IEEE Standard for Media Management System (MMS) Library Management Protocol (LMP)

Sponsor

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Abstract: The protocol syntax and semantics of messages that pass between the Library Manager (LM) and the Media Manager (MM) of an IEEE Media Management System (MMS) are specified. This standard specifies version 1.0 of the Library Management Protocol (LMP).
Keywords: application independent, architecture, automated tape library, content neutral, data model, device manager, distributed, drive manager, fully scalable, heterogeneous environment, information access, interoperability, interoperable, language neutral, library management, library manager, media management, media neutral, middleware, opensource, operating system independent, platform-independent, protocol based, removable media, robotic tape library, secure, software, storage, storage management, storage system, system architecture

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Introduction

[This introduction is not part of the IEEE Std 1244.5-2000 IEEE Standard for Media Management System (MMS) Library Management Protocol (LMP).]

This is one of five MMS standards balloted together under IEEE Project 1244 for Storage System Design:

IEEE Std 1244.1-2000—IEEE Standard for Media Management System (MMS) Architecture

IEEE P1244.2/D041900—Draft Standard for Media Management System (MMS) Session Security, Authentication, Initialization Protocol (SSAIP)

IEEE Std 1244.3-2000—IEEE Standard for Media Management System (MMS) Media Management Protocol (MMP)

IEEE Std 1244.4-2000—IEEE Standard for Media Management System (MMS) Drive Management Protocol (DMP)

IEEE Std 1244.5-2000—IEEE Standard for Media Management System (MMS) Library Management Protocol (LMP)

This MMS Architecture standard (IEEE Std 1244.1-2000) is best understood in the context of the others by reading the first sections of the Architecture. These five standards are the first in a suite of ten approved projects for the IEEE MMS, and all ten might well have been a single standard. However, their separation was maintained to make conformance easier and individual evolution possible.

By permission of SGI™ this standard is based on the SGI™ OpenVault™ product, which SGI™ has released to the open source community. However, the IEEE Media Management System, developed by the IEEE Storage System Standards Working Group (SSSWG), is a significant refinement and extension of OpenVault™ . The IEEE Mass Storage System Reference Model (MSSRM) influenced OpenVault™ design before work began on the MMS, and the present OpenVault™ reflects strong influence in its development by the IEEE SSSWG.

At the time this standard was completed, the Storage System Standards Working Group (SSSWG) had the following members:

John L. (Jack) Cole, *Chair*

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Samuel S. Coleman*	Jan Klier	Geoffrey G. Peck
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Technical editors of these five standards are as follows:

IEEE Std 1244.1-2000—IEEE Standard for Media Management System (MMS) Architecture

—Geoffrey G. Peck (Primary Editor for Architecture)

—Curtis Anderson

—Murali Sathyanarayana (Primary Editor for the Data Model)

—Curtis Anderson, Joel N. Williams, T. Dixon Hutchinson, Alan Rollow

IEEE P1244.2/D041900—Draft Standard for Media Management System (MMS) Session Security, Authentication, Initialization Protocol (SSAIP)

—Bruce K. Haddon (Primary Editor, 2000–present)

—Jan Klier (Primary Editor, 1998-2000)

—Curtis Anderson, Joel N.Williams

IEEE STD 1244.3-2000—IEEE Standard for Media Management System (MMS) Media Management Protocol (MMP)

—Murali Sathyanarayana (Primary Editor)

—Curtis Anderson, Joel N.Williams, Dixon Hutchinson, Alan Rollow

IEEE Std 1244.4-2000—IEEE Standard for Media Management System (MMS) Drive Management Protocol (DMP)

—Joel N.Williams (Primary Editor)

—Murali Sathyanarayana

IEEE Std 1244.5-2000—IEEE Standard for Media Management System (MMS) Library Management Protocol (LMP)

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Sponsor chairs of this standard are as follows:

—Merritt E. Jones (1993-2000)

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IEEE Standard for Media Management System (MMS) Library Management Protocol (LMP)

1. Overview

1.1 Scope

This standard describes the syntax and semantics of the protocol messages that pass between the Library Manager (LM) and the Media Manager (MM). Since the LM exists only in the context of a larger Media Management System (MMS), this standard cannot be understood without a thorough understanding of the architecture of the MMS as described in IEEE Std 1244.1-2000.[1] In addition, certain elements common to all of the modules in the MMS are described in IEEE Std 1244.1-2000 and IEEE P1244.2/D041900,[2] and the MM itself, a system which operates as a peer process with the LM, is described in IEEE Std 1244.3-2000.

1.2 Purpose

This standard specifies the protocol syntax and semantics of messages that pass between the LM and the MM of an IEEE MMS. The language that the MM module uses to communicate with the LM and the corresponding language that the LM uses to communicate with the MM are collectively called the Library Management Protocol (LMP). This protocol determines and/or describes all relevant behavior and the state of the MM and the LM. The standardized protocol and semantics of the LMP allow any conforming MM and LM to operate together as components of a single MMS.

1.3 Conformance

An LM conforms to this standard if it can send and receive protocol messages in the syntax described in this standard, acts in accordance with the semantics of those messages, and operates the underlying device(s) as described in this standard and the related standards mentioned in 1.1. Exactly those protocol messages described in this standard shall be implemented. No additional protocol messages, that is, messages not defined in this standard, may be added. Exactly those objects, as they relate to the LM, described in the database in IEEE Std 1244.1-2000 shall be supported, and no additional objects may be added.

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[1]Information on references can be found in Clause 2.

[2]Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

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This standard specifies version 1.0 of the LMP. It is expected that this protocol will periodically be revised, at which time addenda to or revisions of this standard will be issued. LMs and MMs negotiate for a mutually agreeable version of the DMP as described in IEEE P1244.2/D041900.

1.4 Rationale for the LM

In a traditional approach, everything that could be in a library would be visible to and managed by the MM. This includes, for example, drives, bays, cartridge transfer agents, cartridge access ports, pass-through ports between libraries, etc. (This approach made an LM almost trivial to write, but it also put the whole problem of efficiently managing the resources of an arbitrarily complex library onto the MM).

The approach specified in the IEEE 1244 series of standards centralizes virtually all of the configuration and management problems for a given library into a piece of software that is custom written for that library. This new approach means that new library support can be added to an existing environment by simply adding a new LM, and without changing the MM. In this approach, the LM module is the part of the overall MMS, which knows the intimate details of a particular library and its configuration and control procedures. The LMP is designed to abstract away as many of the details of a library as practical, without compromising the ability of the MM to efficiently manage its resources. An LM can be thought of as a black-box language translator device and/or a device-management module. The LM is responsible for performing the tasks that the MMS asks it to do while efficiently managing the resources of the library. It speaks LMP with the MMS, and some device-specific language to the library itself.

This approach assumes that there will be a custom-written LM for each make/model of library. Since each LM will be custom written for that make/model of library, it must have its own methods of determining the library's configuration and capabilities at run time.

2. References, definitions

A suite of IEEE 1244 standards describes the MMS. This modular approach to standardizing an MMS permits a granularity of conformance not possible otherwise, and allows a degree of independent evolution for the components of an IEEE MMS. Nevertheless, the overall architecture of the IEEE MMS is described in IEEE Std 1244.1-2000, and fundamental information (including the data model) that is common to all related standards is communicated through that standard. Reference to the MMS Architecture is crucial in understanding the LMP.

This standard shall be used in conjunction with the following standards. When the following standards are superseded by an approved revision, the revision shall apply.

IEEE Std 1244.1-2000, IEEE Standard of Media Management System (MMS) Architecture.[3]

P1244.2/D041900—Draft Standard for Media Management System (MMS) Session Security, Authentication, Initialization Protocol (SSAIP).[4]

IEEE Std 1244.3-2000, IEEE Standard for Media Management System (MMS) Media Management Protocol (MMP).

IEEE Std 1244.4-2000, IEEE Standard for Media Management System (MMS) Drive Management Protocol (DMP).

[3]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

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Additional references common to all IEEE MMS standards can be found in Clause 2 of IEEE Std 1244.1-2000; definitions can be found in Clause 3 of IEEE Std 1244.1-2000.

3. Library definitions and characteristics

3.1 Persistent storage

Each LM shall maintain only information that is relevant to the library that it is managing. When an LM is started or restarted, this information may be obtained either by querying the connected library or by retrieving this information as previously stored in the MM by the LM (since the MM is used by the LM for persistent storage). During normal operation, the LM typically maintains some state information about the library. Conceptually, the library itself is the authoritative source for information about the library; the LM is just a buffer and a translator.

3.2 LMs and multi-bay libraries

The following rules apply to the definition of a library:

a) A library may be automated or manual; that is, it may or may not require human operators.

b) A library may or may not contain drives. If a library has no drives, then it is a storage device with import/export capabilities only.

c) If a cartridge is contained in a library that is managed by an LM, then that cartridge cannot be accessible via any other LM or any drive not contained in that library, unless the cartridge is exported. If there are drives in a library, then any cartridge in the library shall be capable of being mounted in any drive in that library, provided that the drive is capable of utilizing that cartridge.

For example, a linked set of five automated libraries with pass-through ports sufficient to move any cartridge to any drive in the complex is defined as one library, and hence must be controlled by one LM. On the other hand, a set of five automated libraries that do not have the required pass-through ports to move any cartridge to any drive shall be structured as separate libraries with separate LMs.

One or more bays may be defined in a library. A bay is simply a contiguous collection of slots for storing cartridges, together with zero or more drives. Each slot shall be in exactly one bay; hence the bays partition the slots into disjoint subsets. Similarly, each drive shall be in exactly one bay; hence the bays partition the drives into disjoint subsets. The bay provides a means of optimizing the mounting of cartridges in drives.

A library also has slotgroups. A slotgroup is a collection of contiguous slots that are contained in a bay. Every slot in the library is in exactly one slotgroup; hence the slotgroups partition the slots in the library into disjoint subsets. Slotgroups are used to model ports and magazines as well as ordinary slots, and for ports there is the additional attribute of the slotgroup's direction.

3.3 Optimization at the library level

Since the LMP language explicitly allows tasks to be queued, and does not mandate that they be executed serially, the LM is free (but not required) to optimize the use of its resources by ordering the movement of cartridges from storage to drives and back. There is, however, the following constraint in task reordering—if one operation depends on the result of another operation queued earlier in time, the two operations may not be reordered with respect to each other.

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Hence the LM, if reordering commands is a possibility, shall perform dependency analysis on the queued commands before it reorders them. For example, the LM must be able to handle move slot22 to slot12 followed by move slot12 to slot32. This has the net effect, when executed in the given order, of moving the contents of slot22 to slot32. If dependency analysis was not done and the commands were reordered, one command would fail (assuming that there is nothing in slot12) and the cartridge in slot22 would end up in slot12.

3.4 Library control constraints

Although only one LM may be managing a library at any time, it is possible to have multiple LMs, with one active and others in reserve in case of a failure of the active manager. The MM ensures that only one LM at a time is actively controlling a library. If the MM switches the controlling LM, it sends an *activate disable* command to the old controlling LM to force it to stop communicating with the drive hardware, then it sends an *activate enable* command to the new controlling LM to force it to resynchronize with the drive hardware.

An LM is required to start itself immediately whenever the machine on which it runs is started. Hence if the machine crashes, or the LM goes down for some other reason, then it must restart itself automatically. The restarted LM may then be activated by the MM. In the case of a failure of one LM, the MM shall not activate another LM until the one that has failed has had sufficient time to restart itself.

If an LM is restarted after a machine crash, or for some other reason, the MM will ask the LM to unmount any cartridges that are no longer in use.

See the **activate** and **ready** commands for details.

4. LMPs overview

The communication between the MM and the LM uses the full-duplex, bi-directional, peer-to-peer interface described in IEEE Std 1244.1-2000. As noted in that standard, the protocol consists of three phases: command, acknowledgement, and response. This standard does not describe that interface, but rather describes the syntax and semantics of the messages that are carried over that interface.

There are two distinct languages used between the LM and the MM, one for each direction in the bi-directional connection. They are as follows:

a) LMP/M: The LMP language spoken by the MM to the LM.

b) LMP/L: The LMP language spoken by the LM to the MM.

One module *speaks* to another if it initiates the command phase of the protocol. In this standard, LMP refers to the Library Management Protocol (LMP), which is made up of both LMP/M and LMP/L.

The LMP/L implements a different command set from the LMP/M language, reflecting its different requirements. The LMP/M language defines a library control interface, while the LMP/L language defines primarily a status reporting, administration, and configuration interface.

The relationship between the MM and an LM is a peer-to-peer relationship. The LM has the ability via the LMP/L language to persistently store information in the database maintained by the MM, to retrieve that information, and to inform the MM of changes in the state of the library.

The LMP utilizes the task identifier mechanism common to all MMS protocols, described in IEEE Std 1244.1-2000. This mechanism directly supports concurrent execution of multiple tasks. The main reason for

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concurrent execution is to allow efficient utilization of a library in which more than one operation may proceed simultaneously. For a very simple library with limited capabilities, concurrent execution may not be appropriate; hence the ability of a library to perform concurrent execution of multiple tasks is not a requirement. Similarly, there may not be much need for that capability for commands defined in the LM/L; hence the ability of the MM to perform concurrent execution of LM/L commands is not a requirement.

An administrative application, specifically written for a particular LM, and running as a client of the MM, may use the setting and reading of special named data elements as a private means of interaction or control. In this case, commands would be passed from the administrative application through the MM to the LM. (See IEEE Std 1244.1-2000 for directions on how to manage such special data elements.) Such named attributes in an LM may be thought of as *control registers*, which cause an operation to occur as a side effect of setting or reading those attributes. For example, writing *10 right* to the private, named data element STK video camera might move a remote television camera 10 degrees right. This mechanism is flexible and extensible, but because the individual private attributes are not standardized, use of private data elements by an administrative application limits it to interaction with a specific type of LM.

The command definitions that follow in Clause 7 and Clause 8 are in Extended Backus-Naur Format (EBNF) as described in IEEE Std 1244.1-2000. Note that all undefined non-terminals resolve to a string, but that for purposes of brevity, this detail is left out. In addition, when these resolve to an entry in the database, this is noted in the subclauses denoted *Identifier arguments*.

5. Response message and command sequencing for LMP

Table 1 lists the protocol sequence, as described in IEEE Std 1244.1-2000.

Table 1—Protocol sequence

Command	Described in Clause 7 and Clause 8.
Acknowledgement	The content and format of the acknowledgement is described in IEEE Std 1244.1-2000. It indicates that the receiving program has or has not successfully received and parsed the command.
Response	The format of the response is described in IEEE Std 1244.1-2000. As noted in that standard, if there are errors in the execution of the command, these errors are returned with the response. In addition, some commands, when executed successfully, contain additional parameters in the response. The specific error codes for this protocol for each command are described with the command in Clause 7 and Clause 8. Error codes that apply to all commands are described in Clause 9. The additional parameters in the response, if any, are listed for each command in Clause 7 and Clause 8.

As noted in IEEE Std 1244.1-2000, the response may include an error message in the format of a message that may be represented in a local language. The EBNF for that message is:

```
<message-clause> ::= "message" "[" { <id-clause> [ <arg-clause> ]
                                   <locale-text-clause>* } "]"
<id-clause> ::= "id" "[" <manufacturer> <model> <messageid> "]"
<arg-clause> ::= "arguments" "[" <arg-pair>+ "]"
<arg-pair> ::= <arg-key> <arg-text>
<locale-text-clause> ::= "loctext" "[" <language> <localized-string> "]"
```

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Messages of this type are used in contexts other than the response, as will be noted in the clauses to follow.

The EBNF for the **response** is:

```
<response-message> ::= "response" { <negative-response> |
                                    <accepted-response> |
                                    <command-response> } ";"
<negative-response> ::= { "unacceptable" [ <message-clause> ] }
<accepted-response> ::= { <task-clause> "accepted"}
<command-response> ::= { <task-identifier>
                         <final-response> [ <message-clause> ] }
<final-response> ::= <response-success> |
                     <response-cancelled> |
                     <response-error>
<response-success> ::= { "success" <response-text>* }
<response-cancelled> ::= "cancelled"
<response-text> ::= text "[" <text-string>+ "]"
<task-clause> ::= task "[" <task-identifier> "]"
```

In addition, certain commands require interaction with the MM through another command. Note that the slotmap, as defined in the data model of IEEE Std 1244.1-2000, contains information describing the location of each of the cartridges in the library. Whenever the MM issues a command to the LM that results in a change in the slotmap, the LM shall send a **config** command to the MM that describes those changes before sending a successful response. Examples of commands that require updating the slotmap are **mount, unmount,** and **move.** In addition, if a library is configured in such a way that cartridges may be introduced into it without any action from the MM or an administrative application, then the introduction of cartridges in this way shall result in one or more **config** commands being sent to the MM by the LM.

For such commands, the sequence (assuming that the command can be executed successfully) is as follows:

a) Command from the MM to the LM.

b) Acknowledgement from the LM to the MM.

c) Action on the part of the LM to execute the command.

d) **config** command from the LM to the MM.

e) Acknowledgement from the MM to the LM.

f) Successful response to the config from the MM to the LM.

g) Successful response from the LM to the MM.

In the case of any acknowledgement or response that does not indicate success, the command sequence is aborted, and the LM takes action to ensure that the library is returned to its previous state.

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6. LMP/M Command definitions

6.1 Command name: mount

The **mount** command is used to mount a cartridge into a drive. The mount arguments are one or more **drives** and one or more **slots**. The operation is to choose one **drive** and **slot** combination out of the **drives** and **slots** specified, and mount the specified side of the cartridge found in that chosen **slot** into the chosen **drive.** A **drive** is specified by its DRIVE.DriveName, while a **slot** is specified by the ordered three-tuple (SLOT.SlotName, CARTRIDGE.Cartridge.PCL, SIDE.SideName).

If the **mount** is successful, the LM updates the slotmap, using the **config** command, and then returns the successful response, which includes the **drive, slot, cartridge PCL,** and **side mounted.**

Since a slot in a SLOTGROUP may be in a port as well as an ordinary slot in the library, the mount command allows the mounting of a cartridge directly from a port, without first storing it in an ordinary slot.

In a sighted library (any library that can read the cartridge PCL automatically), if the cartridge PCL specified does not match the PCL of the cartridge in the slot, the command will fail.

6.1.1 Command specification

```
<mount-command> ::= "mount" <mount-args> ";"
<mount-args> ::= { <task-spec> <drive-spec>+ <slot-spec>+ }
<task-spec> ::= "task" "[" <task-id> "]"
<drive-spec> ::= "drive" "[" <drive-name> "]"
<slot-spec> ::= "slot" "[" <slot-name> <cartridge-pcl> <side-name> "]"
```

6.1.2 Identifier arguments

Identifier arguments are listed in Table 2.

Table 2—Identifier arguments (mount)

Identifier	Argument source or data base location
task	<task-id> is an arbitrary unique string from calling program.
drive	<drive-name> identifies the DRIVE.DriveName.
slot	<slot-name>, <cartridge-pcl>, and <side-name> identify SLOT.SlotName, CARTRIDGE.CartridgePCL, and SIDE.SideName respectively. Note that if the library does not identify SLOTS by name, then <slot-name> shall contain the CARTRIDGE.CartridgePCL, that is, be identical to <cartridge-pcl>.

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