Framework for EPR-Based SML Reference Schemes

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Abstract

The Service Modeling Language [*SML*] specification extends [*XML*] and [*XML Schema*] with a mechanism for incorporating into XML documents references to other documents or document fragments. This technical note addresses the construction of SML reference schemes for document or document fragment references that employ WS-Addressing [*WS-A*] endpoint references (EPRs).

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This document is intended to serve as guidance for designing SML reference schemes that employ WS-Addressing [*WS-A*] endpoint references (EPRs). Currently, this document is consistent with the [*SML*] 1.1 and [*SML-IF*] 1,1 specifications, but it may be obsoleted by future versions of these specifications.

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1. Introduction ***[Bank to Contents]***

The Service Modeling Language [*SML*] specification extends [*XML*] and [*XML Schema*] with a mechanism for incorporating into XML documents references to other documents or document fragments. A reference to another document or document fragment is encoded by means of markup compliant with one or more [reference schemes]. The SML specification defines one reference scheme, the SML URI Reference Scheme, which enables XML documents to use URIs [*RFC 3986*] to identify documents or document fragments. The SML URI Reference Scheme has the significant advantage of guaranteeing referential conformance of models that are exchanged between vendors (see section 5.1 in [*SML-IF*]).

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However, not all documents or document fragments can be retrieved simply by means of a URI that may be dereferenced. For example, the targeted document may be accessible only through a Web service endpoint. There are several protocols, each specifying its own message exchange pattern (MEP), that make documents and document fragments available through interaction with a Web service. These include (but are not limited to):

- WS-Transfer [*WS-T*] and WS-Management [*WS-Man*]
- WS-ResourceProperties [*WS-RP*] and Web Services Distributed Management [*WSDM*]
- CMDB Federation [*CMDBf*]

Other such services may be defined in the future. It is a common characteristic of these services that their endpoints must be addressed using endpoint references (EPRs) as defined in the WS-Addressing [*WS-A*] specification. Consequently, this note considers how SML reference schemes can use Web services endpoint references to refer to services that provide documents or document fragments through message exchanges.

The SML specification provides a mechanism to define other reference schemes beyond the SML URI Reference Scheme in order to accommodate special purpose reference schemes as well as reference schemes that fall outside of the capabilities of URIs. The purpose of this Note is to propose a framework for defining SML reference schemes that accommodate references to documents accessed via EPRs.

EPRs cannot simply be placed in browsers and dereferenced to locate the target resource. Processors must know how to process a given EPR and this knowledge often involves knowing (1) the operations offered by the service and (2) the protocol required for invoking the targeted operation of the service. In this sense, the use of EPRs goes beyond the standard architecture of the Web [*AWWW*]. Therefore, use of the SML URI Reference Scheme is encouraged and remains the recommended approach for SML models. Nevertheless, it is recognized that in some cases model documents may be accessible only through a service that requires being addressed by means of an EPR. For further discussion of EPRs and interoperability, see section 4.2.

2. Framework: Core Characteristics of EPR-Based Reference Schemes *[ToC]*

This section proposes a set of characteristics, or framework, for EPR-based SML reference schemes. These characteristics are based on the Reference Scheme definition requirements of section 4.3 of [*SML*].

2.1 Framework for SML EPR Reference Schemes

The following guidance is recommended for defining EPR-based SML reference schemes:

1. An SML reference element should be identified as an instance of an EPR-based reference scheme if and only if exactly one element information item whose [local name] is `EndpointReference` and whose [namespace name] is defined by a WS-Addressing specification (for example, `http://www.w3.org/2005/08/addressing`) is present as a child of the SML reference element.
2. An instance of an EPR-based SML reference scheme should be resolved by the SML validator by constructing the appropriate message to the service based on the provided EPR and any additional information it has or is provided about how to interact with the Web service endpoint. This additional information includes the signature of the operation that is to be invoked to access the targeted document or document fragment. This operation needs to be bound into a message to the service (e.g., a [*SOAP*] message) according the rules identified below (items a through c).

   Note that to resolve an instance of an EPR-based SML reference scheme compliant with this framework, the SML validator must be a Web services client. If the validator does not have adequate information to construct the appropriate Web services request to the service providing access to the targeted document, then the EPR-based SML reference is unresolved.

   The resolution process should conform to the following rules:

   a. The Web service client should follow the appropriate binding rules for the EPR as specified in the WS-Addressing specification.
   b. The appropriate binding rules for the operation as specified in the [*WSDL*] `binding` element should be applied in constructing the request to the service.
   c. The SML reference [target] should be the content or a child within the content of the service response message. If there is no response message returned by the service (as defined by the service protocol), then the SML reference is unresolved.

The WS-Addressing specification defines the value of the abstract [address] property as an IRI [*RFC 3987*~~*RFC 3987*~~]. Since the IRI in the `wsa:Address` element of the EPR identifies only an endpoint of a service and typically requires out-of-band knowledge to retrieve a document or document fragment from that endpoint, an EPR-based SML

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reference scheme usually does not use [target-complete identifiers]. This Note should not be interpreted as excluding the possibility that the design of a Web service could allow target-complete identifiers.

If this Framework is adopted as a normative basis for defining EPR-based SML reference schemes (see section 3.1), then testing compliance with the framework would require the following changes to the language of the framework.

- All positive Framework assertions (e.g. "should", "is") MUST be interpreted as requirements (MUSTs) in conformity with [*RFC 2119*].
- All negative Framework assertions (e.g. "should not", "is not") MUST be interpreted as requirements (MUST NOTs) in conformity with [*RFC 2119*].
- All Framework assertions of explicit variability (e.g. "may") MUST be interpreted as implementation-defined recommendations (SHOULDs) in conformity with ~~All Framework assertions of explicit variability (e.g. "may") MUST be interpreted as explicit points of variability (implementation-defined) in conformity with~~ [*RFC 2119*].

Comment [kdw1]: This should be a hyperlink to section 2.2 of SML. (Inserting the reference directly into the text breaks up phrase "i-d recommendations".

As noted in point 2 above, the additional knowledge that is required by a Web service client to resolve an instance of the an EPR-based reference scheme may include knowledge of the operations supported by the service endpoint. Because the operations are typically not provided in the EPR itself, and the Framework does not constrain these bindings, two otherwise equal EPRs associated with different service bindings could target different documents. Specific knowledge regarding the MEPs needed to interact with the service pointed to by the EPR may need to be made available to the SML model validator. See section 3.1 for a means by which such knowledge may be made available through an EPR-based SML reference scheme.

2.2 Example of an SML EPR Reference Scheme: The University Course Example

Consider the following simple XML document:

```
<UniversityCourses xmlns="http://www.university.example.org/ns">
   <PHY101>
      . . .
   </PHY101>
   <PHY102>
      . . .
   </PHY102>
   . . .
</UniversityCourses>
```

This simple document will be used in both the following example and the EPR-based SML reference scheme to be developed in section 3. In the following example we will assume that each course entry is indexed by an information item named `CourseName`, whose type is `xs:ID` or `xs:keyref` and whose value is the name of the element.

The following example illustrates the use of an EPR-based SML reference scheme that is compliant with the Framework. The `EnrolledCourse` element references a course named `PHY101` from the preceding document:

```
<EnrolledCourse xmlns:sml="http://www.w3.org/sml/2007/02"
  sml:ref="true">
   <wsa:EndpointReference
    xmlns:wsa="http://www.w3.org/2005/08/addressing">
      <wsa:Address>
        http://www.university.example.org?CourseName=PHY101
      </wsa:Address>
   </wsa:EndpointReference>
</EnrolledCourse>
```

The service providing the university's list of courses is addressed by the URI `http://www.university.example.org`. The service endpoint expects a course name to be encoded in the query component of the IRI in the `wsa:Address` element. Access to the same content may require a different EPR-based SML reference scheme if the university's service interface involves a different means to target the desired fragment. For example, section 3.2 provides another example of an SML reference using a totally different EPR-based SML reference scheme.

3. Using the Framework with Web Services Protocols *[ToC]*

Because of the virtually unlimited latitude in specifying Web service interfaces for retrieving documents, EPR-based SML reference schemes may be defined with mechanisms to address the requirements of specific service protocols. For example, it may be desirable to include in the reference scheme definition a specific `wsa:Action` that the Web service client is to use in constructing the message to the service, or to provide a fragment identifier as a separate operation parameter in the form of a QName or [*XPath*] expression. In some cases, because of the service protocol, it may not be feasible to include this additional information within the `wsa:EndpointReference` element itself. The definition of a specific EPR reference scheme should use the Framework as its basis and may add several conditions for identifying an instance of the specific scheme.

3.1 An SML Reference Scheme for the WS-ResourceFramework

Let us assume that the course listing in the previous example (section 2.2) is maintained by a WS-Resource conformant to the WS-ResourceFramework [*WS-RF*] specification. The WS-ResourceFramework requires the use of EPRs to address conformant services. A definition of a specific SML Reference Scheme based on the WS-ResourceFramework might proceed as follows:

SML WS-RF Reference Scheme Definition:

1. This reference scheme fully complies with the Framework defined in section 2.1.

2. An SML reference element is identified as an instance of the SML WS-RF Reference Scheme if and only if it is identified as using the Framework and it contains the following:

    a. It has exactly one child element information item for which all of the following are true:

        i. Its [local name] is `EndpointReference`.
        ii. Its [namespace name] is `http://www.w3.org/2005/08/addressing`.

    b. It has exactly one child element information item for which all of the following are true:

        i. Its [local name] is `Action`.
        ii. Its [namespace name] is `http://www.w3.org/2005/08/addressing`.
        iii. The content of this element must be a IRI that represents a valid WS-ResourceProperties [*WS-RP*] request operation.

    c. It has at most one valid WS-RF message request element for which all the following are true:

        i. Its [local name] corresponds to a WS-ResourceProperties operation element.
        ii. Its [namespace name] is `http://docs.oasis-open.org/wsrf/rp-2`.
        iii. The content of this element is a single QName or XPath expression.

        NOTE: The WS-ResourceProperties `GetResourcePropertyDocument` operation does not require a message request element. The WS-RP operations `GetResourceProperty` and `Query ResourceProperties` require a single element as the content of the SOAP `Body`. However, the `GetMultipleResourceProperties` operation, which may retrieve multiple resource properties, would, under conditions of normal usage, yield an involved SML reference because of referencing multiple elements.

3. Resolution of this reference scheme should conform with the following rules:

    a) The `EndpointReference` element is mapped to SOAP `Header` element(s) as specified in the WS-Addressing SOAP Binding specification [*WS-A SOAP*].

b) The `Action` child element is mapped to a SOAP `Header` element with the same QName and content value.
c) The WS-RF message request element, if present, is mapped to the SOAP `Body` element with the same QName and content value.
d) The SML reference [target] is the content of the service response message. If there is no response message returned by the service, then the SML reference is unresolved.

4. As a consequence of conforming to the Framework, and not placing additional constraints on the resolution process sufficient to make it fully deterministic in the absence of outside knowledge, this reference scheme does not use [target-complete identifiers].

Note that this definition is not proposed as a normative definition of a WS-ResourceFramework reference scheme; however, this lack of normative standing should not be taken as precluding a similar definition being normatively defined.

Section 4.1 will identify further components of this definition that are required to insure that the reference scheme is interoperable.

3.2 WS-RF Reference Scheme Example

This section illustrates the WS-RF Reference Scheme defined in the preceding section. For simplicity, we will use the same simple XML document introduced in the University Course Example (section 2.2). To conform to the WS-ResourceFramework, we assume that the schema of this document is constructed in the following manner:

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:tns="http://www.university.example.org/ns"
  targetNamespace="http://www.university.example.org/ns">

  <xs:complexType name="CourseType">
    <xs:sequence>
      . . .
    </xs:sequence>
  </xs:complexType>

  <xs:element name="PHY101" type="tns:CourseType"/>
  <xs:element name="PHY102" type="tns:CourseType"/>
   . . .
  <xs:element name="UniversityCourses">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="tns:PHY101"/>
        <xs:element ref="tns:PHY102"/>
        . . .
      </xs:sequence>
    </xs:complexType>
  </xs:element>
```

```
</xs:schema>
```

This example is not meant to imply that this is the best way to design the XML document or the schema for this kind of list; it is meant only as a means to enable both of the SML reference scheme examples to reference instance documents the same simple structure.

To retrieve the `PHY101` element via the WS-RF Reference Scheme, the WS-ResourceProperties `GetResourceProperty` operation may be used. This operation has a `wsa:Action` as follows:

```
<wsa:Action>
  http://docs.oasis-open.org/wsrf/rpw-
2/GetResourceProperty/GetResourcePropertyRequest
</wsa:Action>
```

The WS-ResourceProperties message request element specifies the QName of the targeted document fragment, which must be a Global Element Declaration (GED), as the content value of the element representing the operation:

```
<wsrp:GetResourceProperty
    xmlns:wsrp="http://docs.oasis-open.org/wsrf/rp-2"
    xmlns:tns="http://www.university.example.org/ns">
  tns:PHY101
</wsrp:GetResourceProperty>
```

Thus, a functionally equivalent SML reference to the reference in section 2.2 (for an identically structured XML instance document) could be specified with the WS-RF Reference Scheme as follows:

```
<EnrolledCourse
    xmlns:sml="http://www.w3.org/sml/2007/02"
    xmlns:wsrp="http://docs.oasis-open.org/wsrf/rp-2"
    xmlns:wsa="http://www.w3.org/2005/08/addressing"
    sml:ref="true">
 <wsa:EndpointReference>
  <wsa:Address>http://www.university.example.org</wsa:Address>
 </wsa:EndpointReference>
  <wsa:Action>
    http://docs.oasis-open.org/wsrf/rpw-
2/GetResourceProperty/GetResourcePropertyRequest
  </wsa:Action>
  <wsrp:GetResourceProperty
      xmlns:tns="http://www.university.example.org/ns">
    tns:PHY101
  </wsrp:GetResourceProeprty>
</EnrolledCourse>
```

WS-RF Reference Scheme instances provide to the SML model validator three essential parts for constructing the message that is to be sent to the university course

service: the EPR of the service, the `wsa:Action` that is bound into the SOAP `Header`, and the content of the SOAP `Body`. Note that knowledge of how to use the service bindings in constructing a SOAP message, for example, what component(s) should go into the SOAP `Header` and which into the SOAP `Body`, must be made available to the model consumer. This information is typically provided by the WSDL binding for the service.

4. Interchange and Interoperability Considerations *[ToC]*

4.1 Using EPR-Based SML Reference Schemes in SML-IF Documents

Interchanging SML models consisting of documents containing SML references that use EPR-based SML reference schemes requires special consideration. Interchange is performed by packaging the documents comprising an SML model into a single document as described in the [*SML-IF*] specification. In order to perform interchange set validation, the SML-IF validator must first look to validate any SML reference in terms of what is packaged in the SML-IF document itself. If validation fails from this perspective, SML-IF validators may choose to pursue the reference outside of the SML-IF document; however, given the complexity of de-referencing an EPR, SML-IF validators may be reluctant to do so.

In order to support this internal test of SML reference validity, the SML-IF specification introduces the notion of a document [alias]. For aliases to be usable in the context of SML-IF, an alias name (a URI) must be derivable from the reference scheme instance so that the validator can determine what document in the interchange set the reference scheme is intending to point to. Thus if an EPR-based SML reference scheme will be used in the context of SML-IF, the reference scheme definition should include a method for mapping each EPR to a predictable URI. In particular, consideration should be given to mapping the EPR's [address] value (an IRI) to a URI. (However, to simplify the following discussion, this consideration will be left as an exercise for implementations of this Note.)

The following considerations pertain to the processing of SML references exposing EPR-based SML reference schemes in SML-IF documents by means of aliasing:

4.1.1 Document Aliases

Unless the EPR-based SML reference scheme is sufficiently constrained to make use of target-complete identifiers, which is unlikely for EPRs, its `wsa:Address` cannot be used as an SML-IF document alias. Nevertheless, the referenced document may be embedded in the SML-IF document. If maintaining the fidelity of these links during interchange is necessary, several alternatives are available, including but not limited to:

1. For each EPR-based SML reference scheme of an SML reference, the SML-IF producer adds a second reference scheme instance understood by the receiving SML-IF consumer. This second reference could use a URI that does not follow the SML-IF rules for resolving target-complete identifiers. (See section 5.3.4 in [*SML-IF*].) That is, the URI would fall into "category 3" discussed in that section. Note that the identifier value must be generated dynamically from the information given in the EPR reference scheme instance. Care must be taken to avoid collisions, since SML-IF allows document aliases to be preserved across multiple interchanges.
2. An EPR-based SML reference scheme definition can specify an algorithm for generating target-complete identifiers for the purpose of SML-IF URI reference processing as described in section 5.3.4 in [*SML-IF*].

Using the first case as an example, the SML-IF document producer generates a reference scheme instance based on information in the given instance of the EPR reference scheme that is sufficient to uniquely identify the target document or document fragment within the interchange model. Thus, this scheme specifies a document alias. For example, the SML reference from the example in section 3.2 may have a generated reference scheme instance with an algorithmically generated identifier as shown in the following:

```
<EnrolledCourse
    xmlns:sml="http://www.w3.org/sml/2007/02"
    xmlns:wsrp="http://docs.oasis-open.org/wsrf/rp-2"
    xmlns:wsa="http://www.w3.org/2005/08/addressing"
    sml:ref="true">
 <wsa:EndpointReference>
  <wsa:Address>http://www.university.example.org</wsa:Address>
 </wsa:EndpointReference>
  <wsa:Action>
    http://docs.oasis-open.org/wsrf/rpw-
2/GetResourceProperty/GetResourcePropertyRequest
  </wsa:Action>
  <wsrp:GetResourceProperty
       xmlns:tns="http://www.university.example.org/ns">
     tns:PHY101
  </wsrp:GetResourceProperty>
  <newScheme:generatedWSRFIdentifier
       xmlns:newScheme="http://www.example.com/myNewScheme_namespace"
       xmlns:tns="http://www.university.example.org/ns">
    http://www.university.example.org?GetResourceProperty=tns:PHY101
  </newScheme:generatedWSRFIdentifier>
</EnrolledCourse>
```

The generated reference scheme instance is comprised by the `newScheme:generatedWSRFIdentifier` element. (It is left as an exercise for the reader to trace through the algorithmic steps by which the URI `//www.university.example.org?GetResourceProperty=tns:PHY101` in the generated instance can be computed from the preceding EPR Reference Scheme

instance. Obviously, the schema declaration of `EnrolledCourse` must allow additional elements.)

This new reference scheme targets the document independently of how the document is made available through the Web service targeted by the preceding EPR-based Reference Scheme. The alias for this reference would be:

```
<alias>
  http://www.university.example.org?GetResourceProperty=tns:PHY101
</alias>
```

Moreover, the process by which the identifier is resolved to the targeted document within the SML-IF document must be defined in the reference scheme definition similar to the way the resolution process for target-complete URI references is defined in section 5.3.4 of [*SML-IF*]. (This resolution algorithm is also left as an exercise for the reader.)

> NOTE: While the SML-IF consumer may recognize the reference scheme added by the SML-IF producer, we assume that the reference scheme will *not* be recognized by the SML model processor; thus the SML model processor will not attempt to resolve it. Should the SML model processor recognize the reference scheme (e.g., if the SML URI Reference Scheme is used to contain the document alias URI) and should the SML model processor attempt to resolve it by normal processing for that reference scheme, the reference may fail. Implementations may take steps to prevent this failure.

If the targeted service exposes only the targeted document, or, more precisely, the wsa:`Address` element of the EPR uniquely identifies the target document within the service, it may be possible to utilize the second strategy above and generate a target-complete identifier to both identify and serve as a document alias to the document or document fragment in the SML-IF document. For example, if the service addressed at the URI `http://www.university.example.org` in the University Course Example exposes only that one document, a target-complete identifier in the preceding example might be:

```
http://www.university.example.org#smlxpath1(/u:UniversityCourses/u:PHY101
)
```

where `UniversityCourses` is the root element of the document and the `u` prefix represents the `http://www.university.example.org/ns` namespace. It is not expected that EPR-based SML reference schemes will typically be able to support a target-complete identifier.

4.1.2 Document Locators

EPRs as values of the SML-IF `document/locator` element are subject to the same semantic and processing requirements as are EPR-based reference schemes. EPR [document locators] should be avoided if wide interoperability is desired.

4.2 Interoperability

Because EPR-based SML reference schemes cannot in general be represented by SML URI Reference schemes, an SML-IF document containing EPR-based reference schemes cannot typically be referentially conforming as defined by section 5.1 of [*SML-IF*]. However, the two mechanisms defined in section 4.1.1 for generating aliases within the SML-IF document partially address interoperability issues at the level of the SML-IF document. Other considerations related ot interoperability exists even if the reference schemes may be be defined with sufficient rigor to insure interoperability amongst those who adopt the reference scheme. These other issues include whether model documents are embedded or included by reference only in the SML-IF document and whether the SML-IF document is schema-complete. For further discussion see section 4.5 in [SML-IF].

Definitions of EPR-based SML reference schemes should be sufficiently rigorous to support model interoperability amongst those vendors who agree to use a specific EPR-based reference scheme.

5. Summary *[ToC]*

The following points summarize the issues that should be considered when defining an EPR-based SML reference scheme.

1. Consideration should be given to using the Framework Core described in section 2 and to adopting it as normative.
2. Consideration should be given to the operations and their parameters offered by the service interface through which the document or document fragment is accessed. The critical issue in defining an EPR-based SML reference scheme is how much of this special knowledge should be captured in the EPR-based SML reference scheme itself and how much might be otherwise made available to the model consumer.
3. If the EPR-based SML reference scheme will be used in the context of an SML-IF document, then a method for supporting SML-IF document aliases should be defined as part of the reference scheme definition. This note explored several strategies by which this issue could be addressed. These strategies involve:
    a. Defining an algorithm for generating a reference scheme using a URI identifier with an explicitly stated resolution process, so that targeted documents can be identified within the SML-IF document by SML-IF aliasing mechanism, or
    b. Defining an algorithm for generating a target-complete URI reference scheme so that the alias can be resolved by the mandated process for resolving SML URI Reference Schemes.

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