An Architectural Framework For XML-based Network Management

PhD Thesis Defence

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Contents

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- Related Work
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- Approaches for Solving the Problems
- Applicability of XML Technologies to NM
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Introduction (1)

- Current situation of network management
  - A variety of network devices are emerging
  - The scale of network is large
  - SNMP reveals weaknesses to manage large-scale and complex network

- SNMP problems
  - Management information model: weak
  - Management protocol: weak
  - Analysis: no standard method or support for DB
  - Presentation: no standard method
  ➔ Inappropriate to manage huge and complex networks
Introduction (2)

- XML-based network management (XNM)
  - Much effort to improve the deficiencies of SNMP has failed
  - XNM is proposed as an alternative to SNMP-based NM
  - Advantages of applying XML to network management
    - **XML Schema**: used to define rich structure of management information in a flexible manner
    - **HTTP**: used to reliably transfer bulk management data.
    - **DOM APIs**: used to easily access and manipulate management data from applications
    - **XPath**: used to efficiently address the objects within management data documents
    - **XSL**: used to process management data easily and generate HTML documents for a variety of user interface views
Introduction (3)

- Problems of current XML-based NM
  - General architecture for XML-based NM is not provided
  - Performance of XML-based NM is not validated
  - Concrete method for integrating existing SNMP agents is not supported

- Our Approaches for solving the problems
  - Provide the applicability of XML technologies to network management to solve SNMP problems
  - Propose an architecture of XML-based NMS from the aspect of manager and agent
  - Implement XML-based NMS for network management
  - Evaluate the performance of XNMS
  - Propose a method of XML/SNMP gateway
Related Work: XML Technology Map

- **Program, Scripts, Database, Editor(file)**
  - Input
  - Generate
  - Validate
  - Define

- **XML Document**
  - Input
  - Parse
  - Dump
  - Process
  - Program

- **DOM, SAX**
  - Define
  - Exchange

- **SOAP**
  - Input
  - Define
  - Usage

- **WSDL**
  - Input
  - Exchange

- **DTD, XML Schema**
  - Validate
  - Define

- **XSL**
  - Input

- **XSLT**
  - Input

- **XPath**
  - Input

- **Web Browser**

- **Remote System**
Related Work: XNM (1)

- **Configuration Management**
  - Cisco’s CNS Configuration Registrar
  - Juniper Network’s JUNOScript
  - IETF Working Group on Network Configuration (NetConf)

- **Architecture**
  - J.P Martin’s Web-based Integrated Management Architecture: propose only information model and communication model
  - Our previous XNM: provide an architecture of agent, but insufficient in manager architecture

- Few reports for implementation results yet
- Insufficient information to implement and apply

- Lack of overall architecture of XML-based NM
Related Work: XNM (2)

- **Performance**
  - Network bandwidth of transferring XML data is large because XML is text-based.
  - Not been proved that XML is applicable to embedded systems.
  - Lack of performance evaluation results available.

- **SNMP Integration**
  - Avaya Labs: early stage of research, merely propose a method of the XML/SNMP gateway.
  - J. Muller: provide the simple functionality of gateway.
  - XNAMI: propose a method for complementing the weakness of SNMP.

  - Lack of a gateway architecture and a method to develop the gateway.
Network Management Tasks

Managed Resource

Instrumentation

Modeling

Agent

Specification & Interaction Translation

Communication & Operation (Protocol)

Manager

Presentation

Analysis

Manager Application

Gateway
Problem Definition: SNMP

- **Management information model**
  - Defines management information using Structure of Management Information (SMI)
  - Insufficient to present management information because it does not support concepts such as structured data types, objects, methods, or relationships

- **Management protocol**
  - Only 3 simple management operations: Get, Set, Trap
  - UDP only → not support bulk data retrievals in a reliable manner

- **Analysis**
  - No standard APIs of analysis
  - No support for database

- **Presentation**
  - No standard methods of presentation
Problem Definition: Current XNM

- No general architecture for XML-based NM
  - A general architecture of XNMS consisting of manager and agent is not provided yet

- Insufficient implementation and performance validation of XML-based NMS
  - Implementation experience of XNMS including configuration management is not properly provided
  - Performance evaluation of XNMS is main concern, but no report on performance of XML-based NM

- No concrete method for integrating existing SNMP agents
  - Need to support the management of existing SNMP agents for integrated network management
  - No specific method and system for managing existing SNMP agents using XNMS
Our Approaches (1)

- To solve SNMP problems → Applicability analysis of XML technologies to network management
  - Management information model
    - Use powerful management information modeling of XML Schema
  - Instrumentation
    - Use DOM and SAX for interpretation of XML document
  - Management protocol
    - Transfer XML data using protocols such as HTTP or SOAP
    - Possible to bulk data transfer in a reliable manner
    - Possible to reduce transferred data through compression
  - Analysis
    - Manipulate XML document using DOM parser
    - Use DOM API for management information analysis
  - Presentation
    - Transform XML format to HTML format using XSLT
Our Approaches (2)

- To solve current XNM problems → Propose an architecture & validate it through implementation and performance evaluation
  - Propose an architecture of XNMS from the aspect of manager and agent
  - Implement XNMS for network management based on the proposed architecture
  - Evaluate the performance of XNMS in resource utility, network traffic, and response time
  - Propose a method of XML/SNMP gateway, implement the gateway, and apply the gateway to the management of POSTECH campus network
Applicability Analysis (1)

- **Management information model**
  - Use **XML Schema** for management information model
    • Define the data structure of XML document
    • Flexible and extensible: add new tags
    • Support 44 kinds of basic data types and add new data types
    • Easy to learn
    • Powerful and convenient XML tools are freely-available

- **Instrumentation**
  - Must guarantee consistency between managed objects and managed resources in agent system
  - Use **DOM** or **SAX** for the manipulation of XML document
    • Interpretation, creation, and modification of XML document using DOM or SAX parses
Applicability Analysis (2)

- **Management Protocol**
  - Use HTTP or SOAP
    - Transfer bulk data without the limitation of data size in a reliable manner
    - Compress messages with the HTTP header option and reduces network traffic volumes
    - Define management operations using WSDL and call management operation using SOAP
  - Use **XPath** for the addressing of management information

- **Analysis**
  - Use **DOM and SAX API** to access management data for application
  - Manipulate XML document and analyze management information using DOM API
  - Use **XMLDB** for DB processing
  - Plenty of tools available for XML technologies
Applicability Analysis (3)

- **Presentation**
  - XML separates the contents of the document from the display.
  - Use XSL and XSLT to transform XML data to HTML or another XML document.
  - Transformation from XML to HTML or other display format makes it possible to provide a Web-based management user interface (Web-MUI).
Combinations of Managers and Agents

(a) SNMP Manager

(b) SNMP Manager

(c) XBM Manager

(d) XBM Manager

Device
SNMP Agent

Device
XBM Agent

Device
SNMP Agent

Device
XBM Agent

SNMP

SNMP/XML Gateway

XML/HTTP

XML/HTTP

XML/HTTP

SNMP

XML/HTTP

XML/HTTP

XML/HTTP
Architecture – XBM Manager
Architecture – XBM Agent

Managed System

- Virtual File System
- Embedded System Application
- Mgmt. Backend Interface
- SNMP Agent

XBM Agent

- EWS (HTTP Server Engine)
- HTTP Client Engine
- Mgmt. Script
- Push Handler
- XML Processor
  - SAX Parser
  - XPath Handler
  - Write Module
- Scheduler

HTTP

SNMP

XML/ SNMP Gateway

- SNMP
- HTTP
Architecture of X-CONF
(Xml-based CONFiguration management system)
Architecture of XML/SNMP Gateway

XBM Manager

HTTP Request  HTTP Response with XML fragment  HTTP Message with trap info.

HTTP Server  Request Handler  HTTP Client

Request Information from HTTP GET/POST Message  XML fragment for a request  DOM Event for notification

XPath/XUpdate Handler

DOM Interface call

XML/SNMP Gateway

Information including “OID” for SNMP request  MIB variables for a request  Update trap contents

DOM

Target node  Trap node

XPath/XUpdate Handler

SNMP Stack  Trap Receiver

SNMP Request  SNMP Response  SNMP Trap
Performance Evaluation Environments

XBM Manager (Pentium III 800MHz, CPU 256MB)

100 Mbps

XML/SNMP Gateway (Pentium III 800MHz, CPU 256MB)

100 Mbps

IP sharing device

XBM Agent

SNMP Agent

100 Mbps

Network Device

SNMP Agent

100 Mbps

SNMP Manager (Pentium III 800MHz, CPU 256MB)
Performance Evaluation (1)

- Verify the performance of XBM agent by comparing it with the SNMP agent on the same IP sharing device.
- SNMP agent extends the Net-SNMP and supports only SNMPv1.
- CPU load, run-time memory usage, and executable code size.

<table>
<thead>
<tr>
<th>Agent</th>
<th>CPU load</th>
<th>Run-time memory usage</th>
<th>Executable code size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNMPv1</td>
<td>17 %</td>
<td>600 KB</td>
<td>400 KB</td>
</tr>
<tr>
<td>XBM</td>
<td>20 %</td>
<td>700 KB</td>
<td>550 KB</td>
</tr>
</tbody>
</table>

< Resource Usage of SNMP and XBM Agents >
## Performance Evaluation (2)

### Network traffic (MIB II – system, interfaces group)

<table>
<thead>
<tr>
<th>Management Property</th>
<th>Get request message (bytes)</th>
<th>Get response message (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SNMP</td>
<td>XBM</td>
</tr>
<tr>
<td>sysDescr</td>
<td>82</td>
<td>508</td>
</tr>
<tr>
<td>sysContact</td>
<td>82</td>
<td>510</td>
</tr>
<tr>
<td>system Group</td>
<td>572</td>
<td>511</td>
</tr>
<tr>
<td>inOctets (2 interfaces)</td>
<td>169</td>
<td>511</td>
</tr>
<tr>
<td>outOctets (2 interfaces)</td>
<td>169</td>
<td>511</td>
</tr>
<tr>
<td>interfaces Group</td>
<td>3720</td>
<td>511</td>
</tr>
</tbody>
</table>

< Message Size of Get Request/Response Operation >
Performance Evaluation (3)

- **Response time** (MIB II – system, interfaces group)

<table>
<thead>
<tr>
<th>Management Property</th>
<th>SNMP</th>
<th>XBM</th>
<th>XML/SNMP Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>sysDescr</td>
<td>40</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>system Group</td>
<td>160</td>
<td>140</td>
<td>250</td>
</tr>
<tr>
<td>interfaces Group</td>
<td>980</td>
<td>800</td>
<td>1250</td>
</tr>
</tbody>
</table>

< Response Time of Get Operation >
Performance Evaluation (4)

- Network Traffic (MIB II – system group)

![Graph showing Network Traffic vs Number of SNMP agents]

- SNMP <-> Gateway
- Gateway <-> XBM
Performance Evaluation (5)

- **Response Time** (MIB II – system group)

![Graph showing network traffic (bytes) vs. number of SNMP agents for different configurations: SNMP Gateway <-> Gateway, Gateway <-> XBM, and Total. Each configuration shows an increase in network traffic as the number of SNMP agents increases.]
Concluding Remarks

- Identified the problems of SNMP and current XML-based NM
- Proposed the solutions to SNMP problems using XML technologies
- Provided an architecture of XML-based network management system (XNMS)
  - XBM manager, XBM agent, XML/SNMP Gateway, X-CONF
- Implemented an XNMS and evaluate the performance of our XNMS
Contributions

• Proposed the solutions of the SNMP problems from the aspect of management tasks using XML technologies
• Proposed solutions to the problems of current XML-based NM
• Provided an architecture for XNMS
• Provided a guideline for developing XNMS by implementation experience
• Validated the performance of our XNMS
Future Work

- Optimize the performance of our XNMS
  - XBM manager, XBM agent, XML/SNMP Gateway
- Evaluate the performance of pure XML-based network management
- XNMS using Web Services
  - Use SOAP, WSDL, UDDI
Published Papers (1)

• International Journals: 5
Published Papers (2)

• International Conferences: 12

• Domestic Journal: 4, Domestic Conference: 4
## Comparison of Managers

<table>
<thead>
<tr>
<th>Features</th>
<th>SNMP Manager (SNMPv1/v2)</th>
<th>XBM Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mgmt. User Interface (MUI)</td>
<td>Desktop-MUI or Web-MUI</td>
<td>Web-MUI or Desktop-MUI</td>
</tr>
<tr>
<td>Mgmt. Protocol</td>
<td>SNMP (UDP)</td>
<td>XML/HTTP (TCP)</td>
</tr>
<tr>
<td>Mgmt. Information Model</td>
<td>SNMP SMI, MIB</td>
<td>XML DTD, XML Schema</td>
</tr>
<tr>
<td>Development Cost of Mgmt.</td>
<td>More difficult</td>
<td>Easier</td>
</tr>
<tr>
<td>Functionality</td>
<td>No standard API</td>
<td>Standard API to access XML documents</td>
</tr>
<tr>
<td></td>
<td>Limited support of RDBMS</td>
<td>Support of the third party RDBMS</td>
</tr>
<tr>
<td>Security</td>
<td>Community string</td>
<td>HTTP authentication, HTTPS (HTTP over SSL)</td>
</tr>
<tr>
<td>Resource</td>
<td>Many resources</td>
<td>Many resources</td>
</tr>
</tbody>
</table>
# SNMP-based NM vs. XML-based NM (2)

## Comparison of Agents

<table>
<thead>
<tr>
<th>Features</th>
<th>SNMPv1/v2 Agent</th>
<th>EWS</th>
<th>XBM Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>SNMP (UDP)</td>
<td>HTML/HTTP (TCP)</td>
<td>XML/HTTP (TCP)</td>
</tr>
<tr>
<td>Mgmt. Info. Model</td>
<td>SNMP SMI (MIBII + Private MIB)</td>
<td>No specific model</td>
<td>XML DTD, XML Schema</td>
</tr>
<tr>
<td>Operation</td>
<td>SNMP Get, Set, Trap</td>
<td>HTTP operation (Get, Post)</td>
<td>HTTP operation (Get, Post)</td>
</tr>
<tr>
<td>Security</td>
<td>Community string</td>
<td>HTTP authentication, HTTPS</td>
<td>HTTP authentication, HTTPS</td>
</tr>
<tr>
<td>Development Expertise</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Resource</td>
<td>Small</td>
<td>Small</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Management Information Model (1)

<management information for agent>

Prefix: <xsd:element name="system">
   <xsd:complexType>
      <xsd:all>
         <xsd:element ref="sysDescr" minOccurs="0"/>
         <xsd:element ref="sysObjectId" minOccurs="0"/>
         <xsd:element ref="sysUpTime" minOccurs="0"/>
         <xsd:element ref="sysContact" minOccurs="0"/>
         <xsd:element ref="sysName" minOccurs="0"/>
         <xsd:element ref="sysLocation" minOccurs="0"/>
         <xsd:element ref="sysServices" minOccurs="0"/>
      </xsd:all>
   </xsd:complexType>
</xsd:element>
Management Information Model (2)

<Management Information for Manager>
<table>
<thead>
<tr>
<th>Device equipped with an SNMP Agent</th>
<th>Device equipped with an XBM Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>XNMS/Device/DeviceInfo</td>
<td>XNMS/Device/DeviceInfo</td>
</tr>
<tr>
<td>&lt;? xml version= “1.0” ?&gt;</td>
<td>&lt;? xml version= “1.0” ?&gt;</td>
</tr>
<tr>
<td>&lt;DeviceInfoList DeviceID= “device1” &gt;</td>
<td>&lt;DeviceInfoList DeviceID= “device2” &gt;</td>
</tr>
<tr>
<td>&lt;DeviceIP&gt;141.223.82.121&lt;/DeviceIP&gt;</td>
<td>&lt;DeviceIP&gt;141.223.82.122&lt;/DeviceIP&gt;</td>
</tr>
<tr>
<td>&lt;AdminID&gt;mjchoi&lt;/AdminID&gt;</td>
<td>&lt;AdminID&gt;mjchoi&lt;/AdminID&gt;</td>
</tr>
<tr>
<td>&lt;AlertEmail&gt;<a href="mailto:mjchoi@postech.ac.kr">mjchoi@postech.ac.kr</a>&lt;/AlertEmail&gt;</td>
<td>&lt;AlertEmail&gt;<a href="mailto:meanie@postech.ac.kr">meanie@postech.ac.kr</a>&lt;/AlertEmail&gt;</td>
</tr>
<tr>
<td>&lt;AlertEmail&gt;<a href="mailto:siwa@postech.ac.kr">siwa@postech.ac.kr</a>&lt;/AlertEmail&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;AgentType&gt;1 (SNMP agent)&lt;/AgentType&gt;</td>
<td>&lt;AgentType&gt;2 (XBM agent)&lt;/AgentType&gt;</td>
</tr>
<tr>
<td>&lt;Gateway&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;GatewayIP&gt;141.223.82.77&lt;/GatewayIP&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;ReadCommunity&gt;public&lt;/ReadCommunity&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;WriteCommunity&gt;private&lt;/WriteCommunity&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;MIBName&gt;RFC1213-MIB&lt;/MIBName&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;/Gateway&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;Description&gt;Linux Machine&lt;/Description&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;/DeviceInfoList&gt;</td>
<td></td>
</tr>
</tbody>
</table>
Management Protocol (1)
### Management Protocol (2)

#### XQuery (Get)

<table>
<thead>
<tr>
<th>Between XNMS and the XML/SNMP Gateway</th>
<th>Between XNMS and the XBM Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;DeviceIP&gt;</code> 141.223.82.121</td>
<td><code>&lt;DeviceIP&gt;</code> 141.223.82.122</td>
</tr>
<tr>
<td><code>&lt;Gateway&gt;</code> 141.223.82.56</td>
<td><code>&lt;Gateway&gt;</code> 141.223.82.122</td>
</tr>
<tr>
<td><code>&lt;ReadCommunity&gt;</code> public</td>
<td><code>&lt;ReadCommunity&gt;</code> public</td>
</tr>
<tr>
<td><code>&lt;SNMPVersion&gt;</code> 0</td>
<td><code>&lt;SNMPVersion&gt;</code> 0</td>
</tr>
<tr>
<td><code>&lt;MibName&gt;</code> RFC1213-MIB</td>
<td><code>&lt;MibName&gt;</code> RFC1213-MIB</td>
</tr>
<tr>
<td><code>&lt;XPath&gt;</code> //interfaces</td>
<td><code>&lt;XPath&gt;</code> //interfaces</td>
</tr>
</tbody>
</table>

#### XUpdate (Set)

<table>
<thead>
<tr>
<th>Between XNMS and the XML/SNMP Gateway</th>
<th>Between XNMS and the XBM Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;DeviceIP&gt;</code> 141.223.82.72</td>
<td><code>&lt;DeviceIP&gt;</code> 141.223.82.122</td>
</tr>
<tr>
<td><code>&lt;Gateway&gt;</code> 141.223.82.121</td>
<td><code>&lt;Gateway&gt;</code> 141.223.82.122</td>
</tr>
<tr>
<td><code>&lt;WriteCommunity&gt;</code> media</td>
<td><code>&lt;WriteCommunity&gt;</code> media</td>
</tr>
<tr>
<td><code>&lt;SNMPVersion&gt;</code> 1</td>
<td><code>&lt;SNMPVersion&gt;</code> 1</td>
</tr>
<tr>
<td><code>&lt;MibName&gt;</code> RFC1213-MIB</td>
<td><code>&lt;MibName&gt;</code> RFC1213-MIB</td>
</tr>
<tr>
<td><code>&lt;XPath&gt;</code> //sysConact</td>
<td><code>&lt;XPath&gt;</code> //sysConact</td>
</tr>
<tr>
<td><code>&lt;Modifications&gt;</code> &lt;Update select=”//sysConact”&gt;admin</td>
<td><code>&lt;Modifications&gt;</code> &lt;Update select=”//sysConact”&gt;admin</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><code>&lt;/XQuery&gt;</code></td>
<td><code>&lt;/XQuery&gt;</code></td>
</tr>
</tbody>
</table>
## Analysis (1)

<table>
<thead>
<tr>
<th>Operation</th>
<th>DOM Interfaces</th>
</tr>
</thead>
</table>
| **Creation**               | **interface Document : Node**  
|                            | * Element createElement(in DOMString tagName)                                  |
|                            | **interface Node**                                                           |
|                            | * Node appendChild(in Node newChild) raises(DOMException)                     |
|                            | * Node insertBefore(in Node newChild, in Node refChild) raises(DOMException)   |
| **Deletion**               | **interface Node**                                                           |
|                            | * Node removeChild(Node oldChild) raises(DOMException)                        |
| **Navigation/Retrieval**   | **interface Node**                                                           |
|                            | * readonly attribute Node parentNode                                          |
|                            | * readonly attribute Node firstChild                                         |
|                            | * readonly attribute Node lastChild                                          |
|                            | * readonly attribute Node previousSibling                                     |
|                            | * readonly attribute Node nextSibling                                         |
|                            | * readonly attribute NodeList childNodes                                      |
|                            | **interface NamedNodeMap**                                                    |
|                            | * Node getNamedItem(in DOMString name)                                        |
|                            | **interface Document**                                                       |
|                            | * NodeList getElementsByTagName(in DOMString tagname)                        |
| **Setting values/Modification** | **interface Node**                                                           |
|                            | * attribute DOMString nodeValue                                               |
|                            | **interface Element : Node**                                                 |
|                            | * void setAttribute(in DOMString name, in DOMString value) raises(DOMException) |
## Analysis (2)

<table>
<thead>
<tr>
<th>Operation</th>
<th>DOM Interfaces</th>
</tr>
</thead>
</table>
| Filtering & Scoping | **interface XPathEvaluator**  
|                   | • XPathExpression createExpression  
|                   | • DOMString lookupNamespaceURI(in DOMString prefix)  
|                   | • Node iterateNext() raises(XPathException, dom::DOMException)  
|                   | • Node snapshotItem(in unsigned long index) raises(XPathException)  
|                   | **interface NodeFilter**  
|                   | • short acceptNode(in Node n)  
|                   | **interface TreeWalker : TreeWalker**  
|                   | **interface NodeIterator**  
|                   | • Node nextNode() raises(dom::DOMException)  
|                   | • Node previousNode() raises(dom::DOMException)  
|                   | • void detach()  |
### Presentation (1)

<table>
<thead>
<tr>
<th>XML</th>
<th>XSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>&lt;xsl:template match=&quot;sysDescr</td>
</tr>
<tr>
<td>&lt;system&gt;</td>
<td>&lt;Script Language=&quot;JavaScript&quot;&gt;</td>
</tr>
<tr>
<td>&lt;sysDescr&gt;</td>
<td>var val = &quot;&lt;xsl:value-of select=&quot;.&quot;/&gt;&quot;;</td>
</tr>
<tr>
<td>IBM IRC</td>
<td>if (val == &quot;&quot;</td>
</tr>
<tr>
<td>System/6000</td>
<td>val = &quot;null&quot;;</td>
</tr>
<tr>
<td>Machine Type</td>
<td>data += &quot;</td>
</tr>
<tr>
<td>&lt;/sysDescr&gt;</td>
<td>document.write(&quot;&lt;td&gt;&lt;p align=&quot;center&quot;&gt;&quot; + val + &quot;&lt;/p&gt;&lt;/td&gt;&quot; );</td>
</tr>
<tr>
<td>&lt;sysObjectID&gt;</td>
<td>&lt;/Script&gt;</td>
</tr>
<tr>
<td>.1.3.6.1.4.1.2.3.1.2.1.1.2</td>
<td>&lt;/xsl:template&gt;</td>
</tr>
</tbody>
</table>
Presentation (2)
XBM Agent – Get/Set

XML-based Manager

EWS (HTTP Server Engine)

HTTP Client Engine

MGMT. Script

Get/Set

XML filename

xmlOpen()

XPath

getXpath()

modified XPath

parsed XML document

returnXml()

XML document

xmlClose()

HTTP OK

HTTP Client Engine

HTTP Server Engine

MGMT. Backend Interface

MGMT. Script

XML-based Manager

HTTPS

XBM Agent – Get/Set

XML-based Network Management
XBM Agent - Trap

XML-based Manager

HTTPS

EWS (HTTP Server Engine)

HTTP Client Engine

Mgmt. Script

Scheduler

job list file

no. of jobs

getAddress()

getAddress()

checkJob()

insertJob()

timerHandler()

xmldoc

mxmldoc

mgrt. data

getData()

runWget()

runWget()

clearJob()

clearJob()

checkJob()

insertJob()

timerHandler()

xmldoc

xmldoc

xmltrp

xmltrp

trap info.

Mgmt. Backend Interface

XML-based Network Management
### XBM Agent - XPath

<table>
<thead>
<tr>
<th>Grammar</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>/</td>
<td>The basic Xpath syntax similar to filesystem addressing</td>
<td>//AAA/BBB</td>
</tr>
<tr>
<td>//</td>
<td>All elements in the document which fulfill following criteria are selected</td>
<td>//BBB</td>
</tr>
<tr>
<td>*</td>
<td>All elements located by proceeding path</td>
<td>/*</td>
</tr>
<tr>
<td>@</td>
<td>Attributes are specified by @ prefix</td>
<td>//@id</td>
</tr>
<tr>
<td>[]</td>
<td>Filter</td>
<td>BBB[@id='b1']</td>
</tr>
<tr>
<td>=</td>
<td>Comparative operator</td>
<td>BBB[@id='b1']</td>
</tr>
<tr>
<td></td>
<td>Equals to logical OR</td>
<td>//AAA</td>
</tr>
<tr>
<td>&amp;</td>
<td>Equals to logical AND</td>
<td>//AAA &amp; //BBB</td>
</tr>
</tbody>
</table>
Implementation (1) – XBM Manager

- Implementation environments
  - Linux Server with Pentium-III 800 MHz CPU and 256 MB RAM
  - Apache Xerces 1.4.4 for XML parser
  - Apache Xalan 2.4.0 for XPath & XSLT processor
  - Apache Xindice 1.0 for XMLDB
  - Apache Tomcat 4.0 for HTTP server
  - Innovation’s HTTP Client V0.3
Implementation (2) – XBM Agent

- Implementation considering requirements
  - Low Resource Utility: Implement parts of XML parser and XPath handler for processing management information in XML format
  - Portability: Develop components for each module using C language
  - Security: The access is permitted through authentication with ID and password in the initial contact

- Implementation environment (IP sharing device)
  - Processor: MPC850DE
  - ROM Size: 16MB
  - OS: Embedded Linux based on linux2.2.13-7 Kernel
  - Compiler: powerpc-linux-gcc
Implementation (3) – Gateway

- Implementation environments
  - Linux Server with Pentium-III 800 MHz CPU and 256 MB RAM
  - Apache Xerces 1.4.4 for XML parser
  - Apache Xalan 2.4.0 for XPath & XSLT processor
  - OpenNMS’s joeSNMP 0.2.6 for SNMP Handler and Trap Handler
  - Apache Tomcat 4.0 for HTTP server
  - Innovation’s HTTP Client V0.3
Performance Evaluation Environments

XBM Manager
(Pentium III
800MHz, CPU 256MB)

100 Mbps

SNMP Manager
(Pentium III
800MHz, CPU 256MB)

100 Mbps

XML/SNMP
Gateway
(Pentium III
800MHz, CPU 256MB)

100 Mbps

IP sharing device

XBM Agent
SNMP Agent

100 Mbps

Network Device
SNMP Agent

100 Mbps

100 Mbps
Performance Evaluation - Gateway

XML-based Network Management

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DP&NM Lab.
POSTECH
## Performance Evaluation - Gateway

### Response time (MIB II)

<table>
<thead>
<tr>
<th>Device (MIB size) Method</th>
<th>Device 1 (28 KB)</th>
<th>Device 2 (54 KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNMP Stack: T1 (ms)</td>
<td>1307.1</td>
<td>4283.6</td>
</tr>
<tr>
<td>XML Parser-based Translation: T2 (ms)</td>
<td>1360.6 (4.1 %)</td>
<td>4317.6 (0.8 %)</td>
</tr>
<tr>
<td>HTTP-based Translation: T3 (ms)</td>
<td>1419.1 (8.6 %)</td>
<td>4418.8 (3.2 %)</td>
</tr>
<tr>
<td>SOAP-based Translation: T4 (ms)</td>
<td>1613.3 (23.4 %)</td>
<td>4922.2 (14.9 %)</td>
</tr>
</tbody>
</table>

< Response Time of Get >
Performance Evaluation - Traffic

Network Traffic (MIB II – system group)

![Graph showing network traffic vs number of SNMP agents](image-url)
Performance Evaluation – Response Time

✿ Response Time (MIB II – system group)

![Graph showing response time vs number of SNMP agents]

- SNMP <-> Gateway
- Gateway <-> XBM
- Total (XBM <-> SNMP)

XML-based Network Management - 54 -
Performance Evaluation – Resource Utility

- CPU Usage & Memory Usage

Graph showing the relationship between Resource Utility (%) and the Number of SNMP agents. The graph compares CPU Usage (squares) and Memory Usage (circles) for different numbers of SNMP agents.