CIMDIFF: Advanced Difference Tracking Tool for CIM Compliant Devices

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Outline

- Background
- Model and Problem Definition
- System Overview
- Implementation
- Results
- Conclusion and Future Work
Background (I)

Web Based Enterprise Management (WBEM)

CIM Client

CIM-XML/HTTP

CIM Agent

MOF

CIMOM

Providers

Indication

Security

Repository

CIM_ManagedElement

CIM_ManagedSystemElement

CIM_LogicalElement

CIM_EnabledLogicalElement

CIM_System

CIM_ComputerSystem

CIM_FCPort

CIM_LogicalDevice

CIM_LogicalPort

CIM_NetworkPort
Background (II)

```xml
<?xml version="1.0" ?>
<CIM CIMVERSION="2.0" DTDVERSION="2.0">
  <MESSAGE ID="0" PROTOCOLVERSION="1.0">
    ...
    <INSTANCENAME CLASSNAME="IBMTSDS_StorageSystem">
      <KEYBINDING NAME="Name">
        <KEYVALUE VALUETYPE="string">
          IBM.1750-6887010
        </KEYVALUE>
      </KEYBINDING>
      <KEYBINDING NAME="CreationClassName">
        <KEYVALUE VALUETYPE="string">
          IBMTSDS_StorageSystem
        </KEYVALUE>
      </KEYBINDING>
    </INSTANCENAME>
    <INSTANCE CLASSNAME="IBMTSDS_StorageSystem">
      <PROPERTY NAME="CodeLevel" TYPE="string">
        <VALUE TYPE="string">5.2.2.399</VALUE>
      </PROPERTY>
      <PROPERTY NAME="NVSMemory" TYPE="uint32">
        <VALUE TYPE="uint32">256</VALUE>
      </PROPERTY>
      <PROPERTY NAME="CacheMemory" TYPE="uint32">
        <VALUE TYPE="uint32">2629</VALUE>
      </PROPERTY>
      ...
    </INSTANCE>
  </MESSAGE>
</CIM>
```
Motivation and Problem Definition

• Discovery operation by System Management tool
• Administrators Query difference between systems
• XML Document difference tracking
• NP Hard
• Meaningful Difference Tracking

\[
C_r = \{ N^+ \}
\]
\[
N = \{ C_i \mid C_{op} \mid C_p \}
\]
\[
C_i = \{ C_{op}, C_p \}
\]
\[
C_{op} = \{ C_p^+ \}
\]
Model and Problem Definition (II)

Temporal

Temporal-Syntactic

Snapshot of Same CIM Agent(s)
CIMInstance addition/deletion/.. (e.g. CIM_StorageVolume)

Temporal-Semantic

Snapshot of Same CIM Agent(s)
Logical Actions : Volume Assignment
(e.g. CIM Instance creation/modification Volume, Privilege, ProtocolControllerForUnit Cause of Extrinsic method invocation)

Spatial

Spatial-Syntactic

Snapshot of Different CIM Agent(s)
Diff in CIM Properties
(e.g. CIM_StorageVolume instances)

Spatial-Semantic

Snapshot of Different CIM Agent(s)
Diff in Logical Properties
(e.g. TotalSpace, AvaliableSpace etc..)
System Overview

CIM Repository $<t_0, \text{CIMAgent}_a>$

CIM Repository $<t_1, \text{CIMAgent}_a>$

CIM Repository $<t_m, \text{CIMAgent}_x>$

CIM Repository $<t_n, \text{CIMAgent}_y>$

SAN Simulator

INPUT

CIMDIFF

Hash Maker | Knowledge Base | Hierarchy Resolver

Difference Tracker

OUTPUT
Hash Maker

- <CIM Repository>
  - <CIM Device> → <CIM Class> → <CIM Instance> → <CIM Objectpath>
  - <CIM Device> → <CIM Class> → <CIM Instance> → <CIM Objectpath>
KnowledgeBase (I)
KnowledgeBase - Recipe

```c
//Create Storage Volume on an Array [10GB RAID-5 Volume]
// RequestedSize = 10 * 1024 * 1024 * 1024 // 10 GB

1. Enumerate all StoragePools associated with $StorageArray
2. For each StoragePool {
   if(StoragePool is non-primordial) {
      get StorageCapabilities associated with StoragePool
      if(StorageCapabilities == Volume Requirements) {
         if (StoragePool has free space available) {
            invoke GetSupportedSizes and(or) getSupportedSizeRange
            //Round up using integer arithmetic
            get valid capacity of newly created volume
            Select StoragePool and Select VolumeSize
         } } }
3. Services[] = AssociatorNames(StorageArray)
4. StorageConfigurationService = Services[0]
5. InArguments[ElementType] = 2 // Storage Volume
   InArguments[Goal] = GeneratedStorageSetting
   InArguments[Size] = VolumeSize
   InArguments[InPool] = StoragePool
   InArguments[TheElement] = null
   ReturnValue = InvokeMethod(
                       StorageConfigurationService,
                       CreateOrModifyElementFromStoragePool,
                       InArguments, OutArguments)

6. if ((ReturnValue == 0 || ReturnValue == 4096 & &
       OutArguments[TheElement] != null)) {
      //Reference to the newly created volume
      CreatedVolume--> = OutArguments[TheElement] }
```
KnowledgeBase – StorageVolume Creation
KnowledgeBase – StorageVolume Assignment
calculateMinCostEditScripts(Cr1, Cr2)
{
    /* Hashing */
    Map Cr1 to T1, Map Cr2 to T2
    Hash T1, Hash T2
    /* Traverse CIM Agent Hierarchy */
    /* Traverse Managed Device Hierarchy */
    Traverse CIM Agent hierarchy &
    Traverse Managed Device hierarchy
    {
        /* Check tree isomorphism based on Hash */
        /* Compute Insert, Delete, Update */
        for all Node N in T1 and T2
            for all CIMClass(es)
                for all CIMInstance(s)
                    Compare CIMObjectpath
                    Compare CIMProperties
    }
}
## Implementation

### CIM Diff - Windows Internet Explorer

![CIM Diff](https://cimdiff.almaden.ibm.com/performdiff.html)

**Navigation Panel**
- CIM Agents
  - Register CIM Agent
    - 9.181.193.212
    - 9.181.193.213
  - Unregister CIM Agent
- Knowledgebase Tuning
- Snapshot CIM Agent
- Capture Snapshot
- List Snapshots
- Start CIM Agent (Snapshot)
- Stop CIM Agent (Snapshot)
- Setting

**Temporal Difference**

<table>
<thead>
<tr>
<th>Source CIMOM</th>
<th>Target CIMOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMOM Port</td>
<td>5969</td>
</tr>
<tr>
<td>CIMOM Username</td>
<td>cimuser</td>
</tr>
<tr>
<td>CIMOM Password</td>
<td>**********</td>
</tr>
<tr>
<td>CIMOM Namespace</td>
<td>/roo/bm</td>
</tr>
<tr>
<td>CIMOM Protocol</td>
<td>https</td>
</tr>
<tr>
<td>Description</td>
<td>DS8000 @ Rochester</td>
</tr>
</tbody>
</table>

**Test Connection**

**Result**

<table>
<thead>
<tr>
<th>Device Type</th>
<th>IBM 2107 Storage System</th>
<th>IBM 2107 Storage System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Storage</td>
<td>730 GB</td>
<td>730 GB</td>
</tr>
<tr>
<td>Available Storage</td>
<td>410 GB</td>
<td>260 GB</td>
</tr>
<tr>
<td>Number of Disks</td>
<td>24</td>
<td>36</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIM Repository An</td>
<td>CIM Repository Bm</td>
</tr>
<tr>
<td>74 CIM Classes</td>
<td>78 CIM Classes</td>
</tr>
<tr>
<td>1874 CIM Instances</td>
<td>2436 CIM Instances</td>
</tr>
</tbody>
</table>

### CORRESPONDING CLASSES

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBMTSDS_Volume</td>
<td>LSISSI_StorageVolume</td>
</tr>
<tr>
<td>PowerOnHours</td>
<td>NO Corresponding</td>
</tr>
<tr>
<td>CIMProperty</td>
<td>CIMProperty</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBMTSDS_Volume</td>
<td>LSISSI_StorageVolume</td>
</tr>
<tr>
<td>No Corresponding</td>
<td>RaidLevel</td>
</tr>
<tr>
<td>CIMProperty</td>
<td>CIMProperty</td>
</tr>
</tbody>
</table>

### CORRESPONDING INSTANCE COUNTS

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBMTSDS_Volume</td>
<td>LSISSI_StorageVolume</td>
</tr>
<tr>
<td>212 CIM Instances</td>
<td>120 CIM Instances</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBMTSDS_ExtentPool</td>
<td>LSISSI_StoragePool</td>
</tr>
<tr>
<td>7 CIM Instances</td>
<td>5 CIM Instances</td>
</tr>
<tr>
<td>(Extends from CIM_StoragePool)</td>
<td>(Extends from CIM_StoragePool)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CIM</th>
<th>CIMDIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBMTSDS_DiskDrive</td>
<td>LSISSI_DiskDrive</td>
</tr>
<tr>
<td>36 CIM Instances</td>
<td>12 CIM Instances</td>
</tr>
</tbody>
</table>
# Results

<table>
<thead>
<tr>
<th>CIM Repository An</th>
<th>CIM Repository Bm</th>
</tr>
</thead>
<tbody>
<tr>
<td>RemainingManagedSpace</td>
<td>RemainingManagedSpace</td>
</tr>
<tr>
<td>840 GB</td>
<td>300 GB</td>
</tr>
<tr>
<td>Remaining RAID-5</td>
<td>Remaining RAID-5</td>
</tr>
<tr>
<td>Space 640 GB</td>
<td>Space 300 GB</td>
</tr>
<tr>
<td>Remaining RAID-1</td>
<td>Remaining RAID-1</td>
</tr>
<tr>
<td>Space 140 GB</td>
<td>Space 0 GB</td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>CIMRepository-A0</th>
<th>CIMRepository-A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1874 CIM Instances</td>
<td>1942 CIM Instances</td>
</tr>
<tr>
<td>IBMTSDS-Volume</td>
<td>IBMTSDS-Volume</td>
</tr>
<tr>
<td>212 CIM Instances</td>
<td>[SAME]</td>
</tr>
<tr>
<td></td>
<td>[DELETED]</td>
</tr>
<tr>
<td></td>
<td>216 CIM Instances</td>
</tr>
<tr>
<td></td>
<td>[NEW]</td>
</tr>
<tr>
<td></td>
<td>5 CIM Instances</td>
</tr>
<tr>
<td></td>
<td>[MODIFIED]</td>
</tr>
<tr>
<td></td>
<td>17 CIM Instances</td>
</tr>
<tr>
<td></td>
<td>1 CIM Instances</td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>CIMDiff</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMRepository-A0</td>
<td>CIMRepository-A1</td>
</tr>
<tr>
<td>1874 CIM Instances</td>
<td>1942 CIM Instances</td>
</tr>
</tbody>
</table>

#### Differences:

- **VOLUME CREATION**
  - IBMTSDS-Volume
    - 212 CIM Instances
  - IBMTSDS-Privilege
    - 18 CIM Instances

- **VOLUME ASSIGNMENT**
  - IBMTSDS-Volume
    - 224 CIM Instances
  - IBMTSDS-Privilege
    - 20 CIM Instances
  - IBMTSDS-ProtocolController
    - 48 CIM Instances
  - IBMTSDS-ProtocolController
    - 52 CIM Instances

....
Conclusion and Future Work

• Diff Utility
  • XML, GNU, CVS,...

• Multi-Hierarchical XML Document
  • Standards Based
  • KnowledgeBase Driven
  • Meaningful Diff Tracking

• Powerful tool for system administrators
  & system management tool developers and testers

• Tool can be used in SNIA CTP Environment
• Fast Changing Virtual Environment

• Using Machine learning for automatic pattern detection
• Visual tool for administrator to specify pattern
Thank You!