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Report Series

Requirements for an Application Protocol Development Environment

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1 Introduction

The emerging international standard for the exchange of product model data (STEP[1]) comprises several distinct series of Parts[2]. "Implementation Specifications" provide descriptions of mechanisms for the actual exchange of STEP data (e.g., Clear Text Encoding of the Exchange File [3]). "Descriptive Methods" provide techniques for specifying STEP (e.g., Data Specification Language EXPRESS [2])."Integrated Resources" are considered the basic building blocks of STEP; these Parts provide information models describing generic constructs which are useful in a wide variety of product applications (e.g., Geometry [4]). "Application Protocols" are the Parts of STEP which combine components of Integrated Resources, select implementation mechanisms, and use the established Descriptive Methods to specify what product data is to be exchanged and what the meaning of that data is in a particular industrial context (e.g., Associative Draughting [5]). In essence, Application Protocols (APs) are the Parts of STEP which are implementable. Thus it can be expected that CAx[3] vendors will provide mechanisms in their products which will facilitate data exchange according to particular APs. A thorough introduction to STEP and its constituent specifications can be found in "Overview and Fundamental Principles" [1].

The National PDES Testbed project at the National Institute of Standards and Technology is focussed on the development and implementation of STEP. Principal funding for the National PDES Testbed project comes from the Department of Defense Computer-aided Acquisition and Logistic Support (CALS) office. There are several sub-projects within the National PDES Testbed; among these is the effort to establish an Application Protocol Development Environment.

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1. STEP is being standardized under the auspices of the International Organization for Standardization (ISO) Technical Committee 184 (TC184) Subcommittee 4 (SC4). The term PDES (Product Data Exchange using STEP) refers to the United States contributing effort to this standardization process.
2. STEP will be released as a collection of specifications; each individual specification is known as a "Part" of STEP.
3. The term "CAx" refers to any type of engineering or manufacturing software application system, e.g., Computer-Aided Design (CAD), Computer-Aided Process Planning (CAPP), etc.

This report documents the requirements for an Application Protocol Development Environment (APDE). These requirements provide fundamental guidance as to what software capabilities would benefit Application Protocol developers in their efforts to specify APs. The requirements described in this report are derived from the experiences of current AP developers.

1.1 Motivation

AP development is a time-consuming, labor-intensive, and thereby expensive process. The process for developing APs is defined by ISO/TC184/SC4 and is documented in the "Guidelines for AP Development" [10]. A scheduling estimation from the author of that document states that 6294 man-hours of effort over more than 1.5 years are required for development of a single AP. STEP currently has 2 APs which are being readied for release as international standards while at the same time more than 20 APs are either in development or in the planning stages. The total number of APs which will eventually be defined in STEP can not be accurately predicted at this time; however the number could easily reach into the hundreds.

Given the cost of developing APs and the fundamental relationship between the standardization of APs and the usefulness of STEP, the National PDES Testbed project has initiated an effort to establish an Application Protocol Development Environment. The mission of the effort is to put into place an integrated suite of software tools which together improve the productivity of AP developers and facilitate the specification of high quality APs.

1.2 AP Development Process

The purpose of this section is to give an overview of the AP development process. For complete details of the process the reader is urged to consult the Guidelines document [10]. It is important to note that no software tools are currently available which are specifically intended to facilitate the AP development process. AP developers currently use an ad hoc collection of document processing software, information modeling software, and virtually anything else available which may make these tasks easier.

1.2.1 AP Project Definition

An AP project is initiated by documenting an industry need for the AP, i.e., establishing the requirement for a particular AP in STEP. A high-level statement of scope is agreed upon (and updated as the AP becomes better defined). In order to further document the industry need, the AP developers produce an Application Activity Model (AAM) which specifies the processes that use and produce product data in the context of a specific application. The AAM is documented using IDEF0 [6] methodology. Once a comprehensive AAM is developed, each element of the AAM is examined and a determination is made whether the element is in or out of scope, based on the intended use of the AP. The scope statement, the completed AAM, and a Candidate AP Summary sheet are submitted for approval as an AP project.

Once the AP project is approved, the scope, requirements and AAM are evaluated by experts in the application area who were not involved in the initial modeling effort. These experts should reflect the breadth and depth of the application scope. The AAM is modified to ensure that it meets industry needs, is viable, and accurately reflects the desired scope. The results of the industry review are documented in a separate document, the AP Validation Report.

1.2.2 AP Information Requirements

After the AP scope has been defined and evaluated, the information requirements of the AP are defined through the development of an Application Reference Model (ARM). The ARM may be documented in one of three data modeling languages (EXPRESS [2], IDEF1X [7] or NIAM [9]). The model diagrams are a required part of the AP, but information requirements are normatively described in text. Each element in the ARM diagrams is defined as an Application Object in the AP. Each relationship between elements in the ARM diagram is documented as an Application Construct. The concepts in the ARM are organized into Units of Functionality (UoF). A UoF is a grouping of constructs which reflect one or more distinct concepts within the ARM, possibly corresponding to an application process. The UoFs are potentially useful for evaluating areas of commonality between APs.

The ARM must be evaluated by industry experts as was the AAM. The objective of ARM validation is to provide a high degree of confidence that the model supports industry practices correctly and robustly. It is impractical to conduct a comprehensive review of the ARM due to its complexity. ARM validation is done with the use of representative test pieces and usage scenarios. The model may be validated by several methods. One method is to build a prototype database that replicates the structure of the ARM, another method is to perform "paper populations" of the structure and requirements. The method used to perform ARM validation is documented in the AP Validation Report.

1.2.3 AP Interpretation

The Application Interpreted Model (AIM) is developed by interpreting elements from the STEP Integrated Resource Parts to the information requirements described in the ARM. This process requires the cooperation of those who developed the model and those who have extensive knowledge of the Integrated Resources. Interpretation is typically carried out in a workshop-style meeting. Detailed notes from the interpretation are compiled into an Interpretation Report that becomes part of the AP Validation Report. Another output of the Interpretation workshop is a mapping table that shows the correspondence between elements of the ARM and those from the other Parts of STEP. The AIM is documented by an information model known as a Short Listing. The Short Listing consists of references to Integrated Resource elements and the specializations of those elements for the AP, e.g., the rules that further constrain Integrated Resource elements. An expanded form of the Short Listing is also required in the AP; it is known as the Annotated Listing. The Annotated Listing includes the complete documentation of the AIM, along with definitions of all of the information

elements specified by the AIM. During the development of the Short and Annotated Listings, the AP developers must also develop a high-level graphical model of the information using the diagrammatic form of EXPRESS (EXPRESS-G[1]).

Finally, as with the ARM, validation of the AIM must be performed and documented in the AP Validation Report. AP usage information formulated for the validation process may also be provided as an informative portion of the AP document itself.

1.2.4 Complete AP

Once the AP developers have completed the documentation and validation of the AIM, the remainder of the AP development work involves defining implementation and conformance requirements. This ensures that there are metrics available against which vendor implementations of the AP can be tested for conformance. The information requirements and assertions defined in the ARM and all characteristics defined in the AIM are the starting points for the development of such conformance requirements. Test Groups are defined from the structure of the ARM and Test Purposes are defined for all constructs of the AIM. Review and evaluation of the AP's Conformance Requirements and Test Purposes is performed by application experts and AP methods experts. The results of this evaluation are included in the AP Validation Report.

AP developers are also responsible for compiling all of the requisite components of the AP specification into a document according to established style guidelines [11]. At several stages of AP completion the document is submitted to various committees and representatives of voting members (countries) in ISO for review and comment. Maintaining logs of issues raised against the AP and responding to those issues is another aspect of the AP development process.

1.3 Approach to APDE Development

The National PDES Testbed project to establish an APDE will be a multi-year effort. The first phase of the approach is to identify requirements of AP developers pertaining to software support. The project will later specify the functionality of an APDE which satisfies these requirements. The actual implementation of the specified functionality will take place over a period of several years. The implementation strategy will take into account a prioritization of the requirements based on immediate benefit to AP developers and the resources available to satisfy those requirements. Furthermore, it is likely that the requirements themselves will change over time, particularly given that the process for AP development is itself subject to refinement. Thus the requirements described in this report are considered the initial set from which to begin, but probably not the complete set of requirements.

The APDE is currently envisioned to be a collection of distinct software tools which are tied together through an AP Information Base (InfoBase). The software tools would serve to support the various processes which AP developers must execute. Information resulting from the execution of any one process would be available to any of the other processes through the AP InfoBase. The InfoBase will thus have capabilities to both

1. EXPRESS-G is a graphical subset of EXPRESS. See Annex D of [2] for a description.

store and retrieve information needed by AP developers. Such information may include STEP Integrated Resources, AP components, and even AP development methodology instructions.

2 Technical Requirements

This section identifies the technical requirements for the APDE. Most requirements are categorized according to the stages of AP development to which they apply. The last category (General) captures requirements which are applicable to the environment as a whole. There is no special ordering to the requirements within each category. The reader is reminded that the purpose of this report is to identify requirements; describing how the requirements will be addressed is beyond the scope of this report.

2.1 AP Project Definition Requirements

See section 1.2.1 for a description of the activities involved in this aspect of AP development.

Requirement 2.1.A:
Provide a structured approach for gathering the requirements used to establish the need for a particular AP.

Requirement 2.1.B:
Document activity requirements in a standard format.

Requirement 2.1.C:
Evaluate an AAM decomposition and document the results of the evaluation.

Requirement 2.1.D:
Maintain proper relationships between IDEF0 model constructs in a graphical IDEF0 modeling tool.

Requirement 2.1.E:
Allow the user to control levels of IDEF rule enforcement in a graphical IDEF0 modeling tool.

Requirement 2.1.F:
Allow transfer of information resulting from AAM definition to other software tools supporting other processes.

Requirement 2.1.G:
Automatically produce a template for the AAM glossary from the AAM.

Requirement 2.1.H:
Evaluate the correspondence between the AAM and the AP Scope and Requirements.

Requirement 2.1.I:
Maintain version control between the representations of AP Scope, AP Requirements, and AAM.

2.2 AP Information Requirements

See section 1.2.2 for a description of the activities involved in this aspect of AP development.

Requirement 2.2.A:
Link information models to documentation of model components.

Requirement 2.2.B:
Provide for identification of Units of Functionality and connection to the documentation of same.

Requirement 2.2.C:
Translate among information modeling languages, e.g., IDEF1X to EXPRESS, NIAM to EXPRESS.

Requirement 2.2.D:
Allow printing of graphical information models as "wall charts" with automatically generated cross-page references between model elements.

Requirement 2.2.E:
Check information models to user-specified levels, e.g., consistency, syntax, constraints.

Requirement 2.2.F:
Support information model development by work-groups, i.e., "groupware".

Requirement 2.2.G:
Maintain version control between results of upstream processes, representations of ARM components, and documentation of the ARM.

Requirement 2.2.H:
Allow on-line browsing of other APs' components.

Requirement 2.2.I:
Support ARM validation.

Requirement 2.2.J:
Manage changes between information requirements, AP definition, and documentation.

2.3 AP Interpretation Requirements

See section 1.2.3 for a description of the activities involved in this aspect of AP development.

Requirement 2.3.A:
Provide on-line access to to STEP specifications, e.g., Integrated Resource Parts, APs, etc.

Requirement 2.3.B:
Link information models in STEP Integrated Resource Parts with the documentation of the information models.

Requirement 2.3.C:
Allow queries against Integrated Resources and against the AIM as it is being developed, e.g., determining what entities are implicitly required when a specific entity is chosen; determining whether a specific entity has already been chosen, etc.

Requirement 2.3.D:
Allow creation of constraints for an EXPRESS information model based on a family of specified constraint templates.

Requirement 2.3.E:
Provide on-line access to guidelines for AP interpretation.

Requirement 2.3.F:
Structure the software supporting the interpretation process so that guidelines for AP interpretation are enforced.

Requirement 2.3.G:
Automatically determine the mappings between ARM components and STEP Integrated Resources document the correspondences.

Requirement 2.3.H:
Provide language-sensitive editing of EXPRESS and syntax/semantic checking as well.

Requirement 2.3.I:
Allow creation of the Mapping Table based on a template for the Mapping Table.

Requirement 2.3.J:
Generate the reference paths of the AIM against the Integrated Resources and the documentation of this information.

Requirement 2.3.K:
Verify that all ARM components are interpreted.

Requirement 2.3.L:
Generate the AIM Annotated Listing from the AIM Short Listing; the Annotated Listing produced should reproduce all textual descriptions implicitly associated with the EXPRESS entities from the Integrated Resources.

Requirement 2.3.M:
Verify the correctness of an AIM Annotated Listing given an AIM Short Listing.

Requirement 2.3.N:
Support the storage and retrieval of AICs; allow for the determination/examination of different usages of a specified AIC.

Requirement 2.3.O:
Automatically generate EXPRESS-G diagrams from EXPRESS.

Requirement 2.3.P:
Allow graphical creation and editing of EXPRESS-G models.

Requirement 2.3.Q:
Provide translations from the representation of an EXPRESS-G model into PostScript[1] and other formats which can be imported into document processing software.

Requirement 2.3.R:
Allow for creation and querying of STEP data corresponding to the AIM.

Requirement 2.3.S:
Generate a STEP Exchange File template containing each instance possibility in the AIM.

Requirement 2.3.T:
Support AIM validation.

2.4 Complete AP Requirements

See section 1.2.4 for a description of the activities involved in this aspect of AP development.

Requirement 2.4.A:
Provide templates which conform to ISO style guidelines for use in development of AP document components. Changes to ISO style guidelines should be reflected in such templates and automatically propogated into draft documents.

Requirement 2.4.B:
Verify (English) grammar usage and style in AP document components according to ISO guidelines.

Requirement 2.4.C:
Track AP document component status by identifying which clauses are complete and which are incomplete.

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1. PostScript is a registered trademark of Adobe Systems Incorporated.

Requirement 2.4.D:
Automatically merge templates, boilerplate text, information models, and other AP components into an AP document.

2.5 General

This section describes requirements which are applicable to several or all AP development processes.

Requirement 2.5.A:
Provide translation between LaTeX[1] and WordPerfect[2] (both directions).

Requirement 2.5.B:
Provide simultaneous viewing of multiple pages of a STEP specification.

Requirement 2.5.C:
Search for issues based on keywords.

Requirement 2.5.D:
Provide a uniform format for issues, e.g., date, author, description, action taken, tracking status, date resolved, resources allocated.

Requirement 2.5.E:
Connect issue descriptions to any specified target, e.g., document text, entity definition, rule, etc.

Requirement 2.5.F:
Establish version control mechanisms between particular issues and particular versions of STEP specifications.

Requirement 2.5.G:
Distribute issue descriptions and resolutions to all specified stake-holders.

Requirement 2.5.H:
Establish version control on/between components of AP documents.

Requirement 2.5.I:
Provide all necessary information (e.g., AP development guidelines, ISO style guidelines, STEP Parts, etc.) in one place.

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1. LaTeX is a freely available document processing system [8].
2. WordPerfect is a registered trademark of WordPerfect Corporation.

3 Conclusion

The technical requirements presented in this report constitute a starting point for specification of an Application Protocol Development Environment. This report only seeks to identify an initial set of requirements. Care has been taken to describe what is needed without formulating a specific technical solution. Most, if not all of the requirements can be addressed by a variety of solutions. Some solutions are relatively simple to address but most are not. In conveying the requirements to the authors, AP developers have frequently indicated what solutions are more preferable than others. The APDE project will use that information to balance potential solutions with the ability to deliver such solutions.

It should be noted that not all aspects of AP development have yielded requirements. For example, delivery of conformance requirements and test criteria are necessary tasks, yet there are no requirements for tools or techniques to assist with these tasks. Unfortunately, the lack of requirements is probably not due to the simplicity of the activiity or the availability of existing tools. Instead the absence of requirements is attributed to a lack of experience on those tasks. When all aspects of AP development are exercised, it can be expected that there will be additional requirements for the APDE.

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