Tape Library Virtualization

Based on IEEE Standard 1244

Wolfgang Mueller-Friedt, wolfmuel@de.ibm.com
“Tape and media management is starting to become a problem in the distributed space, and customer requirements are extending beyond the simple tools available in the backup products today.”

Source: Gartner (2003)
“Dynamic device sharing capabilities replace the practice of each backup server owning its own devices and support dynamic assignment of specific drives to applications as they are needed.”

Source: Gartner (2003)
IEEE Standard 1244 for Media Management Systems

Data Model (IEEE 1244.1)
- Defines a set of objects, their attributes and their relations
- Extends standard relational model by allowing the addition of new attributes to objects
- Allows to integrate every kind of removable media (Tape, CD, DVD, MO, etc.)

MMP: Media Management Protocol (IEEE 1244.3)
LMP: Library Management Protocol (IEEE 1244.4)
DMP: Drive Management Protocol (IEEE 1244.5)
- Asynchronous exchange of text messages over TCP/IP connection (like http, ftp, etc.)
- Commands address the specific needs of media-, library and drive management
- Powerful language
IEEE 1244 Middleware

IEEE 1244 Media Management Protocol

Backup Applications
Archive Applications
Other Applications

Data

SAN

Media, Library and Drive Management and Virtualization Middleware

MM Server

SCSI/FC
Streaming Devices (Drives)
Removable Media Hardware
Libraries with SCSI Media Changer interface

SCSI/FC
Media Changer Devices

SCSI/FC
Prop Interface
Streaming Devices (Drives)
Removable Media Hardware
Libraries with proprietary interfaces
IEEE 1244 compliant: IBM Integrated Removable Media Manager (IRMM)
MMS Architecture (cont.)

Host Drive Manager (HDM)

- Designed to:
  - Reports local device handles to media manager
  - Check path when cartridges is loaded
  - Reports statistical data to media manager when cartridge is unloaded

SAN

TSM External Lib. Manager (ELM)

- Designed to:
  - Reports slots, drives, and cartridges to the media manager
  - Controls libraries on behalf of the media manager
  - Encapsulate library hardware

Admin Console

Media Manager

- Command line interface

Library Manager

IRMM

- Designed to:
  - Coordinate access to drives and cartridges
  - Be a central repository
  - Log all activities

IBM TS3500

IBM 3494

SUN/StorageTek ACSLS Libraries

HDM

ELM
(1.) Tivoli Storage Manager server wants to mount a scratch tape

(2.) Tivoli Storage Manager ELM sends request to Media Manager via TCP/IP
MMS Control Flow (cont.)

(3.) Media manager selects scratch cartridge and idle drive

(4.) Media manager forwards request via TCP/IP to the LM

(5.) Library manager moves cartridge to drive

(6.) Drive manager checks path to drive

- TSM External Lib. Manager (ELM)
- Host Drive Manager (HDM)
- IBM TS3500
- IBM 3494
- SUN/StorageTek ACSLS Libraries
- SAN
MMS Control Flow (cont.)

(7.) Media manager updates status
(8.) Response to Tivoli Storage Manager server via TCP and ELM
(9.) Direct access to drive

IBM TS3500
IBM 3494
SUN/StorageTek ACSLS Libraries

SAN

TSM External Lib. Manager (ELM)
Host Drive Manager (HDM)
### Tape virtualization choices

<table>
<thead>
<tr>
<th>Type</th>
<th>What/where?</th>
<th>Description</th>
<th>Chief benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual tape</td>
<td>Temporary disk workspace organized data for writing to tape</td>
<td>More-efficient use of tape cartridges</td>
<td></td>
</tr>
<tr>
<td>Virtual tape library</td>
<td>Disk storage is used to emulate a physical tape library</td>
<td>Increased reliability of restoration, shortened backup times</td>
<td></td>
</tr>
<tr>
<td>Tape library virtualization</td>
<td>Flexibly allocates tape drives and tape slots of a physical tape library</td>
<td>More-efficient use of tape library resources</td>
<td></td>
</tr>
</tbody>
</table>

Source: Mesabi Group

Tape Library Virtualization

Physical Tape Storage

Backup / Archive Applications

Virtual Libraries presented by MMS

Physical Tape Storage

Backup / Archive Applications
One Pool of Tape Storage

- Logical pool of tape storage beyond physical library boundaries
- Applications only have to deal with one library
- Physical storage capacity can easily be added without changes to the application
- Scratch mounts still possible as long as one physical library is online
- MMS may provide workload balancing by distributing scratch mount requests
- Preferably done with homogeneous physical tape drives / media
Multiple Logical Libraries

- Dynamically configurable logical libraries on top of one physical library
- IRMM prevents unauthorized application access
- Supports heterogeneous environments
Dynamic grouping of drives and cartridges

**DriveGroups:**
- Used to aggregate drives
- Drives can be added and removed dynamically
- Used to implement access permission model and preferential usage policy
- May span multiple libraries

**CartridgesGroups:**
- Used to aggregate cartridges
- Cartridges can be added and removed dynamically
- Used to implement access permission model and preferential usage policy
- May span multiple libraries
Access Permission Model:
- Applications are subject to access control
- Two-level access permission model
- Administrative applications may access every Drive
- Standard applications may only access Drives within DriveGroups which have been assigned to them by an administrative application

Preferential Usage Policy:
- DriveGroup-Application relations have priority attribute
- Drives have priority attribute too
- Priority is used by IRMM to find drive for a mount operation
SMC vs. IEEE 1244

- **SCSI Media Changer (SMC) Interface:**
  - In-band
  - Get slot/drive - element address map
  - MOVE MEDIUM FROM element address TO element address

- **IEEE 1244 Interface:**
  - Out-of-band
  - Application awareness
    - Authorization, Ownership, Audit Trails
  - Cartridge state change awareness
    - Scratch ➔ Private
    - Private ➔ Scratch
  - SQL – like queries
  - Rich MM functionality
How to define IRMM managed resources:

1. define library libname libtype=external
2. define path servername libname srctype=server
desttype=library externalmanager= /opt/IBM/ermm/client/tsm/elm
3. define devclass devclassname library=libname devtype=3592 mountretention=5 mountlimit=20
4. define stgpool stgpoolname devclassname maxscratch=500

• That’s all!
• You don’t have to define drives and drive paths!
## Volumes Allocated on Cartridges

### Volumes

<table>
<thead>
<tr>
<th>Name</th>
<th>PCL</th>
<th>Application</th>
<th>Mounted Last</th>
<th>Time Mounted</th>
<th>Mounted</th>
</tr>
</thead>
<tbody>
<tr>
<td>A00013</td>
<td>A00013JA</td>
<td>3494LM</td>
<td>2006-08-29 11:52:37</td>
<td>73313</td>
<td>false</td>
</tr>
<tr>
<td>A00014</td>
<td>A00014JA</td>
<td>3494LM</td>
<td>2006-08-28 13:07:01</td>
<td>170079</td>
<td>false</td>
</tr>
<tr>
<td>A00027</td>
<td>A00027JA</td>
<td>3494LM</td>
<td>2006-08-28 20:47:54</td>
<td>1732</td>
<td>false</td>
</tr>
<tr>
<td>A00039</td>
<td>A00039JA</td>
<td>3494LM</td>
<td>1970-00-01 02:00:00</td>
<td>0</td>
<td>false</td>
</tr>
<tr>
<td>J1D406</td>
<td>J1D406</td>
<td>TSM</td>
<td>2006-08-17 13:47:14</td>
<td>2184</td>
<td>false</td>
</tr>
<tr>
<td>J1D409</td>
<td>J1D409</td>
<td>TSMWIN</td>
<td>2006-08-17 09:27:09</td>
<td>1691</td>
<td>false</td>
</tr>
<tr>
<td>J1D411</td>
<td>J1D411</td>
<td>TSMWIN</td>
<td>2006-08-17 07:58:49</td>
<td>45</td>
<td>false</td>
</tr>
<tr>
<td>J1D412</td>
<td>J1D412</td>
<td>TSM</td>
<td>2006-08-16 15:27:08</td>
<td>59</td>
<td>false</td>
</tr>
<tr>
<td>J1D433</td>
<td>J1D433</td>
<td>TSMWIN</td>
<td>2006-08-17 09:21:30</td>
<td>171</td>
<td>false</td>
</tr>
</tbody>
</table>

**Filter:**

- **First**
- **Prev**
- **Next**
- **Last**

**Total:** 9  **Displayed:** 1 ... 9
### Dynamic Assignment of Cartridges to Groups

#### Cartridges

**Manage Cartridges**

<table>
<thead>
<tr>
<th>PCL</th>
<th>Type</th>
<th>Group</th>
<th>Library</th>
<th>State</th>
<th>Mounts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A00004</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocatable</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>A00013</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocated</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>A00014</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocated</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>A00016</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A00022</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>A00023</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A00024</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A00025</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A00026</td>
<td>ScratchPool</td>
<td>3584-1</td>
<td>allocatable</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A00027</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocated</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>A00039</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocated</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>J1D405</td>
<td>3592JA</td>
<td>0x12c</td>
<td>allocatable</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>J1D406</td>
<td>3592JA</td>
<td>TSM</td>
<td>allocated</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>J1D409</td>
<td>3592JA</td>
<td>TSMWIN</td>
<td>allocated</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>J1D411</td>
<td>3592JA</td>
<td>TSMWIN</td>
<td>allocated</td>
<td>13</td>
</tr>
</tbody>
</table>

**Filter:**

- **Total:** 20
- **Displayed:** 1 ... 15

---

Storage Developer Conference 2008
© 2008 SNIA. All Rights Reserved.

www.storage-developer.org
CartridgeGroups are assigned to Applications

### CartridgeGroup-Application Objects
Manage CartridgeGroup-Application Objects

<table>
<thead>
<tr>
<th>Group</th>
<th>Application</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0x12c</td>
<td>3494LM</td>
</tr>
<tr>
<td>0x12c</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>0x12d</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>0xff00</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>0xff10</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>Default</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>ScratchPool</td>
<td>ERMMSystem</td>
<td>3494LM</td>
</tr>
<tr>
<td>ScratchPool</td>
<td>TSM</td>
<td>1000</td>
</tr>
<tr>
<td>ScratchPool</td>
<td>TSMWIN</td>
<td>1000</td>
</tr>
<tr>
<td>TSM</td>
<td>TSMWIN</td>
<td>1000</td>
</tr>
<tr>
<td>TSMWIN</td>
<td>TSMWIN</td>
<td>1000</td>
</tr>
</tbody>
</table>

3494 Emulation on top of MMS

Common Scratch Pool

Private Pool for every Application

Total: 15 Displayed: 1 ... 15
DriveGroups are assigned to Applications

### DriveGroup-Application Objects
Manage DriveGroup-Application Objects

<table>
<thead>
<tr>
<th>Group</th>
<th>Application</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>3494</td>
<td>3494LM</td>
<td>1000</td>
</tr>
<tr>
<td>3494</td>
<td>ERMMSystem</td>
<td>1000</td>
</tr>
<tr>
<td>Default</td>
<td>ERMMSystem</td>
<td>1000</td>
</tr>
<tr>
<td>Default</td>
<td>TSM</td>
<td>1000</td>
</tr>
<tr>
<td>Default</td>
<td>TSMWIN</td>
<td>1000</td>
</tr>
</tbody>
</table>

First  Prev  Next  Last  Total: 5  Displayed: 1 ... 5
### Three Applications sharing Drives

#### DriveCartridgeAccess

Manage DriveCartridgeAccess

<table>
<thead>
<tr>
<th>Drive</th>
<th>Cartridge</th>
<th>Application</th>
<th>AI</th>
<th>TimeMounted</th>
<th>TimeUnmounted</th>
</tr>
</thead>
</table>

#### Filter:

Total: 174
Displayed: 145 ... 159
# Host – Drive Access

## Drive Managers
Manage Drive Managers

<table>
<thead>
<tr>
<th>Name</th>
<th>Drive</th>
<th>Host</th>
<th>Handle</th>
<th>StateSoft</th>
<th>StateHard</th>
</tr>
</thead>
<tbody>
<tr>
<td>/dev/rmt6@127.0.0.1</td>
<td>00077850</td>
<td>127.0.0.1</td>
<td>/dev/rmt6</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>/dev/rmt5@127.0.0.1</td>
<td>00135980</td>
<td>127.0.0.1</td>
<td>/dev/rmt5</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>/dev/rmt11@127.0.0.1</td>
<td>3584-1-257</td>
<td>127.0.0.1</td>
<td>/dev/rmt11</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>/dev/rmt8@127.0.0.1</td>
<td>3584-1-258</td>
<td>127.0.0.1</td>
<td>/dev/rmt8</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape5@9.155.87.80</td>
<td>00077850</td>
<td>9.155.87.80</td>
<td>//.Tape5</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape1@9.155.87.80</td>
<td>00135980</td>
<td>9.155.87.80</td>
<td>//.Tape1</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape0@9.155.87.80</td>
<td>3584-1-257</td>
<td>9.155.87.80</td>
<td>//.Tape0</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape4@9.155.87.80</td>
<td>3584-1-257</td>
<td>9.155.87.80</td>
<td>//.Tape4</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape2@9.155.87.80</td>
<td>3584-1-258</td>
<td>9.155.87.80</td>
<td>//.Tape2</td>
<td>absent</td>
<td>ready</td>
</tr>
<tr>
<td>//.Tape3@9.155.87.80</td>
<td>3584-1-258</td>
<td>9.155.87.80</td>
<td>//.Tape3</td>
<td>absent</td>
<td>ready</td>
</tr>
</tbody>
</table>

**Total:** 10  **Displayed:** 1 ... 10
### Mount History

#### DriveCartridgeAccess
Manage DriveCartridgeAccess

<table>
<thead>
<tr>
<th>Drive</th>
<th>Cartridge</th>
<th>Application</th>
<th>AI</th>
<th>TimeMounted</th>
<th>TimeUnmounted</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM3584-257</td>
<td>496AFQL2</td>
<td>TSM</td>
<td>TSM@ermm</td>
<td>2005-07-03 12:01:19</td>
<td>2005-07-03 12:03:30</td>
</tr>
<tr>
<td>IBM3584-257</td>
<td>495AFQL2</td>
<td>TSM</td>
<td>TSM@ermm</td>
<td>2005-07-03 11:52:51</td>
<td>2005-07-03 11:54:00</td>
</tr>
</tbody>
</table>

Filter: [Select] [Set] [Reset] [Save]
## Storage Media Library (SML) Profile:

- Clause 4: Storage Library Profile
- Clause 5: Element Counting Subprofile
- Clause 6: InterLibraryPort Connection Subprofile
- Clause 7: Library Capacity Subprofile
- Clause 8: Library/Alert Events/Indications for Library Devices
- Clause 9: Limited Access Port Elements Subprofile
- Clause 10: Media Movement Subprofile
- Clause 11: Virtual Tape Library System Profile
- Clause 12: Virtual Tape Library Copy Profile

### CIM-Mapping for IEEE 1244:

| Title: CIM Mapping of the IEEE SSSWG Media Manager Model |
| Date: 02/24/2000 |
| Author: Andrea Westerinen |

<table>
<thead>
<tr>
<th>IEEE Object</th>
<th>Attribute Name</th>
<th>CIM Property</th>
</tr>
</thead>
</table>

This spreadsheet reflects the class and association hierarchy defined by the CIM Schema V2.2.
IEEE 1244 gaining more traction?

OpenSolaris Project: Media Management System

View the leaders for this project
Project Observers

Endorsing communities
Storage

Welcome to MMS

The Media Management System (MMS) is a new magnetic tape and tape library management facility based on IEEE standard 1244, Media Management System. The primary function of MMS is to provide a removable media mounting surface in a distributed environment.

http://www.opensolaris.org/os/project/mms/
Links & References

- IEEE Storage Systems Standards Working Group
- IBM Integrated Removable Media Manager
- Media Management System for OpenSolaris
- SGI OpenVault
- Troppens, Erkens, Mueller: Storage Networks Explained