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Space data and information transfer systems — XML formatted data unit (XFDU) structure and construction rules

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Space data and information transfer systems — XML formatted data unit (XFDU) structure and construction rules

*Systèmes de transfert des informations et données spatiales —
Structure des unités de données formatées XML (XFDU) et règles de
construction*



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ISO 13527 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 661.0-B-1, September 2008) and was adopted (without modifications except those stated in Clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

Space data and information transfer systems — XML formatted data unit (XFDU) structure and construction rules

1 Scope

This International Standard defines how the packaging of data and metadata, including software, can be put into a single package (e.g. file or message) in order to facilitate information transfer and archiving.

This International Standard also provides a detailed specification of core packaging structures and mechanisms, which accommodate the current computing environment and meet evolving requirements, and which can be implemented to demonstrate practical, near-term results.

This International Standard is applicable to the entire space informatics domain, from operational messaging to interfacing with science archives.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 661.0-B-1, September 2008, *XML formatted data unit (XFDU) structure and construction rules*

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 661.0-B-1.

Pages i to v

This part is information which is relevant to the CCSDS publication only.

Page D-1

Add the following information to the reference indicated:

- [D1] Document CCSDS 620.0-B-2, May 1992, is equivalent to ISO 12175:1994.
- [D2] Document CCSDS 643.0-B-1, November 1992, is equivalent to ISO 14962:1997.
- [D3] Document CCSDS 630.0-B-1, June 1993, is equivalent to ISO 13764:1996.
- [D4] Document CCSDS 632.0-B-1, November 1994, is equivalent to ISO 15395:1998.
- [D5] Document CCSDS 622.0-B-1, May 1997, is equivalent to ISO 15888:2000.
- [D6] Document CCSDS 641.0-B-2, June 2000, is equivalent to ISO 14961:2002.
- [D7] Document CCSDS 650.0-B-1, January 2002, is equivalent to ISO 14721:2003.

3 Revision of publication CCSDS 661.0-B-1

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 661.0-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.



Recommendation for Space Data System Standards

XML FORMATTED DATA UNIT (XFDU) STRUCTURE AND CONSTRUCTION RULES

RECOMMENDED STANDARD

CCSDS 661.0-B-1

BLUE BOOK
September 2008

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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS Recommendations is detailed in the *Procedures Manual for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This document is published and maintained by:

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FOREWORD

This document is a technical Recommendation to use for the packaging of data and metadata, including software, into a single package (e.g., file, document or message) to facilitate information transfer and archiving. It provides a detailed specification of core packaging structures and mechanisms that meet current CCSDS agency requirements and that augment the current CCSDS packaging and language Recommended Standards to accommodate the current computing environment and meet evolving requirements. This Recommended Standard leverages the wide community acceptance and usage of XML technologies by making the packaging manifest an XML document defined by the XML Schema specified in this Recommended Standard.

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommended Standard is therefore subject to CCSDS document management and change control procedures, which are defined in the *Procedures Manual for the Consultative Committee for Space Data Systems*. Current versions of CCSDS documents are maintained at the CCSDS Web site:

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Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 661.0-B-1	XML Formatted Data Unit (XFDU) Structure and Construction Rules, Recommended Standard, Issue 1	September 2008	Original issue

CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1-1
1.1 PURPOSE AND SCOPE	1-1
1.2 RATIONALE	1-1
1.3 STRUCTURE OF THIS DOCUMENT	1-2
1.4 DEFINITIONS	1-4
1.5 CONFORMANCE	1-8
1.6 REFERENCES	1-9
2 OVERVIEW OF XFDU PACKAGING STRUCTURE	2-1
2.1 GENERAL	2-1
2.2 ENVIRONMENT	2-1
2.3 LOGICAL STRUCTURE	2-2
3 PHASED RELEASE DESIGN DECISIONS	3-1
4 XFDU MANIFEST COMPLEX TYPE	4-1
4.1 OVERVIEW OF XFDU MANIFEST	4-1
4.2 XML SCHEMA	4-2
4.3 UTILITY TYPES	4-3
5 PACKAGE HEADER	5-1
5.1 OVERVIEW	5-1
5.2 XML SCHEMA packageHeader Type	5-1
5.3 EXAMPLE: PACKAGE HEADER	5-3
6 CONTENT UNIT	6-1
6.1 OVERVIEW	6-1
6.2 XML SCHEMA FOR contentUnitType	6-1
6.3 EXAMPLES	6-3
6.4 SEMANTICS	6-5
7 INFORMATION PACKAGE MAP	7-1
7.1 OVERVIEW	7-1
7.2 XML SCHEMA INFORMATIONPACKAGEMAPTYPE	7-1
7.3 EXAMPLE: AN INFORMATION PACKAGE MAP	7-2

CONTENTS (continued)

<u>Section</u>	<u>Page</u>
8 DATA OBJECTS	8-1
8.1 OVERVIEW	8-1
8.2 XML SCHEMA FOR DATA OBJECT TYPE	8-1
8.3 EXAMPLES	8-4
8.4 SEMANTICS	8-5
9 METADATA OBJECTS	9-1
9.1 OVERVIEW	9-1
9.2 XML SCHEMA FOR METADATA OBJECTS	9-2
9.3 EXAMPLE: METADATA SECTION USING OAIS INFORMATION MODEL	9-4
10 BEHAVIOR SECTION AND BEHAVIOR OBJECTS	10-1
10.1 OVERVIEW	10-1
10.2 XML SCHEMA FOR BEHAVIOR OBJECTS	10-1
10.3 EXAMPLE OF DEFINING AN INTERFACE AND PARAMETER	10-3
11 FULL XML SCHEMA—NORMATIVE/RULING	11-1
12 SECURITY CONSIDERATIONS	12-1
12.1 OVERVIEW	12-1
12.2 SECURITY CONCERNS RELATED TO THIS RECOMMENDED STANDARD	12-1
12.3 POTENTIAL THREATS AND ATTACK SCENARIOS	12-2
12.4 CONSEQUENCES OF NOT APPLYING SECURITY TO THE TECHNOLOGY	12-2
12.5 DATA SECURITY IMPLEMENTATION SPECIFICS	12-2
ANNEX A COMPLETE EXAMPLE XFDU (INFORMATIVE)	A-1
ANNEX B UML FOR XFDU (INFORMATIVE)	B-1
ANNEX C LEGEND FOR XML AUTHORITY FIGURES (INFORMATIVE)	C-1
ANNEX D INFORMATIVE REFERENCES (INFORMATIVE)	D-1

Figure

2-1 Environment/Conceptual View of an XFDU	2-2
2-2 XFDU Manifest Logical View	2-4
4-1 First Level Decomposition of XFDUType	4-2

CONTENTS (continued)

<u>Figure</u>	<u>Page</u>
4-2 extensionType Schema Diagram	4-4
4-3 referenceType Schema Diagram.....	4-4
4-4 dataObjectPointerType Schema Diagram	4-5
4-5 fileContentType/binaryData/xmlData Schema Diagram	4-5
4-6 checksumInformationType Schema Diagram	4-6
5-1 packageHeaderType Schema Diagram	5-1
6-1 contentUnitType Schema Diagram.....	6-1
7-1 informationPackageMapType Schema Diagram	7-1
8-1 dataObjectType Schema Diagram	8-1
9-1 metadataObjectType and metadataSectionType Schema Diagram	9-2
10-1 behaviorObjectType Schema Diagram	10-1
11-1 Full XFDU Schema Diagram	11-1

Table

3-1 XFDU Functionality by Recommended Standard Issue	3-1
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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The main purpose of this document is to define a CCSDS Recommended Standard for the packaging of data and metadata, including software, into a single package (e.g., file or message) to facilitate information transfer and archiving. Another goal is to provide a detailed specification of core packaging structures and mechanisms which meets current CCSDS agency requirements and augments the current CCSDS packaging and language Recommended Standards (references [D1]-[D6]) to accommodate the current computing environment and meet evolving requirements, and which can be implemented to demonstrate practical, near-term results.

The scope of application of this document is the entire space informatics domain from operational messaging to interfacing with science archives.

1.2 RATIONALE

The current CCSDS Recommended Standards for Data Packaging have not undergone a major revision in 15 years. The computing environment and the understanding of metadata have changed radically:

- Physical media → Electronic Transfer:

The primary form of access to, and delivery of, both archived and recently produced data products has shifted from hard media to include substantial network delivery.

- No standard language for metadata → XML:

After ‘bits’ and ‘ASCII’, the language ‘XML’ can be viewed as the next universal data standard, as it has grown exponentially.

- Homogeneous Remote Procedure Call (RPC) → CORBA, SOAP:

Communicating heterogeneous systems are increasingly using standard remote procedure calls or messaging protocols. The primary RPC and messaging protocol for the WWW is SOAP, an XML based protocol.

- Little understanding of long-term preservation → OAIS Reference Model:

The OAIS Reference Model has become a widely adopted starting point for standardization addressing the preservation of digital information. The OAIS defines and situates within functional and conceptual frameworks the concepts of Information Packages for archiving (Archival Information Packages, or AIPs), producer submission to an archive (Submission Information Packages, or SIPs), and archives’ dissemination to consumers (Dissemination Information Packages, or DIPs).

- Record formats→Self describing data formats:

Commensurate with XML, and rapidly growing computing power and storage capabilities, there has been an increasing tendency to use data formats that are more self-describing.

Further, in the Space domain, there are a number of new requirements to facilitate such functions as being able to describe multiple encodings of a data object, and to better describe the relationships among a set of data objects. Therefore it is necessary to define a new packaging standard while maintaining the existing functionality.

1.3 STRUCTURE OF THIS DOCUMENT

This document is divided into informative and normative sections and annexes.

Sections 1-3 of this document are informative and give a high-level view of the rationale, the conceptual environment, some of the important design issues, and an introduction to the terminology and concepts.

- Section 1 gives purpose and scope, rationale, a view of the overall document structure, and the acronym list, glossary, and normative reference list for this document.
- Section 2 provides a high-level view of the anticipated computing environment and the key concepts in the domain of information packaging for interchange or archiving.
- Section 3 provides an overview of the functionality of the XML Formatted Data Unit (XFDU), and it identifies additional functionality proposed for future issues of this Recommended Standard.

Sections 4-11 of this document are the normative portion of the specification. The primary focus is on the specification of an XML document, called the Manifest document that must also conform to the XML schema defined in this document.

- Section 4, entitled ‘XFDU Manifest Complex Type’ is the transition from informative to normative sections. It provides a description and an XML schema diagram of the first-level elements of the XFDU packaging specification material. It also discusses the ‘utility’ types that are reused many times within the XML Schema sections of this Recommended Standard.
- Sections 5-10 present a detailed breakdown of the important entities represented in the schema. Each section is organized in the following manner:
 - N.1—Overview;
 - N.2—XML schema and XML Authority diagrams;
 - N.3—XML Example (this subsection is informative and should not be considered normative);

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

- N.4—Semantics (this optional section details semantics that cannot be expressed by the W3C XML Schema Language).

There are several notation issues to be understood:

- a) The W3C XML Schema fragments in sections 5-10 are not intended to be complete. The complete and ruling XML Schema for the XFDU Manifest can be found in section 11.
- b) Each XML Schema section contains both an XML Authority schema diagram and the W3C XML Schema Language specification of a high-level type. The developers of XML Authority Schema diagrams have decided on the following specific XML visualizations:
 - Expand declared attribute groups that are specified once and referenced many times in the W3C XML Schema Language Specification. For this reason it may appear that the XML Schema Diagrams have more specified attributes than the corresponding W3C XML Schema language specifications.
 - #wildcard is used by XML Authority schema diagrams to indicate open content and is the diagrammatic form of ##any in the XML Schema Language.
- c) Since the XML Schema portions of this document specify only the XFDU Manifest the term XFDU is used rather than XFDU Manifest or xfd Manifest. This is true only in the W3C XML Schema specification and the associated XML Authority schema diagrams.
- d) To help visually clarify this Recommended Standard, the XML instance examples are in Times 10 point italics and XML Schema fragments are in Arial 9 point.
- e) In the Definitions subsection (1.4), the use of italics indicates that the definition or acronym was initially defined in Reference Model for an Open Archival Information System (OAIS) (reference [D7]).

Section 11 is the full XML Schema for this specification. In the case of differences between the full Schema in section 11 and the narratives and partial schemas in prior sections, the full XML Schema is the ruling specification.

Section 12 discusses security considerations related to implementation of the Recommended Standard.

Annexes A-D are informative:

- Annex A provides an example XFDU Manifest, parts of which are the source of the examples in sections 5-10.
- Annex B provides a Unified Modeling Language (UML) view of the XFDU Manifest.

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

- Annex C is a legend for symbols for the XML Authority Diagrams that appear in sections 4 through 11 of this document.
- Annex D provides Informative References.

1.4 DEFINITIONS

1.4.1 ACRONYMS AND ABBREVIATIONS

AIP	<i>Archival Information Package</i>
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee for Space Data Systems
CORBA	Common Object Request Broker Architecture
CRC	Cyclical Redundancy Check
DIP	<i>Dissemination Information Package</i>
ISBN	International Standard Book Number
ISO	International Organization for Standardization
METS	Metadata Encoding and Transmission Standard
MIME	Multipurpose Internet Mail Extensions
OAIS	<i>Open Archival Information System</i>
OWL	Web Ontology Language
PDI	<i>Preservation Description Information</i>
RDF	Resource Description Framework
RPC	Remote Procedure Call
SFDU	Standard Formatted Data Unit
SIP	Submission Information Package
SOAP	Service Oriented Architecture Protocol
UML	Unified Modeling Language
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name
W3C	World Wide Web Consortium
WWW	Worldwide Web
XFDU	XML Formatted Data Unit
XML	Extensible Markup Language

1.4.2 TERMINOLOGY

Archival Information Package (AIP): An Information Package, consisting of the Content Information and the associated Preservation Description Information (PDI), which is preserved within an OAIS.

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

Behavior Object: Object that contains an interface definition element that represents an abstract definition of the set of behaviors.¹

Behavior Section: A container of zero or more behavior objects.

Collection: Components that are gathered together; analogous to files on a file system.

Component: An object (i.e., file) that can be grouped together to be part of a Collection, or Package.

Content Data Object: The Data Object, which together with associated Representation Information is the original target of preservation.

Content Information: The set of information that is the original target of preservation. It is an Information Object comprised of its Content Data Object and its Representation Information. An example of Content Information could be a single table of numbers representing, and understandable as, temperatures, but excluding the documentation that would explain its history and origin, how it relates to other observations, etc.

Context Information: The information that documents the relationships of the Content Information to its environment. This includes why the Content Information was created and how it relates to other Content Information objects.

Content Objects: The data and/or metadata objects, and any Content Units, logically within a given Content Unit.

Content Unit: XML Structure that contains pointers to data objects and associated metadata objects, and possibly other Content Units.

Data: A reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing. Examples of data include a sequence of bits, a table of numbers, the characters on a page, the recording of sounds made by a person speaking, or a moon rock specimen.

Data Dictionary: A formal repository of terms used to describe data.

Data Object: Object that contains some file content and any data required to allow the information consumer to reverse any transformations that have been performed on the object and restore it to the byte stream intended for the original designated community and described by the Representation metadata pointed to by the repID attribute of the data object.

Data Object Section: Section that contains a number of dataObject elements.

¹In future versions of this Recommended Standard a behavior object will contain one or more mechanisms that either contain or reference a module of executable code that implements and runs those interfaces.

Description Data Unit: A Content Unit in which all the content objects are metadata objects.

Descriptive Information: The set of information, consisting primarily of Package Descriptions, which is provided to Data Management to support the finding, ordering, and retrieving of OAIS information holdings by Consumers.

Designated Community: An identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities.

Digital Object: An object composed of a set of bit sequences.

Dissemination Information Package (DIP): The Information Package, derived from one or more AIPs, received by the Consumer in response to a request to the OAIS.

Finding Aid: A type of Access Aid that allows a user to search for and identify Archival Information Packages of interest.

Fixity Information: The information that documents the authentication mechanisms and provides authentication keys to ensure that the Content Information object has not been altered in an undocumented manner. An example is a Cyclical Redundancy Check (CRC) code for a file.

Information: Any type of knowledge that can be exchanged. In an exchange, it is represented by data. An example is a string of bits (the data) accompanied by a description of how to interpret a string of bits as numbers representing temperature observations measured in degrees Celsius (the representation information).

Information Object: A Data Object together with its Representation Information.

Information Package: The Content Information and associated Preservation Description Information that is needed to aid in the preservation of the Content Information. The Information Package has associated Packaging Information used to delimit and identify the Content Information and Preservation Description Information.

Information Package Map: Outline of a hierarchical structure, for the original object being encoded, using a series of nested contentUnit elements. The Information Package Map is equivalent to highest-level Content Unit included in the XFDU.

Manifest: A document containing metadata about Components, and the relationships among them. This information is stored as a Component, using an XML language designed for just this purpose.

Metadata: Data about other data.

Metadata Section: Section that contains or references all of the static metadata for all items in the XFDU package.

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

Open Archival Information System (OAIS): An archive, consisting of an organization of people and systems, that has accepted the responsibility to preserve information and make it available for a Designated Community. It meets a set of responsibilities, as defined in subsection 3.1 of the OAIS Reference Model that allows an OAIS archive to be distinguished from other uses of the term ‘archive’. The term ‘Open’ in OAIS is used to imply that this Recommended Standard and future related standards are developed in open forums, and it does not imply that access to the archive is unrestricted.

Package: A collection that is bundled together, or packaged, into one file using a defined packaging scheme. All Packages are Collections, but not all Collections have been packaged, so they are not all Packages.

Package Header: Header that contains metadata that apply to the whole XFDU Package. These metadata may include data to inform the XFDU parsing software about volume metadata (e.g., logical volume information and specification version), administrative metadata (e.g., author and creation data) and technical data (e.g., hardware and operating system).

Package Interchange File: A collection of files that have been bundled together into a single container that also contains a manifest describing the contained files and the relationships among those files.

Physical Object: An object (such as a moon rock, bio-specimen, microscope slide) with physically observable properties that represent information that is considered suitable for being adequately documented for preservation, distribution, and independent usage.

Preservation Description Information (PDI): The information which is necessary for adequate preservation of the Content Information and which can be categorized as Provenance, Reference, Fixity, and Context information.

Process Description Unit: Unit that contains a description that can range from an automated scripting language to an English language description of the steps a person/intelligent agent would take in performing a process.

Provenance Information: The information that documents the history of the Content Information. This information tells the origin or source of the Content Information, any changes that may have taken place since it was originated, and who has had custody of it since it was originated. Examples of Provenance Information are the principal investigator who recorded the data, and the information concerning its storage, handling, and migration.

Reference Information: The information that identifies, and if necessary describes, one or more mechanisms used to provide assigned identifiers for the Content Information. It also provides identifiers that allow outside systems to refer, unambiguously, to a particular Content Information. An example of Reference Information is an ISBN.

Representation Information: The information that maps a Data Object into more meaningful concepts. An example is the ASCII definition that describes how a sequence of bits (i.e., a Data Object) is mapped into a symbol.

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

Representation Network: The set of Representation Information that fully describes the meaning of a Data Object. Representation Information in digital forms needs additional Representation Information so its digital forms can be understood over the long term.

Structure Information: The information that imparts meaning about how other information is organized. For example, it maps bit streams to common computer types such as characters, numbers, and pixels, and to aggregations of those types such as character strings and arrays.

Submission Information Package (SIP): An Information Package that is delivered by the Producer to the OAIS for use in the construction of one or more AIPs.

Transformation: A modification to the encoding of a file that is done independent of the definition of the Representation Information. A transformation is usually done to satisfy end-to-end system requirements such as performance or security. A transformation must be reversed to restore the original digital object.

Transformation Object: The part of a Data Object that contains required information (e.g., algorithms and parameters) to reverse any transformations applied to the digital content and restore that to the original binary data object.

XFDU Manifest: A Manifest that is conformant to the XML Schema specified in this Recommended Standard.

XFDU Package: A Package Interchange File that contains an XFDU Manifest and is conformant to the semantics specified in this document. An XFDU Package is a specialization of Package Interchange File.

XML Formatted Data Unit (XFDU): The complete contents as specified by the Information Package Map (i.e., the highest-level Content Unit) component of the XML Manifest. This includes the XML Manifest document, files contained in the XML Manifest, files referenced in the XFDU Manifest including those contained within the XFDU Package, and resources (i.e., files and XFDU Packages) external to the XFDU Package. The XFDU is a logical entity and may never exist as a physical entity.

XML Schema: W3C schema specification for XML documents using XML syntax.

1.5 CONFORMANCE

An **XFDU Manifest** is a Manifest that is conformant to the XML Schema definition specified in this Recommended Standard.

An **XFDU Package** is a Package Interchange File that contains an XFDU Manifest linking all files of the package.

CCSDS RECOMMENDED STANDARD FOR XFDU STRUCTURE AND CONSTRUCTION RULES

1.6 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommended Standard. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommended Standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommended Standards.

- [1] Tim Bray, et al., eds. *Extensible Markup Language (XML) 1.0*. 2nd ed. W3C Recommendation. N.p.: W3C, October 2000. <<http://www.w3.org/TR/2000/REC-xml-20001006>>
- [2] Henry S. Thompson, et al., eds. *XML Schema Part 1: Structures*. W3C Recommendation. N.p.: W3C, May 2001. <<http://www.w3.org/TR/2001/REC-xmlschema-1-20010502/>>
- [3] Paul V. Biron and Ashok Malhotra, eds. *XML Schema Part 2: Datatypes*. W3C Recommendation. N.p.: W3C, May 2001. <<http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/>>
- [4] “TIBCO Turbo XML™.” *TIBCO.com*.
<<http://www.extensibility.com/software/metadata/turboxml.jsp>> (12/18/2006)

NOTE – Informative references are listed in annex D.

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2 OVERVIEW OF XFDU PACKAGING STRUCTURE

2.1 GENERAL

This section provides an overview of some of the key concepts that are incorporated in the design of the XFDU packaging Recommended Standard.

2.2 ENVIRONMENT

Figure 2-1 illustrates an abstract package in a generic computing environment to provide a basis for discussion of concepts relevant to this document. The focus of this diagram is a collection of physical files that have been bundled together because of some interrelationship. Several files have been bundled into a single container called a Package Interchange File with a specially named file called a Manifest Document included as one of the contained files. The Manifest Document describes the relations among the files and indexes the locations of all the files within the Package Interface File containing data and metadata. The Manifest can also contain data and metadata files.

The Manifest Document also references external files. The external files are shown as coming from various resources including other XFDUs, file systems, and registries/repositories. In an environment with sufficient connectivity, reliability, and bandwidth the exchange of Package Interchange Files that include pointers to resources outside of the package allows the recipient to deal with the externally referenced files at its convenience. The resolution of these pointers is beyond the scope of this Recommended Standard.

The term ‘XML Formatted Data Unit’ or ‘XFDU’ is to be understood as referring to not only the Package Interchange File and those files contained within, but also to all the external files and packages referenced from within the included Manifest file. The entire figure represents a single XFDU instance.