique to a single activity in the process, while others are more pervasive throughout the process (e.g., federation manager). Since the applicability of a given role (as well as the set of activities it spans) varies from application to application, the activities described in this recommended practice specify the roles of individuals only in generic terms.

A major source of variation in how the seven-step process is implemented relates to the degree of reuse of existing federation products. In some cases, no previous work may exist, therefore a thoroughly original federation may need to be developed using a newly defined set of requirements to identify an appropriate set of federates and to build the full set of federation products needed to support an execution. In other cases, users of federations with established long-standing requirements will receive additional requirements. In this circumstance, the federation users can choose to reuse previous work, either in part or whole, along with the products of new developmental activities. In these situations, federation developers can often meet new user