Interaction Translation Methods for XML/SNMP Gateway

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Introduction (1)

- **Motivation**
  - Currently, SNMP-based network management is widely deployed
  - XML-based network management has been proposed to complement SNMP
  - XML/SNMP gateway is needed for integrated network management
Introduction (2)

❖ Motivation (cont’d)
  – **XML/SNMP gateway** must provide both specification translation and interaction translation between the two different management domains, **XML** and **SNMP**
  – Recent research on **SMI to XML Schema specification translation** provides the foundation for the XML/SNMP gateway
  – **No concrete or standard interaction translation method for the gateway exists yet**

❖ Propose Interaction Translation Methods for XML/SNMP Gateway
  1. **XML Parser-based Translation** between **DOM/SAX interfaces** and **SNMP operations**
  2. **HTTP-based Translation** applying **XPath, XQuery and XUpdate**
  3. **SOAP-based Translation** based on **SOAP RPC between manager and gateway**
Related Work (1)

- **XML Technologies**
  - **DOM (Document Object Model)**: Platform- and language-independent interface that allows applications to dynamically access and manipulate the content and structure of documents.
  - **SAX (Simple API for XML)**: Event-driven and serial-access mechanism for accessing XML documents.
  - **XPath (XML Path Language)**: Language for addressing specific parts of an XML document.
  - **XQuery (XML Query Language)**: Query language for XML providing document filtering and contents grouping.
  - **SOAP (Simple Object Access Protocol)**: Simple and lightweight protocol for exchanging structured and typed information in a distributed environment using XML.
  - **WSDL (Web Services Description Language)**: XML-based language used to define Web Services and describe how to access them.
Related Work (2)

- **XML/SNMP Integration**
  - **Specification Translation**
    - J.P. Martin-Flatin’s management information model
    - F. Strauss’s libsmi, converting SMI MIBs to XML Schema (or DTD) definitions
    - Our work on MIB to XML translation, validated by developing an XML-based SNMP MIB browser
  - **XML/SNMP Gateway**
    - F. Strauss’s gateway, implemented using mibdump
    - Avaya Labs research on XML-based management interface for SNMP enabled devices, currently implementing a gateway using XML-RPC
**XML/SNMP Gateway**

- **What is XML/SNMP Gateway?**
  - Provides a method to manage networks equipped with SNMP agents using XML-based manager
  - Relays management information and operations between XML-based manager and SNMP agent

- **Basic requirements for the gateway**
Architecture of XML/SNMP Gateway

XML-based Manager

Request  Response  Trap Notification

XML/SNMP Gateway

MIB Definition

MIB to XML Translator

Request Handler

Trap Reporter

XML Parser

XML Document

XML-encoded Response

XML-encoded Trap Information

Trap Information

SNMP Stack

MIB Variables for Request

Information for SNMP Request

Translation Result

Response Information

SNMP Request

SNMP Response

SNMP Trap

SNMP Agent

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1. XML Parser-based Translation (1)

- Specification Translation Results
  - MIB module $\rightarrow$ Node::Document
  - MIB node $\rightarrow$ Node::Element
  - Node value $\rightarrow$ Node::Text

- Example Mappings of DOM Interfaces into SNMP Operations
  - Node::NodeValue
    - Retrieval from the manager: translated into an SNMP GET request
    - Modification from the manager: translated into an SNMP SET request
    - Modification on trap nodes: translated into a notification message through event handler
XML Parser-based Translation (2)

XML-based Manager

XML/SNMP Gateway

DOM

Target node

DOMNode()

Response for Interface Call

DOM Event for Notification

Update Trap Contents

Send “OID”

Update Node Value

SNMP Stack

Trap Handler

SNMP Request

SNMP Response

SNMP Trap

Element node

Text node
2. HTTP-based Translation (1)

- **HTTP GET Method with XQuery** → SNMP GET Request

- **HTTP POST Method with XUpdate** → SNMP SET Request
2. HTTP-based Translation (2)

Examples of XPath, XQuery and XUpdate in HTTP

<table>
<thead>
<tr>
<th>Example of using XPath</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://hostname/gateway?XQuery=">http://hostname/gateway?XQuery=</a>&lt;XQuery&gt;… &lt;XPath&gt;device[@type=&quot;server&quot;]&lt;/XPath&gt; …&lt;XQuery&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example of Using XQuery</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://hostname/gateway?XQuery=">http://hostname/gateway?XQuery=</a>&lt;XQuery&gt;… &lt;result&gt; { Let $t := input() //ifTable/ifEntry/ ifType[contains( ./text(), “6”)]} RETURN &lt;totalInOutOctets count=&quot;{count($t )}&quot;&gt; &lt;in&gt; { sum($t/ifInOctets/text()) } &lt;/in&gt; &lt;out&gt; { sum($t/ifOutOctets/text()) } &lt;/out&gt; &lt;/totalInOutOctets&gt; } &lt;/result&gt; … &lt;/XQuery&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example of Using XUpdate</th>
</tr>
</thead>
<tbody>
<tr>
<td>… &lt;Modifications&gt;&lt;Update select=&quot;/sysContact&quot;&gt;admin&lt;/Update&gt;&lt;Update&gt;…&lt;/Update&gt;&lt;/Modifications&gt; …</td>
</tr>
</tbody>
</table>
HTTP-based Translation (3)

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3. SOAP-based Translation (1)

- SOAP Message Format

```xml
<SOAP-ENV:Envelope
    xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
    <SOAP-ENV:Header>…..</SOAP-ENV:Header>
    <SOAP-ENV:Body>
        XML for advertised methods
    </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

- *get* and *set* operations published by the gateway
  - *get* operation with *XQuery* → SNMP GET
  - *set* operation with *XUpdate* → SNMP SET

- *trap* operation published by the manager in order to receive notification message from the gateway
3. SOAP-based Translation (2)

- WSDL Definition of Basic Operations for SOAP RPC

```xml
<wsdl:definitions (namespace declarations)>
  <wsdl:message name="getRequest">
    <wsdl:part name="param" type="xsd:string" /></wsdl:message>
  <wsdl:message name="getResponse">
    <wsdl:part name="getReturn" type="xsd:string" /></wsdl:message>
  <wsdl:portType name="SoapInterface">
    <wsdl:operation name="get" parameterOrder="param">
      <wsdl:input message="intf:getRequest" name="getRequest" />
      <wsdl:output message="intf:getResponse" name="getResponse" />
    </wsdl:operation></wsdl:portType>
  <wsdl:binding name="SoapInterfaceSoapBinding" type="intf:SoapInterface">
    <wsdlsoap:binding style="rpc"
      transport="http://schemas.xmlsoap.org/soap/http" />
    <wsdl:operation name="get"> ... </wsdl:operation></wsdl:binding>
  <wsdl:service name="SoapInterfaceService">
    <wsdl:port binding="intf:SoapInterfaceSoapBinding" name="SoapInterface">
      <wsdlsoap:address location="http://hostname:8080/axis/SoapInterface.jws" />
    </wsdl:port></wsdl:service></wsdl:definitions>
```
SOAP-based Translation (3)

XML-based Manager

Management Application

Request Information

Response from SOAP Body

XML-based Manager

SOAP Client

HTTP Client

SOAP Server

HTTP Server

HTTP Request

HTTP Response

HTTP POST for Trap

XML/SNMP Gateway

HTTP Server

SOAP Server

HTTP Client

SOAP Client

Method Invocation

Result from Method

XML-encoded Trap

XML/SNMP Gateway

getRequest

setRequest

trap

XML Parser & XPath/XQuery Handler

SNMP Stack

Trap Information

Information for SNMP Request

MIB Variables

SNMP Request

SNMP Response

SNMP Agent

SNMP Trap

Response from SOAP Body

Trap Info. from SOAP Body

Request Information

Response Information

XML-encoded Trap

SNMP Request

SNMP Response

XML/SNMP Gateway

Interaction Translation Methods for XML/SNMP Gateway

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## Analysis of Translation Methods

<table>
<thead>
<tr>
<th>Translation Methods</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>XML Parser-based Translation</td>
<td>- No need for a request handler between <strong>internal gateway</strong> and manager</td>
<td>- Imposes a burden on the <strong>manager</strong> by invoking a series of interfaces for request processing</td>
</tr>
<tr>
<td></td>
<td>- Can be the basis for the other translation methods</td>
<td></td>
</tr>
<tr>
<td>HTTP-based Translation</td>
<td>- Simple to implement in <strong>XML/HTTP.</strong></td>
<td>- No standard in the use of URI string as a request specifier</td>
</tr>
<tr>
<td></td>
<td>- Provides an efficient mechanism for querying managed objects</td>
<td>- Need of <strong>XPath, XQuery</strong> and <strong>XUpdate parsers</strong></td>
</tr>
<tr>
<td>SOAP-based Translation</td>
<td>- Simple to implement over <strong>HTTP.</strong></td>
<td>- Need of <strong>SOAP server/client</strong></td>
</tr>
<tr>
<td></td>
<td>- Inherits advantages in <strong>HTTP-based translation</strong></td>
<td>- Overhead of packaging <strong>SOAP messages</strong></td>
</tr>
<tr>
<td></td>
<td>- Provides a standard method to implement an <strong>RPC</strong></td>
<td></td>
</tr>
</tbody>
</table>
Implementation (1)

- **XML/SNMP Gateway Specification**
  - Linux Server with Pentium-III 800 MHz CPU and 256 MB RAM

- **XML Parser-based Translation**
  - Apache Xerces 1.4.4 for XML parser
  - OpenNMS’s joeSNMP 0.2.6 for SNMP Handler and Trap Handler
  - Validated using a simple manager running with the gateway in the same process

- **HTTP-based Translation**
  - Based on XML parser-based translation
  - Apache Tomcat 4.0 for HTTP server and Innovation’s HTTP Client V0.3
  - Apache Xalan 2.4.0 for XPath processor
  - HTTP GET for MIB Retrieval and POST for MIB modification
  - Query messages are XML-encoded using XPath/XQuery/XUpdate
  - Validated using our XGEMS (XML-based Global Element Management System)
Implementation (2)

- **SOAP-based Translation**
  - Based on XML parser-based translation
  - Apache **Axis 1.0** (SOAP 1.1 and WSDL 1.1 compliant) for SOAP engine
  - Used WSDL for SOAP service definition
  - Service Deployment Methods
    - Using **Java Web Service (JWS)** provided by Axis
    - Automatic generation of WSDL and proxy/skeleton codes
  - Validated using our **XGEMS**
Performance Analysis: Design (1)

- Performance Test Items
  - Latency Performance of XML Parser-, HTTP- and SOAP-based method for MIB II retrieval using iterative SNMP GetNext
  - Performance evaluation of variations of the proposed translation methods

- Performance Testbed

XML-based Manager
- Linux server with Pentium-III 800 MHz CPU
- 256 MB RAM

XML/SNMP Gateway
- Simple XML-based Manager
  - Linux server with Pentium-III 800 MHz CPU
  - 256 MB RAM

SNMP Agent
- 1. L4 switch with 9 ports
- 2. L2 switch with 26 ports
Performance Analysis: Design (2)

XML-based Manager

HTTP Client

SOAP Client

XML/SNMP Gateway

SOAP Server

HTTP Server

XML Parser

XML-based Manager

SNMP Stack

SNMP Agent

SNMP Stack
Performance Analysis: Results (1)

- **Latency Performance of Proposed Translation Methods**
  - Time for MIB-II translation and DOM loading: 535 ms
  - Connection Setup Time: 0.1 ms for HTTP, 17.4 ms for SOAP

<table>
<thead>
<tr>
<th>Method</th>
<th>Device (MIB size)</th>
<th>L4 switch (28 KB)</th>
<th>L2 switch (54 KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNMP Stack: T1 (ms)</td>
<td></td>
<td>1307.1</td>
<td>4283.6</td>
</tr>
<tr>
<td>XML Parser-based Translation: T2 (ms)</td>
<td></td>
<td>1360.6 (4.1%)</td>
<td>4317.6 (0.8%)</td>
</tr>
<tr>
<td>HTTP-based Translation: T3 (ms)</td>
<td></td>
<td>1419.1 (8.6%)</td>
<td>4418.8 (3.2%)</td>
</tr>
<tr>
<td>SOAP-based Translation: T4 (ms)</td>
<td></td>
<td>1613.3 (23.4%)</td>
<td>4922.2 (14.9%)</td>
</tr>
</tbody>
</table>

- Each translation method adds approximately the same amount of overhead time to the basic SNMP processing time (T1)
- Additional translation overhead takes small portion of the overall processing time
### Performance Analysis: Results (2)

**Comparison on Parsing Overhead of XPath**

<table>
<thead>
<tr>
<th>Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>//ifTable</td>
<td>//ifInOctets</td>
<td>//ifType/following-sibling::ifInOctets</td>
<td>//ifType[.='6']/following-sibling::ifInOctets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>//ifOutOctets</td>
<td>//ifType/following-sibling::ifOutOctets</td>
<td>//ifType[.='6']/following-sibling::ifOutOctets</td>
</tr>
<tr>
<td>Retrieved Data Size (KB)</td>
<td>12.4</td>
<td>2.1</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Overhead of XPath Parsing (ms)</td>
<td>0.5</td>
<td>0.6</td>
<td>108.2</td>
<td>1432.2</td>
</tr>
<tr>
<td>Overall Processing Time: T2 (ms)</td>
<td>353.8</td>
<td>103.5</td>
<td>212.3</td>
<td>1682.8</td>
</tr>
</tbody>
</table>

※ Apache Xerces 1.4.4 and Xalan 2.4.0 for XPath Parser
Performance Analysis: Results (3)

- Performance Comparison of HTTP GET and POST in HTTP-based Translation

<table>
<thead>
<tr>
<th>Method</th>
<th>Device (MIB data)</th>
<th>L4 switch</th>
<th>L2 switch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>system group</td>
<td>MIB-II</td>
<td>system group</td>
</tr>
<tr>
<td>HTTP GET (ms)</td>
<td>96.5</td>
<td>1419.1</td>
<td>94.9</td>
</tr>
<tr>
<td>HTTP POST (ms)</td>
<td>112.2</td>
<td>1440.7</td>
<td>101.2</td>
</tr>
</tbody>
</table>

- Latency of Several Variations of SOAP *get* Operation

<table>
<thead>
<tr>
<th>Type</th>
<th>Latency</th>
<th>L4 switch</th>
<th>L2 switch</th>
<th>One method</th>
<th>Two methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ms)</td>
<td>(ms)</td>
<td>(type D)</td>
<td>(type E)</td>
</tr>
<tr>
<td></td>
<td>1 param (type A)</td>
<td>1613.3</td>
<td>4922.2</td>
<td>1613.3</td>
<td>5063.3</td>
</tr>
<tr>
<td></td>
<td>2 params (type B)</td>
<td>1676.6</td>
<td>4993.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 params (type C)</td>
<td>1908.8</td>
<td>5298.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

Interaction Translation Methods in XML/SNMP gateway for XML-based Integrated Management

1. XML parser-based translation provides the manager direct access to management information DOM/SAX interfaces
2. HTTP-based translation provides efficiency improvement in XML/HTTP communication using XPath, XQuery and XUpdate
3. SOAP-based translation provides a flexible and standardized method for interaction between the manager and gateway

Validation of the Proposed Methods

- Implemented and validated XML/SNMP gateway using XML-based Global Element Management System (XGEMS)
- Performed several experiments for latency performance of the proposed methods
- Validated our XML/SNMP gateway provides efficient translation in integrated network management
Future Work

- Performance improvement of the translation mechanism using the SAX parser instead of the DOM parser
- Scalability of the gateway
- Implementation of Web Services using UDDI integration with our current implementation
- Integration with CORBA
- WBEM (Web-based Enterprise Management) implementation using CIM to XML mapping and CIM operations over HTTP
Q & A