eXtensible Access Control Markup Language (XACML) Version 3.0

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Related work:
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Abstract:
This specification defines version 3.0 of the extensible access control markup language.

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Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comments to the Technical Committee by using the "Send A Comment" button on the Technical Committee's web page at http://www.oasis-open.org/committees/xacml/.

Notices

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1 Introduction

1.1 Glossary (non-normative)

1.1.1 Preferred terms

Access

Performing an ***action***

Access control

Controlling ***access*** in accordance with a ***policy*** or ***policy set***

Action

An operation on a ***resource***

Advice

A supplementary piece of information in a ***policy*** or ***policy set*** which is provided to the ***PEP*** with the ***decision*** of the ***PDP***.

Applicable policy

The set of ***policies*** and ***policy sets*** that governs ***access*** for a specific ***decision request***

Attribute

Characteristic of a ***subject***, ***resource***, ***action*** or ***environment*** that may be referenced in a ***predicate*** or ***target*** (see also – ***named attribute***)

Authorization decision

The result of evaluating ***applicable policy***, returned by the ***PDP*** to the ***PEP***. A function that evaluates to “Permit”, “Deny”, “Indeterminate” or “NotApplicable", and (optionally) a set of ***obligations and advice***

Bag

An unordered collection of values, in which there may be duplicate values

Condition

An expression of ***predicates***. A function that evaluates to "True", "False" or “Indeterminate”

Conjunctive sequence

A sequence of ***predicates*** combined using the logical ‘AND’ operation

Context

The canonical representation of a ***decision request*** and an ***authorization decision***

Context handler

The system entity that converts ***decision requests*** in the native request format to the XACML canonical form and converts ***authorization decisions*** in the XACML canonical form to the native response format

Decision

The result of evaluating a ***rule***, ***policy*** or ***policy set***

Decision request

The request by a ***PEP*** to a ***PDP*** to render an ***authorization decision***

Disjunctive sequence

A sequence of ***predicates*** combined using the logical ‘OR’ operation

Effect

The intended consequence of a satisfied ***rule*** (either "Permit" or "Deny")

Environment

The set of ***attributes*** that are relevant to an ***authorization decision*** and are independent of a particular ***subject***, ***resource*** or ***action***

Issuer

A set of ***attributes*** describing the source of a ***policy***

Named attribute

A specific instance of an ***attribute***, determined by the ***attribute*** name and type, the identity of the ***attribute*** holder (which may be of type: ***subject***, ***resource***, ***action*** or ***environment***) and (optionally) the identity of the issuing authority

Obligation

An operation specified in a ***rule***, ***policy*** or ***policy set*** that should be performed by the ***PEP*** in conjunction with the enforcement of an ***authorization decision***

Policy

A set of ***rules***, an identifier for the ***rule-combining algorithm*** and (optionally) a set of ***obligations*** or ***advice***. May be a component of a ***policy set***

Policy administration point (PAP)

The system entity that creates a ***policy*** or ***policy set***

Policy-combining algorithm

The procedure for combining the ***decision*** and ***obligations*** from multiple ***policies***

Policy decision point (PDP)

The system entity that evaluates ***applicable policy*** and renders an ***authorization decision***. This term is defined in a joint effort by the IETF Policy Framework Working Group and the Distributed Management Task Force (DMTF)/Common Information Model (CIM) in **[RFC3198]**. This term corresponds to "Access Decision Function" (ADF) in **[ISO10181-3].**

Policy enforcement point (PEP)

The system entity that performs ***access control***, by making ***decision requests*** and enforcing ***authorization decisions***. This term is defined in a joint effort by the IETF Policy Framework Working Group and the Distributed Management Task Force (DMTF)/Common Information Model (CIM) in **[RFC3198].** This term corresponds to "Access Enforcement Function" (AEF) in **[ISO10181-3]**.

Policy information point (PIP)

The system entity that acts as a source of ***attribute*** values

Policy set

A set of ***policies***, other ***policy sets***, a ***policy-combining algorithm*** and (optionally) a set of ***obligations*** or ***advice***. May be a component of another ***policy set***

Predicate

A statement about ***attributes*** whose truth can be evaluated

Resource

Data, service or system component

Rule

A ***target***, an ***effect***, a ***condition*** and (optionally) a set of ***obligations*** or ***advice.*** A component of a ***policy***

Rule-combining algorithm

The procedure for combining ***decisions*** from multiple ***rules***

Subject

An actor whose ***attributes*** may be referenced by a ***predicate***

Target

The set of ***decision requests***, identified by definitions for ***resource***, ***subject*** and ***action*** that a ***rule***, ***policy,*** or ***policy set*** is intended to evaluate

Type Unification

The method by which two type expressions are "unified". The type expressions are matched along their structure. Where a type variable appears in one expression it is then "unified" to represent the corresponding structure element of the other expression, be it another variable or subexpression. All variable assignments must remain consistent in both structures. Unification fails if the two expressions cannot be aligned, either by having dissimilar structure, or by having instance conflicts, such as a variable needs to represent both "xs:string" and "xs:integer". For a full explanation of ***type unification***, please see **[Hancock]**.

1.1.2 Related terms

In the field of ***access control*** and authorization there are several closely related terms in common use. For purposes of precision and clarity, certain of these terms are not used in this specification.

For instance, the term ***attribute*** is used in place of the terms: group and role.

In place of the terms: privilege, permission, authorization, entitlement and right, we use the term ***rule***.

The term object is also in common use, but we use the term ***resource*** in this specification.

Requestors and initiators are covered by the term ***subject***.

1.2 Terminology

The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this document are to be interpreted as described in **[RFC2119]**.

This specification contains schema conforming to W3C XML Schema and normative text to describe the syntax and semantics of XML-encoded ***policy*** statements.

```
Listings of XACML schema appear like this.
```

```
Example code listings appear like this.
```

Conventional XML namespace prefixes are used throughout the listings in this specification to stand for their respective namespaces as follows, whether or not a namespace declaration is present in the example:

- The prefix `xacml:` stands for the XACML 3.0 namespace.
- The prefix `ds:` stands for the W3C XML Signature namespace **[DS]**.
- The prefix `xs:` stands for the W3C XML Schema namespace **[XS]**.
- The prefix `xf:` stands for the XQuery 1.0 and XPath 2.0 Function and Operators specification namespace **[XF]**.

- The prefix xml: stands for the XML namespace http://www.w3.org/XML/1998/namespace.

This specification uses the following typographical conventions in text: `<XACMLElement>`, `<ns:ForeignElement>`, `Attribute`, `Datatype`, `OtherCode`. Terms in ***bold-face italic*** are intended to have the meaning defined in the Glossary.

1.3 Schema organization and namespaces

The XACML syntax is defined in a schema associated with the following XML namespace:

`urn:oasis:names:tc:xacml:3.0:core:schema:wd-17`

1.4 Normative References

[CMF]	Martin J. Dürst et al, eds., *Character Model for the World Wide Web 1.0: Fundamentals*, W3C Recommendation 15 February 2005, http://www.w3.org/TR/2005/REC-charmod-20050215/
[DS]	D. Eastlake et al., *XML-Signature Syntax and Processing*, http://www.w3.org/TR/xmldsig-core/, World Wide Web Consortium.
[exc-c14n]	J. Boyer et al, eds., *Exclusive XML Canonicalization, Version 1.0*, W3C Recommendation 18 July 2002, http://www.w3.org/TR/2002/REC-xml-exc-c14n-20020718/
[Hancock]	Hancock, *Polymorphic Type Checking*, in Simon L. Peyton Jones, *Implementation of Functional Programming Languages*, Section 8, Prentice-Hall International, 1987.
[Haskell]	Haskell, a purely functional language. Available at http://www.haskell.org/
[Hier]	OASIS Committee Draft 03, *XACML v3.0 Hierarchical Resource Profile Version 1.0*, 11 March 2010, http://docs.oasis-open.org/xacml/3.0/xacml-3.0-hierarchical-v1-spec-cd-03-en.doc
[IEEE754]	IEEE Standard for Binary Floating-Point Arithmetic 1985, ISBN 1-5593-7653-8, IEEE Product No. SH10116-TBR.
[ISO10181-3]	ISO/IEC 10181-3:1996 Information technology – Open Systems Interconnection -- Security frameworks for open systems: Access control framework.
[Kudo00]	Kudo M and Hada S, *XML document security based on provisional authorization*, Proceedings of the Seventh ACM Conference on Computer and Communications Security, Nov 2000, Athens, Greece, pp 87-96.
[LDAP-1]	RFC2256, *A summary of the X500(96) User Schema for use with LDAPv3*, Section 5, M Wahl, December 1997, http://www.ietf.org/rfc/rfc2256.txt
[LDAP-2]	RFC2798, *Definition of the inetOrgPerson*, M. Smith, April 2000 http://www.ietf.org/rfc/rfc2798.txt
[MathML]	*Mathematical Markup Language (MathML)*, Version 2.0, W3C Recommendation, 21 October 2003. Available at: http://www.w3.org/TR/2003/REC-MathML2-20031021/
[Multi]	OASIS Committee Draft 03, *XACML v3.0 Multiple Decision Profile Version 1.0*, 11 March 2010, http://docs.oasis-open.org/xacml/3.0/xacml-3.0-multiple-v1-spec-cd-03-en.doc
[Perritt93]	Perritt, H. Knowbots, *Permissions Headers and Contract Law*, Conference on Technological Strategies for Protecting Intellectual Property in the Networked Multimedia Environment, April 1993. Available at: http://www.ifla.org/documents/infopol/copyright/perh2.txt
[RBAC]	David Ferraiolo and Richard Kuhn, *Role-Based Access Controls*, 15th National Computer Security Conference, 1992.
[RFC2119]	S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*, http://www.ietf.org/rfc/rfc2119.txt, IETF RFC 2119, March 1997.

[RFC2396] Berners-Lee T, Fielding R, Masinter L, *Uniform Resource Identifiers (URI): Generic Syntax*. Available at: http://www.ietf.org/rfc/rfc2396.txt

[RFC2732] Hinden R, Carpenter B, Masinter L, *Format for Literal IPv6 Addresses in URL's*. Available at: http://www.ietf.org/rfc/rfc2732.txt

[RFC3198] IETF RFC 3198: *Terminology for Policy-Based Management*, November 2001. http://www.ietf.org/rfc/rfc3198.txt

[UAX15] Mark Davis, Martin Dürst, *Unicode Standard Annex #15: Unicode Normalization Forms, Unicode 5.1*, available from http://unicode.org/reports/tr15/

[UTR36] Davis, Mark, Suignard, Michel, *Unicode Technocal Report #36: Unicode Security Considerations*. Available at http://www.unicode.org/reports/tr36/

[XACMLAdmin] OASIS Committee Draft 03, *XACML v3.0 Administration and Delegation Profile Version 1.0*. 11 March 2010. http://docs.oasis-open.org/xacml/3.0/xacml-3.0-administration-v1-spec-cd-03-en.doc

[XACMLv1.0] OASIS Standard, *Extensible access control markup language (XACML) Version 1.0*. 18 February 2003. http://www.oasis-open.org/committees/download.php/2406/oasis-xacml-1.0.pdf

[XACMLv1.1] OASIS Committee Specification*, Extensible access control markup language (XACML) Version 1.1*. 7 August 2003. http://www.oasis-open.org/committees/xacml/repository/cs-xacml-specification-1.1.pdf

[XF] *XQuery 1.0 and XPath 2.0 Functions and Operators*, W3C Recommendation 23 January 2007. Available at: http://www.w3.org/TR/2007/REC-xpath-functions-20070123/

[XML] Bray, Tim, et.al. eds, *Extensible Markup Language (XML) 1.0 (Fifth Edition)*, W3C Recommendation 26 November 2008, available at http://www.w3.org/TR/2008/REC-xml-20081126/

[XMLid] Marsh, Jonathan, et.al. eds, *xml:id Version 1.0*. W3C Recommendation 9 September 2005. Available at: http://www.w3.org/TR/2005/REC-xml-id-20050909/

[XS] *XML Schema, parts 1 and 2*. Available at: http://www.w3.org/TR/xmlschema-1/ and http://www.w3.org/TR/xmlschema-2/

[XPath] *XML Path Language (XPath), Version 1.0*, W3C Recommendation 16 November 1999. Available at: http://www.w3.org/TR/xpath

[XSLT] *XSL Transformations (XSLT) Version 1.0*, W3C Recommendation 16 November 1999. Available at: http://www.w3.org/TR/xslt

1.5 Non-Normative References

[CM] *Character model model for the World Wide Web 1.0: Normalization*, W3C Working Draft, 27 October 2005, http://www.w3.org/TR/2005/WD-charmod-norm-20051027/, World Wide Web Consortium.

[Hinton94] Hinton, H, M, Lee, E, S, *The Compatibility of Policies*, Proceedings 2nd ACM Conference on Computer and Communications Security, Nov 1994, Fairfax, Virginia, USA.

[Sloman94] Sloman, M. *Policy Driven Management for Distributed Systems*. Journal of Network and Systems Management, Volume 2, part 4. Plenum Press. 1994.

2 Background (non-normative)

The "economics of scale" have driven computing platform vendors to develop products with very generalized functionality, so that they can be used in the widest possible range of situations. "Out of the box", these products have the maximum possible privilege for accessing data and executing software, so that they can be used in as many application environments as possible, including those with the most permissive security policies. In the more common case of a relatively restrictive security policy, the platform's inherent privileges must be constrained by configuration.

The security policy of a large enterprise has many elements and many points of enforcement. Elements of policy may be managed by the Information Systems department, by Human Resources, by the Legal department and by the Finance department. And the policy may be enforced by the extranet, mail, WAN, and remote-access systems; platforms which inherently implement a permissive security policy. The current practice is to manage the configuration of each point of enforcement independently in order to implement the security policy as accurately as possible. Consequently, it is an expensive and unreliable proposition to modify the security policy. Moreover, it is virtually impossible to obtain a consolidated view of the safeguards in effect throughout the enterprise to enforce the policy. At the same time, there is increasing pressure on corporate and government executives from consumers, shareholders, and regulators to demonstrate "best practice" in the protection of the information assets of the enterprise and its customers.

For these reasons, there is a pressing need for a common language for expressing security policy. If implemented throughout an enterprise, a common policy language allows the enterprise to manage the enforcement of all the elements of its security policy in all the components of its information systems. Managing security policy may include some or all of the following steps: writing, reviewing, testing, approving, issuing, combining, analyzing, modifying, withdrawing, retrieving, and enforcing policy.

XML is a natural choice as the basis for the common security-policy language, due to the ease with which its syntax and semantics can be extended to accommodate the unique requirements of this application, and the widespread support that it enjoys from all the main platform and tool vendors.

2.1 Requirements

The basic requirements of a policy language for expressing information system security policy are:

- To provide a method for combining individual ***rules*** and ***policies*** into a single ***policy set*** that applies to a particular ***decision request***.
- To provide a method for flexible definition of the procedure by which ***rules*** and ***policies*** are combined.
- To provide a method for dealing with multiple ***subjects*** acting in different capacities.
- To provide a method for basing an ***authorization decision*** on ***attributes*** of the ***subject*** and ***resource***.
- To provide a method for dealing with multi-valued ***attributes***.
- To provide a method for basing an ***authorization decision*** on the contents of an information ***resource***.
- To provide a set of logical and mathematical operators on ***attributes*** of the ***subject***, ***resource*** and ***environment***.
- To provide a method for handling a distributed set of ***policy*** components, while abstracting the method for locating, retrieving and authenticating the ***policy*** components.
- To provide a method for rapidly identifying the ***policy*** that applies to a given ***action***, based upon the values of ***attributes*** of the ***subjects***, ***resource*** and ***action***.
- To provide an abstraction-layer that insulates the ***policy***-writer from the details of the application environment.

- To provide a method for specifying a set of ***actions*** that must be performed in conjunction with ***policy*** enforcement.

The motivation behind XACML is to express these well-established ideas in the field of ***access control*** policy using an extension language of XML. The XACML solutions for each of these requirements are discussed in the following sections.

2.2 Rule and policy combining

The complete ***policy*** applicable to a particular ***decision request*** may be composed of a number of individual ***rules*** or ***policies***. For instance, in a personal privacy application, the owner of the personal information may define certain aspects of disclosure policy, whereas the enterprise that is the custodian of the information may define certain other aspects. In order to render an ***authorization decision***, it must be possible to combine the two separate ***policies*** to form the single ***policy*** applicable to the request.

XACML defines three top-level ***policy*** elements: `<Rule>`, `<Policy>` and `<PolicySet>`. The `<Rule>` element contains a Boolean expression that can be evaluated in isolation, but that is not intended to be accessed in isolation by a ***PDP***. So, it is not intended to form the basis of an ***authorization decision*** by itself. It is intended to exist in isolation only within an XACML ***PAP***, where it may form the basic unit of management, and be re-used in multiple ***policies***.

The `<Policy>` element contains a set of `<Rule>` elements and a specified procedure for combining the results of their evaluation. It is the basic unit of ***policy*** used by the ***PDP***, and so it is intended to form the basis of an ***authorization decision***.

The `<PolicySet>` element contains a set of `<Policy>` or other `<PolicySet>` elements and a specified procedure for combining the results of their evaluation. It is the standard means for combining separate ***policies*** into a single combined ***policy***.

Hinton et al **[Hinton94]** discuss the question of the compatibility of separate ***policies*** applicable to the same ***decision request***.

2.3 Combining algorithms

XACML defines a number of combining algorithms that can be identified by a `RuleCombiningAlgId` or `PolicyCombiningAlgId` attribute of the `<Policy>` or `<PolicySet>` elements, respectively. The ***rule-combining algorithm*** defines a procedure for arriving at an ***authorization decision*** given the individual results of evaluation of a set of ***rules***. Similarly, the ***policy-combining algorithm*** defines a procedure for arriving at an ***authorization decision*** given the individual results of evaluation of a set of ***policies***. Standard combining algorithms are defined for:

- Deny-overrides (Ordered and Unordered),
- Permit-overrides (Ordered and Unordered),
- First-applicable and
- Only-one-applicable.

In the case of the Deny-overrides algorithm, if a single `<Rule>` or `<Policy>` element is encountered that evaluates to "Deny", then, regardless of the evaluation result of the other `<Rule>` or `<Policy>` elements in the ***applicable policy***, the combined result is "Deny".

Likewise, in the case of the Permit-overrides algorithm, if a single "Permit" result is encountered, then the combined result is "Permit".

In the case of the “First-applicable” combining algorithm, the combined result is the same as the result of evaluating the first `<Rule>`, `<Policy>` or `<PolicySet>` element in the list of ***rules*** whose ***target*** and ***condition*** is applicable to the ***decision request***.

The "Only-one-applicable" ***policy-combining algorithm*** only applies to ***policies***. The result of this combining algorithm ensures that one and only one ***policy*** or ***policy set*** is applicable by virtue of their ***targets***. If no ***policy*** or ***policy set*** applies, then the result is "NotApplicable", but if more than one ***policy*** or ***policy set*** is applicable, then the result is "Indeterminate". When exactly one ***policy*** or ***policy set*** is applicable, the result of the combining algorithm is the result of evaluating the single ***applicable policy*** or ***policy set***.

Policies and ***policy sets*** may take parameters that modify the behavior of the combining algorithms. However, none of the standard combining algorithms is affected by parameters.

Users of this specification may, if necessary, define their own combining algorithms.

2.4 Multiple subjects

Access control policies often place requirements on the ***actions*** of more than one ***subject***. For instance, the ***policy*** governing the execution of a high-value financial transaction may require the approval of more than one individual, acting in different capacities. Therefore, XACML recognizes that there may be more than one ***subject*** relevant to a ***decision request***. Different ***attribute*** categories are used to differentiate between ***subjects*** acting in different capacities. Some standard values for these ***attribute*** categories are specified, and users may define additional ones.

2.5 Policies based on subject and resource attributes

Another common requirement is to base an ***authorization decision*** on some characteristic of the ***subject*** other than its identity. Perhaps, the most common application of this idea is the ***subject***'s role **[RBAC]**. XACML provides facilities to support this approach. ***Attributes*** of ***subjects*** contained in the request ***context*** may be identified by the `<AttributeDesignator>` element. This element contains a URN that identifies the ***attribute***. Alternatively, the `<AttributeSelector>` element may contain an XPath expression over the `<Content>` element of the ***subject*** to identify a particular ***subject attribute*** value by its location in the ***context*** (see Section 2.11 for an explanation of ***context***).

XACML provides a standard way to reference the ***attributes*** defined in the LDAP series of specifications **[LDAP-1]**, **[LDAP-2]**. This is intended to encourage implementers to use standard ***attribute*** identifiers for some common ***subject attributes***.

Another common requirement is to base an ***authorization decision*** on some characteristic of the ***resource*** other than its identity. XACML provides facilities to support this approach. ***Attributes*** of the ***resource*** may be identified by the `<AttributeDesignator>` element. This element contains a URN that identifies the ***attribute***. Alternatively, the `<AttributeSelector>` element may contain an XPath expression over the `<Content>` element of the ***resource*** to identify a particular ***resource attribute*** value by its location in the ***context***.

2.6 Multi-valued attributes

The most common techniques for communicating ***attributes*** (LDAP, XPath, SAML, etc.) support multiple values per ***attribute***. Therefore, when an XACML ***PDP*** retrieves the value of a ***named attribute***, the result may contain multiple values. A collection of such values is called a ***bag***. A ***bag*** differs from a set in that it may contain duplicate values, whereas a set may not. Sometimes this situation represents an error. Sometimes the XACML ***rule*** is satisfied if any one of the ***attribute*** values meets the criteria expressed in the ***rule***.

XACML provides a set of functions that allow a ***policy*** writer to be absolutely clear about how the ***PDP*** should handle the case of multiple ***attribute*** values. These are the “higher-order” functions (see Section A.3).

2.7 Policies based on resource contents

In many applications, it is required to base an ***authorization decision*** on data contained in the information ***resource*** to which ***access*** is requested. For instance, a common component of privacy ***policy*** is that a person should be allowed to read records for which he or she is the ***subject***. The corresponding ***policy*** must contain a reference to the ***subject*** identified in the information ***resource*** itself.

XACML provides facilities for doing this when the information ***resource*** can be represented as an XML document. The `<AttributeSelector>` element may contain an XPath expression over the

`<Content>` element of the ***resource*** to identify data in the information ***resource*** to be used in the ***policy*** evaluation.

In cases where the information ***resource*** is not an XML document, specified ***attributes*** of the ***resource*** can be referenced, as described in Section 2.5.

2.8 Operators

Information security ***policies*** operate upon ***attributes*** of ***subjects***, the ***resource***, the ***action*** and the ***environment*** in order to arrive at an ***authorization decision***. In the process of arriving at the ***authorization decision***, ***attributes*** of many different types may have to be compared or computed. For instance, in a financial application, a person's available credit may have to be calculated by adding their credit limit to their account balance. The result may then have to be compared with the transaction value. This sort of situation gives rise to the need for arithmetic operations on ***attributes*** of the ***subject*** (account balance and credit limit) and the ***resource*** (transaction value).

Even more commonly, a ***policy*** may identify the set of roles that are permitted to perform a particular ***action***. The corresponding operation involves checking whether there is a non-empty intersection between the set of roles occupied by the ***subject*** and the set of roles identified in the ***policy***; hence the need for set operations.

XACML includes a number of built-in functions and a method of adding non-standard functions. These functions may be nested to build arbitrarily complex expressions. This is achieved with the `<Apply>` element. The `<Apply>` element has an XML attribute called `FunctionId` that identifies the function to be applied to the contents of the element. Each standard function is defined for specific argument data-type combinations, and its return data-type is also specified. Therefore, data-type consistency of the ***policy*** can be checked at the time the ***policy*** is written or parsed. And, the types of the data values presented in the request ***context*** can be checked against the values expected by the ***policy*** to ensure a predictable outcome.

In addition to operators on numerical and set arguments, operators are defined for date, time and duration arguments.

Relationship operators (equality and comparison) are also defined for a number of data-types, including the RFC822 and X.500 name-forms, strings, URIs, etc.

Also noteworthy are the operators over Boolean data-types, which permit the logical combination of ***predicates*** in a ***rule***. For example, a ***rule*** may contain the statement that ***access*** may be permitted during business hours AND from a terminal on business premises.

The XACML method of representing functions borrows from MathML **[MathML]** and from the XQuery 1.0 and XPath 2.0 Functions and Operators specification **[XF]**.

2.9 Policy distribution

In a distributed system, individual ***policy*** statements may be written by several ***policy*** writers and enforced at several enforcement points. In addition to facilitating the collection and combination of independent ***policy*** components, this approach allows ***policies*** to be updated as required. XACML ***policy*** statements may be distributed in any one of a number of ways. But, XACML does not describe any normative way to do this. Regardless of the means of distribution, ***PDPs*** are expected to confirm, by examining the ***policy***'s `<Target>` element that the ***policy*** is applicable to the ***decision request*** that it is processing.

`<Policy>` elements may be attached to the information ***resources*** to which they apply, as described by Perritt **[Perritt93]**. Alternatively, `<Policy>` elements may be maintained in one or more locations from which they are retrieved for evaluation. In such cases, the ***applicable policy*** may be referenced by an identifier or locator closely associated with the information ***resource***.

2.10 Policy indexing

For efficiency of evaluation and ease of management, the overall security ***policy*** in force across an enterprise may be expressed as multiple independent ***policy*** components. In this case, it is necessary to identify and retrieve the ***applicable policy*** statement and verify that it is the correct one for the requested ***action*** before evaluating it. This is the purpose of the `<Target>` element in XACML.

Two approaches are supported:

1. ***Policy*** statements may be stored in a database. In this case, the ***PDP*** should form a database query to retrieve just those ***policies*** that are applicable to the set of ***decision requests*** to which it expects to respond. Additionally, the ***PDP*** should evaluate the `<Target>` element of the retrieved ***policy*** or ***policy set*** statements as defined by the XACML specification.
2. Alternatively, the ***PDP*** may be loaded with all available ***policies*** and evaluate their `<Target>` elements in the context of a particular ***decision request***, in order to identify the ***policies*** and ***policy sets*** that are applicable to that request.

The use of constraints limiting the applicability of a policy was described by Sloman **[Sloman94]**.

2.11 Abstraction layer

PEPs come in many forms. For instance, a ***PEP*** may be part of a remote-access gateway, part of a Web server or part of an email user-agent, etc. It is unrealistic to expect that all ***PEPs*** in an enterprise do currently, or will in the future, issue ***decision requests*** to a ***PDP*** in a common format. Nevertheless, a particular ***policy*** may have to be enforced by multiple ***PEPs***. It would be inefficient to force a ***policy*** writer to write the same ***policy*** several different ways in order to accommodate the format requirements of each ***PEP***. Similarly ***attributes*** may be contained in various envelope types (e.g. X.509 attribute certificates, SAML attribute assertions, etc.). Therefore, there is a need for a canonical form of the request and response handled by an XACML ***PDP***. This canonical form is called the XACML ***context***. Its syntax is defined in XML schema.

Naturally, XACML-conformant ***PEPs*** may issue requests and receive responses in the form of an XACML ***context***. But, where this situation does not exist, an intermediate step is required to convert between the request/response format understood by the ***PEP*** and the XACML ***context*** format understood by the ***PDP***.

The benefit of this approach is that ***policies*** may be written and analyzed independently of the specific environment in which they are to be enforced.

In the case where the native request/response format is specified in XML Schema (e.g. a SAML-conformant ***PEP***), the transformation between the native format and the XACML ***context*** may be specified in the form of an Extensible Stylesheet Language Transformation **[XSLT]**.

Similarly, in the case where the ***resource*** to which ***access*** is requested is an XML document, the ***resource*** itself may be included in, or referenced by, the request ***context***. Then, through the use of XPath expressions **[XPath]** in the ***policy***, values in the ***resource*** may be included in the ***policy*** evaluation.

2.12 Actions performed in conjunction with enforcement

In many applications, ***policies*** specify ***actions*** that MUST be performed, either instead of, or in addition to, ***actions*** that MAY be performed. This idea was described by Sloman **[Sloman94]**. XACML provides facilities to specify ***actions*** that MUST be performed in conjunction with ***policy*** evaluation in the `<Obligations>` element. This idea was described as a provisional action by Kudo **[Kudo00]**. There are no standard definitions for these actions in version 3.0 of XACML. Therefore, bilateral agreement between a ***PAP*** and the ***PEP*** that will enforce its ***policies*** is required for correct interpretation. ***PEPs*** that conform to v3.0 of XACML are required to deny ***access*** unless they understand and can discharge all of the `<Obligations>` elements associated with the ***applicable policy***. `<Obligations>` elements are returned to the ***PEP*** for enforcement.

2.13 Supplemental information about a decision

In some applications it is helpful to specify supplemental information about a decision. XACML provides facilities to specify supplemental information about a decision with the `<Advice>` element. Such ***advice*** may be safely ignored by the ***PEP***.

3 Models (non-normative)

The data-flow model and language model of XACML are described in the following sub-sections.

3.1 Data-flow model

The major actors in the XACML domain are shown in the data-flow diagram of Figure 1.

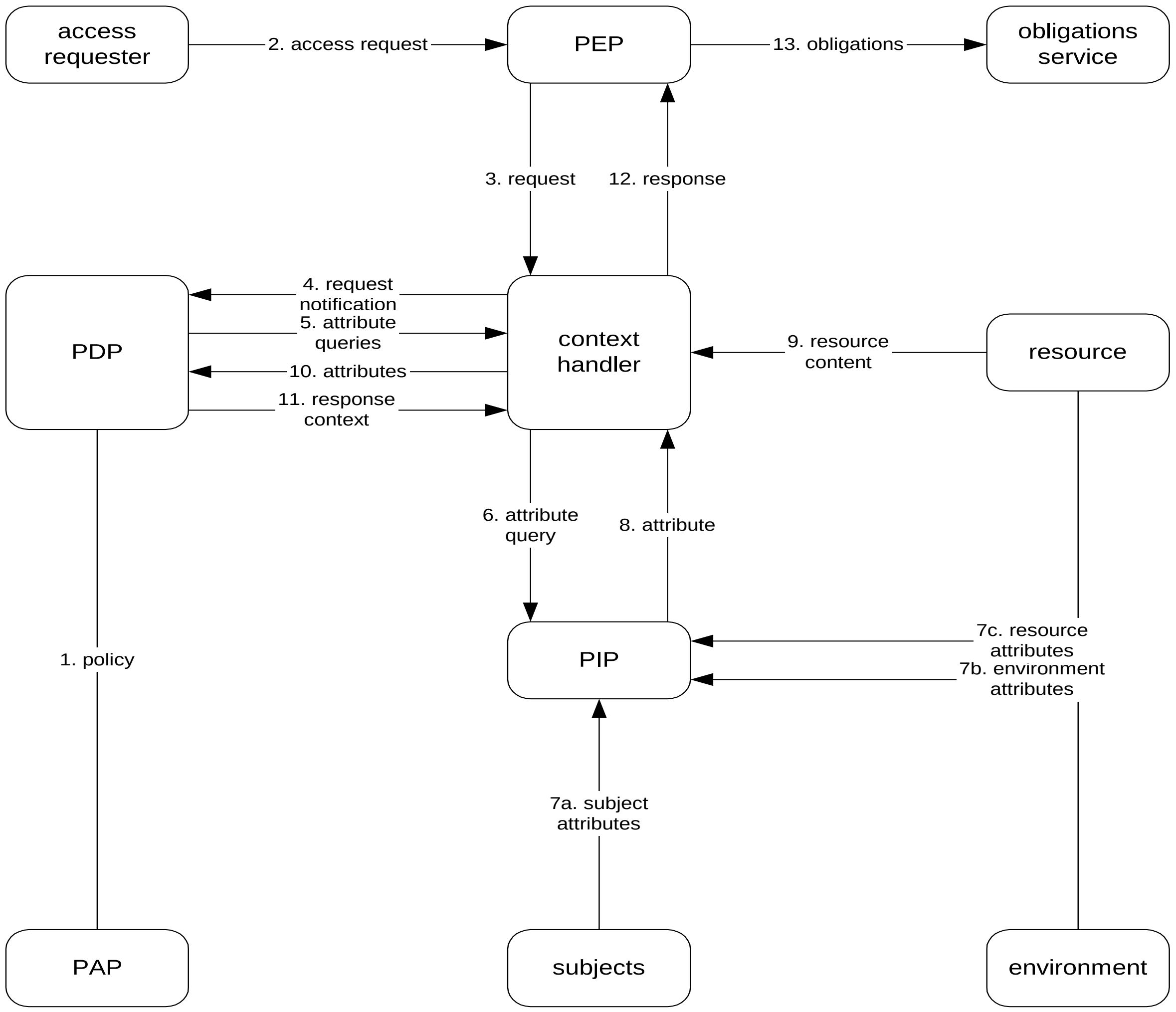

Figure 1 - Data-flow diagram

> Note: some of the data-flows shown in the diagram may be facilitated by a repository. For instance, the communications between the ***context handler*** and the ***PIP*** or the communications between the ***PDP*** and the ***PAP*** may be facilitated by a repository. The XACML specification is not intended to place restrictions on the location of any such repository, or indeed to prescribe a particular communication protocol for any of the data-flows.

The model operates by the following steps.

1. ***PAPs*** write ***policies*** and ***policy sets*** and make them available to the ***PDP***. These ***policies*** or ***policy sets*** represent the complete ***policy*** for a specified ***target***.
2. The ***access*** requester sends a request for ***access*** to the ***PEP***.

3. The ***PEP*** sends the request for ***access*** to the ***context handler*** in its native request format, optionally including ***attributes*** of the ***subjects***, ***resource***, ***action***, ***environment*** and other categories.
4. The ***context handler*** constructs an XACML request ***context*** and sends it to the ***PDP***.
5. The ***PDP*** requests any additional ***subject***, ***resource***, ***action***, ***environment*** and other categories (not shown) ***attributes*** from the ***context handler***.
6. The ***context handler*** requests the ***attributes*** from a ***PIP***.
7. The ***PIP*** obtains the requested ***attributes***.
8. The ***PIP*** returns the requested ***attributes*** to the ***context handler***.
9. Optionally, the ***context handler*** includes the ***resource*** in the ***context***.
10. The ***context handler*** sends the requested ***attributes*** and (optionally) the ***resource*** to the ***PDP***. The ***PDP*** evaluates the ***policy***.
11. The ***PDP*** returns the response ***context*** (including the ***authorization decision***) to the ***context handler***.
12. The ***context handler*** translates the response ***context*** to the native response format of the ***PEP***. The ***context handler*** returns the response to the ***PEP***.
13. The ***PEP*** fulfills the ***obligations***.
14. (Not shown) If ***access*** is permitted, then the ***PEP*** permits ***access*** to the ***resource***; otherwise, it denies ***access***.

3.2 XACML context

XACML is intended to be suitable for a variety of application environments. The core language is insulated from the application environment by the XACML ***context***, as shown in Figure 2, in which the scope of the XACML specification is indicated by the shaded area. The XACML ***context*** is defined in XML schema, describing a canonical representation for the inputs and outputs of the ***PDP***. ***Attributes*** referenced by an instance of XACML ***policy*** may be in the form of XPath expressions over the `<Content>` elements of the ***context***, or attribute designators that identify the ***attribute*** by its category, identifier, data-type and (optionally) its issuer. Implementations must convert between the ***attribute*** representations in the application environment (e.g., SAML, J2SE, CORBA, and so on) and the ***attribute*** representations in the XACML ***context***. How this is achieved is outside the scope of the XACML specification. In some cases, such as SAML, this conversion may be accomplished in an automated way through the use of an XSLT transformation.

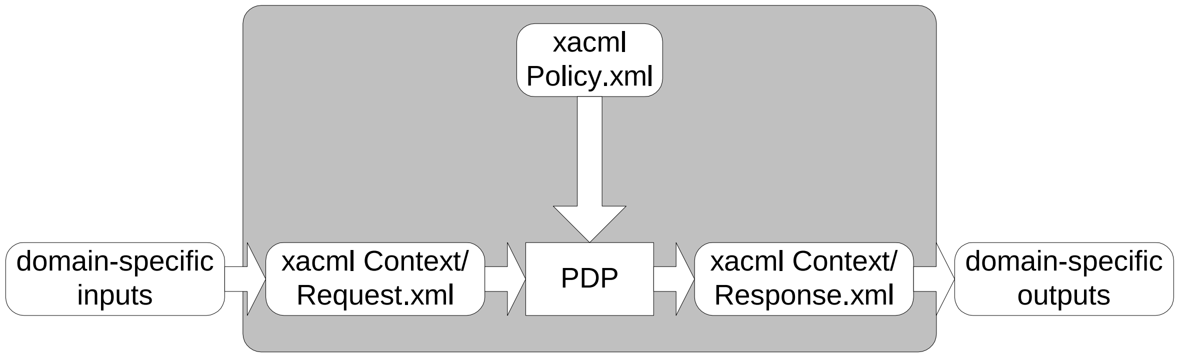

Figure 2 - XACML context

Note: The ***PDP*** is not required to operate directly on the XACML representation of a ***policy***. It may operate directly on an alternative representation.

Typical categories of ***attributes*** in the ***context*** are the ***subject***, ***resource***, ***action*** and ***environment***, but users may define their own categories as needed. See appendix B.2 for suggested ***attribute*** categories.

See Section 7.3.5 for a more detailed discussion of the request ***context***.

3.3 Policy language model

The ***policy*** language model is shown in Figure 3. The main components of the model are:

- ***Rule***;
- ***Policy***; and
- ***Policy set***.

These are described in the following sub-sections.

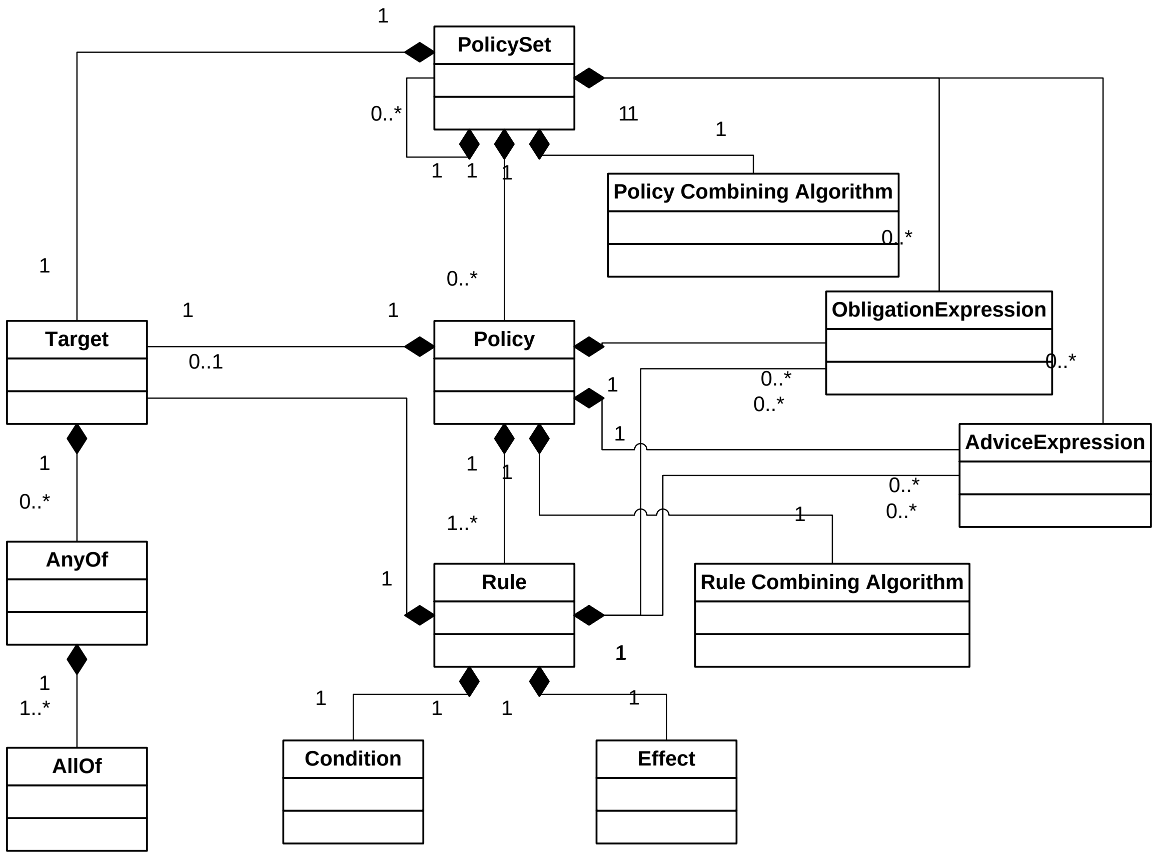

Figure 3 - Policy language model

3.3.1 Rule

A ***rule*** is the most elementary unit of ***policy***. It may exist in isolation only within one of the major actors of the XACML domain. In order to exchange ***rules*** between major actors, they must be encapsulated in a ***policy***. A ***rule*** can be evaluated on the basis of its contents. The main components of a ***rule*** are:

- a ***target***;
- an ***effect***,
- a ***condition***,
- ***obligation*** epxressions, and
- ***advice*** expressions

These are discussed in the following sub-sections.

3.3.1.1 Rule target

The ***target*** defines the set of requests to which the ***rule*** is intended to apply in the form of a logical expression on ***attributes*** in the request. The `<Condition>` element may further refine the applicability established by the ***target***. If the ***rule*** is intended to apply to all entities of a particular data-type, then the corresponding entity is omitted from the ***target***. An XACML ***PDP*** verifies that the matches defined by the ***target*** are satisfied by the ***attributes*** in the request ***context***.

The `<Target>` element may be absent from a `<Rule>`. In this case, the ***target*** of the `<Rule>` is the same as that of the parent `<Policy>` element.

Certain ***subject*** name-forms, ***resource*** name-forms and certain types of ***resource*** are internally structured. For instance, the X.500 directory name-form and RFC 822 name-form are structured ***subject*** name-forms, whereas an account number commonly has no discernible structure. UNIX file-system path-names and URIs are examples of structured ***resource*** name-forms. An XML document is an example of a structured ***resource***.

Generally, the name of a node (other than a leaf node) in a structured name-form is also a legal instance of the name-form. So, for instance, the RFC822 name "med.example.com" is a legal RFC822 name identifying the set of mail addresses hosted by the med.example.com mail server. The XPath value md:record/md:patient/ is a legal XPath value identifying a node-set in an XML document.

The question arises: how should a name that identifies a set of ***subjects*** or ***resources*** be interpreted by the ***PDP***, whether it appears in a ***policy*** or a request ***context***? Are they intended to represent just the node explicitly identified by the name, or are they intended to represent the entire sub-tree subordinate to that node?

In the case of ***subjects***, there is no real entity that corresponds to such a node. So, names of this type always refer to the set of ***subjects*** subordinate in the name structure to the identified node. Consequently, non-leaf ***subject*** names should not be used in equality functions, only in match functions, such as “urn:oasis:names:tc:xacml:1.0:function:rfc822Name-match” not “urn:oasis:names:tc:xacml:1.0:function:rfc822Name-equal” (see Appendix 10.2.9).

3.3.1.2 Effect

The ***effect*** of the ***rule*** indicates the ***rule***-writer's intended consequence of a "True" evaluation for the ***rule***. Two values are allowed: "Permit" and "Deny".

3.3.1.3 Condition

Condition represents a Boolean expression that refines the applicability of the ***rule*** beyond the ***predicates*** implied by its ***target***. Therefore, it may be absent.

3.3.1.4 Obligation expressions

Obligation expressions may be added by the writer of the ***rule***.

When a ***PDP*** evaluates a ***rule*** containing ***obligation***, expressions, it evaluates the ***obligation*** expressions into ***obligations*** and returns certain of those ***obligations*** to the ***PEP*** in the response ***context***. Section 7.16 explains which ***obligations*** are to be returned.

3.3.1.5 Advice

Advice expressions may be added by the writer of the ***rule***.

When a ***PDP*** evaluates a ***rule*** containing ***advice*** expressions, it evaluates the ***advice*** expressions into ***advice*** and returns certain of those ***advice*** to the ***PEP*** in the response ***context***. Section 7.16 explains which ***advice*** are to be returned. In contrast to ***obligations***, ***advice*** may be safely ignored by the ***PEP***.

3.3.2 Policy

From the data-flow model one can see that ***rules*** are not exchanged amongst system entities. Therefore, a ***PAP*** combines ***rules*** in a ***policy***. A ***policy*** comprises four main components:

- a ***target***;
- a ***rule-combining algorithm***-identifier;
- a set of ***rules***;
- ***obligation*** expressions and
- ***advice*** expressions

Rules are described above. The remaining components are described in the following sub-sections.

3.3.2.1 Policy target

An XACML `<PolicySet>`, `<Policy>` or `<Rule>` element contains a `<Target>` element that specifies the set of requests to which it applies. The `<Target>` of a `<PolicySet>` or `<Policy>` may be declared by the writer of the `<PolicySet>` or `<Policy>`, or it may be calculated from the `<Target>` elements of the `<PolicySet>`, `<Policy>` and `<Rule>` elements that it contains.

A system entity that calculates a `<Target>` in this way is not defined by XACML, but there are two logical methods that might be used. In one method, the `<Target>` element of the outer `<PolicySet>` or `<Policy>` (the "outer component") is calculated as the union of all the `<Target>` elements of the referenced `<PolicySet>`, `<Policy>` or `<Rule>` elements (the "inner components"). In another method, the `<Target>` element of the outer component is calculated as the intersection of all the `<Target>` elements of the inner components. The results of evaluation in each case will be very different: in the first case, the `<Target>` element of the outer component makes it applicable to any ***decision request*** that matches the `<Target>` element of at least one inner component; in the second case, the `<Target>` element of the outer component makes it applicable only to ***decision requests*** that match the `<Target>` elements of every inner component. Note that computing the intersection of a set of `<Target>` elements is likely only practical if the ***target*** data-model is relatively simple.

In cases where the `<Target>` of a `<Policy>` is declared by the ***policy*** writer, any component `<Rule>` elements in the `<Policy>` that have the same `<Target>` element as the `<Policy>` element may omit the `<Target>` element. Such `<Rule>` elements inherit the `<Target>` of the `<Policy>` in which they are contained.

3.3.2.2 Rule-combining algorithm

The ***rule-combining algorithm*** specifies the procedure by which the results of evaluating the component ***rules*** are combined when evaluating the ***policy***, i.e. the ***decision*** value placed in the response ***context*** by the ***PDP*** is the value of the ***policy***, as defined by the ***rule-combining algorithm***. A ***policy*** may have combining parameters that affect the operation of the ***rule-combining algorithm***.

See Appendix C for definitions of the normative ***rule-combining algorithms***.

3.3.2.3 Obligation expressions

Obligation expressions may be added by the writer of the ***policy***.

When a ***PDP*** evaluates a ***policy*** containing ***obligation*** expressions, it evaluates the ***obligation*** expressions into ***obligations*** and returns certain of those ***obligations*** to the ***PEP*** in the response ***context***. Section 7.16 explains which ***obligations*** are to be returned.

3.3.2.4 Advice

Advice expressions may be added by the writer of the ***policy***.

When a ***PDP*** evaluates a ***policy*** containing ***advice*** expressions, it evaluates the ***advice*** expressions into ***advice*** and returns certain of those ***advice*** to the ***PEP*** in the response ***context***. Section 7.16 explains which ***advice*** are to be returned. In contrast to ***obligations***, ***advice*** may be safely ignored by the ***PEP***.

3.3.3 Policy set

A ***policy set*** comprises four main components:

- a ***target***;
- a ***policy-combining algorithm***-identifier
- a set of ***policies***;
- ***obligation*** expressions, and
- ***advice*** expressions

The ***target*** and ***policy*** components are described above. The other components are described in the following sub-sections.

3.3.3.1 Policy-combining algorithm

The ***policy-combining algorithm*** specifies the procedure by which the results of evaluating the component ***policies*** are combined when evaluating the ***policy set***, i.e. the `Decision` value placed in the response ***context*** by the ***PDP*** is the result of evaluating the ***policy set***, as defined by the ***policy-combining algorithm***. A ***policy set*** may have combining parameters that affect the operation of the ***policy-combining algorithm***.

See Appendix C for definitions of the normative ***policy-combining algorithms***.

3.3.3.2 Obligation expressions

The writer of a ***policy set*** may add ***obligation*** expressions to the ***policy set***, in addition to those contained in the component ***rules***, ***policies*** and ***policy sets***.

When a ***PDP*** evaluates a ***policy set*** containing ***obligations*** expressions, it evaluates the ***obligation*** expressions into ***obligations*** and returns certain of those ***obligations*** to the ***PEP*** in its response ***context***. Section 7.16 explains which ***obligations*** are to be returned.

3.3.3.3 Advice expressions

Advice expressions may be added by the writer of the ***policy set***.

When a ***PDP*** evaluates a ***policy set*** containing ***advice*** expressions, it evaluates the ***advice*** expressions into ***advice*** and returns certain of those ***advice*** to the ***PEP*** in the response ***context***. Section 7.16 explains which ***advice*** are to be returned. In contrast to ***obligations***, ***advice*** may be safely ignored by the ***PEP***.

4 Examples (non-normative)

This section contains two examples of the use of XACML for illustrative purposes. The first example is a relatively simple one to illustrate the use of ***target***, ***context***, matching functions and ***subject attributes***. The second example additionally illustrates the use of the ***rule-combining algorithm***, ***conditions*** and ***obligations***.

4.1 Example one

4.1.1 Example policy

Assume that a corporation named Medi Corp (identified by its domain name: med.example.com) has an ***access control policy*** that states, in English:

*Any user with an e-mail name in the "med.example.com" namespace is allowed to perform any **action** on any resource.*

An XACML ***policy*** consists of header information, an optional text description of the ***policy***, a ***target***, one or more ***rules*** and an optional set of ***obligation*** expressions.

```
 [a1]    <?xml version="1.0" encoding="UTF-8"?>
 [a2]    <Policy
 [a3]      xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [a4]      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [a5]      xsi:schemaLocation="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17
 [a6]      http://docs.oasis-open.org/xacml/3.0/xacml-core-v3-schema-wd-17.xsd"
 [a7]      PolicyId="urn:oasis:names:tc:xacml:3.0:example:SimplePolicy1"
 [a8]      Version="1.0"
 [a9]      RuleCombiningAlgId="identifier:rule-combining-algorithm:deny-overrides">
[a10]      <Description>
[a11]        Medi Corp access control policy
[a12]      </Description>
[a13]      <Target/>
[a14]      <Rule
[a15]        RuleId= "urn:oasis:names:tc:xacml:3.0:example:SimpleRule1"
[a16]        Effect="Permit">
[a17]        <Description>
[a18]          Any subject with an e-mail name in the med.example.com domain
[a19]          can perform any action on any resource.
[a20]        </Description>
[a21]        <Target>
[a22]          <AnyOf>
[a23]            <AllOf>
[a24]              <Match
[a25]                MatchId="urn:oasis:names:tc:xacml:1.0:function:rfc822Name-match">
[a26]              <AttributeValue
[a27]                DataType="http://www.w3.org/2001/XMLSchema#string"
[a28]                  >med.example.com</AttributeValue>
[a29]              <AttributeDesignator
[a30]                MustBePresent="false"
[a31]                Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-
         subject"
[a32]                AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id"
[a33]                DataType="urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name"/>
[a34]              </Match>
[a35]            </AllOf>
[a36]          </AnyOf>
[a37]        </Target>
[a38]      </Rule>
[a39]    </Policy>
```

[a1] is a standard XML document tag indicating which version of XML is being used and what the character encoding is.

[a2] introduces the XACML ***Policy*** itself.

[a3] - [a4] are XML namespace declarations.

[a3] gives a URN for the XACML ***policies*** schema.

[a7] assigns a name to this ***policy*** instance. The name of a ***policy*** has to be unique for a given ***PDP*** so that there is no ambiguity if one ***policy*** is referenced from another ***policy***. The version attribute specifies the version of this policy is “1.0”.

[a9] specifies the algorithm that will be used to resolve the results of the various ***rules*** that may be in the ***policy***. The deny-overrides ***rule-combining algorithm*** specified here says that, if any ***rule*** evaluates to “Deny”, then the ***policy*** must return “Deny”. If all ***rules*** evaluate to “Permit”, then the ***policy*** must return “Permit”. The ***rule-combining algorithm***, which is fully described in Appendix C, also says what to do if an error were to occur when evaluating any ***rule***, and what to do with ***rules*** that do not apply to a particular ***decision request***.

[a10] - [a12] provide a text description of the ***policy***. This description is optional.

[a13] describes the ***decision requests*** to which this ***policy*** applies. If the ***attributes*** in a ***decision request*** do not match the values specified in the ***policy target***, then the remainder of the ***policy*** does not need to be evaluated. This ***target*** section is useful for creating an index to a set of ***policies***. In this simple example, the ***target*** section says the ***policy*** is applicable to any ***decision request***.

[a14] introduces the one and only ***rule*** in this simple ***policy***.

[a15] specifies the identifier for this ***rule***. Just as for a ***policy***, each ***rule*** must have a unique identifier (at least unique for any ***PDP*** that will be using the ***policy***).

[a16] says what ***effect*** this ***rule*** has if the ***rule*** evaluates to “True”. ***Rules*** can have an ***effect*** of either “Permit” or “Deny”. In this case, if the ***rule*** is satisfied, it will evaluate to “Permit”, meaning that, as far as this one ***rule*** is concerned, the requested ***access*** should be permitted. If a ***rule*** evaluates to “False”, then it returns a result of “NotApplicable”. If an error occurs when evaluating the ***rule***, then the ***rule*** returns a result of “Indeterminate”. As mentioned above, the ***rule-combining algorithm*** for the ***policy*** specifies how various ***rule*** values are combined into a single ***policy*** value.

[a17] - [a20] provide a text description of this ***rule***. This description is optional.

[a21] introduces the ***target*** of the ***rule***. As described above for the ***target*** of a ***policy***, the ***target*** of a ***rule*** describes the ***decision requests*** to which this ***rule*** applies. If the ***attributes*** in a ***decision request*** do not match the values specified in the ***rule target***, then the remainder of the ***rule*** does not need to be evaluated, and a value of “NotApplicable” is returned to the ***rule*** evaluation.

The ***rule target*** is similar to the ***target*** of the ***policy*** itself, but with one important difference. [a22] - [a36] spells out a specific value that the ***subject*** in the ***decision request*** must match. The `<Match>` element specifies a matching function in the `MatchId` attribute, a literal value of “med.example.com” and a pointer to a specific ***subject attribute*** in the request ***context*** by means of the `<AttributeDesignator>` element with an ***attribute*** category which specifies the ***access subject***. The matching function will be used to compare the literal value with the value of the ***subject attribute*** . Only if the match returns “True” will this ***rule*** apply to a particular ***decision request***. If the match returns “False”, then this ***rule*** will return a value of “NotApplicable”.

[a38] closes the ***rule***. In this ***rule***, all the work is done in the `<Target>` element. In more complex ***rules***, the `<Target>` may have been followed by a `<Condition>` element (which could also be a set of ***conditions*** to be ANDed or ORed together).

[a39] closes the ***policy***. As mentioned above, this ***policy*** has only one ***rule***, but more complex ***policies*** may have any number of ***rules***.

4.1.2 Example request context

Let's examine a hypothetical ***decision request*** that might be submitted to a ***PDP*** that executes the ***policy*** above. In English, the ***access*** request that generates the ***decision request*** may be stated as follows:

Bart Simpson, with e-mail name "bs@simpsons.com", wants to read his medical record at Medi Corp.

In XACML, the information in the ***decision request*** is formatted into a request ***context*** statement that looks as follows:

```
   [b1]   <?xml version="1.0" encoding="UTF-8"?>
   [b2]   <Request xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
   [b3]     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   [b4]     xsi:schemaLocation="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17
          http://docs.oasis-open.org/xacml/3.0/xacml-core-v3-schema-wd-17.xsd"
   [b5]     ReturnPolicyIdList="false">
   [b6]     <Attributes Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-
          subject">
   [b7]       <Attribute IncludeInResult="false"
   [b8]         AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id">
   [b9]         <AttributeValue
  [b10]           DataType="urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name"
  [b11]             >bs@simpsons.com</AttributeValue>
  [b12]       </Attribute>
  [b13]     </Attributes>
  [b14]     <Attributes
  [b15]       Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource">
  [b16]       <Attribute IncludeInResult="false"
  [b17]         AttributeId="urn:oasis:names:tc:xacml:1.0:resource:resource-id">
  [b18]         <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#anyURI"
  [b19]             >file://example/med/record/patient/BartSimpson</AttributeValue>
  [b20]       </Attribute>
  [b21]     </Attributes>
  [b22]     <Attributes
  [b23]       Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action">
  [b24]       <Attribute IncludeInResult="false"
  [b25]           AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id">
  [b26]         <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
  [b27]             >read</AttributeValue>
  [b28]       </Attribute>
  [b29]     </Attributes>
  [b30]   </Request>
```

[b1] - [b2] contain the header information for the request ***context***, and are used the same way as the header for the ***policy*** explained above.

The first `<Attributes>` element contains ***attributes*** of the entity making the ***access*** request. There can be multiple ***subjects*** in the form of additional `<Attributes>` elements with different categories, and each ***subject*** can have multiple ***attributes***. In this case, in [b6] - [b13], there is only one ***subject***, and the ***subject*** has only one ***attribute***: the ***subject***'s identity, expressed as an e-mail name, is “bs@simpsons.com”.

The second `<Attributes>` element contains ***attributes*** of the ***resource*** to which the ***subject*** (or ***subjects***) has requested ***access***. Lines [b14] - [b21] contain the one ***attribute*** of the ***resource*** to which Bart Simpson has requested ***access***: the ***resource*** identified by its file URI, which is “file://medico/record/patient/BartSimpson”.

The third `<Attributes>` element contains ***attributes*** of the ***action*** that the ***subject*** (or ***subjects***) wishes to take on the ***resource***. [b22] - [b29] describe the identity of the ***action*** Bart Simpson wishes to take, which is “read”.

[b30] closes the request ***context***. A more complex request ***context*** may have contained some ***attributes*** not associated with the ***subject***, the ***resource*** or the ***action***. Environment would be an example of such an attribute category. These would have been placed in additional `<Attributes>` elements. Examples of such ***attributes*** are ***attributes*** describing the ***environment*** or some application specific category of ***attributes***.

The ***PDP*** processing this request ***context*** locates the ***policy*** in its ***policy*** repository. It compares the ***attributes*** in the request ***context*** with the ***policy target***. Since the ***policy target*** is empty, the ***policy*** matches this ***context***.

The ***PDP*** now compares the ***attributes*** in the request ***context*** with the ***target*** of the one ***rule*** in this ***policy***. The requested ***resource*** matches the `<Target>` element and the requested ***action*** matches the `<Target>` element, but the requesting ***subject***-id ***attribute*** does not match "med.example.com".

4.1.3 Example response context

As a result of evaluating the ***policy***, there is no ***rule*** in this ***policy*** that returns a "Permit" result for this request. The ***rule-combining algorithm*** for the ***policy*** specifies that, in this case, a result of "NotApplicable" should be returned. The response ***context*** looks as follows:

```
[c1]  <?xml version="1.0" encoding="UTF-8"?>
[c2]  <Response xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17
        http://docs.oasis-open.org/xacml/3.0/xacml-core-v3-schema-wd-17.xsd">
[c3]    <Result>
[c4]      <Decision>NotApplicable</Decision>
[c5]    </Result>
[c6]  </Response>
```

[c1] - [c2] contain the same sort of header information for the response as was described above for a ***policy***.

The `<Result>` element in lines [c3] - [c5] contains the result of evaluating the ***decision request*** against the ***policy***. In this case, the result is "NotApplicable". A ***policy*** can return "Permit", "Deny", "NotApplicable" or "Indeterminate". Therefore, the ***PEP*** is required to deny ***access***.

[c6] closes the response ***context***.

4.2 Example two

This section contains an example XML document, an example request ***context*** and example XACML ***rules***. The XML document is a medical record. Four separate ***rules*** are defined. These illustrate a ***rule-combining algorithm***, ***conditions*** and ***obligation*** expressions.

4.2.1 Example medical record instance

The following is an instance of a medical record to which the example XACML ***rules*** can be applied. The `<record>` schema is defined in the registered namespace administered by Medi Corp.

```
 [d1]    <?xml version="1.0" encoding="UTF-8"?>
 [d2]    <record xmlns="urn:example:med:schemas:record"
 [d3]    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
 [d4]      <patient>
 [d5]        <patientName>
 [d6]          <first>Bartholomew</first>
 [d7]          <last>Simpson</last>
 [d8]        </patientName>
 [d9]        <patientContact>
[d10]          <street>27 Shelbyville Road</street>
[d11]          <city>Springfield</city>
[d12]          <state>MA</state>
[d13]          <zip>12345</zip>
[d14]          <phone>555.123.4567</phone>
[d15]          <fax/>
[d16]          <email/>
[d17]        </patientContact>
[d18]        <patientDoB>1992-03-21</patientDoB>
[d19]        <patientGender>male</patientGender>
[d20]        <patient-number>555555</patient-number>
[d21]      </patient>
[d22]      <parentGuardian>
[d23]        <parentGuardianId>HS001</parentGuardianId>
[d24]        <parentGuardianName>
[d25]          <first>Homer</first>
[d26]          <last>Simpson</last>
[d27]        </parentGuardianName>
[d28]        <parentGuardianContact>
[d29]          <street>27 Shelbyville Road</street>
[d30]          <city>Springfield</city>
[d31]          <state>MA</state>
[d32]          <zip>12345</zip>
[d33]          <phone>555.123.4567</phone>
[d34]          <fax/>
```

```
[d35]           <email>homers@aol.com</email>
[d36]         </parentGuardianContact>
[d37]       </parentGuardian>
[d38]       <primaryCarePhysician>
[d39]         <physicianName>
[d40]           <first>Julius</first>
[d41]           <last>Hibbert</last>
[d42]         </physicianName>
[d43]         <physicianContact>
[d44]           <street>1 First St</street>
[d45]           <city>Springfield</city>
[d46]           <state>MA</state>
[d47]           <zip>12345</zip>
[d48]           <phone>555.123.9012</phone>
[d49]           <fax>555.123.9013</fax>
[d50]           <email/>
[d51]         </physicianContact>
[d52]         <registrationID>ABC123</registrationID>
[d53]       </primaryCarePhysician>
[d54]       <insurer>
[d55]         <name>Blue Cross</name>
[d56]         <street>1234 Main St</street>
[d57]         <city>Springfield</city>
[d58]         <state>MA</state>
[d59]         <zip>12345</zip>
[d60]         <phone>555.123.5678</phone>
[d61]         <fax>555.123.5679</fax>
[d62]         <email/>
[d63]       </insurer>
[d64]       <medical>
[d65]         <treatment>
[d66]           <drug>
[d67]             <name>methylphenidate hydrochloride</name>
[d68]             <dailyDosage>30mgs</dailyDosage>
[d69]             <startDate>1999-01-12</startDate>
[d70]           </drug>
[d71]           <comment>
[d72]             patient exhibits side-effects of skin coloration and carpal degeneration
[d73]           </comment>
[d74]         </treatment>
[d75]         <result>
[d76]           <test>blood pressure</test>
[d77]           <value>120/80</value>
[d78]           <date>2001-06-09</date>
[d79]           <performedBy>Nurse Betty</performedBy>
[d80]         </result>
[d81]       </medical>
[d82]     </record>
```

4.2.2 Example request context

The following example illustrates a request ***context*** to which the example ***rules*** may be applicable. It represents a request by the physician Julius Hibbert to read the patient date of birth in the record of Bartholomew Simpson.

```
 [e1]     <?xml version="1.0" encoding="UTF-8"?>
 [e2]     <Request xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [e3]       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [e4]       xsi:schemaLocation="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17
          http://docs.oasis-open.org/xacml/3.0/xacml-core-v3-schema-wd-17.xsd"
 [e5]        ReturnPolicyIdList="false">
 [e6]       <Attributes
 [e7]         Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject">
 [e8]         <Attribute IncludeInResult="false"
 [e9]             AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id"
[e10]           Issuer="med.example.com">
[e11]           <AttributeValue
[e12]             DataType="http://www.w3.org/2001/XMLSchema#string">CN=Julius
          Hibbert</AttributeValue>
[e13]         </Attribute>
[e14]         <Attribute IncludeInResult="false"
[e15]           AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:role"
```

```
[e16]          Issuer="med.example.com">
[e17]          <AttributeValue
[e18]            DataType="http://www.w3.org/2001/XMLSchema#string"
[e19]            >physician</AttributeValue>
[e20]          </Attribute>
[e21]        <Attribute IncludeInResult="false"
[e22]          AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:physician-id"
[e23]          Issuer="med.example.com">
[e24]          <AttributeValue
[e25]          DataType="http://www.w3.org/2001/XMLSchema#string">jh1234</AttributeValue>
[e26]        </Attribute>
[e27]      </Attributes>
[e28]      <Attributes
[e29]        Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource">
[e30]        <Content>
[e31]          <md:record xmlns:md="urn:example:med:schemas:record"
[e32]            xsi:schemaLocation="urn:example:med:schemas:record
[e33]            http://www.med.example.com/schemas/record.xsd">
[e34]            <md:patient>
[e35]              <md:patientDoB>1992-03-21</md:patientDoB>
[e36]              <md:patient-number>555555</md:patient-number>
[e37]              <md:patientContact>
[e38]                <md:email>b.simpson@example.com</md:email>
[e39]              </md:patientContact>
[e40]            </md:patient>
[e41]          </md:record>
[e42]        </Content>
[e43]        <Attribute IncludeInResult="false"
[e44]            AttributeId="urn:oasis:names:tc:xacml:3.0:content-selector" >
[e45]          <AttributeValue
[e46]            XPathCategory="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[e47]            DataType=" urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"
[e48]            >md:record/md:patient/md:patientDoB</AttributeValue>
[e49]        </Attribute>
[e50]        <Attribute IncludeInResult="false"
[e51]            AttributeId="urn:oasis:names:tc:xacml:2.0:resource:target-namespace" >
[e52]          <AttributeValue
[e53]            DataType="http://www.w3.org/2001/XMLSchema#anyURI"
[e54]            >urn:example:med:schemas:record</AttributeValue>
[e55]        </Attribute>
[e56]      </Attributes>
[e57]      <Attributes
[e58]        Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action">
[e59]        <Attribute IncludeInResult="false"
[e60]             AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id" >
[e61]          <AttributeValue
[e62]            DataType="http://www.w3.org/2001/XMLSchema#string">read</AttributeValue>
[e63]        </Attribute>
[e64]      </Attributes>
[e65]      <Attributes
[e66]        Category="urn:oasis:names:tc:xacml:3.0:attribute-category:environment">
[e67]        <Attribute IncludeInResult="false"
[e68]             AttributeId="urn:oasis:names:tc:xacml:1.0:environment:current-date" >
[e69]          <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#date"
[e70]              >2010-01-11</AttributeValue>
[e71]        </Attribute>
[e72]      </Attributes>
[e73]    </Request>
```

[e2] - [e4] Standard namespace declarations.

[e6] - [e27] ***Access subject attributes*** are placed in the urn:oasis:names:tc:xacml:1.0:subject-category:access-subject ***attribute*** category of the `<Request>` element. Each ***attribute*** consists of the ***attribute*** meta-data and the ***attribute*** value. There is only one ***subject*** involved in this request. This value of the ***attribute*** category denotes the identity for which the request was issued.

[e8] - [e13] ***Subject*** subject-id ***attribute***.

[e14] - [e20] ***Subject*** role ***attribute***.

[e21] - [e26] ***Subject*** physician-id ***attribute***.

[e28] - [e56] ***Resource attributes*** are placed in the urn:oasis:names:tc:xacml:3.0:attribute-category:resource ***attribute*** category of the `<Request>` element. Each ***attribute*** consists of ***attribute*** meta-data and an ***attribute*** value.

[e30] - [e42] ***Resource*** content. The XML ***resource*** instance, ***access*** to all or part of which may be requested, is placed here.

[e43] - [e49] The identifier of the ***Resource*** instance for which ***access*** is requested, which is an XPath expression into the `<Content>` element that selects the data to be accessed.

[e57] - [e64] ***Action attributes*** are placed in the urn:oasis:names:tc:xacml:3.0:attribute-category:action ***attribute*** category of the `<Request>` element.

[e59] - [e63] ***Action*** identifier.

4.2.3 Example plain-language rules

The following plain-language ***rules*** are to be enforced:

Rule 1: A person, identified by his or her patient number, may read any record for which he or she is the designated patient.

Rule 2: A person may read any record for which he or she is the designated parent or guardian, and for which the patient is under 16 years of age.

Rule 3: A physician may write to any medical element for which he or she is the designated primary care physician, provided an email is sent to the patient.

Rule 4: An administrator shall not be permitted to read or write to medical elements of a patient record.

These ***rules*** may be written by different ***PAPs*** operating independently, or by a single ***PAP***.

4.2.4 Example XACML rule instances

4.2.4.1 Rule 1

Rule 1 illustrates a simple ***rule*** with a single `<Condition>` element. It also illustrates the use of the `<VariableDefinition>` element to define a function that may be used throughout the ***policy***. The following XACML `<Rule>` instance expresses ***Rule*** 1:

```
 [f1]    <?xml version="1.0" encoding="UTF-8"?>
 [f2]    <Policy
 [f3]      xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [f4]      xmlns:xacml ="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [f5]      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [f6]      xmlns:md="http://www.med.example.com/schemas/record.xsd"
 [f7]      PolicyId="urn:oasis:names:tc:xacml:3.0:example:policyid:1"
 [f8]      RuleCombiningAlgId="urn:oasis:names:tc:xacml:1.0:rule-combining-
         algorithm:deny-overrides"
 [f9]      Version="1.0">
[f10]      <PolicyDefaults>
[f11]        <XPathVersion>http://www.w3.org/TR/1999/REC-xpath-19991116</XPathVersion>
[f12]      </PolicyDefaults>
[f13]      <Target/>
[f14]      <VariableDefinition VariableId="17590034">
[f15]        <Apply FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[f16]          <Apply
[f17]            FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
[f18]            <AttributeDesignator
[f19]              MustBePresent="false"
[f20]              Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-
         subject"
[f21]              AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:patient-
         number"
[f22]              DataType="http://www.w3.org/2001/XMLSchema#string"/>
[f23]          </Apply>
[f24]          <Apply
[f25]            FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
```

```
[f26]           <AttributeSelector
[f27]               MustBePresent="false"
[f28]               Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[f29]               Path="md:record/md:patient/md:patient-number/text()"
[f30]             DataType="http://www.w3.org/2001/XMLSchema#string"/>
[f31]         </Apply>
[f32]       </Apply>
[f33]     </VariableDefinition>
[f34]     <Rule
[f35]       RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:1"
[f36]       Effect="Permit">
[f37]       <Description>
[f38]         A person may read any medical record in the
[f39]         http://www.med.example.com/schemas/record.xsd namespace
[f40]         for which he or she is the designated patient
[f41]       </Description>
[f42]       <Target>
[f43]         <AnyOf>
[f44]           <AllOf>
[f45]             <Match MatchId="urn:oasis:names:tc:xacml:1.0:function:anyURI-equal">
[f46]               <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#anyURI"
[f47]                >urn:example:med:schemas:record</AttributeValue>
[f48]               <AttributeDesignator
[f49]                 MustBePresent="false"
[f50]               Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[f51]               AttributeId="urn:oasis:names:tc:xacml:2.0:resource:target-namespace"
[f52]               DataType="http://www.w3.org/2001/XMLSchema#anyURI"/>
[f53]             </Match>
[f54]             <Match
[f55]               MatchId="urn:oasis:names:tc:xacml:3.0:function:xpath-node-match">
[f56]               <AttributeValue
[f57]                 DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"
[f58]          XPathCategory="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[f59]                   >md:record</AttributeValue>
[f60]               <AttributeDesignator
[f61]                 MustBePresent="false"
[f62]                Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[f63]                AttributeId="urn:oasis:names:tc:xacml:3.0:content-selector"
[f64]                DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"/>
[f65]             </Match>
[f66]           </AllOf>
[f67]         </AnyOf>
[f68]         <AnyOf>
[f69]           <AllOf>
[f70]             <Match
[f71]               MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[f72]               <AttributeValue
[f73]                 DataType="http://www.w3.org/2001/XMLSchema#string"
[f74]                  >read</AttributeValue>
[f75]               <AttributeDesignator
[f76]                 MustBePresent="false"
[f77]                 Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action"
[f78]                 AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id"
[f79]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
[f80]             </Match>
[f81]           </AllOf>
[f82]         </AnyOf>
[f83]       </Target>
[f84]       <Condition>
[f85]         <VariableReference VariableId="17590034"/>
[f86]       </Condition>
[f87]     </Rule>
[f88]   </Policy>
```

[f3] - [f6] XML namespace declarations.

[f11] XPath expressions in the ***policy*** are to be interpreted according to the 1.0 version of the XPath specification.

[f14] - [f33] A `<VariableDefinition>` element. It defines a function that evaluates the truth of the statement: the patient-number ***subject attribute*** is equal to the patient-number in the ***resource***.

[f15] The `FunctionId` attribute names the function to be used for comparison. In this case, comparison is done with the “urn:oasis:names:tc:xacml:1.0:function:string-equal” function; this function takes two arguments of type “http://www.w3.org/2001/XMLSchema#string”.

[f17] The first argument of the variable definition is a function specified by the `FunctionId` attribute. Since urn:oasis:names:tc:xacml:1.0:function:string-equal takes arguments of type “http://www.w3.org/2001/XMLSchema#string” and `AttributeDesignator` selects a ***bag*** of type “http://www.w3.org/2001/XMLSchema#string”, “urn:oasis:names:tc:xacml:1.0:function:string-one-and-only” is used. This function guarantees that its argument evaluates to a ***bag*** containing exactly one value.

[f18] The `AttributeDesignator` selects a ***bag*** of values for the patient-number ***subject attribute*** in the request ***context***.

[f25] The second argument of the variable definition is a function specified by the `FunctionId` attribute. Since “urn:oasis:names:tc:xacml:1.0:function:string-equal” takes arguments of type “http://www.w3.org/2001/XMLSchema#string” and the `AttributeSelector` selects a ***bag*** of type “http://www.w3.org/2001/XMLSchema#string”, “urn:oasis:names:tc:xacml:1.0:function:string-one-and-only” is used. This function guarantees that its argument evaluates to a ***bag*** containing exactly one value.

[f26] The `<AttributeSelector>` element selects a ***bag*** of values from the ***resource*** content using a free-form XPath expression. In this case, it selects the value of the patient-number in the ***resource***. Note that the namespace prefixes in the XPath expression are resolved with the standard XML namespace declarations.

[f35] ***Rule*** identifier.

[f36] ***Rule effect*** declaration. When a ***rule*** evaluates to ‘True’ it emits the value of the `Effect` attribute. This value is then combined with the `Effect` values of other ***rules*** according to the ***rule-combining algorithm***.

[f37] - [f41] Free form description of the ***rule***.

[f42] - [f83] A ***rule target*** defines a set of ***decision requests*** that the ***rule*** is intended to evaluate.

[f43] - [f67] The `<AnyOf>` element contains a ***disjunctive sequence*** of `<AllOf>` elements. In this example, there is just one.

[f44] - [f66] The `<AllOf>` element encloses the ***conjunctive sequence*** of Match elements. In this example, there are two.

[f45] - [f53] The first `<Match>` element compares its first and second child elements according to the matching function. A match is positive if the value of the first argument matches any of the values selected by the second argument. This match compares the ***target*** namespace of the requested document with the value of “urn:example:med:schemas:record”.

[f45] The `MatchId` attribute names the matching function.

[f46] - [f47] Literal ***attribute*** value to match.

[f48] - [f52] The `<AttributeDesignator>` element selects the ***target*** namespace from the ***resource*** contained in the request ***context***. The ***attribute*** name is specified by the `AttributeId`.

[f54] - [f65] The second `<Match>` element. This match compares the results of two XPath expressions applied to the `<Content>` element of the ***resource*** category. The second XPath expression is the location path to the requested XML element and the first XPath expression is the literal value “md:record”. The “xpath-node-match” function evaluates to “True” if the requested XML element is below the “md:record” element.

[f68] - [f82] The `<AnyOf>` element contains a ***disjunctive sequence*** of `<AllOf>` elements. In this case, there is just one `<AllOf>` element.

[f69] - [f81] The `<AllOf>` element contains a ***conjunctive sequence*** of `<Match>` elements. In this case, there is just one `<Match>` element.

[f70] - [f80] The `<Match>` element compares its first and second child elements according to the matching function. The match is positive if the value of the first argument matches any of the values selected by the second argument. In this case, the value of the action-id ***action attribute*** in the request ***context*** is compared with the literal value “read”.

[f84] - [f86] The `<Condition>` element. A ***condition*** must evaluate to “True” for the ***rule*** to be applicable. This ***condition*** contains a reference to a variable definition defined elsewhere in the ***policy***.

4.2.4.2 Rule 2

Rule 2 illustrates the use of a mathematical function, i.e. the `<Apply>` element with `functionId` "urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration" to calculate the date of the patient’s sixteenth birthday. It also illustrates the use of ***predicate*** expressions, with the `functionId` "urn:oasis:names:tc:xacml:1.0:function:and". This example has one function embedded in the `<Condition>` element and another one referenced in a `<VariableDefinition>` element.

```
 [g1]    <?xml version="1.0" encoding="UTF-8"?>
 [g2]    <Policy
 [g3]      xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [g4]      xmlns:xacml="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [g5]      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [g6]      xmlns:xf="http://www.w3.org/2005/xpath-functions"
 [g7]      xmlns:md="http:www.med.example.com/schemas/record.xsd"
 [g8]      PolicyId="urn:oasis:names:tc:xacml:3.0:example:policyid:2"
 [g9]      Version="1.0"
[g10]      RuleCombiningAlgId="urn:oasis:names:tc:xacml:1.0:rule-combining-
         algorithm:deny-overrides">
[g11]      <PolicyDefaults>
[g12]        <XPathVersion>http://www.w3.org/TR/1999/REC-xpath-19991116</XPathVersion>
[g13]      </PolicyDefaults>
[g14]      <Target/>
[g15]      <VariableDefinition VariableId="17590035">
[g16]        <Apply
[g17]          FunctionId="urn:oasis:names:tc:xacml:1.0:function:date-less-or-equal">
[g18]          <Apply
[g19]            FunctionId="urn:oasis:names:tc:xacml:1.0:function:date-one-and-only">
[g20]            <AttributeDesignator
[g21]              MustBePresent="false"
[g22]              Category="urn:oasis:names:tc:xacml:3.0:attribute-category:environment"
[g23]              AttributeId="urn:oasis:names:tc:xacml:1.0:environment:current-date"
[g24]              DataType="http://www.w3.org/2001/XMLSchema#date"/>
[g25]          </Apply>
[g26]          <Apply
[g27]      FunctionId="urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration">
[g28]            <Apply
[g29]              FunctionId="urn:oasis:names:tc:xacml:1.0:function:date-one-and-only">
[g30]              <AttributeSelector
[g31]                MustBePresent="false"
[g32]                Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[g33]                Path="md:record/md:patient/md:patientDoB/text()"
[g34]                DataType="http://www.w3.org/2001/XMLSchema#date"/>
[g35]            </Apply>
[g36]            <AttributeValue
[g37]              DataType="http://www.w3.org/2001/XMLSchema#yearMonthDuration"
[g38]              >P16Y</AttributeValue>
[g39]          </Apply>
[g40]        </Apply>
[g41]      </VariableDefinition>
[g42]      <Rule
[g43]        RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:2"
[g44]        Effect="Permit">
[g45]        <Description>
[g46]          A person may read any medical record in the
[g47]          http://www.med.example.com/records.xsd namespace
[g48]          for which he or she is the designated parent or guardian,
[g49]          and for which the patient is under 16 years of age
[g50]        </Description>
[g51]        <Target>
[g52]          <AnyOf>
[g53]            <AllOf>
```

```
 [g54]             <Match
 [g55]               MatchId="urn:oasis:names:tc:xacml:1.0:function:anyURI-equal">
 [g56]               <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#anyURI"
 [g57]                 >urn:example:med:schemas:record</AttributeValue>
 [g58]               <AttributeDesignator
 [g59]                 MustBePresent="false"
 [g60]                Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
 [g61]              AttributeId= "urn:oasis:names:tc:xacml:2.0:resource:target-namespace"
 [g62]                DataType="http://www.w3.org/2001/XMLSchema#anyURI"/>
 [g63]             </Match>
 [g64]             <Match
 [g65]               MatchId="urn:oasis:names:tc:xacml:3.0:function:xpath-node-match">
 [g66]               <AttributeValue
 [g67]                 DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"
 [g68]          XPathCategory="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
 [g69]                 >md:record</AttributeValue>
 [g70]               <AttributeDesignator
 [g71]                 MustBePresent="false"
 [g72]                Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
 [g73]                 AttributeId="urn:oasis:names:tc:xacml:3.0:content-selector"
 [g74]                DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"/>
 [g75]             </Match>
 [g76]           </AllOf>
 [g77]         </AnyOf>
 [g78]         <AnyOf>
 [g79]           <AllOf>
 [g80]             <Match
 [g81]               MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
 [g82]               <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
 [g83]                  >read</AttributeValue>
 [g84]               <AttributeDesignator
 [g85]                 MustBePresent="false"
 [g86]                 Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action"
 [g87]                 AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id"
 [g88]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
 [g89]             </Match>
 [g90]           </AllOf>
 [g91]         </AnyOf>
 [g92]       </Target>
 [g93]       <Condition>
 [g94]         <Apply FunctionId="urn:oasis:names:tc:xacml:1.0:function:and">
 [g95]           <Apply FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
 [g96]             <Apply
 [g97]            FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
 [g98]               <AttributeDesignator
 [g99]                 MustBePresent="false"
[g100]            Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject"
[g101]                AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:parent-
   guardian-id"
[g102]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
[g103]             </Apply>
[g104]             <Apply
[g105]            FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
[g106]               <AttributeSelector
[g107]                MustBePresent="false"
[g108]                Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[g109]        Path="md:record/md:parentGuardian/md:parentGuardianId/text()"
[g110]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
[g111]             </Apply>
[g112]           </Apply>
[g113]           <VariableReference VariableId="17590035"/>
[g114]         </Apply>
[g115]       </Condition>
[g116]     </Rule>
[g117]   </Policy>
```

[g15] - [g41] The `<VariableDefinition>` element contains part of the ***condition*** (i.e. is the patient under 16 years of age?). The patient is under 16 years of age if the current date is less than the date computed by adding 16 to the patient's date of birth.

[g16] - [g40] "urn:oasis:names:tc:xacml:1.0:function:date-less-or-equal" is used to compare the two date arguments.

[g18] - [g25] The first date argument uses “urn:oasis:names:tc:xacml:1.0:function:date-one-and-only“ to ensure that the ***bag*** of values selected by its argument contains exactly one value of type “http://www.w3.org/2001/XMLSchema#date”.

[g20] The current date is evaluated by selecting the “urn:oasis:names:tc:xacml:1.0:environment:current-date” ***environment attribute***.

[g26] - [g39] The second date argument uses “urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration” to compute the date of the patient’s sixteenth birthday by adding 16 years to the patient’s date of birth. The first of its arguments is of type “http://www.w3.org/2001/XMLSchema#date” and the second is of type “http://www.w3.org/TR/2007/REC-xpath-functions-20070123/#dt-yearMonthDuration”.

[g30] The `<AttributeSelector>` element selects the patient’s date of birth by taking the XPath expression over the ***resource*** content.

[g36] - [g38] Year Month Duration of 16 years.

[g51] - [g92] ***Rule*** declaration and ***rule target***. See ***Rule*** 1 in Section 4.2.4.1 for the detailed explanation of these elements.

[g93] - [g115] The `<Condition>` element. The ***condition*** must evaluate to “True” for the ***rule*** to be applicable. This ***condition*** evaluates the truth of the statement: the requestor is the designated parent or guardian and the patient is under 16 years of age. It contains one embedded `<Apply>` element and one referenced `<VariableDefinition>` element.

[g94] The ***condition*** uses the “urn:oasis:names:tc:xacml:1.0:function:and” function. This is a Boolean function that takes one or more Boolean arguments (2 in this case) and performs the logical “AND” operation to compute the truth value of the expression.

[g95] - [g112] The first part of the ***condition*** is evaluated (i.e. is the requestor the designated parent or guardian?). The function is “urn:oasis:names:tc:xacml:1.0:function:string-equal” and it takes two arguments of type “http://www.w3.org/2001/XMLSchema#string”.

[g96] designates the first argument. Since “urn:oasis:names:tc:xacml:1.0:function:string-equal” takes arguments of type “http://www.w3.org/2001/XMLSchema#string”, “urn:oasis:names:tc:xacml:1.0:function:string-one-and-only” is used to ensure that the ***subject attribute*** “urn:oasis:names:tc:xacml:3.0:example:attribute:parent-guardian-id” in the request ***context*** contains exactly one value.

[g98] designates the first argument. The value of the ***subject attribute*** “urn:oasis:names:tc:xacml:3.0:example:attribute:parent-guardian-id” is selected from the request ***context*** using the <AttributeDesignator> element.

[g104] As above, the “urn:oasis:names:tc:xacml:1.0:function:string-one-and-only” is used to ensure that the ***bag*** of values selected by it’s argument contains exactly one value of type “http://www.w3.org/2001/XMLSchema#string”.

[g106] The second argument selects the value of the `<md:parentGuardianId>` element from the ***resource*** content using the `<AttributeSelector>` element. This element contains a free-form XPath expression, pointing into the `<Content>` element of the resource category. Note that all namespace prefixes in the XPath expression are resolved with standard namespace declarations. The `AttributeSelector` evaluates to the ***bag*** of values of type “http://www.w3.org/2001/XMLSchema#string”.

[g113] references the `<VariableDefinition>` element, where the second part of the ***condition*** is defined.

4.2.4.3 Rule 3

Rule 3 illustrates the use of an ***obligation*** expression.

```
[h1]    <?xml version="1.0" encoding="UTF-8"?>
[h2]    <Policy
[h3]      xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
[h4]      xmlns:xacml ="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
[h5]      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

```
 [h6]   xsi:schemaLocation="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17
      http://docs.oasis-open.org/xacml/3.0/xacml-core-v3-schema-wd-17.xsd"
 [h7]   xmlns:md="http:www.med.example.com/schemas/record.xsd"
 [h8]   PolicyId="urn:oasis:names:tc:xacml:3.0:example:policyid:3"
 [h9]   Version="1.0"
[h10]   RuleCombiningAlgId="urn:oasis:names:tc:xacml:1.0:rule-combining-
      algorithm:deny-overrides">
[h11]   <Description>
[h12]     Policy for any medical record in the
[h13]     http://www.med.example.com/schemas/record.xsd namespace
[h14]   </Description>
[h15]   <PolicyDefaults>
[h16]     <XPathVersion>http://www.w3.org/TR/1999/REC-xpath-19991116</XPathVersion>
[h17]   </PolicyDefaults>
[h18]   <Target>
[h19]     <AnyOf>
[h20]       <AllOf>
[h21]         <Match
[h22]           MatchId="urn:oasis:names:tc:xacml:1.0:function:anyURI-equal">
[h23]           <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#anyURI"
[h24]             >urn:example:med:schemas:record</AttributeValue>
[h25]           <AttributeDesignator
[h26]             MustBePresent="false"
[h27]             Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[h28]             AttributeId="urn:oasis:names:tc:xacml:2.0:resource:target-namespace"
[h29]             DataType="http://www.w3.org/2001/XMLSchema#anyURI"/>
[h30]         </Match>
[h31]       </AllOf>
[h32]     </AnyOf>
[h33]   </Target>
[h34]   <Rule RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:3"
[h35]     Effect="Permit">
[h36]     <Description>
[h37]       A physician may write any medical element in a record
[h38]       for which he or she is the designated primary care
[h39]       physician, provided an email is sent to the patient
[h40]     </Description>
[h41]     <Target>
[h42]       <AnyOf>
[h43]         <AllOf>
[h44]           <Match
[h45]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[h46]             <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[h47]               >physician</AttributeValue>
[h48]             <AttributeDesignator
[h49]               MustBePresent="false"
[h50]          Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject"
[h51]               AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:role"
[h52]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[h53]           </Match>
[h54]         </AllOf>
[h55]       </AnyOf>
[h56]       <AnyOf>
[h57]         <AllOf>
[h58]           <Match
[h59]              MatchId="urn:oasis:names:tc:xacml:3.0:function:xpath-node-match">
[h60]              <AttributeValue
[h61]               DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"
[h62]        XPathCategory="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[h63]                 >md:record/md:medical</AttributeValue>
[h64]              <AttributeDesignator
[h65]                MustBePresent="false"
[h66]              Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[h67]                AttributeId="urn:oasis:names:tc:xacml:3.0:content-selector"
[h68]              DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"/>
[h69]           </Match>
[h70]         </AllOf>
[h71]       </AnyOf>
[h72]       <AnyOf>
[h73]         <AllOf>
[h74]           <Match
[h75]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[h76]             <AttributeValue
```

```
 [h77]                   DataType="http://www.w3.org/2001/XMLSchema#string"
 [h78]                   >write</AttributeValue>
 [h79]                 <AttributeDesignator
 [h80]                   MustBePresent="false"
 [h81]                   Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action"
 [h82]                   AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id"
 [h83]                   DataType="http://www.w3.org/2001/XMLSchema#string"/>
 [h84]               </Match>
 [h85]             </AllOf>
 [h86]           </AnyOf>
 [h87]         </Target>
 [h88]         <Condition>
 [h89]           <Apply FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
 [h90]             <Apply
 [h91]              FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
 [h92]               <AttributeDesignator
 [h93]                 MustBePresent="false"
 [h94]              Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject"
 [h95]           AttributeId="urn:oasis:names:tc:xacml:3.0:example: attribute:physician-id"
 [h96]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
 [h97]             </Apply>
 [h98]             <Apply
 [h99]              FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-one-and-only">
[h100]               <AttributeSelector
[h101]                  MustBePresent="false"
[h102]                 Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[h103]      Path="md:record/md:primaryCarePhysician/md:registrationID/text()"
[h104]                 DataType="http://www.w3.org/2001/XMLSchema#string"/>
[h105]             </Apply>
[h106]           </Apply>
[h107]         </Condition>
[h108]       </Rule>
[h109]       <ObligationExpressions>
[h110]         <ObligationExpression
            ObligationId="urn:oasis:names:tc:xacml:example:obligation:email"
[h111]           FulfillOn="Permit">
[h112]           <AttributeAssignmentExpression
[h113]             AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:mailto">
[h114]             <AttributeSelector
[h115]               MustBePresent="true"
[h116]               Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[h117]               Path="md:record/md:patient/md:patientContact/md:email"
[h118]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[h119]           </AttributeAssignmentExpression>
[h120]           <AttributeAssignmentExpression
[h121]             AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:text">
[h122]             <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[h123]             >Your medical record has been accessed by:</AttributeValue>
[h124]           </AttributeAssignmentExpression>
[h125]           <AttributeAssignmentExpression
[h126]             AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:text">
[h127]             <AttributeDesignator
[h128]               MustBePresent="false"
[h129]              Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject"
[h130]               AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id"
[h131]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[h132]           </AttributeAssignmentExpression>
[h133]         </ObligationExpression>
[h134]       </ObligationExpressions>
[h135]     </Policy>
```

[h2] - [h10] The `<Policy>` element includes standard namespace declarations as well as ***policy*** specific parameters, such as `PolicyId` and `RuleCombiningAlgId`.

[h8] ***Policy*** identifier. This parameter allows the ***policy*** to be referenced by a ***policy set***.

[h10] The ***Rule-combining algorithm*** identifies the algorithm for combining the outcomes of ***rule*** evaluation.

[h11] - [h14] Free-form description of the ***policy***.

[h18] - [h33] ***Policy target***. The ***policy target*** defines a set of applicable ***decision requests***. The structure of the `<Target>` element in the `<Policy>` is identical to the structure of the `<Target>`

element in the `<Rule>`. In this case, the ***policy target*** is the set of all XML ***resources*** that conform to the namespace “urn:example:med:schemas:record”.

[h34] - [h108] The only `<Rule>` element included in this `<Policy>`. Two parameters are specified in the ***rule*** header: `RuleId` and `Effect`.

[h41] - [h87] The ***rule target*** further constrains the ***policy target***.

[h44] - [h53] The `<Match>` element targets the ***rule*** at ***subjects*** whose “urn:oasis:names:tc:xacml:3.0:example:attribute:role” ***subject attribute*** is equal to “physician”.

[h58] - [h69] The `<Match>` element targets the ***rule*** at ***resources*** that match the XPath expression “md:record/md:medical”.

[h74] - [h84] The `<Match>` element targets the ***rule*** at ***actions*** whose “urn:oasis:names:tc:xacml:1.0:action:action-id” ***action attribute*** is equal to “write”.

[h88] - [h107] The `<Condition>` element. For the ***rule*** to be applicable to the ***decision request***, the ***condition*** must evaluate to “True”. This ***condition*** compares the value of the “urn:oasis:names:tc:xacml:3.0:example:attribute:physician-id” ***subject attribute*** with the value of the `<registrationId>` element in the medical record that is being accessed.

[h109] - [h134] The `<ObligationExpressions>` element. ***Obligations*** are a set of operations that must be performed by the ***PEP*** in conjunction with an ***authorization decision***. An ***obligation*** may be associated with a “Permit” or “Deny” ***authorization decision***. The element contains a single ***obligation*** expression, which will be evaluated into an obligation when the policy is evaluated.

[h110] - [h133] The `<ObligationExpression>` element consists of the `ObligationId` attribute, the ***authorization decision*** value for which it must be fulfilled, and a set of ***attribute*** assignments.

[h110] The `ObligationId` attribute identifies the ***obligation***. In this case, the ***PEP*** is required to send email.

[h111] The `FulfillOn` attribute defines the ***authorization decision*** value for which the ***obligation*** derived from the ***obligation*** expression must be fulfilled. In this case, the ***obligation*** must be fulfilled when ***access*** is permitted.

[h112] - [h119] The first parameter indicates where the ***PEP*** will find the email address in the ***resource***. The ***PDP*** will evaluate the `<AttributeSelector>` and return the result to the ***PEP*** inside the resulting ***obligation***.

[h120] - [h123] The second parameter contains literal text for the email body.

[h125] - [h132] The third parameter indicates where the ***PEP*** will find further text for the email body in the ***resource***. The ***PDP*** will evaluate the `<AttributeDesignator>` and return the result to the ***PEP*** inside the resulting ***obligation***.

4.2.4.4 Rule 4

Rule 4 illustrates the use of the "Deny" ***Effect*** value, and a `<Rule>` with no `<Condition>` element.

```
 [i1]  <?xml version="1.0" encoding="UTF-8"?>
 [i2]  <Policy
 [i3]    xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [i4]    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [i5]    xmlns:md="http:www.med.example.com/schemas/record.xsd"
 [i6]    PolicyId="urn:oasis:names:tc:xacml:3.0:example:policyid:4"
 [i7]    Version="1.0"
 [i8]    RuleCombiningAlgId="urn:oasis:names:tc:xacml:1.0:rule-combining-
        algorithm:deny-overrides">
 [i9]    <PolicyDefaults>
[i10]      <XPathVersion>http://www.w3.org/TR/1999/REC-xpath-19991116</XPathVersion>
[i11]    </PolicyDefaults>
[i12]    <Target/>
[i13]    <Rule
[i14]      RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:4"
[i15]      Effect="Deny">
[i16]      <Description>
[i17]        An Administrator shall not be permitted to read or write
```

```
[i18]       medical elements of a patient record in the
[i19]       http://www.med.example.com/records.xsd namespace.
[i20]     </Description>
[i21]     <Target>
[i22]       <AnyOf>
[i23]         <AllOf>
[i24]           <Match
[i25]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[i26]            <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[i27]             >administrator</AttributeValue>
[i28]             <AttributeDesignator
[i29]               MustBePresent="false"
[i30]       Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-subject"
[i31]             AttributeId="urn:oasis:names:tc:xacml:3.0:example:attribute:role"
[i32]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[i33]           </Match>
[i34]         </AllOf>
[i35]       </AnyOf>
[i36]       <AnyOf>
[i37]         <AllOf>
[i38]           <Match
[i39]             MatchId="urn:oasis:names:tc:xacml:1.0:function:anyURI-equal">
[i40]            <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#anyURI"
[i41]             >urn:example:med:schemas:record</AttributeValue>
[i42]             <AttributeDesignator
[i43]               MustBePresent="false"
[i44]           Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[i45]          AttributeId="urn:oasis:names:tc:xacml:2.0:resource:target-namespace"
[i46]               DataType="http://www.w3.org/2001/XMLSchema#anyURI"/>
[i47]           </Match>
[i48]           <Match
[i49]             MatchId="urn:oasis:names:tc:xacml:3.0:function:xpath-node-match">
[i50]             <AttributeValue
[i51]            DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"
[i52]     XPathCategory="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[i53]                >md:record/md:medical</AttributeValue>
[i54]             <AttributeDesignator
[i55]                MustBePresent="false"
[i56]           Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[i57]           AttributeId="urn:oasis:names:tc:xacml:3.0:content-selector"
[i58]           DataType="urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression"/>
[i59]           </Match>
[i60]         </AllOf>
[i61]       </AnyOf>
[i62]       <AnyOf>
[i63]         <AllOf>
[i64]           <Match
[i65]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[i66]           <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[i67]              >read</AttributeValue>
[i68]             <AttributeDesignator
[i69]                MustBePresent="false"
[i70]             Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action"
[i71]               AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id"
[i72]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[i73]           </Match>
[i74]         </AllOf>
[i75]         <AllOf>
[i76]           <Match
[i77]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[i78]            <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[i79]             >write</AttributeValue>
[i80]             <AttributeDesignator
[i81]                MustBePresent="false"
[i82]             Category="urn:oasis:names:tc:xacml:3.0:attribute-category:action"
[i83]               AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id"
[i84]               DataType="http://www.w3.org/2001/XMLSchema#string"/>
[i85]           </Match>
[i86]         </AllOf>
[i87]       </AnyOf>
[i88]     </Target>
[i89]   </Rule>
[i90] </Policy>
```

[i13] - [i15] The `<Rule>` element declaration.

[i15] ***Rule*** `Effect`. Every ***rule*** that evaluates to “True” emits the ***rule effect*** as its value. This ***rule*** `Effect` is “Deny” meaning that according to this ***rule***, ***access*** must be denied when it evaluates to “True”.

[i16] - [i20] Free form description of the ***rule***.

[i21] - [i88] ***Rule target***. The ***Rule target*** defines the set of ***decision requests*** that are applicable to the ***rule***.

[i24] - [i33] The `<Match>` element targets the ***rule*** at ***subjects*** whose “urn:oasis:names:tc:xacml:3.0:example:attribute:role” ***subject attribute*** is equal to “administrator”.

[i36] - [i61] The `<AnyOf>` element contains one `<AllOf>` element, which (in turn) contains two `<Match>` elements. The ***target*** matches if the ***resource*** identified by the request ***context*** matches both ***resource*** match criteria.

[i38] - [i47] The first `<Match>` element targets the ***rule*** at ***resources*** whose “urn:oasis:names:tc:xacml:2.0:resource:target-namespace” ***resource attribute*** is equal to “urn:example:med:schemas:record”.

[i48] - [i59] The second `<Match>` element targets the ***rule*** at XML elements that match the XPath expression “/md:record/md:medical”.

[i62] - [i87] The `<AnyOf>` element contains two `<AllOf>` elements, each of which contains one `<Match>` element. The ***target*** matches if the ***action*** identified in the request ***context*** matches either of the ***action*** match criteria.

[i64] - [i85] The `<Match>` elements ***target*** the ***rule*** at ***actions*** whose “urn:oasis:names:tc:xacml:1.0:action:action-id” ***action attribute*** is equal to ”read” or “write”.

This ***rule*** does not have a `<Condition>` element.

4.2.4.5 Example PolicySet

This section uses the examples of the previous sections to illustrate the process of combining ***policies***. The ***policy*** governing read ***access*** to medical elements of a record is formed from each of the four ***rules*** described in Section 4.2.3. In plain language, the combined ***rule*** is:

- Either the requestor is the patient; or
- the requestor is the parent or guardian and the patient is under 16; or
- the requestor is the primary care physician and a notification is sent to the patient; and
- the requestor is not an administrator.

The following ***policy set*** illustrates the combined ***policies***. ***Policy*** 3 is included by reference and ***policy*** 2 is explicitly included.

```
 [j1]   <?xml version="1.0" encoding="UTF-8"?>
 [j2]   <PolicySet
 [j3]     xmlns="urn:oasis:names:tc:xacml:3.0:core:schema:wd-17"
 [j4]     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 [j5]     PolicySetId="urn:oasis:names:tc:xacml:3.0:example:policysetid:1"
 [j6]     Version="1.0"
 [j7]     PolicyCombiningAlgId=
 [j8]     "urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides">
 [j9]     <Description>
[j10]       Example policy set.
[j11]     </Description>
[j12]     <Target>
[j13]       <AnyOf>
[j14]         <AllOf>
[j15]           <Match
[j16]             MatchId="urn:oasis:names:tc:xacml:1.0:function:string-equal">
[j17]             <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string"
[j18]               >urn:example:med:schema:records</AttributeValue>
[j19]             <AttributeDesignator
[j20]               MustBePresent="false"
```

```
[j21]              Category="urn:oasis:names:tc:xacml:3.0:attribute-category:resource"
[j22]              AttributeId="urn:oasis:names:tc:xacml:2.0:resource:target-namespace"
[j23]              DataType="http://www.w3.org/2001/XMLSchema#string"/>
[j24]          </Match>
[j25]        </AllOf>
[j26]      </AnyOf>
[j27]    </Target>
[j28]    <PolicyIdReference>
[j29]      urn:oasis:names:tc:xacml:3.0:example:policyid:3
[j30]    </PolicyIdReference>
[j31]    <Policy
[j32]      PolicyId="urn:oasis:names:tc:xacml:3.0:example:policyid:2"
[j33]      RuleCombiningAlgId=
[j34]        "urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides"
[j35]      Version="1.0">
[j36]      <Target/>
[j37]      <Rule RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:1"
[j38]        Effect="Permit">
[j39]      </Rule>
[j40]      <Rule RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:2"
[j41]        Effect="Permit">
[j42]      </Rule>
[j43]      <Rule RuleId="urn:oasis:names:tc:xacml:3.0:example:ruleid:4"
[j44]        Effect="Deny">
[j45]      </Rule>
[j46]    </Policy>
[j47]  </PolicySet>
```

[j2] - [j8] The `<PolicySet>` element declaration. Standard XML namespace declarations are included.

[j5] The `PolicySetId` attribute is used for identifying this ***policy set*** for possible inclusion in another ***policy set***.

[j7] - [j8] The ***policy-combining algorithm*** identifier. ***Policies*** and ***policy sets*** in this ***policy set*** are combined according to the specified ***policy-combining algorithm*** when the ***authorization decision*** is computed.

[j9] - [j11] Free form description of the ***policy set***.

[j12] - [j27] The ***policy set*** `<Target>` element defines the set of ***decision requests*** that are applicable to this `<PolicySet>` element.

[j28] - [j30] `PolicyIdReference` includes a ***policy*** by id.

[j31] - [j46] ***Policy*** 2 is explicitly included in this ***policy set***. The ***rules*** in ***Policy*** 2 are omitted for clarity.

5 Syntax (normative, with the exception of the schema fragments)

5.1 Element <PolicySet>

The `<PolicySet>` element is a top-level element in the XACML ***policy*** schema. `<PolicySet>` is an aggregation of other ***policy sets*** and ***policies***. ***Policy sets*** MAY be included in an enclosing `<PolicySet>` element either directly using the `<PolicySet>` element or indirectly using the `<PolicySetIdReference>` element. ***Policies*** MAY be included in an enclosing `<PolicySet>` element either directly using the `<Policy>` element or indirectly using the `<PolicyIdReference>` element.

A `<PolicySet>` element may be evaluated, in which case the evaluation procedure defined in Section 7.12 SHALL be used.

If a `<PolicySet>` element contains references to other ***policy sets*** or ***policies*** in the form of URLs, then these references MAY be resolvable.

Policy sets and ***policies*** included in a `<PolicySet>` element MUST be combined using the algorithm identified by the `PolicyCombiningAlgId` attribute. `<PolicySet>` is treated exactly like a `<Policy>` in all ***policy-combining algorithms***.

A `<PolicySet>` element MAY contain a `<PolicyIssuer>` element. The interpretation of the `<PolicyIssuer>` element is explained in the separate administrative ***policy*** profile **[XACMLAdmin]**.

The `<Target>` element defines the applicability of the `<PolicySet>` element to a set of ***decision requests***. If the `<Target>` element within the `<PolicySet>` element matches the request ***context***, then the `<PolicySet>` element MAY be used by the ***PDP*** in making its ***authorization decision***. See Section 7.12.

The `<ObligationExpressions>` element contains a set of ***obligation*** expressions that MUST be evaluated into ***obligations*** by the ***PDP*** and the resulting ***obligations*** MUST be fulfilled by the ***PEP*** in conjunction with the ***authorization decision***. If the ***PEP*** does not understand or cannot fulfill any of the ***obligations***, then it MUST act according to the PEP bias. See Section 7.2 and 7.16.

The `<AdviceExpressions>` element contains a set of ***advice*** expressions that MUST be evaluated into ***advice*** by the ***PDP***. The resulting ***advice*** MAY be safely ignored by the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16.

```
<xs:element name="PolicySet" type="xacml:PolicySetType"/>
<xs:complexType name="PolicySetType">
  <xs:sequence>
         <xs:element ref="xacml:Description" minOccurs="0"/>
         <xs:element ref="xacml:PolicyIssuer" minOccurs="0"/>
         <xs:element ref="xacml:PolicySetDefaults" minOccurs="0"/>
         <xs:element ref="xacml:Target"/>
         <xs:choice minOccurs="0" maxOccurs="unbounded">
                <xs:element ref="xacml:PolicySet"/>
                <xs:element ref="xacml:Policy"/>
                <xs:element ref="xacml:PolicySetIdReference"/>
                <xs:element ref="xacml:PolicyIdReference"/>
                <xs:element ref="xacml:CombinerParameters"/>
                <xs:element ref="xacml:PolicyCombinerParameters"/>
                <xs:element ref="xacml:PolicySetCombinerParameters"/>
         </xs:choice>
         <xs:element ref="xacml:ObligationExpressions" minOccurs="0"/>
         <xs:element ref="xacml:AdviceExpressions" minOccurs="0"/>
  </xs:sequence>
```

```
        <xs:attribute name="PolicySetId" type="xs:anyURI" use="required"/>
        <xs:attribute name="Version" type="xacml:VersionType" use="required"/>
        <xs:attribute name="PolicyCombiningAlgId" type="xs:anyURI" use="required"/>
        <xs:attribute name="MaxDelegationDepth" type="xs:integer" use="optional"/>
</xs:complexType>
```

The `<PolicySet>` element is of `PolicySetType` complex type.

The `<PolicySet>` element contains the following attributes and elements:

`PolicySetId` [Required]

> ***Policy set*** identifier. It is the responsibility of the ***PAP*** to ensure that no two ***policies*** visible to the ***PDP*** have the same identifier. This MAY be achieved by following a predefined URN or URI scheme. If the ***policy set*** identifier is in the form of a URL, then it MAY be resolvable.

`Version` [Required]

> The version number of the PolicySet.

`PolicyCombiningAlgId` [Required]

> The identifier of the ***policy-combining algorithm*** by which the `<PolicySet>`, `<CombinerParameters>`, `<PolicyCombinerParameters>` and `<PolicySetCombinerParameters>` components MUST be combined. Standard ***policy-combining algorithms*** are listed in Appendix C. Standard ***policy-combining algorithm*** identifiers are listed in Section B.9.

`MaxDelegationDepth` [Optional]

> If present, limits the depth of delegation which is authorized by this ***policy set***. See the delegation profile **[XACMLAdmin]**.

`<Description>` [Optional]

> A free-form description of the ***policy set***.

`<PolicyIssuer>` [Optional]

> ***Attributes*** of the ***issuer*** of the ***policy set***.

`<PolicySetDefaults>` [Optional]

> A set of default values applicable to the ***policy set***. The scope of the <PolicySetDefaults> element SHALL be the enclosing ***policy set***.

`<Target>` [Required]

> The <Target> element defines the applicability of a ***policy set*** to a set of ***decision requests***.
>
> The <Target> element MAY be declared by the creator of the <PolicySet> or it MAY be computed from the <Target> elements of the referenced `<Policy>` elements, either as an intersection or as a union.

`<PolicySet>` [Any Number]

> A ***policy set*** that is included in this ***policy set***.

`<Policy>` [Any Number]

> A ***policy*** that is included in this ***policy set***.

`<PolicySetIdReference>` [Any Number]

> A reference to a ***policy set*** that MUST be included in this ***policy set***. If `<PolicySetIdReference>` is a URL, then it MAY be resolvable.

`<PolicyIdReference>` [Any Number]

> A reference to a ***policy*** that MUST be included in this ***policy set***. If the `<PolicyIdReference>` is a URL, then it MAY be resolvable.

`<ObligationExpressions>` [Optional]

Contains the set of `<ObligationExpression>` elements. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** shall be determined.

`<AdviceExpressions>` [Optional]

Contains the set of `<AdviceExpression>` elements. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** shall be determined.

`<CombinerParameters>` [Optional]

Contains a sequence of `<CombinerParameter>` elements.

`<PolicyCombinerParameters>` [Optional]

Contains a sequence of `<CombinerParameter>` elements that are associated with a particular `<Policy>` or `<PolicyIdReference>` element within the `<PolicySet>`.

`<PolicySetCombinerParameters>` [Optional]

Contains a sequence of `<CombinerParameter>` elements that are associated with a particular `<PolicySet>` or `<PolicySetIdReference>` element within the `<PolicySet>`.

5.2 Element <Description>

The `<Description>` element contains a free-form description of the `<PolicySet>`, `<Policy>`, `<Rule>` or `<Apply>` element. The `<Description>` element is of `xs:string` simple type.

```
<xs:element name="Description" type="xs:string"/>
```

5.3 Element <PolicyIssuer>

The `<PolicyIssuer>` element contains ***attributes*** describing the issuer of the ***policy*** or ***policy set***. The use of the ***policy*** issuer element is defined in a separate administration profile **[XACMLAdmin]**. A PDP which does not implement the administration profile MUST report an error or return an Indeterminate result if it encounters this element.

```
<xs:element name="PolicyIssuer" type="xacml:PolicyIssuerType"/>
<xs:complexType name="PolicyIssuerType">
  <xs:sequence>
    <xs:element ref="xacml:Content" minOccurs="0"/>
    <xs:element ref="xacml:Attribute" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

The `<PolicyIssuer>` element is of `PolicyIssuerType` complex type.

The `<PolicyIssuer>` element contains the following elements:

`<Content>` [Optional]

Free form XML describing the issuer. See Section 5.45.

`<Attribute>` [Zero to many]

An ***attribute*** of the issuer. See Section 5.46.

5.4 Element <PolicySetDefaults>

The `<PolicySetDefaults>` element SHALL specify default values that apply to the `<PolicySet>` element.

```
<xs:element name="PolicySetDefaults" type="xacml:DefaultsType"/>
<xs:complexType name="DefaultsType">
  <xs:sequence>
```

```
            <xs:choice>
                  <xs:element ref="xacml:XPathVersion">
            </xs:choice>
      </xs:sequence>
</xs:complexType>
```

`<PolicySetDefaults>` element is of `DefaultsType` complex type.

The `<PolicySetDefaults>` element contains the following elements:

`<XPathVersion>` [Optional]

Default XPath version.

5.5 Element <XPathVersion>

The `<XPathVersion>` element SHALL specify the version of the XPath specification to be used by `<AttributeSelector>` elements and XPath-based functions in the ***policy set*** or ***policy***.

```
<xs:element name="XPathVersion" type="xs:anyURI"/>
```

The URI for the XPath 1.0 specification is “http://www.w3.org/TR/1999/REC-xpath-19991116”.

The URI for the XPath 2.0 specification is “http://www.w3.org/TR/2007/REC-xpath20-20070123”.

The `<XPathVersion>` element is REQUIRED if the XACML enclosing ***policy set*** or ***policy*** contains `<AttributeSelector>` elements or XPath-based functions.

5.6 Element <Target>

The `<Target>` element identifies the set of ***decision requests*** that the parent element is intended to evaluate. The `<Target>` element SHALL appear as a child of a `<PolicySet>` and `<Policy>` element and MAY appear as a child of a `<Rule>` element.

The `<Target>` element SHALL contain a ***conjunctive sequence*** of `<AnyOf>` elements. For the parent of the `<Target>` element to be applicable to the ***decision request***, there MUST be at least one positive match between each `<AnyOf>` element of the `<Target>` element and the corresponding section of the `<Request>` element.

```
<xs:element name="Target" type="xacml:TargetType"/>
<xs:complexType name="TargetType">
      <xs:sequence minOccurs="0" maxOccurs="unbounded">
            <xs:element ref="xacml:AnyOf"/>
      </xs:sequence>
</xs:complexType>
```

The `<Target>` element is of `TargetType` complex type.

The `<Target>` element contains the following elements:

`<AnyOf>` [Zero to Many]

Matching specification for ***attributes*** in the ***context***. If this element is missing, then the ***target*** SHALL match all ***contexts***.

5.7 Element <AnyOf>

The `<AnyOf>` element SHALL contain a ***disjunctive sequence*** of `<AllOf>` elements.

```
<xs:element name="AnyOf" type="xacml:AnyOfType"/>
<xs:complexType name="AnyOfType">
      <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element ref="xacml:AllOf"/>
      </xs:sequence>
</xs:complexType>
```

The `<AnyOf>` element is of `AnyOfType` complex type.

The `<AnyOf>` element contains the following elements:

`<AllOf>` [One to Many, Required]

See Section 5.8.

5.8 Element <AllOf>

The `<AllOf>` element SHALL contain a ***conjunctive sequence*** of `<Match>` elements.

```
<xs:element name="AllOf" type="xacml:AllOfType"/>
<xs:complexType name="AllOfType">
  <xs:sequence minOccurs="1" maxOccurs="unbounded">
        <xs:element ref="xacml:Match"/>
  </xs:sequence>
</xs:complexType>
```

The `<AllOf>` element is of `AllOfType` complex type.

The `<AllOf>` element contains the following elements:

`<Match>` [One to Many]

A ***conjunctive sequence*** of individual matches of the ***attributes*** in the request ***context*** and the embedded ***attribute*** values. See Section 5.9.

5.9 Element <Match>

The `<Match>` element SHALL identify a set of entities by matching ***attribute*** values in an `<Attributes>` element of the request ***context*** with the embedded ***attribute*** value.

```
<xs:element name="Match" type="xacml:MatchType"/>
<xs:complexType name="MatchType">
  <xs:sequence>
        <xs:element ref="xacml:AttributeValue"/>
        <xs:choice>
              <xs:element ref="xacml:AttributeDesignator"/>
              <xs:element ref="xacml:AttributeSelector"/>
        </xs:choice>
  </xs:sequence>
  <xs:attribute name="MatchId" type="xs:anyURI" use="required"/>
</xs:complexType>
```

The `<Match>` element is of `MatchType` complex type.

The `<Match>` element contains the following attributes and elements:

MatchId [Required]

Specifies a matching function. The value of this attribute MUST be of type `xs:anyURI` with legal values documented in Section 7.6.

`<AttributeValue>` [Required]

Embedded ***attribute*** value.

`<AttributeDesignator>` [Required choice]

MAY be used to identify one or more ***attribute*** values in an `<Attributes>` element of the request ***context***.

`<AttributeSelector>` [Required choice]

MAY be used to identify one or more ***attribute*** values in a `<Content>` element of the request ***context***.

5.10 Element <PolicySetIdReference>

The `<PolicySetIdReference>` element SHALL be used to reference a `<PolicySet>` element by id. If `<PolicySetIdReference>` is a URL, then it MAY be resolvable to the `<PolicySet>` element. However, the mechanism for resolving a ***policy set*** reference to the corresponding ***policy set*** is outside the scope of this specification.

```
<xs:element name="PolicySetIdReference" type="xacml:IdReferenceType"/>
<xs:complexType name="IdReferenceType">
   <xs:simpleContent>
          <xs:extension base="xs:anyURI">
                 <xs:attribute name="xacml:Version"
                    type="xacml:VersionMatchType" use="optional"/>
                 <xs:attribute name="xacml:EarliestVersion"
                    type="xacml:VersionMatchType" use="optional"/>
                 <xs:attribute name="xacml:LatestVersion"
                    type="xacml:VersionMatchType" use="optional"/>
          </xs:extension>
   </xs:simpleContent>
</xs:complexType>
```

Element `<PolicySetIdReference>` is of `xacml:IdReferenceType` complex type.

`IdReferenceType` extends the `xs:anyURI` type with the following attributes:

`Version` [Optional]

Specifies a matching expression for the version of the ***policy set*** referenced.

`EarliestVersion` [Optional]

Specifies a matching expression for the earliest acceptable version of the ***policy set*** referenced.

`LatestVersion` [Optional]

Specifies a matching expression for the latest acceptable version of the ***policy set*** referenced.

The matching operation is defined in Section 5.13. Any combination of these attributes MAY be present in a `<PolicySetIdReference>`. The referenced ***policy set*** MUST match all expressions. If none of these attributes is present, then any version of the ***policy set*** is acceptable. In the case that more than one matching version can be obtained, then the most recent one SHOULD be used.

5.11 Element <PolicyIdReference>

The `<PolicyIdReference>` element SHALL be used to reference a `<Policy>` element by id. If `<PolicyIdReference>` is a URL, then it MAY be resolvable to the `<Policy>` element. However, the mechanism for resolving a ***policy*** reference to the corresponding ***policy*** is outside the scope of this specification.

```
<xs:element name="PolicyIdReference" type="xacml:IdReferenceType"/>
```

Element `<PolicyIdReference>` is of `xacml:IdReferenceType` complex type (see Section 5.10) .

5.12 Simple type VersionType

Elements of this type SHALL contain the version number of the ***policy*** or ***policy set***.

```
<xs:simpleType name="VersionType">
   <xs:restriction base="xs:string">
          <xs:pattern value="(\d+\.)*\d+"/>
   </xs:restriction>
</xs:simpleType>
```

The version number is expressed as a sequence of decimal numbers, each separated by a period (.). 'd+' represents a sequence of one or more decimal digits.

5.13 Simple type VersionMatchType

Elements of this type SHALL contain a restricted regular expression matching a version number (see Section 5.12). The expression SHALL match versions of a referenced ***policy*** or ***policy set*** that are acceptable for inclusion in the referencing ***policy*** or ***policy set***.

```
<xs:simpleType name="VersionMatchType">
   <xs:restriction base="xs:string">
          <xs:pattern value="((\d+|\*)\.)*(\d+|\*|\+)"/>
   </xs:restriction>
</xs:simpleType>
```

A version match is '.'-separated, like a version string. A number represents a direct numeric match. A '*' means that any single number is valid. A '+' means that any number, and any subsequent numbers, are valid. In this manner, the following four patterns would all match the version string '1.2.3': '1.2.3', '1.*.3', '1.2.*' and ‘1.+'.

5.14 Element <Policy>

The `<Policy>` element is the smallest entity that SHALL be presented to the ***PDP*** for evaluation.

A `<Policy>` element may be evaluated, in which case the evaluation procedure defined in Section 7.11 SHALL be used.

The main components of this element are the `<Target>`, `<Rule>`, `<CombinerParameters>`, `<RuleCombinerParameters>`, `<ObligationExpressions>` and `<AdviceExpressions>` elements and the `RuleCombiningAlgId` attribute.

A `<Policy>` element MAY contain a `<PolicyIssuer>` element. The interpretation of the `<PolicyIssuer>` element is explained in the separate administrative ***policy*** profile **[XACMLAdmin]**.

The `<Target>` element defines the applicability of the `<Policy>` element to a set of ***decision requests***. If the `<Target>` element within the `<Policy>` element matches the request ***context***, then the `<Policy>` element MAY be used by the ***PDP*** in making its ***authorization decision***. See Section 7.11.

The `<Policy>` element includes a sequence of choices between `<VariableDefinition>` and `<Rule>` elements.

Rules included in the `<Policy>` element MUST be combined by the algorithm specified by the `RuleCombiningAlgId` attribute.

The `<ObligationExpressions>` element contains a set of ***obligation*** expressions that MUST be evaluated into ***obligations*** by the ***PDP*** and the resulting ***obligations*** MUST be fulfilled by the ***PEP*** in conjunction with the ***authorization decision***. If the ***PEP*** does not understand, or cannot fulfill, any of the ***obligations***, then it MUST act according to the PEP bias. See Section 7.2 and 7.16.

The `<AdviceExpressions>` element contains a set of ***advice*** expressions that MUST be evaluated into ***advice*** by the ***PDP***. The resulting ***advice*** MAY be safely ignored by the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16.

```
<xs:element name="Policy" type="xacml:PolicyType"/>
<xs:complexType name="PolicyType">
   <xs:sequence>
          <xs:element ref="xacml:Description" minOccurs="0"/>
          <xs:element ref="xacml:PolicyIssuer" minOccurs="0"/>
          <xs:element ref="xacml:PolicyDefaults" minOccurs="0"/>
          <xs:element ref="xacml:Target"/>
          <xs:choice maxOccurs="unbounded">
                 <xs:element ref="xacml:CombinerParameters" minOccurs="0"/>
                 <xs:element ref="xacml:RuleCombinerParameters" minOccurs="0"/>
                 <xs:element ref="xacml:VariableDefinition"/>
                 <xs:element ref="xacml:Rule"/>
          </xs:choice>
          <xs:element ref="xacml:ObligationExpressions" minOccurs="0"/>
```

```
        <xs:element ref="xacml:AdviceExpressions" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="PolicyId" type="xs:anyURI" use="required"/>
    <xs:attribute name="Version" type="xacml:VersionType" use="required"/>
    <xs:attribute name="RuleCombiningAlgId" type="xs:anyURI" use="required"/>
    <xs:attribute name="MaxDelegationDepth" type="xs:integer" use="optional"/>
</xs:complexType>
```

The `<Policy>` element is of `PolicyType` complex type.

The `<Policy>` element contains the following attributes and elements:

`PolicyId` [Required]

> ***Policy*** identifier. It is the responsibility of the ***PAP*** to ensure that no two ***policies*** visible to the ***PDP*** have the same identifier. This MAY be achieved by following a predefined URN or URI scheme. If the ***policy*** identifier is in the form of a URL, then it MAY be resolvable.

`Version` [Required]

> The version number of the ***Policy***.

`RuleCombiningAlgId` [Required]

> The identifier of the ***rule-combining algorithm*** by which the `<Policy>`, `<CombinerParameters>` and `<RuleCombinerParameters>` components MUST be combined. Standard ***rule-combining algorithms*** are listed in Appendix C. Standard ***rule-combining algorithm*** identifiers are listed in Section B.9.

`MaxDelegationDepth` [Optional]

> If present, limits the depth of delegation which is authorized by this ***policy***. See the delegation profile **[XACMLAdmin]**.

`<Description>` [Optional]

> A free-form description of the ***policy***. See Section 5.2.

`<PolicyIssuer>` [Optional]

> ***Attributes*** of the ***issuer*** of the ***policy***.

`<PolicyDefaults>` [Optional]

> Defines a set of default values applicable to the ***policy***. The scope of the `<PolicyDefaults>` element SHALL be the enclosing ***policy***.

`<CombinerParameters>` [Optional]

> A sequence of parameters to be used by the ***rule-combining algorithm***.

`<RuleCombinerParameters>` [Optional]

> A sequence of parameters to be used by the ***rule-combining algorithm***.

`<Target>` [Required]

> The `<Target>` element defines the applicability of a `<Policy>` to a set of ***decision requests***.
>
> The `<Target>` element MAY be declared by the creator of the `<Policy>` element, or it MAY be computed from the `<Target>` elements of the referenced `<Rule>` elements either as an intersection or as a union.

`<VariableDefinition>` [Any Number]

> Common function definitions that can be referenced from anywhere in a ***rule*** where an expression can be found.

`<Rule>` [Any Number]

A sequence of ***rules*** that MUST be combined according to the `RuleCombiningAlgId` attribute. ***Rules*** whose `<Target>` elements and conditions match the ***decision request*** MUST be considered. ***Rules*** whose `<Target>` elements or conditions do not match the ***decision request*** SHALL be ignored.

`<ObligationExpressions>` [Optional]

A ***conjunctive sequence*** of ***obligation*** expressions which MUST be evaluated into ***obligations*** byt the PDP. The corresponsding ***obligations*** MUST be fulfilled by the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** SHALL be determined. See section 7.2 about enforcement of ***obligations***.

`<AdviceExpressions>` [Optional]

A ***conjunctive sequence*** of ***advice*** expressions which MUST evaluated into ***advice*** by the ***PDP***. The corresponding ***advice*** provide supplementary information to the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** SHALL be determined.

5.15 Element <PolicyDefaults>

The `<PolicyDefaults>` element SHALL specify default values that apply to the `<Policy>` element.

```
<xs:element name="PolicyDefaults" type="xacml:DefaultsType"/>
<xs:complexType name=”DefaultsType”>
   <xs:sequence>
         <xs:choice>
               <xs:element ref=”xacml:XPathVersion” />
         </xs:choice>
   </xs:sequence>
</xs:complexType>
```

`<PolicyDefaults>` element is of `DefaultsType` complex type.

The `<PolicyDefaults>` element contains the following elements:

`<XPathVersion>` [Optional]

Default XPath version.

5.16 Element <CombinerParameters>

The `<CombinerParameters>` element conveys parameters for a ***policy***- or ***rule-combining algorithm***.

If multiple `<CombinerParameters>` elements occur within the same ***policy*** or ***policy set***, they SHALL be considered equal to one `<CombinerParameters>` element containing the concatenation of all the sequences of `<CombinerParameters>` contained in all the aforementioned `<CombinerParameters>` elements, such that the order of occurence of the `<CominberParameters>` elements is preserved in the concatenation of the `<CombinerParameter>` elements.

Note that none of the combining algorithms specified in XACML 3.0 is parameterized.

```
<xs:element name="CombinerParameters" type="xacml:CombinerParametersType"/>
<xs:complexType name="CombinerParametersType">
   <xs:sequence>
         <xs:element ref="xacml:CombinerParameter" minOccurs="0"
               maxOccurs="unbounded"/>
   </xs:sequence>
</xs:complexType>
```

The `<CombinerParameters>` element is of `CombinerParametersType` complex type.

The `<CombinerParameters>` element contains the following elements:

`<CombinerParameter>` [Any Number]

A single parameter. See Section 5.17.

Support for the `<CombinerParameters>` element is optional.

5.17 Element <CombinerParameter>

The `<CombinerParameter>` element conveys a single parameter for a ***policy***- or ***rule-combining algorithm***.

```
<xs:element name="CombinerParameter" type="xacml:CombinerParameterType"/>
<xs:complexType name="CombinerParameterType">
   <xs:sequence>
          <xs:element ref="xacml:AttributeValue"/>
   </xs:sequence>
   <xs:attribute name="ParameterName" type="xs:string" use="required"/>
</xs:complexType>
```

The `<CombinerParameter>` element is of `CombinerParameterType` complex type.

The `<CombinerParameter>` element contains the following attributes:

`ParameterName` [Required]

The identifier of the parameter.

`<AttributeValue>` [Required]

The value of the parameter.

Support for the `<CombinerParameter>` element is optional.

5.18 Element <RuleCombinerParameters>

The `<RuleCombinerParameters>` element conveys parameters associated with a particular ***rule*** within a ***policy*** for a ***rule-combining algorithm***.

Each `<RuleCombinerParameters>` element MUST be associated with a ***rule*** contained within the same ***policy***. If multiple `<RuleCombinerParameters>` elements reference the same ***rule***, they SHALL be considered equal to one `<RuleCombinerParameters>` element containing the concatenation of all the sequences of `<CombinerParameters>` contained in all the aforementioned `<RuleCombinerParameters>` elements, such that the order of occurrence of the `<RuleCominberParameters>` elements is preserved in the concatenation of the `<CombinerParameter>` elements.

Note that none of the ***rule-combining algorithms*** specified in XACML 3.0 is parameterized.

```
<xs:element name="RuleCombinerParameters"
type="xacml:RuleCombinerParametersType"/>
<xs:complexType name="RuleCombinerParametersType">
   <xs:complexContent>
          <xs:extension base="xacml:CombinerParametersType">
                 <xs:attribute name="RuleIdRef" type="xs:string"
                       use="required"/>
          </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<RuleCombinerParameters>` element contains the following attribute:

`RuleIdRef` [Required]

The identifier of the `<Rule>` contained in the ***policy***.

Support for the `<RuleCombinerParameters>` element is optional, only if support for combiner parameters is not implemented.

5.19 Element <PolicyCombinerParameters>

The `<PolicyCombinerParameters>` element conveys parameters associated with a particular ***policy*** within a ***policy set*** for a ***policy-combining algorithm***.

Each `<PolicyCombinerParameters>` element MUST be associated with a ***policy*** contained within the same ***policy set***. If multiple `<PolicyCombinerParameters>` elements reference the same ***policy***, they SHALL be considered equal to one `<PolicyCombinerParameters>` element containing the concatenation of all the sequences of `<CombinerParameters>` contained in all the aforementioned `<PolicyCombinerParameters>` elements, such that the order of occurrence of the `<PolicyCominberParameters>` elements is preserved in the concatenation of the `<CombinerParameter>` elements.

Note that none of the ***policy-combining algorithms*** specified in XACML 3.0 is parameterized.

```
<xs:element name="PolicyCombinerParameters"
type="xacml:PolicyCombinerParametersType"/>
<xs:complexType name="PolicyCombinerParametersType">
   <xs:complexContent>
         <xs:extension base="xacml:CombinerParametersType">
               <xs:attribute name="PolicyIdRef" type="xs:anyURI"
use="required"/>
         </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<PolicyCombinerParameters>` element is of `PolicyCombinerParametersType` complex type.

The `<PolicyCombinerParameters>` element contains the following attribute:

`PolicyIdRef` [Required]

> The identifier of a `<Policy>` or the value of a `<PolicyIdReference>` contained in the ***policy set***.

Support for the `<PolicyCombinerParameters>` element is optional, only if support for combiner parameters is not implemented.

5.20 Element <PolicySetCombinerParameters>

The `<PolicySetCombinerParameters>` element conveys parameters associated with a particular ***policy set*** within a ***policy set*** for a ***policy-combining algorithm***.

Each `<PolicySetCombinerParameters>` element MUST be associated with a ***policy set*** contained within the same ***policy set***. If multiple `<PolicySetCombinerParameters>` elements reference the same ***policy set***, they SHALL be considered equal to one `<PolicySetCombinerParameters>` element containing the concatenation of all the sequences of `<CombinerParameters>` contained in all the aforementioned `<PolicySetCombinerParameters>` elements, such that the order of occurrence of the `<PolicySetCominberParameters>` elements is preserved in the concatenation of the `<CombinerParameter>` elements.

Note that none of the ***policy-combining algorithms*** specified in XACML 3.0 is parameterized.

```
<xs:element name="PolicySetCombinerParameters"
type="xacml:PolicySetCombinerParametersType"/>
<xs:complexType name="PolicySetCombinerParametersType">
   <xs:complexContent>
         <xs:extension base="xacml:CombinerParametersType">
               <xs:attribute name="PolicySetIdRef" type="xs:anyURI"
use="required"/>
         </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<PolicySetCombinerParameters>` element is of `PolicySetCombinerParametersType` complex type.

The `<PolicySetCombinerParameters>` element contains the following attribute:

`PolicySetIdRef` [Required]

The identifier of a `<PolicySet>` or the value of a `<PolicySetIdReference>` contained in the ***policy set***.

Support for the `<PolicySetCombinerParameters>` element is optional, only if support for combiner parameters is not implemented.

5.21 Element <Rule>

The `<Rule>` element SHALL define the individual ***rules*** in the ***policy***. The main components of this element are the `<Target>`, `<Condition>`, `<ObligationExpressions>` and `<AdviceExpressions>` elements and the `Effect` attribute.

A `<Rule>` element may be evaluated, in which case the evaluation procedure defined in Section 7.10 SHALL be used.

```
<xs:element name="Rule" type="xacml:RuleType"/>
<xs:complexType name="RuleType">
   <xs:sequence>
        <xs:element ref="xacml:Description" minOccurs="0"/>
        <xs:element ref="xacml:Target" minOccurs="0"/>
        <xs:element ref="xacml:Condition" minOccurs="0"/>
        <xs:element ref="xacml:ObligationExpressions" minOccurs="0"/>
        <xs:element ref="xacml:AdviceExpressions" minOccurs="0"/>
   </xs:sequence>
   <xs:attribute name="RuleId" type="xs:string" use="required"/>
   <xs:attribute name="Effect" type="xacml:EffectType" use="required"/>
</xs:complexType>
```

The `<Rule>` element is of `RuleType` complex type.

The `<Rule>` element contains the following attributes and elements:

`RuleId` [Required]

A string identifying this ***rule***.

`Effect` [Required]

Rule effect. The value of this attribute is either “Permit” or “Deny”.

`<Description>` [Optional]

A free-form description of the ***rule***.

`<Target>` [Optional]

Identifies the set of ***decision requests*** that the `<Rule>` element is intended to evaluate. If this element is omitted, then the ***target*** for the `<Rule>` SHALL be defined by the `<Target>` element of the enclosing `<Policy>` element. See Section 7.7 for details.

`<Condition>` [Optional]

A ***predicate*** that MUST be satisfied for the ***rule*** to be assigned its `Effect` value.

`<ObligationExpressions>` [Optional]

A ***conjunctive sequence*** of ***obligation*** expressions which MUST be evaluated into ***obligations*** byt the PDP. The corresponsding ***obligations*** MUST be fulfilled by the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** SHALL be determined. See section 7.2 about enforcement of ***obligations***.

`<AdviceExpressions>` [Optional]

> A ***conjunctive sequence*** of ***advice*** expressions which MUST evaluated into ***advice*** by the ***PDP***. The corresponding ***advice*** provide supplementary information to the ***PEP*** in conjunction with the ***authorization decision***. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** SHALL be determined.

5.22 Simple type EffectType

The `EffectType` simple type defines the values allowed for the `Effect` attribute of the `<Rule>` element and for the `FulfillOn` attribute of the `<ObligationExpression> and <AdviceExpression>` elements.

```
<xs:simpleType name="EffectType">
   <xs:restriction base="xs:string">
         <xs:enumeration value="Permit"/>
         <xs:enumeration value="Deny"/>
   </xs:restriction>
</xs:simpleType>
```

5.23 Element <VariableDefinition>

The `<VariableDefinition>` element SHALL be used to define a value that can be referenced by a `<VariableReference>` element. The name supplied for its `VariableId` attribute SHALL NOT occur in the `VariableId` attribute of any other `<VariableDefinition>` element within the encompassing ***policy***. The `<VariableDefinition>` element MAY contain undefined `<VariableReference>` elements, but if it does, a corresponding `<VariableDefinition>` element MUST be defined later in the encompassing ***policy***. `<VariableDefinition>` elements MAY be grouped together or MAY be placed close to the reference in the encompassing ***policy***. There MAY be zero or more references to each `<VariableDefinition>` element.

```
<xs:element name="VariableDefinition" type="xacml:VariableDefinitionType"/>
<xs:complexType name="VariableDefinitionType">
   <xs:sequence>
         <xs:element ref="xacml:Expression"/>
   </xs:sequence>
   <xs:attribute name="VariableId" type="xs:string" use="required"/>
</xs:complexType>
```

The `<VariableDefinition>` element is of `VariableDefinitionType` complex type. The `<VariableDefinition>` element has the following elements and attributes:

`<Expression>` [Required]

> Any element of `ExpressionType` complex type.

`VariableId` [Required]

> The name of the variable definition.

5.24 Element <VariableReference>

The `<VariableReference>` element is used to reference a value defined within the same encompassing `<Policy>` element. The `<VariableReference>` element SHALL refer to the `<VariableDefinition>` element by string equality on the value of their respective `VariableId` attributes. One and only one `<VariableDefinition>` MUST exist within the same encompassing `<Policy>` element to which the `<VariableReference>` refers. There MAY be zero or more `<VariableReference>` elements that refer to the same `<VariableDefinition>` element.

```
<xs:element name="VariableReference" type="xacml:VariableReferenceType"
substitutionGroup="xacml:Expression"/>
<xs:complexType name="VariableReferenceType">
```

```
   <xs:complexContent>
          <xs:extension base="xacml:ExpressionType">
                 <xs:attribute name="VariableId" type="xs:string"
                     use="required"/>
          </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<VariableReference>` element is of the `VariableReferenceType` complex type, which is of the `ExpressionType` complex type and is a member of the `<Expression>` element substitution group. The `<VariableReference>` element MAY appear any place where an `<Expression>` element occurs in the schema.

The `<VariableReference>` element has the following attribute:

`VariableId` [Required]

The name used to refer to the value defined in a `<VariableDefinition>` element.

5.25 Element <Expression>

The `<Expression>` element is not used directly in a ***policy***. The `<Expression>` element signifies that an element that extends the `ExpressionType` and is a member of the `<Expression>` element substitution group SHALL appear in its place.

```
<xs:element name="Expression" type="xacml:ExpressionType" abstract="true"/>
<xs:complexType name="ExpressionType" abstract="true"/>
```

The following elements are in the `<Expression>` element substitution group:

`<Apply>`, `<AttributeSelector>`, `<AttributeValue>`, `<Function>`, `<VariableReference>` and `<AttributeDesignator>`.

5.26 Element <Condition>

The `<Condition>` element is a Boolean function over ***attributes*** or functions of ***attributes***.

```
<xs:element name="Condition" type="xacml:ConditionType"/>
<xs:complexType name="ConditionType">
   <xs:sequence>
          <xs:element ref="xacml:Expression"/>
   </xs:sequence>
</xs:complexType>
```

The `<Condition>` contains one `<Expression>` element, with the restriction that the `<Expression>` return data-type MUST be “http://www.w3.org/2001/XMLSchema#boolean”. Evaluation of the `<Condition>` element is described in Section 7.9.

5.27 Element <Apply>

The `<Apply>` element denotes application of a function to its arguments, thus encoding a function call. The `<Apply>` element can be applied to any combination of the members of the `<Expression>` element substitution group. See Section 5.25.

```
<xs:element name="Apply" type="xacml:ApplyType"
substitutionGroup="xacml:Expression"/>
<xs:complexType name="ApplyType">
   <xs:complexContent>
          <xs:extension base="xacml:ExpressionType">
                 <xs:sequence>
                        <xs:element ref="xacml:Description" minOccurs="0"/>
                        <xs:element ref="xacml:Expression" minOccurs="0"
                            maxOccurs="unbounded"/>
```

```
            </xs:sequence>
            <xs:attribute name="FunctionId" type="xs:anyURI"
               use="required"/>
        </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<Apply>` element is of `ApplyType` complex type.

The `<Apply>` element contains the following attributes and elements:

`FunctionId` [Required]

The identifier of the function to be applied to the arguments. XACML-defined functions are described in Appendix A.3.

`<Description>` [Optional]

A free-form description of the `<Apply>` element.

`<Expression>` [Optional]

Arguments to the function, which may include other functions.

5.28 Element <Function>

The `<Function>` element SHALL be used to name a function as an argument to the function defined by the parent `<Apply>` element.

```
<xs:element name="Function" type="xacml:FunctionType"
substitutionGroup="xacml:Expression"/>
<xs:complexType name="FunctionType">
   <xs:complexContent>
        <xs:extension base="xacml:ExpressionType">
            <xs:attribute name="FunctionId" type="xs:anyURI"
               use="required"/>
        </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<Function>` element is of `FunctionType` complex type.

The `<Function>` element contains the following attribute:

`FunctionId` [Required]

The identifier of the function.

5.29 Element <AttributeDesignator>

The `<AttributeDesignator>` element retrieves a ***bag*** of values for a ***named attribute*** from the request ***context***. A ***named attribute*** SHALL be considered present if there is at least one ***attribute*** that matches the criteria set out below.

The `<AttributeDesignator>` element SHALL return a ***bag*** containing all the ***attribute*** values that are matched by the ***named attribute***. In the event that no matching ***attribute*** is present in the ***context***, the `MustBePresent` attribute governs whether this element returns an empty ***bag*** or “Indeterminate”. See Section 7.3.5.

The `<AttributeDesignator>` MAY appear in the <Match> element and MAY be passed to the <Apply> element as an argument.

The `<AttributeDesignator>` element is of the `AttributeDesignatorType` complex type.

```
<xs:complexType name="AttributeDesignatorType">
   <xs:complexContent>
        <xs:extension base="xacml:ExpressionType">
```

```
                <xs:attribute name="Category" type="xs:anyURI"
                    use="required"/>
                <xs:attribute name="AttributeId" type="xs:anyURI"
                    use="required"/>
                <xs:attribute name="DataType" type="xs:anyURI"
                    use="required"/>
                <xs:attribute name="Issuer" type="xs:string" use="optional"/>
                <xs:attribute name="MustBePresent" type="xs:boolean"
                    use="required"/>
            </xs:extension>
        </xs:complexContent>
</xs:complexType>
```

A ***named attribute*** SHALL match an ***attribute*** if the values of their respective `Category`, `AttributeId`, `DataType` and `Issuer` attributes match. The attribute designator's `Category` MUST match, by URI equality, the `Category` of the `<Attributes>` element in which the ***attribute*** is present. The attribute designator's `AttributeId` MUST match, by URI equality, the `AttributeId` of the attribute. The attribute designator's `DataType` MUST match, by URI equality, the `DataType` of the same ***attribute***.

If the `Issuer` attribute is present in the attribute designator, then it MUST match, using the "urn:oasis:names:tc:xacml:1.0:function:string-equal" function, the `Issuer` of the same ***attribute***. If the `Issuer` is not present in the attribute designator, then the matching of the ***attribute*** to the ***named attribute*** SHALL be governed by `AttributeId` and `DataType` attributes alone.

The `<AttributeDesignatorType>` contains the following attributes:

`Category` [Required]

    This attribute SHALL specify the `Category` with which to match the ***attribute***.

`AttributeId` [Required]

    This attribute SHALL specify the `AttributeId` with which to match the ***attribute***.

`DataType` [Required]

    The ***bag*** returned by the `<AttributeDesignator>` element SHALL contain values of this data-type.

`Issuer` [Optional]

    This attribute, if supplied, SHALL specify the `Issuer` with which to match the ***attribute***.

`MustBePresent` [Required]

    This attribute governs whether the element returns "Indeterminate" or an empty ***bag*** in the event the ***named attribute*** is absent from the request ***context***. See Section 7.3.5. Also see Sections 7.17.2 and 7.17.3.

5.30 Element <AttributeSelector>

The `<AttributeSelector>` element produces a ***bag*** of unnamed and uncategorized ***attribute*** values. The values shall be constructed from the node(s) selected by applying the XPath expression given by the element's `Path` attribute to the XML content indicated by the element's `Category` attribute. Support for the `<AttributeSelector>` element is OPTIONAL.

See section 7.3.7 for details of `<AttributeSelector>` evaluation.

```
<xs:element name="AttributeSelector" type="xacml:AttributeSelectorType"
substitutionGroup="xacml:Expression"/>
<xs:complexType name="AttributeSelectorType">
    <xs:complexContent>
            <xs:extension base="xacml:ExpressionType">
                <xs:attribute name="Category" type="xs:anyURI"
                     use="required"/>
                <xs:attribute name="ContextSelectorId" type="xs:anyURI"
                     use="optional"/>
                <xs:attribute name="Path" type="xs:string"
                     use="required"/>
                <xs:attribute name="DataType" type="xs:anyURI"
                     use="required"/>
                <xs:attribute name="MustBePresent" type="xs:boolean"
                     use="required"/>
          </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<AttributeSelector>` element is of `AttributeSelectorType` complex type.

The `<AttributeSelector>` element has the following attributes:

`Category` [Required]

This attribute SHALL specify the ***attributes*** category of the `<Content>` element containing the XML from which nodes will be selected. It also indicates the ***attributes*** category containing the applicable `ContextSelectorId` attribute, if the element includes a `ContextSelectorId` xml attribute.

`ContextSelectorId` [Optional]

This attribute refers to the ***attribute*** (by its `AttributeId`) in the request ***context*** in the category given by the `Category` attribute. The referenced ***attribute*** MUST have data type urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression, and must select a single node in the `<Content>` element. The `XPathCategory` attribute of the referenced ***attribute*** MUST be equal to the `Category` attribute of the ***attribute selector***.

`Path` [Required]

This attribute SHALL contain an XPath expression to be evaluated against the specified XML content. See Section 7.3.7 for details of the XPath evaluation during `<AttributeSelector>` processing.

`DataType` [Required]

The attribute specifies the datatype of the values returned from the evaluation of this `<AttributeSelector>` element.

`MustBePresent` [Required]

This attribute governs whether the element returns "Indeterminate" or an empty ***bag*** in the event the XPath expression selects no node. See Section 7.3.5. Also see Sections 7.17.2 and 7.17.3.

5.31 Element <AttributeValue>

The `<AttributeValue>` element SHALL contain a literal ***attribute*** value.

```
<xs:element name="AttributeValue" type="xacml:AttributeValueType"
substitutionGroup="xacml:Expression"/>
<xs:complexType name="AttributeValueType" mixed="true">
   <xs:complexContent mixed="true">
          <xs:extension base="xacml:ExpressionType">
                <xs:sequence>
                       <xs:any namespace="##any" processContents="lax"
                          minOccurs="0" maxOccurs="unbounded"/>
                </xs:sequence>
                <xs:attribute name="DataType" type="xs:anyURI"
                    use="required"/>
                <xs:anyAttribute namespace="##any" processContents="lax"/>
          </xs:extension>
   </xs:complexContent>
```

```
</xs:complexType>
```

The `<AttributeValue>` element is of `AttributeValueType` complex type.

The `<AttributeValue>` element has the following attributes:

`DataType` [Required]

The data-type of the ***attribute*** value.

5.32 Element <Obligations>

The `<Obligations>` element SHALL contain a set of `<Obligation>` elements.

```
<xs:element name="Obligations" type="xacml:ObligationsType"/>
<xs:complexType name="ObligationsType">
  <xs:sequence>
        <xs:element ref="xacml:Obligation" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

The `<Obligations>` element is of `ObligationsType` complexType.

The `<Obligations>` element contains the following element:

`<Obligation>` [One to Many]

A sequence of ***obligations***. See Section 5.34.

5.33 Element <AssociatedAdvice>

The `<AssociatedAdvice>` element SHALL contain a set of `<Advice>` elements.

```
<xs:element name="AssociatedAdvice" type="xacml:AssociatedAdviceType"/>
<xs:complexType name="AssociatedAdviceType">
  <xs:sequence>
        <xs:element ref="xacml:Advice" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

The `<AssociatedAdvice>` element is of `AssociatedAdviceType` complexType.

The `<AssociatedAdvice>` element contains the following element:

`<Advice>` [One to Many]

A sequence of ***advice***. See Section 5.35.

5.34 Element <Obligation>

The `<Obligation>` element SHALL contain an identifier for the ***obligation*** and a set of ***attributes*** that form arguments of the action defined by the ***obligation***.

```
<xs:element name="Obligation" type="xacml:ObligationType"/>
<xs:complexType name="ObligationType">
  <xs:sequence>
        <xs:element ref="xacml:AttributeAssignment" minOccurs="0"
             maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="ObligationId" type="xs:anyURI" use="required"/>
</xs:complexType>
```

The `<Obligation>` element is of `ObligationType` complexType. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** is determined.

The `<Obligation>` element contains the following elements and attributes:

`ObligationId` [Required]

Obligation identifier. The value of the ***obligation*** identifier SHALL be interpreted by the ***PEP***.

`<AttributeAssignment>` [Optional]

Obligation arguments assignment. The values of the ***obligation*** arguments SHALL be interpreted by the ***PEP***.

5.35 Element <Advice>

The `<Advice>` element SHALL contain an identifier for the ***advice*** and a set of ***attributes*** that form arguments of the supplemental information defined by the ***advice***.

```
<xs:element name="Advice" type="xacml:AdviceType"/>
<xs:complexType name="AdviceType">
   <xs:sequence>
         <xs:element ref="xacml:AttributeAssignment" minOccurs="0"
maxOccurs="unbounded"/>
   </xs:sequence>
   <xs:attribute name="AdviceId" type="xs:anyURI" use="required"/>
</xs:complexType>
```

The `<Advice>` element is of `AdviceType` complexType. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** is determined.

The `<Advice>` element contains the following elements and attributes:

`AdviceId` [Required]

Advice identifier. The value of the ***advice*** identifier MAY be interpreted by the ***PEP***.

`<AttributeAssignment>` [Optional]

Advice arguments assignment. The values of the ***advice*** arguments MAY be interpreted by the ***PEP***.

5.36 Element <AttributeAssignment>

The `<AttributeAssignment>` element is used for including arguments in ***obligation*** and ***advice*** expressions. It SHALL contain an `AttributeId` and the corresponding ***attribute*** value, by extending the `AttributeValueType` type definition. The `<AttributeAssignment>` element MAY be used in any way that is consistent with the schema syntax, which is a sequence of `<xs:any>` elements. The value specified SHALL be understood by the ***PEP***, but it is not further specified by XACML. See Section 7.16. Section 4.2.4.3 provides a number of examples of arguments included in ***obligation***.expressions.

```
<xs:element name="AttributeAssignment" type="xacml:AttributeAssignmentType"/>
<xs:complexType name="AttributeAssignmentType" mixed="true">
   <xs:complexContent>
         <xs:extension base="xacml:AttributeValueType">
               <xs:attribute name="AttributeId" type="xs:anyURI"
                   use="required"/>
               <xs:attribute name="Category" type="xs:anyURI"
                   use="optional"/>
               <xs:attribute name="Issuer" type="xs:string" use="optional"/>
         </xs:extension>
   </xs:complexContent>
</xs:complexType>
```

The `<AttributeAssignment>` element is of `AttributeAssignmentType` complex type.

The `<AttributeAssignment>` element contains the following attributes:

`AttributeId` [Required]

The ***attribute*** Identifier.

`Category` [Optional]

An optional category of the ***attribute***. If this attribute is missing, the ***attribute*** has no category. The ***PEP*** SHALL interpret the significance and meaning of any `Category` attribute. Non-normative note: an expected use of the category is to disambiguate ***attributes*** which are relayed from the request.

`Issuer` [Optional]

An optional issuer of the ***attribute***. If this attribute is missing, the ***attribute*** has no issuer. The ***PEP*** SHALL interpret the significance and meaning of any `Issuer` attribute. Non-normative note: an expected use of the issuer is to disambiguate ***attributes*** which are relayed from the request.

5.37 Element <ObligationExpressions>

The `<ObligationExpressions>` element SHALL contain a set of `<ObligationExpression>` elements.

```
<xs:element name="ObligationExpressions"
    type="xacml:ObligationExpressionsType"/>
<xs:complexType name="ObligationExpressionsType">
  <xs:sequence>
         <xs:element ref="xacml:ObligationExpression" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

The `<ObligationExpressions>` element is of `ObligationExpressionsType` complexType.

The `<ObligationExpressions>` element contains the following element:

`<ObligationExpression>` [One to Many]

A sequence of ***obligations*** expressions. See Section 5.39.

5.38 Element <AdviceExpressions>

The `<AdviceExpressions>` element SHALL contain a set of `<AdviceExpression>` elements.

```
<xs:element name="AdviceExpressions" type="xacml:AdviceExpressionsType"/>
<xs:complexType name="AdviceExpressionsType">
  <xs:sequence>
         <xs:element ref="xacml:AdviceExpression" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

The `<AdviceExpressions>` element is of `AdviceExpressionsType` complexType.

The `<AdviceExpressions>` element contains the following element:

`<AdviceExpression>` [One to Many]

A sequence of ***advice*** expressions. See Section 5.40.

5.39 Element <ObligationExpression>

The `<ObligationExpression>` element evaluates to an ***obligation*** and SHALL contain an identifier for an ***obligation*** and a set of expressions that form arguments of the action defined by the ***obligation***. The `FulfillOn` attribute SHALL indicate the ***effect*** for which this ***obligation*** must be fulfilled by the ***PEP***.

```
<xs:element name="ObligationExpression"
     type="xacml:ObligationExpressionType"/>
<xs:complexType name="ObligationExpressionType">
  <xs:sequence>
    <xs:element ref="xacml:AttributeAssignmentExpression" minOccurs="0"
          maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="ObligationId" type="xs:anyURI" use="required"/>
  <xs:attribute name="FulfillOn" type="xacml:EffectType" use="required"/>
</xs:complexType>
```

The `<ObligationExpression>` element is of `ObligationExpressionType` complexType. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** is determined.

The `<ObligationExpression>` element contains the following elements and attributes:

`ObligationId` [Required]

> ***Obligation*** identifier. The value of the ***obligation*** identifier SHALL be interpreted by the ***PEP***.

`FulfillOn` [Required]

> The ***effect*** for which this ***obligation*** must be fulfilled by the ***PEP***.

`<AttributeAssignmentExpression>` [Optional]

> ***Obligation*** arguments in the form of expressions. The expressions SHALL be evaluated by the PDP to constant `<AttributeValue>` elements or ***bags***, which shall be the attribute assignments in the `<Obligation>` returned to the PEP. If an `<AttributeAssignmentExpression>` evaluates to an atomic ***attribute*** value, then there MUST be one resulting `<AttributeAssignment>` which MUST contain this single ***attribute*** value. If the `<AttributeAssignmentExpression>` evaluates to a ***bag***, then there MUST be a resulting `<AttributeAssignment>` for each of the values in the ***bag***. If the ***bag*** is empty, there shall be no `<AttributeAssignment>` from this `<AttributeAssignmentExpression>`.The values of the ***obligation*** arguments SHALL be interpreted by the ***PEP***.

5.40 Element <AdviceExpression>

The `<AdviceExpression>` element evaluates to an ***advice*** and SHALL contain an identifier for an ***advice*** and a set of expressions that form arguments of the supplemental information defined by the ***advice***. The `AppliesTo` attribute SHALL indicate the ***effect*** for which this ***advice*** must be provided to the ***PEP***.

```
<xs:element name="AdviceExpression" type="xacml:AdviceExpressionType"/>
<xs:complexType name="AdviceExpressionType">
  <xs:sequence>
         <xs:element ref="xacml:AttributeAssignmentExpression" minOccurs="0" 
maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="AdviceId" type="xs:anyURI" use="required"/>
  <xs:attribute name="AppliesTo" type="xacml:EffectType" use="required"/>
</xs:complexType>
```

The `<AdviceExpression>` element is of `AdviceExpressionType` complexType. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** is determined.

The `<AdviceExpression>` element contains the following elements and attributes:

`AdviceId` [Required]

> ***Advice*** identifier. The value of the ***advice*** identifier MAY be interpreted by the ***PEP***.

`AppliesTo` [Required]

> The ***effect*** for which this ***advice*** must be provided to the ***PEP***.

`<AttributeAssignmentExpression>` [Optional]

> ***Advice*** arguments in the form of expressions. The expressions SHALL be evaluated by the PDP to constant `<AttributeValue>` elements or ***bags***, which shall be the attribute assignments in the `<Advice>` returned to the PEP. If an `<AttributeAssignmentExpression>` evaluates to an atomic ***attribute*** value, then there MUST be one resulting `<AttributeAssignment>` which MUST contain this single ***attribute*** value. If the `<AttributeAssignmentExpression>`

evaluates to a ***bag***, then there MUST be a resulting `<AttributeAssignment>` for each of the values in the ***bag***. If the ***bag*** is empty, there shall be no `<AttributeAssignment>` from this `<AttributeAssignmentExpression>`. The values of the ***advice*** arguments MAY be interpreted by the ***PEP***.

5.41 Element <AttributeAssignmentExpression>

The `<AttributeAssignmentExpression>` element is used for including arguments in ***obligations*** and ***advice***. It SHALL contain an `AttributeId` and an expression which SHALL by evaluated into the corresponding ***attribute*** value. The value specified SHALL be understood by the ***PEP***, but it is not further specified by XACML. See Section 7.16. Section 4.2.4.3 provides a number of examples of arguments included in ***obligations***.

```
<xs:element name="AttributeAssignmentExpression"
    type="xacml:AttributeAssignmentExpressionType"/>
<xs:complexType name="AttributeAssignmentExpressionType">
  <xs:sequence>
    <xs:element ref="xacml:Expression"/>
  </xs:sequence>
  <xs:attribute name="AttributeId" type="xs:anyURI" use="required"/>
  <xs:attribute name="Category" type="xs:anyURI" use="optional"/>
  <xs:attribute name="Issuer" type="xs:string" use="optional"/>
</xs:complexType>
```

The `<AttributeAssignmentExpression>` element is of `AttributeAssignmentExpressionType` complex type.

The `<AttributeAssignmentExpression>` element contains the following attributes:

`<Expression>` [Required]

The expression which evaluates to a constant ***attribute*** value or a bag of zero or more attribute values. See section 5.25.

`AttributeId` [Required]

The ***attribute*** identifier. The value of the AttributeId attribute in the resulting <AttributeAssignment> element MUST be equal to this value.

`Category` [Optional]

An optional category of the ***attribute***. If this attribute is missing, the ***attribute*** has no category. The value of the `Category` attribute in the resulting <AttributeAssignment> element MUST be equal to this value.

`Issuer` [Optional]

An optional issuer of the ***attribute***. If this attribute is missing, the ***attribute*** has no issuer. The value of the `Issuer` attribute in the resulting <AttributeAssignment> element MUST be equal to this value.

5.42 Element <Request>

The `<Request>` element is an abstraction layer used by the ***policy*** language. For simplicity of expression, this document describes ***policy*** evaluation in terms of operations on the ***context***. However a conforming ***PDP*** is not required to actually instantiate the ***context*** in the form of an XML document. But, any system conforming to the XACML specification MUST produce exactly the same ***authorization decisions*** as if all the inputs had been transformed into the form of an `<Request>` element.

The `<Request>` element contains `<Attributes>` elements. There may be multiple `<Attributes>` elements with the same `Category` attribute if the ***PDP*** implements the multiple decision profile, see **[Multi]**. Under other conditions, it is a syntax error if there are multiple `<Attributes>` elements with the same `Category` (see Section 7.17.2 for error codes).

```
<xs:element name="Request" type="xacml:RequestType"/>
<xs:complexType name="RequestType">
  <xs:sequence>
        <xs:element ref="xacml:RequestDefaults" minOccurs="0"/>
        <xs:element ref="xacml:Attributes" maxOccurs="unbounded"/>
        <xs:element ref="xacml:MultiRequests" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="ReturnPolicyIdList" type="xs:boolean" use="required"/>
  <xs:attribute name="CombinedDecision" type="xs:boolean" use="required" />
</xs:complexType>
```

The `<Request>` element is of `RequestType` complex type.

The `<Request>` element contains the following elements and attributes:

`ReturnPolicyIdList` [Required]

This attribute is used to request that the ***PDP*** return a list of all fully applicable ***policies*** and ***policy sets*** which were used in the decision as a part of the decision response.

`CombinedDecision` [Required]

This attribute is used to request that the ***PDP*** combines multiple decisions into a single decision. The use of this attribute is specified in **[Multi]**. If the ***PDP*** does not implement the relevant functionality in **[Multi]**, then the ***PDP*** must return an Indeterminate with a status code of urn:oasis:names:tc:xacml:1.0:status:processing-error if it receives a request with this attribute set to “true”.

`<RequestDefaults>` [Optional]

Contains default values for the request, such as XPath version. See section 5.43.

`<Attributes>` [One to Many]

Specifies information about ***attributes*** of the request ***context*** by listing a sequence of `<Attribute>` elements associated with an ***attribute*** category. One or more `<Attributes>` elements are allowed. Different `<Attributes>` elements with different categories are used to represent information about the ***subject***, ***resource***, ***action***, ***environment*** or other categories of the ***access*** request.

`<MultiRequests>` [Optional]

Lists multiple ***request contexts*** by references to the `<Attributes>` elements. Implementation of this element is optional. The semantics of this element is defined in **[Multi]**. If the implementation does not implement this element, it MUST return an Indeterminate result if it encounters this element. See section 5.50.

5.43 Element <RequestDefaults>

The `<RequestDefaults>` element SHALL specify default values that apply to the `<Request>` element.

```
<xs:element name="RequestDefaults" type="xacml:RequestDefaultsType"/>
<xs:complexType name="RequestDefaultsType">
  <xs:sequence>
        <xs:choice>
              <xs:element ref="xacml:XPathVersion"/>
        </xs:choice>
  </xs:sequence>
</xs:complexType>
```

`<RequestDefaults>` element is of `RequestDefaultsType` complex type.

The `<RequestDefaults>` element contains the following elements:

`<XPathVersion>` [Optional]

Default XPath version for XPath expressions occurring in the request.

5.44 Element <Attributes>

The `<Attributes>` element specifies ***attributes*** of a ***subject***, ***resource***, ***action***, ***environment*** or another category by listing a sequence of `<Attribute>` elements associated with the category.

```
<xs:element name="Attributes" type="xacml:AttributesType"/>
<xs:complexType name="AttributesType">
   <xs:sequence>
          <xs:element ref="xacml:Content" minOccurs="0"/>
          <xs:element ref="xacml:Attribute" minOccurs="0"
               maxOccurs="unbounded"/>
   </xs:sequence>
   <xs:attribute name="Category" type="xs:anyURI" use="required"/>
   <xs:attribute ref="xml:id" use="optional"/>
</xs:complexType><xs:complexType name="SubjectType">
```

The `<Attributes>` element is of `AttributesType` complex type.

The `<Attributes>` element contains the following elements and attributes:

`Category` [Required]

This attribute indicates which ***attribute*** category the contained ***attributes*** belong to. The `Category` attribute is used to differentiate between ***attributes*** of ***subject***, ***resource***, ***action***, ***environment*** or other categories.

`xml:id` [Optional]

This attribute provides a unique identifier for this `<Attributes>` element. See **[XMLid]** It is primarily intended to be referenced in multiple requests. See **[Multi]**.

`<Content>` [Optional]

Specifies additional sources of ***attributes*** in free form XML document format which can be referenced using `<AttributeSelector>` elements.

`<Attribute>` [Any Number]

A sequence of ***attributes*** that apply to the category of the request.

5.45 Element <Content>

The `<Content>` element is a notional placeholder for additional ***attributes***, typically the content of the ***resource***.

```
<xs:element name="Content" type="xacml:ContentType"/>
<xs:complexType name="ContentType" mixed="true">
   <xs:sequence>
          <xs:any namespace="##any" processContents="lax"/>
   </xs:sequence>
</xs:complexType>
```

The `<Content>` element is of `ContentType` complex type.

The `<Content>` element has exactly one arbitrary type child element.

5.46 Element <Attribute>

The `<Attribute>` element is the central abstraction of the request ***context***. It contains ***attribute*** meta-data and one or more ***attribute*** values. The ***attribute*** meta-data comprises the ***attribute*** identifier and the ***attribute*** issuer. `<AttributeDesignator>` elements in the ***policy*** MAY refer to ***attributes*** by means of this meta-data.

```
<xs:element name="Attribute" type="xacml:AttributeType"/>
<xs:complexType name="AttributeType">
   <xs:sequence>
```

```
		<xs:element ref="xacml:AttributeValue" maxOccurs="unbounded"/>
	</xs:sequence>
	<xs:attribute name="AttributeId" type="xs:anyURI" use="required"/>
	<xs:attribute name="Issuer" type="xs:string" use="optional"/>
	<xs:attribute name="IncludeInResult" type="xs:boolean" use="required"/>
</xs:complexType>
```

The `<Attribute>` element is of `AttributeType` complex type.

The `<Attribute>` element contains the following attributes and elements:

`AttributeId` [Required]

The ***Attribute*** identifier. A number of identifiers are reserved by XACML to denote commonly used ***attributes***. See Appendix B.

`Issuer` [Optional]

The ***Attribute*** issuer. For example, this attribute value MAY be an `x500Name` that binds to a public key, or it may be some other identifier exchanged out-of-band by issuing and relying parties.

`IncludeInResult` [Default: false]

Whether to include this ***attribute*** in the result. This is useful to correlate requests with their responses in case of multiple requests.

`<AttributeValue>` [One to Many]

One or more ***attribute*** values. Each ***attribute*** value MAY have contents that are empty, occur once or occur multiple times.

5.47 Element <Response>

The `<Response>` element is an abstraction layer used by the ***policy*** language. Any proprietary system using the XACML specification MUST transform an XACML ***context*** `<Response>` element into the form of its ***authorization decision***.

The `<Response>` element encapsulates the ***authorization decision*** produced by the ***PDP***. It includes a sequence of one or more results, with one `<Result>` element per requested ***resource***. Multiple results MAY be returned by some implementations, in particular those that support the XACML Profile for Requests for Multiple Resources **[Multi]**. Support for multiple results is OPTIONAL.

```
<xs:element name="Response" type="xacml:ResponseType"/>
<xs:complexType name="ResponseType">
	<xs:sequence>
		<xs:element ref="xacml:Result" maxOccurs="unbounded"/>
	</xs:sequence>
</xs:complexType>
```

The `<Response>` element is of `ResponseType` complex type.

The `<Response>` element contains the following elements:

`<Result>` [One to Many]

An ***authorization decision*** result. See Section 5.48.

5.48 Element <Result>

The `<Result>` element represents an ***authorization decision*** result. It MAY include a set of ***obligations*** that MUST be fulfilled by the ***PEP***. If the ***PEP*** does not understand or cannot fulfill an ***obligation***, then the action of the PEP is determined by its bias, see section 7.1. It MAY include a set of ***advice*** with supplemental information which MAY be safely ignored by the ***PEP***.

```
<xs:complexType name="ResultType">
	<xs:sequence>
```

```
            <xs:element ref="xacml:Decision"/>
            <xs:element ref="xacml:Status" minOccurs="0"/>
            <xs:element ref="xacml:Obligations" minOccurs="0"/>
            <xs:element ref="xacml:AssociatedAdvice" minOccurs="0"/>
            <xs:element ref="xacml:Attributes" minOccurs="0"
                 maxOccurs="unbounded"/>
            <xs:element ref="xacml:PolicyIdentifierList" minOccurs="0"/>
   </xs:sequence>
</xs:complexType>
```

The `<Result>` element is of `ResultType` complex type.

The `<Result>` element contains the following attributes and elements:

`<Decision>` [Required]

The ***authorization decision***: “Permit”, “Deny”, “Indeterminate” or “NotApplicable”.

`<Status>` [Optional]

Indicates whether errors occurred during evaluation of the ***decision request***, and optionally, information about those errors. If the `<Response>` element contains `<Result>` elements whose `<Status>` elements are all identical, and the `<Response>` element is contained in a protocol wrapper that can convey status information, then the common status information MAY be placed in the protocol wrapper and this `<Status>` element MAY be omitted from all `<Result>` elements.

`<Obligations>` [Optional]

A list of ***obligations*** that MUST be fulfilled by the ***PEP***. If the ***PEP*** does not understand or cannot fulfill an ***obligation***, then the action of the PEP is determined by its bias, see section 7.2. See Section 7.16 for a description of how the set of ***obligations*** to be returned by the ***PDP*** is determined.

`<AssociatedAdvice>` [Optional]

A list of ***advice*** that provide supplemental information to the ***PEP***. If the ***PEP*** does not understand an ***advice***, the PEP may safely ignore the ***advice***. See Section 7.16 for a description of how the set of ***advice*** to be returned by the ***PDP*** is determined.

`<Attributes>` [Optional]

A list of ***attributes*** that were part of the request. The choice of which ***attributes*** are included here is made with the `IncludeInResult` attribute of the `<Attribute>` elements of the request. See section 5.46.

`<PolicyIdentifierList>` [Optional]

If the `ReturnPolicyIdList` attribute in the `<Request>` is true (see section 5.42), a ***PDP*** that implements this optional feature MUST return a list of all ***policies*** which were found to be fully applicable. That is, all ***policies*** where both the `<Target>` matched and the `<Condition>` evaluated to true, whether or not the `<Effect>` was the same or different from the `<Decision>`.

5.49 Element <PolicyIdentifierList>

The `<PolicyIdentifierList>` element contains a list of ***policy*** and ***policy set*** identifiers of ***policies*** which have been applicable to a request. The list is unordered.

```
<xs:element name="PolicyIdentifierList"
   type="xacml:PolicyIdentifierListType"/>
<xs:complexType name="PolicyIdentifierListType">
     <xs:choice minOccurs="0" maxOccurs="unbounded">
          <xs:element ref="xacml:PolicyIdReference"/>
          <xs:element ref="xacml:PolicySetIdReference"/>
     </xs:choice>
```

```
</xs:complexType>
```

The `<PolicyIdentifierList>` element is of `PolicyIdentifierListType` complex type.

The `<PolicyIdentifierList>` element contains the following elements.

`<PolicyIdReference>` [Any number]

The identifier and version of a ***policy*** which was applicable to the request. See section 5.11. The `<PolicyIdReference>` element MUST use the `Version` attribute to specify the version and MUST NOT use the `LatestVersion` or `EarliestVersion` attributes.

`<PolicySetIdReference>` [Any number]

The identifier and version of a ***policy set*** which was applicable to the request. See section 5.10. The `<PolicySetIdReference>` element MUST use the `Version` attribute to specify the version and MUST NOT use the `LatestVersion` or `EarliestVersion` attributes.

5.50 Element <MultiRequests>

The `<MultiRequests>` element contains a list of requests by reference to `<Attributes>` elements in the enclosing `<Request>` element. The semantics of this element are defined in **[Multi]**. Support for this element is optional. If an implementation does not support this element, but receives it, the implementation MUST generate an “Indeterminate” response.

```
<xs:element name="MultiRequests" type="xacml:MultiRequestsType"/>
<xs:complexType name="MultiRequestsType">
   <xs:sequence>
         <xs:element ref="xacml:RequestReference" maxOccurs="unbounded"/>
   </xs:sequence>
</xs:complexType>
```

The `<MultiRequests>` element contains the following elements.

`<RequestReference>` [one to many]

Defines a request instance by reference to `<Attributes>` elements in the enclosing `<Request>` element. See section 5.51.

5.51 Element <RequestReference>

The `<RequestReference>` element defines an instance of a request in terms of references to `<Attributes>` elements. The semantics of this element are defined in **[Multi]**. Support for this element is optional.

```
<xs:element name="RequestReference" type="xacml:RequestReference "/>
<xs:complexType name="RequestReferenceType">
   <xs:sequence>
         <xs:element ref="xacml:AttributesReference" maxOccurs="unbounded"/>
   </xs:sequence>
</xs:complexType>
```

The `<RequestReference>` element contains the following elements.

`<AttributesReference>` [one to many]

A reference to an `<Attributes>` element in the enclosing `<Request>` element. See section 5.52.

5.52 Element <AttributesReference>

The `<AttributesReference>` element makes a reference to an `<Attributes>` element. The meaning of this element is defined in **[Multi]**. Support for this element is optional.

```
<xs:element name="AttributesReference" type="xacml:AttributesReference "/>
```

```
<xs:complexType name="AttributesReferenceType">
   <xs:attribute name="ReferenceId" type="xs:IDREF" use="required" />
</xs:complexType>
```

The `<AttributesReference>` element contains the following attributes.

`ReferenceId` [required]

A reference to the `xml:id` attribute of an `<Attributes>` element in the enclosing `<Request>` element.

5.53 Element <Decision>

The `<Decision>` element contains the result of ***policy*** evaluation.

```
<xs:element name="Decision" type="xacml:DecisionType"/>
<xs:simpleType name="DecisionType">
   <xs:restriction base="xs:string">
         <xs:enumeration value="Permit"/>
         <xs:enumeration value="Deny"/>
         <xs:enumeration value="Indeterminate"/>
         <xs:enumeration value="NotApplicable"/>
   </xs:restriction>
</xs:simpleType>
```

The `<Decision>` element is of `DecisionType` simple type.

The values of the `<Decision>` element have the following meanings:

“Permit”: the requested ***access*** is permitted.

“Deny”: the requested ***access*** is denied.

“Indeterminate”: the ***PDP*** is unable to evaluate the requested ***access***. Reasons for such inability include: missing ***attributes***, network errors while retrieving ***policies***, division by zero during ***policy*** evaluation, syntax errors in the ***decision request*** or in the ***policy***, etc.

“NotApplicable”: the ***PDP*** does not have any ***policy*** that applies to this ***decision request***.

5.54 Element <Status>

The `<Status>` element represents the status of the ***authorization decision*** result.

```
<xs:element name="Status" type="xacml:StatusType"/>
<xs:complexType name="StatusType">
   <xs:sequence>
         <xs:element ref="xacml:StatusCode"/>
         <xs:element ref="xacml:StatusMessage" minOccurs="0"/>
         <xs:element ref="xacml:StatusDetail" minOccurs="0"/>
   </xs:sequence>
</xs:complexType>
```

The `<Status>` element is of `StatusType` complex type.

The `<Status>` element contains the following elements:

`<StatusCode>` [Required]

Status code.

`<StatusMessage>` [Optional]

A status message describing the status code.

`<StatusDetail>` [Optional]

Additional status information.

5.55 Element <StatusCode>

The `<StatusCode>` element contains a major status code value and an optional sequence of minor status codes.

```
<xs:element name="StatusCode" type="xacml:StatusCodeType"/>
<xs:complexType name="StatusCodeType">
   <xs:sequence>
          <xs:element ref="xacml:StatusCode" minOccurs="0"/>
   </xs:sequence>
   <xs:attribute name="Value" type="xs:anyURI" use="required"/>
</xs:complexType>
```

The `<StatusCode>` element is of `StatusCodeType` complex type.

The `<StatusCode>` element contains the following attributes and elements:

`Value` [Required]

  See Section B.8 for a list of values.

`<StatusCode>` [Any Number]

  Minor status code. This status code qualifies its parent status code.

5.56 Element <StatusMessage>

The `<StatusMessage>` element is a free-form description of the status code.

```
<xs:element name="StatusMessage" type="xs:string"/>
```

The `<StatusMessage>` element is of `xs:string` type.

5.57 Element <StatusDetail>

The `<StatusDetail>` element qualifies the `<Status>` element with additional information.

```
<xs:element name="StatusDetail" type="xacml:StatusDetailType"/>
<xs:complexType name="StatusDetailType">
   <xs:sequence>
          <xs:any namespace="##any" processContents="lax" minOccurs="0"
               maxOccurs="unbounded"/>
   </xs:sequence>
</xs:complexType>
```

The `<StatusDetail>` element is of `StatusDetailType` complex type.

The `<StatusDetail>` element allows arbitrary XML content.

Inclusion of a `<StatusDetail>` element is optional. However, if a ***PDP*** returns one of the following XACML-defined `<StatusCode>` values and includes a `<StatusDetail>` element, then the following rules apply.

urn:oasis:names:tc:xacml:1.0:status:ok

A ***PDP*** MUST NOT return a `<StatusDetail>` element in conjunction with the “ok” status value.

urn:oasis:names:tc:xacml:1.0:status:missing-attribute

A ***PDP*** MAY choose not to return any `<StatusDetail>` information or MAY choose to return a `<StatusDetail>` element containing one or more `<MissingAttributeDetail>` elements.

urn:oasis:names:tc:xacml:1.0:status:syntax-error

A ***PDP*** MUST NOT return a `<StatusDetail>` element in conjunction with the “syntax-error” status value. A syntax error may represent either a problem with the ***policy*** being used or with the request ***context***. The ***PDP*** MAY return a `<StatusMessage>` describing the problem.

urn:oasis:names:tc:xacml:1.0:status:processing-error

A ***PDP*** MUST NOT return `<StatusDetail>` element in conjunction with the "processing-error" status value. This status code indicates an internal problem in the ***PDP***. For security reasons, the ***PDP*** MAY choose to return no further information to the ***PEP***. In the case of a divide-by-zero error or other computational error, the ***PDP*** MAY return a `<StatusMessage>` describing the nature of the error.

5.58 Element <MissingAttributeDetail>

The `<MissingAttributeDetail>` element conveys information about ***attributes*** required for ***policy*** evaluation that were missing from the request ***context***.

```
<xs:element name="MissingAttributeDetail"
type="xacml:MissingAttributeDetailType"/>
<xs:complexType name="MissingAttributeDetailType">
<xs:sequence>
         <xs:element ref="xacml:AttributeValue" minOccurs="0"
              maxOccurs="unbounded"/>
</xs:sequence>
<xs:attribute name="Category" type="xs:anyURI" use="required"/>
<xs:attribute name="AttributeId" type="xs:anyURI" use="required"/>
<xs:attribute name="DataType" type="xs:anyURI" use="required"/>
   <xs:attribute name="Issuer" type="xs:string" use="optional"/>
</xs:complexType>
```

The `<MissingAttributeDetail>` element is of `MissingAttributeDetailType` complex type.

The `<MissingAttributeDetal>` element contains the following attributes and elements:

`<AttributeValue>` [Optional]

The required value of the missing ***attribute***.

`Category` [Required]

The category identifier of the missing ***attribute***.

`AttributeId` [Required]

The identifier of the missing ***attribute***.

`DataType` [Required]

The data-type of the missing ***attribute***.

`Issuer` [Optional]

This attribute, if supplied, SHALL specify the required `Issuer` of the missing ***attribute***.

If the ***PDP*** includes `<AttributeValue>` elements in the `<MissingAttributeDetail>` element, then this indicates the acceptable values for that ***attribute***. If no `<AttributeValue>` elements are included, then this indicates the names of ***attributes*** that the ***PDP*** failed to resolve during its evaluation. The list of ***attributes*** may be partial or complete. There is no guarantee by the ***PDP*** that supplying the missing values or ***attributes*** will be sufficient to satisfy the ***policy***.

6 XPath 2.0 definitions

The XPath 2.0 specification leaves a number of aspects of behavior implementation defined. This section defines how XPath 2.0 SHALL behave when hosted in XACML.

http://www.w3.org/TR/2007/REC-xpath20-20070123/#id-impl-defined-items defines the following items:

1. The version of Unicode that is used to construct expressions.
   XACML leaves this implementation defined. It is RECOMMENDED that the latest version is used.
2. The statically-known collations.
   XACML leaves this implementation defined.
3. The implicit timezone.
   XACML defined the implicit time zone as UTC.
4. The circumstances in which warnings are raised, and the ways in which warnings are handled.
   XACML leaves this implementation defined.
5. The method by which errors are reported to the external processing environment.
   An XPath error causes an XACML Indeterminate value in the element where the XPath error occurs. The StatusCode value SHALL be "urn:oasis:names:tc:xacml:1.0:status:processing-error". Implementations MAY provide additional details about the error in the response or by some other means.
6. Whether the implementation is based on the rules of XML 1.0 or 1.1.
   XACML is based on XML 1.0.
7. Whether the implementation supports the namespace axis.
   XACML leaves this implementation defined. It is RECOMMENDED that users of XACML do not make use of the namespace axis.
8. Any static typing extensions supported by the implementation, if the Static Typing Feature is supported.
   XACML leaves this implementation defined.

http://www.w3.org/TR/2007/REC-xpath-datamodel-20070123/#implementation-defined defines the following items:

1. Support for additional user-defined or implementation-defined types is implementation-defined.
   It is RECOMMENDED that implementations of XACML do not define any additional types and it is RECOMMENDED that users of XACML do not make user of any additional types.
2. Some typed values in the data model are undefined. Attempting to access an undefined property is always an error. Behavior in these cases is implementation-defined and the host language is responsible for determining the result.
   An XPath error causes an XACML Indeterminate value in the element where the XPath error occurs. The StatusCode value SHALL be "urn:oasis:names:tc:xacml:1.0:status:processing-error". Implementations MAY provide additional details about the error in the response or by some other means.

http://www.w3.org/TR/2007/REC-xpath-functions-20070123/#impl-def defines the following items:

1. The destination of the trace output is implementation-defined.
   XACML leaves this implementation defined.
2. For xs:integer operations, implementations that support limited-precision integer operations must either raise an error [err:FOAR0002] or provide an implementation-defined mechanism that allows users to choose between raising an error and returning a result that is modulo the largest representable integer value.
   XACML leaves this implementation defined. If an implementation chooses to raise an error, the

StatusCode value SHALL be “urn:oasis:names:tc:xacml:1.0:status:processing-error”. Implementations MAY provide additional details about the error in the response or by some other means.

3. For xs:decimal values the number of digits of precision returned by the numeric operators is implementation-defined.
XACML leaves this implementation defined.

4. If the number of digits in the result of a numeric operation exceeds the number of digits that the implementation supports, the result is truncated or rounded in an implementation-defined manner.
XACML leaves this implementation defined.

5. It is implementation-defined which version of Unicode is supported.
XACML leaves this implementation defined. It is RECOMMENDED that the latest version is used.

6. For fn:normalize-unicode, conforming implementations must support normalization form "NFC" and may support normalization forms "NFD", "NFKC", "NFKD", "FULLY-NORMALIZED". They may also support other normalization forms with implementation-defined semantics.
XACML leaves this implementation defined.

7. The ability to decompose strings into collation units suitable for substring matching is an implementation-defined property of a collation.
XACML leaves this implementation defined.

8. All minimally conforming processors must support year values with a minimum of 4 digits (i.e., YYYY) and a minimum fractional second precision of 1 millisecond or three digits (i.e., s.sss). However, conforming processors may set larger implementation-defined limits on the maximum number of digits they support in these two situations.
XACML leaves this implementation defined, and it is RECOMMENDED that users of XACML do not expect greater limits and precision.

9. The result of casting a string to xs:decimal, when the resulting value is not too large or too small but nevertheless has too many decimal digits to be accurately represented, is implementation-defined.
XACML leaves this implementation defined.

10. Various aspects of the processing provided by fn:doc are implementation-defined. Implementations may provide external configuration options that allow any aspect of the processing to be controlled by the user.
XACML leaves this implementation defined.

11. The manner in which implementations provide options to weaken the stable characteristic of fn:collection and fn:doc are implementation-defined.
XACML leaves this implementation defined.

7 Functional requirements

This section specifies certain functional requirements that are not directly associated with the production or consumption of a particular XACML element.

7.1 Unicode issues

7.1.1 Normalization

In Unicode, some equivalent characters can be represented by more than one different Unicode character sequence. See **[CMF]**. The process of converting Unicode strings into equivalent character sequences is called "normalization" **[UAX15]**. Some operations, such as string comparison, are sensitive to normalization. An operation is normalization-sensitive if its output(s) are different depending on the state of normalization of the input(s); if the output(s) are textual, they are deemed different only if they would remain different were they to be normalized.

For more information on normalization see **[CM]**.

An XACML implementation MUST behave as if each normalization-sensitive operation normalizes input strings into Unicode Normalization Form C ("NFC"). An implementation MAY use some other form of internal processing (such as using a non-Unicode, "legacy" character encoding) as long as the externally visible results are identical to this specification.

7.1.2 Version of Unicode

The version of Unicode used by XACML is implementation defined. It is RECOMMENDED that the latest version is used. Also note security issues in section 9.3.

7.2 Policy enforcement point

This section describes the requirements for the ***PEP***.

An application functions in the role of the ***PEP*** if it guards ***access*** to a set of ***resources*** and asks the ***PDP*** for an ***authorization decision***. The ***PEP*** MUST abide by the ***authorization decision*** as described in one of the following sub-sections

In any case any ***advice*** in the ***decision*** may be safely ignored by the ***PEP***.

7.2.1 Base PEP

If the ***decision*** is "Permit", then the ***PEP*** SHALL permit ***access***. If ***obligations*** accompany the ***decision***, then the ***PEP*** SHALL permit ***access*** only if it understands and it can and will discharge those ***obligations***.

If the ***decision*** is "Deny", then the ***PEP*** SHALL deny ***access***. If ***obligations*** accompany the ***decision***, then the ***PEP*** shall deny ***access*** only if it understands, and it can and will discharge those ***obligations***.

If the ***decision*** is “Not Applicable”, then the ***PEP***’s behavior is undefined.

If the ***decision*** is “Indeterminate”, then the ***PEP***’s behavior is undefined.

7.2.2 Deny-biased PEP

If the ***decision*** is "Permit", then the ***PEP*** SHALL permit ***access***. If ***obligations*** accompany the ***decision***, then the ***PEP*** SHALL permit ***access*** only if it understands and it can and will discharge those ***obligations***.

All other ***decisions*** SHALL result in the denial of ***access***.

Note: other actions, e.g. consultation of additional ***PDPs***, reformulation/resubmission of the ***decision request***, etc., are not prohibited.

7.2.3 Permit-biased PEP

If the ***decision*** is "Deny", then the ***PEP*** SHALL deny ***access***. If ***obligations*** accompany the ***decision***, then the ***PEP*** shall deny ***access*** only if it understands, and it can and will discharge those ***obligations***.

All other ***decisions*** SHALL result in the permission of ***access***.

Note: other actions, e.g. consultation of additional ***PDPs***, reformulation/resubmission of the ***decision request***, etc., are not prohibited.

7.3 Attribute evaluation

Attributes are represented in the request ***context*** by the ***context handler***, regardless of whether or not they appeared in the original ***decision request***, and are referred to in the ***policy*** by attribute designators and attribute selectors. A ***named attribute*** is the term used for the criteria that the specific attribute designators use to refer to particular ***attributes*** in the `<Attributes>` elements of the request ***context***.

7.3.1 Structured attributes

`<AttributeValue>` elements MAY contain an instance of a structured XML data-type, for example `<ds:KeyInfo>`. XACML 3.0 supports several ways for comparing the contents of such elements.

1. In some cases, such elements MAY be compared using one of the XACML string functions, such as “string-regexp-match”, described below. This requires that the element be given the data-type "http://www.w3.org/2001/XMLSchema#string". For example, a structured data-type that is actually a `ds:KeyInfo/KeyName` would appear in the ***Context*** as:

```
<AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string">
   &lt;ds:KeyName&gt;jhibbert-key&lt;/ds:KeyName&gt;
</AttributeValue>
```

In general, this method will not be adequate unless the structured data-type is quite simple.

2. The structured ***attribute*** MAY be made available in the `<Content>` element of the appropriate ***attribute*** category and an `<AttributeSelector>` element MAY be used to select the contents of a leaf sub-element of the structured data-type by means of an XPath expression. That value MAY then be compared using one of the supported XACML functions appropriate for its primitive data-type. This method requires support by the ***PDP*** for the optional XPath expressions feature.
3. The structured ***attribute*** MAY be made available in the `<Content>` element of the appropriate ***attribute*** category and an `<AttributeSelector>` element MAY be used to select any node in the structured data-type by means of an XPath expression. This node MAY then be compared using one of the XPath-based functions described in Section A.3.15. This method requires support by the ***PDP*** for the optional XPath expressions and XPath functions features.

See also Section 7.3.

7.3.2 Attribute bags

XACML defines implicit collections of its data-types. XACML refers to a collection of values that are of a single data-type as a ***bag***. ***Bags*** of data-types are needed because selections of nodes from an XML ***resource*** or XACML request ***context*** may return more than one value.

The `<AttributeSelector>` element uses an XPath expression to specify the selection of data from free form XML. The result of an XPath expression is termed a node-set, which contains all the nodes from the XML content that match the ***predicate*** in the XPath expression. Based on the various indexing functions provided in the XPath specification, it SHALL be implied that a resultant node-set is the collection of the matching nodes. XACML also defines the `<AttributeDesignator>` element to have the same matching methodology for ***attributes*** in the XACML request ***context***.

The values in a ***bag*** are not ordered, and some of the values may be duplicates. There SHALL be no notion of a ***bag*** containing ***bags***, or a ***bag*** containing values of differing types; i.e., a ***bag*** in XACML SHALL contain only values that are of the same data-type.

7.3.3 Multivalued attributes

If a single `<Attribute>` element in a request ***context*** contains multiple `<AttributeValue>` child elements, then the ***bag*** of values resulting from evaluation of the `<Attribute>` element MUST be identical to the ***bag*** of values that results from evaluating a ***context*** in which each `<AttributeValue>` element appears in a separate `<Attribute>` element, each carrying identical meta-data.

7.3.4 Attribute Matching

A ***named attribute*** includes specific criteria with which to match ***attributes*** in the ***context***. An ***attribute*** specifies a `Category`, `AttributeId` and `DataType`, and a ***named attribute*** also specifies the `Issuer`. A ***named attribute*** SHALL match an ***attribute*** if the values of their respective `Category`, `AttributeId`, `DataType` and optional `Issuer` attributes match. The `Category` of the ***named attribute*** MUST match, by URI equality, the `Category` of the corresponding ***context attribute***. The `AttributeId` of the ***named attribute*** MUST match, by URI equality, the `AttributeId` of the corresponding ***context attribute***. The `DataType` of the ***named attribute*** MUST match, by URI equality, the `DataType` of the corresponding ***context attribute***. If `Issuer` is supplied in the ***named attribute***, then it MUST match, using the urn:oasis:names:tc:xacml:1.0:function:string-equal function, the `Issuer` of the corresponding ***context attribute***. If `Issuer` is not supplied in the ***named attribute***, then the matching of the ***context attribute*** to the ***named attribute*** SHALL be governed by `AttributeId` and `DataType` alone, regardless of the presence, absence, or actual value of `Issuer` in the corresponding ***context attribute***. In the case of an attribute selector, the matching of the ***attribute*** to the ***named attribute*** SHALL be governed by the XPath expression and `DataType`.

7.3.5 Attribute Retrieval

The ***PDP*** SHALL request the values of ***attributes*** in the request ***context*** from the ***context handler***. The ***PDP*** SHALL reference the ***attributes*** as if they were in a physical request ***context*** document, but the ***context handler*** is responsible for obtaining and supplying the requested values by whatever means it deems appropriate. The ***context handler*** SHALL return the values of ***attributes*** that match the attribute designator or attribute selector and form them into a ***bag*** of values with the specified data-type. If no ***attributes*** from the request ***context*** match, then the ***attribute*** SHALL be considered missing. If the ***attribute*** is missing, then `MustBePresent` governs whether the attribute designator or attribute selector returns an empty ***bag*** or an “Indeterminate” result. If `MustBePresent` is “False” (default value), then a missing ***attribute*** SHALL result in an empty ***bag***. If `MustBePresent` is “True”, then a missing ***attribute*** SHALL result in “Indeterminate”. This “Indeterminate” result SHALL be handled in accordance with the specification of the encompassing expressions, ***rules***, ***policies*** and ***policy sets***. If the result is “Indeterminate”, then the `AttributeId`, `DataType` and `Issuer` of the ***attribute*** MAY be listed in the ***authorization decision*** as described in Section 7.15. However, a ***PDP*** MAY choose not to return such information for security reasons.

7.3.6 Environment Attributes

Standard ***environment attributes*** are listed in Section B.7. If a value for one of these ***attributes*** is supplied in the ***decision request***, then the ***context handler*** SHALL use that value. Otherwise, the ***context handler*** SHALL supply a value. In the case of date and time ***attributes***, the supplied value SHALL have the semantics of the "date and time that apply to the ***decision request***".

7.3.7 AttributeSelector evaluation

An `<AttributeSelector>` element will be evaluated according to the following processing model.

NOTE: It is not necessary for an implementation to actually follow these steps. It is only necessary to produce results identical to those that would be produced by following these steps.

1. Construct an XML data structure suitable for xpath processing from the `<Content>` element in the ***attributes*** category given by the `Category` attribute. The data structure shall be constructed so that the document node of this structure contains a single document element which corresponds to the single child element of the `<Content>` element. The constructed data structure shall be equivalent to one that would result from parsing a stand-alone XML document consisting of the contents of the `<Content>` element (including any comment and processing-instruction markup). Namespace declarations which are not "visibly utilized", as defined by **[exc-c14n]**, MAY not be present and MUST NOT be utilized by the XPath expression in step 3. The data structure must meet the requirements of the applicable xpath version.
2. Select a context node for xpath processing from this data structure. If there is a `ContextSelectorId` attribute, the context node shall be the node selected by applying the XPath expression given in the ***attribute*** value of the designated ***attribute*** (in the ***attributes*** category given by the `<AttributeSelector> Category` attribute). It shall be an error if this evaluation returns no node or more than one node, in which case the return value MUST be an "Indeterminate" with a status code "urn:oasis:names:tc:xacml:1.0:status:syntax-error". If there is no `ContextSelectorId`, the document node of the data structure shall be the context node.
3. Evaluate the XPath expression given in the `Path` attribute against the xml data structure, using the context node selected in the previous step. It shall be an error if this evaluation returns anything other than a sequence of nodes (possibly empty), in which case the `<AttributeSelector>` MUST return "Indeterminate" with a status code "urn:oasis:names:tc:xacml:1.0:status:syntax-error".
4. If the data type is a primitive data type, convert the text value of each selected node to the desired data type, as specified in the `DataType` attribute. Each value shall be constructed using the appropriate constructor function from **[XF]** Section 5 listed below, corresponding to the specified data type.

   xs:string()
   xs:boolean()
   xs:integer()
   xs:double()
   xs:dateTime()
   xs:date()
   xs:time()
   xs:hexBinary()
   xs:base64Binary()
   xs:anyURI()
   xs:yearMonthDuration()
   xs:dayTimeDuration()

   If the `DataType` is not one of the primitive types listed above, then the return values shall be constructed from the nodeset in a manner specified by the of the particular `DataType` extension specification. If the data type extension does not specify an appropriate contructor function, then the `<AttributeSelector>` MUST return "Indeterminate" with a status code "urn:oasis:names:tc:xacml:1.0:status:syntax-error".

   If an error occurs when converting the values returned by the XPath expression to the specified `DataType`, then the result of the `<AttributeSelector>` MUST be "Indeterminate", with a status code "urn:oasis:names:tc:xacml:1.0:status:processing-error"

7.4 Expression evaluation

XACML specifies expressions in terms of the elements listed below, of which the `<Apply>` and `<Condition>` elements recursively compose greater expressions. Valid expressions SHALL be type correct, which means that the types of each of the elements contained within `<Apply>` elements SHALL agree with the respective argument types of the function that is named by the `FunctionId` attribute. The resultant type of the `<Apply>` element SHALL be the resultant type of the function, which MAY be narrowed to a primitive data-type, or a ***bag*** of a primitive data-type, by type-unification. XACML defines an evaluation result of "Indeterminate", which is said to be the result of an invalid expression, or an operational error occurring during the evaluation of the expression.

XACML defines these elements to be in the substitution group of the `<Expression>` element:

- `<xacml:AttributeValue>`
- `<xacml:AttributeDesignator>`
- `<xacml:AttributeSelector>`
- `<xacml:Apply>`
- `<xacml:Condition>`
- `<xacml:Function>`
- `<xacml:VariableReference>`

7.5 Arithmetic evaluation

IEEE 754 **[IEEE754]** specifies how to evaluate arithmetic functions in a context, which specifies defaults for precision, rounding, etc. XACML SHALL use this specification for the evaluation of all integer and double functions relying on the Extended Default Context, enhanced with double precision:

flags - all set to 0

trap-enablers - all set to 0 (IEEE 854 §7) with the exception of the “division-by-zero” trap enabler, which SHALL be set to 1

precision - is set to the designated double precision

rounding - is set to round-half-even (IEEE 854 §4.1)

7.6 Match evaluation

The ***attribute*** matching element `<Match>` appears in the `<Target>` element of ***rules***, ***policies*** and ***policy sets***.

This element represents a Boolean expression over ***attributes*** of the request ***context***. A matching element contains a `MatchId` attribute that specifies the function to be used in performing the match evaluation, an `<AttributeValue>` and an `<AttributeDesignator>` or `<AttributeSelector>` element that specifies the ***attribute*** in the ***context*** that is to be matched against the specified value.

The `MatchId` attribute SHALL specify a function that takes two arguments, returning a result type of "http://www.w3.org/2001/XMLSchema#boolean". The ***attribute*** value specified in the matching element SHALL be supplied to the `MatchId` function as its first argument. An element of the ***bag*** returned by the `<AttributeDesignator>` or `<AttributeSelector>` element SHALL be supplied to the `MatchId` function as its second argument, as explained below. The `DataType` of the `<AttributeValue>` SHALL match the data-type of the first argument expected by the `MatchId` function. The DataType of the `<AttributeDesignator>` or `<AttributeSelector>` element SHALL match the data-type of the second argument expected by the `MatchId` function.

In addition, functions that are strictly within an extension to XACML MAY appear as a value for the `MatchId` attribute, and those functions MAY use data-types that are also extensions, so long as the extension function returns a Boolean result and takes two single base types as its inputs. The function used as the value for the `MatchId` attribute SHOULD be easily indexable. Use of non-indexable or complex functions may prevent efficient evaluation of ***decision requests***.

The evaluation semantics for a matching element is as follows. If an operational error were to occur while evaluating the `<AttributeDesignator>` or `<AttributeSelector>` element, then the result of the entire expression SHALL be "Indeterminate". If the `<AttributeDesignator>` or `<AttributeSelector>` element were to evaluate to an empty ***bag***, then the result of the expression SHALL be "False". Otherwise, the `MatchId` function SHALL be applied between the `<AttributeValue>` and each element of the ***bag*** returned from the `<AttributeDesignator>` or `<AttributeSelector>` element. If at least one of those function applications were to evaluate to "True", then the result of the entire expression SHALL be "True". Otherwise, if at least one of the function applications results in "Indeterminate", then the result SHALL be "Indeterminate". Finally, if all function applications evaluate to "False", then the result of the entire expression SHALL be "False".

It is also possible to express the semantics of a ***target*** matching element in a ***condition***. For instance, the ***target*** match expression that compares a "***subject***-name" starting with the name "John" can be expressed as follows:

```
<Match
MatchId="urn:oasis:names:tc:xacml:1.0:function:string-regexp-match">
    <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string">
       John.*
    </AttributeValue>
    <AttributeDesignator
          Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-
subject"
          AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id"
          DataType="http://www.w3.org/2001/XMLSchema#string"/>
</Match>
```

Alternatively, the same match semantics can be expressed as an `<Apply>` element in a ***condition*** by using the "urn:oasis:names:tc:xacml:1.0:function:any-of" function, as follows:

```
<Apply FunctionId="urn:oasis:names:tc:xacml:1.0:function:any-of">
    <Function
FunctionId="urn:oasis:names:tc:xacml:1.0:function:string-regexp-match"/>
    <AttributeValue DataType="http://www.w3.org/2001/XMLSchema#string">
        John.*
    </AttributeValue>
    <AttributeDesignator
         Category="urn:oasis:names:tc:xacml:1.0:subject-category:access-
subject"
         AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id"
         DataType="http://www.w3.org/2001/XMLSchema#string"/>
</Apply>
```

7.7 Target evaluation

An empty ***target*** matches any request. Otherwise the ***target*** value SHALL be "Match" if all the AnyOf specified in the ***target*** match values in the request ***context***. Otherwise, if any one of the AnyOf specified in the ***target*** is "No Match", then the ***target*** SHALL be "No Match". Otherwise, the ***target*** SHALL be "Indeterminate". The ***target*** match table is shown in Table 1.

<AnyOf> values	***Target*** value
All "Match"	"Match"
At least one "No Match"	"No Match"
Otherwise	"Indeterminate"

Table 1 Target match table

The AnyOf SHALL match values in the request ***context*** if at least one of their `<AllOf>` elements matches a value in the request ***context***. The AnyOf table is shown in Table 2.

`<AllOf>` values	`<AnyOf>` Value
At least one “Match”	“Match”
None matches and at least one “Indeterminate”	“Indeterminate”
All “No match”	“No match”

Table 2 AnyOf match table

An AllOf SHALL match a value in the request ***context*** if the value of all its `<Match>` elements is “True”.

The AllOf table is shown in Table 3.

`<Match>` values	`<AllOf>` Value
All “True”	“Match”
No “False” and at least one “Indeterminate”	“Indeterminate”
At least one “False”	“No match”

Table 3 AllOf match table

7.8 VariableReference Evaluation

The `<VariableReference>` element references a single `<VariableDefinition>` element contained within the same `<Policy>` element. A `<VariableReference>` that does not reference a particular `<VariableDefinition>` element within the encompassing `<Policy>` element is called an undefined reference. ***Policies*** with undefined references are invalid.

In any place where a `<VariableReference>` occurs, it has the effect as if the text of the `<Expression>` element defined in the `<VariableDefinition>` element replaces the `<VariableReference>` element. Any evaluation scheme that preserves this semantic is acceptable. For instance, the expression in the `<VariableDefinition>` element may be evaluated to a particular value and cached for multiple references without consequence. (I.e. the value of an `<Expression>` element remains the same for the entire ***policy*** evaluation.) This characteristic is one of the benefits of XACML being a declarative language.

A variable reference containing circular references is invalid. The PDP MUST detect circular references either at policy loading time or during runtime evaluation. If the PDP detects a circular reference during runtime the variable reference evaluates to “Indeterminate” with status code urn:oasis:names:tc:xacml:1.0:status:processing-error.

7.9 Condition evaluation

The ***condition*** value SHALL be "True" if the `<Condition>` element is absent, or if it evaluates to "True". Its value SHALL be "False" if the `<Condition>` element evaluates to "False". The ***condition*** value SHALL be "Indeterminate", if the expression contained in the `<Condition>` element evaluates to "Indeterminate."

7.10 Rule evaluation

A ***rule*** has a value that can be calculated by evaluating its contents. ***Rule*** evaluation involves separate evaluation of the ***rule***'s ***target*** and ***condition***. The ***rule*** truth table is shown in Table 4.

Target	Condition	***Rule*** Value
"Match" or no target	"True"	***Effect***
"Match" or no target	"False"	"NotApplicable"
"Match" or no target	"Indeterminate"	"Indeterminate"
"No-match"	Don't care	"NotApplicable"
"Indeterminate"	Don't care	"Indeterminate"

Table 4 Rule truth table.

If the ***target*** value is "No-match" or "Indeterminate" then the ***rule*** value SHALL be "NotApplicable" or "Indeterminate", respectively, regardless of the value of the ***condition***. For these cases, therefore, the ***condition*** need not be evaluated.

If the ***target*** value is "Match", or there is no ***target*** in the ***rule***, and the ***condition*** value is "True", then the ***effect*** specified in the enclosing `<Rule>` element SHALL determine the ***rule***'s value.

7.11 Policy evaluation

The value of a ***policy*** SHALL be determined only by its contents, considered in relation to the contents of the request ***context***. A ***policy***'s value SHALL be determined by evaluation of the ***policy***'s ***target*** and ***rules***.

The ***policy***'s ***target*** SHALL be evaluated to determine the applicability of the ***policy***. If the ***target*** evaluates to "Match", then the value of the ***policy*** SHALL be determined by evaluation of the ***policy***'s ***rules***, according to the specified ***rule-combining algorithm***. If the ***target*** evaluates to "No-match", then the value of the ***policy*** SHALL be "NotApplicable". If the ***target*** evaluates to "Indeterminate", then the value of the ***policy*** SHALL be "Indeterminate".

The ***policy*** truth table is shown in Table 5.

Target	***Rule*** values	***Policy*** Value
"Match"	At least one ***rule*** value is its ***Effect***	Specified by the ***rule-combining algorithm***
"Match"	All ***rule*** values are "NotApplicable"	"NotApplicable"
"Match"	At least one ***rule*** value is "Indeterminate"	Specified by the ***rule-combining algorithm***
"No-match"	Don't care	"NotApplicable"
"Indeterminate"	Don't care	"Indeterminate"

Table 5 Policy truth table

A ***rules*** value of "At least one ***rule*** value is its ***Effect***" means either that the `<Rule>` element is absent, or one or more of the ***rules*** contained in the ***policy*** is applicable to the ***decision request*** (i.e., it returns the value of its "***Effect***"; see Section 7.10). A ***rules*** value of "All ***rule*** values are 'NotApplicable'" SHALL be used if no ***rule*** contained in the ***policy*** is applicable to the request and if no ***rule*** contained in the ***policy*** returns a value of "Indeterminate". If no ***rule*** contained in the ***policy*** is applicable to the request, but one or more ***rule*** returns a value of "Indeterminate", then the ***rules*** SHALL evaluate to "At least one ***rule*** value is 'Indeterminate'".

If the ***target*** value is "No-match" or “Indeterminate” then the ***policy*** value SHALL be “NotApplicable” or “Indeterminate”, respectively, regardless of the value of the ***rules***. For these cases, therefore, the ***rules*** need not be evaluated.

If the ***target*** value is “Match” and the ***rule*** value is “At least one ***rule*** value is it’s ***Effect***” or “At least one ***rule*** value is ‘Indeterminate’”, then the ***rule-combining algorithm*** specified in the ***policy*** SHALL determine the ***policy*** value.

Note that none of the ***rule-combining algorithms*** defined by XACML 3.0 take parameters. However, non-standard combining algorithms MAY take parameters. In such a case, the values of these parameters associated with the ***rules***, MUST be taken into account when evaluating the ***policy***. The parameters and their types should be defined in the specification of the combining algorithm. If the implementation supports combiner parameters and if combiner parameters are present in a ***policy***, then the parameter values MUST be supplied to the combining algorithm implementation.

7.12 Policy Set evaluation

The value of a ***policy set*** SHALL be determined by its contents, considered in relation to the contents of the request ***context***. A ***policy set***'s value SHALL be determined by evaluation of the ***policy set***'s ***target***, ***policies,*** and ***policy sets***, according to the specified ***policy-combining algorithm***.

The ***policy set***'s ***target*** SHALL be evaluated to determine the applicability of the ***policy set***. If the ***target*** evaluates to "Match" then the value of the ***policy set*** SHALL be determined by evaluation of the ***policy set***'s ***policies*** and ***policy sets***, according to the specified ***policy-combining algorithm***.   If the ***target*** evaluates to "No-match", then the value of the ***policy set*** shall be "NotApplicable". If the ***target*** evaluates to "Indeterminate", then the value of the ***policy set*** SHALL be "Indeterminate".

The ***policy set*** truth table is shown in Table 6.

Target	***Policy*** values	***Policy set*** Value
“Match”	At least one ***policy*** value is its ***Decision***	Specified by the ***policy-combining algorithm***
“Match”	All ***policy*** values are “NotApplicable”	“NotApplicable”
“Match”	At least one ***policy*** value is “Indeterminate”	Specified by the ***policy-combining algorithm***
“No-match”	Don’t care	“NotApplicable”
“Indeterminate”	Don’t care	“Indeterminate”

Table 6 Policy set truth table

A ***policies*** value of "At least one ***policy*** value is its Decision" SHALL be used if there are no contained or referenced ***policies*** or ***policy sets***, or if one or more of the ***policies*** or ***policy sets*** contained in or referenced by the ***policy set*** is applicable to the ***decision request*** (i.e., returns a value determined by its combining algorithm) A ***policies*** value of “All ***policy*** values are ‘NotApplicable’” SHALL be used if no ***policy*** or ***policy set*** contained in or referenced by the ***policy set*** is applicable to the request and if no ***policy*** or ***policy set*** contained in or referenced by the ***policy set*** returns a value of “Indeterminate”. If no ***policy*** or ***policy set*** contained in or referenced by the ***policy set*** is applicable to the request but one or more ***policy*** or ***policy set*** returns a value of “Indeterminate”, then the ***policies*** SHALL evaluate to "At least one ***policy*** value is ‘Indeterminate’".

If the ***target*** value is "No-match" or “Indeterminate” then the ***policy set*** value SHALL be “NotApplicable” or “Indeterminate”, respectively, regardless of the value of the ***policies***. For these cases, therefore, the ***policies*** need not be evaluated.

If the ***target*** value is “Match” and the ***policies*** value is “At least one ***policy*** value is its Decision” or “At least one ***policy*** value is ‘Indeterminate’”, then the ***policy-combining algorithm*** specified in the ***policy set*** SHALL determine the ***policy set*** value.

Note that none of the ***policy-combining algorithms*** defined by XACML 3.0 take parameters. However, non-standard combining algorithms MAY take parameters. In such a case, the values of these parameters associated with the ***policies***, MUST be taken into account when evaluating the ***policy set***. The parameters and their types should be defined in the specification of the combining algorithm. If the implementation supports combiner parameters and if combiner parameters are present in a ***policy***, then the parameter values MUST be supplied to the combining algorithm implementation.

7.13 PolicySetIdReference and PolicyIdReference evaluation

A policy set id reference or a policy id reference is evaluated by resolving the reference and evaluating the referenced policy set or policy.

If resolving the reference fails, the reference evaluates to “Indeterminate” with status code urn:oasis:names:tc:xacml:1.0:status:processing-error.

A policy set id reference or a policy id reference containing circular references is invalid. The PDP MUST detect circular references either at policy loading time or during runtime evaluation. If the PDP detects a circular reference during runtime the reference evaluates to “Indeterminate” with status code urn:oasis:names:tc:xacml:1.0:status:processing-error.

7.14 Hierarchical resources

It is often the case that a ***resource*** is organized as a hierarchy (e.g. file system, XML document). XACML provides several optional mechanisms for supporting hierarchical ***resources***. These are described in the XACML Profile for Hierarchical Resources **[Hier]** and in the XACML Profile for Requests for Multiple Resources **[Multi]**.

7.15 Authorization decision

In relation to a particular ***decision request***, the ***PDP*** is defined by a ***policy-combining algorithm*** and a set of ***policies*** and/or ***policy sets***. The ***PDP*** SHALL return a response ***context*** as if it had evaluated a single ***policy set*** consisting of this ***policy-combining algorithm*** and the set of ***policies*** and/or ***policy sets***.

The ***PDP*** MUST evaluate the ***policy set*** as specified in Sections 5 and 7. The ***PDP*** MUST return a response ***context***, with one `<Decision>` element of value "Permit", "Deny", "Indeterminate" or "NotApplicable".

If the ***PDP*** cannot make a ***decision***, then an "Indeterminate" `<Decision>` element SHALL be returned.

7.16 Obligations and advice

A ***rule***, ***policy,*** or ***policy set*** may contain one or more ***obligation*** or ***advice*** expressions. When such a ***rule***, ***policy,*** or ***policy set*** is evaluated, the ***obligation*** or ***advice*** expression SHALL be evaluated to an ***obligation*** or ***advice*** respectively, which SHALL be passed up to the next level of evaluation (the enclosing or referencing ***policy***, ***policy set,*** or ***authorization decision***) only if the ***effect*** of the ***rule***, ***policy,*** or ***policy set*** being evaluated matches the value of the `FulfillOn` attribute of the ***obligation*** or the `AppliesTo` attribute of the ***advice***. If any of the ***attribute*** assignment expressions in an ***obligation*** or ***advice*** expression with a matching `FulfillOn` or `AppliesTo` attribute evaluates to “Indeterminate”, then the whole ***rule***, ***policy,*** or ***policy set*** SHALL be “Indeterminate”. If the `FulfillOn` or `AppliesTo` attribute does not match the result of the combining algorithm or the ***rule*** evaluation, then any indeterminate in an ***obligation*** or ***advice*** expression has no effect.

As a consequence of this procedure, no ***obligations*** or ***advice*** SHALL be returned to the ***PEP*** if the ***rule***, ***policies,*** or ***policy sets*** from which they are drawn are not evaluated, or if their evaluated result is "Indeterminate" or "NotApplicable", or if the ***decision*** resulting from evaluating the ***rule***, ***policy,*** or ***policy set*** does not match the ***decision*** resulting from evaluating an enclosing ***policy set***.

If the ***PDP***'s evaluation is viewed as a tree of ***rules***, ***policy sets*** and ***policies***, each of which returns "Permit" or "Deny", then the set of ***obligations*** and ***advice*** returned by the ***PDP*** to the ***PEP*** will include only the ***obligations*** and ***advice*** associated with those paths where the ***effect*** at each level of evaluation is the same as the ***effect*** being returned by the ***PDP***. In situations where any lack of determinism is unacceptable, a deterministic combining algorithm, such as ordered-deny-overrides, should be used.

Also see Section 7.2.

7.17 Exception handling

XACML specifies behavior for the ***PDP*** in the following situations.

7.17.1 Unsupported functionality

If the ***PDP*** attempts to evaluate a ***policy set*** or ***policy*** that contains an optional element type or function that the ***PDP*** does not support, then the ***PDP*** SHALL return a `<Decision>` value of "Indeterminate". If a `<StatusCode>` element is also returned, then its value SHALL be "urn:oasis:names:tc:xacml:1.0:status:syntax-error" in the case of an unsupported element type, and "urn:oasis:names:tc:xacml:1.0:status:processing-error" in the case of an unsupported function.

7.17.2 Syntax and type errors

If a ***policy*** that contains invalid syntax is evaluated by the XACML ***PDP*** at the time a ***decision request*** is received, then the result of that ***policy*** SHALL be "Indeterminate" with a `StatusCode` value of "urn:oasis:names:tc:xacml:1.0:status:syntax-error".

If a ***policy*** that contains invalid static data-types is evaluated by the XACML ***PDP*** at the time a ***decision request*** is received, then the result of that ***policy*** SHALL be "Indeterminate" with a `StatusCode` value of "urn:oasis:names:tc:xacml:1.0:status:processing-error".

7.17.3 Missing attributes

The absence of matching ***attributes*** in the request ***context*** for any of the attribute designators attribute or selectors that are found in the ***policy*** will result in an enclosing `<AllOf>` element to return a value of "Indeterminate",if the designator or selector has the `MustBePresent` XML attribute set to true, as described in Sections 5.29 and 5.30 and may result in a <Decision> element containing the "Indeterminate" value. If, in this case, and a status code is supplied, then the value

"urn:oasis:names:tc:xacml:1.0:status:missing-attribute"

SHALL be used, to indicate that more information is needed in order for a definitive ***decision*** to be rendered. In this case, the `<Status>` element MAY list the names and data-types of any ***attributes*** that are needed by the ***PDP*** to refine its ***decision*** (see Section 5.58). A ***PEP*** MAY resubmit a refined request ***context*** in response to a `<Decision>` element contents of "Indeterminate" with a status code of

"urn:oasis:names:tc:xacml:1.0:status:missing-attribute"

by adding ***attribute*** values for the ***attribute*** names that were listed in the previous response. When the ***PDP*** returns a `<Decision>` element contents of "Indeterminate", with a status code of

"urn:oasis:names:tc:xacml:1.0:status:missing-attribute",

it MUST NOT list the names and data-types of any ***attribute*** for which values were supplied in the original request. Note, this requirement forces the ***PDP*** to eventually return an ***authorization decision*** of "Permit", "Deny", or "Indeterminate" with some other status code, in response to successively-refined requests.

8 XACML extensibility points (non-normative)

This section describes the points within the XACML model and schema where extensions can be added.

8.1 Extensible XML attribute types

The following XML attributes have values that are URIs. These may be extended by the creation of new URIs associated with new semantics for these attributes.

`Category`,

`AttributeId`,

`DataType`,

`FunctionId`,

`MatchId`,

`ObligationId`,

`AdviceId`,

`PolicyCombiningAlgId`,

`RuleCombiningAlgId`,

`StatusCode`,

`SubjectCategory`.

See Section 5 for definitions of these ***attribute*** types.

8.2 Structured attributes

`<AttributeValue>` elements MAY contain an instance of a structured XML data-type. Section 7.3.1 describes a number of standard techniques to identify data items within such a structured ***attribute***. Listed here are some additional techniques that require XACML extensions.

1. For a given structured data-type, a community of XACML users MAY define new ***attribute*** identifiers for each leaf sub-element of the structured data-type that has a type conformant with one of the XACML-defined primitive data-types. Using these new ***attribute*** identifiers, the ***PEPs*** or ***context handlers*** used by that community of users can flatten instances of the structured data-type into a sequence of individual `<Attribute>` elements. Each such `<Attribute>` element can be compared using the XACML-defined functions. Using this method, the structured data-type itself never appears in an `<AttributeValue>` element.
2. A community of XACML users MAY define a new function that can be used to compare a value of the structured data-type against some other value. This method may only be used by ***PDPs*** that support the new function.

9 Security and privacy considerations (non-normative)

This section identifies possible security and privacy compromise scenarios that should be considered when implementing an XACML-based system. The section is informative only. It is left to the implementer to decide whether these compromise scenarios are practical in their environment and to select appropriate safeguards.

9.1 Threat model

We assume here that the adversary has access to the communication channel between the XACML actors and is able to interpret, insert, delete, and modify messages or parts of messages.

Additionally, an actor may use information from a former message maliciously in subsequent transactions. It is further assumed that ***rules*** and ***policies*** are only as reliable as the actors that create and use them. Thus it is incumbent on each actor to establish appropriate trust in the other actors upon which it relies. Mechanisms for trust establishment are outside the scope of this specification.

The messages that are transmitted between the actors in the XACML model are susceptible to attack by malicious third parties. Other points of vulnerability include the ***PEP***, the ***PDP,*** and the ***PAP***. While some of these entities are not strictly within the scope of this specification, their compromise could lead to the compromise of ***access control*** enforced by the ***PEP***.

It should be noted that there are other components of a distributed system that may be compromised, such as an operating system and the domain-name system (DNS) that are outside the scope of this discussion of threat models. Compromise in these components may also lead to a policy violation.

The following sections detail specific compromise scenarios that may be relevant to an XACML system.

9.1.1 Unauthorized disclosure

XACML does not specify any inherent mechanisms to protect the confidentiality of the messages exchanged between actors. Therefore, an adversary could observe the messages in transit. Under certain security ***policies***, disclosure of this information is a violation. Disclosure of ***attributes*** or the types of ***decision requests*** that a ***subject*** submits may be a breach of privacy policy. In the commercial sector, the consequences of unauthorized disclosure of personal data may range from embarrassment to the custodian, to imprisonment and/or large fines in the case of medical or financial data.

Unauthorized disclosure is addressed by confidentiality safeguards.

9.1.2 Message replay

A message replay attack is one in which the adversary records and replays legitimate messages between XACML actors. This attack may lead to denial of service, the use of out-of-date information or impersonation.

Prevention of replay attacks requires the use of message freshness safeguards.

Note that encryption of the message does not mitigate a replay attack since the message is simply replayed and does not have to be understood by the adversary.

9.1.3 Message insertion

A message insertion attack is one in which the adversary inserts messages in the sequence of messages between XACML actors.

The solution to a message insertion attack is to use mutual authentication and message sequence integrity safeguards between the actors. It should be noted that just using SSL mutual authentication is not sufficient. This only proves that the other party is the one identified by the ***subject*** of the X.509

certificate. In order to be effective, it is necessary to confirm that the certificate ***subject*** is authorized to send the message.

9.1.4 Message deletion

A message deletion attack is one in which the adversary deletes messages in the sequence of messages between XACML actors. Message deletion may lead to denial of service. However, a properly designed XACML system should not render an incorrect ***authorization decision*** as a result of a message deletion attack.

The solution to a message deletion attack is to use message sequence integrity safeguards between the actors.

9.1.5 Message modification

If an adversary can intercept a message and change its contents, then they may be able to alter an ***authorization decision***. A message integrity safeguard can prevent a successful message modification attack.

9.1.6 NotApplicable results

A result of "NotApplicable" means that the ***PDP*** could not locate a ***policy*** whose ***target*** matched the information in the ***decision request***. In general, it is highly recommended that a "Deny" ***effect policy*** be used, so that when a ***PDP*** would have returned "NotApplicable", a result of "Deny" is returned instead.

In some security models, however, such as those found in many web servers, an ***authorization decision*** of "NotApplicable" is treated as equivalent to "Permit". There are particular security considerations that must be taken into account for this to be safe. These are explained in the following paragraphs.

If "NotApplicable" is to be treated as "Permit", it is vital that the matching algorithms used by the ***policy*** to match elements in the ***decision request*** be closely aligned with the data syntax used by the applications that will be submitting the ***decision request***. A failure to match will result in “NotApplicable” and be treated as "Permit". So an unintended failure to match may allow unintended ***access***.

Commercial http responders allow a variety of syntaxes to be treated equivalently. The "%" can be used to represent characters by hex value. The URL path "/../" provides multiple ways of specifying the same value. Multiple character sets may be permitted and, in some cases, the same printed character can be represented by different binary values. Unless the matching algorithm used by the ***policy*** is sophisticated enough to catch these variations, unintended ***access*** may be permitted.

It may be safe to treat "NotApplicable" as "Permit" only in a closed environment where all applications that formulate a ***decision request*** can be guaranteed to use the exact syntax expected by the ***policies***. In a more open environment, where ***decision requests*** may be received from applications that use any legal syntax, it is strongly recommended that "NotApplicable" NOT be treated as "Permit" unless matching ***rules*** have been very carefully designed to match all possible applicable inputs, regardless of syntax or type variations. Note, however, that according to Section 7.2, a ***PEP*** must deny ***access*** unless it receives an explicit “Permit” ***authorization decision***.

9.1.7 Negative rules

A negative ***rule*** is one that is based on a ***predicate*** not being "True". If not used with care, negative ***rules*** can lead to policy violations, therefore some authorities recommend that they not be used. However, negative ***rules*** can be extremely efficient in certain cases, so XACML has chosen to include them. Nevertheless, it is recommended that they be used with care and avoided if possible.

A common use for negative ***rules*** is to deny ***access*** to an individual or subgroup when their membership in a larger group would otherwise permit them ***access***. For example, we might want to write a ***rule*** that allows all vice presidents to see the unpublished financial data, except for Joe, who is only a ceremonial vice president and can be indiscreet in his communications. If we have complete control over the administration of ***subject attributes***, a superior approach would be to define “Vice President” and “Ceremonial Vice President” as distinct groups and then define ***rules*** accordingly. However, in some environments this approach may not be feasible. (It is worth noting in passing that referring to individuals in ***rules*** does not scale well. Generally, shared ***attributes*** are preferred.)

If not used with care, negative ***rules*** can lead to policy violations in two common cases: when ***attributes*** are suppressed and when the base group changes. An example of suppressed ***attributes*** would be if we have a ***policy*** that ***access*** should be permitted, unless the ***subject*** is a credit risk. If it is possible that the ***attribute*** of being a credit risk may be unknown to the ***PDP*** for some reason, then unauthorized ***access*** may result. In some environments, the ***subject*** may be able to suppress the publication of ***attributes*** by the application of privacy controls, or the server or repository that contains the information may be unavailable for accidental or intentional reasons.

An example of a changing base group would be if there is a ***policy*** that everyone in the engineering department may change software source code, except for secretaries. Suppose now that the department was to merge with another engineering department and the intent is to maintain the same ***policy***. However, the new department also includes individuals identified as administrative assistants, who ought to be treated in the same way as secretaries. Unless the ***policy*** is altered, they will unintentionally be permitted to change software source code. Problems of this type are easy to avoid when one individual administers all ***policies***, but when administration is distributed, as XACML allows, this type of situation must be explicitly guarded against.

9.1.8 Denial of service

A denial of service attack is one in which the adversary overloads an XACML actor with excessive computations or network traffic such that legitimate users cannot access the services provided by the actor.

The urn:oasis:names:tc:xacml:3.0:function:access-permitted function may lead to hard to predict behavior in the ***PDP***. It is possible that the function is invoked during the recursive invocations of the ***PDP*** such that loops are formed. Such loops may in some cases lead to large numbers of requests to be generated before the ***PDP*** can detect the loop and abort evaluation. Such loops could cause a denial of service at the ***PDP***, either because of a malicious ***policy*** or because of a mistake in a ***policy***.

9.2 Safeguards

9.2.1 Authentication

Authentication provides the means for one party in a transaction to determine the identity of the other party in the transaction. Authentication may be in one direction, or it may be bilateral.

Given the sensitive nature of ***access control*** systems, it is important for a ***PEP*** to authenticate the identity of the ***PDP*** to which it sends ***decision requests***. Otherwise, there is a risk that an adversary could provide false or invalid ***authorization decisions***, leading to a policy violation.

It is equally important for a ***PDP*** to authenticate the identity of the ***PEP*** and assess the level of trust to determine what, if any, sensitive data should be passed. One should keep in mind that even simple "Permit" or "Deny" responses could be exploited if an adversary were allowed to make unlimited requests to a ***PDP***.

Many different techniques may be used to provide authentication, such as co-located code, a private network, a VPN, or digital signatures. Authentication may also be performed as part of the communication protocol used to exchange the ***contexts***. In this case, authentication may be performed either at the message level or at the session level.

9.2.2 Policy administration

If the contents of ***policies*** are exposed outside of the ***access control*** system, potential ***subjects*** may use this information to determine how to gain unauthorized ***access***.

To prevent this threat, the repository used for the storage of ***policies*** may itself require ***access control***. In addition, the `<Status>` element should be used to return values of missing ***attributes*** only when exposure of the identities of those ***attributes*** will not compromise security.

9.2.3 Confidentiality

Confidentiality mechanisms ensure that the contents of a message can be read only by the desired recipients and not by anyone else who encounters the message while it is in transit. There are two areas in which confidentiality should be considered: one is confidentiality during transmission; the other is confidentiality within a `<Policy>` element.

9.2.3.1 Communication confidentiality

In some environments it is deemed good practice to treat all data within an ***access control*** system as confidential. In other environments, ***policies*** may be made freely available for distribution, inspection, and audit. The idea behind keeping ***policy*** information secret is to make it more difficult for an adversary to know what steps might be sufficient to obtain unauthorized ***access***. Regardless of the approach chosen, the security of the ***access control*** system should not depend on the secrecy of the ***policy***.

Any security considerations related to transmitting or exchanging XACML `<Policy>` elements are outside the scope of the XACML standard. While it is important to ensure that the integrity and confidentiality of `<Policy>` elements is maintained when they are exchanged between two parties, it is left to the implementers to determine the appropriate mechanisms for their environment.

Communications confidentiality can be provided by a confidentiality mechanism, such as SSL. Using a point-to-point scheme like SSL may lead to other vulnerabilities when one of the end-points is compromised.

9.2.3.2 Statement level confidentiality

In some cases, an implementation may want to encrypt only parts of an XACML `<Policy>` element.

The XML Encryption Syntax and Processing Candidate Recommendation from W3C can be used to encrypt all or parts of an XML document. This specification is recommended for use with XACML.

It should go without saying that if a repository is used to facilitate the communication of cleartext (i.e., unencrypted) ***policy*** between the ***PAP*** and ***PDP***, then a secure repository should be used to store this sensitive data.

9.2.4 Policy integrity

The XACML ***policy*** used by the ***PDP*** to evaluate the request ***context*** is the heart of the system. Therefore, maintaining its integrity is essential. There are two aspects to maintaining the integrity of the ***policy***. One is to ensure that `<Policy>` elements have not been altered since they were originally created by the ***PAP***. The other is to ensure that `<Policy>` elements have not been inserted or deleted from the set of ***policies***.

In many cases, both aspects can be achieved by ensuring the integrity of the actors and implementing session-level mechanisms to secure the communication between actors. The selection of the appropriate mechanisms is left to the implementers. However, when ***policy*** is distributed between organizations to be acted on at a later time, or when the ***policy*** travels with the protected ***resource***, it would be useful to sign the ***policy***. In these cases, the XML Signature Syntax and Processing standard from W3C is recommended to be used with XACML.

Digital signatures should only be used to ensure the integrity of the statements. Digital signatures should not be used as a method of selecting or evaluating ***policy***. That is, the ***PDP*** should not request a ***policy*** based on who signed it or whether or not it has been signed (as such a basis for selection would, itself, be a matter of policy). However, the ***PDP*** must verify that the key used to sign the ***policy*** is one controlled by the purported ***issuer*** of the ***policy***. The means to do this are dependent on the specific signature technology chosen and are outside the scope of this document.

9.2.5 Policy identifiers

Since ***policies*** can be referenced by their identifiers, it is the responsibility of the ***PAP*** to ensure that these are unique. Confusion between identifiers could lead to misidentification of the ***applicable policy***.

This specification is silent on whether a ***PAP*** must generate a new identifier when a ***policy*** is modified or may use the same identifier in the modified ***policy***. This is a matter of administrative practice. However, care must be taken in either case. If the identifier is reused, there is a danger that other ***policies*** or ***policy sets*** that reference it may be adversely affected. Conversely, if a new identifier is used, these other ***policies*** may continue to use the prior ***policy***, unless it is deleted. In either case the results may not be what the ***policy*** administrator intends.

If a ***PDP*** is provided with ***policies*** from distinct sources which might not be fully trusted, as in the use of the administration profile **[XACMLAdmin]**, there is a concern that someone could intentionally publish a ***policy*** with an id which collides with another ***policy***. This could cause ***policy*** references that point to the wrong ***policy,*** and may cause other unintended consequences in an implementation which is predicated upon having unique ***policy*** identifiers.

If this issue is a concern it is RECOMMENDED that distinct ***policy*** issuers or sources are assigned distinct namespaces for ***policy*** identifiers. One method is to make sure that the ***policy*** identifier begins with a string which has been assigned to the particular ***policy*** issuer or source. The remainder of the ***policy*** identifier is an issuer-specific unique part. For instance, Alice from Example Inc. could be assigned the ***policy*** identifiers which begin with http://example.com/xacml/policyId/alice/. The ***PDP*** or another trusted component can then verify that the authenticated source of the ***policy*** is Alice at Example Inc, or otherwise reject the ***policy***. Anyone else will be unable to publish ***policies*** with identifiers which collide with the ***policies*** of Alice.

9.2.6 Trust model

Discussions of authentication, integrity and confidentiality safeguards necessarily assume an underlying trust model: how can one actor come to believe that a given key is uniquely associated with a specific, identified actor so that the key can be used to encrypt data for that actor or verify signatures (or other integrity structures) from that actor? Many different types of trust models exist, including strict hierarchies, distributed authorities, the Web, the bridge, and so on.

It is worth considering the relationships between the various actors of the ***access control*** system in terms of the interdependencies that do and do not exist.

- None of the entities of the authorization system are dependent on the ***PEP***. They may collect data from it, (for example authentication data) but are responsible for verifying it themselves.
- The correct operation of the system depends on the ability of the ***PEP*** to actually enforce ***policy decisions***.
- The ***PEP*** depends on the ***PDP*** to correctly evaluate ***policies***. This in turn implies that the ***PDP*** is supplied with the correct inputs. Other than that, the ***PDP*** does not depend on the ***PEP***.
- The ***PDP*** depends on the ***PAP*** to supply appropriate ***policies***. The ***PAP*** is not dependent on other components.

9.2.7 Privacy

It is important to be aware that any transactions that occur with respect to ***access control*** may reveal private information about the actors.   For example, if an XACML ***policy*** states that certain data may only be read by ***subjects*** with “Gold Card Member” status, then any transaction in which a ***subject*** is permitted ***access*** to that data leaks information to an adversary about the ***subject***'s status. Privacy considerations may therefore lead to encryption and/or to ***access control*** requirements surrounding the enforcement of XACML ***policy*** instances themselves: confidentiality-protected channels for the request/response protocol messages, protection of ***subject attributes*** in storage and in transit, and so on.

Selection and use of privacy mechanisms appropriate to a given environment are outside the scope of XACML. The ***decision*** regarding whether, how, and when to deploy such mechanisms is left to the implementers associated with the environment.

9.3 Unicode security issues

There are many security considerations related to use of Unicode. An XACML implementation SHOULD follow the advice given in the relevant version of **[UTR36]**.

10 Conformance

10.1 Introduction

The XACML specification addresses the following aspect of conformance:

The XACML specification defines a number of functions, etc. that have somewhat special applications, therefore they are not required to be implemented in an implementation that claims to conform with the OASIS standard.

10.2 Conformance tables

This section lists those portions of the specification that MUST be included in an implementation of a ***PDP*** that claims to conform to XACML v3.0. A set of test cases has been created to assist in this process. These test cases can be located from the OASIS XACML TC Web page. The site hosting the test cases contains a full description of the test cases and how to execute them.

Note: "M" means mandatory-to-implement. "O" means optional.

The implementation MUST follow sections 5, 6, 7, A, B and C where they apply to implemented items in the following tables.

10.2.1 Schema elements

The implementation MUST support those schema elements that are marked “M”.

Element name	M/O
xacml:Advice	M
xacml:AdviceExpression	M
xacml:AdviceExpressions	M
xacml:AllOf	M
xacml:AnyOf	M
xacml:Apply	M
xacml:AssociatedAdvice	M
xacml:Attribute	M
xacml:AttributeAssignment	M
xacml:AttributeAssignmentExpression	M
xacml:AttributeDesignator	M
xacml:Attributes	M
xacml:AttributeSelector	O
xacml:AttributesReference	O
xacml:AttributeValue	M
xacml:CombinerParameter	O
xacml:CombinerParameters	O
xacml:Condition	M
xacml:Content	O
xacml:Decision	M
xacml:Description	M
xacml:Expression	M
xacml:Function	M
xacml:Match	M
xacml:MissingAttributeDetail	M
xacml:MultiRequests	O
xacml:Obligation	M
xacml:ObligationExpression	M
xacml:ObligationExpressions	M
xacml:Obligations	M

xacml:Policy	M
xacml:PolicyCombinerParameters	O
xacml:PolicyDefaults	O
xacml:PolicyIdentifierList	O
xacml:PolicyIdReference	M
xacml:PolicyIssuer	O
xacml:PolicySet	M
xacml:PolicySetDefaults	O
xacml:PolicySetIdReference	M
xacml:Request	M
xacml:RequestDefaults	O
xacml:RequestReference	O
xacml:Response	M
xacml:Result	M
xacml:Rule	M
xacml:RuleCombinerParameters	O
xacml:Status	M
xacml:StatusCode	M
xacml:StatusDetail	O
xacml:StatusMessage	O
xacml:Target	M
xacml:VariableDefinition	M
xacml:VariableReference	M
xacml:XPathVersion	O

10.2.2 Identifier Prefixes

The following identifier prefixes are reserved by XACML.

Identifier
urn:oasis:names:tc:xacml:3.0
urn:oasis:names:tc:xacml:2.0
urn:oasis:names:tc:xacml:2.0:conformance-test
urn:oasis:names:tc:xacml:2.0:context
urn:oasis:names:tc:xacml:2.0:example
urn:oasis:names:tc:xacml:1.0:function
urn:oasis:names:tc:xacml:2.0:function
urn:oasis:names:tc:xacml:2.0:policy
urn:oasis:names:tc:xacml:1.0:subject
urn:oasis:names:tc:xacml:1.0:resource
urn:oasis:names:tc:xacml:1.0:action
urn:oasis:names:tc:xacml:1.0:environment
urn:oasis:names:tc:xacml:1.0:status

10.2.3 Algorithms

The implementation MUST include the ***rule***- and ***policy-combining algorithms*** associated with the following identifiers that are marked "M".

Algorithm	M/O
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-overrides	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-overrides	M
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-overrides	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-overrides	M
urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:first-applicable	M
urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:first-applicable	M
urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:only-one-	M

applicable	
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-deny-overrides	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-deny-overrides	M
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-permit-overrides	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-permit-overrides	M
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-unless-permit	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-unless-permit	M
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-unless-deny	M
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-unless-deny	M

10.2.4 Status Codes

Implementation support for the `<StatusCode>` element is optional, but if the element is supported, then the following status codes must be supported and must be used in the way XACML has specified.

Identifier	M/O
urn:oasis:names:tc:xacml:1.0:status:missing-attribute	M
urn:oasis:names:tc:xacml:1.0:status:ok	M
urn:oasis:names:tc:xacml:1.0:status:processing-error	M
urn:oasis:names:tc:xacml:1.0:status:syntax-error	M

10.2.5 Attributes

The implementation MUST support the ***attributes*** associated with the following identifiers as specified by XACML. If values for these ***attributes*** are not present in the ***decision request***, then their values MUST be supplied by the ***context handler***. So, unlike most other ***attributes***, their semantics are not transparent to the ***PDP***.

Identifier	M/O
urn:oasis:names:tc:xacml:1.0:environment:current-time	M
urn:oasis:names:tc:xacml:1.0:environment:current-date	M
urn:oasis:names:tc:xacml:1.0:environment:current-dateTime	M

10.2.6 Identifiers

The implementation MUST use the ***attributes*** associated with the following identifiers in the way XACML has defined. This requirement pertains primarily to implementations of a ***PAP*** or ***PEP*** that uses XACML, since the semantics of the ***attributes*** are transparent to the ***PDP***.

Identifier	M/O
urn:oasis:names:tc:xacml:1.0:subject:authn-locality:dns-name	O
urn:oasis:names:tc:xacml:1.0:subject:authn-locality:ip-address	O
urn:oasis:names:tc:xacml:1.0:subject:authentication-method	O
urn:oasis:names:tc:xacml:1.0:subject:authentication-time	O
urn:oasis:names:tc:xacml:1.0:subject:key-info	O
urn:oasis:names:tc:xacml:1.0:subject:request-time	O
urn:oasis:names:tc:xacml:1.0:subject:session-start-time	O
urn:oasis:names:tc:xacml:1.0:subject:subject-id	O
urn:oasis:names:tc:xacml:1.0:subject:subject-id-qualifier	O
urn:oasis:names:tc:xacml:1.0:subject-category:access-subject	M
urn:oasis:names:tc:xacml:1.0:subject-category:codebase	O

urn:oasis:names:tc:xacml:1.0:subject-category:intermediary-subject	O
urn:oasis:names:tc:xacml:1.0:subject-category:recipient-subject	O
urn:oasis:names:tc:xacml:1.0:subject-category:requesting-machine	O
urn:oasis:names:tc:xacml:1.0:resource:resource-location	O
urn:oasis:names:tc:xacml:1.0:resource:resource-id	M
urn:oasis:names:tc:xacml:1.0:resource:simple-file-name	O
urn:oasis:names:tc:xacml:1.0:action:action-id	O
urn:oasis:names:tc:xacml:1.0:action:implied-action	O

10.2.7 Data-types

The implementation MUST support the data-types associated with the following identifiers marked "M".

Data-type	M/O
http://www.w3.org/2001/XMLSchema#string	M
http://www.w3.org/2001/XMLSchema#boolean	M
http://www.w3.org/2001/XMLSchema#integer	M
http://www.w3.org/2001/XMLSchema#double	M
http://www.w3.org/2001/XMLSchema#time	M
http://www.w3.org/2001/XMLSchema#date	M
http://www.w3.org/2001/XMLSchema#dateTime	M
http://www.w3.org/2001/XMLSchema#dayTimeDuration	M
http://www.w3.org/2001/XMLSchema#yearMonthDuration	M
http://www.w3.org/2001/XMLSchema#anyURI	M
http://www.w3.org/2001/XMLSchema#hexBinary	M
http://www.w3.org/2001/XMLSchema#base64Binary	M
urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name	M
urn:oasis:names:tc:xacml:1.0:data-type:x500Name	M
urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression	O
urn:oasis:names:tc:xacml:2.0:data-type:ipAddress	M
urn:oasis:names:tc:xacml:2.0:data-type:dnsName	M

10.2.8 Functions

The implementation MUST properly process those functions associated with the identifiers marked with an "M".

Function	M/O
urn:oasis:names:tc:xacml:1.0:function:string-equal	M
urn:oasis:names:tc:xacml:1.0:function:boolean-equal	M
urn:oasis:names:tc:xacml:1.0:function:integer-equal	M
urn:oasis:names:tc:xacml:1.0:function:double-equal	M
urn:oasis:names:tc:xacml:1.0:function:date-equal	M
urn:oasis:names:tc:xacml:1.0:function:time-equal	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-equal	M
urn:oasis:names:tc:xacml:3.0:function:dayTimeDuration-equal	M
urn:oasis:names:tc:xacml:3.0:function:yearMonthDuration-equal	M
urn:oasis:names:tc:xacml:3.0:function:string-equal-ignore-case	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-equal	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-equal	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-equal	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-equal	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-equal	M
urn:oasis:names:tc:xacml:1.0:function:integer-add	M
urn:oasis:names:tc:xacml:1.0:function:double-add	M
urn:oasis:names:tc:xacml:1.0:function:integer-subtract	M
urn:oasis:names:tc:xacml:1.0:function:double-subtract	M
urn:oasis:names:tc:xacml:1.0:function:integer-multiply	M

urn:oasis:names:tc:xacml:1.0:function:double-multiply	M
urn:oasis:names:tc:xacml:1.0:function:integer-divide	M
urn:oasis:names:tc:xacml:1.0:function:double-divide	M
urn:oasis:names:tc:xacml:1.0:function:integer-mod	M
urn:oasis:names:tc:xacml:1.0:function:integer-abs	M
urn:oasis:names:tc:xacml:1.0:function:double-abs	M
urn:oasis:names:tc:xacml:1.0:function:round	M
urn:oasis:names:tc:xacml:1.0:function:floor	M
urn:oasis:names:tc:xacml:1.0:function:string-normalize-space	M
urn:oasis:names:tc:xacml:1.0:function:string-normalize-to-lower-case	M
urn:oasis:names:tc:xacml:1.0:function:double-to-integer	M
urn:oasis:names:tc:xacml:1.0:function:integer-to-double	M
urn:oasis:names:tc:xacml:1.0:function:or	M
urn:oasis:names:tc:xacml:1.0:function:and	M
urn:oasis:names:tc:xacml:1.0:function:n-of	M
urn:oasis:names:tc:xacml:1.0:function:not	M
urn:oasis:names:tc:xacml:1.0:function:integer-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:integer-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:integer-less-than	M
urn:oasis:names:tc:xacml:1.0:function:integer-less-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:double-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:double-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:double-less-than	M
urn:oasis:names:tc:xacml:1.0:function:double-less-than-or-equal	M
urn:oasis:names:tc:xacml:3.0:function:dateTime-add-dayTimeDuration	M
urn:oasis:names:tc:xacml:3.0:function:dateTime-add-yearMonthDuration	M
urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-dayTimeDuration	M
urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-yearMonthDuration	M
urn:oasis:names:tc:xacml:3.0:function:date-add-yearMonthDuration	M
urn:oasis:names:tc:xacml:3.0:function:date-subtract-yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:function:string-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:string-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:string-less-than	M
urn:oasis:names:tc:xacml:1.0:function:string-less-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:time-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:time-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:time-less-than	M
urn:oasis:names:tc:xacml:1.0:function:time-less-than-or-equal	M
urn:oasis:names:tc:xacml:2.0:function:time-in-range	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-less-than	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-less-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:date-greater-than	M
urn:oasis:names:tc:xacml:1.0:function:date-greater-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:date-less-than	M
urn:oasis:names:tc:xacml:1.0:function:date-less-than-or-equal	M
urn:oasis:names:tc:xacml:1.0:function:string-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:string-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:string-is-in	M
urn:oasis:names:tc:xacml:1.0:function:string-bag	M
urn:oasis:names:tc:xacml:1.0:function:boolean-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:boolean-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:boolean-is-in	M
urn:oasis:names:tc:xacml:1.0:function:boolean-bag	M
urn:oasis:names:tc:xacml:1.0:function:integer-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:integer-bag-size	M

urn:oasis:names:tc:xacml:1.0:function:integer-is-in	M
urn:oasis:names:tc:xacml:1.0:function:integer-bag	M
urn:oasis:names:tc:xacml:1.0:function:double-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:double-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:double-is-in	M
urn:oasis:names:tc:xacml:1.0:function:double-bag	M
urn:oasis:names:tc:xacml:1.0:function:time-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:time-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:time-is-in	M
urn:oasis:names:tc:xacml:1.0:function:time-bag	M
urn:oasis:names:tc:xacml:1.0:function:date-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:date-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:date-is-in	M
urn:oasis:names:tc:xacml:1.0:function:date-bag	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-is-in	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-bag	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-is-in	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-bag	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-is-in	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-bag	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-is-in	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-bag	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-is-in	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-bag	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-is-in	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-bag	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-is-in	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-bag	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-one-and-only	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-bag-size	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-is-in	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-bag	M
urn:oasis:names:tc:xacml:2.0:function:ipAddress-one-and-only	M
urn:oasis:names:tc:xacml:2.0:function:ipAddress-bag-size	M
urn:oasis:names:tc:xacml:2.0:function:ipAddress-is-in	M
urn:oasis:names:tc:xacml:2.0:function:ipAddress-bag	M
urn:oasis:names:tc:xacml:2.0:function:dnsName-one-and-only	M
urn:oasis:names:tc:xacml:2.0:function:dnsName-bag-size	M
urn:oasis:names:tc:xacml:2.0:function:dnsName-is-in	M
urn:oasis:names:tc:xacml:2.0:function:dnsName-bag	M
urn:oasis:names:tc:xacml:2.0:function:string-concatenate	M
urn:oasis:names:tc:xacml:3.0:function:boolean-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-boolean	M
urn:oasis:names:tc:xacml:3.0:function:integer-from-string	M

urn:oasis:names:tc:xacml:3.0:function:string-from-integer	M
urn:oasis:names:tc:xacml:3.0:function:double-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-double	M
urn:oasis:names:tc:xacml:3.0:function:time-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-time	M
urn:oasis:names:tc:xacml:3.0:function:date-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-date	M
urn:oasis:names:tc:xacml:3.0:function:dateTime-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-dateTime	M
urn:oasis:names:tc:xacml:3.0:function:anyURI-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-anyURI	M
urn:oasis:names:tc:xacml:3.0:function:dayTimeDuration-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-dayTimeDuration	M
urn:oasis:names:tc:xacml:3.0:function:yearMonthDuration-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-yearMonthDuration	M
urn:oasis:names:tc:xacml:3.0:function:x500Name-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-x500Name	M
urn:oasis:names:tc:xacml:3.0:function:rfc822Name-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-rfc822Name	M
urn:oasis:names:tc:xacml:3.0:function:ipAddress-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-ipAddress	M
urn:oasis:names:tc:xacml:3.0:function:dnsName-from-string	M
urn:oasis:names:tc:xacml:3.0:function:string-from-dnsName	M
urn:oasis:names:tc:xacml:3.0:function:string-starts-with	M
urn:oasis:names:tc:xacml:3.0:function:anyURI-starts-with	M
urn:oasis:names:tc:xacml:3.0:function:string-ends-with	M
urn:oasis:names:tc:xacml:3.0:function:anyURI-ends-with	M
urn:oasis:names:tc:xacml:3.0:function:string-contains	M
urn:oasis:names:tc:xacml:3.0:function:anyURI-contains	M
urn:oasis:names:tc:xacml:3.0:function:string-substring	M
urn:oasis:names:tc:xacml:3.0:function:anyURI-substring	M
urn:oasis:names:tc:xacml:1.0:function:any-of	M
urn:oasis:names:tc:xacml:1.0:function:all-of	M
urn:oasis:names:tc:xacml:1.0:function:any-of-any	M
urn:oasis:names:tc:xacml:1.0:function:all-of-any	M
urn:oasis:names:tc:xacml:1.0:function:any-of-all	M
urn:oasis:names:tc:xacml:1.0:function:all-of-all	M
urn:oasis:names:tc:xacml:1.0:function:map	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-match	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-match	M
urn:oasis:names:tc:xacml:1.0:function:string-regexp-match	M
urn:oasis:names:tc:xacml:2.0:function:anyURI-regexp-match	M
urn:oasis:names:tc:xacml:2.0:function:ipAddress-regexp-match	M
urn:oasis:names:tc:xacml:2.0:function:dnsName-regexp-match	M
urn:oasis:names:tc:xacml:2.0:function:rfc822Name-regexp-match	M
urn:oasis:names:tc:xacml:2.0:function:x500Name-regexp-match	M
urn:oasis:names:tc:xacml:3.0:function:xpath-node-count	O
urn:oasis:names:tc:xacml:3.0:function:xpath-node-equal	O
urn:oasis:names:tc:xacml:3.0:function:xpath-node-match	O
urn:oasis:names:tc:xacml:1.0:function:string-intersection	M
urn:oasis:names:tc:xacml:1.0:function:string-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:string-union	M
urn:oasis:names:tc:xacml:1.0:function:string-subset	M
urn:oasis:names:tc:xacml:1.0:function:string-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:boolean-intersection	M
urn:oasis:names:tc:xacml:1.0:function:boolean-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:boolean-union	M
urn:oasis:names:tc:xacml:1.0:function:boolean-subset	M

urn:oasis:names:tc:xacml:1.0:function:boolean-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:integer-intersection	M
urn:oasis:names:tc:xacml:1.0:function:integer-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:integer-union	M
urn:oasis:names:tc:xacml:1.0:function:integer-subset	M
urn:oasis:names:tc:xacml:1.0:function:integer-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:double-intersection	M
urn:oasis:names:tc:xacml:1.0:function:double-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:double-union	M
urn:oasis:names:tc:xacml:1.0:function:double-subset	M
urn:oasis:names:tc:xacml:1.0:function:double-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:time-intersection	M
urn:oasis:names:tc:xacml:1.0:function:time-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:time-union	M
urn:oasis:names:tc:xacml:1.0:function:time-subset	M
urn:oasis:names:tc:xacml:1.0:function:time-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:date-intersection	M
urn:oasis:names:tc:xacml:1.0:function:date-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:date-union	M
urn:oasis:names:tc:xacml:1.0:function:date-subset	M
urn:oasis:names:tc:xacml:1.0:function:date-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-intersection	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-union	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-subset	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-intersection	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-union	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-subset	M
urn:oasis:names:tc:xacml:1.0:function:anyURI-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-intersection	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-union	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-subset	M
urn:oasis:names:tc:xacml:1.0:function:hexBinary-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-intersection	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-union	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-subset	M
urn:oasis:names:tc:xacml:1.0:function:base64Binary-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-intersection	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-union	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-subset	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-intersection	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-union	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-subset	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-intersection	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-union	M
urn:oasis:names:tc:xacml:1.0:function:x500Name-subset	M

urn:oasis:names:tc:xacml:1.0:function:x500Name-set-equals	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-intersection	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-at-least-one-member-of	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-union	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-subset	M
urn:oasis:names:tc:xacml:1.0:function:rfc822Name-set-equals	M
urn:oasis:names:tc:xacml:3.0:function:access-permitted	O

10.2.9 Identifiers planned for future deprecation

These identifiers are associated with previous versions of XACML and newer alternatives exist in XACML 3.0. They are planned to be deprecated at some unspecified point in the future. It is RECOMMENDED that these identifiers not be used in new polices and requests.

The implementation MUST properly process those features associated with the identifiers marked with an "M".

Function	M/O
urn:oasis:names:tc:xacml:1.0:function:xpath-node-count	O
urn:oasis:names:tc:xacml:1.0:function:xpath-node-equal	O
urn:oasis:names:tc:xacml:1.0:function:xpath-node-match	O
urn:oasis:names:tc:xacml:2.0:function:uri-string-concatenate	M
http://www.w3.org/TR/2002/WD-xquery-operators-20020816#dayTimeDuration	M
http://www.w3.org/TR/2002/WD-xquery-operators-20020816#yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-equal	M
urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-equal	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-add-dayTimeDuration	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-add-yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-subtract-dayTimeDuration	M
urn:oasis:names:tc:xacml:1.0:function:dateTime-subtract-yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:function:date-subtract-yearMonthDuration	M
urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides	M
urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides	M
urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:permit-overrides	M
urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:permit-overrides	M
urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-deny-overrides	M
urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-deny-overrides	M
urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-permit-overrides	M
urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-permit-overrides	M

A. Data-types and functions (normative)

A.1 Introduction

This section specifies the data-types and functions used in XACML to create ***predicates*** for ***conditions*** and ***target*** matches.

This specification combines the various standards set forth by IEEE and ANSI for string representation of numeric values, as well as the evaluation of arithmetic functions. It describes the primitive data-types and ***bags***. The standard functions are named and their operational semantics are described.

A.2 Data-types

Although XML instances represent all data-types as strings, an XACML ***PDP*** must operate on types of data that, while they have string representations, are not just strings. Types such as Boolean, integer, and double MUST be converted from their XML string representations to values that can be compared with values in their domain of discourse, such as numbers. The following primitive data-types are specified for use with XACML and have explicit data representations:

- http://www.w3.org/2001/XMLSchema#string
- http://www.w3.org/2001/XMLSchema#boolean
- http://www.w3.org/2001/XMLSchema#integer
- http://www.w3.org/2001/XMLSchema#double
- http://www.w3.org/2001/XMLSchema#time
- http://www.w3.org/2001/XMLSchema#date
- http://www.w3.org/2001/XMLSchema#dateTime
- http://www.w3.org/2001/XMLSchema#anyURI
- http://www.w3.org/2001/XMLSchema#hexBinary
- http://www.w3.org/2001/XMLSchema#base64Binary
- http://www.w3.org/2001/XMLSchema#dayTimeDuration
- http://www.w3.org/2001/XMLSchema#yearMonthDuration
- urn:oasis:names:tc:xacml:1.0:data-type:x500Name
- urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name
- urn:oasis:names:tc:xacml:2.0:data-type:ipAddress
- urn:oasis:names:tc:xacml:2.0:data-type:dnsName
- urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression

For the sake of improved interoperability, it is RECOMMENDED that all time references be in UTC time.

An XACML ***PDP*** SHALL be capable of converting string representations into various primitive data-types. For doubles, XACML SHALL use the conversions described in **[IEEE754]**.

XACML defines four data-types representing identifiers for ***subjects*** or ***resources***; these are:

"urn:oasis:names:tc:xacml:1.0:data-type:x500Name",

"urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name"

"urn:oasis:names:tc:xacml:2.0:data-type:ipAddress" and

"urn:oasis:names:tc:xacml:2.0:data-type:dnsName"

These types appear in several standard applications, such as TLS/SSL and electronic mail.

X.500 directory name

The “urn:oasis:names:tc:xacml:1.0:data-type:x500Name” primitive type represents an ITU-T Rec. X.520 Distinguished Name. The valid syntax for such a name is described in IETF RFC 2253 "Lightweight Directory Access Protocol (v3): UTF-8 String Representation of Distinguished Names".

RFC 822 name

The “urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name” primitive type represents an electronic mail address. The valid syntax for such a name is described in IETF RFC 2821, Section 4.1.2, Command Argument Syntax, under the term "Mailbox".

IP address

The “urn:oasis:names:tc:xacml:2.0:data-type:ipAddress” primitive type represents an IPv4 or IPv6 network address, with optional mask and optional port or port range. The syntax SHALL be:

ipAddress = address ["/" mask] [":" [portrange]]

For an IPv4 address, the address and mask are formatted in accordance with the syntax for a "host" in IETF RFC 2396 "Uniform Resource Identifiers (URI): Generic Syntax", section 3.2.

For an IPv6 address, the address and mask are formatted in accordance with the syntax for an "ipv6reference" in IETF RFC 2732 "Format for Literal IPv6 Addresses in URL's". (Note that an IPv6 address or mask, in this syntax, is enclosed in literal "[" "]" brackets.)

DNS name

The “urn:oasis:names:tc:xacml:2.0:data-type:dnsName” primitive type represents a Domain Name Service (DNS) host name, with optional port or port range. The syntax SHALL be:

dnsName = hostname [":" portrange]

The hostname is formatted in accordance with IETF RFC 2396 "Uniform Resource Identifiers (URI): Generic Syntax", section 3.2, except that a wildcard "*" may be used in the left-most component of the hostname to indicate "any subdomain" under the domain specified to its right.

For both the “urn:oasis:names:tc:xacml:2.0:data-type:ipAddress” and “urn:oasis:names:tc:xacml:2.0:data-type:dnsName” data-types, the port or port range syntax SHALL be

portrange = portnumber | "-"portnumber | portnumber"-"[portnumber]

where "portnumber" is a decimal port number. If the port number is of the form "-x", where "x" is a port number, then the range is all ports numbered "x" and below. If the port number is of the form "x-", then the range is all ports numbered "x" and above. [This syntax is taken from the Java SocketPermission.]

XPath expression

The “urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression” primitive type represents an XPath expression selects over the XML in a `<Content>` element. The syntax is defined by the XPath W3C recommendation. The content of this data type also includes the context in which namespaces prefixes in the expression are resolved, which distinguishes it from a plain string and the XACML ***attribute*** category of the `<Content>` element to which it applies. When the value is encoded in an `<AttributeValue>` element, the namespace context is given by the `<AttributeValue>` element and an XML attribute called XPathCategory gives the category of the `<Content>` element where the expression applies.

The XPath expression MUST be evaluated in a context which is equivalent of a stand alone XML document with the only child of the `<Content>` element as the document element. Namespace declarations which are not “visibly utilized”, as defined by **[exc-c14n]**, MAY not be present and MUST NOT be utilized by the XPath expression. The context node of the XPath expression is the document node of this stand alone document.

A.3 Functions

XACML specifies the following functions. If an argument of one of these functions were to evaluate to "Indeterminate", then the function SHALL be set to "Indeterminate".

A.3.1 Equality predicates

The following functions are the equality functions for the various primitive types. Each function for a particular data-type follows a specified standard convention for that data-type.

- urn:oasis:names:tc:xacml:1.0:function:string-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL return "True" if and only if the value of both of its arguments are of equal length and each string is determined to be equal. Otherwise, it SHALL return "False". The comparison SHALL use Unicode codepoint collation, as defined for the identifier http://www.w3.org/2005/xpath-functions/collation/codepoint by **[XF]**.

- urn:oasis:names:tc:xacml:3.0:function:string-equal-ignore-case

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be "True" if and only if the two strings are equal as defined by urn:oasis:names:tc:xacml:1.0:function:string-equal after they have both been converted to lower case with urn:oasis:names:tc:xacml:1.0:function:string-normalize-to-lower-case.

- urn:oasis:names:tc:xacml:1.0:function:boolean-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#boolean" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL return "True" if and only if the arguments are equal. Otherwise, it SHALL return "False".

- urn:oasis:names:tc:xacml:1.0:function:integer-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#integer" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL return "True" if and only if the two arguments represent the same number.

- urn:oasis:names:tc:xacml:1.0:function:double-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#double" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL perform its evaluation on doubles according to IEEE 754 **[IEEE754]**.

- urn:oasis:names:tc:xacml:1.0:function:date-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#date" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL perform its evaluation according to the "op:date-equal" function **[XF]** Section 10.4.9.

- urn:oasis:names:tc:xacml:1.0:function:time-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL perform its evaluation according to the "op:time-equal" function **[XF]** Section 10.4.12.

- urn:oasis:names:tc:xacml:1.0:function:dateTime-equal

This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#dateTime" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL perform its evaluation according to the "op:dateTime-equal" function **[XF]** Section 10.4.6.

- urn:oasis:names:tc:xacml:3.0:function:dayTimeDuration-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#dayTimeDuration" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". This function shall perform its evaluation according to the "op:duration-equal" function **[XF]** Section 10.4.5. Note that the lexical representation of each argument MUST be converted to a value expressed in fractional seconds **[XF]** Section 10.3.2.

- urn:oasis:names:tc:xacml:3.0:function:yearMonthDuration-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#yearMonthDuration" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". This function shall perform its evaluation according to the "op:duration-equal" function **[XF]** Section 10.4.5. Note that the lexical representation of each argument MUST be converted to a value expressed in fractional seconds **[XF]** Section 10.3.2.

- urn:oasis:names:tc:xacml:1.0:function:anyURI-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#anyURI" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL return "True" if and only if the values of the two arguments are equal on a codepoint-by-codepoint basis.

- urn:oasis:names:tc:xacml:1.0:function:x500Name-equal

  This function SHALL take two arguments of "urn:oasis:names:tc:xacml:1.0:data-type:x500Name" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if each Relative Distinguished Name (RDN) in the two arguments matches. Otherwise, it SHALL return "False". Two RDNs shall be said to match if and only if the result of the following operations is "True" .

  1. Normalize the two arguments according to IETF RFC 2253 "Lightweight Directory Access Protocol (v3): UTF-8 String Representation of Distinguished Names".
  2. If any RDN contains multiple attributeTypeAndValue pairs, re-order the Attribute ValuePairs in that RDN in ascending order when compared as octet strings (described in ITU-T Rec. X.690 (1997 E) Section 11.6 "Set-of components").
  3. Compare RDNs using the rules in IETF RFC 3280 "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", Section 4.1.2.4 "Issuer".

- urn:oasis:names:tc:xacml:1.0:function:rfc822Name-equal

  This function SHALL take two arguments of data-type "urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the two arguments are equal. Otherwise, it SHALL return "False". An RFC822 name consists of a local-part followed by "@" followed by a domain-part. The local-part is case-sensitive, while the domain-part (which is usually a DNS host name) is not case-sensitive. Perform the following operations:

  1. Normalize the domain-part of each argument to lower case
  2. Compare the expressions by applying the function "urn:oasis:names:tc:xacml:1.0:function:string-equal" to the normalized arguments.

- urn:oasis:names:tc:xacml:1.0:function:hexBinary-equal

This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#hexBinary" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if the octet sequences represented by the value of both arguments have equal length and are equal in a conjunctive, point-wise, comparison using the "urn:oasis:names:tc:xacml:1.0:function:integer-equal" function. Otherwise, it SHALL return "False". The conversion from the string representation to an octet sequence SHALL be as specified in **[XS]** Section 3.2.15.

- urn:oasis:names:tc:xacml:1.0:function:base64Binary-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#base64Binary" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if the octet sequences represented by the value of both arguments have equal length and are equal in a conjunctive, point-wise, comparison using the "urn:oasis:names:tc:xacml:1.0:function:integer-equal" function. Otherwise, it SHALL return "False". The conversion from the string representation to an octet sequence SHALL be as specified in **[XS]** Section 3.2.16.

A.3.2 Arithmetic functions

All of the following functions SHALL take two arguments of the specified data-type, integer, or double, and SHALL return an element of integer or double data-type, respectively. However, the "add" and "multiply" functions MAY take more than two arguments. Each function evaluation operating on doubles SHALL proceed as specified by their logical counterparts in IEEE 754 **[IEEE754]**. For all of these functions, if any argument is "Indeterminate", then the function SHALL evaluate to "Indeterminate". In the case of the divide functions, if the divisor is zero, then the function SHALL evaluate to "Indeterminate".

- urn:oasis:names:tc:xacml:1.0:function:integer-add

  This function MUST accept two or more arguments.

- urn:oasis:names:tc:xacml:1.0:function:double-add

  This function MUST accept two or more arguments.

- urn:oasis:names:tc:xacml:1.0:function:integer-subtract
- urn:oasis:names:tc:xacml:1.0:function:double-subtract
- urn:oasis:names:tc:xacml:1.0:function:integer-multiply

  This function MUST accept two or more arguments.

- urn:oasis:names:tc:xacml:1.0:function:double-multiply

  This function MUST accept two or more arguments.

- urn:oasis:names:tc:xacml:1.0:function:integer-divide
- urn:oasis:names:tc:xacml:1.0:function:double-divide
- urn:oasis:names:tc:xacml:1.0:function:integer-mod

The following functions SHALL take a single argument of the specified data-type. The round and floor functions SHALL take a single argument of data-type "http://www.w3.org/2001/XMLSchema#double" and return a value of the data-type "http://www.w3.org/2001/XMLSchema#double".

- urn:oasis:names:tc:xacml:1.0:function:integer-abs
- urn:oasis:names:tc:xacml:1.0:function:double-abs
- urn:oasis:names:tc:xacml:1.0:function:round
- urn:oasis:names:tc:xacml:1.0:function:floor

A.3.3 String conversion functions

The following functions convert between values of the data-type "http://www.w3.org/2001/XMLSchema#string" primitive types.

- urn:oasis:names:tc:xacml:1.0:function:string-normalize-space

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL normalize the value by stripping off all leading and trailing white space characters. The whitespace characters are defined in the metasymbol S (Production 3) of **[XML]**.

- urn:oasis:names:tc:xacml:1.0:function:string-normalize-to-lower-case

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL normalize the value by converting each upper case character to its lower case equivalent. Case mapping shall be done as specified for the fn:lower-case function in **[XF]** with no tailoring for particular languages or environments.

A.3.4 Numeric data-type conversion functions

The following functions convert between the data-type "http://www.w3.org/2001/XMLSchema#integer" and" http://www.w3.org/2001/XMLSchema#double" primitive types.

- urn:oasis:names:tc:xacml:1.0:function:double-to-integer

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#double" and SHALL truncate its numeric value to a whole number and return an element of data-type "http://www.w3.org/2001/XMLSchema#integer".

- urn:oasis:names:tc:xacml:1.0:function:integer-to-double

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#integer" and SHALL promote its value to an element of data-type "http://www.w3.org/2001/XMLSchema#double" with the same numeric value. If the integer argument is outside the range which can be represented by a double, the result SHALL be Indeterminate, with the status code "urn:oasis:names:tc:xacml:1.0:status:processing-error".

A.3.5 Logical functions

This section contains the specification for logical functions that operate on arguments of data-type "http://www.w3.org/2001/XMLSchema#boolean".

- urn:oasis:names:tc:xacml:1.0:function:or

  This function SHALL return "False" if it has no arguments and SHALL return "True" if at least one of its arguments evaluates to "True". The order of evaluation SHALL be from first argument to last. The evaluation SHALL stop with a result of "True" if any argument evaluates to "True", leaving the rest of the arguments unevaluated.

- urn:oasis:names:tc:xacml:1.0:function:and

  This function SHALL return "True" if it has no arguments and SHALL return "False" if one of its arguments evaluates to "False". The order of evaluation SHALL be from first argument to last. The evaluation SHALL stop with a result of "False" if any argument evaluates to "False", leaving the rest of the arguments unevaluated.

- urn:oasis:names:tc:xacml:1.0:function:n-of

  The first argument to this function SHALL be of data-type http://www.w3.org/2001/XMLSchema#integer. The remaining arguments SHALL be of data-type http://www.w3.org/2001/XMLSchema#boolean. The first argument specifies the minimum number of the remaining arguments that MUST evaluate to "True" for the expression to be considered "True". If the first argument is 0, the result SHALL be "True". If the number of arguments after the first one is less than the value of the first argument, then the expression SHALL result in "Indeterminate". The order of evaluation SHALL be: first evaluate the integer value, and then evaluate each subsequent argument. The evaluation SHALL stop and return "True" if the specified number of arguments evaluate to "True". The evaluation of arguments SHALL stop if it is determined that evaluating the remaining arguments will not satisfy the requirement.

- urn:oasis:names:tc:xacml:1.0:function:not

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#boolean". If the argument evaluates to "True", then the result of the expression SHALL be "False". If the argument evaluates to "False", then the result of the expression SHALL be "True".

Note: When evaluating and, or, or n-of, it MAY NOT be necessary to attempt a full evaluation of each argument in order to determine whether the evaluation of the argument would result in "Indeterminate". Analysis of the argument regarding the availability of its ***attributes***, or other analysis regarding errors, such as "divide-by-zero", may render the argument error free. Such arguments occurring in the expression in a position after the evaluation is stated to stop need not be processed.

A.3.6 Numeric comparison functions

These functions form a minimal set for comparing two numbers, yielding a Boolean result. For doubles they SHALL comply with the rules governed by IEEE 754 **[IEEE754]**.

- urn:oasis:names:tc:xacml:1.0:function:integer-greater-than
- urn:oasis:names:tc:xacml:1.0:function:integer-greater-than-or-equal
- urn:oasis:names:tc:xacml:1.0:function:integer-less-than
- urn:oasis:names:tc:xacml:1.0:function:integer-less-than-or-equal
- urn:oasis:names:tc:xacml:1.0:function:double-greater-than
- urn:oasis:names:tc:xacml:1.0:function:double-greater-than-or-equal
- urn:oasis:names:tc:xacml:1.0:function:double-less-than
- urn:oasis:names:tc:xacml:1.0:function:double-less-than-or-equal

A.3.7 Date and time arithmetic functions

These functions perform arithmetic operations with date and time.

- urn:oasis:names:tc:xacml:3.0:function:dateTime-add-dayTimeDuration

  This function SHALL take two arguments, the first SHALL be of data-type "http://www.w3.org/2001/XMLSchema#dateTime" and the second SHALL be of data-type "http://www.w3.org/2001/XMLSchema#dayTimeDuration". It SHALL return a result of "http://www.w3.org/2001/XMLSchema#dateTime". This function SHALL return the value by adding the second argument to the first argument according to the specification of adding durations to date and time **[XS]** Appendix E.

- urn:oasis:names:tc:xacml:3.0:function:dateTime-add-yearMonthDuration

  This function SHALL take two arguments, the first SHALL be a "http://www.w3.org/2001/XMLSchema#dateTime" and the second SHALL be a "http://www.w3.org/2001/XMLSchema#yearMonthDuration". It SHALL return a result of "http://www.w3.org/2001/XMLSchema#dateTime". This function SHALL return the value by adding the second argument to the first argument according to the specification of adding durations to date and time **[XS]** Appendix E.

- urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-dayTimeDuration

  This function SHALL take two arguments, the first SHALL be a "http://www.w3.org/2001/XMLSchema#dateTime" and the second SHALL be a "http://www.w3.org/2001/XMLSchema#dayTimeDuration". It SHALL return a result of "http://www.w3.org/2001/XMLSchema#dateTime". If the second argument is a positive duration, then this function SHALL return the value by adding the corresponding negative duration, as per the specification **[XS]** Appendix E. If the second argument is a negative duration, then the result SHALL be as if the function "urn:oasis:names:tc:xacml:1.0:function:dateTime-add-dayTimeDuration" had been applied to the corresponding positive duration.

- urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-yearMonthDuration

    This function SHALL take two arguments, the first SHALL be a “http://www.w3.org/2001/XMLSchema#dateTime” and the second SHALL be a “http://www.w3.org/2001/XMLSchema#yearMonthDuration”. It SHALL return a result of “http://www.w3.org/2001/XMLSchema#dateTime”. If the second argument is a positive duration, then this function SHALL return the value by adding the corresponding negative duration, as per the specification **[XS]** Appendix E. If the second argument is a negative duration, then the result SHALL be as if the function “urn:oasis:names:tc:xacml:1.0:function:dateTime-add-yearMonthDuration” had been applied to the corresponding positive duration.

- urn:oasis:names:tc:xacml:3.0:function:date-add-yearMonthDuration

    This function SHALL take two arguments, the first SHALL be a “http://www.w3.org/2001/XMLSchema#date” and the second SHALL be a “http://www.w3.org/2001/XMLSchema#yearMonthDuration”. It SHALL return a result of “http://www.w3.org/2001/XMLSchema#date”. This function SHALL return the value by adding the second argument to the first argument according to the specification of adding duration to date **[XS]** Appendix E.

- urn:oasis:names:tc:xacml:3.0:function:date-subtract-yearMonthDuration

    This function SHALL take two arguments, the first SHALL be a “http://www.w3.org/2001/XMLSchema#date” and the second SHALL be a “http://www.w3.org/2001/XMLSchema#yearMonthDuration”. It SHALL return a result of “http://www.w3.org/2001/XMLSchema#date”. If the second argument is a positive duration, then this function SHALL return the value by adding the corresponding negative duration, as per the specification **[XS]** Appendix E. If the second argument is a negative duration, then the result SHALL be as if the function “urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration” had been applied to the corresponding positive duration.

A.3.8 Non-numeric comparison functions

These functions perform comparison operations on two arguments of non-numerical types.

- urn:oasis:names:tc:xacml:1.0:function:string-greater-than

    This function SHALL take two arguments of data-type “http://www.w3.org/2001/XMLSchema#string” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return "True" if and only if the first argument is lexicographically strictly greater than the second argument. Otherwise, it SHALL return “False”. The comparison SHALL use Unicode codepoint collation, as defined for the identifier http://www.w3.org/2005/xpath-functions/collation/codepoint by **[XF]**.

- urn:oasis:names:tc:xacml:1.0:function:string-greater-than-or-equal

    This function SHALL take two arguments of data-type “http://www.w3.org/2001/XMLSchema#string” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return "True" if and only if the first argument is lexicographically greater than or equal to the second argument. Otherwise, it SHALL return “False”. The comparison SHALL use Unicode codepoint collation, as defined for the identifier http://www.w3.org/2005/xpath-functions/collation/codepoint by **[XF]**.

- urn:oasis:names:tc:xacml:1.0:function:string-less-than

    This function SHALL take two arguments of data-type “http://www.w3.org/2001/XMLSchema#string” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return "True" if and only the first argument is lexigraphically strictly less than the second argument. Otherwise, it SHALL return “False”. The comparison SHALL use Unicode codepoint collation, as defined for the identifier http://www.w3.org/2005/xpath-functions/collation/codepoint by **[XF]**.

- urn:oasis:names:tc:xacml:1.0:function:string-less-than-or-equal

This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only the first argument is lexigraphically less than or equal to the second argument. Otherwise, it SHALL return "False". The comparison SHALL use Unicode codepoint collation, as defined for the identifier http://www.w3.org/2005/xpath-functions/collation/codepoint by **[XF]**.

- urn:oasis:names:tc:xacml:1.0:function:time-greater-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#time" **[XS]** Section 3.2.8. Otherwise, it SHALL return "False". Note: it is illegal to compare a time that includes a time-zone value with one that does not. In such cases, the time-in-range function should be used.

- urn:oasis:names:tc:xacml:1.0:function:time-greater-than-or-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than or equal to the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#time" **[XS]** Section 3.2.8. Otherwise, it SHALL return "False". Note: it is illegal to compare a time that includes a time-zone value with one that does not. In such cases, the time-in-range function should be used.

- urn:oasis:names:tc:xacml:1.0:function:time-less-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is less than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#time" **[XS]** Section 3.2.8. Otherwise, it SHALL return "False". Note: it is illegal to compare a time that includes a time-zone value with one that does not. In such cases, the time-in-range function should be used.

- urn:oasis:names:tc:xacml:1.0:function:time-less-than-or-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is less than or equal to the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#time" **[XS]** Section 3.2.8. Otherwise, it SHALL return "False". Note: it is illegal to compare a time that includes a time-zone value with one that does not. In such cases, the time-in-range function should be used.

- urn:oasis:names:tc:xacml:2.0:function:time-in-range

  This function SHALL take three arguments of data-type "http://www.w3.org/2001/XMLSchema#time" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if the first argument falls in the range defined inclusively by the second and third arguments. Otherwise, it SHALL return "False". Regardless of its value, the third argument SHALL be interpreted as a time that is equal to, or later than by less than twenty-four hours, the second argument. If no time zone is provided for the first argument, it SHALL use the default time zone at the ***context handler***. If no time zone is provided for the second or third arguments, then they SHALL use the time zone from the first argument.

- urn:oasis:names:tc:xacml:1.0:function:dateTime-greater-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#dateTime" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#dateTime" by **[XS]** part 2, section 3.2.7. Otherwise, it SHALL return "False". Note: if a dateTime value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:dateTime-greater-than-or-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#dateTime" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than or equal to the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#dateTime" by **[XS]** part 2, section 3.2.7. Otherwise, it SHALL return "False". Note: if a dateTime value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:dateTime-less-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#dateTime" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is less than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#dateTime" by [XS, part 2, section 3.2.7]. Otherwise, it SHALL return "False". Note: if a dateTime value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:dateTime-less-than-or-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema# dateTime" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is less than or equal to the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#dateTime" by **[XS]** part 2, section 3.2.7. Otherwise, it SHALL return "False". Note: if a dateTime value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:date-greater-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#date" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#date" by **[XS]** part 2, section 3.2.9. Otherwise, it SHALL return "False". Note: if a date value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:date-greater-than-or-equal

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#date" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is greater than or equal to the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#date" by **[XS]** part 2, section 3.2.9. Otherwise, it SHALL return "False". Note: if a date value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:date-less-than

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#date" and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". It SHALL return "True" if and only if the first argument is less than the second argument according to the order relation specified for "http://www.w3.org/2001/XMLSchema#date" by **[XS]** part 2, section 3.2.9. Otherwise, it SHALL return “False”. Note: if a date value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

- urn:oasis:names:tc:xacml:1.0:function:date-less-than-or-equal

  This function SHALL take two arguments of data-type “http://www.w3.org/2001/XMLSchema#date” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return "True" if and only if the first argument is less than or equal to the second argument according to the order relation specified for “http://www.w3.org/2001/XMLSchema#date” by **[XS]** part 2, section 3.2.9. Otherwise, it SHALL return “False”. Note: if a date value does not include a time-zone value, then an implicit time-zone value SHALL be assigned, as described in **[XS]**.

A.3.9 String functions

The following functions operate on strings and convert to and from other data types.

- urn:oasis:names:tc:xacml:2.0:function:string-concatenate

  This function SHALL take two or more arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return a "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the concatenation, in order, of the arguments.

- urn:oasis:names:tc:xacml:3.0:function:boolean-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be the string converted to a boolean.

- urn:oasis:names:tc:xacml:3.0:function:string-from-boolean

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#boolean", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the boolean converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:integer-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#integer". The result SHALL be the string converted to an integer.

- urn:oasis:names:tc:xacml:3.0:function:string-from-integer

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#integer", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the integer converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:double-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#double". The result SHALL be the string converted to a double.

- urn:oasis:names:tc:xacml:3.0:function:string-from-double

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#double", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the double converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:time-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#time". The result SHALL be the string converted to a time.

- urn:oasis:names:tc:xacml:3.0:function:string-from-time

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#time", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the time converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:date-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#date". The result SHALL be the string converted to a date.

- urn:oasis:names:tc:xacml:3.0:function:string-from-date

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#date", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the date converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:dateTime-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#dateTime". The result SHALL be the string converted to a dateTime.

urn:oasis:names:tc:xacml:3.0:function:string-from-dateTime

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#dateTime", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the dateTime converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:anyURI-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return a "http://www.w3.org/2001/XMLSchema#anyURI". The result SHALL be the URI constructed by converting the argument to an URI.

- urn:oasis:names:tc:xacml:3.0:function:string-from-anyURI

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#anyURI", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the URI converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:dayTimeDuration-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#dayTimeDuration ". The result SHALL be the string converted to a dayTimeDuration.

- urn:oasis:names:tc:xacml:3.0:function:string-from-dayTimeDuration

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#dayTimeDuration ", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the dayTimeDuration converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:yearMonthDuration-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "http://www.w3.org/2001/XMLSchema#yearMonthDuration". The result SHALL be the string converted to a yearMonthDuration.

- urn:oasis:names:tc:xacml:3.0:function:string-from-yearMonthDuration

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#yearMonthDuration", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the yearMonthDuration converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:x500Name-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "urn:oasis:names:tc:xacml:1.0:data-type:x500Name". The result SHALL be the string converted to an x500Name.

- urn:oasis:names:tc:xacml:3.0:function:string-from-x500Name

  This function SHALL take one argument of data-type "urn:oasis:names:tc:xacml:1.0:data-type:x500Name", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the x500Name converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:rfc822Name-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name". The result SHALL be the string converted to an rfc822Name.

- urn:oasis:names:tc:xacml:3.0:function:string-from-rfc822Name

  This function SHALL take one argument of data-type "urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the rfc822Name converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:ipAddress-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "urn:oasis:names:tc:xacml:2.0:data-type:ipAddress". The result SHALL be the string converted to an ipAddress.

- urn:oasis:names:tc:xacml:3.0:function:string-from-ipAddress

  This function SHALL take one argument of data-type "urn:oasis:names:tc:xacml:2.0:data-type:ipAddress", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the ipAddress converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:dnsName-from-string

  This function SHALL take one argument of data-type "http://www.w3.org/2001/XMLSchema#string", and SHALL return an "urn:oasis:names:tc:xacml:2.0:data-type:dnsName". The result SHALL be the string converted to a dnsName.

- urn:oasis:names:tc:xacml:3.0:function:string-from-dnsName

  This function SHALL take one argument of data-type "urn:oasis:names:tc:xacml:2.0:data-type:dnsName", and SHALL return an "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the dnsName converted to a string.

- urn:oasis:names:tc:xacml:3.0:function:string-starts-with

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the second string begins with the first string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:anyURI-starts-with

  This function SHALL take a first argument of data-type"http://www.w3.org/2001/XMLSchema#string" and an a second argument of data-type "http://www.w3.org/2001/XMLSchema#anyURI" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the URI converted to a string begins with the string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:string-ends-with

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the second string ends with the first string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:anyURI-ends-with

  This function SHALL take a first argument of data-type "http://www.w3.org/2001/XMLSchema#string" and an a second argument of data-type "http://www.w3.org/2001/XMLSchema#anyURI" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the URI converted to a string ends with the string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:string-contains

  This function SHALL take two arguments of data-type "http://www.w3.org/2001/XMLSchema#string" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the second string contains the first string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:anyURI-contains

  This function SHALL take a first argument of data-type "http://www.w3.org/2001/XMLSchema#string" and an a second argument of data-type "http://www.w3.org/2001/XMLSchema#anyURI" and SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The result SHALL be true if the URI converted to a string contains the string, and false otherwise. Equality testing SHALL be done as defined for urn:oasis:names:tc:xacml:1.0:function:string-equal.

- urn:oasis:names:tc:xacml:3.0:function:string-substring

  This function SHALL take a first argument of data-type "http://www.w3.org/2001/XMLSchema#string" and a second and a third argument of type "http://www.w3.org/2001/XMLSchema#integer" and SHALL return a "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the substring of the first argument beginning at the position given by the second argument and ending at the position before the position given by the third argument. The first character of the string has position zero. The negative integer value -1 given for the third arguments indicates the end of the string. If the second or third arguments are out of bounds, then the function MUST evaluate to Indeterminate with a status code of `urn:oasis:names:tc:xacml:1.0:status:processing-error.`

- urn:oasis:names:tc:xacml:3.0:function:anyURI-substring

This function SHALL take a first argument of data-type "http://www.w3.org/2001/XMLSchema#anyURI" and a second and a third argument of type "http://www.w3.org/2001/XMLSchema#integer" and SHALL return a "http://www.w3.org/2001/XMLSchema#string". The result SHALL be the substring of the first argument converted to a string beginning at the position given by the second argument and ending at the position before the position given by the third argument. The first character of the URI converted to a string has position zero. The negative integer value -1 given for the third arguments indicates the end of the string. If the second or third arguments are out of bounds, then the function MUST evaluate to Indeterminate with a status code of `urn:oasis:names:tc:xacml:1.0:status:processing-error`. If the resulting substring is not syntactically a valid URI, then the function MUST evaluate to Indeterminate with a status code of `urn:oasis:names:tc:xacml:1.0:status:processing-error`.

A.3.10 Bag functions

These functions operate on a ***bag*** of 'type' values, where type is one of the primitive data-types, and x.x is a version of XACML where the function has been defined. Some additional conditions defined for each function below SHALL cause the expression to evaluate to "Indeterminate".

- urn:oasis:names:tc:xacml:x.x:function:type-one-and-only

  This function SHALL take a ***bag*** of 'type' values as an argument and SHALL return a value of '-type'. It SHALL return the only value in the ***bag***. If the ***bag*** does not have one and only one value, then the expression SHALL evaluate to "Indeterminate".

- urn:oasis:names:tc:xacml:x.x:function:type-bag-size

  This function SHALL take a ***bag*** of 'type' values as an argument and SHALL return an "http://www.w3.org/2001/XMLSchema#integer" indicating the number of values in the ***bag***.

- urn:oasis:names:tc:xacml:x.x:function:type-is-in

  This function SHALL take an argument of 'type' as the first argument and a ***bag*** of type values as the second argument and SHALL return an "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL evaluate to "True" if and only if the first argument matches by the "urn:oasis:names:tc:xacml:x.x:function:type-equal" any value in the ***bag***. Otherwise, it SHALL return "False".

- urn:oasis:names:tc:xacml:x.x:function:type-bag

  This function SHALL take any number of arguments of 'type' and return a ***bag*** of 'type' values containing the values of the arguments. An application of this function to zero arguments SHALL produce an empty ***bag*** of the specified data-type.

A.3.11 Set functions

These functions operate on ***bags*** mimicking sets by eliminating duplicate elements from a ***bag***.

- urn:oasis:names:tc:xacml:x.x:function:type-intersection

  This function SHALL take two arguments that are both a ***bag*** of 'type' values. It SHALL return a ***bag*** of 'type' values such that it contains only elements that are common between the two ***bags***, which is determined by "urn:oasis:names:tc:xacml:x.x:function:type-equal". No duplicates, as determined by "urn:oasis:names:tc:xacml:x.x:function:type-equal", SHALL exist in the result.

- urn:oasis:names:tc:xacml:x.x:function:type-at-least-one-member-of

  This function SHALL take two arguments that are both a ***bag*** of 'type' values. It SHALL return a "http://www.w3.org/2001/XMLSchema#boolean". The function SHALL evaluate to "True" if and only if at least one element of the first argument is contained in the second argument as determined by "urn:oasis:names:tc:xacml:x.x:function:type-is-in".

- urn:oasis:names:tc:xacml:x.x:function:type-union

This function SHALL take two or more arguments that are both a ***bag*** of ‘type’ values. The expression SHALL return a ***bag*** of ‘type’ such that it contains all elements of all the argument ***bags***. No duplicates, as determined by "urn:oasis:names:tc:xacml:x.x:function:type-equal", SHALL exist in the result.

- urn:oasis:names:tc:xacml:x.x:function:type-subset

  This function SHALL take two arguments that are both a ***bag*** of ‘type’ values. It SHALL return a “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return "True" if and only if the first argument is a subset of the second argument. Each argument SHALL be considered to have had its duplicates removed, as determined by "urn:oasis:names:tc:xacml:x.x:function:type-equal", before the subset calculation.

- urn:oasis:names:tc:xacml:x.x:function:type-set-equals

  This function SHALL take two arguments that are both a ***bag*** of ‘type’ values. It SHALL return a “http://www.w3.org/2001/XMLSchema#boolean”. It SHALL return the result of applying "urn:oasis:names:tc:xacml:1.0:function:and" to the application of "urn:oasis:names:tc:xacml:x.x:function:type-subset" to the first and second arguments and the application of "urn:oasis:names:tc:xacml:x.x:function:type-subset" to the second and first arguments.

A.3.12 Higher-order bag functions

This section describes functions in XACML that perform operations on ***bags*** such that functions may be applied to the ***bags*** in general.

In this section, a general-purpose functional language called Haskell **[Haskell]** is used to formally specify the semantics of these functions. Although the English description is adequate, a formal specification of the semantics is helpful.

For a quick summary, in the following Haskell notation, a function definition takes the form of clauses that are applied to patterns of structures, namely lists. The symbol “[]” denotes the empty list, whereas the expression “(x:xs)” matches against an argument of a non-empty list of which “x” represents the first element of the list, and “xs” is the rest of the list, which may be an empty list. We use the Haskell notion of a list, which is an ordered collection of elements, to model the XACML ***bags*** of values.

A simple Haskell definition of a familiar function “urn:oasis:names:tc:xacml:1.0:function:and” that takes a list of values of type Boolean is defined as follows:

```
and:: [Bool]    -> Bool
and []          = True
and (x:xs)      = x && (and xs)
```

The first definition line denoted by a “::” formally describes the data-type of the function, which takes a list of Booleans, denoted by “[Bool]”, and returns a Boolean, denoted by “Bool”. The second definition line is a clause that states that the function “and” applied to the empty list is "True". The third definition line is a clause that states that for a non-empty list, such that the first element is “x”, which is a value of data-type Bool, the function “and” applied to x SHALL be combined with, using the logical conjunction function, which is denoted by the infix symbol “&&”, the result of recursively applying the function “and” to the rest of the list. Of course, an application of the “and” function is "True" if and only if the list to which it is applied is empty or every element of the list is "True". For example, the evaluation of the following Haskell expressions,

```
(and []), (and [True]), (and [True,True]), (and [True,True,False])
```

evaluate to "True", "True", "True", and "False", respectively.

- urn:oasis:names:tc:xacml:1.0:function:any-of

  This function applies a Boolean function between specific primitive values and a ***bag*** of values, and SHALL return "True" if and only if the ***predicate*** is "True" for at least one element of the ***bag***.

This function SHALL take n+1 arguments, where n is one or greater. The first argument SHALL be an `<Function>` element that names a Boolean function that takes n arguments of primitive types. Under the remaining n arguments, n-1 parameters SHALL be values of primitive data-types and one SHALL be a ***bag*** of a primitive data-type. The expression SHALL be evaluated as if the function named in the `<Function>` argument were applied to the n-1 non-bag arguments and each element of the bag argument and the results are combined with “urn:oasis:names:tc:xacml:1.0:function:or”.

For example, the following expression SHALL return "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:any-of”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-equal”/>
   <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#string”>Paul</AttributeValue>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-bag”>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#string”>John</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#string”>Paul</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#string”>George</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#string”>Ringo</AttributeValue>
   </Apply>
</Apply>
```

This expression is "True" because the first argument is equal to at least one of the elements of the ***bag***, according to the function.

- urn:oasis:names:tc:xacml:1.0:function:all-of

This function applies a Boolean function between a specific primitive values and a ***bag*** of values, and returns "True" if and only if the ***predicate*** is "True" for every element of the ***bag***.

This function SHALL take n+1 arguments, where n is one or greater. The first argument SHALL be a `<Function>` element that names a Boolean function that takes n arguments of primitive types. Under the remaining n arguments, n-1 parameters SHALL be values of primitive data-types and one SHALL be a ***bag*** of a primitive data-type. The expression SHALL be evaluated as if the function named in the `<Function>` argument were applied to the n-1 non-bag arguments and each element of the bag argument and the results are combined with “urn:oasis:names:tc:xacml:1.0:function:and”.

For example, the following expression SHALL evaluate to "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:all-of”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:2.0:function:integer-
greater-than”/>
   <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#integer”>10</AttributeValue>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#integer”>9</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#integer”>3</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#integer”>4</AttributeValue>
          <AttributeValue 
DataType=”http://www.w3.org/2001/XMLSchema#integer”>2</AttributeValue>
   </Apply>
</Apply>
```

This expression is "True" because the first argument (10) is greater than all of the elements of the ***bag*** (9,3,4 and 2).

- urn:oasis:names:tc:xacml:1.0:function:any-of-any

This function applies a Boolean function on each tuple from the cross product on all bags arguments, and returns "True" if and only if the ***predicate*** is "True" for at least one inside-function call.

This function SHALL take n+1 arguments, where n is one or greater. The first argument SHALL be an `<Function>` element that names a Boolean function that takes n arguments. The remaining arguments are either primitive data types or bags of primitive types. The expression SHALL be evaluated as if the function named in the `<Function>` argument was applied between every tuple of the cross product on all bags and the primitive values, and the results were combined using “urn:oasis:names:tc:xacml:1.0:function:or”. The semantics are that the result of the expression SHALL be "True" if and only if the applied ***predicate*** is "True" for at least one function call on the tuples from the ***bags*** and primitive values.

For example, the following expression SHALL evaluate to "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:any-of-any”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-equal”/>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>Ringo</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>Mary</AttributeValue>
   </Apply>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>John</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>Paul</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>George</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>Ringo</AttributeValue>
   </Apply>
</Apply>
```

This expression is "True" because at least one of the elements of the first ***bag***, namely “Ringo”, is equal to at least one of the elements of the second ***bag***.

- urn:oasis:names:tc:xacml:1.0:function:all-of-any

This function applies a Boolean function between the elements of two ***bags***. The expression SHALL be “True” if and only if the supplied ***predicate*** is 'True' between each element of the first ***bag*** and any element of the second ***bag***.

This function SHALL take three arguments. The first argument SHALL be an `<Function>` element that names a Boolean function that takes two arguments of primitive types. The second argument SHALL be a ***bag*** of a primitive data-type. The third argument SHALL be a ***bag*** of a primitive data-type. The expression SHALL be evaluated as if the “urn:oasis:names:tc:xacml:1.0:function:any-of” function had been applied to each value of the first ***bag*** and the whole of the second ***bag*** using the supplied xacml:Function, and the results were then combined using “urn:oasis:names:tc:xacml:1.0:function:and”.

In Haskell, taking advantage of the “any_of” function defined in Haskell above, the semantics of the “all_of_any” function are as follows:

```
all_of_any :: ( a -> b -> Bool )              -> [a]-> [b] -> Bool
all_of_any  f  []           ys                = True
all_of_any  f  (x:xs)       ys                = (any_of  f  x  ys) && (all_of_any f  xs  ys)
```

In the above notation, “f” is the function to be applied and “(x:xs)” represents the first element of the list as “x” and the rest of the list as “xs”.

For example, the following expression SHALL evaluate to "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:all-of-any”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:2.0:function:integer-
greater-than”/>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>10</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>20</AttributeValue>
   </Apply>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>1</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>3</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>5</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>19</AttributeValue>
   </Apply>
</Apply>
```

This expression is “True” because each of the elements of the first ***bag*** is greater than at least one of the elements of the second ***bag***.

- urn:oasis:names:tc:xacml:1.0:function:any-of-all

This function applies a Boolean function between the elements of two ***bags***. The expression SHALL be “True” if and only if the supplied ***predicate*** is “True” between each element of the second ***bag*** and any element of the first ***bag***.

This function SHALL take three arguments. The first argument SHALL be an `<Function>` element that names a Boolean function that takes two arguments of primitive types. The second argument SHALL be a ***bag*** of a primitive data-type. The third argument SHALL be a ***bag*** of a primitive data-type. The expression SHALL be evaluated as if the ”rn:oasis:names:tc:xacml:1.0:function:any-of” function had been applied to each value of the second ***bag*** and the whole of the first ***bag*** using the supplied xacml:Function, and the results were then combined using “urn:oasis:names:tc:xacml:1.0:function:and”.

In Haskell, taking advantage of the “all_of” function defined in Haskell above, the semantics of the “any_of_all” function are as follows:

```
any_of_all :: ( a -> b -> Bool )          -> [a]-> [b] -> Bool
any_of_all  f  []          ys             = False
any_of_all  f  (x:xs)      ys             = (all_of  f  x  ys) || ( any_of_all  f  xs  ys)
```

In the above notation, “f” is the function name to be applied and “(x:xs)” represents the first element of the list as “x” and the rest of the list as “xs”.

For example, the following expression SHALL evaluate to "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:any-of-all”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:2.0:function:integer-
greater-than”/>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>3</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>5</AttributeValue>
   </Apply>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>1</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>2</AttributeValue>
```

```
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>3</AttributeValue>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>4</AttributeValue>
   </Apply>
</Apply>
```

This expression is “True” because, for all of the values in the second ***bag***, there is a value in the first ***bag*** that is greater.

- urn:oasis:names:tc:xacml:1.0:function:all-of-all

This function applies a Boolean function between the elements of two ***bags***. The expression SHALL be "True" if and only if the supplied ***predicate*** is "True" between each and every element of the first ***bag*** collectively against all the elements of the second ***bag***.

This function SHALL take three arguments. The first argument SHALL be an `<Function>` element that names a Boolean function that takes two arguments of primitive types. The second argument SHALL be a ***bag*** of a primitive data-type. The third argument SHALL be a ***bag*** of a primitive data-type. The expression is evaluated as if the function named in the `<Function>` element were applied between every element of the second argument and every element of the third argument and the results were combined using “urn:oasis:names:tc:xacml:1.0:function:and”. The semantics are that the result of the expression is "True" if and only if the applied ***predicate*** is "True" for all elements of the first ***bag*** compared to all the elements of the second ***bag***.

In Haskell, taking advantage of the “all_of” function defined in Haskell above, the semantics of the “all_of_all” function is as follows:

```
all_of_all :: ( a -> b -> Bool )   -> [a] -> [b] -> Bool
all_of_all  f  []          ys      = True
all_of_all  f  (x:xs)      ys      = (all_of  f  x  ys) && (all_of_all  f  xs  ys)
```

In the above notation, “f” is the function to be applied and “(x:xs)” represents the first element of the list as “x” and the rest of the list as “xs”.

For example, the following expression SHALL evaluate to "True":

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:all-of-all”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:2.0:function:integer-
greater-than”/>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>6</AttributeValue>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>5</AttributeValue>
   </Apply>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:integer-bag”>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>1</AttributeValue>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>2</AttributeValue>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>3</AttributeValue>
         <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#integer”>4</AttributeValue>
   </Apply>
</Apply>
```

This expression is "True" because all elements of the first ***bag***, “5” and “6”, are each greater than all of the integer values “1”, ”2”, ”3”, ”4” of the second ***bag***.

- urn:oasis:names:tc:xacml:1.0:function:map

This function converts a ***bag*** of values to another ***bag*** of values.

This function SHALL take n+1 arguments, where n is one or greater. The first argument SHALL be a `<Function>` element naming a function that takes a n arguments of a primitive data-type and returns a value of a primitive data-type Under the remaining n arguments, n-1 parameters SHALL be values of primitive data-types and one SHALL be a ***bag*** of a primitive data-type. The expression SHALL be evaluated as if the function named in the `<Function>` argument were applied to the n-1 non-bag arguments and each element of the bag argument and resulting in a ***bag*** of the converted value. The result SHALL be a ***bag*** of the primitive data-type that is returned by the function named in the <xacml:Function> element.

For example, the following expression,

```
<Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:map”>
   <Function FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-
normalize-to-lower-case”>
   <Apply FunctionId=”urn:oasis:names:tc:xacml:1.0:function:string-bag”>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>Hello</AttributeValue>
          <AttributeValue
DataType=”http://www.w3.org/2001/XMLSchema#string”>World!</AttributeValue>
   </Apply>
</Apply>
```

evaluates to a ***bag*** containing “hello” and “world!”.

A.3.13 Regular-expression-based functions

These functions operate on various types using regular expressions and evaluate to “http://www.w3.org/2001/XMLSchema#boolean”.

- urn:oasis:names:tc:xacml:1.0:function:string-regexp-match

  This function decides a regular expression match. It SHALL take two arguments of “http://www.w3.org/2001/XMLSchema#string” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be a general string. The function specification SHALL be that of the “xf:matches” function with the arguments reversed **[XF]** Section 7.6.2.

- urn:oasis:names:tc:xacml:2.0:function:anyURI-regexp-match

  This function decides a regular expression match. It SHALL take two arguments; the first is of type “http://www.w3.org/2001/XMLSchema#string” and the second is of type “http://www.w3.org/2001/XMLSchema#anyURI”. It SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be a URI. The function SHALL convert the second argument to type “http://www.w3.org/2001/XMLSchema#string”, then apply “urn:oasis:names:tc:xacml:1.0:function:string-regexp-match”.

- urn:oasis:names:tc:xacml:2.0:function:ipAddress-regexp-match

  This function decides a regular expression match. It SHALL take two arguments; the first is of type “http://www.w3.org/2001/XMLSchema#string” and the second is of type “urn:oasis:names:tc:xacml:2.0:data-type:ipAddress”. It SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be an IPv4 or IPv6 address. The function SHALL convert the second argument to type “http://www.w3.org/2001/XMLSchema#string”, then apply “urn:oasis:names:tc:xacml:1.0:function:string-regexp-match”.

- urn:oasis:names:tc:xacml:2.0:function:dnsName-regexp-match

  This function decides a regular expression match. It SHALL take two arguments; the first is of type “http://www.w3.org/2001/XMLSchema#string” and the second is of type “urn:oasis:names:tc:xacml:2.0:data-type:dnsName”. It SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be a DNS name. The function SHALL convert the second argument to type “http://www.w3.org/2001/XMLSchema#string”, then apply “urn:oasis:names:tc:xacml:1.0:function:string-regexp-match”.

- urn:oasis:names:tc:xacml:2.0:function:rfc822Name-regexp-match

  This function decides a regular expression match. It SHALL take two arguments; the first is of type “http://www.w3.org/2001/XMLSchema#string” and the second is of type “urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name”. It SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be an RFC 822 name. The function SHALL convert the second argument to type “http://www.w3.org/2001/XMLSchema#string”, then apply “urn:oasis:names:tc:xacml:1.0:function:string-regexp-match”.

- urn:oasis:names:tc:xacml:2.0:function:x500Name-regexp-match

  This function decides a regular expression match. It SHALL take two arguments; the first is of type “http://www.w3.org/2001/XMLSchema#string” and the second is of type “urn:oasis:names:tc:xacml:1.0:data-type:x500Name”. It SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The first argument SHALL be a regular expression and the second argument SHALL be an X.500 directory name. The function SHALL convert the second argument to type “http://www.w3.org/2001/XMLSchema#string”, then apply “urn:oasis:names:tc:xacml:1.0:function:string-regexp-match”.

A.3.14 Special match functions

These functions operate on various types and evaluate to “http://www.w3.org/2001/XMLSchema#boolean” based on the specified standard matching algorithm.

- urn:oasis:names:tc:xacml:1.0:function:x500Name-match

  This function shall take two arguments of "urn:oasis:names:tc:xacml:1.0:data-type:x500Name" and shall return an "http://www.w3.org/2001/XMLSchema#boolean". It shall return “True” if and only if the first argument matches some terminal sequence of RDNs from the second argument when compared using x500Name-equal.

- urn:oasis:names:tc:xacml:1.0:function:rfc822Name-match

  This function SHALL take two arguments, the first is of data-type “http://www.w3.org/2001/XMLSchema#string” and the second is of data-type “urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name” and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. This function SHALL evaluate to "True" if the first argument matches the second argument according to the following specification.

  An RFC822 name consists of a local-part followed by "@" followed by a domain-part. The local-part is case-sensitive, while the domain-part (which is usually a DNS name) is not case-sensitive.

  The second argument contains a complete rfc822Name. The first argument is a complete or partial rfc822Name used to select appropriate values in the second argument as follows.

  In order to match a particular address in the second argument, the first argument must specify the complete mail address to be matched. For example, if the first argument is “Anderson@sun.com”, this matches a value in the second argument of “Anderson@sun.com” and “Anderson@SUN.COM”, but not “Anne.Anderson@sun.com”, “anderson@sun.com” or “Anderson@east.sun.com”.

  In order to match any address at a particular domain in the second argument, the first argument must specify only a domain name (usually a DNS name). For example, if the first argument is “sun.com”, this matches a value in the first argument of “Anderson@sun.com” or “Baxter@SUN.COM”, but not “Anderson@east.sun.com”.

  In order to match any address in a particular domain in the second argument, the first argument must specify the desired domain-part with a leading ".". For example, if the first argument is “.east.sun.com”, this matches a value in the second argument of "Anderson@east.sun.com" and "anne.anderson@ISRG.EAST.SUN.COM" but not "Anderson@sun.com".

A.3.15 XPath-based functions

This section specifies functions that take XPath expressions for arguments. An XPath expression evaluates to a node-set, which is a set of XML nodes that match the expression. A node or node-set is not in the formal data-type system of XACML. All comparison or other operations on node-sets are performed in isolation of the particular function specified. The context nodes and namespace mappings of the XPath expressions are defined by the XPath data-type, see section B.3. The following functions are defined:

- urn:oasis:names:tc:xacml:3.0:function:xpath-node-count

  This function SHALL take an “urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression” as an argument and evaluates to an “http://www.w3.org/2001/XMLSchema#integer”. The value returned from the function SHALL be the count of the nodes within the node-set that match the given XPath expression. If the `<Content>` element of the category to which the XPath expression applies to is not present in the request, this function SHALL return a value of zero.

- urn:oasis:names:tc:xacml:3.0:function:xpath-node-equal

  This function SHALL take two “urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression” arguments and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. The function SHALL return "True" if any of the XML nodes in the node-set matched by the first argument equals any of the XML nodes in the node-set matched by the second argument. Two nodes are considered equal if they have the same identity. If the `<Content>` element of the category to which either XPath expression applies to is not present in the request, this function SHALL return a value of “False”.

- urn:oasis:names:tc:xacml:3.0:function:xpath-node-match

  This function SHALL take two “urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression” arguments and SHALL return an “http://www.w3.org/2001/XMLSchema#boolean”. This function SHALL evaluate to "True" if one of the following two conditions is satisfied: (1) Any of the XML nodes in the node-set matched by the first argument is equal to any of the XML nodes in the node-set matched by the second argument; (2) any node below any of the XML nodes in the node-set matched by the first argument is equal to any of the XML nodes in the node-set matched by the second argument. Two nodes are considered equal if they have the same identity. If the `<Content>` element of the category to which either XPath expression applies to is not present in the request, this function SHALL return a value of “False”.

NOTE: The first ***condition*** is equivalent to "xpath-node-equal", and guarantees that "xpath-node-equal" is a special case of "xpath-node-match".

A.3.16 Other functions

- urn:oasis:names:tc:xacml:3.0:function:access-permitted

  This function SHALL take an “http://www.w3.org/2001/XMLSchema#anyURI” and an "http://www.w3.org/2001/XMLSchema#string" as arguments. The first argument SHALL be interpreted as an ***attribute*** category. The second argument SHALL be interpreted as the XML content of an `<Attributes>` element with `Category` equal to the first argument. The function evaluates to an "http://www.w3.org/2001/XMLSchema#boolean". This function SHALL return "True" if and only if the ***policy*** evaluation described below returns the value of "Permit".

  The following evaluation is described as if the ***context*** is actually instantiated, but it is only required that an equivalent result be obtained.

  The function SHALL construct a new ***context***, by copying all the information from the current ***context***, omitting any `<Attributes>` element with `Category` equal to the first argument. The second function argument SHALL be added to the ***context*** as the content of an <Attributes> element with `Category` equal to the first argument.

The function SHALL invoke a complete ***policy*** evaluation using the newly constructed ***context***. This evaluation SHALL be completely isolated from the evaluation which invoked the function, but shall use all current ***policies*** and combining algorithms, including any per request ***policies***.

The ***PDP*** SHALL detect any loop which may occur if successive evaluations invoke this function by counting the number of total invocations of any instance of this function during any single initial invocation of the ***PDP***. If the total number of invocations exceeds the bound for such invocations, the initial invocation of this function evaluates to Indeterminate with a "urn:oasis:names:tc:xacml:1.0:status:processing-error" status code. Also, see the security considerations in section 9.1.8.

A.3.17 Extension functions and primitive types

Functions and primitive types are specified by string identifiers allowing for the introduction of functions in addition to those specified by XACML. This approach allows one to extend the XACML module with special functions and special primitive data-types.

In order to preserve the integrity of the XACML evaluation strategy, the result of an extension function SHALL depend only on the values of its arguments. Global and hidden parameters SHALL NOT affect the evaluation of an expression. Functions SHALL NOT have side effects, as evaluation order cannot be guaranteed in a standard way.

A.4 Functions, data types and algorithms planned for deprecation

The following functions, data types and algorithms have been defined by previous versions of XACML and newer and better alternatives are defined in XACML 3.0. Their use is discouraged for new use and they are candidates for deprecation in future versions of XACML.

The following xpath based functions have been replaced with equivalent functions which use the new urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression datatype instead of strings.

- urn:oasis:names:tc:xacml:1.0:function:xpath-node-count
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:xpath-node-count
- urn:oasis:names:tc:xacml:1.0:function:xpath-node-equal
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:xpath-node-equal
- urn:oasis:names:tc:xacml:1.0:function:xpath-node-match
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:xpath-node-match

The following URI and string concatenation function has been replaced with a string to URI conversion function, which allows the use of the general string functions with URI through string conversion.

- urn:oasis:names:tc:xacml:2.0:function:uri-string-concatenate
  - Replaced by urn:oasis:names:tc:xacml:3.0:function:string-from-anyURI

The following identifiers have been replaced with official identifiers defined by W3C.

- http://www.w3.org/TR/2002/WD-xquery-operators-20020816#dayTimeDuration
  - Replaced with http://www.w3.org/2001/XMLSchema#dayTimeDuration
- http://www.w3.org/TR/2002/WD-xquery-operators-20020816#yearMonthDuration
  - Replaced with http://www.w3.org/2001/XMLSchema#yearMonthDuration

The following functions have been replaced with functions which use the updated dayTimeDuration and yearMonthDuration data types.

- urn:oasis:names:tc:xacml:1.0:function:dayTimeDuration-equal
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:dayTimeDuration-equal
- urn:oasis:names:tc:xacml:1.0:function:yearMonthDuration-equal
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:yearMonthDuration-equal

- urn:oasis:names:tc:xacml:1.0:function:dateTime-add-dayTimeDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:dateTime-add-dayTimeDuration
- urn:oasis:names:tc:xacml:1.0:function:dateTime-add-yearMonthDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:dateTime-add-yearMonthDuration
- urn:oasis:names:tc:xacml:1.0:function:dateTime-subtract-dayTimeDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-dayTimeDuration
- urn:oasis:names:tc:xacml:1.0:function:dateTime-subtract-yearMonthDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:dateTime-subtract-yearMonthDuration
- urn:oasis:names:tc:xacml:1.0:function:date-add-yearMonthDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:date-add-yearMonthDuration
- urn:oasis:names:tc:xacml:1.0:function:date-subtract-yearMonthDuration
  - Replaced with urn:oasis:names:tc:xacml:3.0:function:date-subtract-yearMonthDuration

The following combining algorithms have been replaced with new variants which allow for better handling of “Indeterminate” results.

- urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-overrides
- urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-overrides
- urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:permit-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-overrides
- urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:permit-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-overrides
- urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-deny-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-deny-overrides
- urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-deny-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-deny-overrides
- urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-permit-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-permit-overrides
- urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-permit-overrides
  - Replaced with urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-permit-overrides

B. XACML identifiers (normative)

This section defines standard identifiers for commonly used entities.

B.1 XACML namespaces

XACML is defined using this identifier.

`urn:oasis:names:tc:xacml:3.0:core:schema`

B.2 Attribute categories

The following ***attribute*** category identifiers MUST be used when an XACML 2.0 or earlier ***policy*** or request is translated into XACML 3.0.

Attributes previously placed in the ***Resource***, ***Action,*** and ***Environment*** sections of a request are placed in an ***attribute*** category with the following identifiers respectively. It is RECOMMENDED that they are used to list ***attributes*** of ***resources***, ***actions,*** and the ***environment*** respectively when authoring XACML 3.0 ***policies*** or requests.

`urn:oasis:names:tc:xacml:3.0:attribute-category:resource`

`urn:oasis:names:tc:xacml:3.0:attribute-category:action`

`urn:oasis:names:tc:xacml:3.0:attribute-category:environment`

Attributes previously placed in the ***Subject*** section of a request are placed in an ***attribute*** category which is identical of the ***subject*** category in XACML 2.0, as defined below. It is RECOMMENDED that they are used to list ***attributes*** of ***subjects*** when authoring XACML 3.0 ***policies*** or requests.

This identifier indicates the system entity that initiated the ***access*** request. That is, the initial entity in a request chain. If ***subject*** category is not specified in XACML 2.0, this is the default translation value.

`urn:oasis:names:tc:xacml:1.0:subject-category:access-subject`

This identifier indicates the system entity that will receive the results of the request (used when it is distinct from the access-***subject***).

`urn:oasis:names:tc:xacml:1.0:subject-category:recipient-subject`

This identifier indicates a system entity through which the ***access*** request was passed. There may be more than one. No means is provided to specify the order in which they passed the message.

`urn:oasis:names:tc:xacml:1.0:subject-category:intermediary-subject`

This identifier indicates a system entity associated with a local or remote codebase that generated the request. Corresponding ***subject attributes*** might include the URL from which it was loaded and/or the identity of the code-signer. There may be more than one. No means is provided to specify the order in which they processed the request.

`urn:oasis:names:tc:xacml:1.0:subject-category:codebase`

This identifier indicates a system entity associated with the computer that initiated the ***access*** request. An example would be an IPsec identity.

`urn:oasis:names:tc:xacml:1.0:subject-category:requesting-machine`

B.3 Data-types

The following identifiers indicate data-types that are defined in Section A.2.

`urn:oasis:names:tc:xacml:1.0:data-type:x500Name.`

`urn:oasis:names:tc:xacml:1.0:data-type:rfc822Name`

`urn:oasis:names:tc:xacml:2.0:data-type:ipAddress`

`urn:oasis:names:tc:xacml:2.0:data-type:dnsName` `urn:oasis:names:tc:xacml:3.0:data-type:xpathExpression`

The following data-type identifiers are defined by XML Schema **[XS]**.

`http://www.w3.org/2001/XMLSchema#string`

`http://www.w3.org/2001/XMLSchema#boolean`

`http://www.w3.org/2001/XMLSchema#integer`

`http://www.w3.org/2001/XMLSchema#double`

`http://www.w3.org/2001/XMLSchema#time`

`http://www.w3.org/2001/XMLSchema#date`

`http://www.w3.org/2001/XMLSchema#dateTime`

`http://www.w3.org/2001/XMLSchema#anyURI`

`http://www.w3.org/2001/XMLSchema#hexBinary`

`http://www.w3.org/2001/XMLSchema#base64Binary`

The following data-type identifiers correspond to the dayTimeDuration and yearMonthDuration data-types defined in **[XF]** Sections 10.3.2 and 10.3.1, respectively.

`http://www.w3.org/2001/XMLSchema#dayTimeDuration`

`http://www.w3.org/2001/XMLSchema#yearMonthDuration`

B.4 Subject attributes

These identifiers indicate ***attributes*** of a ***subject***. When used, it is RECOMMENDED that they appear within an `<Attributes>` element of the request ***context*** with a ***subject*** category (see section B.2).

At most one of each of these ***attributes*** is associated with each ***subject***. Each ***attribute*** associated with authentication included within a single `<Attributes>` element relates to the same authentication event.

This identifier indicates the name of the ***subject***.

`urn:oasis:names:tc:xacml:1.0:subject:subject-id`

This identifier indicates the security domain of the subject. It identifies the administrator and ***policy*** that manages the name-space in which the ***subject*** id is administered.

`urn:oasis:names:tc:xacml:1.0:subject:subject-id-qualifier`

This identifier indicates a public key used to confirm the ***subject***'s identity.

`urn:oasis:names:tc:xacml:1.0:subject:key-info`

This identifier indicates the time at which the ***subject*** was authenticated.

`urn:oasis:names:tc:xacml:1.0:subject:authentication-time`

This identifier indicates the method used to authenticate the ***subject***.

`urn:oasis:names:tc:xacml:1.0:subject:authentication-method`

This identifier indicates the time at which the ***subject*** initiated the ***access*** request, according to the ***PEP***.

`urn:oasis:names:tc:xacml:1.0:subject:request-time`

This identifier indicates the time at which the ***subject***'s current session began, according to the ***PEP***.

`urn:oasis:names:tc:xacml:1.0:subject:session-start-time`

The following identifiers indicate the location where authentication credentials were activated.

This identifier indicates that the location is expressed as an IP address.

`urn:oasis:names:tc:xacml:1.0:subject:authn-locality:ip-address`

The corresponding ***attribute*** SHALL be of data-type "http://www.w3.org/2001/XMLSchema#string".

This identifier indicates that the location is expressed as a DNS name.

`urn:oasis:names:tc:xacml:1.0:subject:authn-locality:dns-name`

The corresponding ***attribute*** SHALL be of data-type "http://www.w3.org/2001/XMLSchema#string".

Where a suitable ***attribute*** is already defined in LDAP **[LDAP-1]**, **[LDAP-2]**, the XACML identifier SHALL be formed by adding the ***attribute*** name to the URI of the LDAP specification. For example, the ***attribute*** name for the userPassword defined in the RFC 2256 SHALL be:

`http://www.ietf.org/rfc/rfc2256.txt#userPassword`

B.5 Resource attributes

These identifiers indicate ***attributes*** of the ***resource***. When used, it is RECOMMENDED they appear within the `<Attributes>` element of the request ***context*** with `Category` `urn:oasis:names:tc:xacml:3.0:attribute-category:resource.`

This ***attribute*** identifies the ***resource*** to which ***access*** is requested.

`urn:oasis:names:tc:xacml:1.0:resource:resource-id`

This ***attribute*** identifies the namespace of the top element(s) of the contents of the `<Content>` element. In the case where the ***resource*** content is supplied in the request ***context*** and the ***resource*** namespaces are defined in the ***resource***, the ***PEP*** MAY provide this ***attribute*** in the request to indicate the namespaces of the ***resource*** content. In this case there SHALL be one value of this ***attribute*** for each unique namespace of the top level elements in the `<Content>` element. The type of the corresponding ***attribute*** SHALL be “http://www.w3.org/2001/XMLSchema#anyURI”.

`urn:oasis:names:tc:xacml:2.0:resource:target-namespace`

B.6 Action attributes

These identifiers indicate ***attributes*** of the ***action*** being requested. When used, it is RECOMMENDED they appear within the `<Attributes>` element of the request ***context*** with `Category` `urn:oasis:names:tc:xacml:3.0:attribute-category:action.`

This ***attribute*** identifies the ***action*** for which ***access*** is requested.

`urn:oasis:names:tc:xacml:1.0:action:action-id`

Where the ***action*** is implicit, the value of the action-id ***attribute*** SHALL be

`urn:oasis:names:tc:xacml:1.0:action:implied-action`

This ***attribute*** identifies the namespace in which the action-id ***attribute*** is defined.
`urn:oasis:names:tc:xacml:1.0:action:action-namespace`

B.7 Environment attributes

These identifiers indicate ***attributes*** of the ***environment*** within which the ***decision request*** is to be evaluated. When used in the ***decision request***, it is RECOMMENDED they appear in the `<Attributes>` element of the request ***context*** with `Category` urn:oasis:names:tc:xacml:3.0:attribute-category:environment.

This identifier indicates the current time at the ***context handler***. In practice it is the time at which the request ***context*** was created. For this reason, if these identifiers appear in multiple places within a `<Policy>` or `<PolicySet>`, then the same value SHALL be assigned to each occurrence in the evaluation procedure, regardless of how much time elapses between the processing of the occurrences.

`urn:oasis:names:tc:xacml:1.0:environment:current-time`

The corresponding ***attribute*** SHALL be of data-type “http://www.w3.org/2001/XMLSchema#time”.

`urn:oasis:names:tc:xacml:1.0:environment:current-date`

The corresponding ***attribute*** SHALL be of data-type “http://www.w3.org/2001/XMLSchema#date”.

`urn:oasis:names:tc:xacml:1.0:environment:current-dateTime`

The corresponding ***attribute*** SHALL be of data-type “http://www.w3.org/2001/XMLSchema#dateTime”.

B.8 Status codes

The following status code values are defined.

This identifier indicates success.

`urn:oasis:names:tc:xacml:1.0:status:ok`

This identifier indicates that all the ***attributes*** necessary to make a ***policy decision*** were not available (see Section 5.58).

`urn:oasis:names:tc:xacml:1.0:status:missing-attribute`

This identifier indicates that some ***attribute*** value contained a syntax error, such as a letter in a numeric field.

`urn:oasis:names:tc:xacml:1.0:status:syntax-error`

This identifier indicates that an error occurred during ***policy*** evaluation. An example would be division by zero.

`urn:oasis:names:tc:xacml:1.0:status:processing-error`

B.9 Combining algorithms

The deny-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-overrides`

The deny-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-overrides`

The permit-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-overrides`

The permit-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-overrides`

The first-applicable ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:first-applicable`

The first-applicable ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:first-applicable`

The only-one-applicable-policy ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:only-one-applicable`

The ordered-deny-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-deny-overrides`

The ordered-deny-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-deny-overrides`

The ordered-permit-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-permit-overrides

The ordered-permit-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-permit-overrides

The deny-unless-permit ***rule-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-unless-permit

The permit-unless-deny ***rule-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-unless-deny

The deny-unless-permit ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-unless-permit

The permit-unless-deny ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-unless-deny

The legacy deny-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides

The legacy deny-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides

The legacy permit-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:permit-overrides

The legacy permit-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:permit-overrides

The legacy ordered-deny-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-deny-overrides

The legacy ordered-deny-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-deny-overrides

The legacy ordered-permit-overrides ***rule-combining algorithm*** has the following value for the `ruleCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-permit-overrides

The legacy ordered-permit-overrides ***policy-combining algorithm*** has the following value for the `policyCombiningAlgId` attribute:

urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-permit-overrides

C. Combining algorithms (normative)

This section contains a description of the ***rule***- and ***policy-combining algorithms*** specified by XACML. Pseudo code is normative, descriptions in English are non-normative.

The legacy ***combining algorithms*** are defined in previous versions of XACML, and are retained for compatibility reasons. It is RECOMMENDED that the new ***combining algorithms*** are used instead of the legacy ***combining algorithms*** for new use.

C.1 Extended Indeterminate value

Some combining algorithms are defined in terms of an extended set of “Indeterminate” values. For these algorithms, the ***PDP*** MUST keep track of the extended set of “Indeterminate” values during ***rule*** and ***policy*** combining. The extended set associated with the “Indeterminate” contains the potential effect values which could have occurred if there would not have been an error causing the “Indeterminate”. The possible extended set “Indeterminate” values are

- “Indeterminate{D}”: an “Indeterminate” from a ***policy*** or ***rule*** which could have evaluated to “Deny”, but not “Permit”
- “Indeterminate{P}”: an “Indeterminate” from a ***policy*** or ***rule*** which could have evaluated to “Permit”, but not “Deny”
- “Indeterminate{DP}”: an “Indeterminate” from a ***policy*** or ***rule*** which could have evaluated to “Deny” or “Permit”.

The combining algorithms which are defined in terms of the extended “Indeterminate” make use of the additional information to allow for better treatment of errors in the algorithms.

The following define the base cases for rule evaluation:

- A ***rule*** which evaluates to “Indeterminate” and has Effect=”Permit” results in an “Indeterminate{P}”.
- A ***rule*** which evaluates to “Indeterminate” and has Effect=”Deny” results in an “Indeterminate{D}”.

C.2 Deny-overrides

This section defines the “Deny-overrides” ***rule-combining algorithm*** of a ***policy*** and ***policy-combining algorithm*** of a ***policy set***.

This ***combining algorithm*** makes use of the extended “Indeterminate”.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-overrides`

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-overrides`

The following is a non-normative informative description of this ***combining algorithm***.

> The deny overrides ***combining algorithm*** is intended for those cases where a deny decision should have priority over a permit decision. This algorithm has the following behavior.

1. If any decision is "Deny", the result is "Deny".
2. Otherwise, if any decision is "Indeterminate{DP}", the result is "Indeterminate{DP}".
3. Otherwise, if any decision is "Indeterminate{D}" and another decision is “Indeterminate{P} or Permit, the result is "Indeterminate{DP}".
4. Otherwise, if any decision is "Indeterminate{D}", the result is "Indeterminate{D}".
5. Otherwise, if any decision is "Permit", the result is "Permit".

6. Otherwise, if any decision is "Indeterminate{P}", the result is "Indeterminate{P}".
7. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***combining algorithm***.

```
Decision denyOverridesCombiningAlgorithm(Decision[] decisions)
{
   Boolean atLeastOneErrorD  = false;
   Boolean atLeastOneErrorP  = false;
   Boolean atLeastOneErrorDP  = false;
   Boolean atLeastOnePermit = false;
   for( i=0 ; i < lengthOf(decisions) ; i++ )
   {
          Decision decision = decisions[i];
          if (decision == Deny)
          {
                 return Deny;
          }
          if (decision == Permit)
          {
                 atLeastOnePermit = true;
                 continue;
          }
          if (decision == NotApplicable)
          {
                 continue;
          }
          if (decision == Indeterminate{D})
          {
                 atLeastOneErrorD = true;
                 continue;
          }
          if (decision == Indeterminate{P})
          {
                 atLeastOneErrorP = true;
                 continue;
          }
          if (decision == Indeterminate{DP})
          {
                 atLeastOneErrorDP = true;
                 continue;
          }
   }
   if (atLeastOneErrorDP)
   {
          return Indeterminate{DP};
   }
   if (atLeastOneErrorD && (atLeastOneErrorP || atLeastOnePermit))
   {
          return Indeterminate{DP};
   }
   if (atLeastOneErrorD)
   {
          return Indeterminate{D};
   }
   if (atLeastOnePermit)
   {
          return Permit;
   }
   if (atLeastOneErrorP)
   {
          return Indeterminate{P};
   }
   return NotApplicable;
}
```

Obligations and ***advice*** shall be combined as described in Section 7.16.

C.3 Ordered-deny-overrides

The following specification defines the "Ordered-deny-overrides" ***rule-combining algorithm*** of a ***policy***.

The behavior of this algorithm is identical to that of the “Deny-overrides” ***rule-combining algorithm*** with one exception. The order in which the collection of ***rules*** is evaluated SHALL match the order as listed in the ***policy***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-deny-overrides`

The following specification defines the "Ordered-deny-overrides" ***policy-combining algorithm*** of a ***policy set***.

The behavior of this algorithm is identical to that of the “Deny-overrides” ***policy-combining algorithm*** with one exception. The order in which the collection of ***policies*** is evaluated SHALL match the order as listed in the ***policy set***.

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-deny-overrides`

C.4 Permit-overrides

This section defines the “Permit-overrides” ***rule-combining algorithm*** of a ***policy*** and ***policy-combining algorithm*** of a ***policy set***.

This ***combining algorithm*** makes use of the extended “Indeterminate”.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-overrides`

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-overrides`

The following is a non-normative informative description of this combining algorithm.

The permit overrides ***combining algorithm*** is intended for those cases where a permit decision should have priority over a deny decision. This algorithm has the following behavior.

1. If any decision is "Permit", the result is "Permit".
2. Otherwise, if any decision is "Indeterminate{DP}", the result is "Indeterminate{DP}".
3. Otherwise, if any decision is "Indeterminate{P}" and another decision is “Indeterminate{D} or Deny, the result is "Indeterminate{DP}".
4. Otherwise, if any decision is "Indeterminate{P}", the result is "Indeterminate{P}".
5. Otherwise, if decision is "Deny", the result is "Deny".
6. Otherwise, if any decision is "Indeterminate{D}", the result is "Indeterminate{D}".
7. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***combining algorithm***.

```
Decision permitOverridesCombiningAlgorithm(Decision[] decisions)
{
   Boolean atLeastOneErrorD  = false;
   Boolean atLeastOneErrorP  = false;
   Boolean atLeastOneErrorDP  = false;
```

```
    Boolean atLeastOneDeny = false;
    for( i=0 ; i < lengthOf(decisions) ; i++ )
    {
            Decision decision = decisions[i];
            if (decision == Deny)
            {
                    atLeastOneDeny = true;
                    continue;
            }
            if (decision == Permit)
            {
                    return Permit;
            }
            if (decision == NotApplicable)
            {
                    continue;
            }
            if (decision == Indeterminate{D})
            {
                    atLeastOneErrorD = true;
                    continue;
            }
            if (decision == Indeterminate{P})
            {
                    atLeastOneErrorP = true;
                    continue;
            }
            if (decision == Indeterminate{DP})
            {
                    atLeastOneErrorDP = true;
                    continue;
            }
    }
    if (atLeastOneErrorDP)
    {
            return Indeterminate{DP};
    }
    if (atLeastOneErrorP && (atLeastOneErrorD || atLeastOneDeny))
    {
            return Indeterminate{DP};
    }
    if (atLeastOneErrorP)
    {
            return Indeterminate{P};
    }
    if (atLeastOneDeny)
    {
            return Deny;
    }
    if (atLeastOneErrorD)
    {
            return Indeterminate{D};
    }
    return NotApplicable;
}
```

Obligations and ***advice*** shall be combined as described in Section 7.16.

C.5 Ordered-permit-overrides

The following specification defines the "Ordered-permit-overrides" ***rule-combining algorithm*** of a ***policy***.

The behavior of this algorithm is identical to that of the “Permit-overrides” ***rule-combining algorithm*** with one exception. The order in which the collection of ***rules*** is evaluated SHALL match the order as listed in the ***policy***.

The ***rule combining algorithm*** defined here has the following identifier:

```
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:ordered-permit-
overrides
```

The following specification defines the "Ordered-permit-overrides" ***policy-combining algorithm*** of a ***policy set***.

The behavior of this algorithm is identical to that of the “Permit-overrides” ***policy-combining algorithm*** with one exception. The order in which the collection of ***policies*** is evaluated SHALL match the order as listed in the ***policy set***.

The ***policy combining algorithm*** defined here has the following identifier:

```
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:ordered-permit-
overrides
```

C.6 Deny-unless-permit

This section defines the “Deny-unless-permit” ***rule-combining algorithm*** of a ***policy*** or ***policy-combining algorithm*** of a ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

```
urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:deny-unless-permit
```

The ***policy combining algorithm*** defined here has the following identifier:

```
urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:deny-unless-permit
```

The following is a non-normative informative description of this ***combining algorithm***.

The “Deny-unless-permit” ***combining algorithm*** is intended for those cases where a permit decision should have priority over a deny decision, and an “Indeterminate” or “NotApplicable” must never be the result. It is particularly useful at the top level in a ***policy*** structure to ensure that a ***PDP*** will always return a definite “Permit” or “Deny” result. This algorithm has the following behavior.

1. If any decision is "Permit", the result is "Permit".
2. Otherwise, the result is "Deny".

The following pseudo-code represents the normative specification of this ***combining algorithm***.

```
Decision denyUnlessPermitCombiningAlgorithm(Decision[] decisions)
{
   for( i=0 ; i < lengthOf(decisions) ; i++ )
   {
         if (decisions[i] == Permit)
         {
               return Permit;
         }
   }
   return Deny;
}
```

Obligations and ***advice*** shall be combined as described in Section 7.16.

C.7 Permit-unless-deny

This section defines the “Permit-unless-deny” ***rule-combining algorithm*** of a ***policy*** or ***policy-combining algorithm*** of a ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:rule-combining-algorithm:permit-unless-deny`

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:3.0:policy-combining-algorithm:permit-unless-deny`

The following is a non-normative informative description of this ***combining algorithm***.

> The “Permit-unless-deny” ***combining algorithm*** is intended for those cases where a deny decision should have priority over a permit decision, and an “Indeterminate” or “NotApplicable” must never be the result. It is particularly useful at the top level in a ***policy*** structure to ensure that a ***PDP*** will always return a definite “Permit” or “Deny” result. This algorithm has the following behavior.
>
> 1. If any decision is "Deny", the result is "Deny".
> 2. Otherwise, the result is "Permit".

The following pseudo-code represents the normative specification of this ***combining algorithm***.

```
Decision permitUnlessDenyCombiningAlgorithm(Decision[] decisions)
{
   for( i=0 ; i < lengthOf(decisions) ; i++ )
   {
          if (decisions[i] == Deny)
          {
                 return Deny;
          }
   }
   return Permit;
}
```

Obligations and ***advice*** shall be combined as described in Section 7.16.

C.8 First-applicable

This section defines the “First-applicable” ***rule-combining algorithm*** of a ***policy*** and ***policy-combining algorithm*** of a ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:first-applicable`

The following is a non-normative informative description of the "First-Applicable” ***rule-combining algorithm*** of a ***policy***.

> Each ***rule*** SHALL be evaluated in the order in which it is listed in the ***policy***. For a particular ***rule***, if the ***target*** matches and the ***condition*** evaluates to "True", then the evaluation of the ***policy*** SHALL halt and the corresponding ***effect*** of the ***rule*** SHALL be the result of the evaluation of the ***policy*** (i.e. "Permit" or "Deny"). For a particular ***rule*** selected in the evaluation, if the ***target*** evaluates to "False" or the ***condition*** evaluates to "False", then the next ***rule*** in the order SHALL be evaluated. If no further ***rule*** in the order exists, then the ***policy*** SHALL evaluate to "NotApplicable".
>
> If an error occurs while evaluating the ***target*** or ***condition*** of a ***rule***, then the evaluation SHALL halt, and the ***policy*** shall evaluate to "Indeterminate", with the appropriate error status.

The following pseudo-code represents the normative specification of this ***rule-combining algorithm***.

```
Decision firstApplicableEffectRuleCombiningAlgorithm(Rule[] rules)
{
   for( i = 0 ; i < lengthOf(rules) ; i++ )
   {
          Decision decision = evaluate(rules[i]);
          if (decision == Deny)
          {
                 return Deny;
          }
```

```
            if (decision == Permit)
            {
                  return Permit;
            }
            if (decision == NotApplicable)
            {
                  continue;
            }
            if (decision == Indeterminate)
            {
                  return Indeterminate;
            }
      }
      return NotApplicable;
}
```

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:first-applicable`

The following is a non-normative informative description of the "First-applicable" ***policy-combining algorithm*** of a ***policy set***.

> Each ***policy*** is evaluated in the order that it appears in the ***policy set***. For a particular ***policy***, if the ***target*** evaluates to "True" and the ***policy*** evaluates to a determinate value of "Permit" or "Deny", then the evaluation SHALL halt and the ***policy set*** SHALL evaluate to the ***effect*** value of that ***policy***. For a particular ***policy***, if the ***target*** evaluate to "False", or the ***policy*** evaluates to "NotApplicable", then the next ***policy*** in the order SHALL be evaluated. If no further ***policy*** exists in the order, then the ***policy set*** SHALL evaluate to "NotApplicable".
>
> If an error were to occur when evaluating the ***target***, or when evaluating a specific ***policy***, the reference to the ***policy*** is considered invalid, or the ***policy*** itself evaluates to "Indeterminate", then the evaluation of the ***policy-combining algorithm*** shall halt, and the ***policy set*** shall evaluate to "Indeterminate" with an appropriate error status.

The following pseudo-code represents the normative specification of this policy-combination algorithm.

```
Decision firstApplicableEffectPolicyCombiningAlgorithm(Policy[] policies)
{
    for( i = 0 ; i < lengthOf(policies) ; i++ )
    {
        Decision decision = evaluate(policies[i]);
        if(decision == Deny)
        {
            return Deny;
        }
        if(decision == Permit)
        {
            return Permit;
        }
        if (decision == NotApplicable)
        {
            continue;
        }
        if (decision == Indeterminate)
        {
            return Indeterminate;
        }
    }
    return NotApplicable;
}
```

Obligations and ***advice*** of the individual ***policies*** shall be combined as described in Section 7.16.

C.9 Only-one-applicable

This section defines the “Only-one-applicable” ***policy-combining algorithm*** of a ***policy set***.

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:only-one-applicable`

The following is a non-normative informative description of the “Only-one-applicable" ***policy-combining algorithm*** of a ***policy set***.

> In the entire set of ***policies*** in the ***policy set***, if no ***policy*** is considered applicable by virtue of its ***target***, then the result of the policy-combination algorithm SHALL be "NotApplicable". If more than one ***policy*** is considered applicable by virtue of its ***target***, then the result of the policy-combination algorithm SHALL be "Indeterminate".
>
> If only one ***policy*** is considered applicable by evaluation of its ***target***, then the result of the ***policy-combining algorithm*** SHALL be the result of evaluating the ***policy***.
>
> If an error occurs while evaluating the ***target*** of a ***policy***, or a reference to a ***policy*** is considered invalid or the ***policy*** evaluation results in "Indeterminate, then the ***policy set*** SHALL evaluate to "Indeterminate", with the appropriate error status.

The following pseudo-code represents the normative specification of this ***policy-combining algorithm***.

```
Decision onlyOneApplicablePolicyPolicyCombiningAlogrithm(Policy[] policies)
{
  Boolean           atLeastOne     = false;
  Policy            selectedPolicy = null;
  ApplicableResult appResult;

  for ( i = 0; i < lengthOf(policies) ; i++ )
  {
     appResult = isApplicable(policies[I]);

     if ( appResult == Indeterminate )
     {
         return Indeterminate;
     }
     if( appResult == Applicable )
     {
         if ( atLeastOne )
         {
             return Indeterminate;
         }
         else
         {
             atLeastOne     = true;
             selectedPolicy = policies[i];
         }
     }
     if ( appResult == NotApplicable )
     {
         continue;
     }
  }
  if ( atLeastOne )
  {
      return evaluate(selectedPolicy);
  }
  else
  {
      return NotApplicable;
  }
}
```

Obligations and ***advice*** of the individual ***rules*** shall be combined as described in Section 7.16.

C.10 Legacy Deny-overrides

This section defines the legacy “Deny-overrides” ***rule-combining algorithm*** of a ***policy*** and ***policy-combining algorithm*** of a ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides`

The following is a non-normative informative description of this combining algorithm.

> The “Deny–overrides” rule combining algorithm is intended for those cases where a deny decision should have priority over a permit decision. This algorithm has the following behavior.
>
> 1. If any rule evaluates to "Deny", the result is "Deny".
> 2. Otherwise, if any rule having Effect="Deny" evaluates to "Indeterminate", the result is "Indeterminate".
> 3. Otherwise, if any rule evaluates to "Permit", the result is "Permit".
> 4. Otherwise, if any rule having Effect="Permit" evaluates to "Indeterminate", the result is "Indeterminate".
> 5. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***rule-combining algorithm***.

```
Decision denyOverridesRuleCombiningAlgorithm(Rule[] rules)
{
   Boolean atLeastOneError  = false;
   Boolean potentialDeny    = false;
   Boolean atLeastOnePermit = false;
   for( i=0 ; i < lengthOf(ruless) ; i++ )
   {
          Decision decision = evaluate(rules[i]);
          if (decision == Deny)
          {
                 return Deny;
          }
          if (decision == Permit)
          {
                 atLeastOnePermit = true;
                 continue;
          }
          if (decision == NotApplicable)
          {
                 continue;
          }
          if (decision == Indeterminate)
          {
                 atLeastOneError = true;

                 if (effect(rules[i]) == Deny)
                 {
                        potentialDeny = true;
                 }
                 continue;
          }
   }
   if (potentialDeny)
   {
          return Indeterminate;
   }
   if (atLeastOnePermit)
   {
```

```
            return Permit;
        }
        if (atLeastOneError)
        {
            return Indeterminate;
        }
        return NotApplicable;
    }
```

Obligations and ***advice*** of the individual ***rules*** shall be combined as described in Section 7.16.

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides`

The following is a non-normative informative description of this combining algorithm.

> The ”Deny–overrides” policy combining algorithm is intended for those cases where a deny decision should have priority over a permit decision. This algorithm has the following behavior.
>
> 1. If any policy evaluates to "Deny", the result is "Deny".
> 2. Otherwise, if any policy evaluates to "Indeterminate", the result is "Deny".
> 3. Otherwise, if any policy evaluates to "Permit", the result is "Permit".
> 4. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***policy-combining algorithm***.

```
Decision denyOverridesPolicyCombiningAlgorithm(Policy[] policies)
{
    Boolean atLeastOnePermit = false;
    for( i=0 ; i < lengthOf(policies) ; i++ )
    {
        Decision decision = evaluate(policies[i]);
        if (decision == Deny)
        {
            return Deny;
        }
        if (decision == Permit)
        {
            atLeastOnePermit = true;
            continue;
        }
        if (decision == NotApplicable)
        {
            continue;
        }
        if (decision == Indeterminate)
        {
            return Deny;
        }
    }
    if (atLeastOnePermit)
    {
        return Permit;
    }
    return NotApplicable;
}
```

Obligations and ***advice*** of the individual ***policies*** shall be combined as described in Section 7.16.

C.11 Legacy Ordered-deny-overrides

The following specification defines the legacy "Ordered-deny-overrides” ***rule-combining algorithm*** of a ***policy***.

The behavior of this algorithm is identical to that of the “Deny-overrides” ***rule-combining algorithm*** with one exception. The order in which the collection of ***rules*** is evaluated SHALL match the order as listed in the ***policy***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-deny-overrides`

The following specification defines the legacy "Ordered-deny-overrides" ***policy-combining algorithm*** of a ***policy set***.

The behavior of this algorithm is identical to that of the “Deny-overrides” ***policy-combining algorithm*** with one exception. The order in which the collection of ***policies*** is evaluated SHALL match the order as listed in the ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-deny-overrides`

C.12 Legacy Permit-overrides

This section defines the legacy “Permit-overrides” ***rule-combining algorithm*** of a ***policy*** and ***policy-combining algorithm*** of a ***policy set***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:permit-overrides`

The following is a non-normative informative description of this combining algorithm.

The ”Permit-overrides” rule combining algorithm is intended for those cases where a permit decision should have priority over a deny decision. This algorithm has the following behavior.

1. If any rule evaluates to "Permit", the result is "Permit".
2. Otherwise, if any rule having Effect="Permit" evaluates to "Indeterminate" the result is "Indeterminate".
3. Otherwise, if any rule evaluates to "Deny", the result is "Deny".
4. Otherwise, if any rule having Effect="Deny" evaluates to "Indeterminate", the result is "Indeterminate".
5. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***rule-combining algorithm***.

```
Decision permitOverridesRuleCombiningAlgorithm(Rule[] rules)
{
   Boolean atLeastOneError  = false;
   Boolean potentialPermit  = false;
   Boolean atLeastOneDeny   = false;
   for( i=0 ; i < lengthOf(rules) ; i++ )
   {
          Decision decision = evaluate(rules[i]);
          if (decision == Deny)
          {
                 atLeastOneDeny = true;
                 continue;
          }
          if (decision == Permit)
          {
                 return Permit;
          }
          if (decision == NotApplicable)
          {
                 continue;
          }
```

```
            if (decision == Indeterminate)
            {
                  atLeastOneError = true;

                  if (effect(rules[i]) == Permit)
                  {
                        potentialPermit = true;
                  }
                  continue;
            }
      }
      if (potentialPermit)
      {
            return Indeterminate;
      }
      if (atLeastOneDeny)
      {
            return Deny;
      }
      if (atLeastOneError)
      {
            return Indeterminate;
      }
      return NotApplicable;
}
```

Obligations and ***advice*** of the individual ***rules*** shall be combined as described in Section 7.16.

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:permit-overrides`

The following is a non-normative informative description of this combining algorithm.

> The ”Permit–overrides” policy combining algorithm is intended for those cases where a permit decision should have priority over a deny decision. This algorithm has the following behavior.
>
> 1. If any policy evaluates to "Permit", the result is "Permit".
> 2. Otherwise, if any policy evaluates to "Deny", the result is "Deny".
> 3. Otherwise, if any policy evaluates to "Indeterminate", the result is "Indeterminate".
> 4. Otherwise, the result is "NotApplicable".

The following pseudo-code represents the normative specification of this ***policy-combining algorithm***.

```
Decision permitOverridesPolicyCombiningAlgorithm(Policy[] policies)
{
      Boolean atLeastOneError = false;
      Boolean atLeastOneDeny  = false;
      for( i=0 ; i < lengthOf(policies) ; i++ )
      {
            Decision decision = evaluate(policies[i]);
            if (decision == Deny)
            {
                  atLeastOneDeny = true;
                  continue;
            }
            if (decision == Permit)
            {
                  return Permit;
            }
            if (decision == NotApplicable)
            {
                  continue;
            }
            if (decision == Indeterminate)
            {
                    atLeastOneError = true;
                    continue;
            }
    }
    if (atLeastOneDeny)
    {
            return Deny;
    }
    if (atLeastOneError)
    {
            return Indeterminate;
    }
    return NotApplicable;
}
```

Obligations and ***advice*** of the individual ***policies*** shall be combined as described in Section 7.16.

C.13 Legacy Ordered-permit-overrides

The following specification defines the legacy "Ordered-permit-overrides" ***rule-combining algorithm*** of a ***policy***.

> The behavior of this algorithm is identical to that of the “Permit-overrides” ***rule-combining algorithm*** with one exception. The order in which the collection of ***rules*** is evaluated SHALL match the order as listed in the ***policy***.

The ***rule combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.1:rule-combining-algorithm:ordered-permit-overrides`

The following specification defines the legacy "Ordered-permit-overrides" ***policy-combining algorithm*** of a ***policy set***.

> The behavior of this algorithm is identical to that of the “Permit-overrides” ***policy-combining algorithm*** with one exception. The order in which the collection of ***policies*** is evaluated SHALL match the order as listed in the ***policy set***.

The ***policy combining algorithm*** defined here has the following identifier:

`urn:oasis:names:tc:xacml:1.1:policy-combining-algorithm:ordered-permit-overrides`

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E. Revision History

[optional; should not be included in OASIS Standards]

Revision	Date	Editor	Changes Made
WD 05	10 Oct 2007	Erik Rissanen	Convert to new OASIS template. Fixed typos and errors.
WD 06	18 May 2008	Erik Rissanen	Added missing MaxDelegationDepth in schema fragments. Added missing urn:oasis:names:tc:xacml:1.0:resource:xpath identifier. Corrected typos on xpaths in the example policies. Removed use of xpointer in the examples. Made the <Content> element the context node of all xpath expressions and introduced categorization of XPaths so they point to a specific <Content> element. Added <Content> element to the policy issuer. Added description of the <PolicyIssuer> element. Updated the schema figure in the introduction to reflect the new AllOf/AnyOf schema. Remove duplicate <CombinerParameters> element in the <Policy> element in the schema. Removed default attributes in the schema. (Version in <Policy(Set)> and MustBePresent in <AttributeDesignator> in <AttributeSelector>) Removed references in section 7.3 to the <Condition> element having a FunctionId attribute. Fixed typos in data type URIs in section A.3.7.
WD 07	3 Nov 2008	Erik Rissanen	Fixed "…:data-types:…" typo in conformace section. Removed XML default attribute for IncludeInResult for element <Attribute>. Also added this attribute in the associated schema file. Removed description of non-existing XML attribute "ResourceId" from the element <Result>. Moved the urn:oasis:names:tc:xacml:3.0:function:access-permitted function into here from the delegation profile.

			Updated the daytime and yearmonth duration data types to the W3C defined identifiers. Added <Description> to <Apply>. Added XPath versioning to the request. Added security considerations about denial service and the access-permitted function. Changed <Target> matching so NoMatch has priority over Indeterminate. Fixed multiple typos in identifiers. Lower case incorrect use of “MAY”. Misc minor typos. Removed whitespace in example attributes. Removed an incorrect sentence about higher order functions in the definition of the <Function> element. Clarified evaluation of empty or missing targets. Use Unicode codepoint collation for string comparisons. Support multiple arguments in multiply functions. Define Indeterminate result for overflow in integer to double conversion. Simplified descriptions of deny/permit overrides algorithms. Add ipAddress and dnsName into conformance section. Don’t refer to IEEE 754 for integer arithmetic. Rephrase indeterminate result for artithmetic functions. Fix typos in examples. Clarify Match evaluation and drop list of example functions which can be used in a Match. Added behavior for circular policy/variable references. Fix obligation enforcement so it refers to PEP bias. Added Version xml attribute to the example policies. Remove requirement for PDP to check the target-namespace resource attribute. Added policy identifier list to the response/request. Added statements about Unicode normalization. Clarified definitions of string functions.

			Added new string functions. Added section on Unicode security issues.
WD 08	5 Feb 2009	Erik Rissanen	Updated Unicode normalization section according to suggestion from W3C working group. Set union functions now may take more than two arguments. Made obligation parameters into runtime expressions. Added new combining algorithms Added security consideration about policy id collisions. Added the <Advice> feature Made obligations mandatory (per the 19th Dec 2008 decision of the TC) Made obligations/advice available in rules Changed wording about deprecation
WD 09			Clarified wording about normative/informative in the combining algorithms section. Fixed duplicate variable in comb.algs and cleaned up variable names. Updated the schema to support the new multiple request scheme.
WD 10	19 Mar 2009	Erik Rissanen	Fixed schema for <Request> Fixed typos. Added optional Category to AttributeAssignments in obligations/advice.
WD 11		Erik Rissanen	Cleanups courtesy of John Tolbert. Added Issuer XML attribute to <AttributeAssignment> Fix the XPath expressions in the example policies and requests Fix inconsistencies in the conformance tables. Editorial cleanups.
WD 12	16 Nov 2009	Erik Rissanen	(Now working draft after public review of CD 1) Fix typos Allow element selection in attribute selector. Improve consistency in the use of the terms olibagation, advice, and advice/obligation expressions and where they can appear. Fixed inconsistency in PEP bias between sections 5.1 and 7.2. Clarified text in overview of combining algorithms. Relaxed restriction on matching in xpath-node-

			match function. Remove note about XPath expert review. Removed obsolete resource:xpath identifier. Updated reference to XML spec. Defined error behavior for string-substring and uri-substring functions. Reversed the order of the arguments for the following functions: string-starts-with, uri-starts-with, string-ends-with, uri-ends-with, string-contains and uri-contains Renamed functions: • uri-starts-with to anyURI-starts-with • uri-ends-with to anyURI-ends-with • uri-contains to anyURI-contains • uri-substring to anyURI-substring Removed redundant occurrence indicators from RequestType. Don't use "…:os" namespace in examples since this is still just "..:wd-12". Added missing MustBePresent and Version XML attributes in example policies. Added missing ReturnPolicyIdList and IncludeInResult XML attributes in example requests. Clarified error behavior in obligation/advice expressions. Allow bags in attribute assignment expressions. Use the new daytimeduration and yearmonthduration identifiers consistently.
WD 13	14 Dec 2009	Erik Rissanen	Fix small inconsistency in number of arguments to the multiply function. Generalize higher order bag functions. Add ContextSelectorId to attribute selector. Use <Policy(Set)IdReference> in <PolicyIdList>. Fix typos and formatting issues. Make the conformance section clearly reference the functional requirements in the spec. Conformance tests are no longer hosted by Sun.
WD 14	17 Dec 2009	Erik Rissanen	Update acknowledgments
WD 15		Erik Rissanen	Replace DecisionCombiningAlgorithm with a simple Boolean for CombinedDecision. Restrict <Content> to a single child element

			and update the <AttributeSelector> and XPathExpression data type accordingly.
WD 16	12 Jan 2010	Erik Rissanen	Updated cross references Fix typos and minor inconsistencies. Simplify schema of <PolicyIdentifierList> Refactor some of the text to make it easier to understand. Update acknowledgments
WD 17	8 Mar 2010	Erik Rissanen	Updated cross references. Fixed OASIS style issues.
WD 18	23 Jun 2010	Erik Rissanen	Fixed typos in examples. Fixed typos in schema fragments.